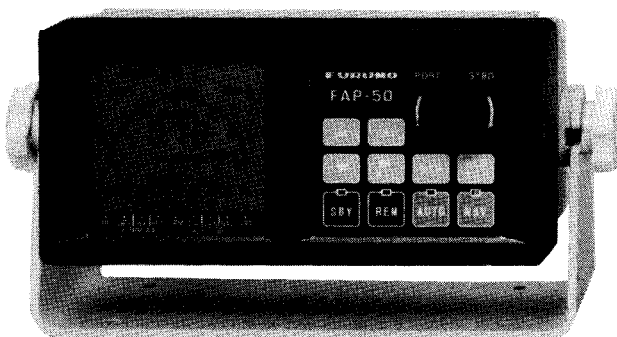


FURUNO

OPERATOR'S MANUAL

AUTOPILOT

MODEL FAP-50



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FURUNO ELECTRIC CO., LTD.
NISHINOMIYA, JAPAN

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YOUR LOCAL AGENT/DEALER

WARNING AND CAUTION

* * * * *

An autopilot is a very convenient and useful piece of equipment if it is used properly. Accidents and collisions are usually due to misuse and misunderstanding of the system.

When using the autopilot, the following precautions should be taken.

- 1) DO NOT USE AUTO/NAV MODES IN THE FOLLOWING CASES.
(Operate in SBY mode in the following cases.)
 - (1) In heavy traffic areas and narrow channels.
 - (2) In bad weather conditions, such as poor visibility, strong wind and current, rough sea, etc.
 - (3) When changing course to avoid collision with other vessels.
 - (4) In the areas where local laws prohibit use of an autopilot.

- 2) Keep the following points in mind when sailing in the AUTO/NAV modes.
 - (1) DO NOT LEAVE THE HELM UNATTENDED.
 - (2) Do not place magnetic materials or magnetic field generating equipment near the magnetic compass.
 - (3) Verify the course and position of the vessel, both before engaging the autopilot and while using it.

- 3) No one navigational aid should be relied upon exclusively for the safety of vessel and crew. The navigator has the responsibility to check all aids available to confirm his position. Electronic aids are not a substitute for basic navigational principles and common sense.

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PRINCIPLE OF OPERATION

An autopilot is a system connected to the ship's steering gear to automatically control the rudder movement in order to steer the ship on a set course. Anyone can appreciate the advantages of being free to carry out navigational checks, trim adjustments, or simply to relax and enjoy himself.

To better understand how the autopilot system works, a brief knowledge of the history of the autopilot is necessary.

The first generation autopilot was developed in the 1930's. Off-course error was detected by a contact wire. The contact is made when the boat moves to one side of the desired course, the contact is broken when the boat moves to the other side. This causes the boat to continually "hunt" back and forth across the correct heading. Hence, the name hunting autopilot.

Although the components in this type of autopilot are relatively simple, the constant zig-zagging across the correct heading decreases fuel economy and increases wear and tear on the autopilot and the steering system.

The second type of autopilot, which was developed in the late 1940's, utilizes two contacts, one for port off-course, and one for starboard off-course. If the boat is on course neither contact is made, resulting in a small arc, or deadband. When a heading error greater than the deadband is detected, the helm is moved in the appropriate direction in an amount proportional to the heading error. As long as the boat remains on a course within this deadband, the helm is at rest.

One of the advantages of this type of autopilot is that it eliminates the constant zig-zagging across the heading. However the boat still may wander within the deadband, thus the course is usually not as tight as desirable.

The latest generation of autopilots, the FAP-50 included, utilizes a proportional rate system to steer the boat. The proportional rate system is similar to the highly accurate and reliable system used on aircraft, missiles, and space vehicles. The proportional rate autopilot provides the necessary course correction to the helm proportional to the speed and the amount the boat moved off-course.

With the removal of the deadband (NAV Mode), the autopilot no longer wanders within a deadband but now steers a prescribed course, taking action within the presence of even a minute course error. The amount of action depends on the course error detected; i.e., when the course error rate is small a very low helm correction rate is applied.

Because the wandering is eliminated, the proportional rate autopilot has the advantages of low power consumption and low wear and tear on the autopilot and the steering system. Off-course correction is smooth, not jerking back and forth at full speed.

The force necessary to steer the boat back onto the set course is provided by a power or drive unit.

Now let's see how an off-course error is detected and how the boat is steered back onto the set course. Figure A on the next page shows the simplified block diagram of the autopilot.

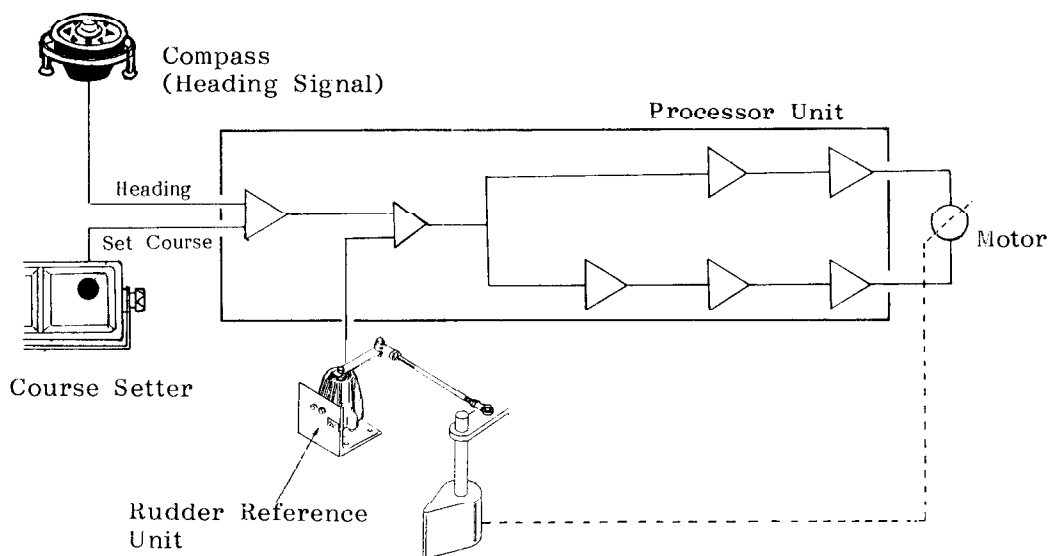


Fig.A Simplified Block Diagram of Autopilot

In the AUTO mode, the primary heading information (on most small boats a magnetic compass or fluxgate sensor) is continuously compared with the set course. With the boat on course, the two signals are equal.

Once the boat goes off course, the difference between the primary heading and the set course will change proportionally and there will be an imbalance at the comparator, whose output will move up or down depending on whether the course error is to the left or right of the set heading.

The rudder continues to move until a balanced condition is obtained at the comparator, at which point the drive switches off.

To set the rudder when the boat is off-course, the rudder angle signal is generated at the rudder reference unit, then fed back to the processor unit.

Although the autopilot is capable of steering a steady course for the helmsman, it cannot think for him. Always post a lookout while under way and never use the autopilot in congested harbors or areas of heavy traffic.

As a final note of caution, it must be remembered that no machine can perform to the utmost of its ability unless it is installed and maintained properly. The reliability and performance of your autopilot is directly related to the quality of the installation. The installation is one of the most complicated of all marine electronics equipment and is best left to a qualified technician. Happy sailing.

CONFIGURATIONS

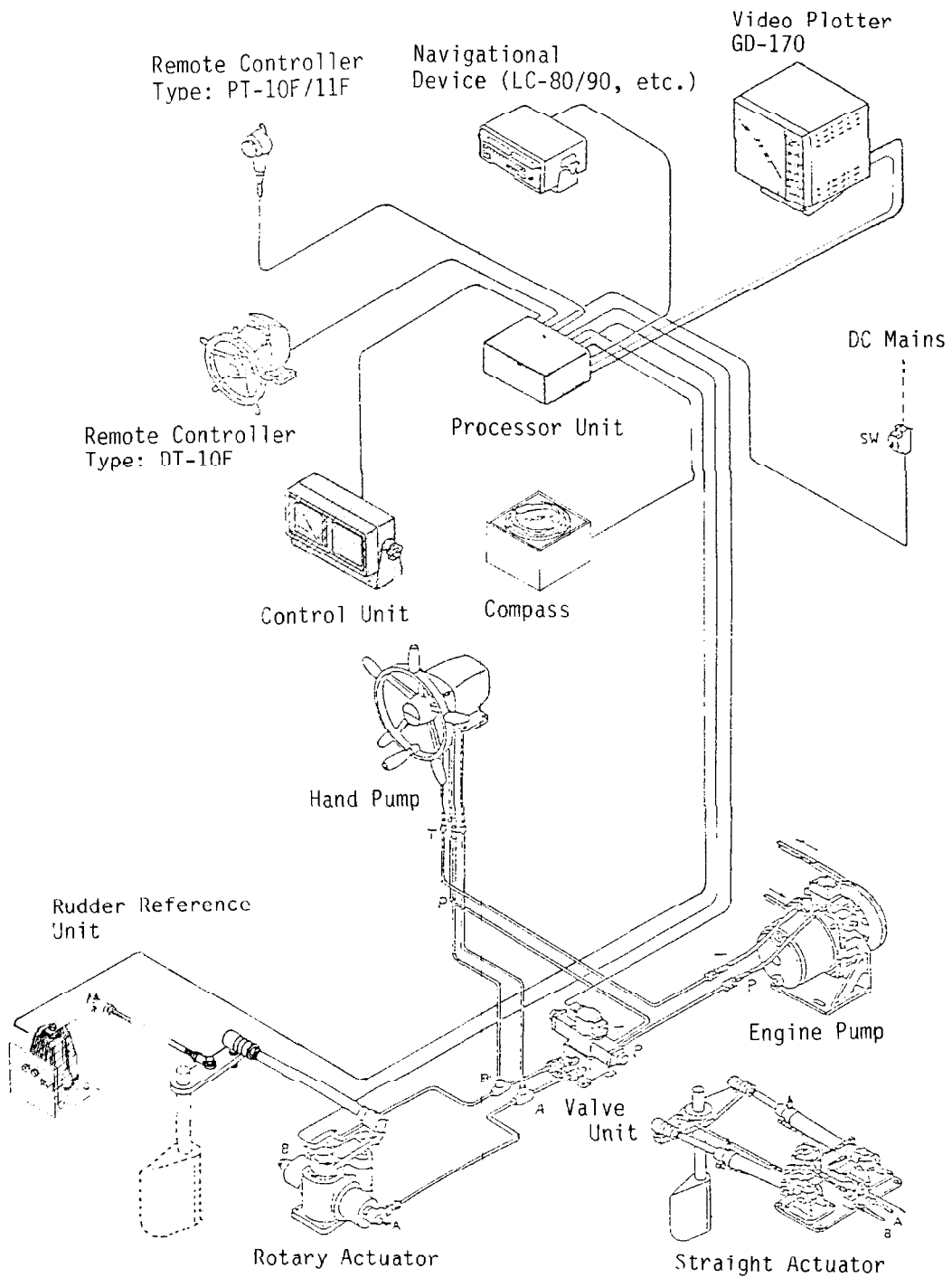


Fig.1 Hydraulic Steering Boat with Valve Unit

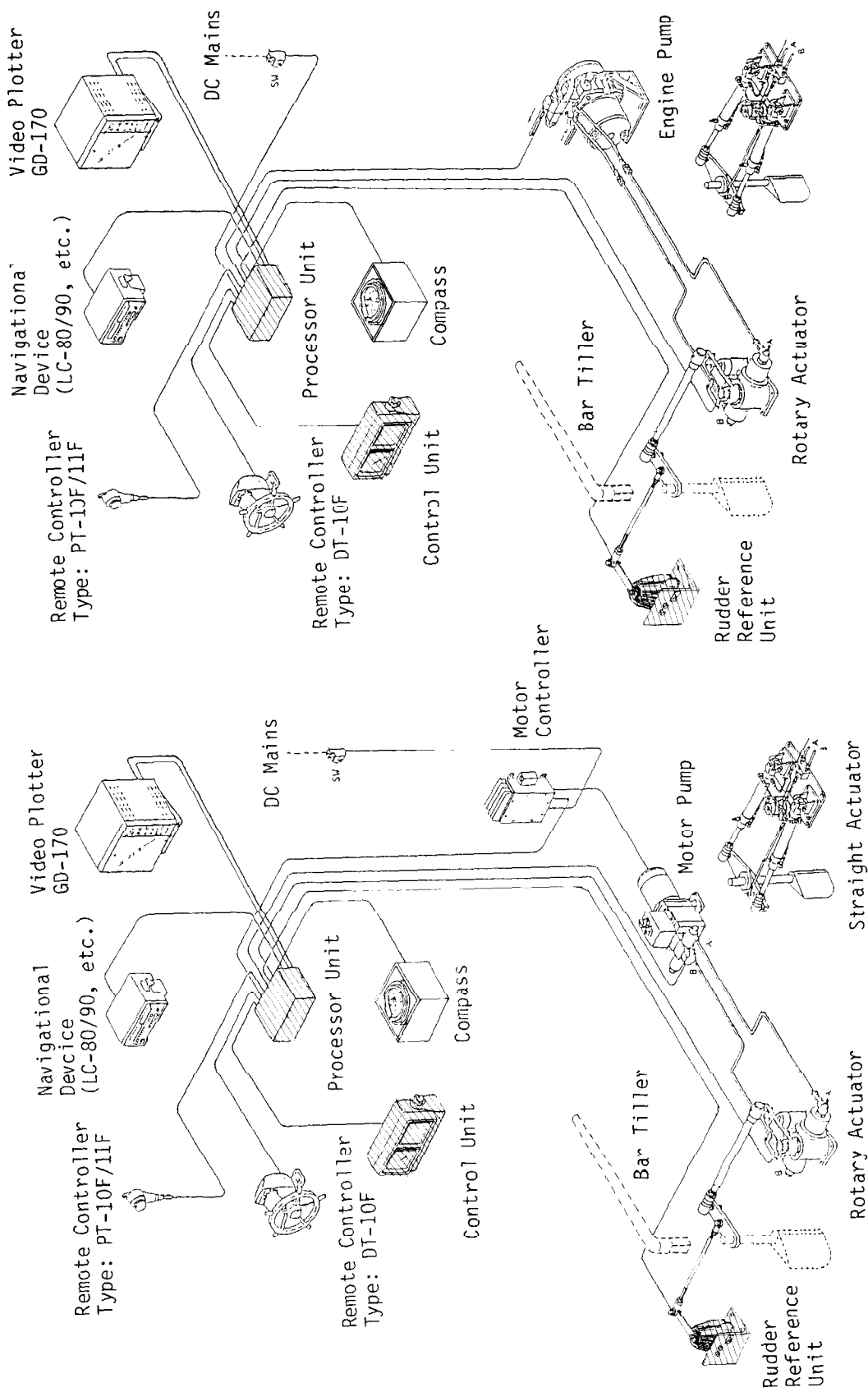


Fig-2 Hydraulic Steering Boats with Bar Tiller

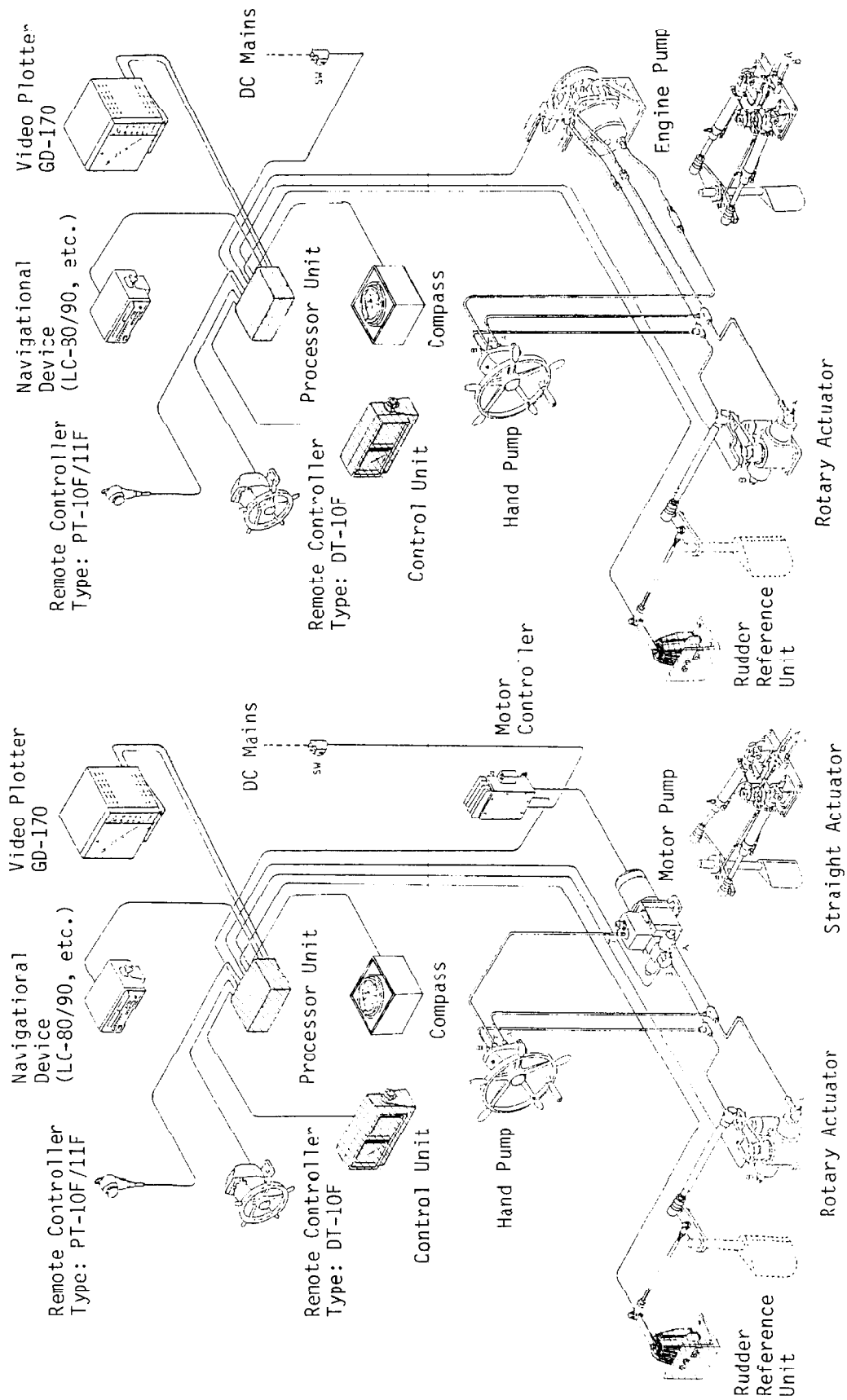


Fig.3 Hydraulic Steering Boats with Hand Pump

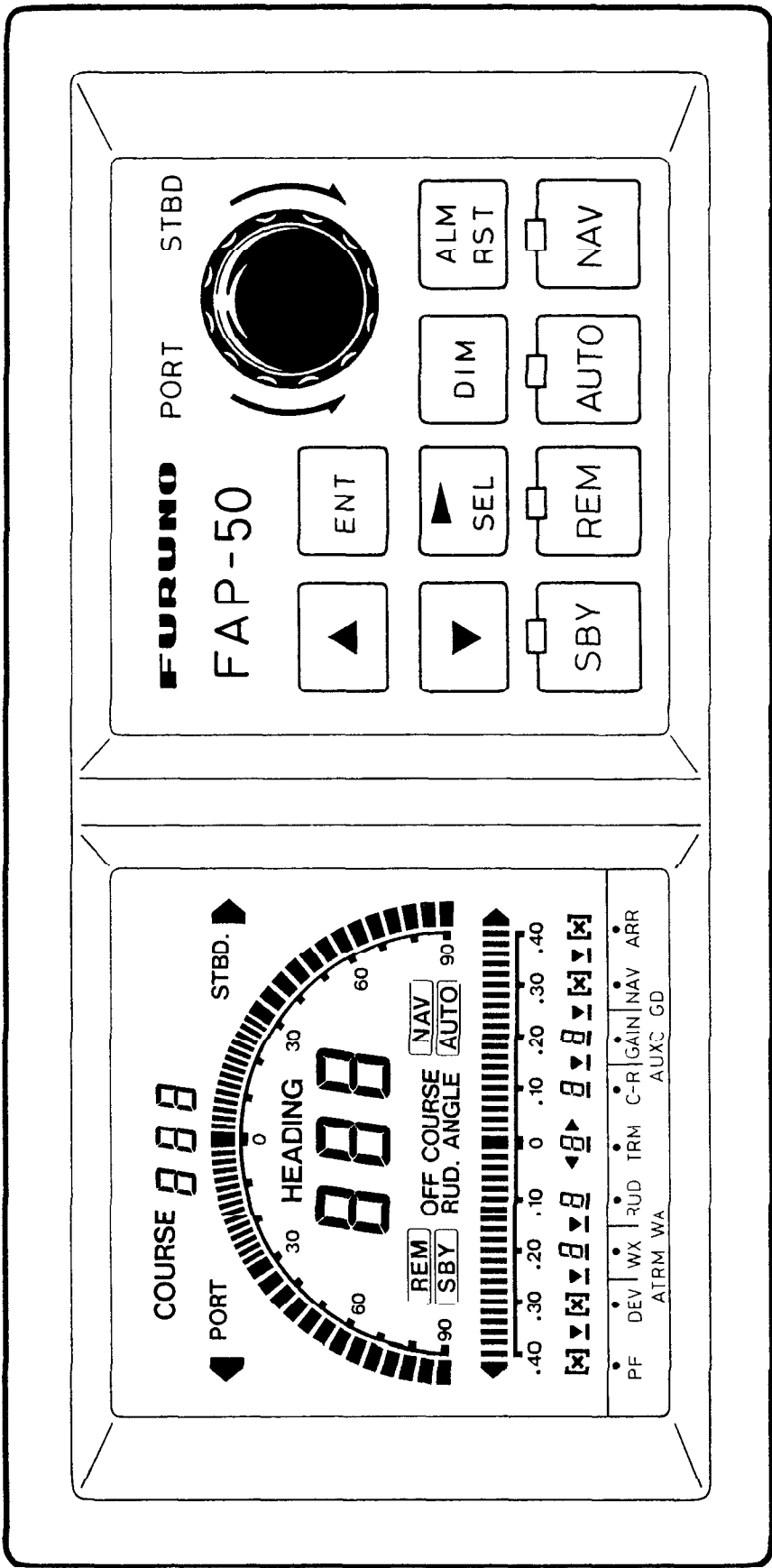


Fig.4 FAP-50 Control Head Panel

OPERATIONAL OVERVIEW

Examine the front panel. You will note that there is a large LCD (Liquid Crystal Display) taking up most of the left-hand side of the front panel, touchpads and a rotary control knob on the right-hand side, and all sorts of abbreviations provided on the panel below the display. These abbreviated labels indicate the various functions and settings. When the alarm indicator is on, an "X" mark will blink inside the brackets above the NAV, ARR, PF and DEV labels.

