COURSEMASTER
AUTOPILOTS

Australia's world leader in autopilot technology

# CM650 OWNER'S MANUAL

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**Your Coursemaster CM650 is engineered for accurate and reliable steering. But remember that it cannot keep a lookout.**

**SAFE NAVIGATION IS ALWAYS YOUR RESPONSIBILITY.**


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**CM650 OWNER'S MANUAL**

## CONTENTS 2

# CHAPTER 1 SYSTEM DESCRIPTION

Your CM650 is a computer-controlled autopilot system which has been engineered for use principally in commercial vessels and power craft. The control panel, electronics and steering drive are integrated into a single case for ease of installation. Normal operations are controlled by knobs, while an easy-to-read display provides easy monitoring of the performance of the system. The CM650 has a rate gyro option and may be operated either as a stand-alone system or with a GPS or other navigation system.

## 1.1 SYSTEM COMPONENTS

The full system, with its optional attachments, is shown in Fig 1.1. The core system components, shown with shading, are:

**CM650 Central Controller.**

This houses the control microcomputer, the control panel, display, interfaces with other system components and the steering drive electronics. The drive system is robust and is designed to drive mechanical, hydraulic pump and solenoid controlled steering systems.

**CM426 Fluxgate compass.**

The compass is a fluxgate type and accommodates a wide range of pitch and roll.

**CM120 Rudder Transducer.**

This is a fully sealed heavy duty potentiometer type.

**Steer Motor.**

There are many mechanical or hydraulic steering options. A suitable drive can either by supplied by Coursemmaster or the autopilot may be connected to an exisiting steering drive on the vessel.

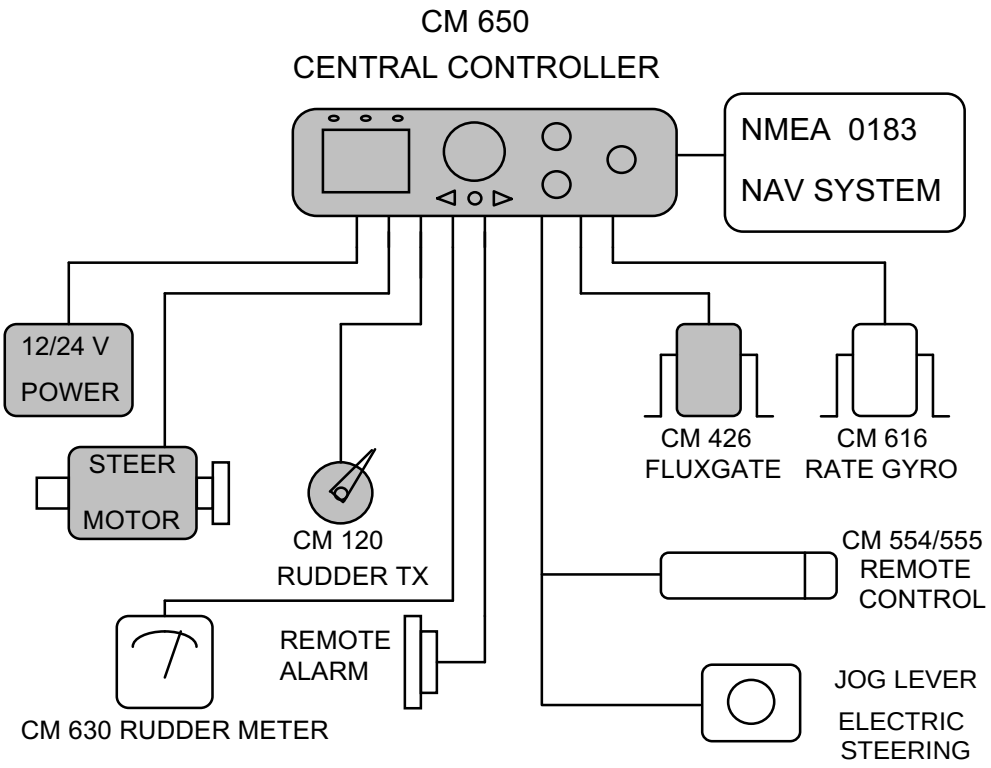



Figure 1.1 System Configuration, showing standard and optional attachments.

## 1.2 OPTIONAL ATTACHMENTS

**CM616 Rate Gyro.**

The Rate Gyro is a vibrating crystal type which works in conjunction with the fluxgate compass to give more precise steering control in all sea states. It provides a very stable short-term heading output which is independent of pitch and roll in the vessel. The fluxgate output is then used to correct for drift in the gyro so that long-term stability is also achieved. Using the rate gyro overcomes the 'southerly heading' softness sometimes encountered at high boat speeds in the southern hemisphere, or the converse problem in the northern hemisphere. The rate gyro also quietens rudder activity in a heavy swell.

**Remote Steering**

Several remote steering options are available: a hand-held unit with a cable (CM554) or a panel-mount unit (CM555). Both are fitted with a steering knob and a three-position switch (PILOT-STANDBY-HAND/REMOTE) and both operate in the same way. In addition, a Jog Lever or an auxilliary electric steering wheel may be fitted.

**CM630 Rudder Angle Indicator.**

This indicator gives an analog display of the rudder angle and may be located either with the Controller or on another part of the vessel.

**Remote Alarm**

A piezoelectric beeper is available which repeats the internal alarms generated by the autopilot.

# CHAPTER 2 OPERATING INSTRUCTIONS

## 2.1 THE CONTROL PANEL

The front panel of the Central Controller (Fig 2.1) contains a text/graphics display, three course error lamps, the power switch, rudder factor knob, a course control knob, a sea state control and three push-buttons. The use of these is described in this chapter.

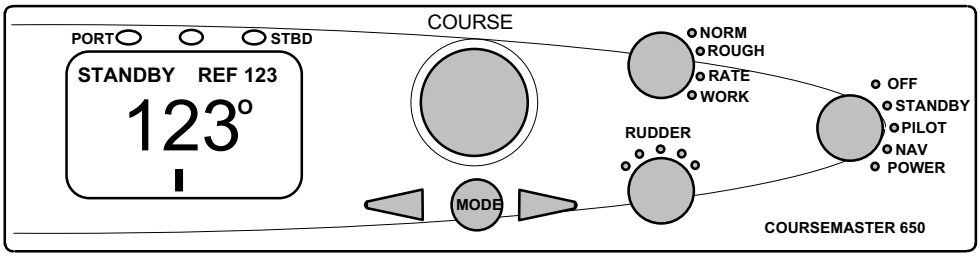



Figure 2.1 The Control Panel

### DISPLAY

In normal operation, the top left of the display shows the current mode of the autopilot - STANDBY, PILOT or REMOTE. The top right shows the reference course which the autopilot will steer to. When in autonavigate mode, this area shows the heading-to-steer and cross track error received from the GPS system. The centre of the display shows the current heading of the vessel and the lower part is a bar indicating the rudder angle.

### THE POWER SWITCH

**STANDBY** Switches the system on. When operating in any mode, returning the switch to this position puts the system in STANDBY and switches the steering drive off. It also sets the reference course to be equal to the current heading.

**PILOT** Engages the autopilot and locks the vessel onto the current heading.

**NAV**

Engages the autopilot and steers the vessel to a course set by a GPS system.

**POWER**

Converts the course control knob into a manual steering wheel.

**SEA STATE CONTROL**

Selects one of four different control characteristics for the autopilot.

**RUDDER FACTOR**

Adjusts the amount of rudder movement for a given course error.

**COURSE**

Adjusts the reference course when in STANDBY or PILOT modes and acts as a direct steering control in the POWER mode.

**LEFT/RIGHT KEYS**

Used to dodge when in pilot mode and to adjust system settings.

**MODE**

Used to select the display, cancel alarms and to access the internal program menu.

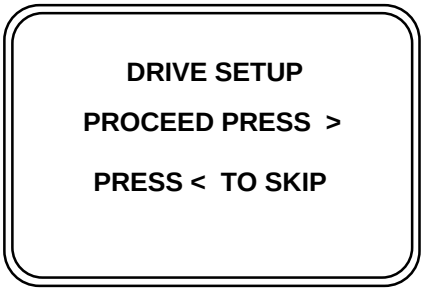
**COURSE LAMPS**

The amber lamp indicates that the vessel is on course within 8 degrees. The red or green lamps indicate an error greater than 8 degrees.

## 2.2 GETTING STARTED

Before operating the autopilot for the first time, it must be installed and adjusted as described in Chapter 3. (If optional attachments and interfaces are being used, though, these can be fitted after initial trials of the system.)

