COURSEMASTER

AUTOPILOTS

ustralia's world leader in autopilot technology

CM650 OWNER'S MANUAL

Series 2

06-03

CM650 OWNER'S MANUAL

Series 2

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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Third Edition

The information in this manual applies to CM650 Series 2 systems with software versions 2.20 or higher. The Fluxgate Compass, Compass Slave and Rate Gyro have been upgraded and the new versions are described.

OPERATING SUMMARY

- Install and check the system as described in Chapter 3.
- Turn the main switch to STANDBY to turn the system on.
- Steer to the desired course and turn the main switch to PILOT.
- Use the course knob to change course and the arrow keys to trim the course.
- To steer a course set by a GPS system, turn the main switch to NAV.
- Use the sea state knob to select the type of control and rudder factor knob to adjust the strength of the helm response.

CM650 OWNER'S MANUAL

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CHAPTER 1 SYSTEM DESCRIPTION

1.1 INTRODUCTION TO AUTPILOTS

The main job of a marine autopilot is to hold the heading of a vessel on a reference course, which is held in the memory of the autopilot. When it is operating, the autopilot continuously compares the vessel's heading with a reference course and, if they are different, it applies helm to bring the vessel back on course. Since there has to be a compromise between the accuracy of course holding and the activity of the rudder, the autopilot has controls which let the user set the balance between these two factors.

The four basic components of an autopilot are a compass, an electronic control box, a rudder angle sensor (transducer) and the steering drive. See Fig 1.1.

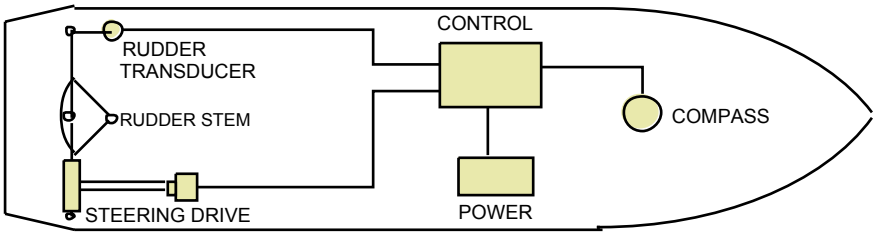


Figure 1.1 Basic components of a marine autopilot.

Modern autopilots perform other functions as well and this introduction explains how these fit in with the basic function and how they provide a wider range of options for the user.

1.1.1 THE REFERENCE COURSE

When the autopilot is first turned on, it rests in an idle (STANDBY) state in which it displays the heading, but does not steer the vessel. It is activated by switching it into the PILOT state. At the moment this is done, the current heading is put into memory as the reference course and the autopilot starts steering to hold the heading on this reference course. The user can change the reference course at any time and the heading will swing round to match the new course.

There are two other ways of setting the reference course. If the autopilot is connected to a GPS navigation receiver, the heading is then controlled to place the vessel on a direct track between the origin waypoint and the next waypoint. The third option may be used on yachts fitted with a compatible wind-sensing instrument. In this case, the reference course adjusts itself to maintain a constant relative angle to the wind.

1.1.2 STEERING CONTROL

When the vessel swings off course or the reference course is changed, the autopilot should apply helm in a way which brings the vessel onto course quickly, but without overshooting the reference course. The correct rudder angle depends on the amount of the error, the speed of the vessel, its size and the effectiveness of its rudder. This choice is managed by two adjustments which the user can make and are described below.

Rudder Factor

The sensitivity or RUDDER FACTOR sets how many degrees of helm are applied for a given course error. A mid-range rudder factor setting applies half a degree of helm for each degree off course. In large, or slow vessels, it would be more and in light fast boats it may be less.

Setting the rudder factor too high cam cause oversteering or ‘snaking’ as illustrated in Fig 1.2. Too low a setting causes understeer and a sluggish response. Fortunately, most vessels tolerate a range of settings and still steer well.

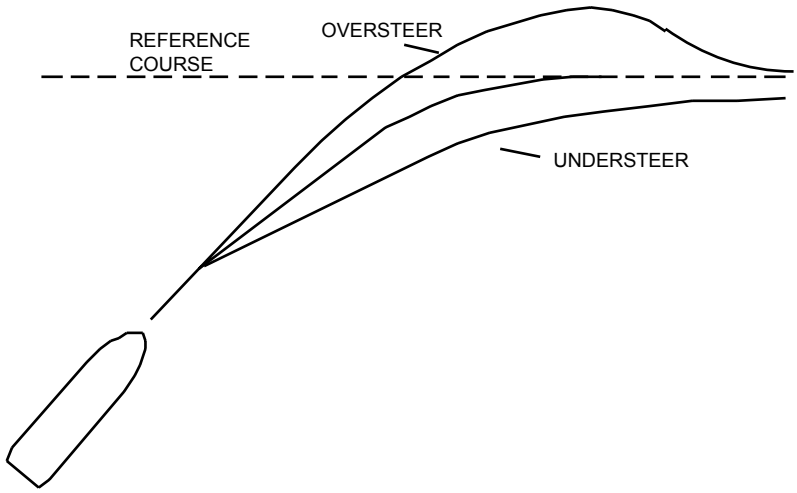


Figure 1.2. Illustration of oversteer if the rudder factor is set too high and understeer if it is set too low.

Sea State

The SEA STATE setting adjusts the kind of control according to the sea conditions and the weight of the vessel. The NORMAL setting simply applies helm in proportion to the course error. The ROUGH mode is used when the vessel rolls and yaws in a heavy sea. Rudder activity is quietened down by not reacting to small heading shifts. But full control is applied as the shift becomes larger. The RATE mode is intended for vessels whose helm response is slow and/or continue to turn for some time after helm is removed. In this mode, normal helm is applied to start the vessel turning. As the turn rate builds up, the helm is backed off. When the vessel is close to the reference course, reverse helm or counter-rudder is applied to stop the turn.

The action of the RATE mode during a turn is illustrated in Fig 1.3. Generally, vessels in the RATE mode hold a course better but change course more slowly. This mode also improves control for most vessels operating in a following sea.

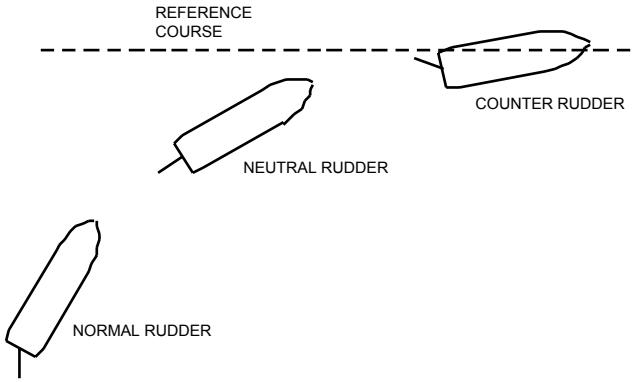


Figure 1.3 Rudder action during a turn in the RATE mode.