KEYBOARD

Now look at the keyboard. The mode select keys are placed on the bottom row, and provide the following functions:

SBY: The vessel is steered manually with the helm wheel.

REM: The vessel is steered with the remote steering unit, either handheld or helm unit.

AUTO: The vessel is steered by the autopilot on a straight course at a selected heading.

NAV: This mode is used in connection with navigational equipment such as the Furuno Color Video Plotter GD-170 or Loran LC-90. The Loran C receiver supplies the autopilot with a Cross-Track Error signal, which will correct the set course on the autopilot according to the selected waypoints. The GD-170 sends deviation angle data to the autopilot.

The mode selected is indicated with a lit LED and with an LCD indicator. When the "on/off" switch on the remote controller is turned on during the AUTO or NAV mode, the LED on the selected mode key will blink, and the [REM] key will light up. At the same time, an LCD indicator(REM) appears and the AUTO or NAV LCD indicator is flashing.

The [ALM RST] key stands for Alarm Reset. It is used to silence the audible alarm.

The [DIM] key is used to vary the level of backlighting for the display. There are four levels of backlighting intensity: bright, medium, dim and off. Each time the [DIM] key is pressed, the level will change in the above sequence.

The [SEL] (▶) key selects one of the functions to set its values or to turn it on/off. Pressing this key causes the cursor to move horizontally to select the function into which data will be entered. If the on/off function is selected at the AUX C and GD positions, the inverted triangle mark will appear.

The two arrow keys, ▼ and ▲, and the [ENT] key are used to enter the preset parameters and to turn on/off a function.

A distinctive "beep" is made to confirm that each touchpad key is pressed. An incorrect key sequence causes the "beep" to sound twice, as will an attempt to select a function which is not available (such as attempting to select GD mode when no GD-170 is connected). This will also happen if you attempt to switch to "AUX C" while in the AUTO mode. In order to select the secondary compass, switch to SBY, change the compass input, then switch back to the "AUTO" mode.

COURSE SELECTOR

The Course Selector is located at the upper right-hand side of the front panel and is used for course setting in the AUTO mode. Turning the control will change the desired ship's course. One notch of the control gives a 1 degree course change. Clockwise turning allows starboard course change, and counterclockwise rotation allows port course change. The course selector may be also used for dodging operation.

INTERPRETING THE DISPLAY

Shown below is a typical display from the FAP-50. The ship's present heading is displayed at the center of the display just below the "HEADING" indicator.

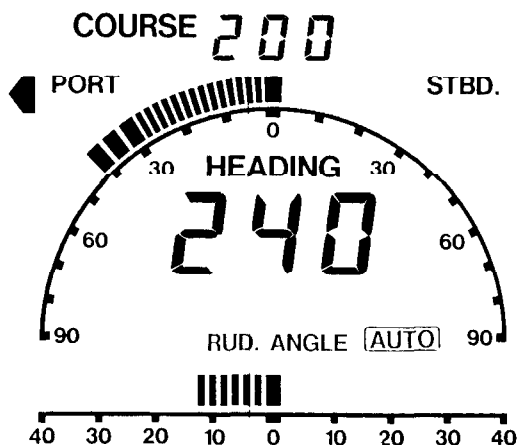


Fig.5

The set course appears to the right of the "COURSE" indicator at the top row. The bearing displayed is the same as that of the HEADING display in the SBY and REM modes. Below and to the left and right of the course indicator are the PORT and STBD indicators. These indicate which direction the ship is being steered. A semi-circle scale graduated every 10° shows the course deviation between the set course and the ship's heading. The direction of the deviation is shown and its value is indicated with LCDs, one LCD representing 2 degrees deviation up to 30° and every 5° thereafter. For example, in the display above there are fourteen small LCDs and three large LCDs displayed on the left side, indicating a 40° course deviation to the starboard side.

The horizontal scale at the bottom of the display is marked every 10° and shows the Rudder Angle in degrees. Each LCD is equal to 2 degrees. In the above example, the rudder angle is 12° port side. This scale is used as an "Off-course" indicator in the NAV mode. The message OFF COURSE appears above the scale and the scale is marked every .10nm. The Cross-Track Error is displayed in 0.02nm steps (one LCD) to a maximum 0.40nm. See Fig.6.

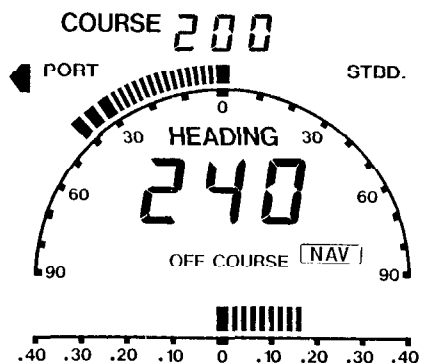


Fig.6 "OFF COURSE" Reading in NAV mode

SUMMARY OF FUNCTIONS AND INDICATORS

PF (Power Failure): The power failure indicator will activate when the main power supply drops by 10% of the rated value.

DEV (Deviation): In NAV mode, this alarm will be activated when the Cross-Track Error (XTE) is greater than 0.30nm (NMEA 0180) or 0.40nm (NMEA 0183).

ATRM (Auto Trim): Used to automatically compensate for constant deviation from the track line caused by wind and current conditions.

WX (Weather): Used to soften the steering in accordance with the weather and sea conditions. (WEATHER ADJUSTMENT)

WA (Watch): When the watch alarm function is on, the reversed triangle mark appears above this label. The alarm sound will be released every 4th and 5th minutes to warn the helmsman to check the situation around the boat.

RUD (Rudder): Used to adjust the rudder setting so that the vessel keeps a straight course with a minimum number of rudder commands. (RUDDER ADJUSTMENT)

TRM (Trim): Used to compensate for constant deviation from the track line caused by wind and current conditions. (TRIM ADJUSTMENT)

C-R (Counter Rudder): Used to select the desired amount of counter rudder to stabilize the vessel. (COUNTER RUDDER ADJUSTMENT)

AUX C (AUX Compass): On a dual compass installation, the reversed triangle mark appears when the auxiliary compass is selected.

GAIN (Gain): Used to determine how quickly the vessel will swing onto the track line. (GAIN ADJUSTMENT)

GD (GD-170): When the navigation signal being fed from the GD-170 Color Video Plotter is selected, the reversed triangle mark appears.

NAV (Navigation): This alarm will be activated when the signal coming out of the navigational receiver is in error.

ARR (Arrival): This alarm warns that the vessel is approaching a destination waypoint. - for NMEA 0183 only

MODE SELECTION

SBY

In this mode, the steering may be carried out by the helm wheel. All autopilot functions are disconnected or disabled, but the readout from the display (Heading and Rudder Angle indication) is available.

REMOTE (REM)

The vessel is steered by the remote controller in this mode. There are

three types of remote controllers: PT-10F, without on/off switch; PT-11F, with on/off switch; and DT-10F, wheel type, and any two of them can be connected. With the "on/off" switch on the remote controller in the "on" position, the autostearing and navigational steering are temporarily disabled, and the vessel can be steered by means of the remote controller.

When the remote controller is switched on during the AUTO and NAV modes, the light on the [REM] key and the LCD indicator(REM) will be on, while the LED/LCD mode indicator for AUTO(NAV) is flashing.

AUTO

The FAP-50 will maintain the vessel's heading automatically at the set course. If the ship's heading deviates from the set course, the autopilot compensates for this deviation automatically. The set course may be manually adjusted by rotating the course selector on the control unit in 1° steps. The set course is indicated on the top row of the display. When the "on/off" switch on the remote controller is turned on during the Auto mode, the AUTO key will blink and the REM key will light up, and the vessel can be steered by the remote controller.

To ensure safe navigation, the maximum rudder angle is limited in the AUTO mode. The limit angle is 10°, 20° and 30°, depending on the RUD setting.

In the AUTO mode, the boat may drift due to wind and current. See Fig.7.

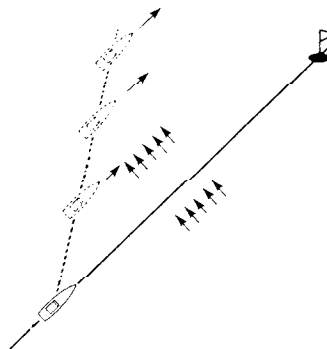


Fig.7 Boat drifting in AUTO mode

The following controls are set depending upon the vessel speed, hull shape, rudder shape, loading condition and weather. Different settings are selected by pressing the [SEL] key until the cursor moves to the desired line. The value can then be changed with the two arrow keys, INCREASE (▲) or DECREASE (▼), followed by the [ENT] key.

Settings

WEATHER (WX):

The function of the WEATHER (sometimes called Yaw Sensitivity or Sea State) setting is to reduce the response of the autopilot to short term heading errors caused by a heavy sea. In other words, quick changes of compass signal are filtered out to soften the steering in accordance with the weather and sea conditions. Normally the WEATHER is set to "1" or "2" in good sea conditions and maximum course holding. It should be raised to avoid unnecessary steering corrections due to the natural yawing characteristics of the vessel in heavy sea. 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. There are nine settings, numbered 1 - 9, to cover $\pm 1^\circ$ to $\pm 10^\circ$ approximately.

Fig.8 shows the ship's course with two different weather settings, "3" and "7." Increasing the value of the WEATHER setting causes low sensitivity, resulting in a wider non-detected angle of course deviation (Dead Band). As long as the boat remains on a course within this dead band, the pilot is at rest (the rudder is not controlled by the autopilot).

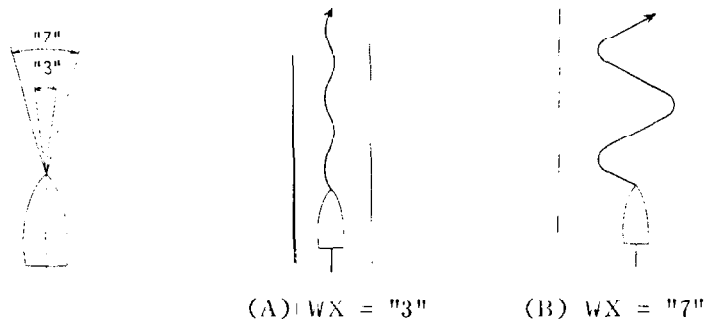


Fig.8 Setting of "WX"

Now let's try actual operation for a WEATHER setting of "7."

1. By pressing the [SEL] key, move the cursor just above the "WX" label.
2. Press the ▲ or ▼ key until "7" appears, and press the [ENT] key.

RUDDER (RUD):

The RUDDER function automatically changes the rudder effect (Rudder Ratio) according to the course error. This is also called P-factor and is the most important value to be set for correct use of the autopilot. This is adjustable to avoid over or under steering at varying vessel speeds, loading, or sea conditions. When the rudder is set to minimum ("1") approximately 0.2 degrees of rudder is applied for every degree of course error. When the rudder is set to maximum ("10") approximately three degrees of rudder are applied for every degree of course error.

The figure below shows an illustration of the various Rudder settings.

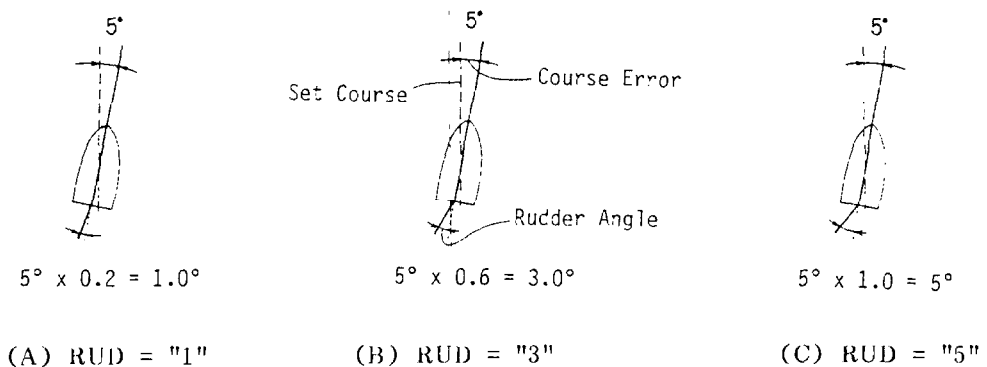


Fig.9 Setting of RUDDER

As a vessel's rudder is less effective at slow speeds, in rough seas or in fully loaded conditions, the RUDDER (Rudder Ratio) must be increased to obtain the proper steering response. In conditions of light loading or high speeds the rudder ratio must be reduced to avoid oversteering. The correct adjustment may be obtained by advancing the rudder control until the vessel just starts to oversteer and then slightly reducing the amount applied.

For example, the key sequence to enter a rudder of "6" is:

1. Call up the "RUD" function by pressing the [SEL] key.
2. Press the ▲ or ▼ key until "6" appears, followed by the [ENT] key.

COUNTER RUDDER (C-R):

This setting is capable of stabilizing the vessel. The correct selection also gives enough counter rudder to bring the vessel smoothly on course after course changes.

The following illustrations show a ship's track where the counter rudder is on and off.

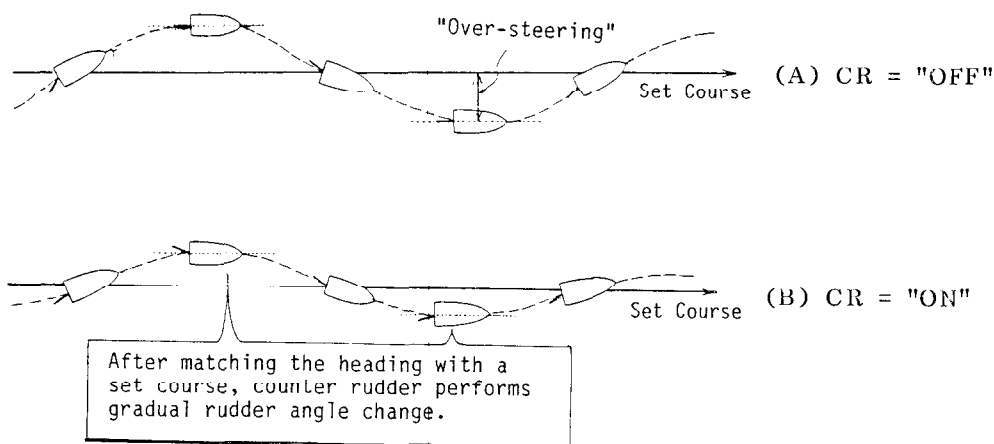


Fig. 10 Effect of Counter Rudder

To set this control correctly, increase the amount of counter rudder applied until the vessel oversteers, or excess rudder corrections occur. Then reduce the amount slightly. When this control is set to "0," no counter rudder is applied.

TRIM (TRM):

A vessel tends to stray off-course with the rudder in midship position. The trim control provides a permanent offset of the rudder to compensate for the drift. The TRIM can be preset with a maximum of 9° at both port and starboard sides. The port side trim is selected by pressing the ▼ key until the desired number is displayed, while the indicator (◀) appears. Then, press the [ENT] key. For the starboard trim, press the ▲ key until the desired number appears with the ▶ mark, followed by pressing the [ENT] key.

The following illustrations give an example to set a port trim of "3" to keep the boat on a straight course with the rudder midship.

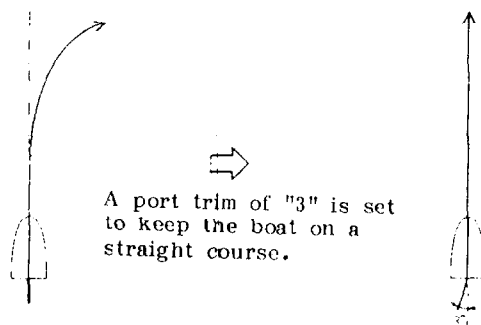


Fig.11 "TRIM" Setting

1. Select the TRIM function by pressing the [SEL] key.
2. Press the ▲ key until "3" appears, and then press the [ENT] key.

When this is set at "0," no trim is applied.

AUTO TRIM (ATRM):

When the auto trim function is turned on, the rudder angle is automatically adjusted to compensate for a standing helm. The rudder angle applied can be read above the "TRM" label. A maximum of 9° rudder angle can be applied automatically at both port and starboard sides. A flashing "9" above the TRM" label shows that the FAP-50 requires a trim of more than 9°.

When the auto trim function is off, the value of the trim setting returns to the manual setting which was used previously. To turn on the auto trim function,

1. Move the cursor above the "ATRM" label, using the [SEL] key.
2. Then, press the ▲ and [ENT] key. A ▼ mark appears above the "ATRM" label.
3. To turn off the function, press the ▼ and [ENT] key.

GAIN:

This setting adjusts the turning speed and the reference time for auto trim calculation. For example, with a GAIN setting of "5," the boat will turn at a speed of 4°/sec. to face to the set course when the AUTO mode is selected and the auto trim is calculated every 25.6 seconds. A higher setting provides faster turning speed but more frequent trim adjustments.

To set a GAIN of "5," follow the procedure below.

1. Move the cursor above the "GAIN" label, using the [SEL] key.
2. Press the ▲ or ▼ key until "5" appears, followed by the [ENT] key.

The table below lists the setting and corresponding value for each preset control.