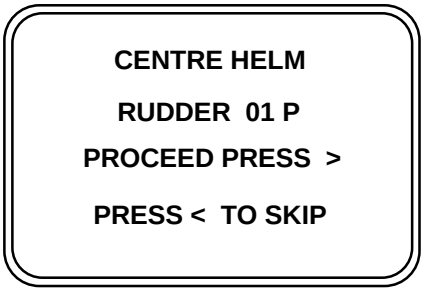
To switch on for the first time, turn the power switch to STANDBY. The system enters a special mode to ensure that the steering drive and rudder transducer have been phased correctly. After the SELF TEST display, the screen will show:




There are two choices. If you wish to examine some of the autopilot features without carrying out the setup, press the LEFT ARROW. This will bypass the setup and will permit various displays to be examined. However, the system will not switch into PILOT.

To carry out the setup, follow these steps:

1. Press the RIGHT ARROW key.




2. The display now asks you to centre the helm. Move the helm to its natural centre. The rudder angle shown on the screen should be within 2 degrees of centre. If it is not, go to the rudder transducer, loosen the clamp on its shaft and use a screwdriver to rotate the shaft until the display shows a 00 rudder angle. Press the RIGHT ARROW key.

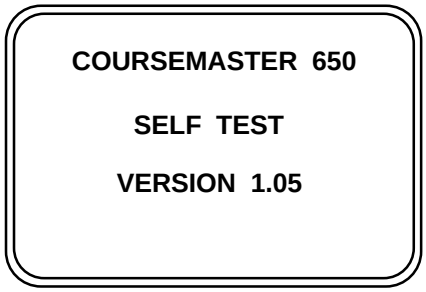
3. The display now asks you to turn the helm STARBOARD. Turn it to an angle between 5 and 15 degrees and press the RIGHT ARROW. If the rudder transducer and motor phasing are correct, the helm will be driven back to centre and the display will return to the normal STANDBY mode.

4. If a REVERSE RTX message appears after step 3, turn the autopilot off and interchange the blue and orange wires to the rudder transducer. Then repeat the above steps.

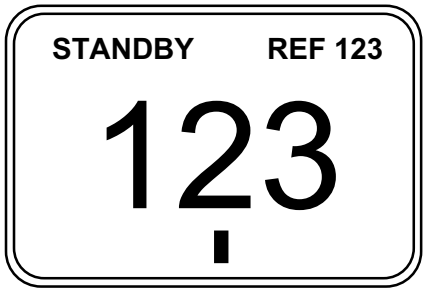
5. If the RTX phasing is correct, but the motor wiring is reversed, the motor will move away from centre for a moment, then stop. The screen will display the 'Reverse Motor' message. Again, turn the system off, correct the problem by interchanging the MOTOR+ and MOTOR- wires and repeat the setup.

## 2.3 NORMAL OPERATION

**SWITCHING ON** Turn the power switch to STANDBY. The system does a self-test for 10 seconds and displays the version number of the software installed, eg:




When the self-test is complete the normal STANDBY display appears and shows the current heading of the vessel.




**AUTOPILOT** With the system in STANDBY, steer the vessel to the desired heading and turn the switch to PILOT. The autopilot will now lock onto that heading and maintain it. The display will show 'PILOT' in the top left corner.

**AUTONAV** If a GPS receiver or other source of navigation data is

connected, the vessel can be steered to head towards a waypoint with minimum cross-track error. Turn to NAV to turn on auto navigation. If only heading-to-steer data is being received, the top right of the display shows this heading, eg.

**NAV 123**

If the crosstrack error is also being received, the vessel steers to minimise the error and the top right of the display alternates between the heading-to-steer and the cross track error, eg.

**XT 0.07 L**

If NMEA data is not being received, the top right of the display reads:

**NAV WAIT**

and the vessel will continue to hold the previous reference course. It this message does not clear within 15 seconds, consult the NMEA installation section of Chap 3.

**POWER STEER**

To steer the vessel manually, switch to POWER. The current position of the helm is now held and may be turned port or starboard by the COURSE knob. Half a turn of the knob produces the maximum a rudder angle of 25 degrees.

**RUDDER FACTOR**

The RUDDER FACTOR knob gives a continuous control of the amount of helm applied for a given course error. For most vessels, a factor between 30% and 50% of maximum is best. Too low a setting will give a soft course holding, while too high a setting causes oversteering and may make the vessel 'snake' from side to side around the programmed course.

**ADJUSTING THE COURSE**

To adjust the current heading, turn the COURSE knob. The reference course shown in the top right of the display will change to show the new reference.

**Note.** In the auto navigate mode the reference will not change, since it is controlled by the GPS or other navigation device.

**SEA STATE**

Four different control modes may be selected, with the following

effects on steering performance:

**NORMAL**

A direct, almost proportional control, without averaging. It suits medium or small vessels in smooth or choppy conditions and will give reasonable control in all vessels.

**ROUGH**

This suits most craft in heavy conditions. The control has a deadband which permits a 5 deg yaw about the reference course before correction is applied. Rudder activity and power consumption are therefore kept to a minimum.

**RATE**

A counter rudder mode which applies a correction according to both the error and the rate of turn. When turning towards a course, reverse helm is applied before the course is reached, in order to cancel the turning momentum. RATE is best suited to heavy vessels which are slow to respond to helm corrections. Other vessels in a following sea may also respond well in the RATE mode.

**WORK**

A special mode for slow speed operation, such as trawling, when the helm may be offset by drag on the boat. The basic control is as for NORMAL, but the helm centre is automatically compensated for offsets.

**DODGING**

In any of the autopilot modes, holding the left or right arrow keys will apply full helm in that direction to provide a rapid course change. The helm returns to normal operation as soon as the key is released.

**REMOTE STEER**

If a Remote Helm or similar attachment is fitted, switching it to the HAND mode overrides normal autopilot functions and provides direct rudder control. In this mode, the display shows REMOTE in the top left corner. The knob on the unit now directly controls the rudder and permits it to be moved out to +/- 20 deg., regardless of the preset rudder limits. To return control to the main system, either

switch to STANDBY, which will disengage the steering drive, or switch to PILOT, which will lock the system onto the present heading and resume autopilot control.

When returning control to the main system, you can override the power switch setting. For example, if the switch is set to PILOT and a remote is switched to STANDBY, the system will go into STANDBY. The power switch will take control again as soon as it is operated or if the MODE key is pressed.

If two Remote units are fitted and both are switched to HAND, the unit connected to the Remote 1 port takes control.

The switches should be left in STANDBY or PILOT when the units are not in use.

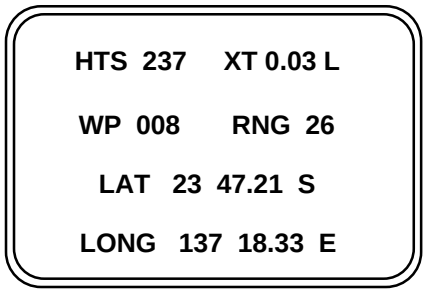
A Jog Lever operates in a similar way and switches the system to REMOTE when it is operated. To return to normal, press the MODE key.

## 2.4 THE MODE KEY

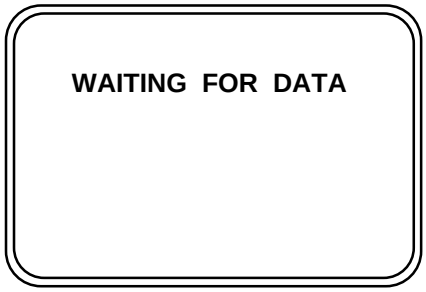
The MODE key cancels alarms if they are present, returns the system after using a REMOTE control and gives access to alternative displays and program menus.

### 2.4.1 NAVIGATION DISPLAY

Pressing the MODE key once brings up a screen which displays navigation data received from the GPS or other device. The display can show up to six navigation parameters if available, namely: heading to steer to waypoint, cross track error and direction, waypoint identifier, range to waypoint in nautical miles and current latitude and longitude.