Autotrim

Vessels often show a steering bias or offset, which can be due to weather, propeller torque or towing a load off-centre. The autopilot responds to this by progressively trimming the centre position of the rudder until the average heading of the vessel equals the reference course.

1.1.3 POWER STEERING

Since the autopilot controls a power steering system, options are available to use this, via the control panel or a remote control, to steer the vessel by hand while away from the main wheel. This can be done by a hand-held device on a cable or a permanently mounted second steering station.

1.1.4 OPTIONS

The autopilot commonly uses a fluxgate compass for its heading measurement. Such compasses, though effective, suffer from acceleration errors and a very effective way to reduce these errors is to combine a fluxgate with a rate-of-turn gyro. A further option is to fit a pickup device (slave) on the ship's compass and take advantage of its dynamic performance and the fact that it has been magnetically compensated. This version of the CM650 also offers the option of using a digital heading input from a ship's gyro or other

electronic heading sensor. The autopilot has built-in facilities for automatic or manual compass calibration.

When connected into an NMEA data system, the autopilot can receive navigation data, as mentioned above or wind direction data. Some of this data, which is not used for autopilot operation, is displayed on the autopilot screen for convenience. There are two digital data input ports and the system automatically reads data from both. The autopilot generates output data containing the current heading, which can be fed into a plotter or radar system.

Autopilots intended for yacht use have an automatic tacking feature which is useful for single-handed sailing.

1.1.5 WORKING WITH OTHER EQUIPMENT

The physical and electrical environment in a boat can be harsh. This autopilot has been engineered with this in mind and tolerates poorly regulated power supplies, overloaded steering, radio transmitters, radars and the like. Conversely, it has also been engineered to operate without causing interference to radio receivers and other communications equipment. Coursemaster autopilots carry a CE mark to indicate compliance with the relevant EMC standards. The installation sections of this manual have been carefully developed to minimise problems when the autopilot in this environment. Please study and follow them!

1.2 THE CM650 SYSTEM

The full system, with its optional attachments, is shown in Fig 1.4. The core system components are shown with shading.

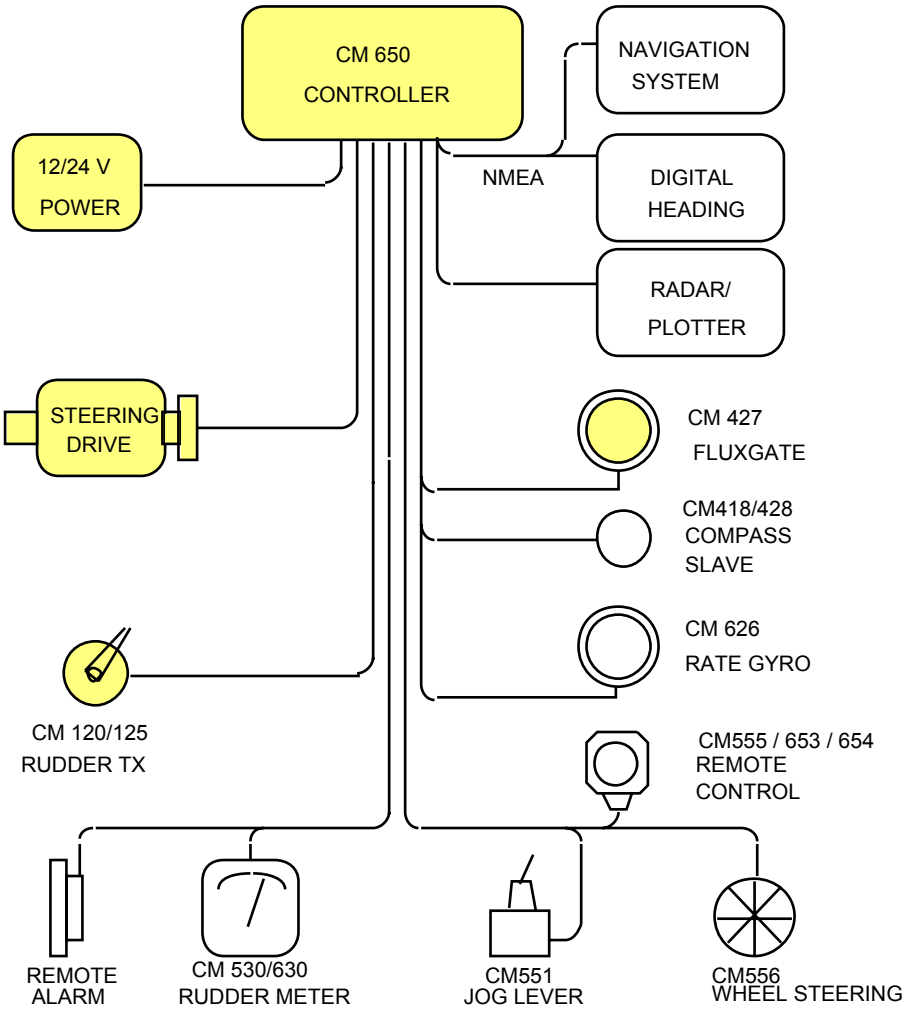


Figure 1.4 System Configuration, showing standard and optional attachments.

CM650 Controller - Series 2

The Controller contains the control microcomputer, control panel, interfaces with other system components and the steering drive electronics. All system cables are terminated in the Controller. The drive system is robust and is designed to drive mechanical, hydraulic pump and solenoid controlled steering systems.

The front panel has four knobs for the main controls and three push-buttons to select and adjust other functions. An LCD display shows information on the current operation of the autopilot.

Compass

The system normally uses a CM427 electronic fluxgate compass to measure the heading, but this may be replaced by a CM418 or CM428 compass follower which is 'slaved' to the ship's compass.

Rudder Transducer

The standard rudder transducer is a CM120, which is suitable for recreational vessels. For commercial vessels, the heavy-duty CM125 is recommended. Both are fully sealed potentiometer types and are interchangeable.

Steering Drive

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

1.3 OPTIONAL ATTACHMENTS

CM626 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

A number of remote steering options are available. The CM654 is a hand-held unit with a cable and the CM555 is a panel-mount version of the 654. Both are fitted with a steering knob and a three-position switch (PILOT-STANDBY-HAND/REMOTE). The CM653 is a cable-connected remote without a switch. It comes into service automatically whenever the knob is turned away from the centre position.

The CM551 is a panel-mounted Jog Lever and the CM556 is heavy-duty steering wheel hub suitable for a full power-steer second station. Finally, a mode switch to switch between STANDBY and PILOT is available as a CM553.

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. It is available in two versions: CM530 and CM630.

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 Controller (Fig 2.1) contains a text and graphics display, three course error lamps, the main 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.

