UNITEST

MARINE TRAINING SOFTWARE, SIMULATORS AND DIESEL ENGINE TESTERS

MARINE TRAINING SOFTWARE Engineering CBT

Operator's Handbook

Part 1 & 2

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MARINE TRAINING SOFTWARE
Part 1 & 2

Contents

Installation instruction

1. Do not insert the Hardlock Key before the software installation!

2. Start the computer and load the Windows 98 / Me / 2000 / XP / 2003 / Vista operating system.

3. Please wait for the CD-ROM auto-start sequence, or:

    a. Insert the CD into the CD-ROM drive.

    b. Click the “Start” menu.

    c. Select “Run…”.

    d. Type “[CD-ROM drive letter]:\setup.exe” (e.g. d:\setup.exe), or click ‘Browse…’ button and locate ‘setup.exe’ file on the CD-ROM.

    e. Click “OK” button.

4. Follow the instructions shown on the screen.

5. After the installation has completed, please insert the Hardlock Key.

6. In order to read the manual pdf files, please install the “Adobe Reader”, which is included on the CD-ROM.

HYDROPHORE INSTALLATION

1. General description

The educational program HYDROPHORE INSTALLATION is intended for teaching the basic principles of how to operate a typical hydrophore installation for sanitary water used in marine power plant.
The hydrophore's aim is to supply sanitary water to the receivers by keeping a determined pressure in the installation.
The following elements are incorporated in the hydrophore installation /fig. 1/:
1. Pressure vessel / hydrophore / provided with the following fittings:
    - pressure gauge
    - differential pressure control with cut-off valve
    - water level glass
    - compressed air system connection
    - safety valve
    - drain valves (release extraction)
    - inlet and outlet valves
2. Water pump / centrifugal self - priming type with pressure gauges and valves /

3. Water tanks No 1 and No 2

4. Water filter

5. Control panel with lighted push button 'STOP', 'AUTO'.

Graphic symbols which are used in hydrophore installation diagram are described in the legend /fig. 2/.
On the diagram:
- blue colour indicates water
- white colour indicates the absence of water flow in the pipe and the presence of air inside the pressure vessel.

Some valves on the diagram are active i.e. their opening or closing is operated by mouse clicking the rectangle's field. The control panel enables pump automatic operating (yellow push button - 'AUTO'; red push-button - 'STOP')

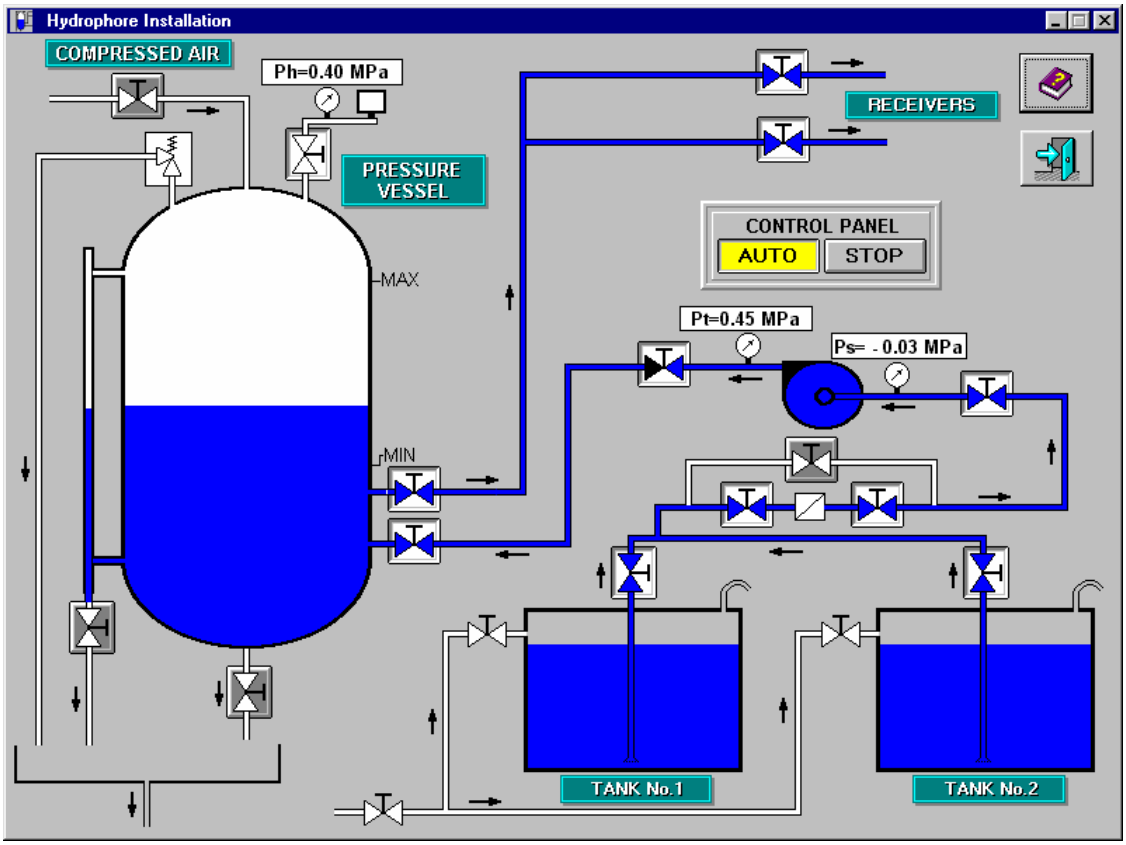

Fig. 1 Hydrophore installation diagram

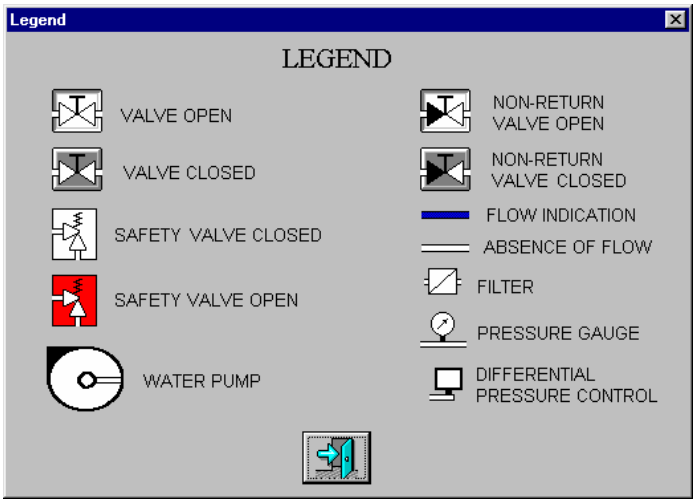

Fig. 2 Legend

2. Operating principles

The hydrophore installation functions automatically. An electrically - driven centrifugal pump sucks water form tanks through a filter. The pump forces the water into the pressure vessel, which is filled partly with water, partly with air. The differential pressure control, installed in the upper part of the pressure vessel, cuts - off the electricity supply to A/C motor of the pump when the pressure in the vessel is 0,55 MPa. The current is connected again when the pressure in the vessel decreases to 0,35 MPa. The water level in the pressure vessel should be related with pressure, it means that in the event the pressure is 0,35 MPa (the moment of pump starting), the water level should be at minimum ('MIN' marked on right part of the vessel). In the event the pressure is 0,55 MPa the water level should correspond to maximum ('MAX'). From the pressure vessel /hydrophore/ water is conducted to the receivers.

3. Operating instruction

Starting procedure:

Attention !

After program starting the water level in the pressure vessel is in the middle between MAX and MIN and the air pressure (Ph) is equal to 0,45 MPa. The inlet valve to the pressure vessel and valves on the suction and discharge side of the water pump are open.

1. Switch on the push button 'AUTO' on the control panel.
2. Open outlet valve on the pressure vessel.
3. Open valves to receivers.
4. The water level inside the pressure vessel shall decrease and the air pressure shall drop also. When the air pressure is equal to 0,35 MPa, the differential pressure control switches on the pump and after reaching 0,55 MPa, the pump stops.

Water level setting procedure after receivers pipeline aeration:

Receivers pipeline aeration occurs (as an extreme situation), in the following events:

-Pump control panel is not switched on 'AUTO' mode

-Pump control panel is switched 'AUTO' but the pump is not supplying water (for e.g. due to faulty valve operation).

In both cases the outlet and receivers valves are open.

1. Press push-button 'AUTO' on control panel and open valves on the suction and discharge side on the water pump.
2. Close outlet valve on the pressure vessel.

3. Fill the pressure vessel till MAX water level and press push-button ’STOP’ on control panel.
4. Open compressed air valve (on the upper part of the pressure vessel) and create an air bag pressure inside the vessel equal to 0,55 MPa.
5. Close the compressed air valve.
6. Press push-button ’AUTO’ on control panel
7. Open outlet and receivers valves.

Water level setting procedure in case of low air bag

Low air bag inside the pressure vessel occurs for instance when, after receivers pipeline aeration, the air bag pressure is not corrected (by opening the compressed air valve). This will cause frequent pump stopping and starting (quick low air bag compression and decompression) or in an extreme situation safety valve opening.

1. Press push-button ’STOP’ on control panel.
2. Open outlet and receivers valves.
3. Open air compressed valve.
4. After reaching MAX water level, close outlet valve on the pressure vessel.
5. After achieving air bag pressure 0,55 MPa, close air compressed valve.
6. Press push button ’START’.
7. Open outlet and receivers valves.

DIESEL ENGINES

General description

The educational program DIESEL ENGINES describes the principles of diesel engines operation. The program consists of three parts:

1. Two - stroke engine/fig. 1/
2. Four - stroke engine *I* fig. *2/*
3. Fuel injection system / fig. 3/

The choice of appropriate part is operated by mouse-clicking at the strip in the upper part of the screen.

The part concerning two - stroke and four - stroke engines contains a circle diagram (with inlet, outlet and injection timing) and indicator diagrams (P-V). The program makes possible the observation of how engine power (Ne) has an effect on the change of indicator diagram.

The part regarding fuel injection system presents the visualisation of typical fuel installation as well as a pressure diagram (fuel pressure in relation to crankshaft positioning).

In all program's parts power changes are realised by mouse clicking in the arrow field. Information concerning the applied engine may be found in 'INFO'.

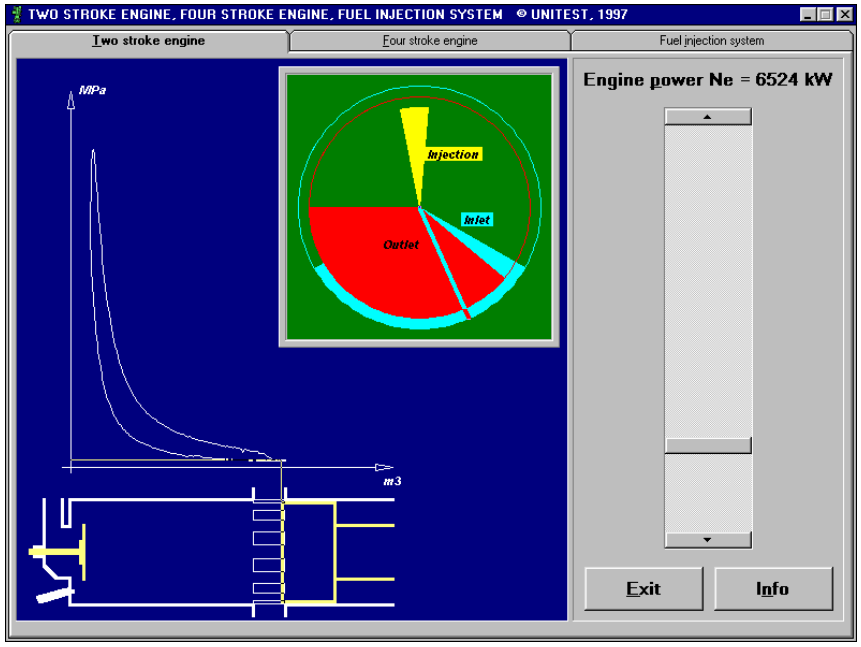

Fig. 1 Two – stroke engine diagram

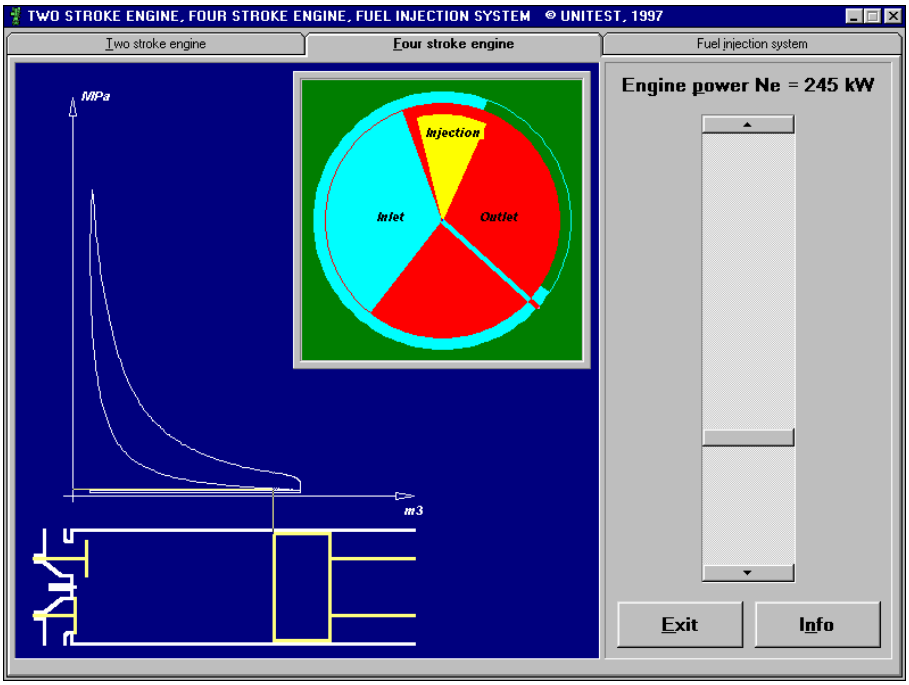

Fig. 2 Four – stroke engine diagram

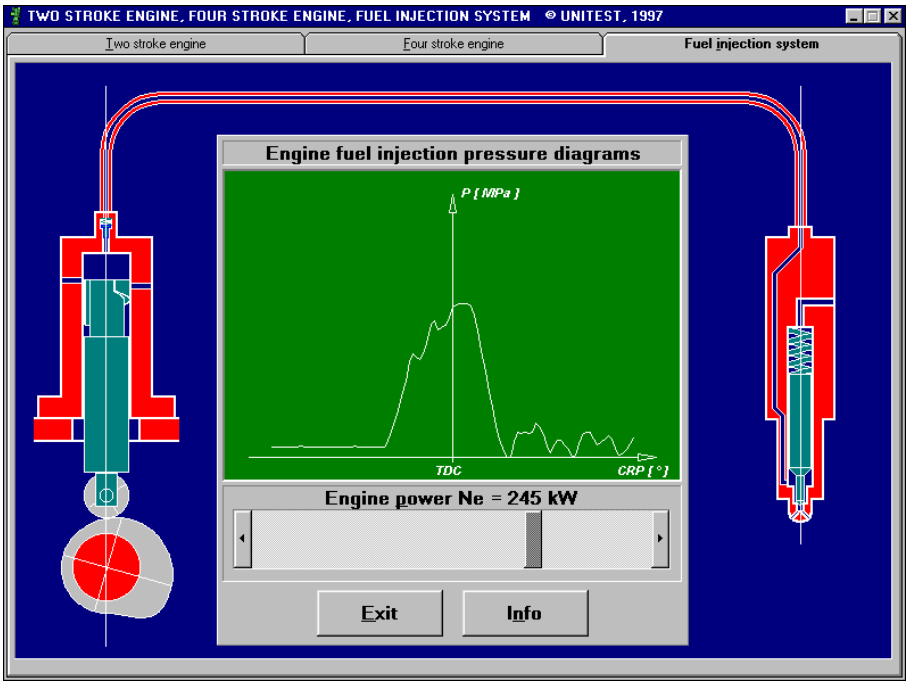

Fig. 3 Fuel injection system

DIESEL ENGINE GENERATORS

1. General description

The DIESEL ENGINE GENERATORS - training simulator program's aim is to teach basic principles of how to operate marine diesel engine generators.
This program is based on two diesel engine generators, which work in a semi-automatic system.
The program consists of three parts:

1. Control panel
2. Main switchboard
3. Diagrams

The choice of the appropriate part is operated by mouse-clicking at the strip in the upper part of the screen.