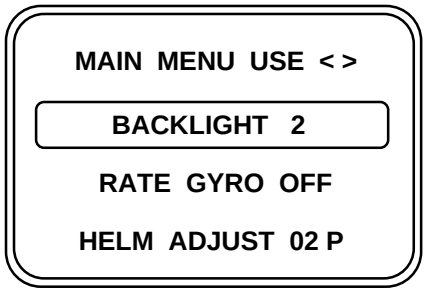

Parts of the display may be blank if some of the data is not available and if no valid NMEA data is being received, the screen shows:



## 2.5 PROGRAM MENU

### 2.5.1 MENU 1

Two program menus give access to a number of system settings which may be used to fine-tune the performance and select various options. Adjusted settings are stored in permanent memory and are retained while the system is turned off. Hold the MODE key for 2 - 3 seconds to enter the menu, then use single presses of the MODE key to scroll down. **To exit the menus** at any time and return to the normal display, **hold down the MODE key for 2 - 3 seconds.**




**BACKLIGHT** The backlight for the display can be set to 4 different brightness levels. Use the arrow keys to adjust.

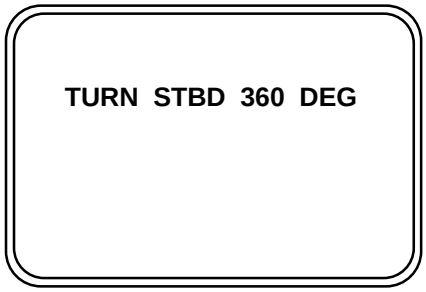
**RATE GYRO** If a rate gyro has been fitted as an optional attachment, it is turned on or off by using one of the ARROW KEYS.

**HELM ADJUST** For best overall performance, it is recommended that the displayed rudder angle be adjusted to read zero when the helm is dead ahead. This adjustment compensates for errors in the transducer linkage and other offsets in the steering gear. The current helm angle is displayed and should read 00 at the centre. Use the arrow keys to trim the reading.

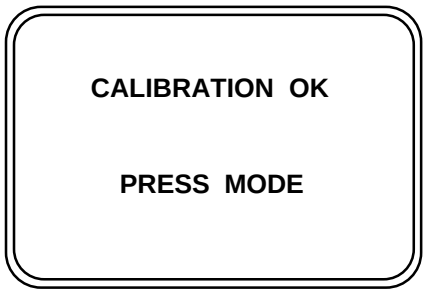
**HEADING ADJUST** The current fluxgate heading is displayed and compass mounting errors may be compensated using the arrow keys.

**AUTO COMPASS CALIBRATION**

This is one of two options to reduce deviations caused by magnetic components and material on the vessel. To carry out this calibration, press the right arrow. The display will read:




With the vessel under way and steering it by hand, turn it slowly through a full circle. When the circle is complete, the display will show:



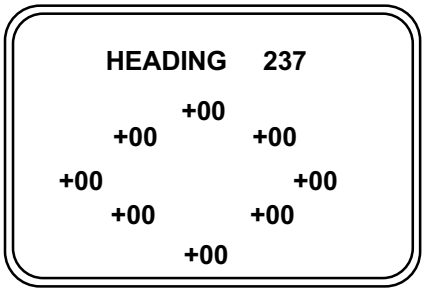

Press the MODE key to return to normal operation. This method of calibration is simple and is a recommended procedure for all vessels. But there are some magnetic anomalies which are not fully removed. Fine-tuning the calibration, after the automatic step, gives the highest level of compass accuracy.

**MANUAL**

Manual calibration can be carried out independently of auto

**COMPASS CALIBRATION**

calibration, but is best done after an autocalibration procedure. Press the right arrow and the display shows the current heading and shows the deviation stored for each of the eight cardinal and inter-cardinal points. (All deviations are initially zero, even if an auto calibration has been carried out.)




Turn the vessel to a heading which is close to one of the cardinal or inter-cardinal points, ie.

000, 045, 090, 135, 180, 225, 270, or 315.

Then use the arrow keys to adjust the deviation up or down until the heading agrees with that of the ship's compass or other reference compass. Turn to the next point and repeat the procedure until all eight have been checked or adjusted. Press MODE.

The manual calibration may be fine-tuned at any time by selecting this function and turning, for example, to just one cardinal point which may need adjustment.

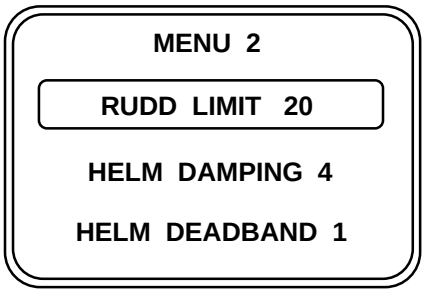
Note that all calibration settings are cleared when a COLD START is carried out.

**COLD START**

This option restores the original factory preset parameters in the autopilot and should be used if there has been some malfunction or if new software has been installed. When the prompt appears, press the right arrow. After the presets have been re-loaded, the display will show:

### 2.5.2 MENU 2

Press the right arrow to bring up the second menu or continue to scroll through the main menu.




**RUDDER LIMITS** The maximum rudder angle is preset to 20 degrees in pilot this limit may be changed from 20 deg., using the arrow keys, though such a change is usually unnecessary. The limits for remote steering are preset in the remote control unit.

**HELM DAMPING** The Helm Damping control compensates for inertia or overshoot in the steering drive, which may be present in most hydraulic or electrical systems. To check the suitability of the preset value of 2, turn the helm manually to about 20 deg. rudder angle and press PILOT to centre the helm. Observe the rudder movement. If the rudder stops short and then "inches" into the centre position, reduce the damping factor. If it overshoots and "inches" back, increase the damping factor. (In some versions the setting of Helm Damping may be automatic and this option will not appear.)

**HELM DEADBAND** The deadband acts as a filter which prevents the steering drive from pulsing on and off in response to very small error signals. If it is set too high, the steering will be slow to respond to small corrections. The best setting is one just above the value which produces continuous pulsing of the steering gear.

**RATE FACTOR** If the RATE sea state is used, the strength of the counter rudder action may be varied with this factor. The preset value of 2 is generally suitable, but a value of 1 may be better for high-speed vessels. Slow vessels with a tendency to a steering overshoot may be better with a setting of 3 to 4.

**HELM ALERT** As a safety feature, a HELM ALERT alarm is sounded after a fixed time when the system is in the PILOT mode. This is an aid to ensure that the helmsman is keeping watch. The time interval for an alert may be selected to 5 or 15 minutes.

**PORT SELECT** There are two input ports in the Junction Box for NMEA data and in some installations it may be desired to connect two different sources to these ports. The active port is selectable between A or B

**ADJUST VARIATION** A magnetic variation value must be entered if GPS sentences containing TRUE headings are used. The variation is displayed on a 360 degree scale, i.e. 13 degrees east appears as 013, while 10 degrees west appears as 350. Use the COURSE keys to adjust the variation.

## 2.6 ALARMS

The CM650 has a number of alarm functions. When an alarm occurs, the beeper sounds and an alarm message appears in the lower part of the normal display. To cancel an alarm, press the MODE key.

**OFF COURSE** The vessel has been more than 8 deg off course for 12 seconds. This only operates in the PILOT mode and while the alarm is active, all other functions operate normally. Cancel it by returning to course or by pressing the MODE key.

**HELM ALERT** In PILOT mode, this sounds each 5 minutes (or longer) as a safety feature to ensure that the wheel is attended. It is cancelled by the MODE key, or by selecting STANDBY and may be changed via the second program menu.

**DRIVE OVERLOAD** The current drawn by the steering gear has exceeded the limits and the drive has been turned off. See Chap. 4 for further information.

**RUDDER OVERRANGE** The rudder has travelled past its preset limits and the drive has been turned off. This could indicate a mechanical or electrical problem with the transducer. (See Chap.4). The limits in

STANDBY and REMOTE are fixed at 60 deg., while the PILOT limits are at 33 degrees.

**COMPASS FAULT** The magnetic field being sensed by the compass is above or below preset limits. Further information is given in Chap. 4.

# CHAPTER 3 INSTALLATION

## Step – by – step summary

Before proceeding with the installation, check the contents of the shipment to ensure that all components ordered are present and undamaged. If a steering motor or hydraulic drive is included, check that its voltage rating is suitable for the vessel's supply. Read right through this chapter before starting and then follow this step-by-step guide:

1. Mount the Central Controller as described in Sect 3.1. Take care that the polarity of the battery wires is correct and that the metal parts of the terminal blocks grip the wires and not the insulation.

2. Mount the Compass as described in Sect 3.2. Take care to keep it away from the sources of stray magnetic fields listed in that section.

3. Mount the Rudder Transducer as shown in Sect 3.3 Ensure that the linkage geometry is correct and if it is in a storage area, ensure that heavy objects will not fall on the linkage.

4. Install and connect any additional attachments as described in Sect 3.4. (Or, if preferred, these could be installed after initial commissioning.)

5. Install the steering drive as described in Sect 3.5

6. Apply power to the Central Controller. Now turn to Section 2.2 of this Manual - Getting Started - and carry out the initial setup as described.