Table 1 Setting and Corresponding Value on AUTO mode

Rudder:

Setting	1	2	3	4	5	6	7	8	9
Ratio	0.2	0.4	0.6	0.8	1.0	1.2	1.5	2.0	3.0
Limit	10°		20°				30°		

Weather:

Setting	1	2	3	4	5	6	7	8	9
Dead Zone	+1°	+2°	+3°	+4°	+5°	+6°	+7°	+8°	+10°

Counter Rudder:

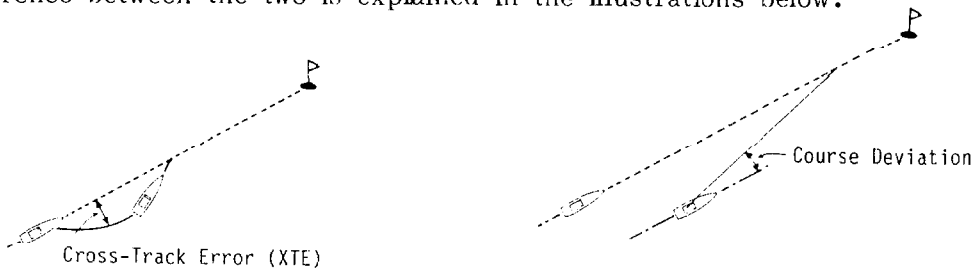
Setting	0	1	2	3	4	5	6	7	8	9
Level	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0

Trim:

Setting(▶)	0	1	2	3	4	5	6	7	8	9
C. Balance	0	+1°	+2°	+3°	+4°	+5°	+6°	+7°	+8°	+9°
Setting(◀)	1	2	3	4	5	6	7	8	9	
C. Balance(Port Side)	-1°	-2°	-3°	-4°	-5°	-6°	-7°	-8°	-9°	

NAV

There are two ways to accomplish the Navigational (NAV) mode operation; using the Cross-Track Error signal from the Navigational Receiver or the Course-to-Steer signal from the Furuno Color Video Plotter, GD-170. The difference between the two is explained in the illustrations below.



(A) NAV mode with navigational device

(B) NAV mode with GD-170

Fig.12 NAVIGATIONAL Steering

Cross-Track Error Signal:

The NAV mode utilizes the Cross-Track Error (XTE) from the navigational receiver to supervise the autopilot in maintaining an accurate over-the-ground heading. The vessel will follow the intended track line between the start waypoint and the arrival waypoint. See Fig.12(A).

The autopilot uses the XTE to make small changes to the vessel's course to obtain the shortest distance between the two waypoints. In this way, currents and weather will have very little effect on the vessel's track line.

Navigational steering must only be used in open waters. The vessel normally follows the intended course with a deviation of ± 0.31 (NMEA 0180) and ± 0.41 (NMEA 0183), higher deviation can temporarily occur due to currents, wind and speed or at start up from a position out of the track line.

The FAP-50 is able to receive a navigational signal of NMEA 180 format or NMEA 0183 format. The correct format is selected by means of DIP switch S1 #4 inside the processor unit. (See page 39.)

If your navigational device provides the Route function and new waypoint data is sent out from it, the boat is steered automatically, following a selected route. Automatic update of the set course to the next waypoint is performed on the FAP-50 ten seconds after the boat arrives at the arrival alarm area.

Course to Steer Signal:

In addition to the above connection, the FAP-50 can be used with the Furuno Color Video Plotter GD-170. The deviation between the set course and the actual heading is sent to the FAP-50 from the GD-170 and the boat is controlled to keep the ship's heading toward the intended course (set course). See Fig.12(B).

When the FAP 50 is used in connection with the GD 170, the "GD" function should be set to on; select the SBY mode, move the cursor just above the "GD" label, press ▲ and the [ENT] key, and back to the NAV mode. To disable the GD function, press ▼ and the [ENT] key on the SBY mode.

In the NAV mode, the GAIN must be adjusted. The setting of the gain is dependent on the make of the 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.

Fig.13 illustrates examples of GAIN settings which are too high, proper, and too low.

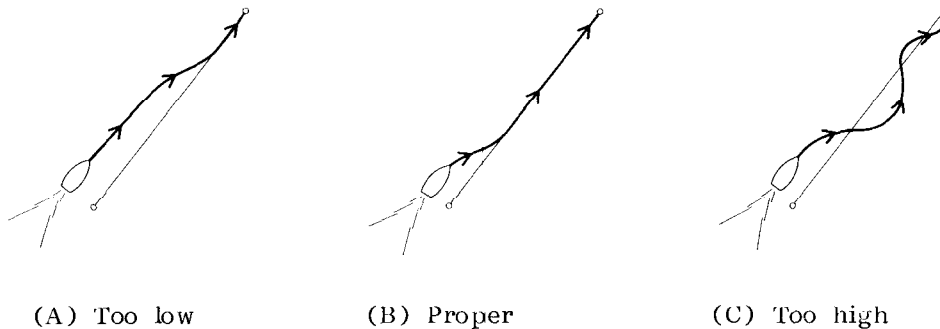


Fig. 13 Setting of GAIN

The oscillation of the boat may be caused by the error of the compass signal and the improper smoothing rate on the Loran C navigator. The high or low tracking speed of the Loran C navigator also effects the oscillation of the boat. Note that the oscillation may occur if the boat stops during the NAV steering.

Now we will assume that the GAIN is set at "5." When the FAP-50 is used in connection with Loran C, the ship's course is changed 2 degrees every second to compensate the Cross-Track Error. When connecting to the GD-170, the ship's course is changed 1 degree every 19.2 seconds (e.g. 96 steering signals from the GD-170). For faster boats, the setting of the GAIN should be higher.

NOTE

Normally, the GAIN setting of "5" is suitable for the ship's speed of 10 to 15 knots.

OPERATING PROCEDURE

Before using the autopilot, read the warnings and cautions on page i.

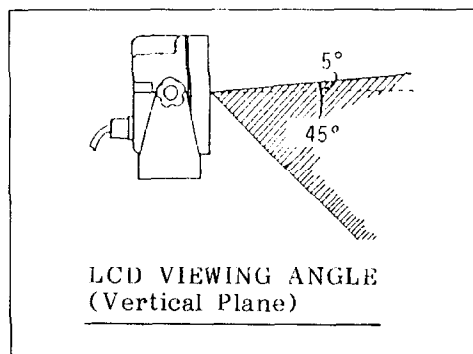
TURNING THE UNIT ON AND OFF

There is no power switch on the control and processor units. The power is applied to the units through the circuit breaker supplied locally. To turn the FAP-50 on, set the circuit breaker to the ON position. After several seconds (during which time the FAP-50 will be performing an internal self-check) the display on the control unit will activate. Should an error be detected during the self-check sequence, an error message will be displayed. Refer to page 24 for the details of the self-check.

At the power-up, the alarm sound will be released if the heading deviates more than 30 degrees from the latest heading. To reset the alarm, press the [ENT] key.

Adjust the LCD viewing angle (Vertical Plane). The proper viewing angle is illustrated in the right-hand figure.

To turn the FAP-50 off, set the main breaker to the OFF position. Settings for TRIM, GAIN, RUD, C RUD and WX are maintained by the back-up battery while the ship's mains is out off.



CHECK BEFORE SAILING

It is very important for safe navigation to check and confirm the functions of the autopilot before sailing. Check the following items while the boat is moored.

1. With the power turned off, steer Hand Pump hardover to hardover to confirm the movement of Cylinder/Rudder. If Tiller Arm is used instead of Hand Pump, steer with Tiller Arm to confirm the movement of Rudder.

After the confirmation of Rudder movement, set Rudder to the neutral (center) position.

2. Set the main breaker to the ON position to apply power to the FAP-50. A diagnosis on the control and processor units will be carried out automatically. Confirm that no error message is displayed.
3. In the SBY mode, rotate the Hand Pump to both port and starboard sides and confirm that the rudder angle indicator shows the correct rudder angle, increasing and decreasing the number of the LCDs as the hand pump is rotated. The rudder angle should read up to $\pm 40^\circ$. If the rudder angle is greater than 40° , a triangle mark will blink at either end of the scale.
4. Press the [REM] key and operate the remote controller(s) to the port and starboard limits. If a course change to "starboard" is desired, turn the

setting knob CW, and if "port," turn it CCW. The rudder angle indicator should function in the same manner as that on the SBY mode.

After checking of the REM mode, the on/off switch should be turned off and the setting knob on the remote controller should be at mid-position.

5. Press the [AUTO] key and rotate the course selector knob CW by six notches. The deviation between the set course and the ship's heading should be 6°, indicated by three LCDs over the semi-circle scale. The rudder angle should also read 6°, indicated by three LCDs at port side.

STEERING ON EACH MODE

SBY Steering:

1. Set the rudder at the "midship" position.
2. Set the main breaker at the "on" position.
3. Press the [SBY] key for Manual Steering.
4. Turn the steering wheel to either the right-hand or the left-hand side. The rudder angle is indicated by the rudder angle indicator. The ship's heading is read on the heading indicator.

REMOTE Steering:

1. Follow steps 1 and 2 above.
2. Press the [REM] key for remote steering.
3. Switch on and turn the setting knob on the portable remote controller, or turn the steering wheel of the wheel type remote controller.

WARNING

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

- 1) While in heavy traffic, in narrow channels or close to obstructions such as a breakwater.
- 2) Near or while passing under steel bridges or in close proximity to large steel vessels. Magnetic influences created by large steel structures may cause inadvertent course change.
- 3) With the wind dead astern in very strong winds and large seas.

CAUTION

NEVER LEAVE THE HELM UNATTENDED. Although the autopilot will faithfully maintain the vessel's heading, it will not replace the man-on-watch.

AUTO Steering:

1. Confirm that the on/off switch on the remote controller is at the off position.
2. Set the boat on the desired course by means of manual steering.
3. Press the [AUTO] key.
4. Adjust the settings; WEATHER, RUDDER, COUNTER RUDDER, TRIM and GAIN according to the conditions of the sea and the loading cargoes.

Optimization of the settings for different weather and vessel conditions requires practice. If you are still in doubt of the settings, please refer to page 10. Here are a few basic rules to follow:

A) On calm seas, a lower setting of the WEATHER control is recommended. On rough seas, the WEATHER control must be increased. If the ship is "S"ing (oscillating) largely without yawing due to extreme sea conditions, the COUNTER RUDDER settings should be increased.

B) If the steering responds too frequently, the WEATHER setting should be increased. Basically, it is necessary to test for settings which minimize rudder movement and maintain the intended course within the desired limits of accuracy.

C) In case of rough seas or following, an increase in rudder response might be necessary. Cruising at half or low speed also requires an increase of the rudder response setting.

D) If the ship shows a tendency to overshoot during course changes, the COUNTER RUDDER is set too low, and if course changes are executed too slowly, then COUNTER RUDDER is set too high. In such cases, it might possibly be necessary to increase rudder response as well. A loaded vessel requires more COUNTER RUDDER than an unloaded one.

Note: Oscillations may occur when the RUDDER and WEATHER are set at minimum; especially when the rudder speed is fast. The oscillations can be cancelled out by increasing the WEATHER setting.

5. If a large deviation from the intended course has resulted due to wind or rough seas, adjust the course by turning the course selector.
6. COURSE CHANGE; Rotate the course selector until the desired new course is displayed at the Course Display. When making changes at high speed, make them in small increments to limit the turn to a comfortable rate. The course may also be altered by turning the pilot to SBY, hand steering to a new course and then re-engaging the pilot through the normal sequence. Course change can also be made by rotating the setting knob on the remote controller. Refer to the section of "Dodging" on page 23.

NAV Steering:

1. Set the course to the first waypoint on the navigational device by entering "From" and "To" waypoints.
2. On the navigational device, read the course to the first waypoint.

3. Confirm that the on/off switch on the remote controller is switched off.
4. Set the course to the first waypoint, and select the AUTO mode. This step is for confirming that the autopilot works normally in the AUTO mode before getting into the NAV mode.
5. Ensure that the navigational device has good reception conditions without any warning flags and bearing signal is being fed to the autopilot.
6. Check that on the navigational device, the Cross-Track Error should not exceed 0.31nm (NMEA 0180) or 0.41nm (NMEA 0183).
7. Press the [NAV] key. The autopilot now automatically changes course to reduce the Cross-Track Error to zero.
8. Observe the Cross-Track Error(XTE) on the navigational device and check that it agrees with the readout on the FAP-50.
9. Select a proper GAIN setting so that the oscillation of the boat may be cancelled out. Remember that rapid changes of the compass signal, an improper "smoothing" rate and the tracking speed of the Loran C navigator also cause oscillation of the boat. A higher smoothing rate provides less oscillation of the boat, however a time delay will result.

At slower speeds, the turn response may degrade somewhat, but this is due to the slower response of the boat, and is normal. Increasing of the WEATHER will also degrade the response, and will cause the autopilot to take longer to come onto course. The WEATHER should always be set at a lower value when precise maneuvering or optimum response is required.
10. Selection of the GD mode; On the SBY mode, move the cursor just above the "GD" label, and press ▲ and the [ENT] key.

WARNING/CAUTION

(1) NAV steering must only be used in open waters.

(2) While the vessel normally follows the intended course with a deviation of $\pm 0.31\text{nm}$ (or $\pm 0.41\text{nm}$), higher deviation can temporarily occur due to change of current, wind and speed or at start up from a position of the intended course.

NOTE

(1) The selection of GD and AUX compass can be made only on the SBY mode.

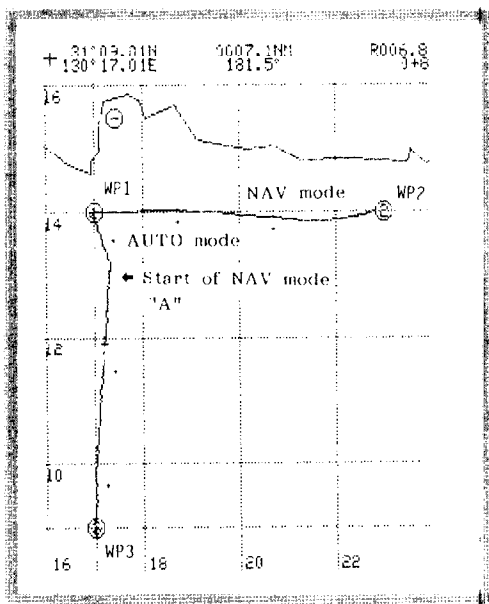
(2) Select the SBY mode when the boat is stopped!

DIFFERENCE BETWEEN AUTO AND NAV MODES

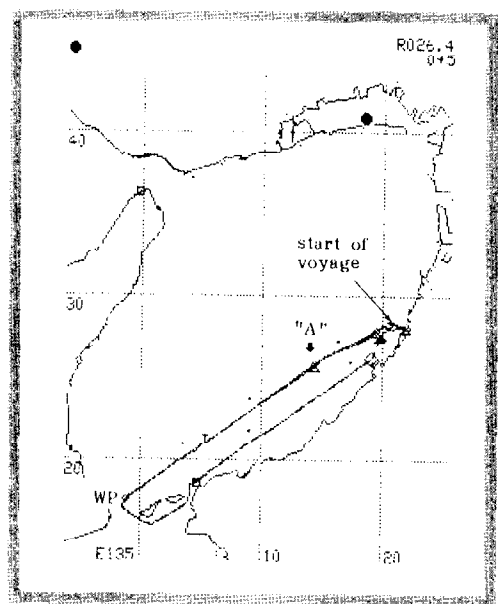
The function of the AUTO and NAV modes is explained on pages 12 thru 17. Now, referring to Fig.14, an actual track displayed on the GD-170 Color Video Plotter. We can recognize the difference between the AUTO and NAV modes clearly with these figures; In the AUTO mode, the boat may drift due to wind and current but in the NAV mode, wind or current have very little effect on the ship's coursesline, because the course is changing continually to compensate for these effects.

In Fig.14(A), the boat departed from waypoint 2 with a ship's heading of 270° , then changed her course manually to 180° (South) at the arrival at waypoint 1, and arrived at waypoint 3. The AUTO mode was used from waypoint 1 up to the point "A," where the NAV steering was selected. The fact that the boat drifted SSE during the AUTO mode can be seen in the illustration.

Another example is shown in Fig.14(B). The boat has started sailing toward a waypoint in the AUTO mode. Look at the ship's track at the beginning of the voyage. The boat was moving towards 245° while the autopilot was maintaining the set heading (235°). The autopilot was switched over to the NAV mode at point "A."



(A)



(B)

Fig.14 Examples of Actual Track on AUTO and NAV modes

APPLICATION

This example will demonstrate the use of the autopilot FAP-50. Refer to Fig.15. We begin with the boat moored in the port while warming the engine. The operator can take this time to turn on the navigational receiver, and to check and confirm the functions of the autopilot. The check should be carried out as explained in the section of "CHECK BEFORE SAILING," on page 17.

Next enter waypoint 1 into the navigational receiver and/or the GD-170. If your FAP-50 is connected with the Furuno LC-90 Loran C navigator, enter waypoints 1 and 2 in the PLN mode for establishing a route.

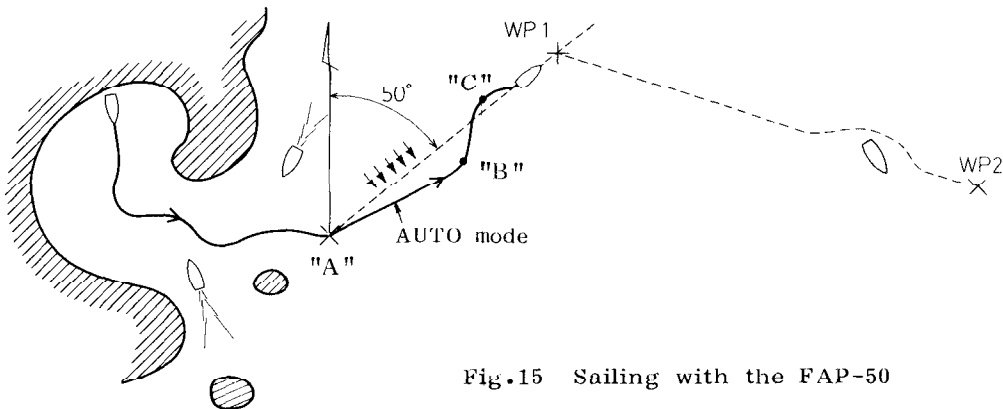


Fig.15 Sailing with the FAP-50

1. Now, let's leave the port with the autopilot disengaged (in the SBY mode).

Remember that the REM, AUTO and NAV modes should not be used in a congested harbor or areas of heavy traffic.

2. When you reach the open sea (point "A" in Fig.15), turn the boat to the direction of waypoint 1. Then, press the [AUTO] key. For example, in the illustration above, the set course is 50° and the display would be similar to the one below.

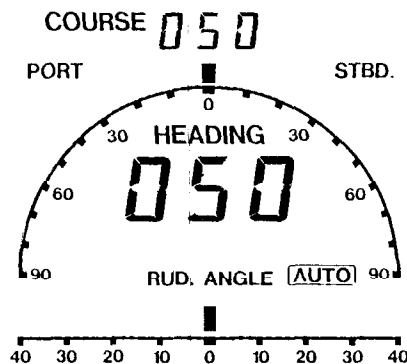


Fig.16 Example of Display on the AUTO mode

3. Readjust settings; WEATHER, RUDDER, COUNTER RUDDER and TRIM according to the conditions of the sea and the loading cargoes.
4. The boat is drifting to starboard gradually due to wind and currents. Taking into this effect, the new heading of 40° is selected at the point "B."
5. Because the heading of 40° is pushing the boat off-course to the right of the intended course, the heading is changed to 45° at the point "C."
6. You may switch from the autopilot to the NAV mode after confirming that the boat is steered on the AUTO mode normally. To get into the NAV mode, press the [NAV] key. You cannot get into the NAV mode if the "beep" sounds twice upon pressing the [NAV] key, because the NAV signal is not being fed to the autopilot.
7. On the NAV mode, adjust the GAIN setting so that the boat maintains a satisfactory heading without extreme long or short term "S"ing (oscillating).

DODGING

We assume that dodging other vessels or objects on the AUTO or NAV mode is accomplished during the navigation between WP1 and WP2. There are three methods for dodging as follows.