The control panel contains /fig, 1/:

- DG 1 and DG2 tachometer
- alarm's block with lamps
  a) LUBRICATING OIL /L.O/ LOW PRESS
  b) FRESHWATER /F.W/ / LOW PRESS
  c) START AIR LOW PRESS
  d) L.O HIGH TEMP.
  e) F.W HIGH TEMP. and STAND BY lamps.
- push-buttons START and STOP for manual DG operation
- DG START SELECTION switch which selects manual or automatic engine start / OFF, MANUAL, AUTO/
- control lamps of the prelubricating pump /START,STOP,AUTO/
- switch PRELUBRICATING PUMP MODE -/START,STOP,AUTO/
- push-button LAMP TEST
- push-button RESET AFTER SHUT DOWN
- switch DG STAND-BY SELECTION /OFF, DG1, DG2/
- push-button ALARM CONFIRMATION

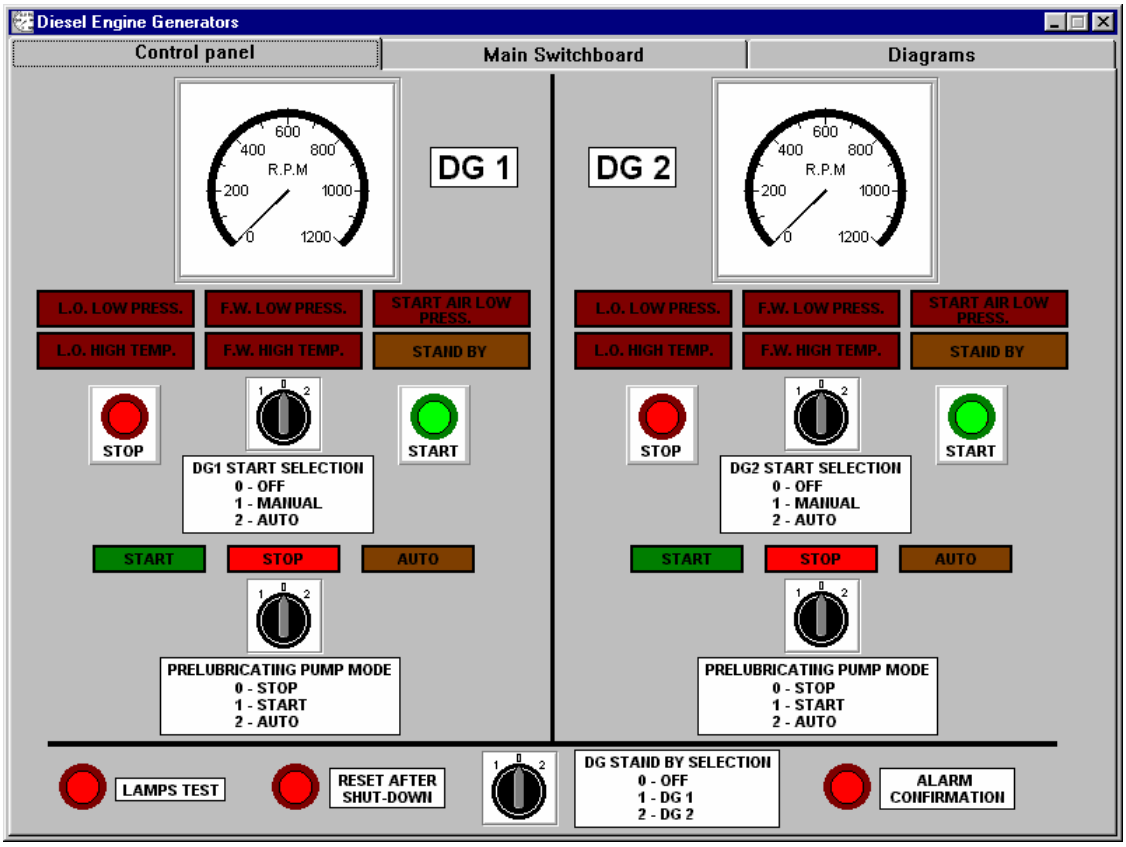

Fig. 1 Control panel

The main switchboard contains /fig. 2/:

On the left and the right side of the main switchboard there are two identical generator's fields- GENERATOR 1 and GENERATOR 2, which consist of:

- active power indicator MW
- reactive power indicator MVar
- phase-to-phase voltage indicator
- current indicator A
- switch L1,L2,L3 to measure phase-to-phase voltage
- push-button ON with a control lamp
- push-button OFF with a control lamp
- switch STATOR HEAT - ON / OFF

The generator synchronisation block is located in the central part of the switchboard and it consists of:

- bars voltage indicator V
- Hz frequency indicator I - the voltage frequency between bars
  II - the generator's voltage frequency
- SYNCHROSCOPE
- switch BUS- BARS - / L1 - L2, L2 - L3, L3 - L1 /
- lamps DARK MANUAL SYNCHRONISATION
- push-buttons manual SPEED AD JUSTMENT - " + ", " - "
- switch SYNCHRONISATION - 0 - OFF, 1 - GEN.1, 2 - GEN.2
- switch SYNCHRONISATION SELECTOR - 1. MANUAL / 2. AUTO
- push-button AUTO SYNCHR.ON
- switch AUTO GENERATOR UNLOAD. and OFF
- lamps GEN.1 and GEN.2 - OFF / ON
- insulation's resistance indicator

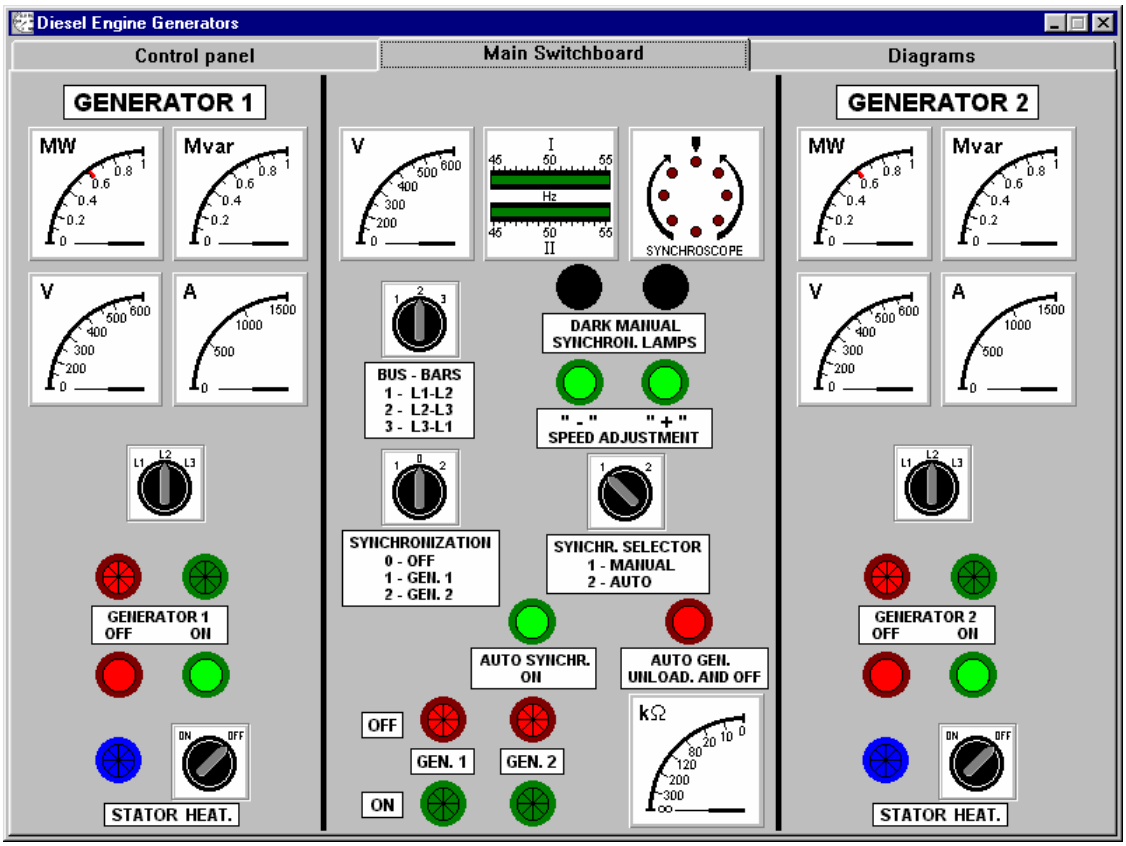

Fig. 2 Main switchboard

The DIAGRAMS part includes /fig. 3/:

- lubricating oil system - L.O
- freshwater cooling system - F.W
- seawater cooling system - S.W
- start air system
- fuel oil system

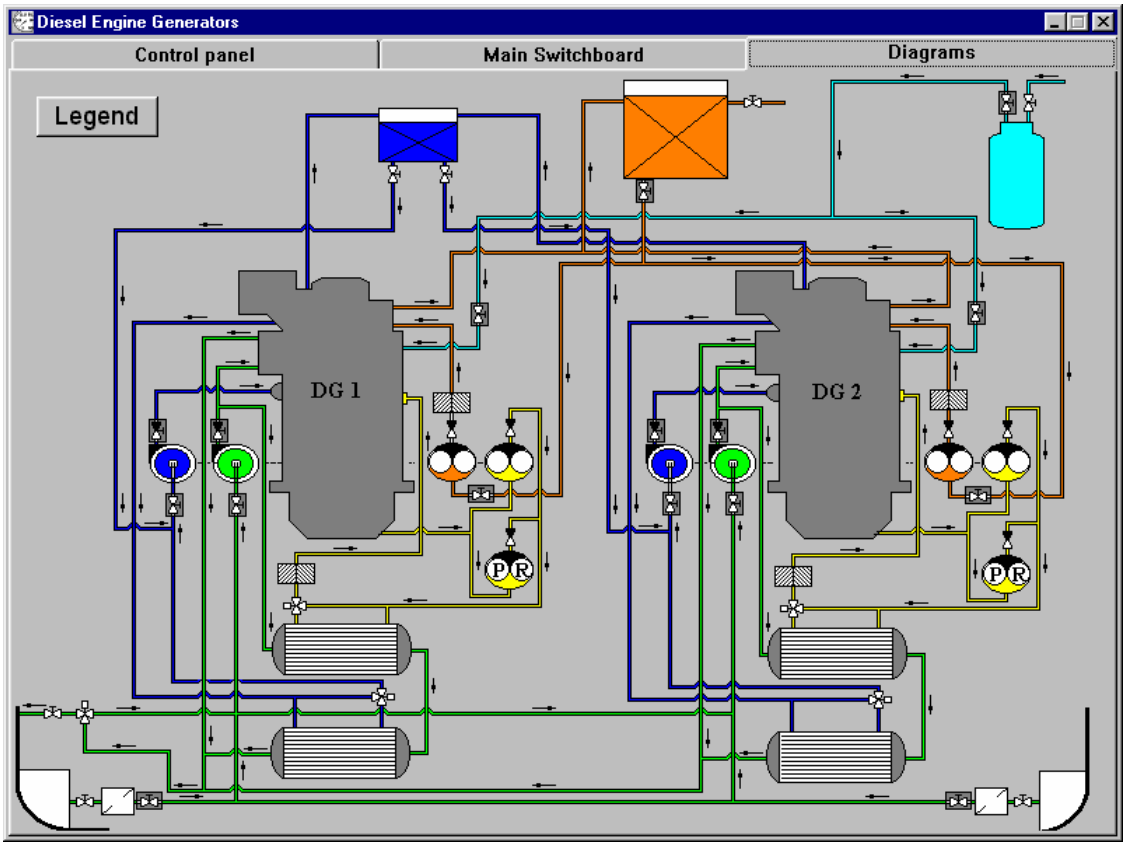

Fig. 3 Diagrams

The symbols used on the diagrams and the colours of the pipes are described in the LEGEND /fig. 4/.

Attention:

All the push-buttons, the switches or the valves thorough all the parts of the program are operated by mouse-clicking the described area of the screen.

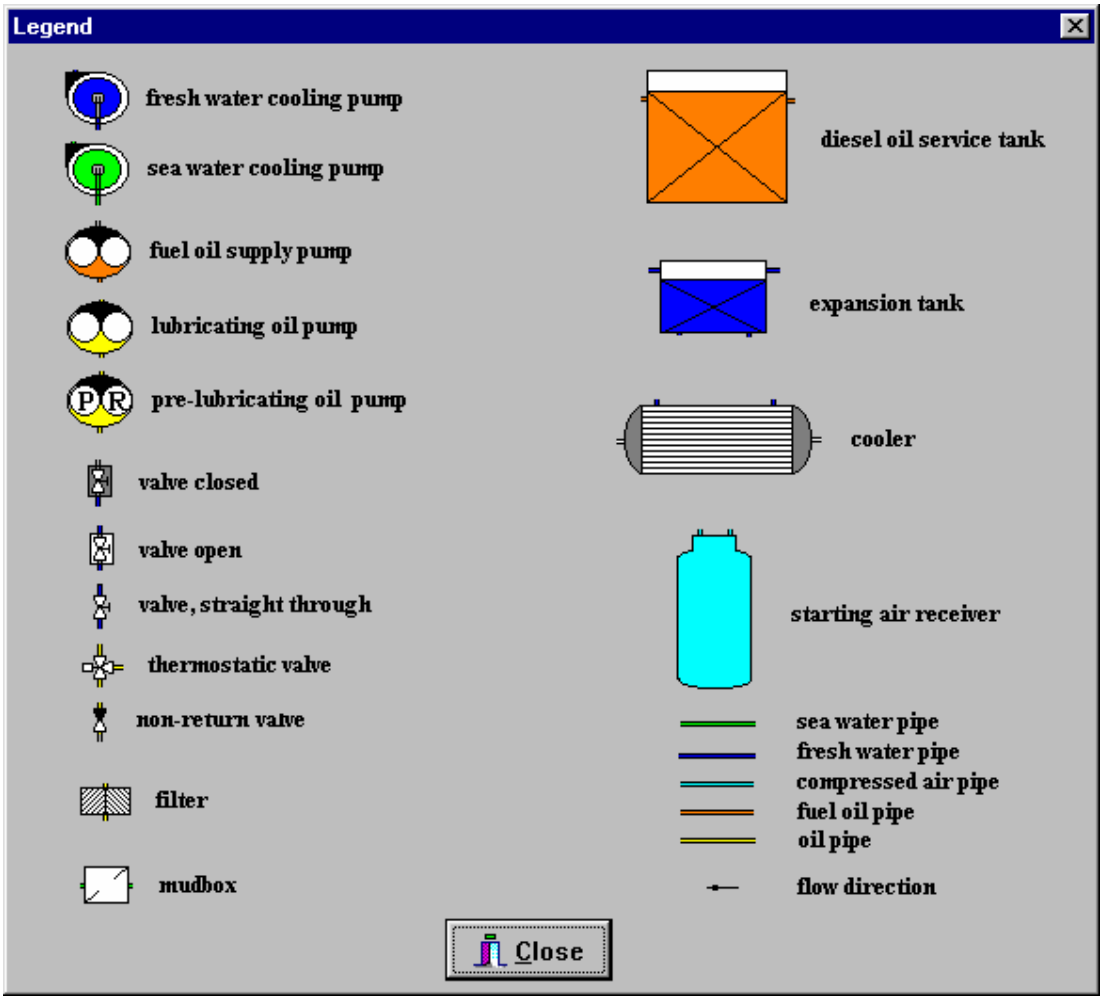

Fig. 4 Legend

1. Starting the engine

1. 0pen the proper valves in the installations / Diagrams /
2. Start for a few minutes the prelubricating pump / switch the PRELUBRICATING PUMP MODE on the START position and then on the STOP position.
3. Switch the DG START POSITION on the MANUAL position.
4. Start the engine with the START push-button. After the start of the engine its revolutions should be at around 1000 rev./ min.

Attention:

In the case of faulty valves positioning of the lubricating oil and the water cooling installations, the engine stops automatically / SHUT- DOWN / and the alarms sound. The closed valves of the air pressure will prevent starting the engine and will cause the START AIR LOW PRESS ALARM . The alarm should be confirmed with the ALARM CONFIRMATION push-button.
If, however, the fuel installation's valves are not open the engine starts but it will shut down after a few seconds / NO ALARM /. The alarms sound causes instant stopping of the engine /SHUT - DOWN/ though the activation of L.O LOW PRESS, F.W HIGH TEMP. and L.O HIGH TEMP. Before the next attempt to start the engine, after the ALARM CONFIRMATION, the push-button RESET AFTER SHUT- DOWN should be pressed.

5. Repeat the procedure for the second engine.

2. Starting the first generator /or after BLACK OUT/

Attention:

Before starting the generator the switch STATOR HEAT should be ON, while after starting the generator on the bar it should be OFF /heating off /. After starting the engine the voltage indicator in the generator field will display 390 V.
1. Switch on the generator on the bars by pressing the ON push-button in the generator's field.