## 3.1 CONTROLLER

The Controller may be either flush mounted in a dashboard cut out or surface-mounted using the trunnion bracket provided. It should be protected from the weather and be well above the bilge water level in the vessel. The two further considerations are that the rear of the case should be easily accessible for making connections and that there is a space of at least 50mm on all four sides to permit air circulation. After checking that the chosen mounting is satisfactory, remove the six screws holding the back plate and lie it on a surface behind the case.

An exploded view of the interior of the controller is shown below in Fig 3.1

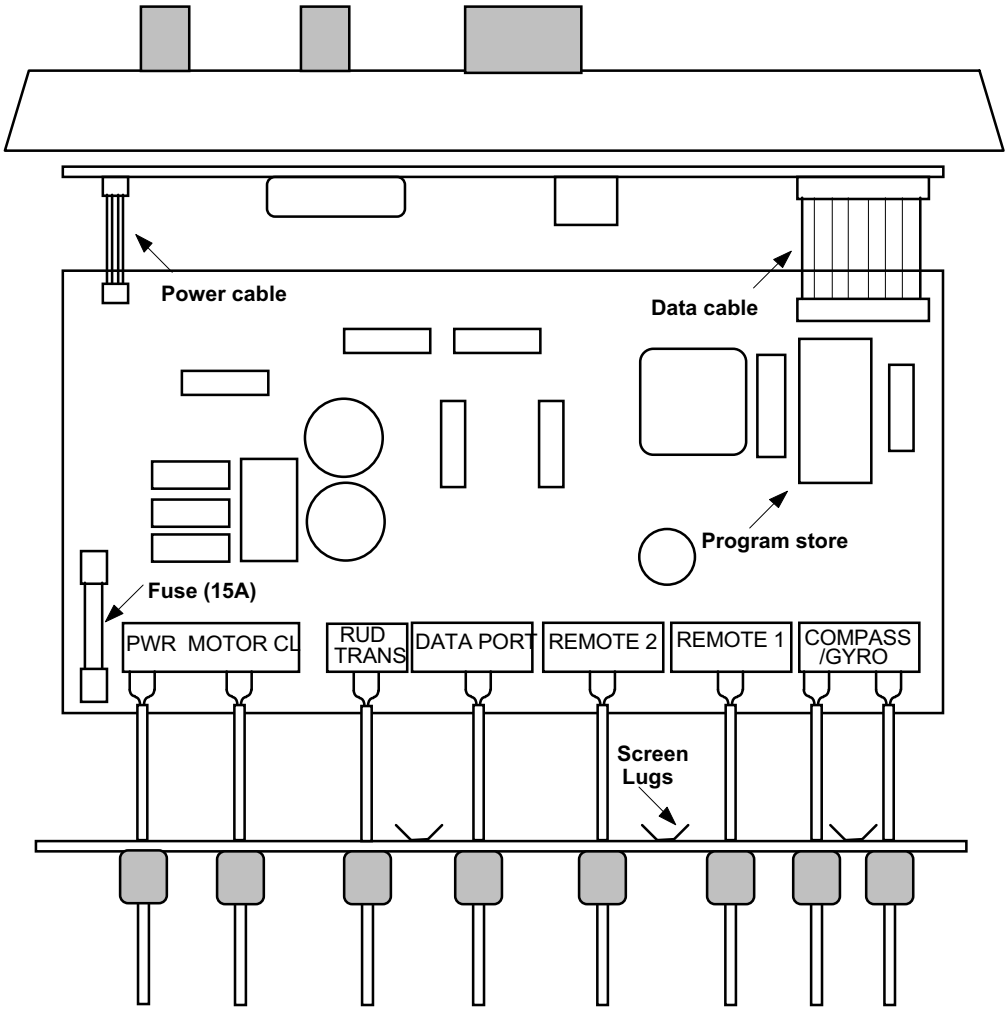



Figure 3.1 Exploded view of Central Controller.

Before commencing the wiring, remove the fuse from the left-hand side of the main circuit board. Note that all connections are made to removable plugs. Cables are fed through the cable gland closest to the appropriate socket. The screens of the compass, rudder transducer, gyro, NMEA data and remote cables are terminated in spade connectors which are mated with the lugs on the inside of the backplate.

The quality of the power supply to the Junction Box is important for reliable operation. Large voltage spikes caused by switching other electrical gear on the vessel, or the supply voltage moving outside the specified limits can cause the system to reset. These problems are reduced by using heavy wiring and connecting the system to a point as close as practical to the main batteries.

Lay a 20 amp twin-core cable to the vessel's supply, feeding it through the left-hand gland (viewed from the rear) and connecting it to the six-way heavy duty plug on the left. We recommend inserting a 20amp switch between the Controller and the power bus so that the CM650 can be isolated during unattended periods. Fig 3.2 shows the connections for both mechanical and hydraulic steering systems.

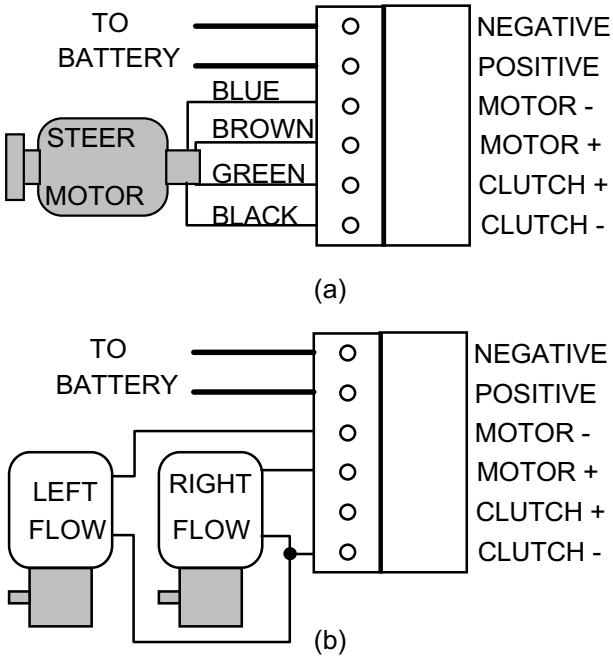



Figure 3.2 Power and steering connections for (a) mechanical and (b) hydraulic systems.

## 3.2 COMPASS

The performance of the compass affects the performance of the whole system and some care should be taken in locating it in the best position. The guidelines for this choice are as follows:

Ideally, the compass should be mounted at the roll centre of the vessel, at or slightly above the waterline. It should be at least 1 metre away from the engine and from other objects with strong magnetic fields such as loudspeakers and wiring which carries large currents. In timber, fibreglass or aluminium hulls, these conditions should be easily met. But in steel hulls, some trial and error may be needed to find the best position. Generally, the compass will not perform well if totally enclosed in a steel structure. Further notes on mounting in steel vessel are given below.

Mount the compass on the upper side of a horizontal surface so that its bracket is at right angles to the keel and the cable entry is on the port side. (The compass will not operate correctly if mounted upside down.) Corrections for small errors in orientation can be made as a programming option in the autopilot. Lay the cable back to the Controller, feed it through the right hand gland and connect it to the right-hand plug, terminating the screen on a spade connector. (Fig 3.3)

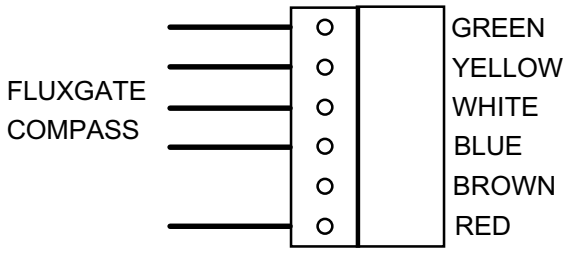



Figure 3.3 Compass socket connections.

**STEEL VESSELS**

Steel hulls distort the natural pattern of the earth's magnetic field. In many cases, these deviations can be adjusted out through the calibration procedures. In others, a strong vertical field component may exist which will prevent the compass giving good performance. We recommend that the compass be mounted temporarily so that the best site can be found by experimenting. The following notes should help find the best mounting:

1. In the first instance, try siting the compass unit below decks but centrally within the vessel. Keep well clear of vertical steel bulkheads and position the compass at least 45 cm (18 in) above a steel floor.

2. As an initial check, complete the other steps in the installation and turn the autopilot on to STANDBY. Turn the vessel through a full circle, noting at 45 deg. intervals the difference between the heading displayed and a reference (ship's) compass. (The Rate Gyro must be disabled during this operation.)