1) Switch from "AUTO" or "NAV" mode directly to "SBY" mode and avoid the obstacle by the manual helm. - We recommend this easier method.

2) Adjust the course selector knob in the "AUTO" mode. When in the "NAV" mode, switch back to "AUTO" mode for the course selector knob to operate.

3) Turn on the "on/off" switch and adjust the setting knob on the remote controller. (This method is effective only when switch #3 of S1 inside the processor unit is set to the "on" position. It is factory-set to the "off" position. See page 39.) After dodging, turn off the remote controller.

In the AUTO mode, the boat maintains the latest set course and the boat will return to the intended course in the NAV mode automatically. See the figure below.

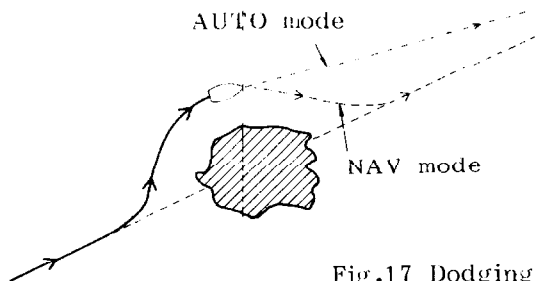


Fig.17 Dodging

EMERGENCY PROCEDURE

Disengage the autopilot by pressing the SBY key and steer the Hand Wheel.

ALARM FUNCTION

The following alarms are provided on the FAP-50. The mode which each alarm is activated is shown to the right of each heading. Which alarm is sounding can be recognized by the visual alarm indicators; but the audio alarm is released in the pattern of the highest priority. To reset the audio alarm, press the [ALM RST] key.

1) CPU Failure (All modes):

The FAP-50 carries out a ROM/RAM check for the control and processor units at every power-up. If the check sequence detects any fault, the display indicates the faulty circuit in the COURSE and/or HEADING indicators. The result of the ROM/RAM check for the control unit is displayed in the COURSE indicator and the one for the processor unit in the HEADING indicator.

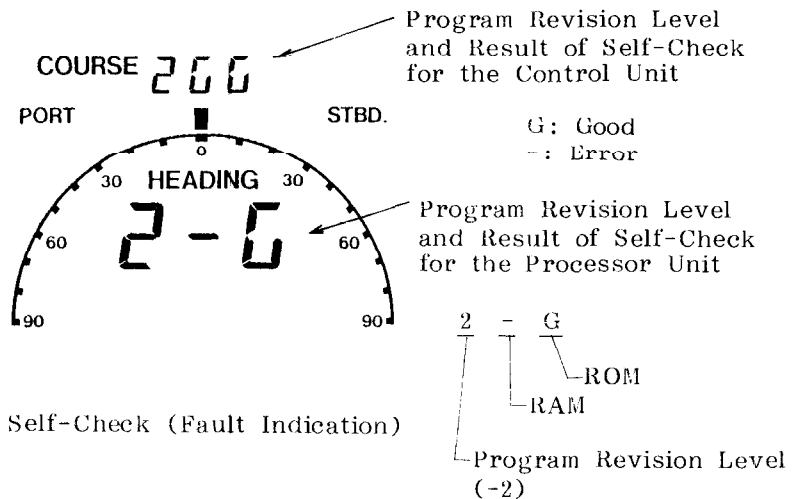


Fig.18 Result of Self-Check (Fault Indication)

2) Low Power (All modes):

When the main power supply drops by 10% of the rated value, the PF indicator will blink and the alarm will sound.

3) Output Data Error (All modes):

The output data from the processor unit to the rudder drive unit is monitored to determine whether the proper data is being sent out according to the mode selected. If incorrect data is being fed out, the PORT (◀) and STBD (▶) indicators will blink and the mode is automatically set to "SBY," where the autopilot is disengaged.

4) Feedback Signal Error (All modes):

The feedback signal from the rudder reference unit is monitored by the CPU inside the processor unit. When an abnormal signal is detected, the ◀ and ▶ marks blink at both ends of the rudder indicator and the SBY mode is automatically selected.

5) Watch (AUTO/NAV modes):

When the watch alarm function is turned on, it will alternate between a four-minute caution alarm followed by a much louder one-minute warning alarm. The alarm warns the helmsman to check the autopilot.

6) Course Deviation (AUTO/NAV modes):

In the AUTO mode, when the ship's heading deviates from the set course by more than 30°, the audio alarm will be released and the large LCDs over the semi-circle will blink. In the NAV mode, this alarm is released and the LCDs at both ends of the semi-circle scale blink when a 90° course deviation is detected.

7) Heading Signal Error (All modes):

When the autopilot receives an abnormal heading signal, the heading indicator will display "888" (blinking). When the bearing signal is not being fed to the autopilot, the heading indicator displays a blinking "---." In addition, the heading indicator will blink when the bearing is changed by more than 30°. To acknowledge the new bearing, press the [ENT] key.

8) NAV Signal Error (NAV mode):

When no navigational signal or an invalid signal is being fed to the autopilot, the NAV indicator will blink and the alarm will sound. When the FAP-50 is used in connection with the LC-90, confirm that the NAV signal format is selected correctly from the keyboard on the LC-90 and in the FAP-50 processor unit.

9) Arrival Alarm (NAV mode):

When the boat is nearing a destination waypoint, the ARR indicator will blink and the alarm will sound. The area that defines an arrival zone is determined on the navigational receiver.

If the waypoint selected is an intermediate waypoint in the selected route, the ARR indicator flashes for 10 seconds and then the boat is steered to the next waypoint.

10) Offset Alarm (NAV mode):

The FAP-50 calculates the offset necessary to reach the original track, based on the Cross-Track Error. When this value becomes maximum in the NAV mode, the set course indicator will blink without an audio alarm.

11) Cross-Track Error (NAV mode):

When the Cross-Track Error exceeds 0.31nm in NMEA 0180 format and 0.41nm in NMEA 0183 format, the DEV indicator will blink and the alarm will sound.

12) Power Failure (All modes):

If power to the autopilot is interrupted, the external (optional) alarm will sound.

NOTE

Intermittent Power Failure; When the duration of a power failure is 2 seconds or less, the set mode automatically returns to the one which was used before power was interrupted. If the power failure is more than 2 seconds, the SBY mode is selected automatically.

The following table lists each visual alarm and its causes. Fig.19 shows the "on/off" pattern of each alarm.

Table 2 Summary of Alarm Function

Visual Alarm	Cause of Alarm	Mode	Audio Alarm (See Fig.19.)
1. Error Message	CPU Failure	All modes	A
2. P F [x]	Low Voltage	All modes	C
3. PORT/STBD indicators blinking	Output Data Error	All modes	C
4. LCDs at the ends of rudder angle indicator blinking	Feedback Signal Error	All modes	C
5. WA (▼)	Watch	AUTO/NAV	B
6. Semi-circle indicator blinking	Deviation of more than 30°/90°	AUTO/NAV	C
7. "888" or "---" blinking	Heading Signal Error	All modes	C
8. Heading Indicator blinking	Bearing change of more than 30°	All modes	C
9. Set Course Indicator blinking	Offset Alarm	NAV	no audio
10. NAV [x]	NAV Signal Error	NAV	C
11. ARR [x]	Arrival Alarm	NAV	C
12. DEV [x]	Cross-Track Error	NAV	C
13. Lamp on external alarm	Power failure	All modes	A (if external alarm provided.)

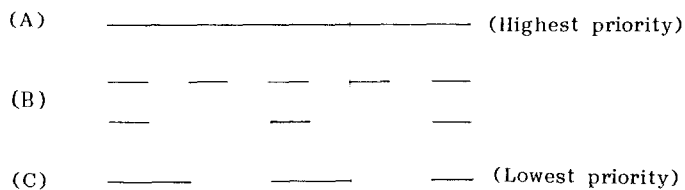


Fig.19 "on/off" Pattern of Audio Alarm

PROBLEM SOLVING

1) Power cannot be applied to the autopilot.

- Cause: a) Tripped circuit breaker
 b) Blown fuses on the power and processor boards inside the processor unit.

- Remedy: a) Reset the circuit breaker.
 b) Replace the fuse with a new one.

If the circuit breaker trips again or the fuse blows again, call for service.

2) "---" is blinking in the Heading Display.

- Cause: a) Heading signal not being fed to the autopilot.

- Remedy: a) Check that there is no discontinuity between the processor unit and the compass (heading sensor).

3) "888" is blinking in the Heading Display.

- Cause: a) Abnormal heading signal is being fed to the autopilot.

- Remedy: a) Check for the correct output data from compass or heading sensor.

4) Blinking Heading Indication

- Cause: a) The heading is changed by more than 30° for a short period.

- Remedy: a) Press the [ENT] key to acknowledge the change.

5) The "AUTO" mode cannot be selected.

- Cause: a) Heading signal not being fed to the autopilot.

- Remedy: a) Check that the heading signal is being fed to the autopilot.

6) Alarm sound is released and the large LCDs over the semi-circle scale blink when the AUTO mode is selected or when the autopilot is turned on.

- Cause: a) Set course deviates from the ship's heading by more than 30°.

- Remedy: a) The alarm stops automatically when the deviation becomes less than 30°. To stop the audio alarm, press the [ALM RST] key.

b) Change the set course or the ship's heading.

7) "◀" and "▶" marks are blinking at both ends of the rudder angle indicator.

Cause: a) Abnormal rudder reference signal being detected.

Remedy: b) Check that the output signal of the rudder reference unit is normal.

8) PORT/STBD indicator is blinking.

Cause: a) Rudder reference signal not being fed back to the processor unit.

b) The output signal of the autopilot is abnormal.

Remedy: a) Check that there is no discontinuity between the processor unit and the rudder reference unit.

b) Check that the output signal of the rudder reference unit is normal.

9) The "NAV" mode cannot be selected.

Cause: a) Heading signal not being fed to the autopilot --"---" blinking.

b) NAV signal not being fed to the autopilot--NAV [x] blinking.

c) Erroneous NAV signal--NAV [x] or DEV [x] blinking.

Remedy: a) Check that there is no discontinuity between the processor unit and the compass (heading sensor).

b) Check that there is no discontinuity between the processor unit and the navigational device.

c) Check that the cross-track error does not exceed 0.31nm or 0.41nm, the navigational device has good reception conditions without any warning flags, the correct data format is selected on the navigational device and the FAP-50 processor unit, and the deviation between the ideal course and the actual heading is not greater than 30° on the GD-170 display.

10) Set course indicator is blinking. (no audio)

Cause: a) The maximum offset is reached.

Remedy: a) Wait until the offset is decreased.

11) Set Parameters ("35005") are blinking at the bottom of the display.

Cause: a) The stored data is destroyed due to low voltage in the keep-alive battery.

Remedy: a) Replace the keep-alive battery with a new one. (Press the [ENT] key and preset each parameter for your boat for temporary use.)

12) The boat zig zags in the AUTO mode.

One common complaint with autopilots is that the boat zig zags when the AUTO mode is selected. This may be caused by several of the things; such as slack cables, stretched chains or air in the hydraulic lines.

When using in connection with a fluid compasses, another problem which we'll call compass lag may be experienced. Boat vibration or a bubble in the compass fluid can cause the needle to "walk," which makes the boat think it is turning when it really isn't. When a fluid compass goes into a turn, the indicator needle is held back by the compass fluid, which resists the movement. If you have ever noticed that ice stays put when you turn the glass, you will understand how this works. But by the time you stop turning, the ice is moving and continues to turn. It is the same with a fluid indicator needle along with it. The end result is a series of over corrections of the helm, caused by the fluid lag in the compass. Solid state electronic compasses are immune to this problem.

A problem that all types of autopilots face is steering in a following sea, especially one off the stern quarter. Let's suppose a wave meets the boat on the starboard quarter. It throws the stern to port as it passes and the autopilot reacts by putting the rudders hard to port to bring the boat back around. By the time the rudders are hard to port, the wave has passed under the bow and thrown it to port as well, essentially putting the boat back on its original course. But meanwhile, the rudders are still hard to port, resulting in countersteering. The way to correct such a problem is to tell the autopilot to let the boat swing farther off course before correcting itself. On the autopilot, this distance can be adjusted by a WEATHER setting. Thus, in following seas you will increase the WEATHER setting so the autopilot isn't disturbed when the boat gets flung back and forth waves.

Another way to help the boat in a following sea is by increasing the RUDDER setting (reducing the sensitivity) or cruising at half or low speed, which reduces the amount the rudder turns. This will keep the rudder from going all the way to port, which means the boat can recover faster after the wave has passed. The RUDDER setting should also be adjusted for either trolling or running, since the boat needs less rudder movement to turn it when it is going faster.

APPENDIX A SPECIFICATIONS

1. Heading Sensor:
 - a) Magnetic compass B-150F, P-150F or equivalent with pick-off coil 900.100 and interface pcb inside the processor unit
 - b) Fluxgate Heading Sensor
 - c) Gyrocompass with gyro converter AD-10S

Two compasses can be connected to processor unit. The selection is made by selecting the "AUX C" function.
2. Course Setting: Done by easy-to-use rotary control
3. Setting of parameters: All settings are made through the keyboard.

Rudder(RUD) -- rudder angle/course deviation ratio, 0.2 - 3.0 in 9 steps, rudder angle limit provided

Weather (WX) -- Dead zone setting, 1° - 10° to port and starboard side in 9 steps

Counter Rudder(C-R) -- overshoot correction, in 10 steps

Trim (TRM) -- counterbalance setting, + 9° to port and starboard side, in 9 steps

Gain (GAIN) -- turning response adjustment in AUTO/NAV mode, in 9 steps

Dimmer (DIM) -- brightness control, in 4 steps including off position
4. Selection of External Unit: Performed through keyboard.
5. Operation Mode: Manual(SBY), Remote (REM), Automatic (AUTO) and Navigational (NAV)
6. LCD display:
 - 1) Set Course in 1° steps
 - 2) Heading in 1° steps
 - 3) Course deviation in 2°/5° increments
 - 4) Rudder Angle in 2° increments
 - 5) Preset parameters
 - 6) Alarm
 - 7) Mode Indicator
7. Navigational Equipment to be connected: Navigational equipment providing NMEA 0180/0183 format data output (LC-80/LC-90, etc.) or GD-170
8. Alarm: Both visual and audible alarms (Arrival Alarm, Navigational Signal Error, Off-Course Alarm, Low-Voltage Alarm, etc.)

9. Self-Check: Microprocessor and LCD are self-checked at every power-up.
10. Steering Unit: Hydraulic or optional mechanical steering system
11. Power Supply: Control and Processor Units; 10 - 42VDC
Solenoid Valve Unit; 12/24/32VDC
12. Operating Temperature: -10° to +55°C
13. Structure: Control Unit; Splashproof
Processor Unit; Splashproof
Rudder Reference Unit; Waterproof
Remote Units; Waterproof

COMPLETE SET

	Name	Type	Q'ty	Remarks
1	Control Unit	FAP-501-10	1	w/10m cable
2	Processor Unit	FAP-502	1	
3	Rudder Reference Unit	FT-10-2F-NH	1	w/20m cable
4	Installation Materials		1 set	
5	Accessories		1 set	
6	Spare Parts		1 set	

INSTALLATION MATERIALS

	Name	Type	Q'ty	Remarks
1	Power Cable Assy.	1.25sq, 5m with crimp-on lug	1	
2	Cable for navigational equipment	3-pair shielded, 5m with NH and SRC connector	1	
3	Copper Strap	30x1200x0.3	1	
4	Copper Strap Fixing Plate		1	

ACCESSORIES

	Name	Type	Code No.	Q'ty	Remarks
1	Bracket Assy.	FP04-00310	004-285-420	1	*1
2	Knob Bolt	KG-B2 M8x20	000-800-418	2	*1
3	Tapping Screw	M5x20 SUS304	000-800-488	4	
4	Flat Washer	M5 SUS304	000-864-128	4	
5	Tapping Screw	M5x20 SUS304	000-800-488	4	
6	Flat Washer	M5 SUS304	000-864-128	4	

*1: Supplied with Control Unit

SPARE PARTS

	Name	Type	Q'ty	Remarks
1	Fuse	3A	6	
2	Fuse	5A	3	

OPTION

	Name	Type	Remarks
1	Control Unit	FAP-501-10 w/10m cable	2nd station
2	Remote Controller	PT-11FNIH w/12m cable	portable type
3	Remote Controller	PT-10FNIH w/12m cable	portable type, no sw
4	Remote Controller	DT-10F w/5m cable	with helm
5	Valve Unit	SPF-1SVF-12 w/8m cable	12Vdc
		SPF-1SVF-24 w/8m cable	24Vdc
		SPF-1SVF-32 w/8m cable	32Vdc
6	External Alarm Unit	FAP-503	
7	Motor Drive Unit	FAP-504	
8	Pick-off Coil & Interface P.C.B.	900.100 w/2m cable & 100.138A	The P.C.B is installed inside FAP-502 Processor Unit.
9	Fluxgate Heading Sensor		
10	AD Converter	AD-10S	
11	Magnetic Compass	B-150F, 150mm card	in wooden box
12	Magnetic Compass	P-150F, 150mm card	illuminated
13	Interconnection Cable Assy. for GD-170	64S40200	5m

APPENDIX B INSTALLATION

GENERAL

Refer to the typical installation diagram in Fig.27, page 43, before proceeding with the installation. Boats differ widely in their layouts and steering systems, but there are nevertheless certain guidelines applicable to all installations:-

- 1) The compass safe distances must be observed.
- 2) The DC power supply cable should be kept as short as possible, and should be taken directly from the battery for the processor unit, via the circuit breaker (30A fuse incorporated) supplied locally. Longer cable runs require an even larger wire size to minimize voltage drop.

Under no circumstances should a cable be used to supply both the autopilot and other equipment: ship's power lines are notorious for being "dirty" electrically. The voltage can go all over the place as various heavy loads are placed on the line, and the power wiring is a prime source for interfering electrical signals (from such sources as alternators or generators, and other electronics equipment, like radars or echosounders).

- 3) All signal circuit cables should be separated (not parallel) as far as possible from cables carrying RF or pulsed signals. At least 1m (3ft) separation is recommended.
- 4) The supplied cables should not be lengthened, otherwise the performance of the unit will be greatly reduced.
- 5) Shield of a cable should be grounded.
- 6) The heading sensor should not be installed in an area of magnetic interference.
- 7) Remember that 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.

CONTROL UNIT INSTALLATION

Although the unit is designed to be splashproof, locate it in a position where it can be viewed and operated conveniently but where there is no danger of salt or fresh water spray or immersion.

Fig.20 shows the proper viewing angle for the control unit.

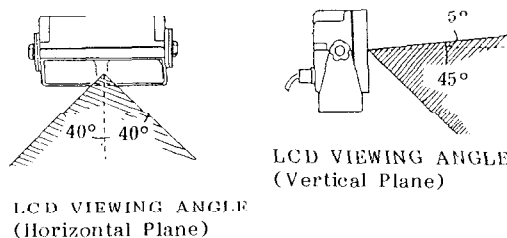


Fig.20 Proper Viewing Angle

Even though the LCD (Liquid Crystal) readout display is quite legible even in bright sunlight, it is a good idea to keep the Control Unit out of direct sunlight or at least shaded because of heat that can build up inside the cabinet.

The control unit is mounted in a trunnion mount. The mount itself can be installed either overhead, on a bulkhead, or on a tabletop.

The drawing on page 47 gives the mounting dimensions for this unit. You can use the mounting hanger itself as a template for locating the mounting bolt holes.

PROCESSOR UNIT INSTALLATION

The unit is fixed with four woodscrews, either on a tabletop or on a bulkhead. (When installing on a bulkhead, mount the unit right side up, i.e., the cable glands should be facing the deck.) The unit should not be mounted where it is directly exposed to the environment!

Do not remove any plastic blanking plates from unused holes for the cable gland.

REMOTE CONTROLLER INSTALLATION

Both types of remote controllers are fully waterproof and may be kept in exposed areas (e.g., on the fore deck), but some users keep the portable type remote controller inside a hatch or locker, and pull it out when required. This does have the advantage of keeping the cable from becoming tangled.