Attention:

The start of the generator on the bars is confirmed by green control lights turning on in the generator field and the synchronisation block. In the synchronisation block, the frequency indicator /Hz - I, voltage frequency between bars / should indicate 50 Hz. The display on the indicator II /generator's voltage frequency/ will depend on the position of the SYNCHRONISATION switch.

3. The generator's synchronisation procedure - automatic

1. Check whether the engine of the generator for synchronisation has been started / the voltage indicator in the generator's field should display around 390 V /
2. Switch the SYNCHRONISATION on the generator to be synchronised.
3. Switch the SYNCHR. SELECTOR on the AUTO position .
4. Switch on the automatic synchronisation by pressing the AUTO SYNCHR. ON push-button.

Attention:

After synchronisation, the generator switched on will take over automatically 50% of the first generator's load.

4. The generator's synchronisation procedure – manual

1. Check whether the engine of the generator for synchronisation has been started / the voltage indicator in the generator's field should display around 390 V /
2. Switch the SYNCHRONISATION on the generator to be synchronised.
3. Switch the SYNCHR. SELECTOR on MANUAL .

Attention:

After selecting the manual method, the lamps DARK MANUAL SYNCHRON.LAMP will switch on and off with a frequency depending on the difference between the frequencies of the generator on the bars and the generator synchronised. Also the SYNCHROSCOPE will indicate by the rotating LED the differences in their frequencies. If the LED rotates on the right, the frequency is too fast / TOO FAST /, on the left - too slow / TOO SLOW / The adjustment of the appropriate frequency of the synchronised generator is operated by changing the engine speed, with the " + ", " -" SPEED ADJUSTMENT push-buttons.

4. A synchronised generator can be switched on the bars with the ON push-button, in their generator's field, in the case the synchronisation lamps "dark" are completely extinguished and the LED in the synchroscope is switched on in the position marked with an arrow.

After an unsuccessful attempt of manual synchronisation both the generators will turn off of the bars / BLACK - OUT / and the whole procedure of turning on and synchronisation will have to be repeated from the beginning /i.e. from the moment the first generator was started/ . After synchronisation, the generator switched on will take over automatically 50% of the first one's load.

5. The procedure of unloading and switching off the generator

1. Set the SYNCHRONISATION switch on the position of the generator, to be switched off.
2. Start the unloading and switching off procedure by pressing the AUTO GEN.UNLOAD. AND OFF push-button.

Attention:

The generator remaining on the bars will take over the load while the second one, after the voltage's decrease to a zero value, will switch off automatically of the bars / this generator's engine will continue running /.

6. Stopping the engine

1. Check whether the engine's generator to be stopped is switched off of the bars.
2. The engine will stop by pressing the STOP push-button on the control switchboard / independently of the position of the switch DG START SELECTION /.
3. When the engine stops, switch on the prelubricating pump for a few minutes.

7. Engine's stand - by position /STAND-BY /

Attention:

This option means, that if one generating- set is working and if its engine stops or if the generator switches off, then the engine in the stand-by position will be automatically started and the generator switched on the bars.

1. Switch the DG START SELECTION on the AUTO position.
2. Switch the PRELUBRICATING PUMP MODE on the AUTO position / the prelubricating pump will be turned on periodically /.
3. Switch the DG STAND BY SELECTION on the appropriate DG position / selection of the engine's stand-by is confirmed by a yellow lamp STAND - BY on in the alarms block.

FIXED DELIVERY SINGLE ACTING PUMP STEERING GEAR SIMULATOR

1. General description.

The educational program FIXED DELIVERY SINGLE ACTING PUMP STEERING GEAR SIMULATOR is intended for teaching the fundamental principles of how to operate this kind of steering gear.

This program consists of the following four parts:

- installation diagram,
- power switchboard panel,
- bridge control panel,
- engine control room panel.

When the program is running the power switchboard panel is shown on the computer display. The choice of other panels is done by means of a cursor (it should be in the field of desired panel) and single clicking of the left right button.

2. Steering gear and installation description - fig. 1.

The steering gear (with the rudder) besides the main engine is one of the most important ship devices, it ensures to the ship operational safety. This device performs the following two basic tasks:

- keeps right course of the ship,
- changes course of the ship in order to manoeuvre it.

The steering gear described is an example of electrohydraulic steering devices i.e. driving of the rudder is performed in a hydraulic way while its movement of control is carried out in an electrohydraulic way.

This steering gear consists of two hydraulic cylinders (29, 30) with two pistons inside defined as rudder actuator unit. The pistons affect the rudder tiller (32) by means of the strand assembly and the rudder tiller affects the rudder stock (31) directly. This action causes the movement of the rudder blade (the rudder blade is not visible on the figure 1). The nominal pressure is approx. 16 MPa (the maximal pressure, which opens safety valves 7, 8, 23, 24 equals 20 MPa) and it is generated by two independent gear pump drive units (1, 2). The high pressure of installation may be measured by pressure gauges (5, 6) by opening the manometer valves. During the steering gear operation, manometer valves should be closed because of the risk of damage by high pressure in installation. The steering gear is ready for work when one or both electric motors are put into service.. The electric motor drives the pump, which pumps oil further into installation.

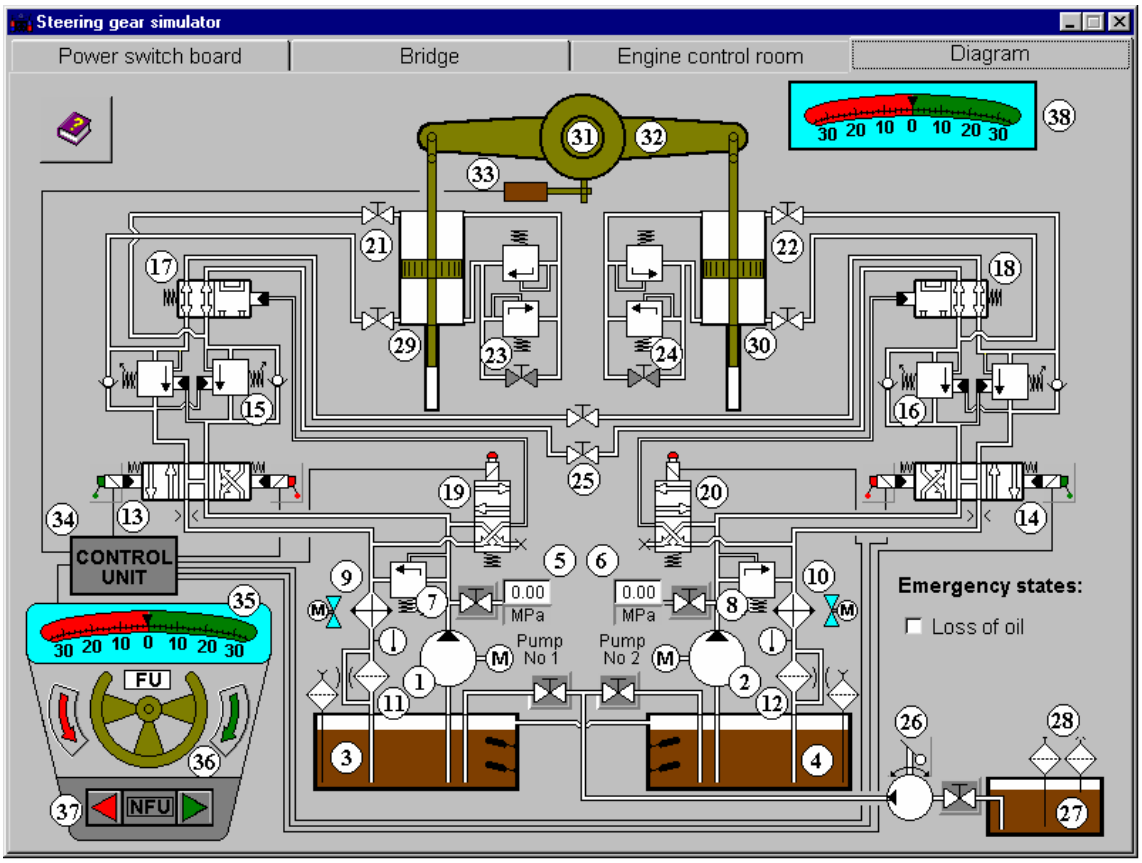

Fig. 1. Steering gear - installation diagram

Legend:

1, 2. Fixed delivery single acting pump
3, 4. Oil reservoir
5, 6. Pressure gauge
7, 8. Relief valve
9, 10. Air oil cooler
11, 12. Return line oil filter
13, 14. Spring loaded three-position four-connection manual & solenoid directional valve
15, 16. Counter-balance valve
17, 18. Spring loaded two-position four-connection directional valve
19, 20. Spring loaded two-position four-connection solenoid directional valve
21, 22. Manual shut-off valve
23, 24. Safety valve block
25. Manual shut-off valve
26. Manual operated refilling pump
27. Oil storage reservoir

28. Air breather & filler
29, 30. Cylinder with the piston
31. Rudder stock
32. Rudder tiller
33. Feedback circuit
34. Control unit
35. Rudder setting position indicator
36. Follow-up control
37. Non-follow-up control
38. Rudder position indicator

If the main directional control valve (13 or 14) is not set over on the valve block, the oil flows through the valve block and then through the air oil cooler (9 or 10). The air oil cooler keeps appropriate oil temperature whereas the air oil cooler fan is running when oil temperature achieves 40 °C. It is stopped when the electric motor of appropriate drive unit is also stopped The oil flows through the return line oil filter (11 or 12) to the oil reservoir (3 or 4). This constitutes the steering gear **idle running operation**.

The direction of the oil flow is controlled by means of the solenoid directional primary control valve (it is not visible on the fig. 1). Once the control begins, the electric remote control system sends the control signal on clamping rings of solenoid directional primary control valve. The slide of this valve is set on the extreme position and supplies oil to the control chamber of main directional control valve (13 or 14). The slide of main directional control valve is set into appropriate extreme position. Then oil is pressed through the counter-balance valve (15 or 16). The task of counter-balance is to supply oil only when the pump delivery pressure is superior than the draining pressure from the system and it also maintains the rudder in the given position. Afterwards the oil flows through the cut-off valve (17 or 18, depending on the kind of manoeuvring) to the proper chambers of cylinders (29 or 30).

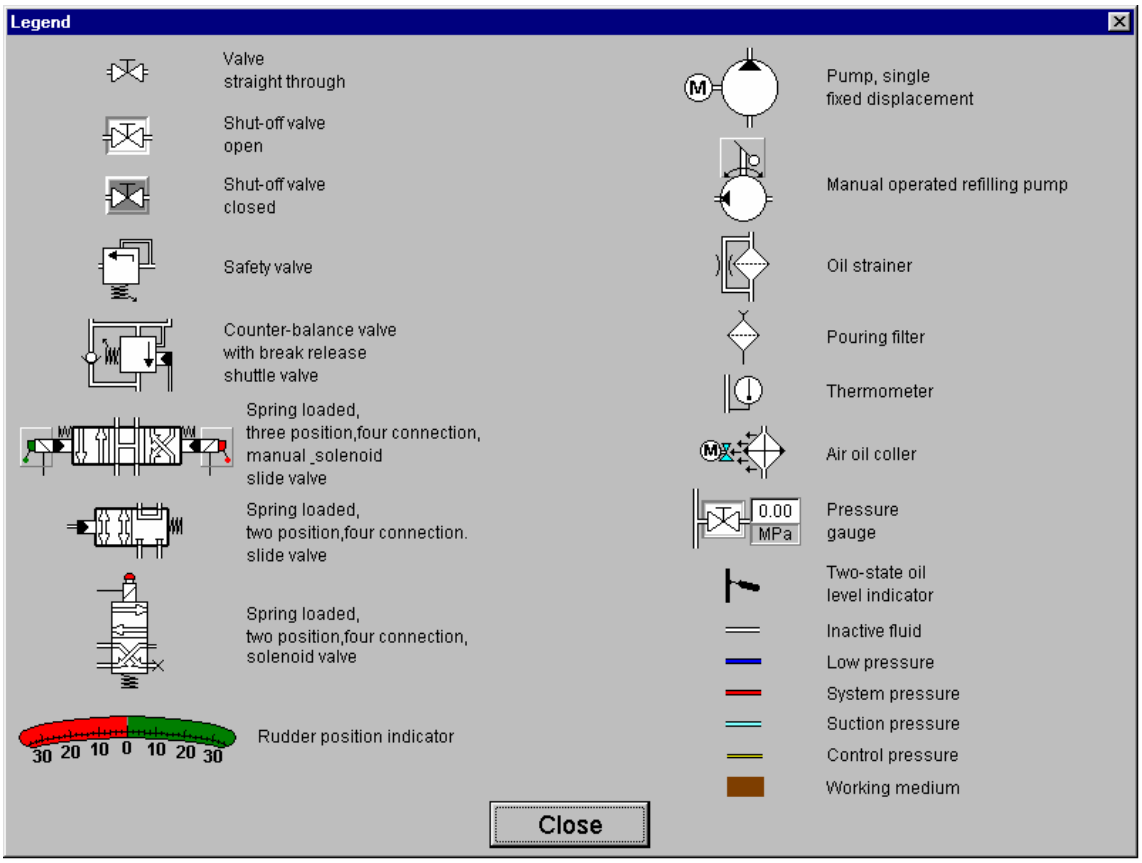

Fig. 2. Legend.

By switching-off the control signal, the slides of solenoid directional primary control valves return to the middle position due to the springs. Then oil flows back to the tank (3 or 4) from the main solenoid directional control valve (13 or 14).

From time to time, during steering gear exploitation a loss of oil may occur. Oil reservoirs (3 or 4) are refilled by manually operated refilling pump (26). This operation is carried out by clicking the left mouse button at the active field above the pump. Obviously, all suitable valves should be opened earlier (depending on the fact which tank will be refilled).

3. Power switchboard panel description - fig. 3.

The electrical system of drive units consists of the following elements:
- two supply boxes,
- two supply boxes of oil cooler fan's motor.

Normally, these boxes are fixed separately on the ship's board. Taking into consideration the fact that all boxes of any drive unit are symmetric, they were placed together on one display and defined as "Power switchboard panel".

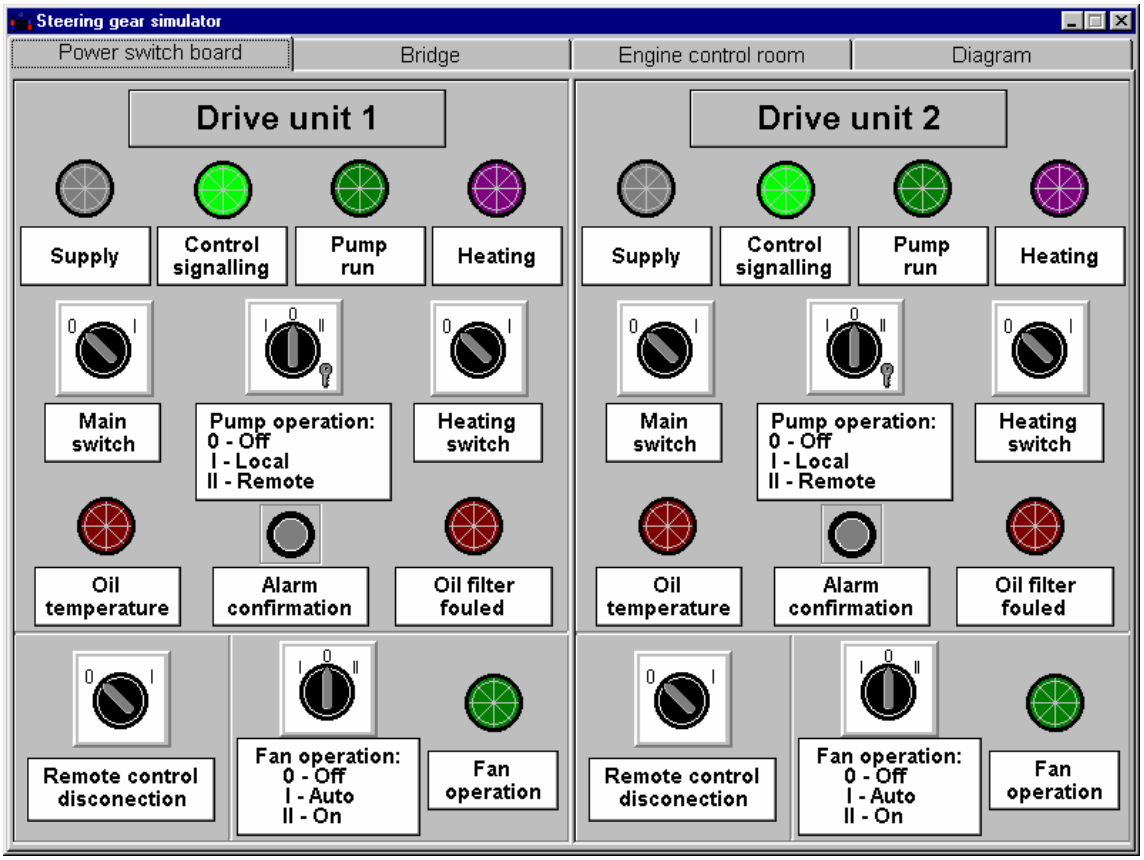

Fig. 3. Power switchboard panel.