   Should the deviations exceed 30 deg in any position, keep re-siting the compass until a position giving less than 30 deg. error is found. If errors still exceed 30 deg.,the compass should be mounted above deck level, preferably in the dog house near a window. If this is done, repeat (2) above.

If no position is found giving less than 30 deg deviation, the services of a compass adjuster should be sought. The autopilot will not operate satisfactorily with compass deviations above 30 deg.

We recommend that a compass calibration (See Sec 2.4) be carried out after completing the installation.

## 3.3 RUDDER TRANSDUCER

Mount the rudder transducer next to the rudder post. The transducer should normally have its arm uppermost, but may be inverted if this is more convenient. The linkage schematic is shown in Fig 3.4. When fitting it is important that the effective lengths of the transducer arm and the quadrant or tiller arm (marked D1) be equal to each other and that the connector arm be the same length as the spacing between the transducer and rudder post (D2). This is to ensure that the transducer angle tracks the angle of the rudder. Mount the transducer so that its arm is over the cable entry point when the rudder is centred.

When carrying out the setup procedure (Sec 2.2) later on, it may be necessary to adjust the zero position of the transducer. To do this, loosen the clamp holding the transducer arm and rotate the shaft with a screwdriver until the reading is correct.

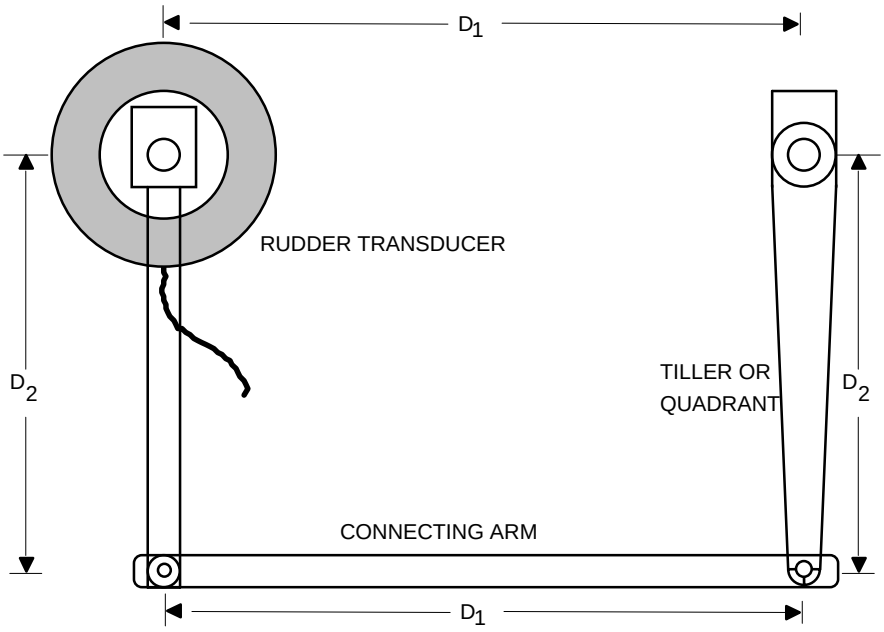



Figure 3.4 Rudder Transducer Linkage, Lay the cable back to the Controller and terminate it in the Rudder Transducer plug. (Fig 3.5)

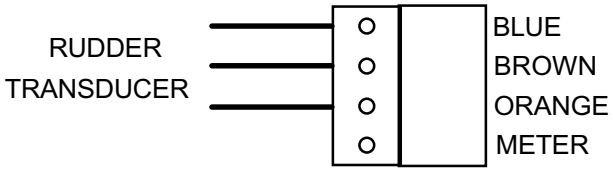



Figure 3.5 Rudder transducer connections.

## 3.4 ATTACHMENTS

### 3.4.1 REMOTE STEERING

The Junction Box has two Remote ports, with Remote 1 being used for a remote steering control or a jog-lever. Remote 2 can be used for a second remote steering control.

The remote steering options include: a hand-held unit with a cable (CM554) or a panel-mount unit (CM555). Both are fitted with a steering knob and a three-position switch (PILOT-STANDBY-HAND/REMOTE) and are connected as shown in Fig 3.6(a). A single remote unit should be connected REMOTE 1 socket.

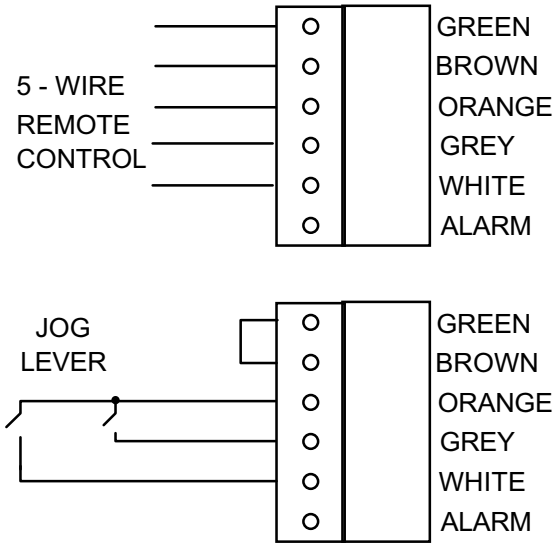



Figure 3.6 Port connections for remote steering.

When fitting a Jog Lever, the common wire goes to ORANGE on REMOTE 1 and the two switched wires go to WHITE and GREY. The BROWN terminal on the socket should be linked to the ground pin (GREEN). (Fig 3.6)

### 3.4.2 RATE GYRO

The Gyro is supplied in a similar housing to the fluxgate and should be mounted on a horizontal surface in an area free from engine vibration. Otherwise, no precautions are needed with respect to magnetic fields. The gyro has a three-wire cable which feeds through the second gland from the right and connects to the Compass socket using the marked colour codes. See Fig 3.7.

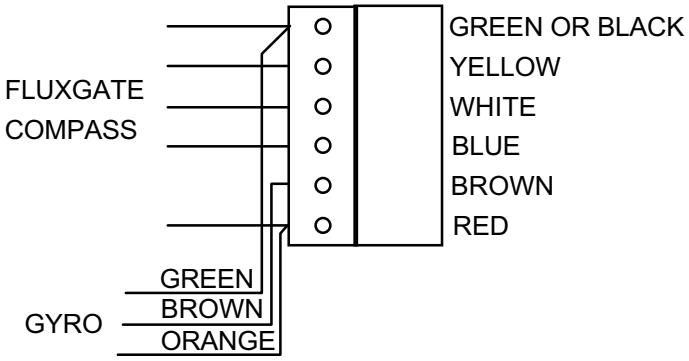



Figure 3.7 Rate gyro connections.

### 3.4.3 RUDDER ANGLE INDICATOR

The CM630 Rudder Angle indicator is a two-wire meter which is connected between the METER and ORANGE terminals of the Rudder Transducer socket in the Controller. (See Fig 3.5) . The polarity of the connection may be changed to obtain the correct direction of indication.

### 3.4.4 REMOTE ALARM

A piezoelectric beeper is available which repeats the internal alarm and key beeps of the Controller. This two-wire unit is connected between the ALARM (positive) and GREEN (negative) terminals of the REMOTE 1 socket. (See Fig 3.6) Any beeper may be used which is compatible with the drive available of 35mA (max) at 10.5V dc.

### 3.4.5 NAVIGATION INTERFACE

The Junction Box has a socket which provides two input ports and one output porttion for a data cable using RS232 or RS422 signal levels. The data cable is normally connected to a navigation system and/or cockpit display instruments which use the NMEA 0183 standard. There is one pair of output terminals at the centre of the socket. If there is one input source, it should be connected to Port A. Port B may be used for a second source of navigation data. The legend is shown in Fig 3.8 below.

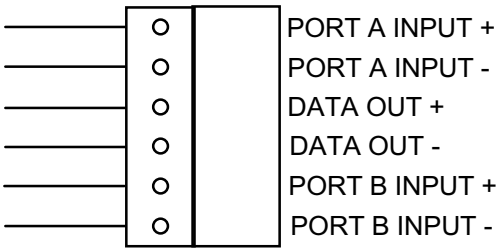



Figure 3.8 Data Port connections.

**INTERFACE CONNECTIONS**

The screened data cable is connected to the input and output terminals on the NMEA socket. The correct polarities are as follows: when the external NMEA system is transmitting, the wire which goes positive is connected to the + terminal of the input pair.

After the connection is made, complete the other parts of the installation before checking for correct reception.