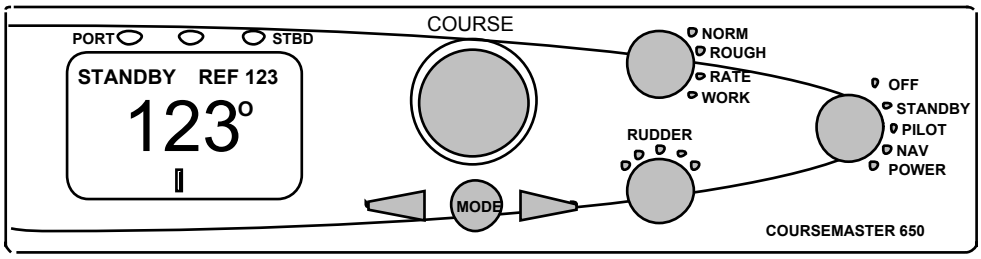


Figure 2.1 The Control Panel

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 auto-navigate 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 MAIN 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 trim the reference course when in pilot mode or to adjust system settings when the menus are displayed.

MODE

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

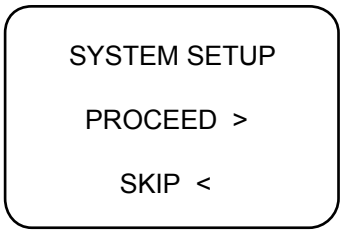
COURSE LAMPS

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.)

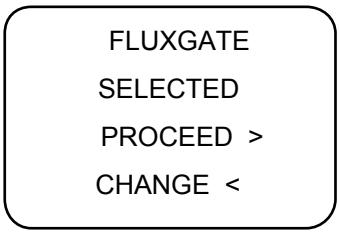
To switch on for the first time, turn the power switch to STANDBY. The system enters a special mode to ensure that the steering drive and rudder transducer have been phased correctly. After the SELF TEST display, the screen will show:

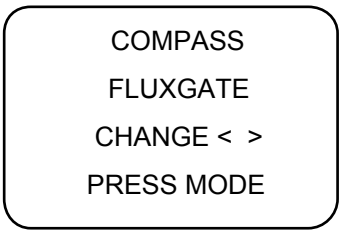


There are two choices. If you wish to examine some of the autopilot features without carrying out the setup, press the LEFT ARROW. This will bypass the setup and will permit various displays to be examined. However, the system will not switch into PILOT.

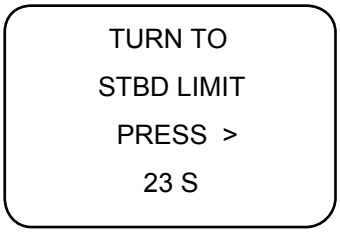
To carry out the setup, follow these steps:

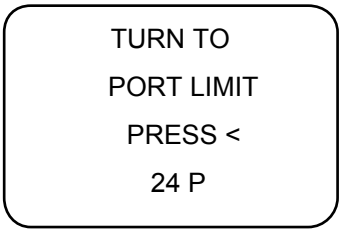
1. Press the RIGHT ARROW key. The display shown below on the left appears and allows you to select a digital heading input if desired. The 'fluxgate' option also applies to a compass slave. Press the right arrow to keep this selection or the left arrow to change it. In the latter case, the display below on the right appears and lets you choose between an HDG or an HDT digital heading sentence. After selecting the heading input, press the mode key.





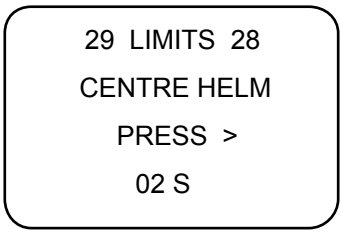
2. The next two prompts are for storing the mechanical rudder limit positions and the rudder transducer phasing in the autopilot memory. The stored limits are set 4 degrees inside the actual stop positions and this ensures that no autopilot operations will push the steering drive right to the stops.





Turn the helm to starboard until it reaches the mechanical stop. The last line of the screen shows the helm angle. If it reads PORT instead of starboard, this will be corrected automatically when you press the right arrow key. Now press the right arrow key. Note that if the helm angle is less than 10 degrees at the stop, the system will not respond. After pressing the right arrow, the port limit prompt appears. Now turn the helm to port until it reaches the mechanical stop. At this

stage, the helm direction will read correctly. Press the left arrow and the final prompt appears:



The top line shows the stored values of the port and starboard rudder limits. Check that these are close to what you expect and are balanced within 5 degrees. Bring the helm to the position which your experience shows to be centred - the indicated angle may now be different from zero. Press the right arrow.

> **Warning:** This action will start the steering drive. Make sure that it is safe to do so before pressing the right arrow.

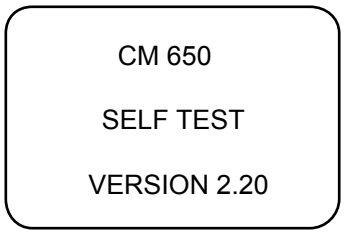
Three things now happen. The current helm position is now placed in memory at the helm centre, the helm then moves to 10 deg port, pauses and then returns to centre. This operation corrects any small alignment errors in the rudder transducer, stores the correct drive phasing and completes the setup operation, returning the system to STANDBY.

Note that if the helm is not centred within 5 degrees, an 'Off Centre' alarm will occur and the setup will not continue. Re-centre the helm by adjusting the rudder transducer. Later, when the vessel is at cruising speed, it is recommended that the HELM ADJUST option be used to fine-tune the helm centre. (Sec 2.5).

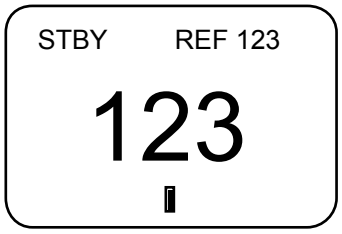
If a digital heading was selected and no data is coming in, the NO HDG DATA alarm will now appear. The beeper will become silent after 10 seconds and this alarm can be ignored until the autopilot is to be used.

2.3 NORMAL OPERATION

SWITCHING ON Turn the power switch to STANDBY. The system does a self-test for 6 seconds and displays the version number of the software installed, eg:

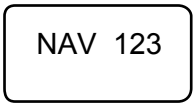


When the self-test is complete the normal STANDBY display appears and shows the current heading of the vessel.

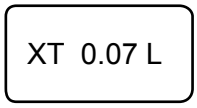


AUTOPILOT With the system in STANDBY, steer the vessel to the desired heading and turn the switch to PILOT. The autopilot will now lock onto that heading and maintain it. The display will show 'PILOT' in the top left corner.

AUTONAV If a GPS receiver or other source of navigation data is connected, the vessel can be steered to head towards a waypoint with a 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.



If the cross-track 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.



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

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 over-steering and may make the vessel 'snake' from side to side around the programmed course.