The signalling lamps, switches and buttons located on the power switchboard panel are described below:

- **Main switch** - switches off current supply but it has no influence on signalling supply,
- **Pump operation** switch - it selects the kind of drive unit operation. In reality this switch is blocked by means of special key (visible on figure 3, only as an imitation). This protects the switch against the shifting into undesired position by unauthorised persons,
- **Heating switch** - switching it into position **I** causes heating of the switchboard attached to it and protects the switchboard against corrosion effect and contacts aerugo in areas with high humidity level in the air,
- **Remote control disconnection** switch - it allows the rudder telemanipulator supply switch to be set off (position I),
- **Fan operation** switch - it selects the kind of fan operation.

Functioning of the signalling lamps:

- **Supply** - presence of voltage supply,
- **Control signalling** - presence of voltage supply for controlling,
- **Pump run** - drive unit is running,
- **Heating** - heater is working,
- **Oil temperature** - that means oil achieves high temperature,
- **Oil filter fouled** - oil filter is contaminated,
- **Fan operation** - fan is running.

The electrical drive system of steering gear also ensures separation of the main hydraulic circuits in case of failure (e.g. oil leak) in one of the two circuits. The signal controlling the separation of the hydraulic circuits is obtained from the oil level sensors installed in the reservoirs (3, 4). Each of the tanks has two oil level sensors (low and very low level sensor). The separation is carried by the solenoid directional control valve (19 or 20) attached to the given drive unit (1 or 2).

The action of a low oil level sensor switches-on the shut off valve attached to the working pump. In such a situation the damaged part of the hydraulic circuit is identified. This state is signalled by acoustic and flashing alarm and **Hyd. circuits separation** lamp will blink on the bridge panel. At the same time **Low oil level** lamp will be flashing in engine control room panel and at the bridge panel. All alarms should be acknowledged by means of **Alarm confirmation** button (lamps will be continuously flashing until removal of the damage). In case the oil level is still above the limit that activates the very low oil level sensor, the work of steering gear is maintained by the efficient part of hydraulic circuit. On the other hand, when the oil level is still dropping and it reaches a very low level (signalled by blinking **Low oil level** lamp on the engine control room panel and at the bridge panel). The alarm should also be confirmed in the above mentioned way. In this case the pump must be switched off . Further work of the pump with no oil in it, may cause a pump damage (alarm **Overload** is activated). The work of the steering gear should be continued by switching on the second pump (if **Stand-by** button on the bridge panel was pressed, the second pump should switch over automatically but if **Stand-by** button was not pressed earlier the second pump should be run manually by means of **Remote drive switching** switch on the bridge).

In above mentioned situation switching on the second pump switches off the shut-off valve attached to the up-to now working pump and the shut-off valve belonging to starting-up pump is switched-on. The hydraulic circuit in which the failure occurred is disconnected (**Hyd. circuits separation** lamp is lighting).

4. Bridge control panel description - fig. 4.

The bridge signalling system ensures signalling of the following steering gear operation and failure modes:

- **Pump supply,**
- **Pump run,**
- **Failure,** means failure of supply system,
- **Overload** of pump electric motor,
- **Hyd. circuits separation** i.e. hydraulic circuits separation,
- **No phase,**
- **Low oil level,**
- **Hydraulic lock** of steering gear.

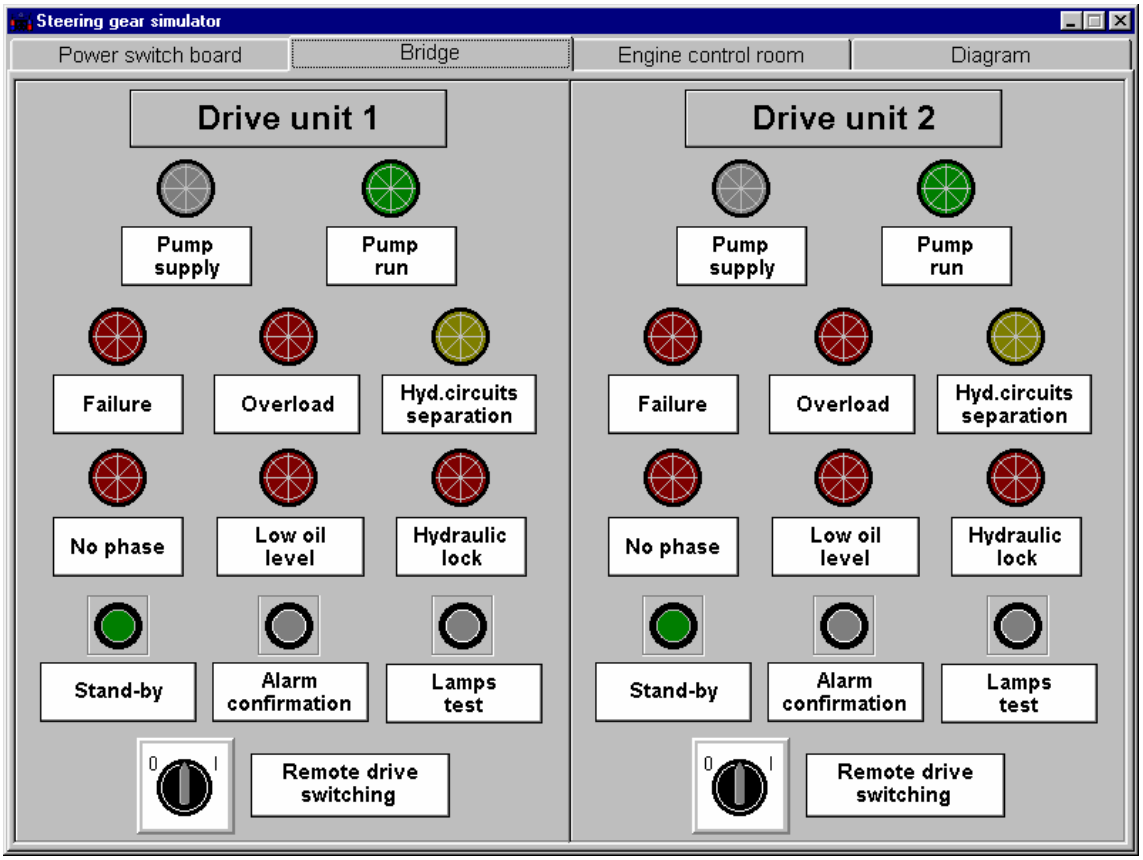

Fig. 4. Bridge control panel

In the lower part of this panel the following elements are situated:

- **Stand-by** button - is intended to allow the take over the work by the second drive unit,
- **Alarm confirmation** button,
- **Lamps test** button **-** to test the state of all lamps,
- **Remote drive switching** - it is self-aligning switch to switch pump on or off by remote way.

note:

The **Hydraulic lock** signalling detects the failure in the control system of each working pump. This signalling prevents the risk of the hydraulic lock occurring in the steering gear. Directional control primary valve of each drive unit is equipped with two limit switches signalling the extreme position of the directional control valve's slide. The signal on the position of the directional control valve's slide is sent to the signalling system, where it is compared with the voltage presence signal given on the directional control valve's coil. The lack of compatibility of these two signals after the time delay 3÷5 seconds switches on the failure signal. Failures are signalled for each pump separately either when one pump works or two pumps work simultaneously.

The failure signalled during the work of one pump makes it is necessary to switch it off on the bridge and to switch on the efficient one.

The failure signalled during the work of both pumps makes it necessary to switch off the pump with broken control system.

The failure conditions are signalled by the blinking lamps. After confirmation of the failure, they turn from flashing into continuous lighting. A successive failure in the other controlled group of parameters (although the cause of the previous failure has been not removed yet) activates the blinking light.
It is possible to simulate a „hydraulic lock" in the following way - one drive unit should be switched on in a remote way (Main switch - position I, Pump operation - position II, Remote control disconnection - position 0, Fan operation - position I and self-aligning switch should be on position I). The other drive unit should be switched on manually (Main switch - position I, Pump operation - position I, Remote control disconnection - position I, Fan operation - position II). Then, the slide of main directional control valve of this pump which was started manually should be shifted over by clicking and keeping the left mouse button on the active field of slide valve lever. This action should cause a „hydraulic lock" of steering gear.

5. Engine control room panel - fig. 5.

Engine control room signalling system ensures signalling of the following steering gear operation and failure modes:

- **Pump supply,**
- **Pump run,**
- **Failure,** means failure of supply system,
- **Overload** of pump electric motor,

- **No phase,**
- **Low oil level,**
- **Hydraulic lock** of steering gear.

In the lower part of this panel the following elements are situated:
- **Alarm confirmation** button,
- **Lamps test** button **-** to test all lamps condition,

The engine control room panel serves only to signal failure modes but is not possible to put into service any devices of the steering gear from this level.

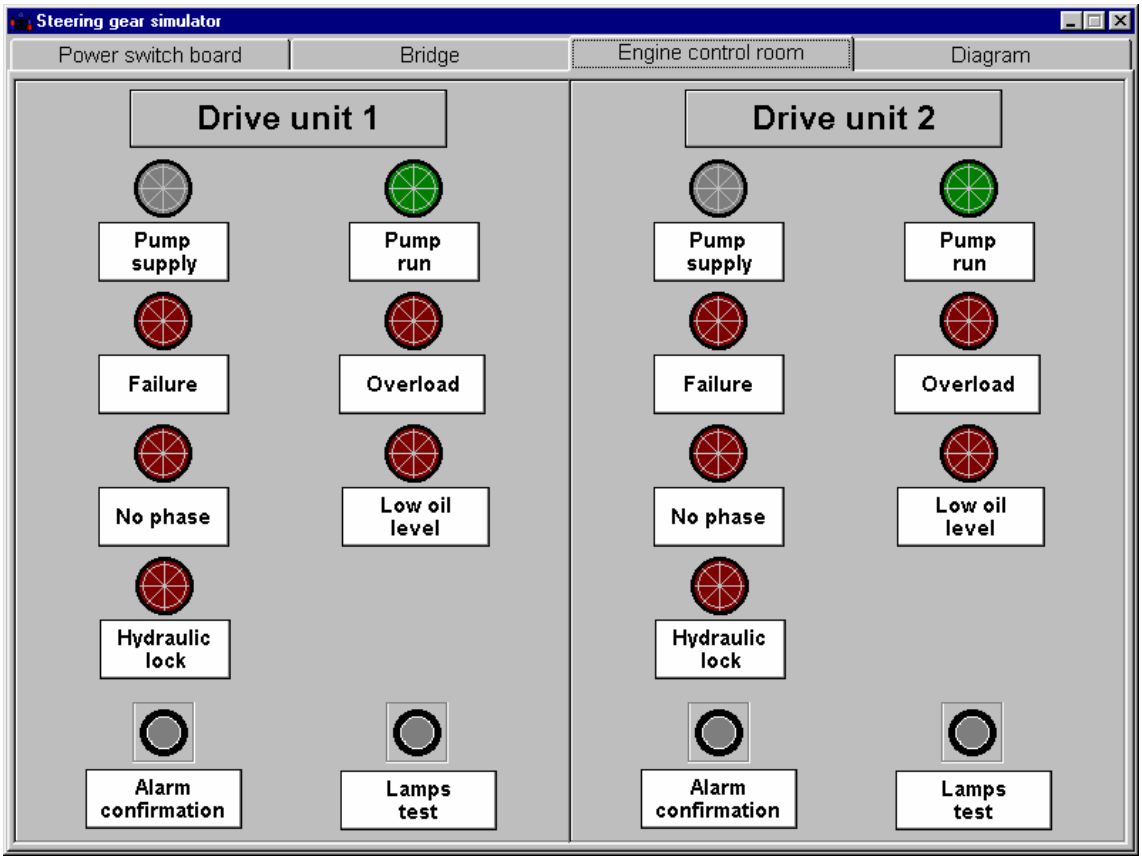

Fig. 5. Engine control room panel

6. Operating mode

The steering gear may operate in one of the following three operation modes during its exploitation:

a) **basic operation**: one pump works with two hydraulic cylinders. Pumps should be switched-over every 24 hours during exploitation according to the producer's advice;
b) **emergency operation** means that one pump works with one hydraulic cylinder attached to it;
c) **additional operation**, it is a special kind of steering gear operation: two pumps and two hydraulic cylinders operate simultaneously. Both pumps can work simultaneously in areas where the Maritime Administration Authorities require such kind of operation or during manoeuvres. In case of simultaneous operation of both pumps, rudder putting over time from α= -35° do α= +30° equals to half of the normal period of time.

NOTE:
The operation of two pumps with one cylinder IS NOT permissible !

Table 1. States of pumps, cylinders and valves during different kind of steering gear operation

Kind of operation	Operates (+ yes, – no)				Valves					
	Pump		cylinder		O-opened			C-closed		
	1	**2**	**29**	**30**	**21**	**23**	**22**	**24**	**19**	**20**
basic	+	–	+	+	O	C	O	C	O	O
	–	+	+	+	O	C	O	C	O	O
emergency	+	–	+	–	O	C	O	C	C	O
	–	+	–	+	O	C	O	C	O	C
additional	+	+	+	+	O	C	O	C	O	O

7. Steering gear controlling

Each of the pumps has its independent hydraulic and electrical control system. Setting adequate set rudder deflection value is performed by means of steering wheel (**follow-up control,** abbreviation **FU**). That sort of controlling in the simulator program is performed by clicking the appropriate arrow (red or green, depending whether the ship turns on the left –red arrow or the right side – green arrow) in the FU part (36) of the control column. One mouse clicking corresponds to approx. 2° of rudder deflection angle, while a series of clicking gives greater rudder deflection value. To keep the desired course of the ship it is necessary to hold the left mouse button continuously. Releasing this button causes return of set value into zero position. Rudder deflection set angle is visible on the rudder setting position indicator (35).

Other steering gear controlling way is **non-follow-up control**, with the abbreviation **NFU**. This kind of controlling is set up by the buttons of the control column NFU part (37) or by the control levers of the solenoid directional control valves (on Figure 1 - red and

green active lever). Both follow-up and non-follow-up control constitute a **remote** way of controlling.

In case of **local control** (by means of buttons or control levers of the solenoid directional control valves, from the steering gear room) it is required to disconnect the remote control circuit at the power switchboard (although remote control is normally efficient). **Remote control disconnection** switch should be set into position I. Actual rudder position is shown on indicator (38).

Control signal is sent from the control column. First, it is amplified and after amplification arrives to the control unit (34) - which also constitutes a comparison element. Then, the signal is directed to a given solenoid directional primary control valve depending on the manoeuvre to be performed. Deflection of rudder blade activates feedback circuit (33). The feedback circuit is mechanically attached to the rudder tiller. Thus, the signal is also sent from the feedback device to the comparison element. In the proper moment, the control unit causes the shutting off of the control primary valve voltage terminal. This shall cause idle running operation of the steering gear.

During follow-up control mode, the control signal is switched off when the feedback transmitter sends the signal indicating that the desired angle has been reached.

During non-follow-up control mode from the bridge or local control from the steering gear room, the control signal is switched off by a wheelman. By switching off the control signal, the slide of the primary control valve returns to the middle position due to spring operation, so the tiller stops.

8. Starting procedure

Switching on the steering gear for basic operation consists in switching any electric motor of the drive unit. In case the drive unit 1 is working for instance, the drive unit 2 should be on „stand-by" mode (push the button „stand-by" at the field of the drive unit 2 of the bridge control panel). This enables the functioning of the automatic system - in the event that any default occurs in the working drive unit, the drive unit in the „stand-by" mode shall start working automatically). This state of steering gear controlling is called **coupled work** and moreover it is optimal from the operational and safety point of view.