Turn the system on and press the MODE key. The display may now show:

**WAITING FOR DATA**

and may remain for up to 15 sec. If it stays longer, there is some fault with the interface. Try reversing the input wires. Then check that the NMEA device has also been set up correctly. If it is a GPS receiver, the message being sent will be read as invalid if the GPS has not acquired the required number of satellites.

The NMEA output port sends two alternating sentences, VHW and HDM, both containing the current heading.

## 3.5 STEERING DRIVE

Four options are covered in this section: electric motor drive to mechanical steering, coupling into a motor-drive hydraulic system, coupling into a solenoid-controlled hydraulic system and a hydraulic linear drive. For existing hydraulic systems using a helm pump, instructions are given below for adding a Coursemaster/Hydrive pump motor. But for systems supplied by other manufacturers, installers should consult the data supplied by the manufacturer.

Through the wide variety of possible drive systems and the load placed on them, the goal is to move the rudder from one limit to the other in not more than 15 sec. and not less than 8 sec. Steering systems which perform outside these limits may not give satisfactory autopilot operation.

### 3.5.1 CHAIN DRIVEN MECHANICAL

The drive sprocket on the steering motor matches 12.7mm (1/2 inch) British Standard simple chain. The size of the driven sprocket on the steering wheel should be chosen from Table 3.1 below. Alternatively, the sprocket may be mounted on an intermediate shaft in the steering system, in which case the figures below apply to that shaft.

**TABLE 3.1**

| Helm Ratio<br>Total turns<br>+25 to -25 deg | 12V system<br>Light* | <br>Medium* | 24V system<br>Light* | <br>Medium* |
|---|---|---|---|---|
| | Driven Sprocket Size (teeth) | | | |
| 1 | 45 | 45 | 60 | 60 |
| 2 | 38 | 45 | 50 | 50 |
| 3 | 30 | 38 | 45 | 50 |
| 4 | 25 | 38 | 38 | 50 |
| 5 | 20 | 25 | 25 | 38 |
| 6 | 20 | 25 | 25 | 38 |

**NOTE:** Medium stiffness corresponds to a torque of 240 kg-cm (20ft-lb) measured at the shaft carrying the driven sprocket.

Mount the drive unit so that its shaft is parallel to the driven shaft and the two sprockets are in line. After fitting the chain and adjusting its tension, there should be 12mm of deflection for each metre length of chain. (1/2" for each 3 ft.) Lay the four-core motor/clutch cable back to the Controller and terminate it according to the legend in Figure 3.2(a) above.

### 3.4.2. SOLENOID CONTROLLED HYDRAULICS

The motor-drive output of the Junction Box is suitable for direct connection to flow-control solenoids, provided that their operating voltage is the same as the supply voltage to the CM650 and the solenoid current does not exceed 10A. The connections to the Junction Box are shown below in Fig 3.2(b).

IMPORTANT: Before connecting the solenoids, make sure that their wiring is not connected to ground or any other part of the vessel's wiring.

### 3.4.3 HYDRAULIC SYSTEM WITH OCTOPUS PUMP

Connecting autopilot pumps to hydraulic systems from different manufacturers is not difficult and the following guidelines will be adequate for most installations. If there is a doubt about the correct way to proceed, consult the manufacturer of the steering gear. Electrically, the pump is connected as for a mechanical steering motor (Fig 3.2(a))

**CONNECTIONS**

Connections between the pump and the system should be made with three 50 cm. lengths of 1/4 inch fabric braided rubber hose, type SAE 100R3. Use of other types of hose, such as nylon or steel braid construction may make the system noisy, since the SAE 100R3 hose acts as a filter for pump pulses.

The following installation schematics show an OPTIONAL LOCK VALVE. Though this is not essential for the normal operation of the system, it is an additional safeguard in the unlikely event of the failure of the octopus pump. This valve isolates the system into two completely independent sources of steering power and can be supplied by your Coursemaster agent, if required.

**TWO-LINE STEERING SYSTEMS**

Two-line systems are by far the most common and are manufactured by many companies world-wide. The best known types include Flexatrol, Hydrive, Marol, Morse, Palm Beach, Seastar, Seipem, Servis, Tenfjord, Teleflex, Vetus, Wills Ridley and Wagner.

Some two-line systems are supplied with a lock valve as part of the helm pump and no additional lock valve needs to be purchased. But the lock valve is an option on, for example, Hydrive and Vetus system. It must be used on Syten outboard systems. If a lock valve is not installed, it must be fitted as shown in Fig 3.9.

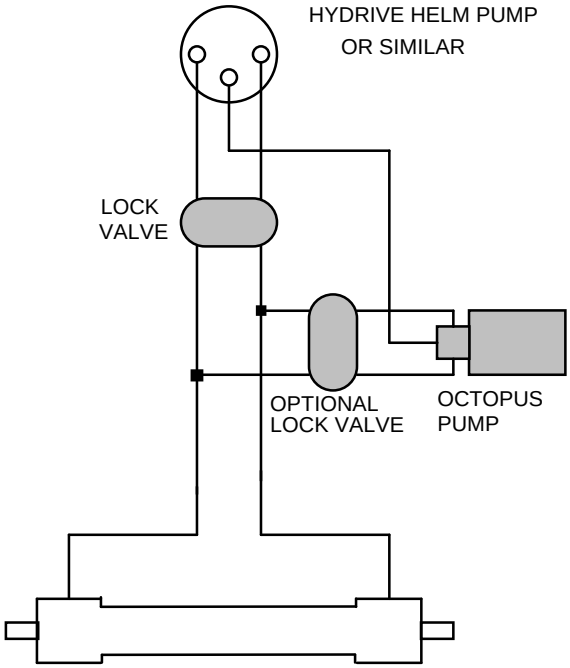
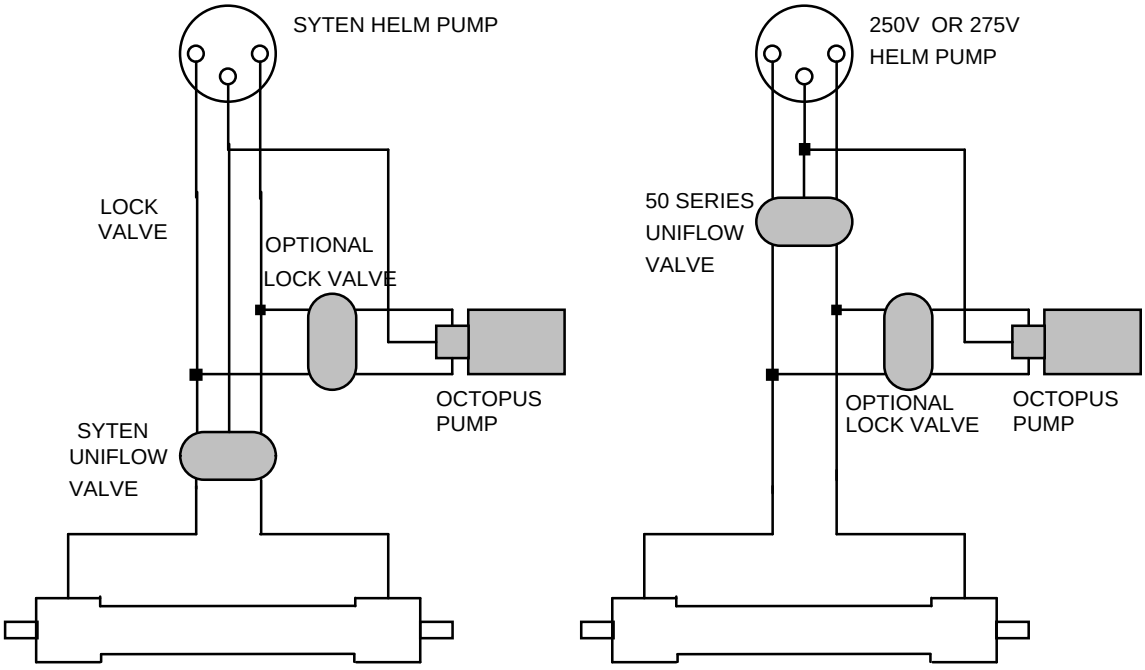



Figure 3.9 Connection to a typical two-line system

**THREE-LINE SYSTEMS**

Teleflex Canada Ltd. manufacture some 3-line hydraulic systems using a "Uniflow" valve. Two types of valve are produced: the 50-series in aluminium or bronze and the Syten in plastic. Connection of the Octopus pump to such systems is illustrated in Figs 3.10(a) and (b).




(a) (b)

Figure 3.10. Alternative connections to a three-line system.