If the Hull Size is set to 2 (See Menu 3), the effect of the Rudder Factor is doubled, to suit vessels above 20 m.

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 in 5 degree steps for each click in the knob position. For fine adjustments in 1 degree steps, press the left or right arrow keys. The top right hand corner of the display shows the new reference course.

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. In this mode, hand-steer the vessel so that it is steering dead ahead. Then switch to pilot. The current helm position is now stored as the new helm centre and The basic control is as for RATE, but the helm centre is automatically compensated for offsets.

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.

For remote controls with a knob and a switch (CM 555, 654) and wheel steering (CM 556), REMOTE is activated by switching to REMOTE. The rudder angle now follows the knob position. When it is switched back to PILOT, the current heading becomes the reference, or in NAV mode it reverts to the GPS heading to steer. For the unswitched remote control (CM 653), moving the knob away from the centre automatically put the system in REMOTE and it returns to PILOT when the knob is centred. For a jog lever (CM551), moving it places the system in REMOTE and runs the helm out until the lever is released. When it is released, the helm stays in that position. The system is returned to PILOT by pressing the PILOT key.

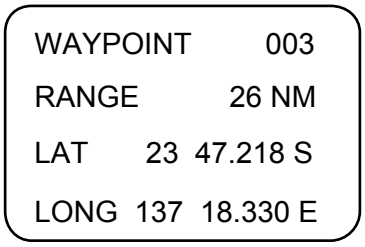
The CM650 system responds to the most recent input from either the control panel or a remote attachment. Therefore, when the system is turned on, the setting of all remotes is ignored until some input is made to them, Similarly, pressing STANDBY or PILOT on the control panel will override a remote. If two remote attachments are fitted, the system responds to whichever has been used most recently.

Note. As a safely feature, remote controls may be disabled when the main switch is in STANDBY (See Menu 3).

2.4 THE MODE KEY

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

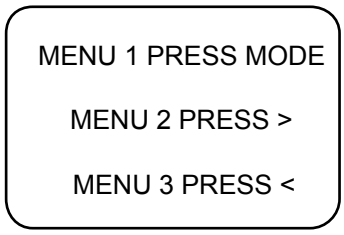
NAVIGATION DISPLAY Pressing the MODE key once brings up a screen which displays navigation data received from the GPS or other device. The display can show up to six navigation parameters if available, namely: heading to steer to waypoint, cross track error and direction, waypoint identifier, range to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



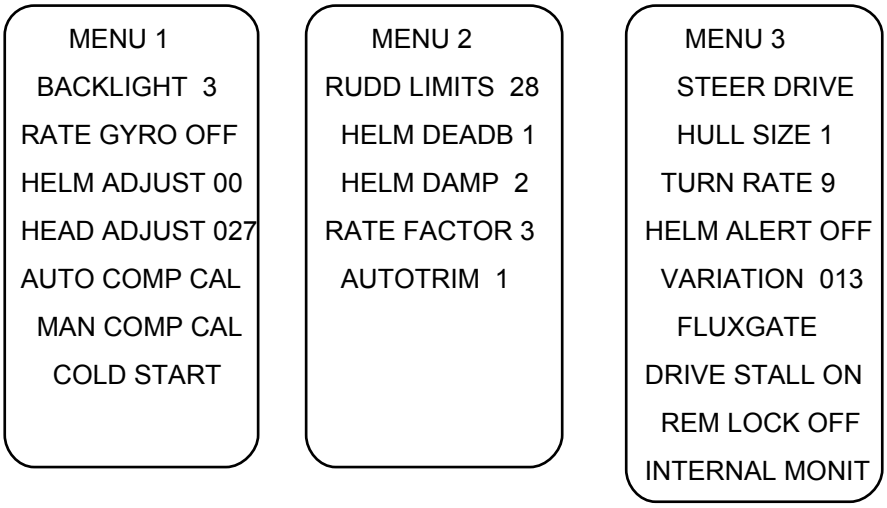
Parts of the display may be blank if some of the data is not available and if no valid NMEA data is being received, the screen reads WAITING FOR DATA.

2.4.1 PROGRAM MENUS

Three 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. The screen reads:



The content of the menus is summarised below. Select one and 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.**



Menu 1

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 The current fluxgate heading is displayed and compass **ADJUST** 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:

TURN 360 DEG

TURN PROGRESS

012

With the vessel under way and steering it by hand, turn it slowly through a full circle. The display shows the angle turned through, relative to the starting point. You may turn in either direction, but should continue in that direction until finished. When the circle is complete, the display shows a report on the quality of the field and calibration, eg:

CALIB REPORT
MAG FIELD MEDIUM
PERMAG ERROR LOW
SOFT ERROR MED

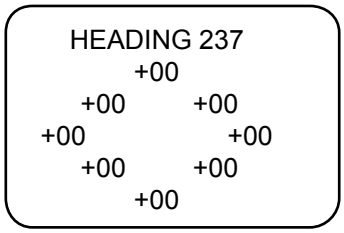
Line 2 rates the overall strength of the earth's field at the compass as low, medium or high. A high reading should be seen at the equator and medium or low from 20 degrees or more away from the

equator. Line 3 rates the level of error produced by magnetised material in the vessel and Line 4 rates the error produced by concentrations of soft iron in the vessel. The results are for guidance only as there are interactions between the three ratings. Sec 3.3 gives more information on optimising compass performance.

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 COMPASS CALIBRATION

Manual calibration can be carried out independently of auto 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 deg.

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. The System Setup must be done again after a Cold Start. When the Cold Start prompt appears, press the right arrow. After the presets have been re-loaded, the display confirms that a Cold Start has been carried out. Press Mode to commence the set-up.

Menu 2

RUDDER LIMITS This setting controls the maximum rudder angle used when the system is in PILOT mode. It is preset to 20 degrees and may be changed using the arrow keys. It should always be less than the mechanical limits stored during the System Setup procedure.

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.

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.)

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. If Hull Size is set to 2, the effective Rate Factor is double that applying with a Hull Size of 1.

AUTOTRIM The autotrim continuously adjusts the helm centre by averaging the course errors over time. A setting of 1 is normally satisfactory, but it may be increased if the vessel takes too long to settle on course in the presence of offsetting wind or current forces. Autotrim is disabled by setting it to 0.

Menu 3

STEER DRIVE This may be used to run the steering drive continuously for bleeding purposes. Note that if the rudder transducer is not coupled, there is a risk of driving the steering gear against the stops. Press the left or right arrows to start and stop the drive.

HULL SIZE A setting of 1 produces the standard 650 steering characteristics and is recommended for hull lengths up to 25m. Above 30m, a setting of 2 doubles the rudder factor and rate factor and changes internal filtering to suit larger vessels. A setting of 2 will give poor control in smaller vessels. In the 20 to 30m range, it may be necessary to experiment to see which suits the vessel better.