To put the steering gear into service the following duties should be performed:

- at the power switchboard of the drive unit 1:

1. Set up the **Main switch** into position **I** (the white lamp **Supply** lights up),
2. Set up **Pump operation** switch into position **II** (**Remote operation),**
3. Turn on **Remote control disconnection** switch into position **0**,
4. Switch **Fan operation** into position **I,**

- at the bridge control panel of drive unit 1:

5. Set up switch **Remote drive switching** into position **I** (the green lamp **Pump run** lights up),

- at the power switchboard of the drive unit 2:

6. Set up the **Main switch** into position **I** (the white lamp **Supply** lights up),
7. Set up **Pump operation** switch into position **II (Remote operation),**
8. Turn on **Remote control disconnection** switch into position **0,**
9. Switch **Fan operation** into position **I,**

- at the bridge control panel of drive unit 2:

10. Push the button **Stand-by** (the button lights up in blue colour).

Local steering gear starting procedure is shown below:

In this case the steering gear performs a basic operation by means of control levers of the solenoid control slide valve. This kind of steering gear switching on mode is used during the acceptance tests, overhauls or emergency situations. In order to put steering gear into operation, it is necessary:

- at the power switchboard of any drive unit :

1. Set up the **Main switch** into position **I** (the white lamp **Supply** lights up),
2. Turn on **Pump operation** switch into position **I (Local operation),**
3. Set up **Remote control disconnection** switch into position **I.**

9. Short-term stopping procedure (steering gear is still ready to operate)

This way of steering gear stopping procedure consists in switching-off both electric motors of drive units. The following operations should be effectuated:

- at the bridge control panel:

1. Turn on switch- **Remote drive switching** into position **0** (the green lamp **Pump run** is switched off).

10. Long-term stopping procedure (e.g. overhaul of steering gear)

This kind of steering gear stopping procedure consists in switching-off both working electric motors of drive units. In order to achieve it, the following operations should be carried-out:

- at the bridge control panel of working drive unit:

1. Turn on switch **Remote drive switching** into position 0 (the green lamp **Pump run** is switched off),

- at the power switchboard of working drive:

2. Set up **Pump operation** switch into position **0,**
3. Turn fan off (**Fan operation** switch should be into position **0**),
4. Set up the **Main switch** into position **0** (the white lamp **Supply** is switched off),
5. **Remote control disconnection** switch should be into position **I**.

VARIABLE DELIVERY PUMP STEERING GEAR SIMULATOR

1. General description.

The educational program VARIABLE DELIVERY PUMP STEERING GEAR SIMULATOR is intended for teaching the fundamental principles of how to operate this kind of steering gear.

This program consists of the following four parts:

- installation diagram,
- power switchboard panel,
- bridge control panel,
- engine control room panel.

When the program is running, the power switchboard panel is shown on the computer display. The choice of other panels is done by means of a cursor (it should be in the field of desired panel) and single clicking of the left right button.

2. Steering gear and installation description - fig. 1.

The steering gear (with the rudder) besides the main engine is one of the most important ship devices, it ensures the ship operational safety. This device performs the following two basic tasks:

- keeps right course of the ship,
- changes course of the ship in order to manoeuvre it.

The steering gear described in the program is an example of electro-hydraulic steering device i.e. drive of the rudder is performed in a hydraulic way while its movement of control is carried out in an electro-hydraulic way.

This steering gear consists of two hydraulic cylinders (39, 40) with two pistons inside which are defined as rudder actuator unit. The pistons affect the rudder tiller (37) by means of the strand assembly and the rudder tiller affects the rudder stock (36) directly. This action causes the movement of the rudder blade (the rudder blade is not visible on the Figure 1). The nominal pressure is equal to approx. 25 MPa and it is generated by two independent variable delivery pump drive units (1, 2). The high pressure of installation may be measured by pressure gauges (11, 12), by opening the manometer valves. During steering gear operation, manometer valves should be closed because of the risk of damage by high pressure in installation. The maximal pressure, which opens safety valves 13,14,15,16,33 and 34 equals to 31,5 MPa.

Steering gear is ready for work when one or both electric motors are put into operation.

The electric motor drives the main pump (1, 2) as well as auxiliary (boost) pump (3,4). The purpose of auxiliary pumps is to generate the proper control pressure, aprox. 1,8 MPa (this pressure is set by relief valve 17,18). In case when the control pressure created by auxiliary pump will be inadequate (low) the main variable delivery pump (connected with auxiliary pump by means of drive shaft 5,6) may work only in idle running operation .
Refilling and cooling of oil into hydraulic installation is realized only through an auxiliary pump. The oil is sucked from oil circulating tank 47 or 48 and supplied by pressure relief and boost inlet valves 13,15 (Pump no 1) or 14,16 (Pump no 2) to main pump close circuit (on the side of low pressure). The cooling process of oil overflow and leakage is realized through main pump housing and next through the flow to fan air/oil cooler.
The air oil cooler keeps appropriate oil temperature whereas the air/oil cooler fan is running when oil temperature achieves 40 °C.
Air oil cooler is stopped when the electric motor of appropriate drive unit is also stopped.
Then the oil flows through the return line oil filter (21 or 22) to the oil circulating tank (47 or 48).
In reality, the main variable delivery pump, auxiliary pump and servo-mechanism for flow direction and displacement control are fixed in the same housing..
From time to time, during steering gear exploitation a loss of oil may occur. Oil circulating tanks (47 or 48) are refilled by manually operated refilling pump (46). This operation is carried out by clicking the left mouse button at the active field above the pump. Obviously, all suitable valves should be opened earlier (depending on the fact which tank will be refilled).

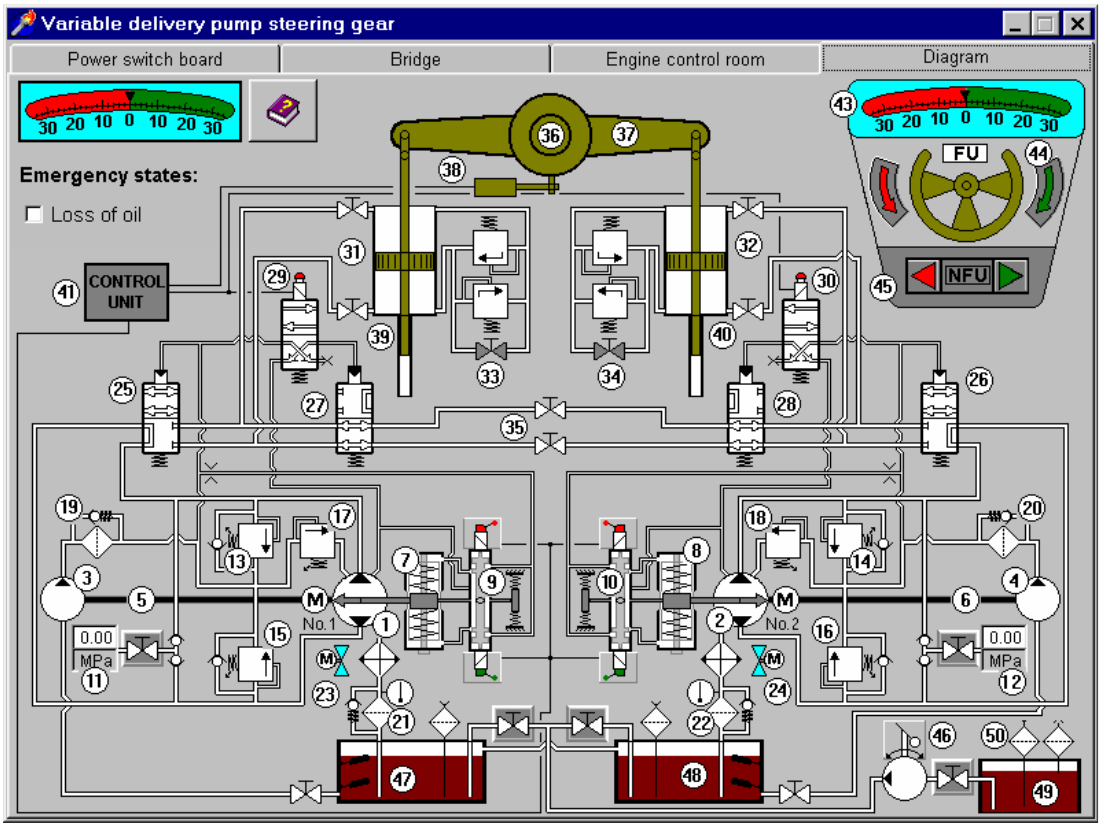

Fig. 1 Steering gear – installation diagram

Legend:

1, 2	Variable delivery main pump (axial piston pump)
3, 4	Auxiliary pump (boost pump)
5, 6	Drive shaft
7, 8	Servo-mechanism
9, 10	Proportional directional valves
11,12	Pressure gauge
13,14	Relief and boost inlet valve
15,16	Relief and boost inlet valve
17,18	Auxiliary pump relief valve
19,20	Auxiliary pump oil strainer
21,22	Return line oil filter
23,24	Fan air/oil cooler
25,26	Spring loaded, two position, directional valve
27,28	Spring loaded, two position, directional valve
29,30	Spring loaded, two position, solenoid directional valve

31,32 Manual shut-off valves
33,34 Safety valve block
35 Manual shut-off valves
36 Rudder stock
37 Rudder tiller
38 Feedback circuit
39,40 Cylinder with piston
41 Control unit
42 Rudder position indicator
43 Rudder setting position indicator
44 Follow-up control
45 Non-follow-up control
46 Manual operated refilling pump
47,48 Oil circulating tank
49 Oil storage tank
50 Pouring filter

The symbols used on the diagrams and the colours of the pipes are described in the LEGEND /fig. 2/.

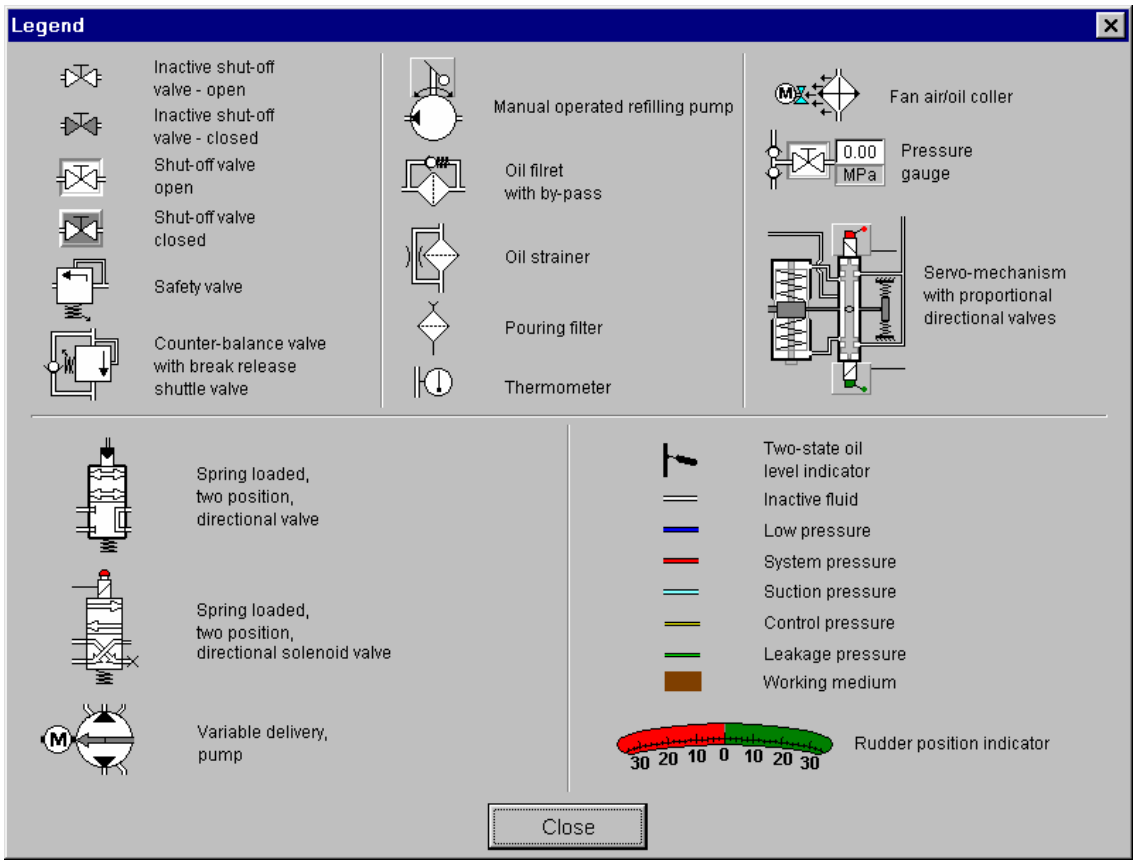

Fig. 2 Legend

3. Variable delivery pump description (fig. 3)

The steering gear main pumps are axial, multi-pistons type. Pump's delivery and flow direction are controlled by proportional directional slide valves.

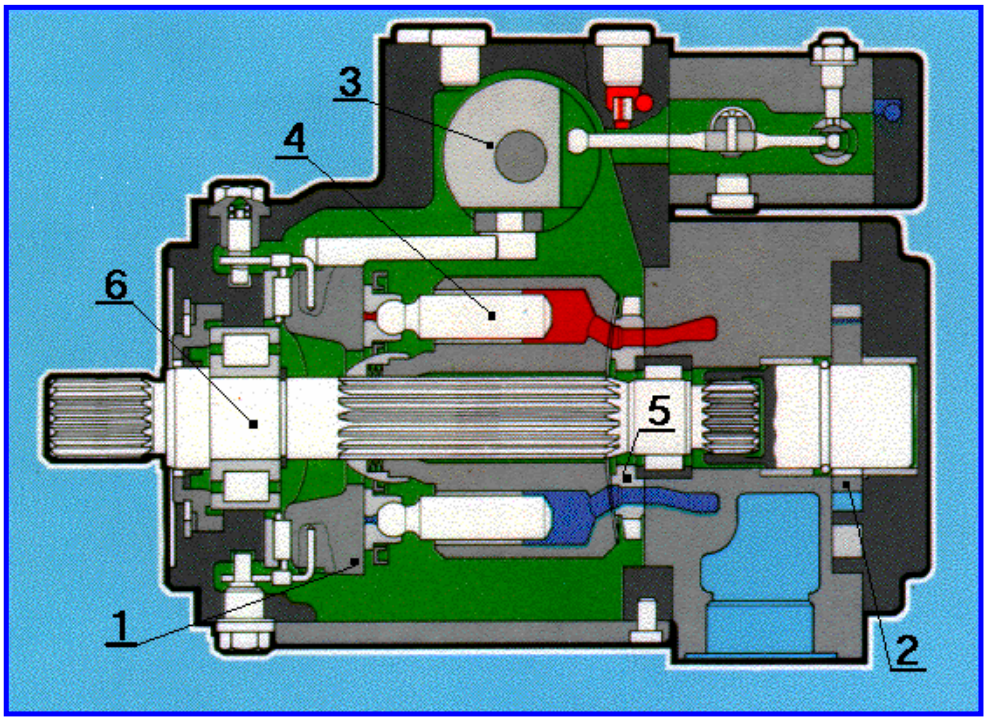

Fig. 3 Variable delivery axial pump cross-section

Legend:

1. Swash plate
2. Auxiliary (boost) pump
3. Control device (servo-mechanism)
4. Axial piston
5. Control plate
6. Drive shaft

Main pump functions in close hydraulic circuit i.e. working medium (oil) returning from receiver (main hydraulic cylinder) is conducted to the pump suction side.
Pump displacement is proportional to drive speed and swivel angle of control device.

An integral auxiliary pump serves as boost and pilot pump. The maximum boost pressure is limited by built-in pressure relief valve. Cross section of auxiliary pump is shown on fig. 4. Auxiliary pump is a gear with inner meshing type and is connected with main pump drive shaft by means of muff coupling.

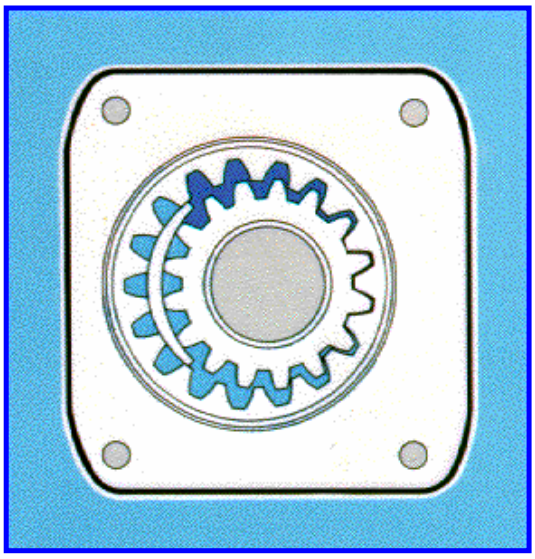

Fig. 4 Auxiliary pump cross- section

On Fig. 5 servo-mechanism of control device is presented. The main purpose of this device is pump delivery adjustment and flow direction control.
Altering the position of the control pistons alters the position of the swash plate, running on a roller bearing assembly and then it affects the swivel angle of the pump.