**PRESSURISED SYSTEMS**

Hynautic and Teleflex Canada (220 series) both make systems in which the oil in the system is pressurised with air. Connection to the Hynautic system is illustrated in Fig. 3.11(a) and to the Teleflex 220 in Fig 3.11(b). Note that if the Octopus pump is run in a system with the air pressure significantly above the manufacturer's recommendation, the life of the motor shaft seals may be reduced.

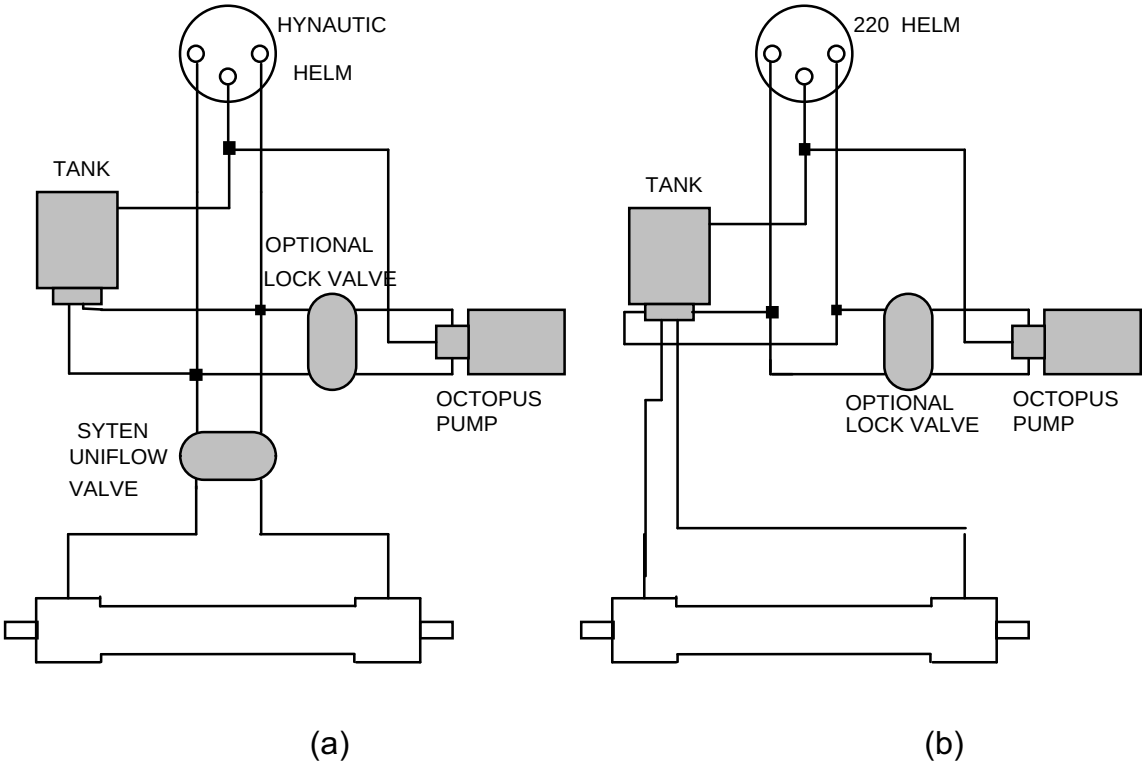



Figure 3.11 Connection to pressurised systems:
(a) Hynautic and (b)Teleflex 220

**PROCEDURE**

1. Install the pump according to the hydraulic connection instructions, mounting it close to the tubes connecting the helm pump and cylinder. The pump must be mounted with its rubber foot horizontal.

2. Connect the pump to the system tubing using hose and tubing which is rated for the steering system pressures as specified by the manufacturer. Short lengths of reinforced high pressure hose should be used to isolate mechanically the Octopus pump from the rigid tubes of the system, as this reduces noise and vibration. The bleed line should not be too narrow as the system may be difficult to purge and may cavitate. Avoid air traps by sloping the pipes upwards from the drive unit.

3. Make sure that there is no foreign matter, such as swarf, in the lines as this may foul the valves and pump. Similarly, thread sealant should be carefully applied well back from the end of the thread.

   **Teflon tape should not be used.**

4. Secure the pipes where necessary to avoid 'pipe whip', since sustained mechanical vibration in the pipes can cause hardening and cracking of the copper.

5. Never install a drive unit without the third (balance) pipe, since the internal pressure build-up could destroy the seals in the pump.

6. Using a short length of 4mm cable, connect the two pump wires to the Motor terminals in the CM650 Controller noting that no connection is made to the clutch drive in this type of installation. The polarity of the connection is not important.

7. Fill both the steering system and the pump completely with hydraulic fluid and bleed the hand steering components according to the instructions supplied by the manufacturer.

8. After this bleeding operation, leave the reservoir in the helm open and keep it topped up with fluid. Open the bleeder nipple(s) in the slave cylinder. Run the drive pump in one direction by temporarily removing the drive wires and connecting them directly to the battery. Allow the motor to run for 2 or 3 minutes to purge air through cylinder lines and help to clear the balance line of air. Under no circumstances allow the oil level to drop in the manual hydraulic helm units - this level must be maintained at all times during the bleeding of the pilot unit.

9. When step 8 has been successful, run the motor in the opposite direction so that both sides of the system are purged. Keep the helm pump reservoir topped up during this operation.

10. When both sides of the autopilot pump system have been bled, repeat the bleed of the drive unit once again, top up the reservoirs, close them and close the bleed nipples. Re-connect the pump wires to the Junction Box. The system is now ready for the setup procedure.

**PUMP OUTPUT ADJUSTMENT**

The Octopus pump has a flow rate adjustment which can be altered to obtain the correct rudder response time of 8 seconds limit-to-limit for planing vessels and 12 seconds for displacement vessels and yachts. To adjust the flow rate, loosen the two screws located on the pump body sufficiently to allow it to be rotated. (If they are loosened too far, oil will be lost.) Rotate the pump body clockwise to decrease the flow or anticlockwise to increase it.

**PUMP MAINTENANCE**

The Octopus pump has a minimum of moving parts and should give hundreds of hours of service without requiring attention. If it fails to run, check first that it is receiving the correct drive voltage from the CM650 Junction Box. Next, ensure that the pump shaft is not jammed by turning it with a screwdriver in the slotted end of the shaft. If it turns freely and still fails to run, check the motor brush gear.

If the pump runs but does not pump oil, make sure that the system is purged. If that does not succeed, contact your Coursemaster dealer.

### 3.5.4 HYDRAULIC LINEAR DRIVE

It is vital that the cylinder is installed with the correct geometry. The final position of the mounting bracket is ascertained with the piston rod at the middle of its stroke. (Use a ruler to set this position.) With the rudder dead centre and the piston rod at right angles to the quadrant, mark the position of the bracket and fix it using four stainless steel bolts with locknuts or lock-washers.

The recommended distances from the attachment pin to the centre of the rudder-stock are:

| Ram Type | Stroke (mm) | Distance to rudder stock(mm) |
|---|---|---|
| 216 | 200 | 175 - 200 (7 - 8") |
| 216 | 310 | 225 - 300 (9 - 12") |
| 314 | | 200 - 250 (8 - 10") |

1. Mount the hydraulic pump close to the cylinder on a horizontal surface. Remove the plastic reservoir cap and replace it with the vented aluminium cap.

2 Ensure that the rudder stops are installed to prevent the cylinder hitting the end of its travel.

3. There are 4 wires on the pump: two for the motor and two for the solenoid bypass valve. When not in PILOT, the bypass valve permits oil to bypass the pump and flow back to the cylinder. Connect the orange and black motor wires to the motor terminals in the Junction Box, using at least 20 amp cable. Connect the two red solenoid wires to the clutch terminals in the Junction Box. Polarity is not important.

4. The cylinder has been bled before shipping. Check the oil level in the pump and, if necessary, top up with automatic transmission fluid.

5. Go to Step 8 in the step-by-step guide at the beginning of the chapter and complete the steps.

6. The hydraulic pump has a flow-rate adjustment which should be set to give a response time of 8 - 10 seconds limit-to-limit for yachts less than 40 feet and 10 -12 seconds for vessels above 40 feet. To adjust, loosen the two screws on the pump body just enough to allow it to be rotated. Rotate the body clockwise to decrease the flow or anticlockwise to increase it.

7. Bleeding. If it becomes necessary to re-bleed the system, carry out the following:

   (a) Fill the reservoir with automatic transmission fluid.
   (b) Locate the two brass bypass screws, one on each side of the solenoid and loosen both 3 - 4 turns.
   (c) Disconnect the red solenoid wires from the autopilot and apply power directly to the solenoid.
   (d) Move the piston through its full stroke, one way, then the other. Any air in the system will bubble into the reservoir. Refill the cylinder and repeat until all air has been purged from the system.
   (e) Re-tighten the bypass screws and reconnect the red solenoid wires.