TURN RATE The maximum turn rate, in deg per sec. may be set using this option, though on slower vessels it can be left at its maximum value of 9.

HELM ALERT As a safety feature, a HELM ALERT alarm is sounded after a selectable delay of 5, 10 or 15 minutes. One minute before the alarm sounds, a the HELM ALERT message flashes at the top of the normal display and is cancelled by pressing the MODE switch. This is an aid to ensure that the helmsman is keeping watch. This

function may be switched off, but we strongly recommend that it be switched on.

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.

COMPASS TYPE This allows a selection between a heading input from a fluxgate compass (or slave) and a digital heading input via one of the NMEA ports. There are two digital heading options: a magnetic heading (HDG) or a true heading (HDT). If the true input is used, a T symbol appears on the right of the working display and all navigation headings are shown as true.

DRIVE STALL ON The Drive Stall alarm is activated after a Cold Start, but this option may be used to disable it, if necessary. We recommend that it not be disabled for normal use.

REMOTE LOCK If the Remote Lock is switched on, the system will only respond to a remote steering attachment when it is in PILOT.

COMPASS MONIT Used to measure fluxgate output voltages for diagnostics.

2.5 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 30 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 at preset intervals as a safety feature to ensure that the wheel is attended. (See Menu 3 for more details.)

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.
DRIVE STALLED	If the steering drive is activated and the helm moves less than 1 degree in 2.5 seconds, the system is switched to STANDBY and this alarm is set.
RUDDER OVER RANGE	Either the rudder has travelled past the limits set during System Setup or an electrical fault has developed in the Rudder Transducer. The system switches to STANDBY.
RUDDER OVER RANGE	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 are set during the System Setup operation.
COMPASS FAULT	The magnetic field being sensed by the compass is above or below preset limits. Further information is given in Chap. 4. This alarm is disabled if a digital heading input is used.
NO HEADING DATA	If a digital heading input has been selected, a valid heading sentence is not being received.
OFF CENTRE	This alarm is only used during the setup procedure and occurs if the helm is not correctly centred for the last stage of the setup.

CHAPTER 3 INSTALLATION

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 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 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. For a simple installation, removing the backplate gives sufficient access for cabling. The socket positions are shown below in this section of the manual. But for full access, the cover of the Controller is removed as follows:

1. Remove the four screws holding the trim moulding at the front of the case and ease the trim off the case.
2. Remove two screws holding the case cover at the lower rear of the case and lift the cover clear.
3. Reverse this process to assemble.

An exploded view of the interior of the Controller is show n below in Fig 3.1.

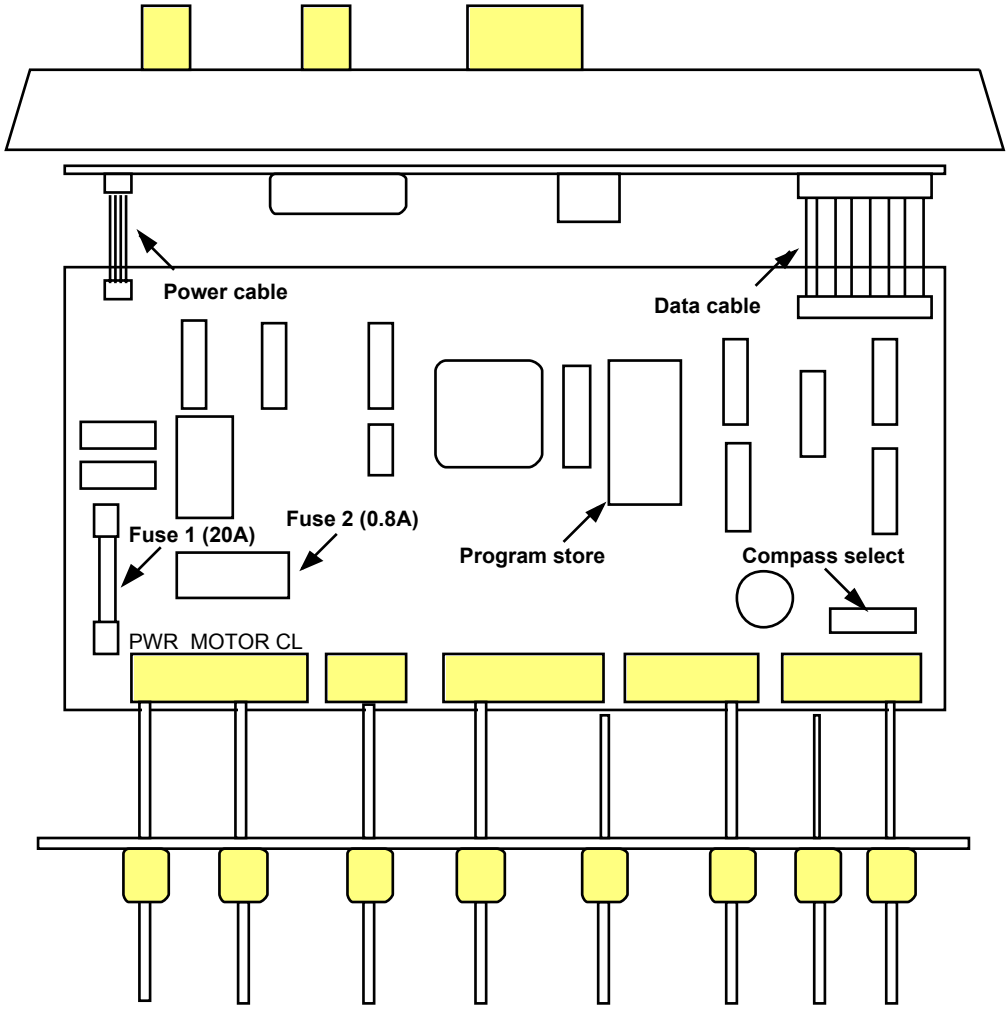


Figure 3.1 Exploded view of Central Controller.

A rear view of the sockets is shown below in Fig 3.2. Connections for the basic systems components are made to the top row of sockets, with the four on the lower row being used for extra components.