- Increasing the swivel angle increases the output flow of the pump
- Decreasing the swivel angle decreases the output flow of the pump

In central “0” position the pump flow is also zero.
Traversing the swash plate through the neutral position gradually reverses the direction of flow through the pump. Strong return springs hold the pump in neutral position if no external control signals are present. These springs also return the pump to neutral position if this signals fail for any reason. Maximum swivel angle is +/- 20º

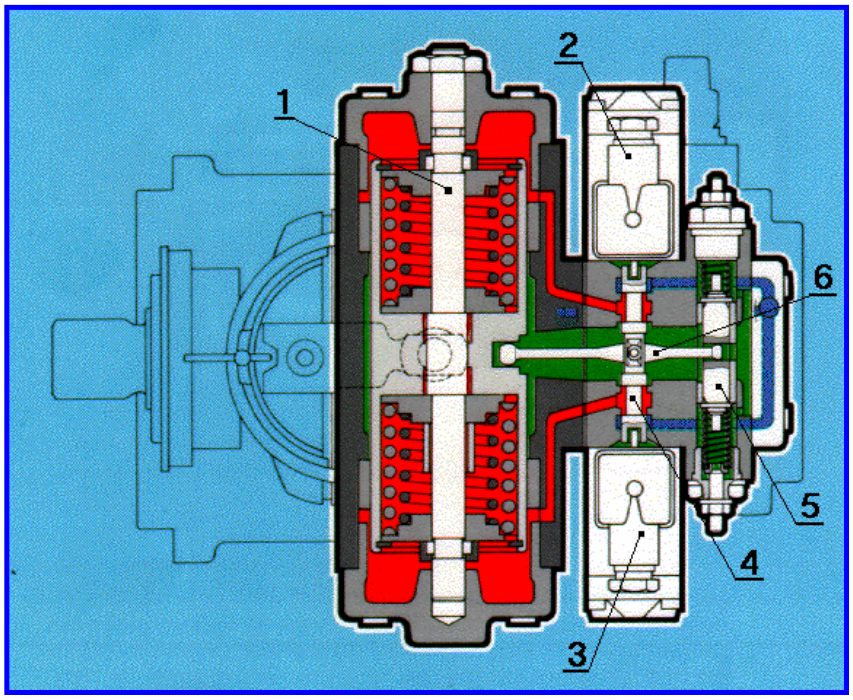

Fig. 5 Servo-mechanism of control device

Legend:

1 - positioning piston rod
2 ,3 - proportional solenoids
4 - proportional directional slide valves
5 - damping device
6 - lever

The pump is equipped with two pressure relief valves on the high pressure (fig. 6) ports. These valves protect the hydrostatic transmission (pump and motor) from overloads and also function as boost inlet valves. The oil flowing out from auxiliary boost relief valve is used to cool the pump housing.

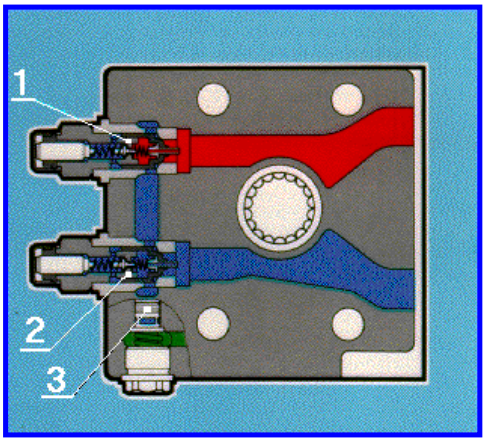

Fig. 6 Pressure relief and boost inlet valves

Legend:

1,2 - Main pump pressure relief and boost inlet valves
3 - Auxiliary pump pressure relief valve

In relation to the pre-selected current, control pressure is supplied to the positioning cylinder of the pump via two proportional solenoids. The displacement of the pump is thus gradually variable. One solenoid is assigned to each direction flow.
Operating curve of proportional solenoids is presented on fig. 7. In this case the maximum pump displacement (Vn) in achieved at current (I) equal to 600 mA . Displacement equals to zero when current is 200 mA. Displacement (V) will depend on the pre-selected current between 200-600 mA.

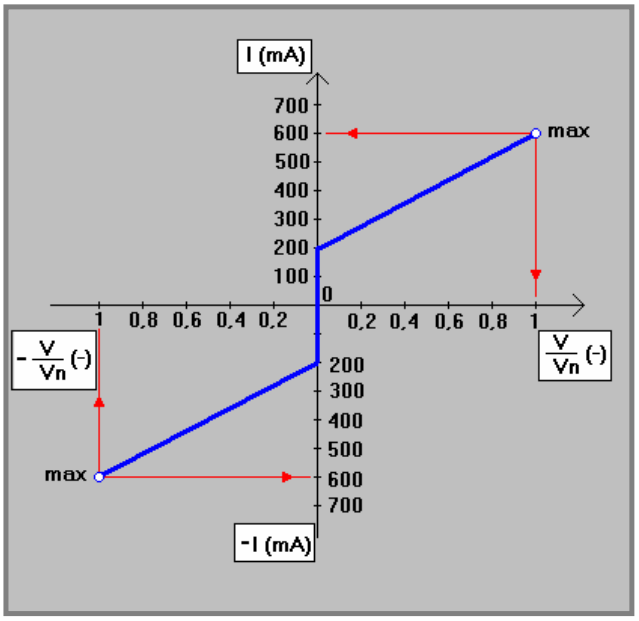

Fig. 7 Solenoid operating curve (displacement/current characteristic).

For better understanding the control device servo-mechanism functioning principles, it this necessary to take under consideration certain characteristic points A, B and C of this device. These are presented on fig. 8.

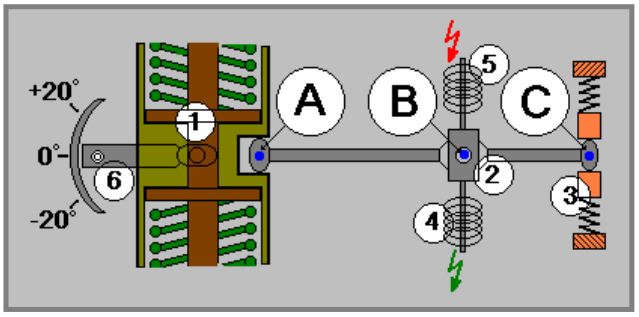

Fig. 8 Servo-mechanism diagram

Legend:

1 - Positioning piston
2 - Lever
3 - Damping element
4,5 - Proportional solenoids
6 - Swash plate

The case of pump displacement change caused by ship course alternation will be analysed. In this situation the adequate current will occur – for example on one of the solenoids (Pos.4 on fig. 8).
In consequence, the directional slide valve will move down and the control oil will flow to the lower cylinder of the servo-mechanism, thus moving the positioning piston up. This positioning piston movement will change swash plate angle, until the moment when differential signal of pre-selected ship course will be equal to real (actual) ship course.
In case when demanded ship course will be equal to real one, the control unit will cut current delivery to solenoid . Then the servo-mechanism positioning piston will return to its neutral position (swash plate angle will be equal to zero). Returning movement will be smoothed by damping element.
Successive phases of servo-mechanism lever movement are shown on fig. 9 to 11.

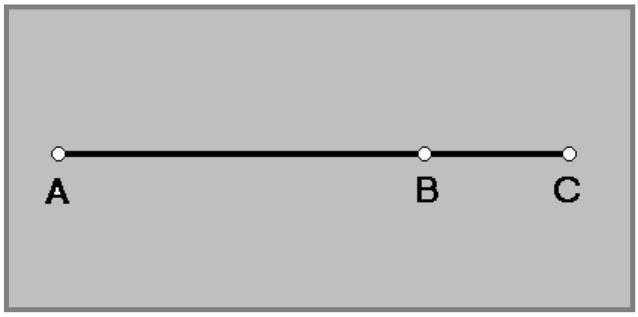

Fig. 9 Phase I - initial stage

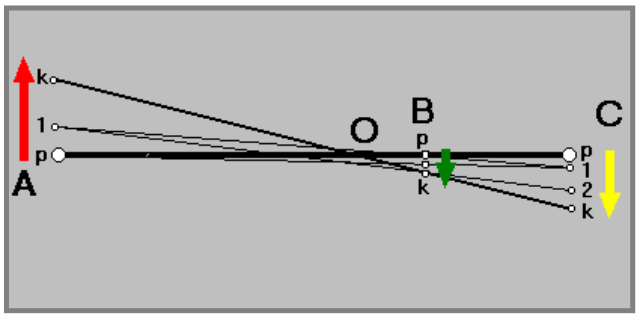

Fig. 10 Phase II – gradual displacement increase
(p – initial position, 1,2 – intermediate positions, k – final position, O – instantaneous
rotation centre)

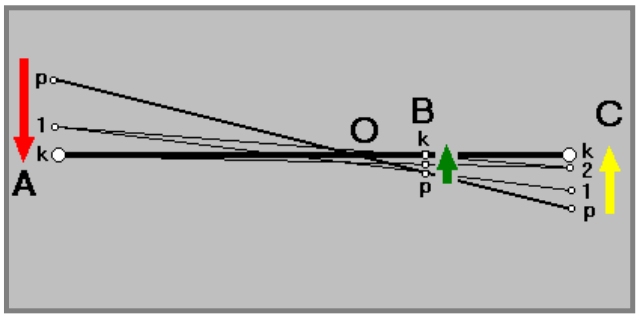

Fig. 11 Phase II - gradual displacement drop after control signal decay
(p – initial position, 1,2 – intermediate positions, k – final position, O – instantaneous
rotation centre)

4. Power switchboard panel description - fig. 12.

The electrical system of drive units consists of the following elements:

- two supply boxes,
- two supply boxes of oil cooler fan's motor.

Normally, these boxes are fixed separately on the ship's board. Taking into consideration the fact that all boxes of any drive unit are symmetric , they were placed together on one display and defined as "**Power switchboard panel**".

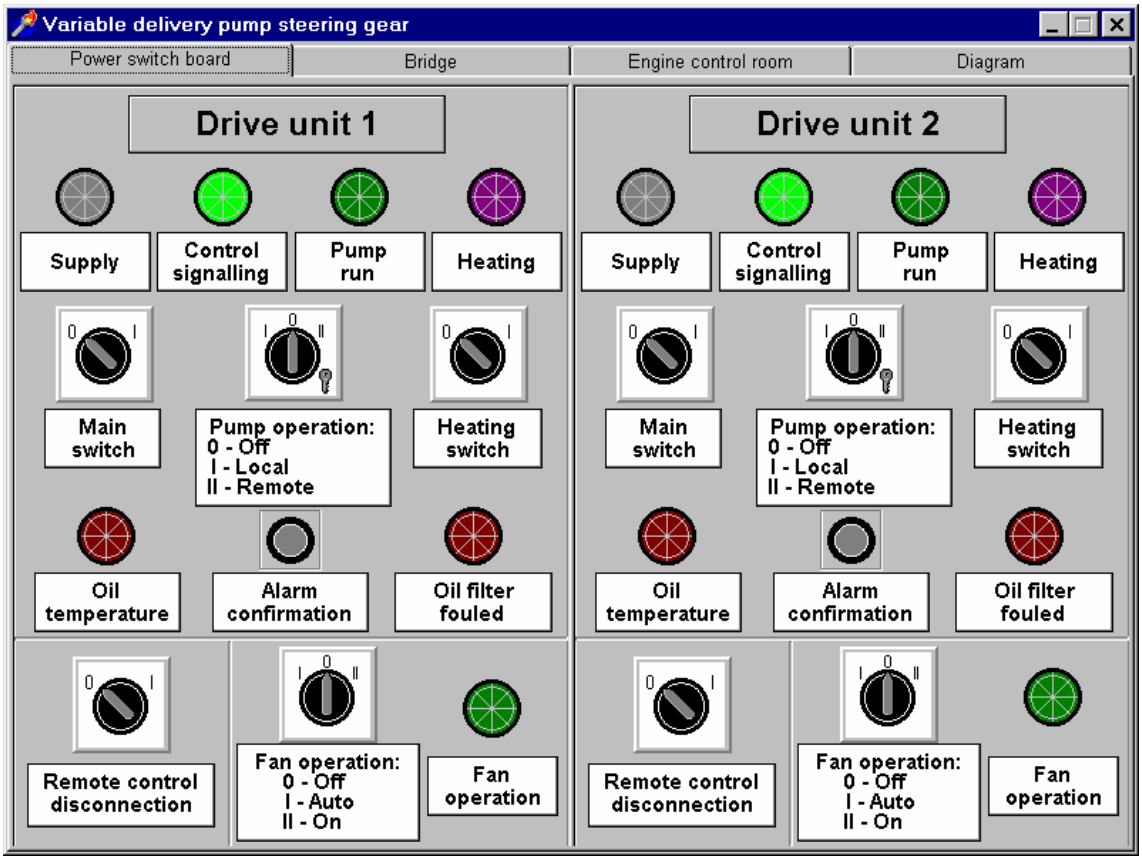

Fig. 12. Power switchboard panel.

The signalling lamps, switches and buttons located on the power switchboard panel are described below:

- **Main switch** - switches off current supply but it has no influence on signalling supply,
- **Pump operation** switch - it selects the kind of operation of drive unit. In reality this switch is blocked by means of special key (visible on Figure 12, only as an imitation). This protects the switch against the shifting into undesired position by unauthorized persons,
- **Heating switch** - switching it into position **I** causes heating of the switchboard attached to it and protects the switchboard against corrosion effect in areas with high humidity level in the air
- **Remote control disconnection** switch - it allows rudder remote control supply switch to be set off (position I),
- **Fan operation** switch - it selects the kind of fan operation.

Functioning of the signalling lamps:

- **Supply** - presence of voltage supply,
- **Control signalling** - presence of voltage supply for controlling,
- **Pump run** - drive unit is running,
- **Heating** - heater is working,
- **Oil temperature** - that means oil achieves high temperature,
- **Oil filter fouled** - oil filter is contaminated,
- **Fan operation** - fan is running.

The electrical drive system of steering gear also ensures separation of the main hydraulic circuits in case of failure (for e.g. oil leak) in one of the two circuits. The signal controlling the separation of the hydraulic circuits is obtained from the oil level sensors installed in the oil circulating tanks (47, 48). Each of the tanks has two oil level sensors (low and very low level sensor). The separation is carried by the solenoid directional control valve (29 or 30) attached to the given drive unit (1 or 2).

The action of a low oil level sensor switches-on the shut off valve attached to the working pump. In such a situation the damaged part of the hydraulic circuit is identified. This state is signalled by acoustic and flashing alarm and **Hyd. circuits separation** lamp will blink on the bridge panel. At the same time **Low oil level** lamp will be flashing in engine control room panel and at the bridge panel. All alarms should be acknowledged by means of **Alarm confirmation** button (lamps will be continuously flashing until removal of the damage). In case the oil level is still above the limit that activates the very low oil level sensor, the work of steering gear is maintained by the efficient part of hydraulic circuit. On the other hand, when the oil level is still dropping and it reaches a very low level it shall be signalled by blinking **Low oil level** lamp on the engine control room panel and at the bridge panel. The alarm should also be confirmed in the above mentioned way. In this case the pump must be switched off . Further work of the pump with no oil in it, may cause a pump damage (alarm **Overload** is activated). The work of the steering gear should be continued by

switching on the second pump (if **Stand-by** button on the bridge panel was pressed, the second pump should switch over automatically but if **Stand-by** button was not pressed earlier the second pump should be run manually by means of **Remote drive switching** switch on the bridge).

In the above mentioned situation switching on the second pump switches off the shut-off (directional) valve attached to the up-to now working pump. At the same time, the shut-off (directional) valve belonging to starting-up pump is switched-on. The hydraulic circuit in which the failure occurred is disconnected (**Hyd. circuits separation** lamp is lighting).

5. Bridge control panel description - fig. 13.

The bridge signalling system ensures signalling of the following steering gear operation and failure modes:

- **Pump supply,**
- **Pump run,**
- **Failure,** means failure of supply system,
- **Overload** of pump electric motor,
- **Hyd. circuits separation** i.e. hydraulic circuits separation,
- **No phase,**
- **Low oil level,**
- **Hydraulic lock** of steering gear.