RUDDER REFERENCE UNIT INSTALLATION

The unit is waterproof, but it is only common sense to give it some protection.

The rudder reference unit is mechanically linked to the rudder and rudder angle is transferred to the rudder reference unit in a 1:1 ratio. Accordingly it is essential for autopilot performance that the signal is correct and that there is a minimum of slack in the transmission between the rudder stock and the rudder reference unit. An illustration showing parallel arrangement of the rudder reference unit is provided on page 42.

The following is the summary of the installation of the rudder reference unit.

- 1) Middle rudder position should correspond to the rudder reference unit in the middle position, and 90° relationships are maintained with the rudder in mid position. See Fig.21.

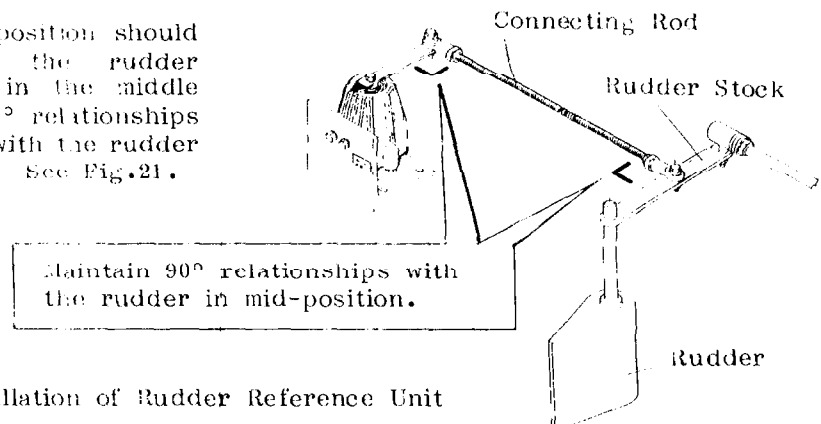


Fig.21 Installation of Rudder Reference Unit

- 2) The unit may be placed at either side of the rudder.
- 3) The distance between the reference unit and the rudder stock must be within 600mm and the height of the rudder reference unit must be adjusted so that the connecting rod is installed horizontally. Apply grease to both ends of the connecting rod.

Where possible, the cables should be run through a conduit to the processor unit to avoid mechanical damage.

VALVE UNIT INSTALLATION (optional)

The solenoid valve unit is installed horizontally as close to the power unit as possible.

SENSOR INTERFACE PCB (optional)

The six spacers for mounting the sensor interface p.c. board are provided below the processor board inside the processor unit.

CONNECTIONS

On the control unit, connect a heavy duty ground wire to the ground terminal. The following describes the connection on the processor unit.

Control Unit;

Connect the control unit to J12 and/or J10. The FAP-50 is designed to accept up to two remote control units. J11 is used only for the Remote Display Unit.

Heading Sensor;

Heading signal is applied to J8 (AUX compass) or J9 from a gyrocompass through a compass converter AD-10S or a Fluxgate Heading Sensor.

Remote Controller;

Connect the remote controller to J14 or J15. When the remote controller not provided with an on/off switch is connected, change of the DIP switch setting is required. See the section on "DIP Switch Setting," page 39.

Rudder Reference Unit;

Connect the rudder reference unit to J16. If the rudder angle is indicated in the opposite direction, simply interchange the black and white wires from the reference unit on J16 in the processor unit.

Navigational Aid;

Either NMEA 0180 or NMEA 0183 position data is applied to J6. (DIP switch selection required on the Processor Board, see page 39.) When connected with the LC-70, cut two jumpers, JP11 and JP12, on the processor board. JP11 and JP12 are located between J5 and J6.

NOTE

Furuno Satellite Navigator FSN-50 can provide position data to the FAP-50 in NMEA 0183 format. However, remember that positioning by the satnav is not very consistent (DR position can be greatly corrected by a satellite fix).

GD-170;

The connectors "GPIF" and "APIF" on the color video plotter GD-170 are connected to J5 and J4 on the FAP-50 respectively. The position data from the navigational device is applied to the connector "GPIF" through the autopilot, and the autopilot control signal is sent out from the connector "APIF."

Power;

The processor unit can take input voltages from 10 - 42VDC. However, the preset (jumper-selection) for the Power Failure Alarm is required as described on the following page. The power to the control unit is applied from the processor unit.

Ground;

As shown in Fig.22, the processor unit must be grounded with the copper strap and the fixing plate supplied. Do not "share" ground leads that go to other equipment, but instead run a copper strap for the FAP-50 alone.

NOTE

Do not fail to connect the ground wire to the control and processor units, otherwise the ship's heading may be changed suddenly by the autopilot when radio communication equipment is operated.

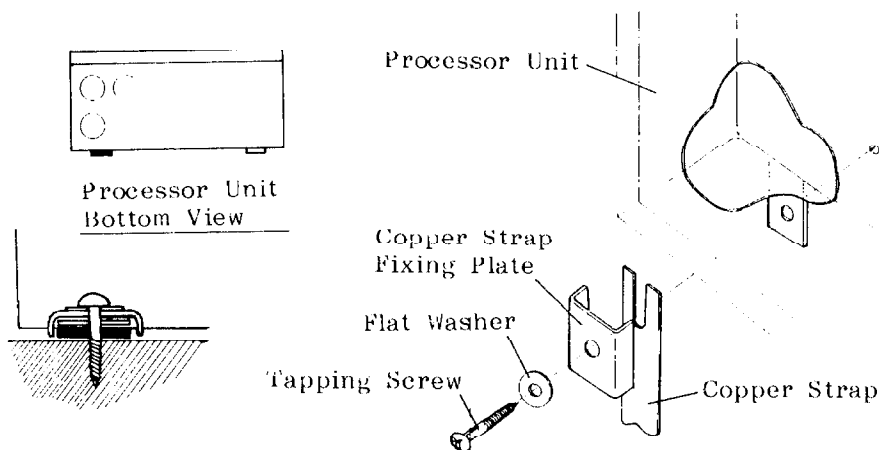


Fig.22 Grounding the Processor Unit

HOW TO USE THE CABLE GLAND

Six cable glands are provided at the middle of the bottom chassis on the processor unit. These are used for the Power cable, Sensor cable (2 glands), Solenoid cable, External Alarm cable and spare. The other cable glands are supplied with fittings on each cable and are mounted onto the processor unit without removal from the cable. Use the following procedure.

1. Remove the gland fixing nut (Parts No.2 in Fig.23).
2. Then, put the gland body (Parts No.1) into one of the holes at the bottom chassis of the processor unit.
3. Fix the gland body to the chassis by means of the gland fixing nut.

Since connection to the terminal board and connectors may be difficult because of limited space inside the processor unit, the position of the cable gland may be changed. For this reason it is also recommended that the cable gland be tightened after all connections have been made.

When the gland is removed and disassembled for some reason, be sure the position and direction of the cable gland elements are correct, otherwise water may seep into the cable gland. See the illustration below.

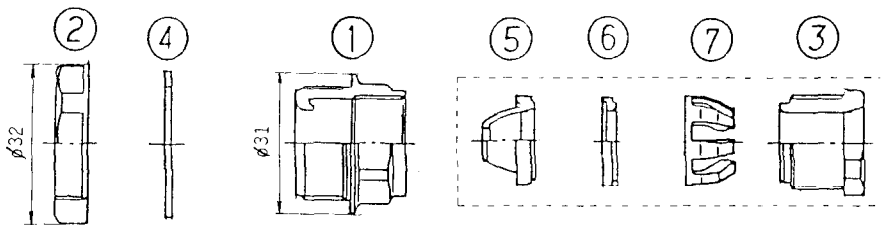


Fig.23 Assembling of Cable Gland

The shield of each cable should be connected to the chassis of the processor unit. See Fig.24. Thirteen threaded holes are provided on the bottom chassis for this purpose.

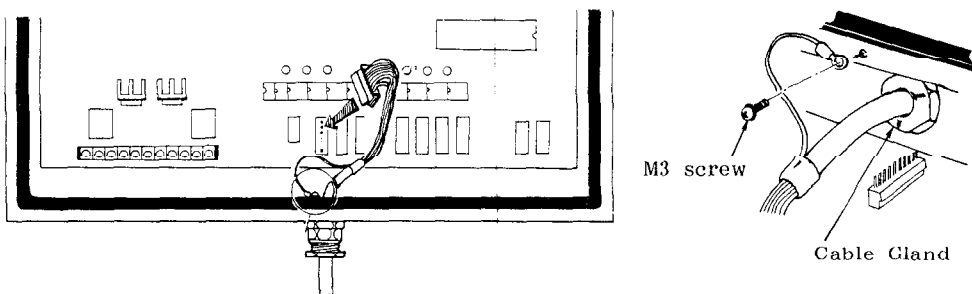


Fig.24 How to Ground each Cable on the Processor Unit

PRESETTING AND ADJUSTMENT AT INSTALLATION

Items 1 thru 5 are carried out on the processor unit and item 6 on the control unit. See Fig.25 for the location of the parts.

1. DIP Switch Setting

The following items are switch-selectable with S1 on the processor board.

Table 3 DIP Switch Setting Inside the Processor Unit

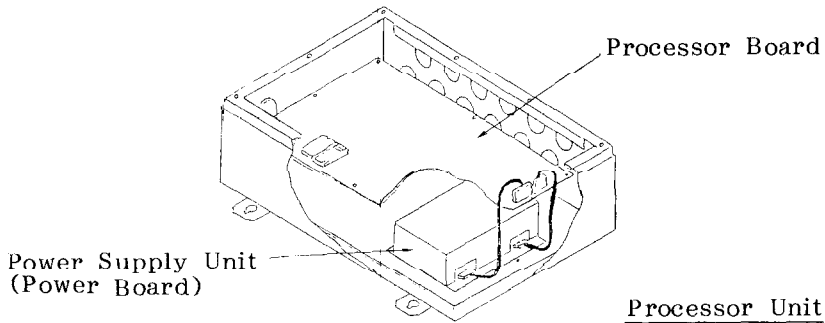
No.	Items	OFF (factory set)	ON
1.	Switch on Remote Controller 1 (note 1)	provided	Not provided
2.	Switch on Remote Controller 2 (note 1)	provided	Not provided
3.	Dodging and course change function on AUTO and NAV modes	accomplished only from control unit	accomplished from control unit and remote controller
4.	NMEA Format	NMEA 0180 simplex 1200 bps (LC-70/80/90)	NMEA 0183 complex 4800 bps (LC-90)
5.	not used		
6.	Set course to wp (When switching over to AUTO and NAV modes.)	Ship's heading (note 2)	Bearing selected by course selector
7.	Function of Horizontal Scale	Rudder angle in SBY and REM & AUTO modes, and Off-course in NAV modes.	Rudder angle indicator in all modes
8.	Self Check (factory use)	off	on

Note 1) Set this switch to the "OFF" position when remote controller is not connected.

Note 2) On the SBY and REM modes, the heading and set course indications are the same. The course selector can function as remote controller on the REM mode.

2. Selection of PF voltage (JP1)

Change the jumper connection at JP1 on the power board in the processor unit according to the ship's mains. To gain access to the power board, remove the processor board. 12V is selected at the factory.



3. Zero Adjustment (VR3)

Connect a multimeter between TP9 and TP10 on the processor board, and adjust VR3 for 0V.

4. Max. Rudder Angle Adjustment (VR2)

Set the course setting knob on the remote control unit fully CW, and adjust VR2 on the processor board for the rudder angle of 40°.

5. Jumper Selection for the External Alarm

Three jumpers on the processor board, JP5, JP6 and JP8, should be changed according to the type of the external alarm to be connected as below.

Input voltage of Ext. Alarm	JP5	JP8
12V *	#1 - #2	#1 - #3
24V	#1 - #3	#1 - #2
32V	#1 - #3	#1 - #3

Type of alarm to be connected	JP6
FAP-503 *	ON
Conventional Alarm (The output of FAP-50 is connected in parallel)	OFF

*: factory set

6. Type of Mode Indication (SW1)

The selected mode is indicated in a box on the display. However, if you desire the mode indication without the box, set DIP switch SW1 #1 to the "OFF" position inside the control unit. To gain access to SW1, remove the course selector knob on the front panel, then separate the front panel by loosening four screws.

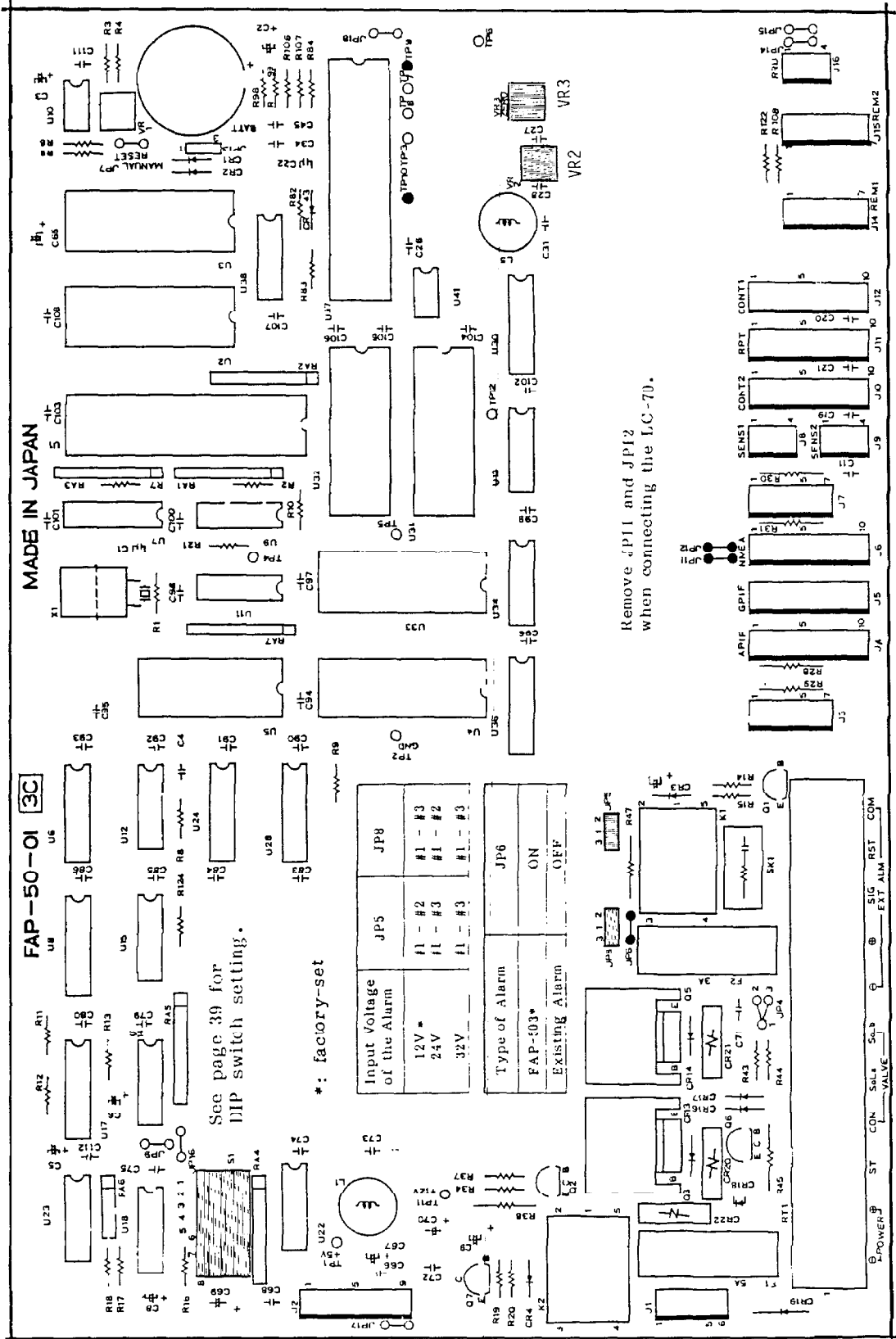


Fig.25 Processor Board, Parts Side - The location of the parts have been changed, but the board is electrically the same as the old one.