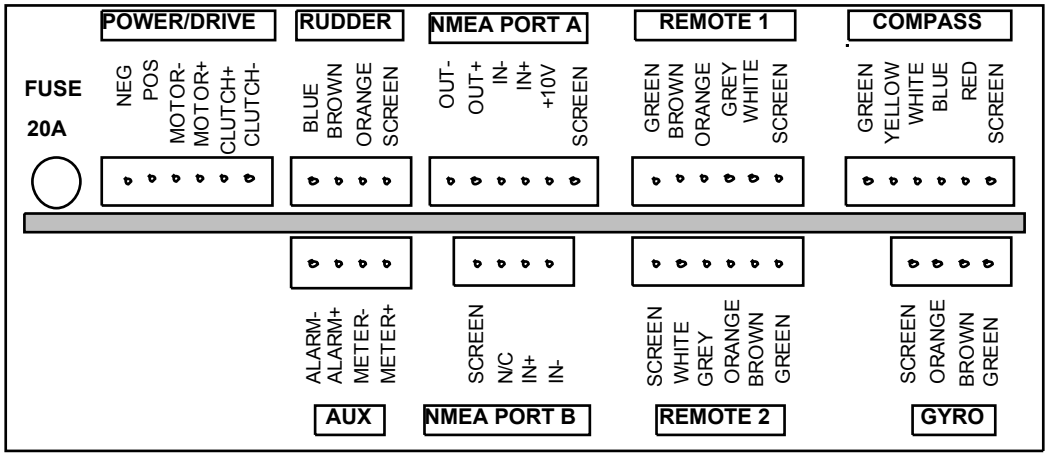


Figure 3.2 Rear view of the Controller case.

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 the same socket as the other wires in that cable.

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 NEG and POS terminals on 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. Connections to the steering drive are given in Sec 3.5.

3.2 COMPASS

The compass to be fitted is either a CM427 fluxgate, a CM418 or CM428 compass slave. The guidelines below apply mainly to a fluxgate. If a compass slave is fitted, it is mounted on the window covering the ship's compass card and the autopilot performance then depends on the performance of the ship's compass. The connections are shown below in Fig 3.3. It is important for the Compass Select switches (See Fig 3.2) to be set correctly. For a fluxgate compass or a CM428 slave, all of the 8 white switch toggles should all be set towards the rear edge of the main board. For a CM418 slave, they must all be set towards the front edge of the board.

(a) (b)

Figure 3.3 Cable connections for(a) CM427 fluxgate
and (b) CM418/428 compass slave.

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. 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 a vertical surface, which is at right angles to the keel and with the label facing the stern. The arrow on the label should point up and the cable

gland points down. (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 as shown in Fig 3.3.

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 15 deg in any position, keep re-siting the compass until a position giving less than 15 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 very slowly rotate the shaft with a screwdriver until the reading is correct.

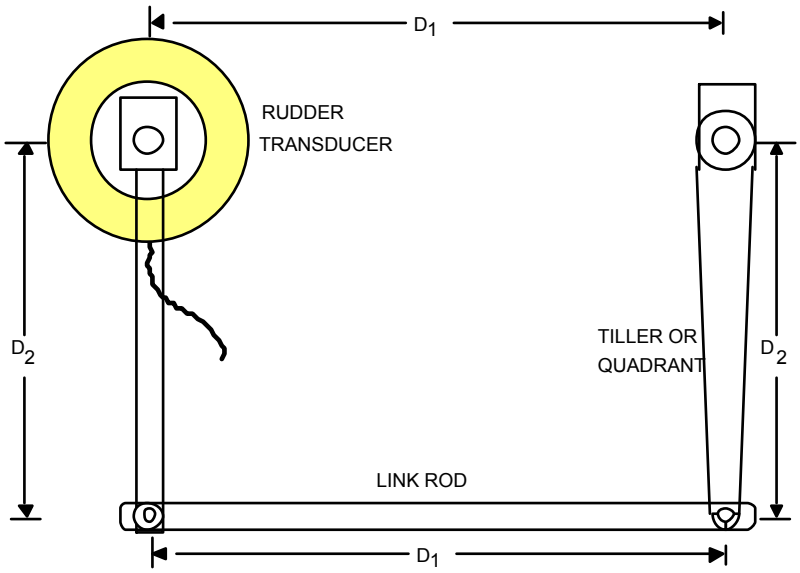


Figure 3.4 Rudder Transducer Linkage

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

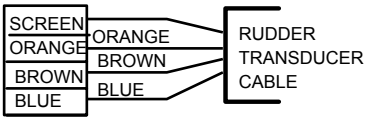


Figure 3.5 Rudder transducer connections.

3.4 ATTACHMENTS

3.5.1 REMOTE STEERING

The Junction Box has two Remote ports. Either or both ports may be used for remote controls.

Most of the of remote steering options use a five-wire cable, which is connected as shown in Fig 3.6(a). The CM551 Jog lever uses a three-wire cable and is connected as in Fig 3.6(b). The three-wire CM553 switch is connected according to Fig 3.6(c) below.

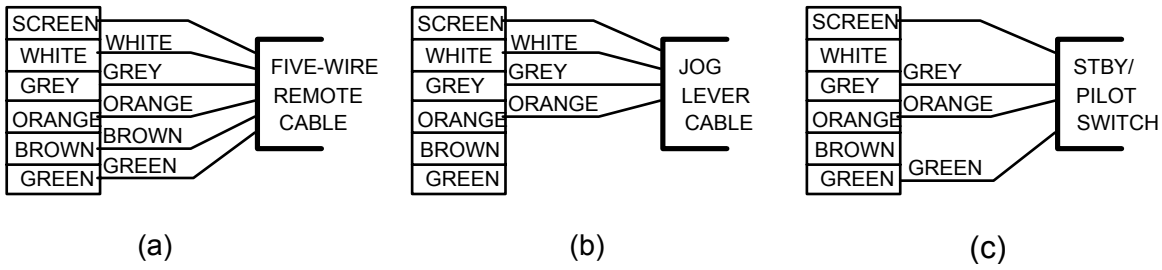


Figure 3.6. Remote attachment connections for (a) Five-wire Remotes, (b) Jog Lever and (c) STBY/PILOT switch.

3.4.2 RATE GYRO

The Gyro is supplied in a similar housing to the fluxgate and should be mounted on a vertical 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.

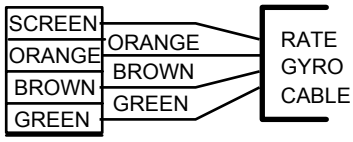


Figure 3.7 Rate gyro connections.

3.4.3 RUDDER ANGLE INDICATOR

The CM630 Rudder Angle indicator is a two-wire meter which is connected between the METER+ and METER- terminals on the Auxiliary socket in the Controller. (See Fig 3.2) . 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 + and ALARM - terminals of the Auxiliary socket. (See Fig 3.2) 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 NMEA socket provides two input ports and one output port 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 may be connected to either port.

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 connections are made, complete the other parts of the installation before checking for correct reception.

To check 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 CM650 can select data from a number of NMEA sentences and carries out an automatic search for the most suitable sentences. Details of the suitable sentences are given in Chap 5.

The NMEA output port sends the HDG (magnetic) heading sentence.

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 STEERING

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 is chosen to give the recommended helm response time for the length of the hull. The sprocket size is chosen from Table 3.2 or 3.3 below, depending on the voltage. If the sprocket is mounted on an intermediate shaft in the steering system, the 'wheel revolutions' in the table apply to that shaft. Note that the tables are for a helm swing between 20 degree limits and are not the lock-to-lock ratings. The response times will vary according to the stiffness of the steering.