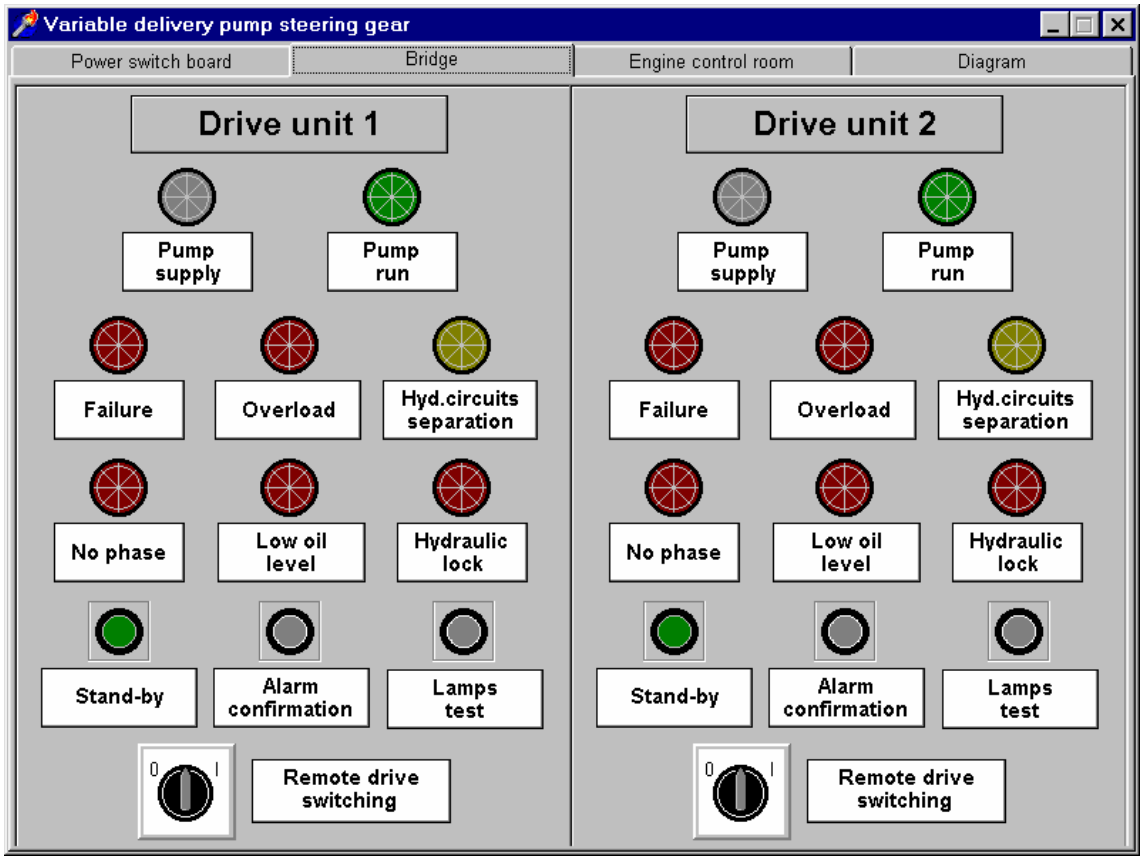

Fig. 13 Bridge control panel

In the lower part of this panel the following elements are situated:

- **Stand-by** button - is intended to allow the take over of the work by the second drive unit,
- **Alarm confirmation** button,
- **Lamps test** button **-** to test the state of all lamps,
- **Remote drive switching** – is indented for main pump remote switching from the bridge

Note:

The **Hydraulic lock** signalling detects the failure in the control system of each working pump. This signalling prevents the risk of hydraulic lock occurring in the steering gear. Directional control primary valve of each drive unit is equipped with two limit switches signalling the extreme position of the rotary swash plate angle. The signal on the position of the rotary swash plate is sent to the signalling system,

where it is compared with the voltage presence signal given on the directional control valve's coil. The lack of compatibility of these two signals after the time delay of 3÷5 seconds switches on the failure signal. Failures are signalled for each pump separately either when one pump works or two pumps work simultaneously.

The failure signalled during the work of one pump makes it is necessary to switch it off on the bridge and to switch on the efficient one.

The failure signalled during the work of both pumps makes it necessary to switch off the pump with a failure of control system.

The failure state is signalled by blinking lamps. After confirmation of the failure, they turn from flashing into continuous lighting. A successive failure in the other controlled group of parameters (although the cause of the previous failure has not been removed yet) activates the blinking light.
It is possible to simulate a „hydraulic lock" in the following way - one drive unit should be switched on in a remote way (**Main switch** - position **I**, **Pump operation** - position **II**, **Remote control disconnection** - position **0**, **Fan operation** - position **I** and **Remote drive switching** switch should be on position I). The other drive unit should be switched on manually (**Main switch** - position I, **Pump operation** - position I, **Remote control disconnection** - position **I**, **Fan operation** - position II). Then, the proportional directional valve of this pump which was started manually should be shifted over by clicking and keeping the left mouse button on the active field of manual valve lever. This action should cause a „hydraulic lock" of steering gear.

6. Engine control room panel - fig. 14.

Engine control room signalling system ensures signalling of the following steering gear operation and failure modes:

- **Pump supply,**
- **Pump run,**
- **Failure,** means failure of supply system,
- **Overload** of pump electric motor,
- **No phase,**
- **Low oil level,**
- **Hydraulic lock** of steering gear.

In the lower part of this panel the following elements are situated:
- **Alarm confirmation** button,
- **Lamps test** button **-** to test all lamps condition,

The engine control room panel serves only to signal failure modes but is not possible to put into service any devices of the steering gear from this level.

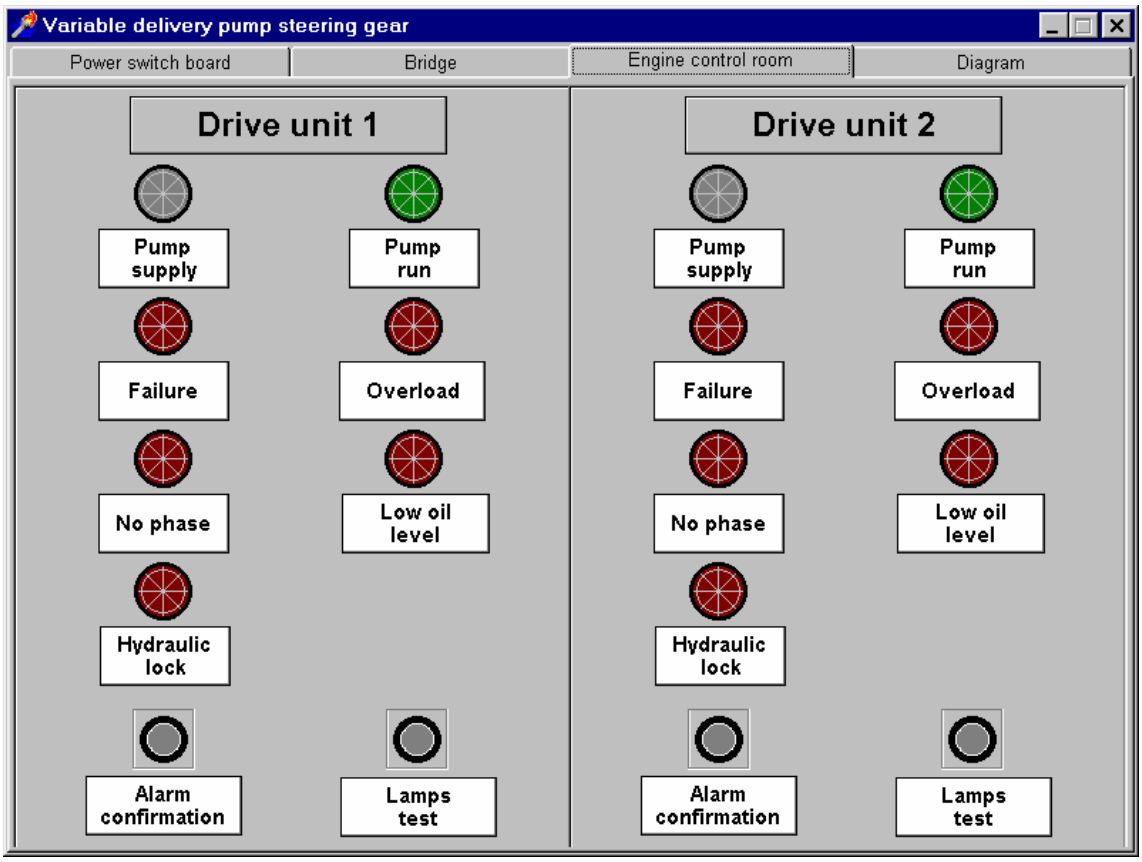

Fig. 14 Engine control room panel

7. Operating mode

The steering gear may operate in one of the following three operation modes during its exploitation:

a) **basic operation**: one pump works with two hydraulic cylinders. Pumps should be
switched-over every 24 hours during exploitation according to the producer's advice;

b) **emergency operation** means that one pump works with one hydraulic cylinder attached to it;

c) **additional operation**, it is a special kind of steering gear operation: two pumps and two hydraulic cylinders operate simultaneously. Both pumps can work simultaneously in areas where the Maritime Administration Authorities require such kind of operation or during manoeuvres. In case of simultaneous operation of both pumps, rudder putting over time from α= -35° do α= +30° equals to half of the normal period of time.

NOTE:
The operation of two pumps with one cylinder IS NOT permissible !

Table 1. Status of pumps, cylinders and valves during different kind of steering gear operation (see fig. 1)

Type Of Operation	Operates (+ yes, – no)				Valves					
	Pump		cylinder		O-opened			C-closed		
	1	**2**	**39**	**40**	**31**	**33**	**32**	**34**	**29**	**30**
Basic	+	–	+	+	O	C	O	C	O	O
	–	+	+	+	O	C	O	C	O	O
emergency	+	–	+	–	O	C	O	C	C	O
	–	+	–	+	O	C	O	C	O	C
additional	+	+	+	+	O	C	O	C	O	O

8. Steering gear controlling

Each of the pumps has its independent hydraulic and electrical control system. Setting adequate value of angle rudder is performed by means of steering wheel (**follow-up control,** abbreviation **FU**). That sort of controlling in the simulator program is performed by clicking the appropriate arrow (red or green, depending whether the ship turns on the left – red arrow or the right side – green arrow) in the FU area (pos.44 on fig.1)) of the control column. One mouse clicking corresponds to approx. 2° of rudder deflection angle, while a series of clicking gives greater rudder deflection value. To keep the desired course of the ship it is necessary to hold the left mouse button continuously. Releasing this button causes return of set value into zero position. Rudder deflection set angle is visible on the rudder setting position indicator (pos. 43 on fig.1).

Other steering gear controlling way is **non-follow-up control**, with the abbreviation **NFU**. This kind of controlling is set up by the buttons of the control column area marked as NFU (pos.45 on Fig.1) or by the control levers of the solenoid directional control valves (pos. 9 or 10 on Fig. 1 - red and green active lever). Both follow-up and non-follow-up control constitute a **remote** way of controlling.

In case of **local control** (by means of buttons or manually through control levers of the solenoid proportional directional valves, from the steering gear room) it is required to disconnect the remote control circuit at the power switchboard. **Remote control disconnection** switch should be set into position **I**. Actual rudder position is shown on indicator (pos. 42 on Fig.1).

Control signal is sent from the control column on the bridge. First, it is amplified and after amplification arrives to the control unit (pos. 41 on Fig.1) - which also constitutes a comparison element. Then, the signal is directed to a given proportional solenoid (pos.9 or 10 on Fig.1) depending on the manoeuvre to be performed. Deflection of rudder blade activates feedback circuit (pos.38 on Fig 1). The feedback circuit is mechanically attached to the rudder tiller. Thus, the signal is sent from the feedback device to the comparison element. At the proper moment, the control unit causes the shutting off of the current delivery to solenoid. This shall cause idle running operation of the main pump .

During follow-up control mode, the control signal is switched off when the feedback transmitter sends the signal indicating that the desired angle has been reached.

During non-follow-up control mode from the bridge or local control from the steering gear room, the control signal is switched off by a wheelman. By switching off the control signal, the slide directional valve returns to the middle position due to spring operation, so the tiller stops.

9. Starting procedure

Switching on the steering gear for basic operation consists in switching any electric motor of the drive unit. In case the drive unit 1 is working, for instance, the drive unit 2 should be on „stand-by" mode (push the button „**stand-by**" at the field of the drive unit 2 of the bridge control panel). This enables the functioning of the automatic system - in the event that any failure occurs in the working drive unit, the drive unit in the „**stand-by**" mode shall start working automatically). This state of steering gear controlling is called **coupled work** and moreover it is optimal from the operational and safety point of view.

To put the steering gear into service the following duties should be performed:

- at the power switchboard of the drive unit 1:

1. Set up the **Main switch** into position **I** (the white lamp **Supply** lights up),
2. Set up **Pump operation** switch into position **II** (**Remote operation),**
3. Turn on **Remote control disconnection** switch into position **0**,
4. Switch **Fan operation** into position **I,**

- at the bridge control panel of drive unit 1:

5. Set up switch **Remote drive switching** into position **I** (the green lamp **Pump run** lights up),

- at the power switchboard of the drive unit 2:

6. Set up the **Main switch** into position **I** (the white lamp **Supply** lights up),
7. Set up **Pump operation** switch into position **II (Remote operation),**
8. Turn on **Remote control disconnection** switch into position **0,**
9. Switch **Fan operation** into position **I,**

- at the bridge control panel of drive unit 2:

10. Push the button **Stand-by** (the button lights up in blue colour).

Local steering gear starting procedure is shown below:

In this case the steering gear functions in basic operation mode by means of control levers of the solenoid directional slide valve. This kind of steering gear switching on mode is used during the acceptance tests, overhauls or emergency situations. In order to put steering gear into operation, it is necessary:

- at the power switchboard of any drive unit :

1. Set up the **Main switch** into position **I** (the white lamp **Supply** lights up),
2. Turn on **Pump operation** switch into position **I (Local operation),**
3. Set up **Remote control disconnection** switch into position **I.**

10. Short-term stopping procedure (steering gear is still ready to operate)

This way of steering gear stopping procedure consists in switching-off both electric motors of drive units. The following operations should be effectuated:

- at the bridge control panel:

1. Turn on switch- **Remote drive switching** into position **0** (the green lamp **Pump run** is switched off).

11. Long-term stopping procedure (e.g. overhaul of steering gear)

This kind of steering gear stopping procedure consists in switching-off both working electric motors of drive units. In order to achieve it, the following operations should be carried-out:

- at the bridge control panel of working drive unit:

2. Turn on switch **Remote drive switching** into position 0 (the green lamp **Pump run** is switched off),

- at the power switchboard of working drive:

2. Set up **Pump operation** switch into position **0,**
3. Turn fan off (**Fan operation** switch should be into position **0**),
4. Set up the **Main switch** into position **0** (the white lamp **Supply** is switched off),
5. **Remote control disconnection** switch should be into position **I**.

OILY WATER SEPARATOR

1. General description

The OILY WATER SEPARATOR – training simulator is designated for learning the essential principles of the marine oil separation plant maintenance.

The program is based on typical marine oily water separator using the coalescing plate pack principle of separation.

The program consists of the following two parts:

- control panel
- installation diagram

The choice of the appropriate part of the program is done by mouse clicking at the strip in the upper part of the screen.

Application

The main purpose for installing the plant on the ship is to guard the coastal sea water and other water areas protected by MARPOL Convention or the other regulations against oil pollution from overboard discharge of bilges and ballast, by limiting the maximum amount of oil in the discharge water to 15 parts per million (p.p.m).

This oily water separator can be mounted on ship of unlimited cruising area and is running in full automatic mode.

Another benefit is the further use of the recovered oil collected by the process.

Working principle

The oily water separation system is a combination of a gravity separator with integrated coalescer.

The fabricated steel vessel contains a multi-stage corrugated plate pack, the plates being vertical. One positive displacement pump is mounted on the unit with a control panel fitted at the inlet end. Two capacitance probes are fitted to detect the oil level in the oil chamber and to control the pump to give fully automatic operation. A third probe is fitted close to the water outlet to prevent oil discharge due to a fault.

Oily water mixture is drawn into the separator where the majority of oil separates in the gravity stage of the oil chamber where it rises and collects. The water pump draws the liquid through the plate pack which encourages the remaining oil droplets to coalesce and

rise through the pack, eventually to the oil chamber. Clean water is drawn from the rear end of the unit into the water pump to an overboard discharge connection..

A 15 p.p.m oil content bilge alarm is fitted with the separator to satisfy the legislation requirements, wired to prevent any discharge above 15 p.p.m.