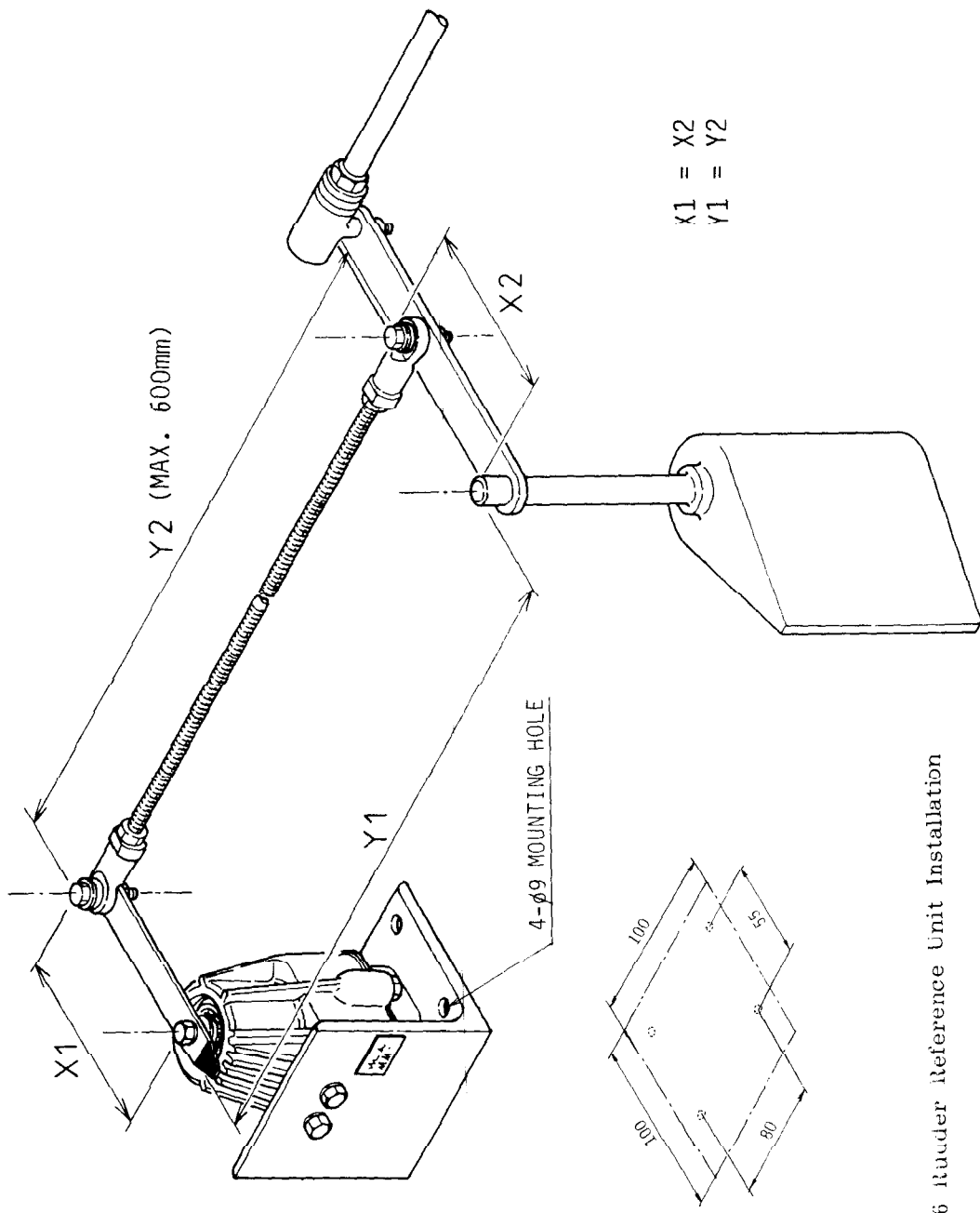


Fig. 26 Rudder Reference Unit Installation

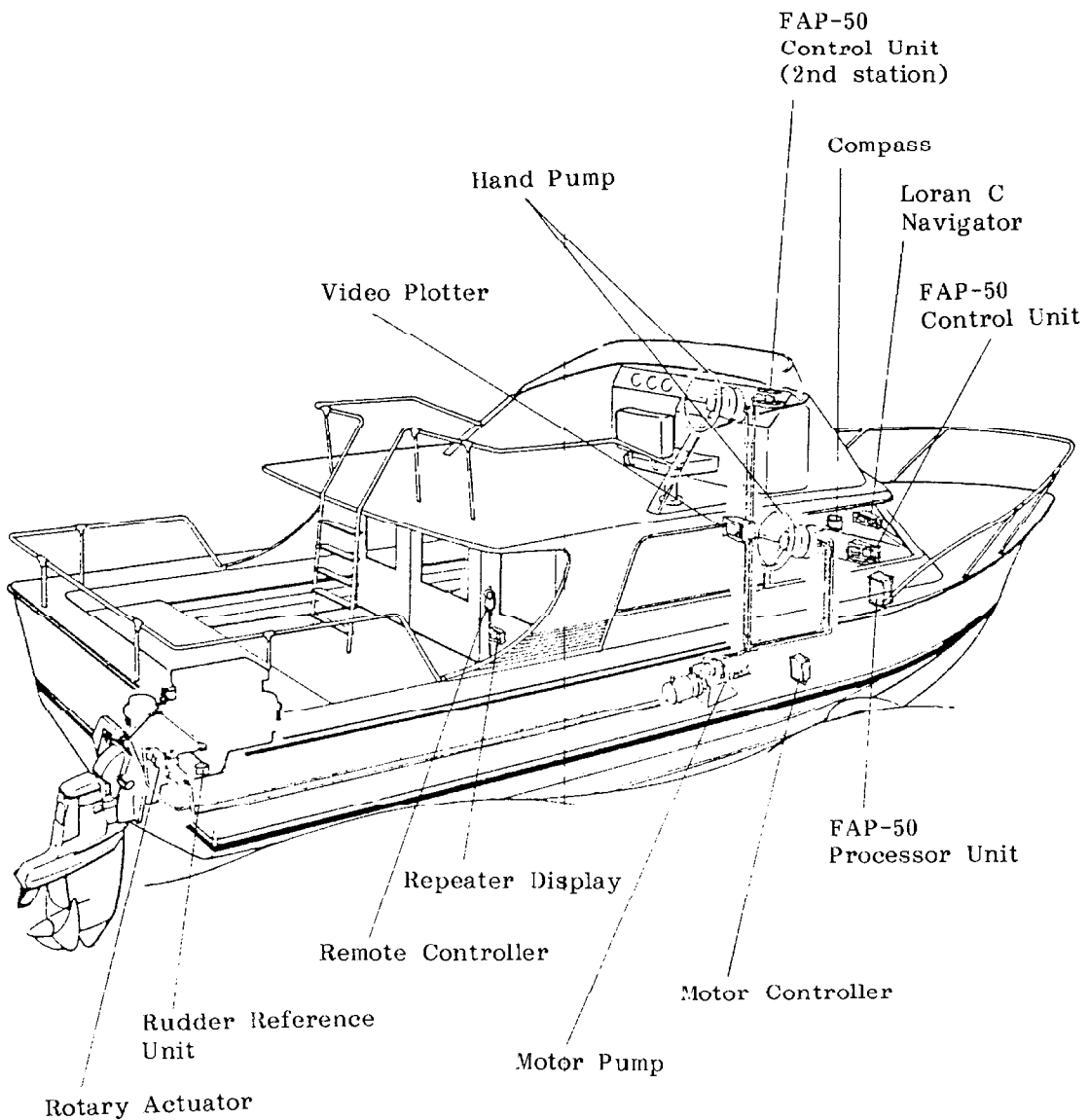


Fig.27 Typical Installation on a Hydraulic Steering Boat

CHECKING AFTER INSTALLATION (DOCKSIDE TESTS):

Prior to following the procedure below, read pages 7 thru 9 to understand the operation of your FAP-50 fully.

WARNING

If the rudder drives continuously during the following tests, switch off the FAP-50 (or press the [SBY] key) at once.

IMPORTANT!

Before moving the rudder make sure that no one is working in the area and there are no other obstructions.

1. VISUAL CHECKS - Check that all system connections and all exposed moving parts relating to the steering gear and autopilot are sufficiently guarded to prevent accidental catching of extremities and/or clothing.
2. Check that the steering moves freely from lock to lock without undue stiffness.
3. Set the rudder at midship.
4. Turn on the FAP-50, and the LED on the [SBY] key will light.
5. Make sure there is no rudder angle LCD over the horizontal scale. If any LCD appears, adjustment of VR3 is required. VR3 is used to electronically center the rudder feedback unit. See page 40.
6. Steer the rudder to the port side slowly. Check the horizontal scale. The number of LCDs appearing over the horizontal scale will increase as the rudder is steered. When the rudder angle is greater than 40°, the far left-hand side LCD will blink.
7. Steer the rudder to the starboard side slowly, and check for the correct rudder angle indication.
8. Check that the heading indication on the FAP-50 coincides with the compass reading. If "--" or "888" is blinking on the heading indicator, the heading signal is in error.
9. Set rudder to mid-position, using manual steering.
10. Press the [REM] key, and the LED on the [REM] key will come on.
11. Turn on the remote controller. Then confirm that the rudder angle indicator reads "0."
12. Rotate the setting knob CW on the remote controller, confirming rudder movement to the starboard side by observing the rudder angle indicator.
13. With the setting knob fully CW, confirm that the rudder indicator reads 40°. If not, adjust VR2 in the processor unit. See page 40.

14. Rotate the setting knob CCW, and check for correct rudder movement and maximum rudder angle.
15. Set the setting knob at the center position and turn off the remote controller.
16. Press the [AUTO] key and the LED on the key will light up.
17. Confirm the following settings (factory set); WX=3; RUD=5; TRIM=0; CR=0; and GAIN=5.
18. Rotate the course selector CW by ten notches. The course indication should become 10° greater than the heading indication. The 10° course error can also be recognized by five LCDs lit over the semi-circle scale. To compensate this error, the rudder is steered by 10° .
19. Further rotate the course selector by 3 notches. And the rudder indicator should read 13° .
20. Do the same check as steps 18 and 19 for CCW rotation of the course selector. Then, set the rudder at midship.
21. Set the RUDDER control at "2." (Press the [SEL] key until the cursor is over the RUD indicator. Then, press the ▲ key twice, followed by the [ENT] key.)
22. Rotate the course selector CW by more than 10 notches. Confirm that the rudder angle limit is 10° .
23. Do the same for CCW rotation.
24. With the RUDDER control set at "7," confirm that the rudder angle limit is 30° by using the similar manner as above step.
25. Press the [SEL] key until the cursor is over the TRIM indicator. Then, press the ▲ key six times so that the rudder indicator reads 6° starboard side. Press the ▼ key eight times so that the rudder indicator reads 2° port side.
26. Check your Loran C navigator for stable reception and enter a waypoint on it.
27. Confirm that DIP switch (#4) is selected properly for the output of your Loran C navigator (OFF; NMEA 0180 or ON; NMEA 0183).
28. Press the [NAV] key. Then, confirm that the LED on the [NAV] key lights up and the NAV alarm indicator is not activated.
29. Read the bearing to the waypoint on the Loran C navigator and compare it with the Course Indication on the FAP-50. The two readings should be same.
30. Change all settings to the values of factory set (step 17) for sea trial.

SEA TRIAL

The test should be performed in an area where large course changes and steering corrections can be made, namely, free of other vessels or navigational hazards. The sea conditions should be relatively good, with minimum wind and tide.

1. Steer the boat by hand on a fixed heading.
2. Ensure it is safe for the steering gear to start automatically.
3. Set rudder to midship using manual steering, then get into the AUTO mode by pressing the [AUTO] key.

WARNING

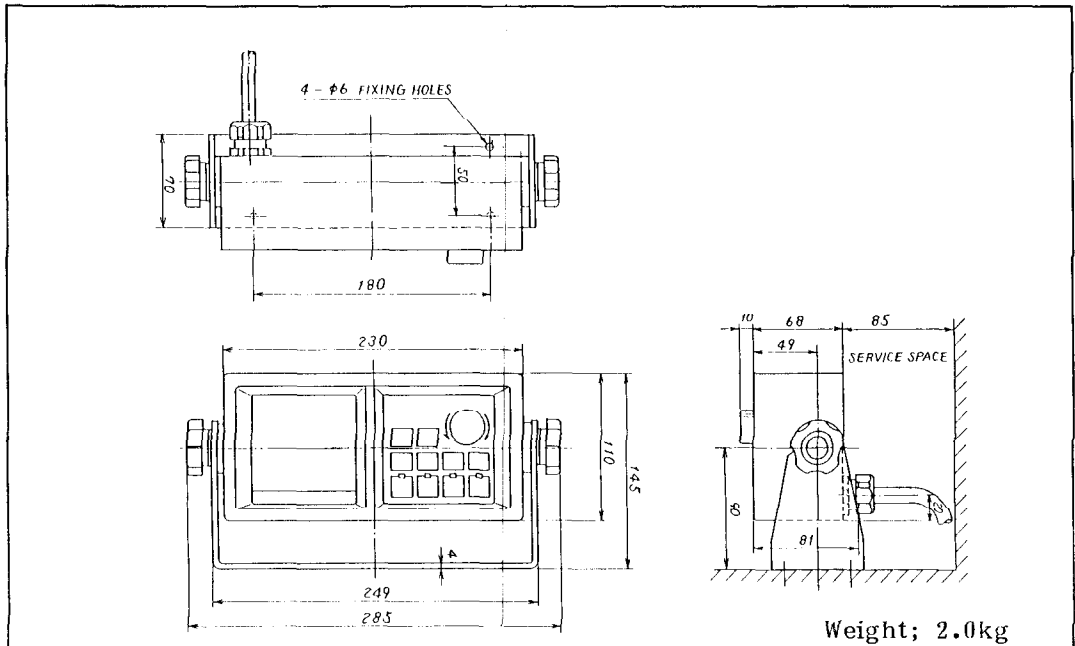
If the rudder drives continuously, switch off the autopilot at once.

4. Set the course 20° starboard from the ship's heading, rotating the course selector CW by 20 notches. Now the course indication is greater than the heading indication by 20° and this error is indicated on the semi-circle scale.

The boat will turn to the direction of the set course, then maintain that heading. Turning speed is determined by the GAIN setting.

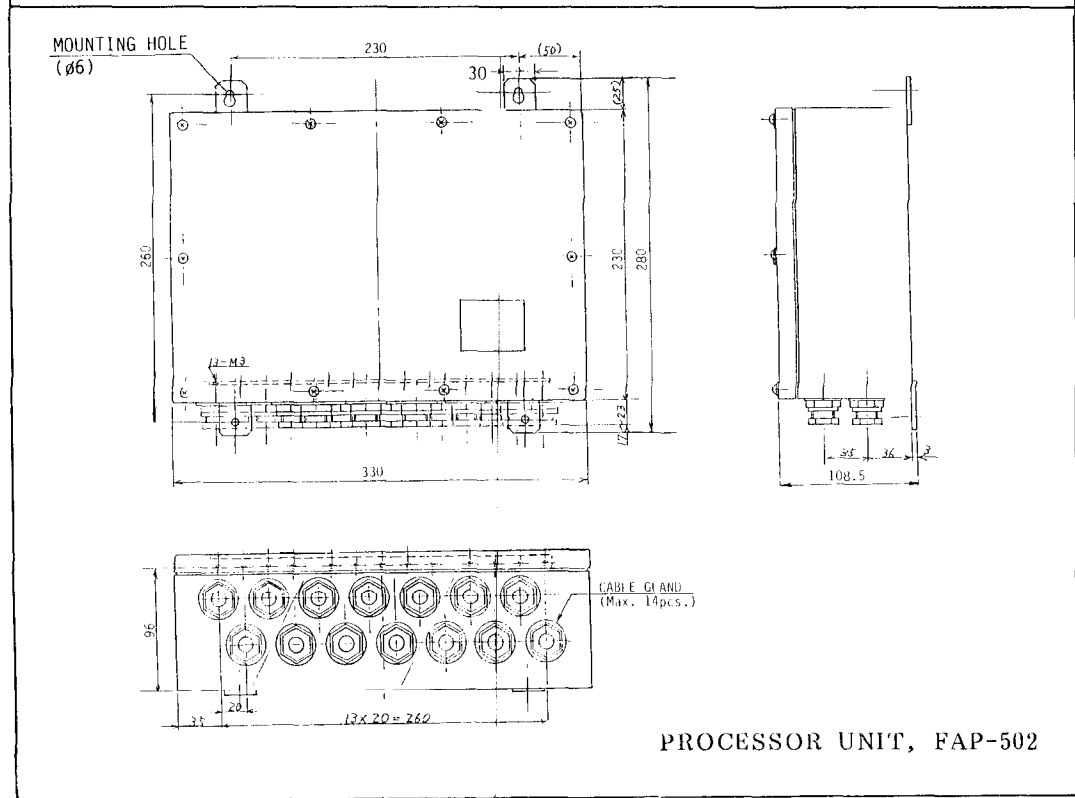
5. Check the Auto Trim function. When the auto trim function is active, the boat should maintain its heading on the set course.
6. Test the FAP-50 on the NAV mode by using the procedure on page 19.

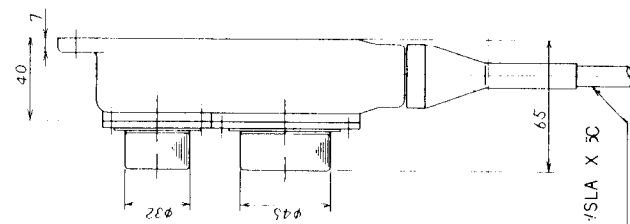
OUTLINE DRAWINGS



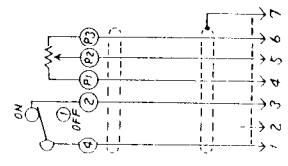
Refer to page 51
for Flush Mounting.

CONTROL UNIT, FAP-501



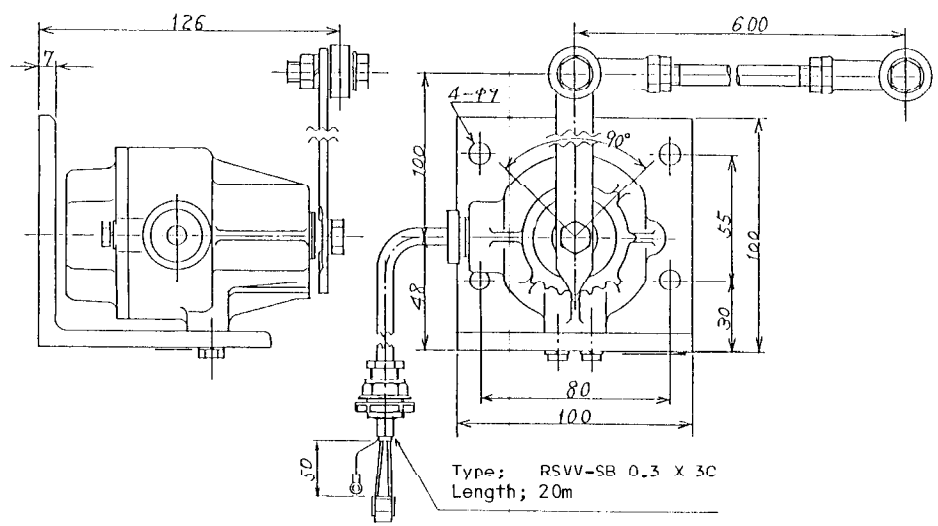


Type: RNE-1SLA X 3C
Length; 12m

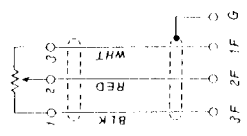


Weight; 1.5kg

REMOTE CONTROLLER, PT-11F-NH
(Portable Type)

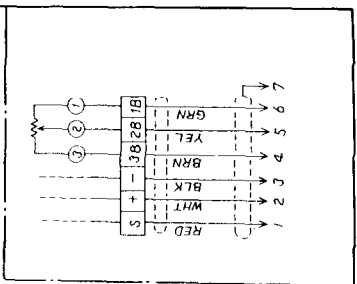
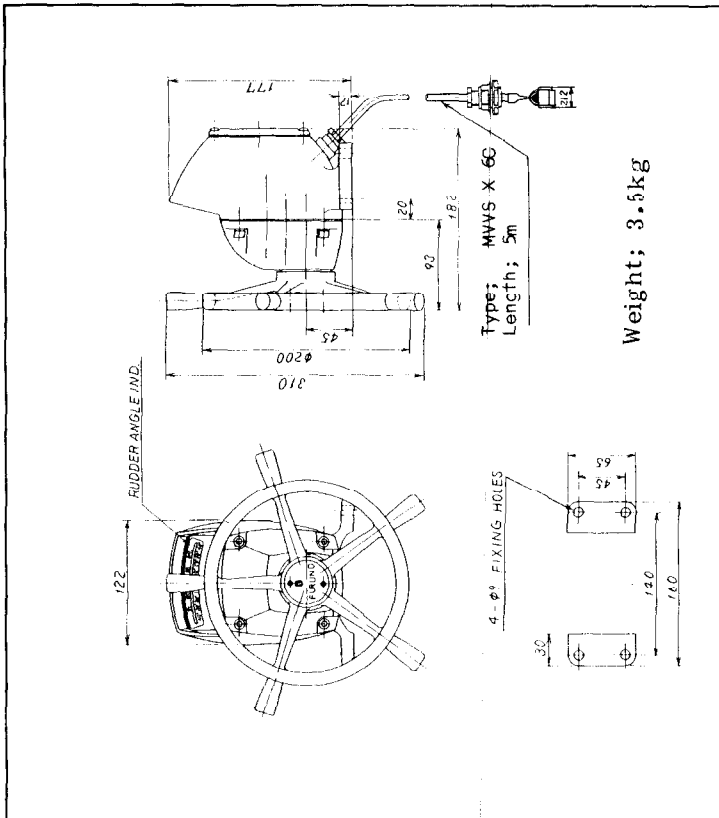


Weight; 2.5kg



Type: RSVV-SB 0.3 X 3C
Length; 20m

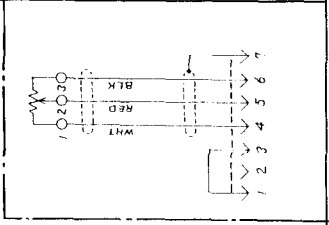
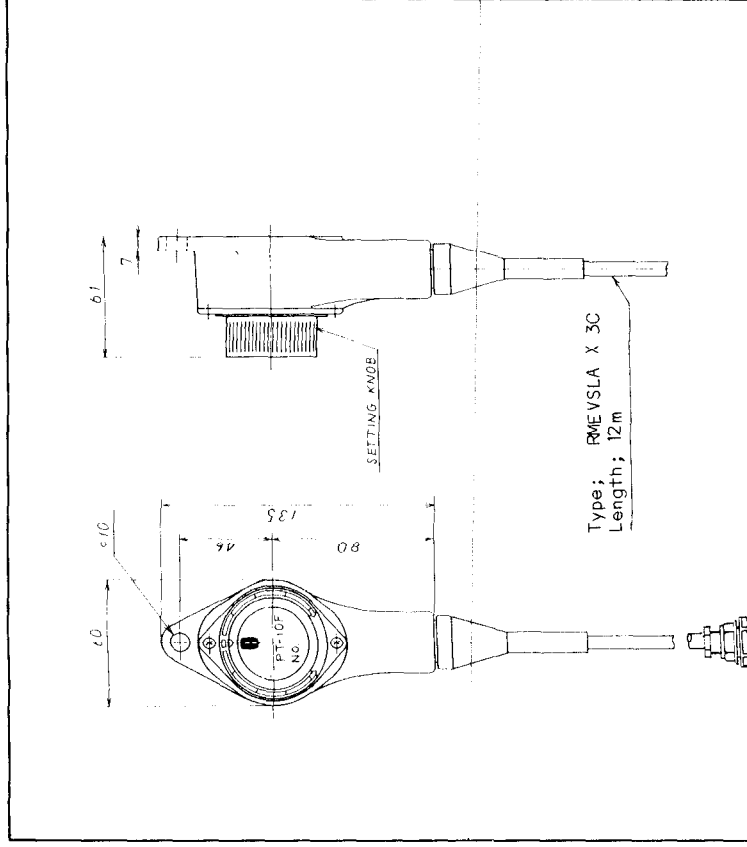
RUDDER REFERENCE UNIT, FT-10-2F-NH