Table 3.2 Driven sprocket sizes for a 12V system.

Hull length	Up to 11 m	11 to 13 m	Above 13 m
Response time - 20 to +20 deg	8 sec	10 sec	12 sec
Shaft revolutions for -20 to +20 deg	Driven Sprocket Size (teeth)		
1	48	60	80
2	25	30	38
3	20	25	25
4	13	15	20
5	13	13	15

Table 3.3. Driven sprocket sizes for a 24V system.

Hull length	Up to 11 m	11 to 13 m	Above 13 m
Response time - 20 to +20 deg	8 sec	10 sec	12 sec
Shaft revolutions for -20 to +20 deg	Driven Sprocket Size (teeth)		
1	70	85	105
2	38	38	48
3	25	30	38
4	15	20	25
5	15	15	20

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 Junction Box and terminate it according to Fig 3.8. Note that the CLUTCH NEG terminal is internally connected to the negative power supply terminal.

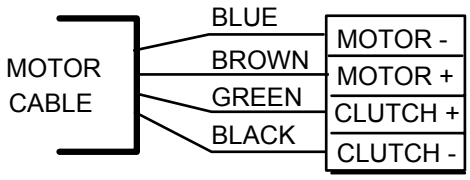


Figure 3.8 Connections to a mechanical drive system.

3.5.2. 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 3.9.

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

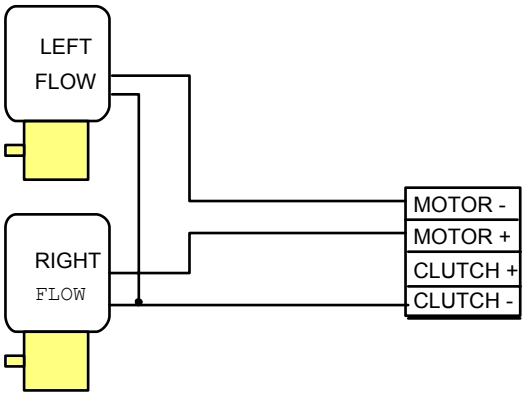


Figure 3.9 Connection to flow-control solenoids.

3.5.3 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.

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.

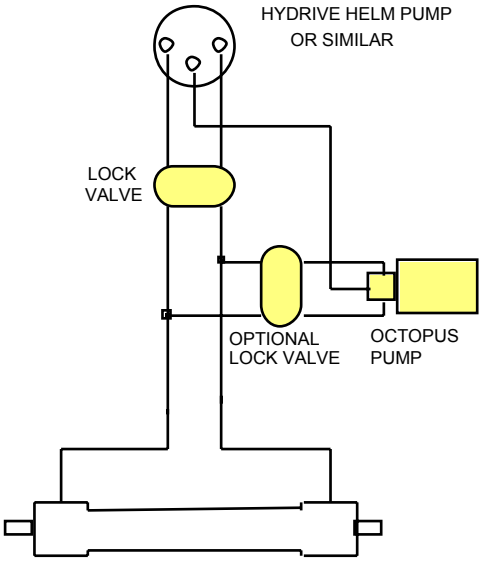
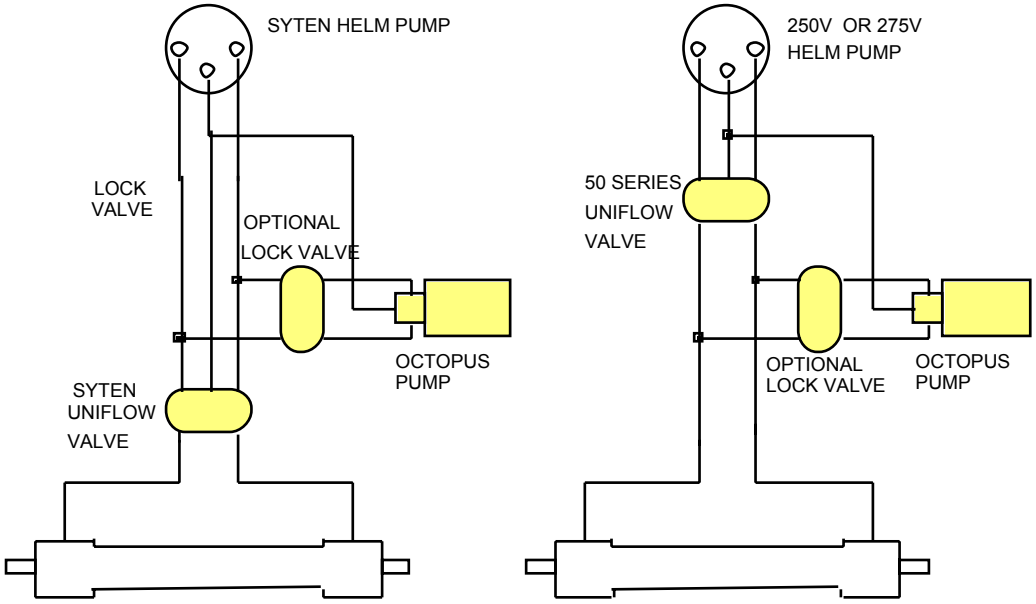


Figure 3.10 Connection to a typical two-line system

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 installed, it must be fitted as shown in Fig 3.10.

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 3.11(a) and (b).



(a) (b)

Figure 3.11 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. 3.12(a) and to the Teleflex 220 in Fig 3.12(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.