**MAINTENANCE**

Check the oil level in the pump at regular intervals. Grease the mounting bracket every 3 months using waterproof grease.

# CHAPTER 4 TROUBLE-SHOOTING

## 4.1 ERROR MESSAGES

The CM650 is programmed to provide a number of messages on its display when a fault occurs. Some of these are warnings arising out of the way the autopilot is being used. Others mean that a real problem has developed. They are listed alphabetically below and users are advised to read through the list so that they know which ones call for action. After each message is given the direct condition which triggers the message, the response of the CM650 to the condition and a list of possible causes. By using this as an aid, many problems can be fixed simply by the owner. If the assistance of a Coursemaster agent is required, quoting the error message will expedite repairs.

**COMPASS FAULT**

The heading signals from the fluxgate are above or below the preset limits. The fault must last more than 12 seconds before this alarm becomes active. This prevents a false alarm from being triggered, for example by the fields in a rolling steel vessel. The message can only be cleared by the MODE key if the fault is corrected.

**Causes.**

If the error comes up on all headings and cannot be cancelled, the possible causes are a defective connection or cable to the fluxgate, or a defective fluxgate unit. If the message comes up only on some headings, the probable cause is the magnetic environment of the compass - either an excessive horizontal field or vertical field due to local magnetic material. In this case, consult the guidelines in Chap 3.

**DRIVE OVERLOAD**

The system is in PILOT or one of the power steer modes and the motor drive current has exceeded 15A for 1 second. The system is forced into STANDBY and the message can only be cleared by pressing the STANDBY key after the overcurrent condition is removed.

**Causes.**

The fault can occur if the mechanical drive or hydraulic pump motor has stalled or jammed. Otherwise, look for a short-circuit in the drive-motor wiring. The fault can also indicate damage to the vessel's steering gear.

**HELM ALERT**

This is only a warning. If the alarm is selected, a timer is started in the system, when in autopilot, which brings up this message and an alarm tone every 5 or 10 minutes. The condition does no affect autopilot operation and is cancelled by the MODE key.

**OFF COURSE**

The system is in autopilot and the vessel has been more than 8 deg. off course for 12 seconds. This alarm does not affect the normal operation of the pilot. It cancels itself when the vessel returns to course or may be reset by the MODE key or switching the system out of PILOT. During a turn, an extra delay is inserted in this function so that it does not come up prematurely.

**RUDDER OVER-RANGE**

The rudder transducer output is above or below the allowed range. This alarm forces the system into STANDBY and may only be cancelled by pressing the STANDBY key after the condition has been removed.

**Causes.**

This alarm comes up if the rudder angle exceeds 33 deg. in the autopilot or remote steer modes, or 60 deg. in the STANDBY mode. If those conditions have not occurred, the causes are probably in the rudder transducer cable, connections, mechanical linkage or in the transducer itself. A further condition which can cause the alarm to appear is if the transducer is off-centre by more than 10 deg. and wide limits have been set.

## 4.2 OTHER FAULTS

If there are large voltage spikes on the power supply, these can sometimes cause the system to reset and revert to STANDBY without an error message appearing. If this happens frequently, consult your dealer about measures to filter the supply.

If the system will not switch on, a more direct investigation is required. With a voltmeter, check that the correct voltage is applied to the two power terminals and that the polarity is not reversed. A voltage above 6V should also appear on the yellow and blue Controller leads when the system is off. If these conditions are correct, disconnect all cables except the power input and Controller and try to switch on. If the self-test message now appears, the fault is in one of the attachments.

If these tests do not reveal the problem, another possibility is that the program store (EPROM) has not been fitted correctly and that a pin is bent or broken. If that is not the problem, a service call is required.

# CHAPTER 5 SYSTEM SPECIFICATIONS

## 5.1 AUTOPILOT

| | |
|---|---|
| Supply Voltage | 11 to 26V dc |
| Supply Current | |
| Basic system in STANDBY | 0.33A |
| In Pilot with 20% duty | 2.5A |
| Compass | Fluxgate in floating suspension |
| Typical deviation | 2.5 deg rms. |
| Rudder Transducer | Potentiometer type |
| Rudder position accuracy | 1 deg. |
| Max rudder angle | +/- 32 deg. |
| Clutch drive (12V supply) | 11V at 1A max |
| Steering Drive | |
| Output for 12V supply | 12V at rated load |
| | 12A internal current limit |
| Output for 24V supply | 22V at rated load |
| | 9A internal current limit |
| Minimum effective load resistance (continuous) | 0.8 ohm at 12V |
| | 2.0 ohm at 24V |
| Mechanical drive steering motor | Printed rotor with gearbox and electromechanical clutch |
| Torque | 12V unit: 120kg-cm at 30 rpm. |
| | 24V unit: 180kg-cm at 30 rpm. |
| Hydraulic drive systems | See manufacturers' specs. |
| Recommended response times: | |
| Displacement vessels | |
| < 12 m | 8 sec limit-to-limit |
| > 12 m | 10 - 12 sec. limit-to-limit. |
| Planing hulls | 8 sec. limit-to-limit |

## 5.2 NAVIGATION INTERFACE

NMEA PORTS

Serial data format:

| | |
|---|---|
| Baud Rate | 4800 |
| Character format: | start bit |
| | 8 data bits, LSB first |
| | MSB (bit 7) = 0 |
| | no parity bit |
| | 1 or 2 stop bits |
| Polarity | |
| Idle, stop bit,logic'1' | Line A < 0.5V above line B. |
| Start bit, logic '0' | Line A > 4V above Line B. |

| | |
|---|---|
| Input PORT | Isolated via optocoupler |
| Input resistance | 1000 ohm min. |
| Input Sentences | Automatic selection from: |
| | RMB, RMC, APB, APA, GLL, |
| | BOD, XTE. |

Output Port :

Speed and Heading

$APVHW,,T,DDD,M,00.00,N,,K<CR><LF>

and $IIHDM,,T,DDD,M,00.00,N,,K<CR><LF>

The above pair of messages alternate as standard and are not selectable from the Controller.

# CHAPTER 6 MAINTENANCE AND WARRANTY

## 6.1 MAINTENANCE

The only parts of the CM650 requiring maintenance are the mechanical components of the steering gear. Chain drives and the rudder transducer linkage (but not the transducer itself) should be oiled every 200 hours of operation. The steel drive sprockets should be lightly smeared with grease to inhibit corrosion.

**CAUTION**: Lubricate the clutch very sparingly, using a very light oil.

For hydraulic systems, follow the maintenance instructions supplied with the system.

Great care has been taken in the selection and sealing of materials in the system to minimise the risk of corrosion. If, however, the controller or any other component is accidentally immersed in water, it should be drained immediately and returned promptly to your Coursemaster agent for cleaning and rectification.

## 6.2 SOFTWARE UPGRADES

If a software upgrade is supplied by Coursemaster, it may be installed by an owner who is skilled in working on electronic equipment. The procedure is:

Remove the backplate of the Controller and disconnect all cables. Remove the four screws holding the black plastic trim to the front of the case and pull the the front panel assembly forward from the case until the two internal cables are accessible. Unplug both cables from the main board and set the front panel to one side.

Remove the four screws holding the main board in the case and remove the board. (In some models, the front mounting screws are a different size from the rear screws.) Referring to the internal layout diagram in Fig 3.1, locate the EEPROM package holding the system software. Using a screwdiver between the package and its socket, gently lever it up and unplug it. Insert the new package with the Pin 1 notch towards the front of the board and press into place. Check that no pins are bent or have failed to make contact with the socket.
Re-assemble the unit by reversing the above procedure.

## 6.3 WARRANTY

Coursemaster Autopilots Pty. Ltd. is committed to the principles of product support and customer satisfaction. It warrants its autopilots and accessories against defective materials and workmanship for a period of twelve months (six months in the case of commercial applications) from the date of installation, provided that the total period does not exceed eighteen months from the date of shipment from Coursemaster Autopilots.

Parts exhibiting defective material or workmanship will be repaired or replaced at our option without charge to the first owner for the duration of the warranty, provided that they are returned to our factory at the owner's cost and risk.

Coursemaster Autopilots Pty. Ltd. shall not be liable for any expenses or for any direct or consequential damage caused by defects, failure or malfunction of their autopilots or accessories whether a claim is based on a warranty contract, tort or otherwise.