MOUNTING DIMENSION

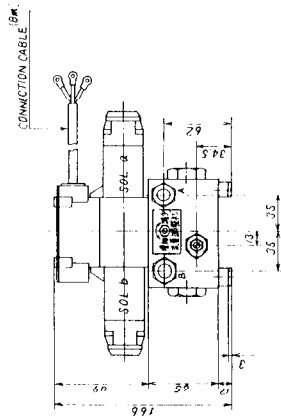
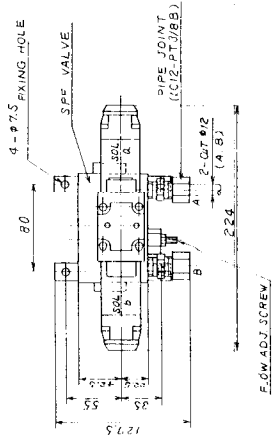
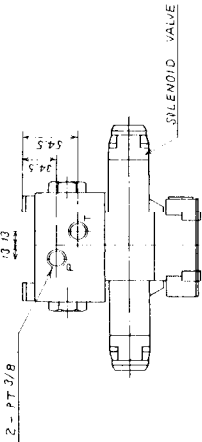
REMOTE CONTROLLER, DT-10F-NH
(with Helm)

Weight; 3.5kg

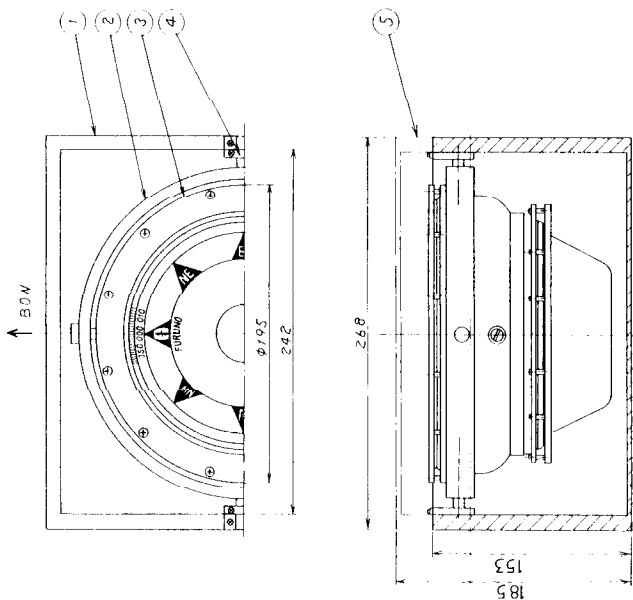


Weight; 0.5kg

REMOTE CONTROLLER, PT-10F-NH
(Portable Type)



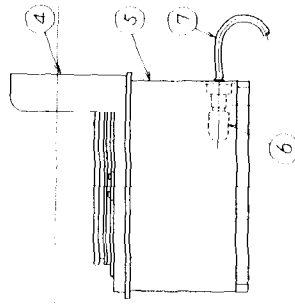
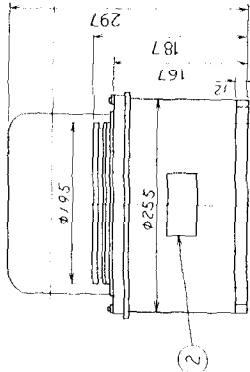
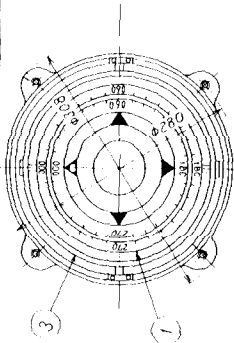
VALVE UNIT SPF-1SVF-12/24/32



MAGNETIC COMPASS B-150F

ITEM	NAME	MATERIAL	QTY	DWG NO.	REMARKS
5	LID	WOOD	1		
4	SUPPORTER	BS	2		
3	BOWL	PLASTICS	1		
2	GIMBAL	SC	1		
1	HOUSING	WOOD	1		

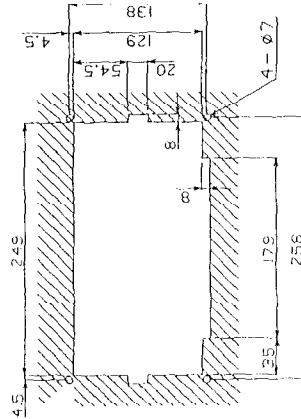
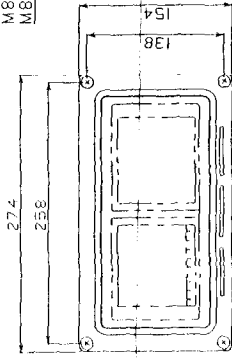
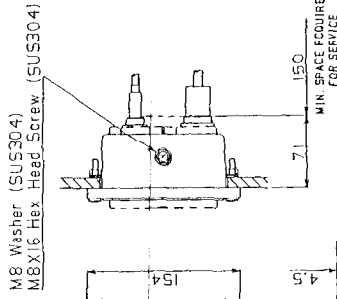
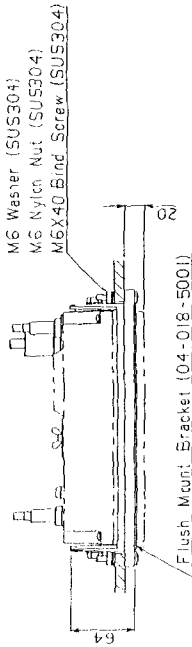
4-35 FIXING HOLES



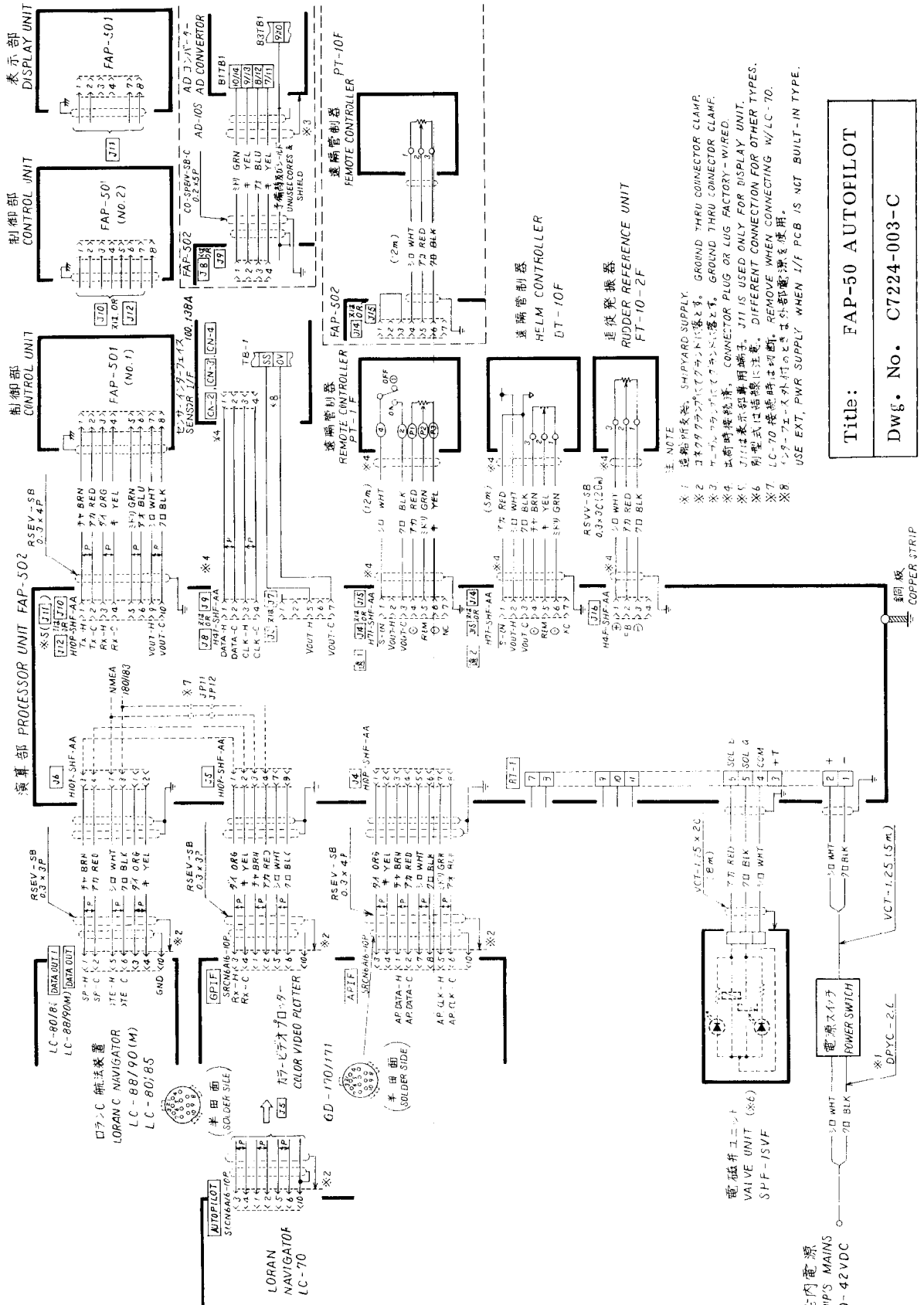
MAGNETIC COMPASS P-150F

ITEM	NAME	MATERIAL	QTY	DWG NO	REMARKS
7	CABLE		1		0.5m
6	LAMP		1		BAASD-24V5W
5	BINNACLE	BC AL	1		
4	SHADOW PLATE	BC	1		
3	GIMBAL	BC	1		
2	NAML PLATE	TE/IRON	1		
1	SOXL	BC	1		

FLUSH MOUNT BRACKET FOR LC-90/FAP-50



MOUNTING DIMENSIONS

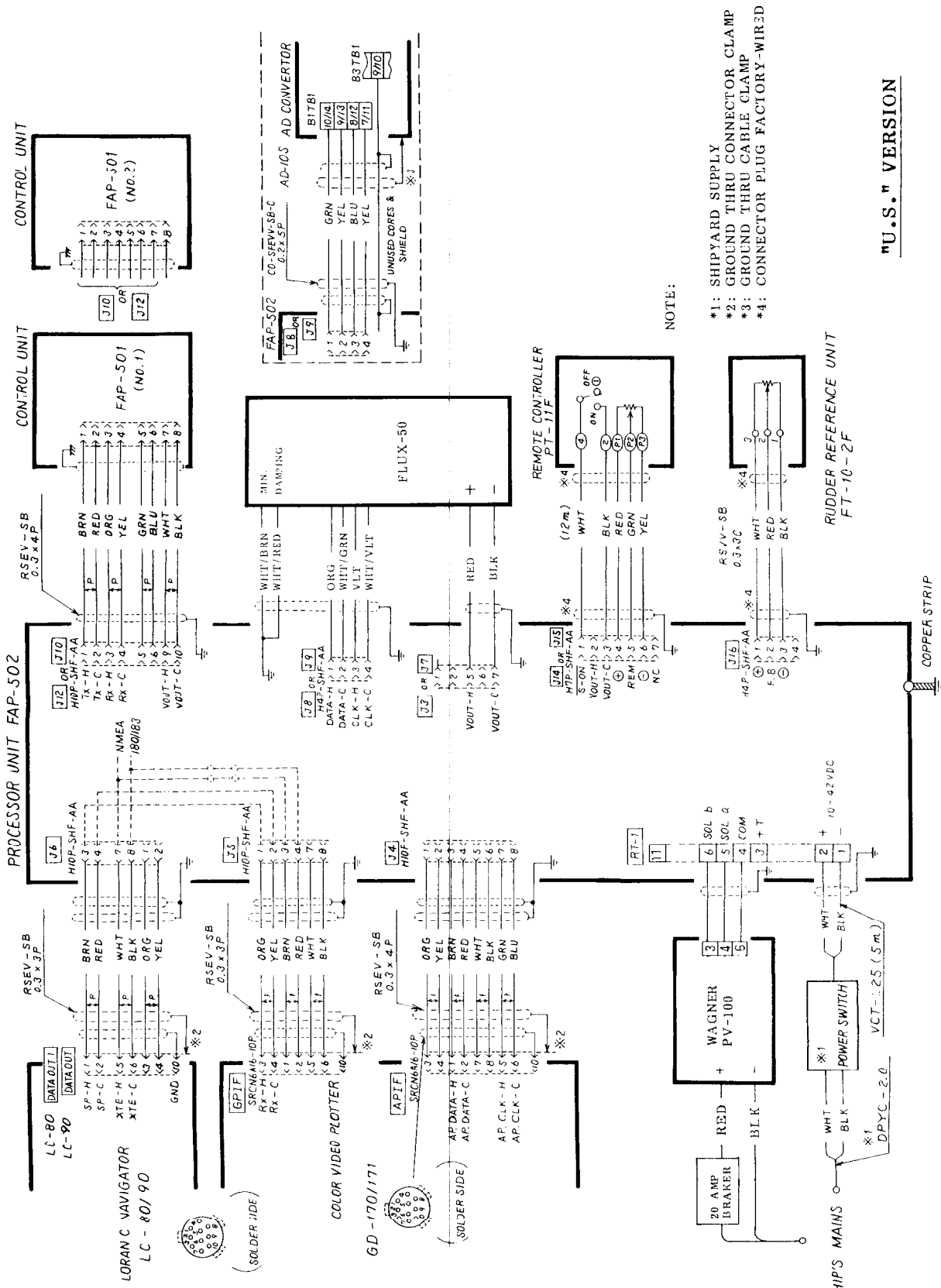


注: 造船所支給。SHIPYARD SUPPLY.
 ※2 工場777から777(777)に接続する。GROUND THRU CONNECTOR CLAMP.
 ※3 工場777から777(777)に接続する。GROUND THRU CONNECTOR WIRED.
 ※4 工場777から777(777)に接続する。GROUND THRU CONNECTOR WIRED.
 ※5 工場777から777(777)に接続する。GROUND THRU CONNECTOR WIRED.
 ※6 J11は表示制御用端子。J11 IS USED ONLY FOR DISPLAY UNIT. DIFFERENT CONNECTION FOR OTHER TYPES.
 ※7 LC-70接続時切断。REMOVE CONNECTION FOR LC-70.
 ※8 工場777から777(777)に接続する。GROUND THRU CONNECTOR WIRED.
 USE EXT. PWR SUPPLY WHEN I/F PCB IS NOT BUILT-IN TYPE.

Title: FAP-50 AUTOPILOT
 DWG. No. C7224-003-C

船内電源
 SHIP'S MAINS
 10-42VDC

銅板
 COPPER STRIP



"U.S." VERSION

APPENDIX C PICK-OFF COIL AND SENSOR I/F BOARD

PICK-OFF COIL (900.100)

SPECIFICATIONS;

Weight: 0.2kg
Environmental
classification: Splashproof

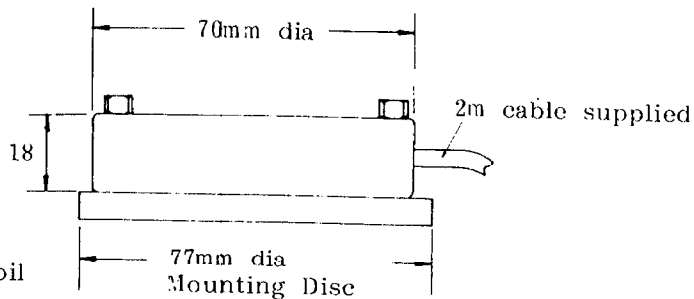


Fig. 28 900.100
Pick-off Coil

DESCRIPTION;

When heading information is required from a conventional magnetic compass, the heading signal is obtained by attaching a small pick-off coil under the main steering compass which must be an externally gimballed type. For example, any externally gimballed Class A or B compass.

INSTALLATION;

Positioning of the pick-off coil should be carried out carefully as follows;

- The center of the coil must be accurately under the card pivot point.
- The plane must be horizontal with the face of the compass.
- The \uparrow mark must be in line with the fore-aft line of the vessel and facing forward with the word "TOP" facing upward.

See Fig. 29. The distance (D2) of the coil, relative to the compass magnets, has a reasonable degree of latitude but should not be so small that the pick-off is saturated or so great that control is lost. To calculate D2;

- Locate the position where the compass field and the earth's field cancel each other by holding a small hand compass near the ship's compass and directly under the pivot, looking for the point of instability.
- Estimate the distance between this point and the ship's compass magnets.
- Determine D1 by halving the distance calculated in (b) above, then subtract the distance between the compass magnet and the base to obtain D2.

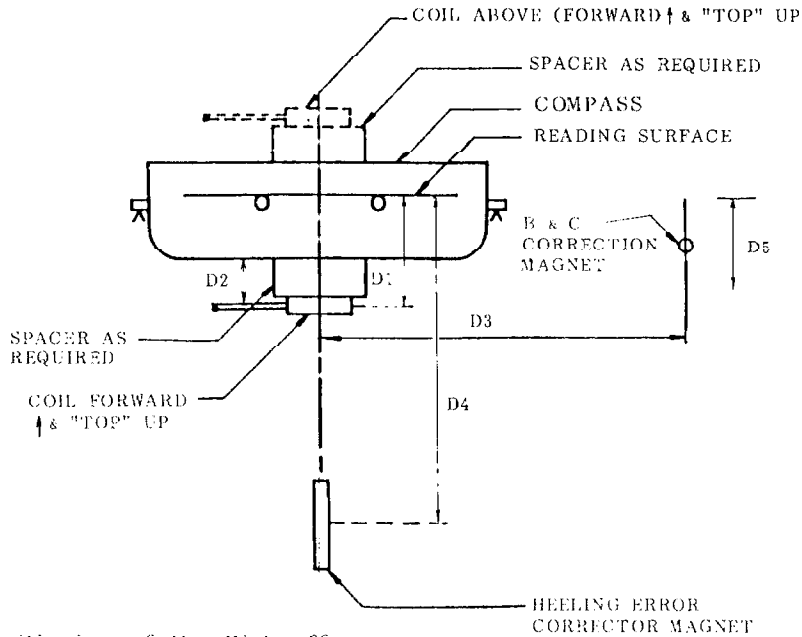


Fig.29 Positioning of the Pick-off Coil

On a typical 180mm (7") card compass, D2 is usually 25mm (1"). Thus, a S.R.B.P. spacer is arranged locally. As an alternative to the S.R.B.P., a spacer made of magnetic-free brass can be used.

Having established D2, connect the pick-off coil to 100.138A CN1 connector as described on the following page. Power up the unit, hold the coil in the correct position on the spacer and check that the compass does not deflect by more than 1/2 degree. If necessary, increase the width of the spacer to reduce the deflection below this figure.

Cement the coil and spacer together and then cement the carrier/spacer assembly to the compass, using CEMEDAIN high super (or quick-setting epoxy resin). Clamp the coil lead securely at the compass gimbaling point, ensuring that it does not interfere in any way with the gimbaling action.

Note: CEMEDAIN high super is a two-part epoxy. Mix them just before use.

The positioning of the corrector magnets can affect the accuracy of the coil. The requirements are as follows.

- a) Distance D3 must not be less than 250mm (10").
- b) Distance D5 (range of vertical alignment) must not be more than 100mm (4").
- c) Distance D4 should not be less than 2 1/2 times the heeling error corrector magnet length.

SENSOR I/F BOARD (100.138A)

INSTALLATION;

Sensor Interface Board 100.138A is mounted inside the processor unit as follows;-

1. Remove the processor board after disconnecting all connectors and removing pcb fixing screws on it. Since the processor board contains a keep-alive battery, utmost care should be taken to prevent the components from being damaged due to accidental shortcircuiting.
2. Fix the sensor interface board onto the spacers provided by using M3 screws.
3. Remove the cable gland fixed on the processor board; then pass it through the heading signal cable coming from the pick-off coil.