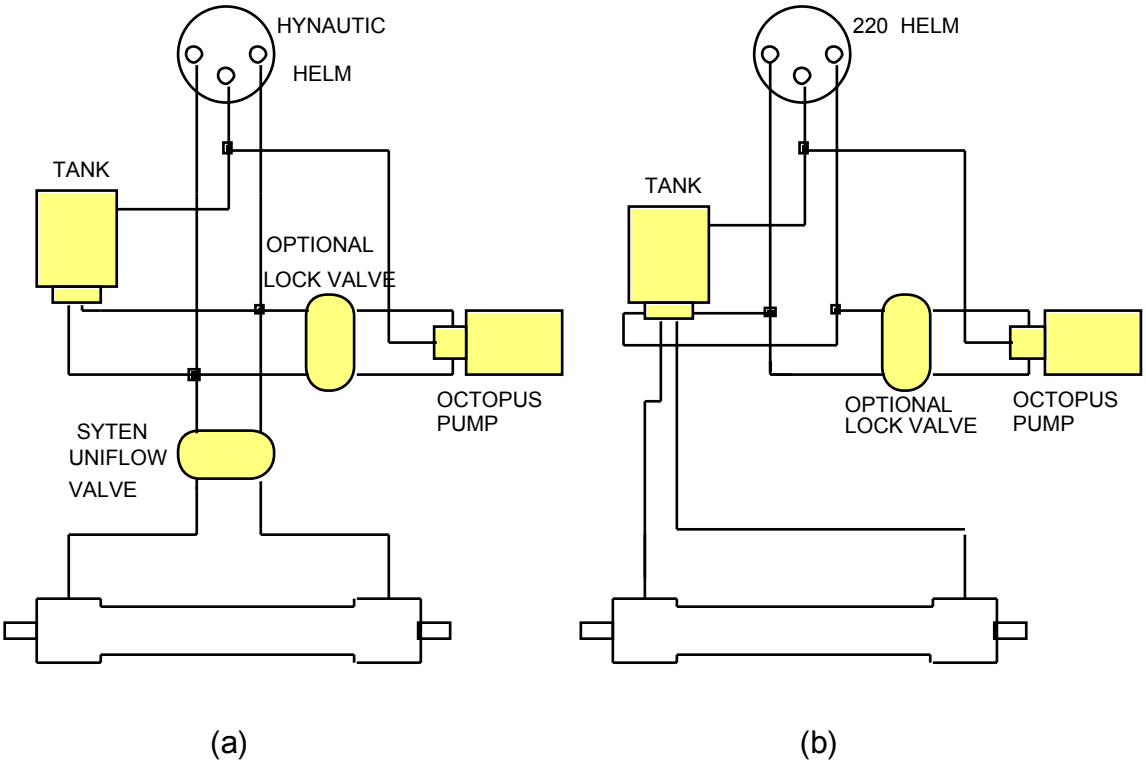


Figure 3.12 Connection to pressurised systems:
(a) Hynautic and (b)Teleflex 220

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 20 amp cable, connect the two pump wires to the Motor terminals in the Junction Box (see Fig 3.9), 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. Check the Specifications chapter of this manual (p 5-2) for the right value for your vessel. 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 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.

3.6.4 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 given in Table 3.4.

Table 3.4 Hydraulic Ram Mounting

Ram Type	Stroke (mm)	Distance to rudder stock (mm).
210, 213	200	175 - 200
213, HD200-12	300	225 - 300

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. (Lighter cable may be used.) 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 the correct rudder response time. Check page 5-2 of this manual for the correct time and adjust if necessary. 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. (If preferred, the STEER DRIVE option in Menu 3.)

(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 system is then held in STANDBY and the message can only be cleared by the STANDBY 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, a fault in the compass electronics in the Junction Box, 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 20A 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.

DRIVE STALLED

The drive is on, but the helm has not moved over a 2.5 second period. The causes for this can be similar to Drive Overload, but it can also be caused by a linkage failure at the rudder transducer.

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, 10 or 15 minutes. The condition does no affect autopilot operation and is cancelled by the PILOT or STANDBY keys.

OFF COURSE

The system is in autopilot and the vessel has been more than 8 deg. off course for 30 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 PILOT key or switching the system out of PILOT.

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 the limits which were set during the System Setup operation. If this has not occurred, the causes are probably in the rudder transducer cable, connections, mechanical linkage or in the transducer itself. Conditions which can cause the alarm to appear are if the transducer is off-centre by more than 10 deg. or the autopilot rudder limit has been set beyond the mechanical limit.

4.2 OTHER FAULTS

If there are large voltage spikes on the power supply, the system may reset itself 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, check Fuses 1 and 2 (See Fig 3.1). Using 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 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 or that a pin is bent or broken. If that is not the problem, a service call is required.

The steering drive transistors are electronically protected, but can be damaged by extreme stress. The common symptom is that the steering will drive one way and not the other. Other types of damage can cause the main fuse to blow when the system is switched from STANDBY to PILOT. In such cases, the Junction Box should be returned to your dealer or to Coursemaster for repair.

The CM650 is fitted with an over-voltage trip which operates if the supply voltage exceeds 38V. This will switch the system off until the voltage has fallen to a safe value.

4.3 FUSES

The main 20A fuse (Fuse 1) protects the complete system. Fuse 2 is rated at 0.8A and protects the internal electronics. The most likely event to cause Fuse 1 to blow is an external short-circuit in the steering drive. For Fuse 2, the most likely cause is an excessive voltage surge on the vessel's power supply.

CHAPTER 5 SYSTEM SPECIFICATIONS

AUTOPILOT

Supply Voltage Range (nominal)	12 to 24V dc
Maximum Supply Voltage Range	10 to 30V dc
Over-voltage trip level	38V
Supply Current	
Basic system in STANDBY	0.3A
Compass	Fluxgate in damped 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	10V at rated load
Output for 24V supply	22V at rated load
Max continuous current 18 A	
Max current for 0.5 sec.	40A

Mechanical drive steering motor	Printed rotor with gearbox and electromechanical clutch
Torque	12V unit: 120kg-cm at 30 rpm/5A. 24V unit: 150kg-cm at 40 rpm/7.5A.
Hydraulic drive systems	See manufacturers' specs.

Recommended response times:

Hull length up to 11 m	8 sec. for -20 to +20 deg swing.
Hull length 11 to 13 m	10 sec. for -20 to +20 deg swing.
Hull length above 13 m	12 sec. for -20 to +20 deg swing.

NAVIGATION INTERFACE

NMEA PORTS

Data format and sentences to comply with NMEA0183 V3.00

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(S)	Isolated via optocoupler
Input resistance	1000 ohm min.
INPUT PORT SELECTION	Automatic. (each port is sampled 4 times per second to detect the presence of data.)
OUTPUT PORT	Non-isolated differential output
Output voltage	18 V p-p (typical)
Source resistance	1500 ohm max

AUTOMATIC SENTENCE SELECTION

The system looks for groups of NMEA sentences in this order:

RMB and RMC
RMB and GLL
APB and GLL
APA and GLL
BOD and XTE

The search stops on the first complete group. If only one sentence is found from the above combinations, the autopilot operates from the data in that sentence.

For a digital heading input, the system looks either for the HDG or HDT sentence, depending on which one is selected in the Menu 3 option. Variation and deviation fields are not read.

OUTPUT DATA

The system outputs heading data in the HDG (magnetic) sentences.

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 INSTALLATION OF NEW SOFTWARE

It is recommended that software upgrades be installed by a Coursemaster agent, but if this is not possible, the following procedure should be followed carefully by the owner. The memory package containing the software for the main circuit board in the Junction Box has a label beginning CM760V..... Open the Junction Box and, referring to Fig 3.1 in the manual, locate the Program Store. Slip a slim bladed screwdriver between the package and its socket at the end nearest the plug edge of the board. With a gentle twisting movement of the screwdriver, lever the package up so that it remains parallel to the surface of the board until free of the socket.

Check the new package to ensure that all pins are straight and at right angles to the package. If they tend to splay outwards, bend them inwards by rocking the package on a hard smooth surface. Insert the package in the socket, making certain that the small notch at the end of the package lines up with the small notch on the socket.

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.