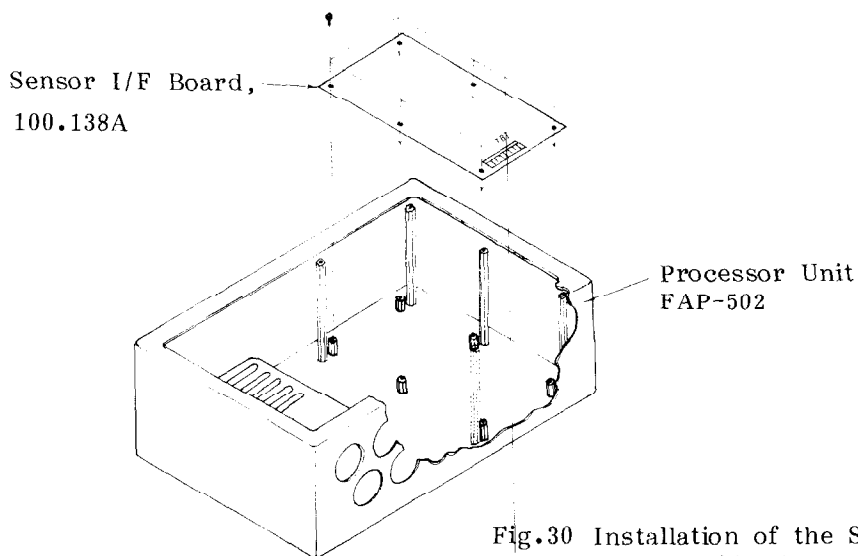


Fig.30 Installation of the Sensor I/F Board inside the processor unit

4. Solder the supplied NH connector to the heading signal cable as shown in the figure below.

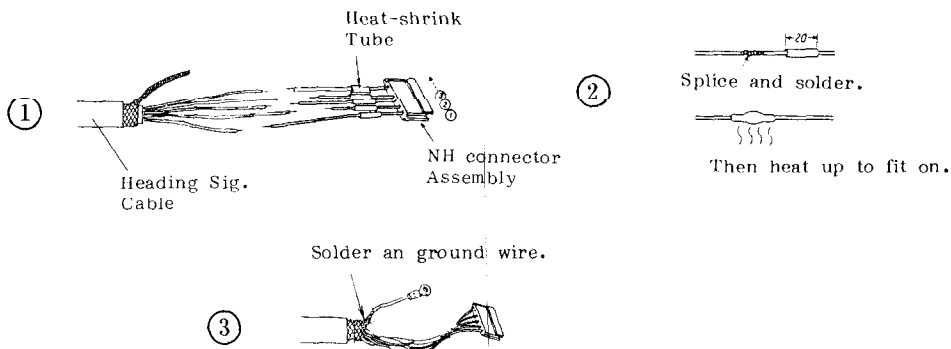


Fig.31 Connecting NH connector Assembly to the Heading Signal Cable

5. Connect the above NII connector to connector CN1, 4-way plug of the interconnection cable supplied to connector CN2 and power cable supplied to the terminal board TB1 (i.e., WHIT - #SS and BLK - #0V) on the interface board.

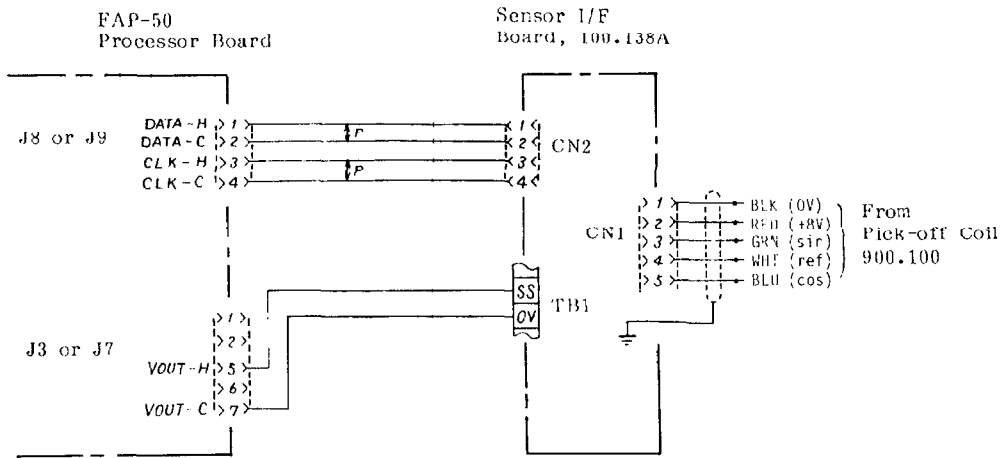


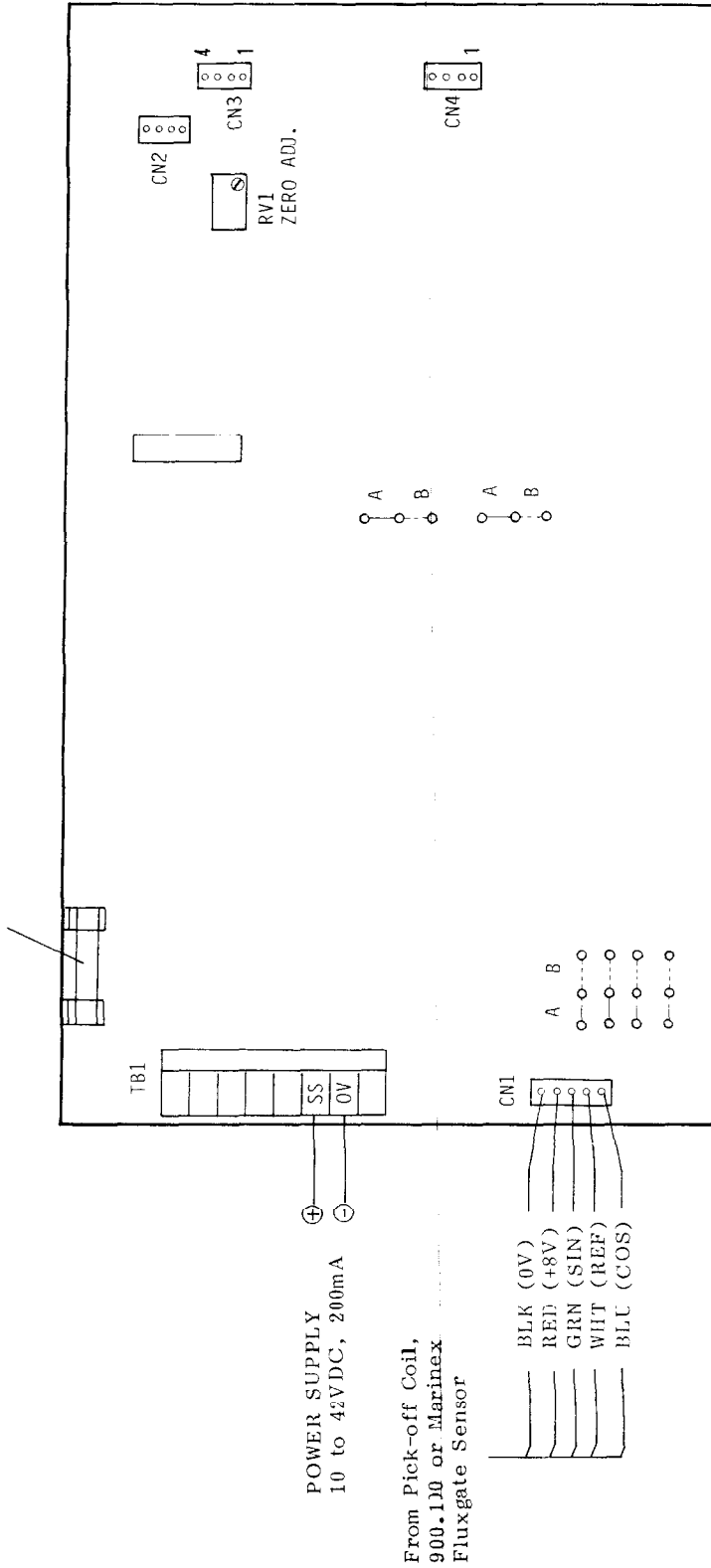
Fig.32 Interconnection between Pick-off Coil, Sensor I/F Board and FAP-50 Processor Board

6. Refix the cable gland to the processor unit and tighten it for complete watertightness.
7. Ground the shield (screen) of the heading signal cable, using a sensor I/F board fixing screw.
8. Put the processor board back onto the spacers, not placing the interconnection cables under the board.
9. Connect the interconnection cables to the processor board; the power cable to J3 or J7 and the 4-way plug to connector J8 or J9.

NOTE

- 1) The heading signal cable should be separated (and not run parallel) as far as possible from cables carrying RF or pulsed signals.
- 2) When using an external sensor I/F unit, power to the sensor I/F board should not be taken from the processor board; but use an external power source.

500mA Fuse (length: 20mm)



- 1) For Pick-off Coil links in position A
- 2) For Marinex Fluxgate Sensor links in position B
- 3) All outputs, CN2, CN3 and CN4 = #1: data (H); #2: data (C); #3: clock (H); #4: clock (C)

Fig.33 Sensor I/F Board, 100.138A, Parts Side

APPENDIX D FLUX-50 HEADING SENSOR

DESCRIPTION;

The FLUX-50 Heading Sensor outputs the heading data in the same format as that of A/D converter AD-10S.

INSTALLATION;

The principal advantage of having a remote sensor unit is that you can put it virtually anywhere on the boat. Ideally the sensor should be mounted near the center of gravity of the boat, but this is not critical. In selecting a location, choose a spot that is as far from iron or steel as possible. The more carefully you place the sensor, the less compensation you will have to do.

Care must be taken to align the arrow on the top of the sensor with the keel line of the boat, making certain the arrow points forward.

Once you have found a good location, mount the sensor by using the enclosed screws. Drill the holes in the center of the slots in the base of the sensor. Put the screws in only hand tight. The slots allow you to turn the sensor slightly to align it with the keel line of the boat (for fine tuning). Before tightening the screws, check that the digital heading readout is the same as the ship's compass reading. If not, turn the sensor so that the arrow points exactly forward. The sensor is internally gimballed, so it is not horizontal as possible. The faceplate on the sensor is the TOP. Never mount it upside down! Do not mount the sensor on a vertical bulkhead unless you are using some sort of right angle bracket to keep the sensor approximately horizontal.

The wiring data of the FLUX-50 is as follows.

<u>Output Cable</u>			<u>Power Cable</u>	
Black	Spare		Red	+12V
Brown	Data 1 - H1	(5) *	Black	Gr.d
Red	Data 1 - H2	(6)		
Orange	Data 2 - H	(10)		
Yellow	Data 3 - H	(14)		
Green	Shift 1 - H1	(2)		
Blue	Shift 1 - H2	(3)		
Violet	Shift 2 - H	(8)		
White	Shift 3 - H	(12)		
White/Black	Spare			
White/Brown	Damping 0			
White/Red	Damping 1			
White/Orange	Data 3 - C	(13)		
White/Yellow	Data 1 - C	(4)		
White/Green	Data 2 - C	(9)		
White/Blue	Shift 3 - C	(11)		
White/Violet	Shift 2 - C	(7)		
White/White	Shift 1 - C	(1)		

*: Figure in parenthesis is an equivalent AD-10S terminal.

Connection to FAP-50;

In the figure below, the FLUX-50 is directly connected with the FAP-50 processor unit, using Data 2.

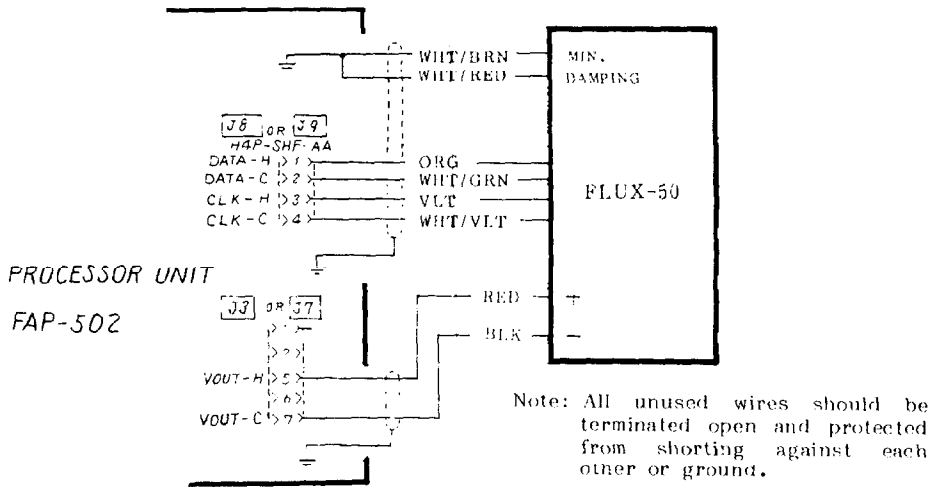


Fig.34 Interconnection between FAP-502 and FLUX-50

Refer to page 56 for soldering a NII connector to the FLUX-50 cable.

Compensation;

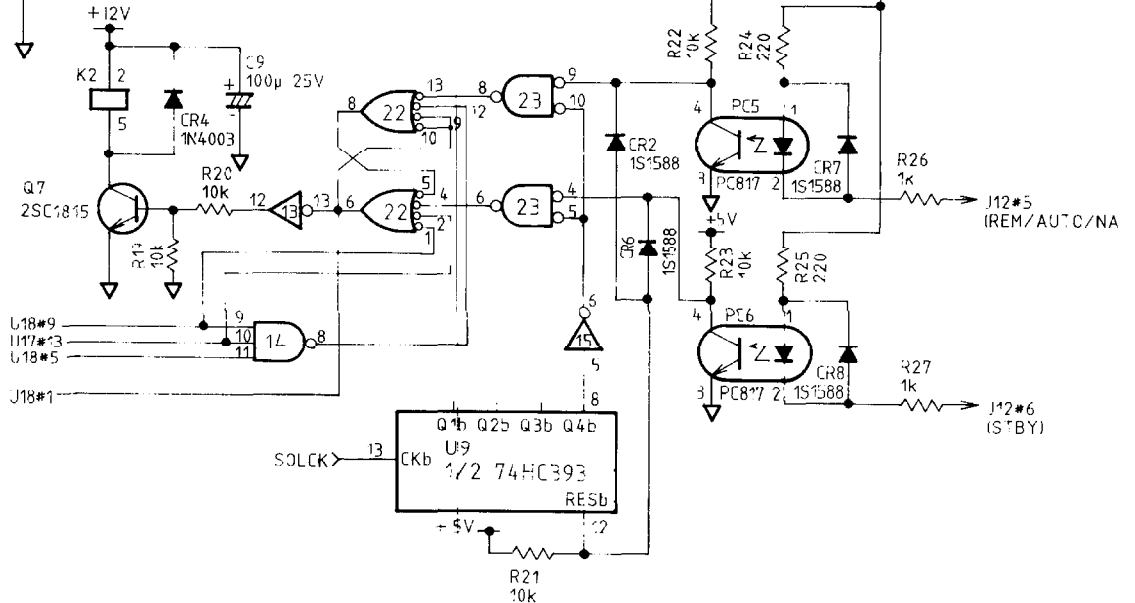
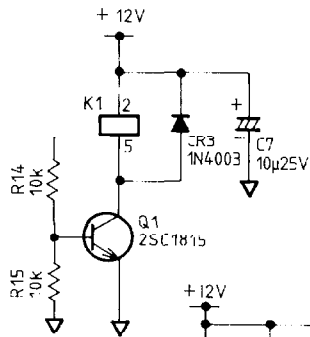
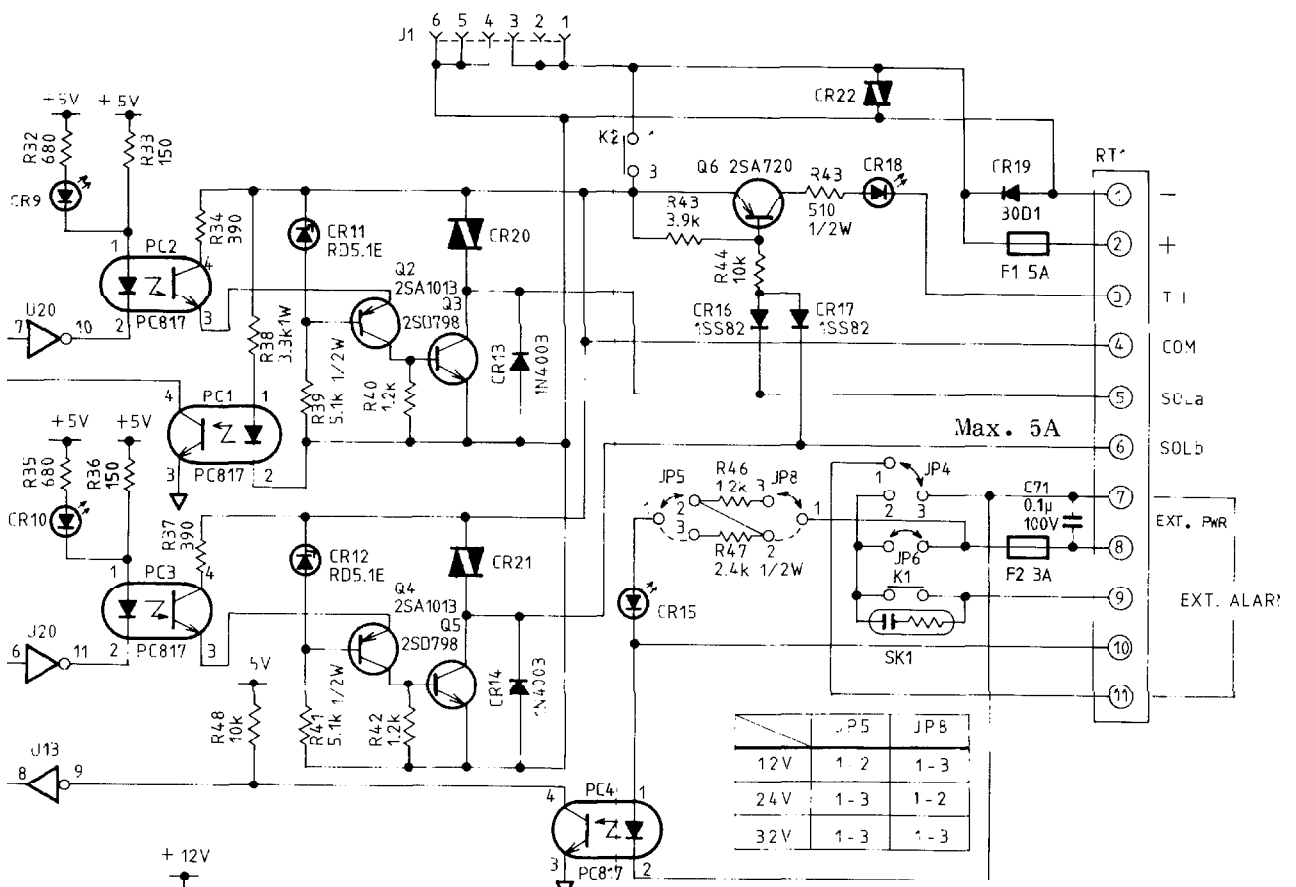
Adjusting the sensor is done in exactly the same manner as with a normal magnetic compass. There are two screws on top on the sensor unit. Remove these protective stainless screws to reveal two smaller screws inside. These screws control electronic adjustment coils inside the sensor, but the effect is identical to moving the compensating magnets in a normal compass. Turn the screw marked E/W to correct for east-west errors and turn the screw marked N/S to compensate for north-south anomalies.

IMPORTANT: All compasses must be compensated before being used.

Damping Control;

Four damping responses can be selected on the FLUX-50 as shown in the Table below. However, the fastest (minimum) damping should be selected for the connection with the FAP-50, grounding White/Brown and White/Red wires.

Damping Response	Connect to Ground:
1 (fastest)	Damping 0 and 1 (WHT/BRN and WHT/RED wires)
2	1 (WHT/RED)
3	0 (WHT/BRN)
4 (slowest)	Neither



FAP-50 OUTPUT CIRCUIT

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