Main components

The basic element of the plant is the fabricated steel vessel divided into following two chambers (fig. 1):

- oil chamber (I)
- coalescing pack chamber (II)

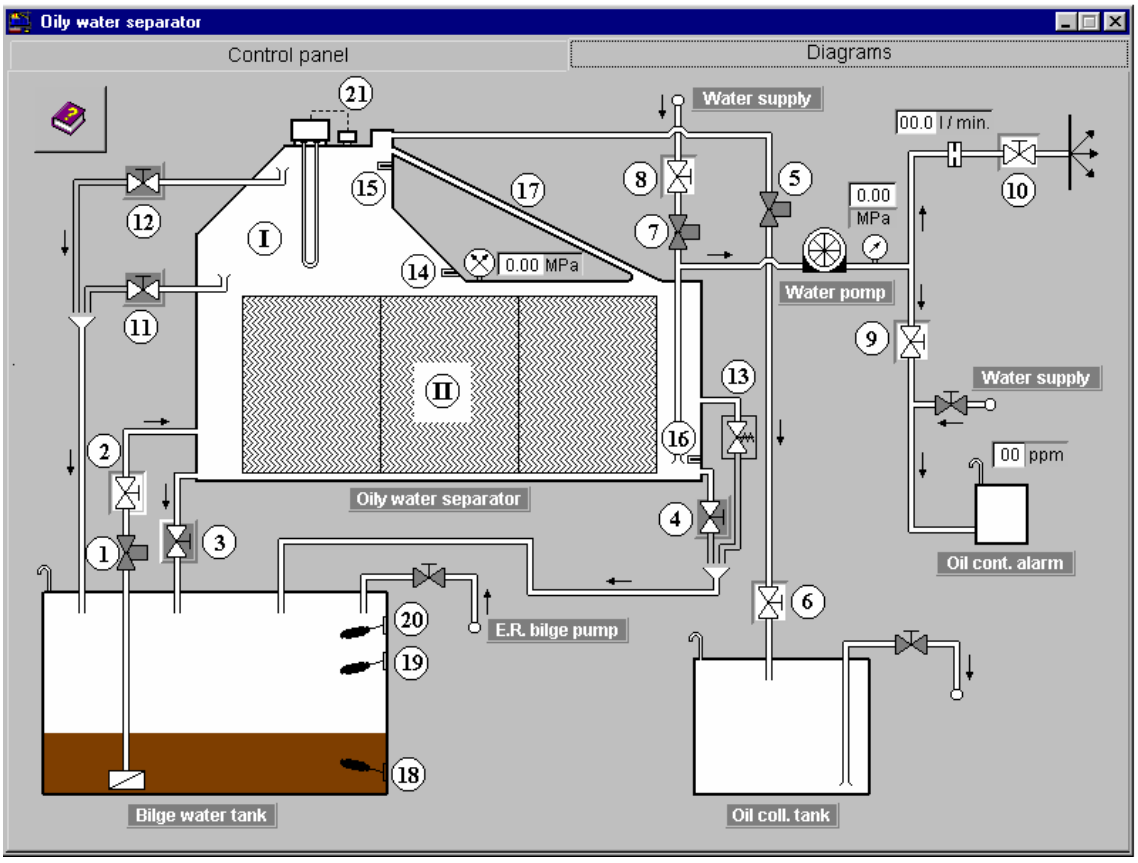

Fig. 1 Oily water separator installation

Legend:

I – Oil chamber
II – Coalescing plate pack chamber
1. Bilge solenoid valve
2. Oily water inlet valve
3. Drain & sludge outlet valve
4. Sample drain valve
5. Oil outlet solenoid valve
6. Oil outlet valve
7. Clean water inlet solenoid valve
8. Clean water inlet valve
9. Water inlet valve to oil alarm monitor
10. Overboard valve
11. Oil check valve
12. Oil check valve
13. Pressure relief valve
14. Lower oil probe
15. Upper oil probe
16. Alarm oil probe
17. Oil pipeline
18. Float switch – low level
19. Float switch – high level
20. Float switch – alarm high level
21. Heater with float switch

Graphic symbols which are used on the installation diagram are described in the legend (fig.2)

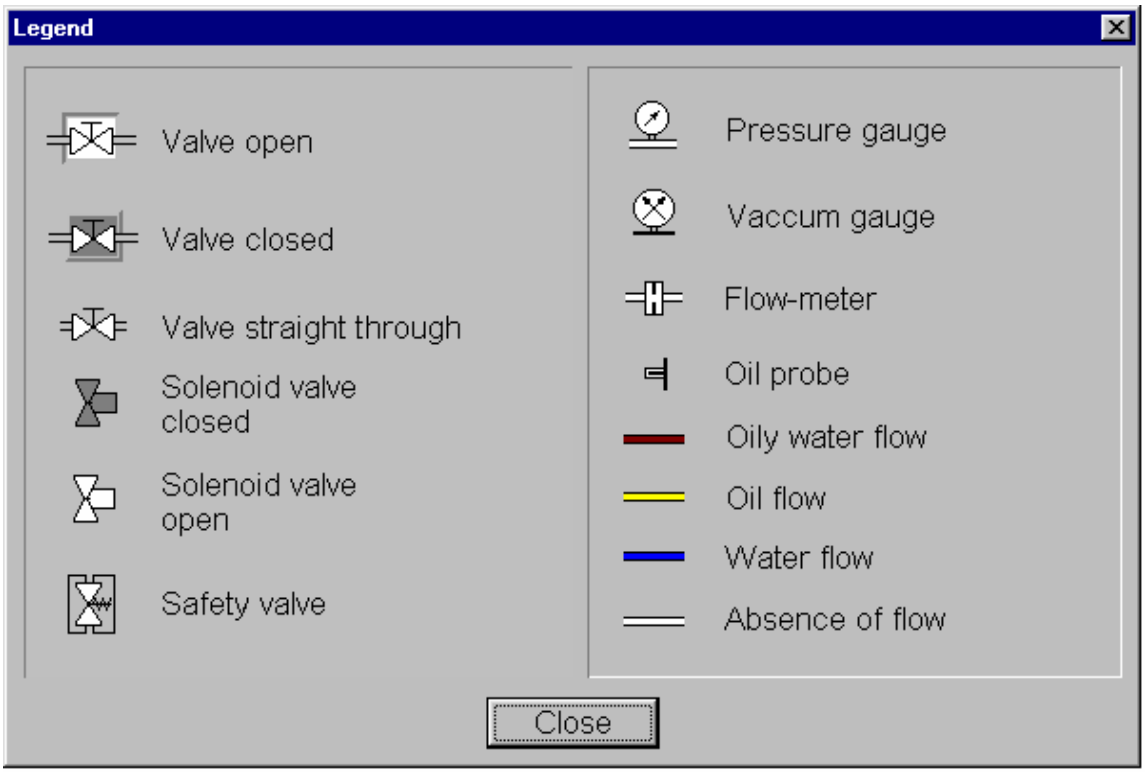

Fig. 2 Legend

Control panel

The control panel (fig. 3) contains:

- Main switch with control lamp " Supply"
- Switch "Control mode" (I – Manual, II – Auto)
- Switch "Manual control" (I – Water pump, II – Oil/water solenoids, 0 – Off)
- Switch "Heater (I – On, 0– Off)
- Push-button "Lamps control"
- Push-button "Alarm confirmation"
- Push-buttons "Reset"
- Alarm lamps: "Alarm oil level"
  " Alarm oil level - outlet"
  " Bilge water tank alarm level"
- Control lamps: " Water pump run"

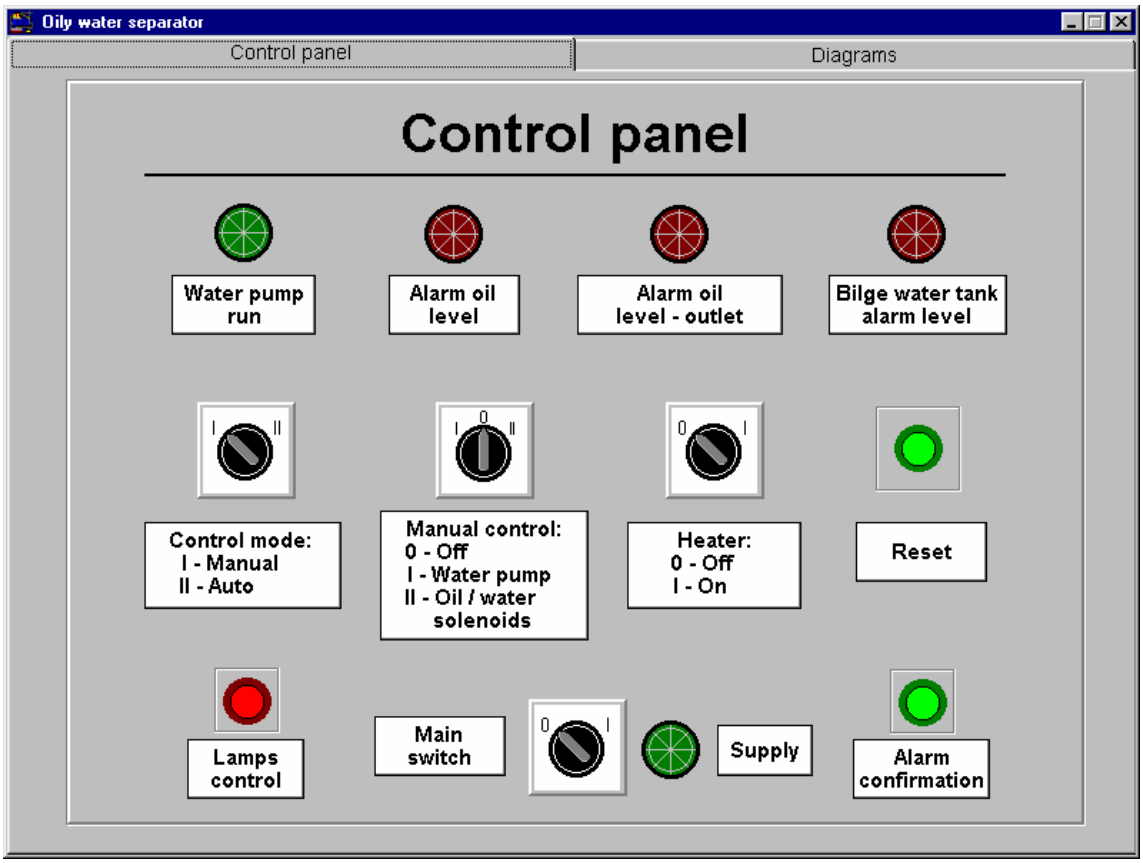

Fig. 3 Control panel

2. Operating instructions

Preparation for starting the plant

1. Open valves 2, 6, 8, 9 and 10
   Attention: After the program starting the valves 2, 6, 8, 9 and 10 are open – the valves 3, 4, 11 and 12 are closed (separator is empty).
2. Switch „ Control mode" on „ II - Auto"
3. Switch „ Heater" on „0 - Off"
4. Switch „ Manual control" on „0 - Off "

5. Set „Main switch" on „ I " . The following signal lamp shall now light:
   - „ Supply"
   - „Alarm oil level"
   - „ Alarm oil level - outlet"

   Push the button „ Alarm confirmation"
6. Push the button „Lamps control" in order to check whether all signal lamps are in good condition.
7. Fill up the chambers with water by pressing push-button „Reset". For filling up both sea water and fresh water can be used. During filling up procedure the solenoid valves 5 and 7 are open and signal lamps „Alarm oil level - outlet" and later „ Alarm oil level „shall turn-off. The filling-up procedure ends when the water reaches the level of upper oil probe 15. Solenoid valve 5 and 7 will keep closed position..

Starting the plant

1. Press again push-button „Reset" for plant starting. Solenoid valve 1 opens and water pump starts - separation process begins.
2. The heater 21 needs only to be switched on when very heavy oils are in the unit, being difficult and slow to discharge.

Automatic control functioning

When oil covers the lower probe 14, the water pump stops, the bilge solenoid valve 1 is closed and the water inlet and oil/air discharge valves 5 and 7 are open to discharge the oil/air. When the upper probe 15 again senses water the bilge solenoid valve 1 opens, the oil/air 5 and water inlet 7 valves close and water pump starts. This sequence will continue automatically when controlled by a high 19 and low 18 float switches in the bilge water tank.
The air drawn into the unit will be vented via the oil discharge line.

Manual control

Changing over the plant operation into manual control mode is made by setting the switch „Control mode" into position „ I – Manual".
In the manual control mode the following actions can be actuated:
a) Water discharging by setting switch „Manual control" in „I -Water pump;": position
b) Oil discharging by setting switch „ Manual control" in „II – Oil/water solenoids" position.

BIOLOGICAL SEWAGE TREATMENT PLANT

1. General description

The BIOLOGICAL SEWAGE TREATMENT PLANT – training simulator is designated for learning the essential principles of the marine sewage treatment plant maintenance. The program is based on typical marine sewage treatment plants, type LK 30 A, produced by Pomeranian Ship Equipment Works –WARMA – Poland.

The program consists of two parts, as follows:

- control panel
- installation diagram

The choice of the appropriate part of the program is done by mouse clicking at the strip in the upper part of the screen.

Application

The main purpose for installing the plant on the ship is to guard the coastal sea water and other water areas protected by MARPOL Convention or other regulations against pollution by sewage.

The sewage treatment plant of the type LK is designated for neutralisation of faecal matter and sanitary sewage arising on ships. According to the MARPOL Convention, faecal matter is named “black sewage” while the sanitary sewage is named “grey sewage”.

This sewage treatment plant can be mounted on ship of unlimited cruising area and is running in a full automatic mode.

Working principle

For its operation, the LK 30 A sewage treatment plant utilises the natural biological process of faecal matter decomposition by aerobic bacteria. The sewage is aerated in the activated sludge chamber and then transferred into the setting tank. The setting collected in this chamber as well as the surface scum are recirculated for additional decomposition into the activated sludge chamber. The purified sludge is directed into the chlorination chamber for disinfection.

The sanitary sewage (”grey” sewage) is fed directly into this chamber. The disinfection is realised by means of a sodium hypochlorite solution (NaOCl). The ship should be equipped with separate piping system for both, faecal and sanitary sewage.

Main components

The basic element of the plant is the body made with steel sheets, divided into the following four chambers (fig. 1):

- preliminary chamber (I)
- activated sludge chamber (II)
- sedimentation chamber (III)
- chlorinating chamber (IV)

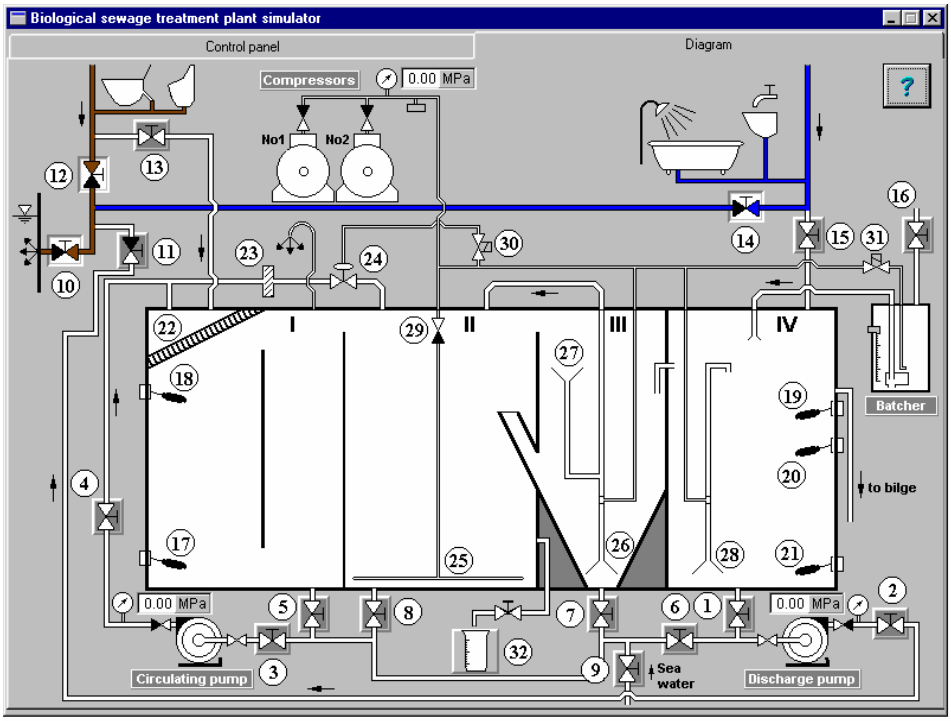

Fig. 1 Sewage treatment plant – installation diagram

Legend:

I. Preliminary chamber
II. Activated sludge chamber
III. Sedimentation chamber
IV. Chlorinating chamber
1. Valve - outlet from chlorination chamber
2. Valve - discharge pump outlet
3. Valve - circulating pump inlet
4. Valve - circulating pump outlet

5. Valve - outlet from preliminary chamber
6. Valve - discharge pump inlet
7. Valve - outlet from sedimentation chamber
8. Valve - outlet from activated sludge chamber
9. Valve - sea water inlet
10. Valve - „black" sewage overboard
11. Valve - discharge pump outlet
12. Valve - „black" sewage outlet
13. Valve - „black" sewage inlet to preliminary chamber
14. Valve - „grey" sewage outlet
15. Valve - „grey" sewage inlet to chlorinating chamber
16. Valve - batcher refilling
17. Float switch – low level in preliminary chamber
18. Float switch – high level in preliminary chamber
19. Float switch – emergency level in chlorinating chamber
20. Float switch – high level in chlorinating chamber
21. Float switch – low level in chlorinating chamber
22. Grate
23. Strainer
24. Diaphragm valve
25. Aerating nozzles
26. Air ejector - sedimentation chamber
27. Funnel
28. Air ejector - chlorinating chamber
29. Non-return valve
30. Solenoid valve – controlling diaphragm valve
31. Solenoid valve – for dosing NaOCl-solution
32. Beaker

Graphic symbols which are used on the installation diagram are described in legend (fig.2)

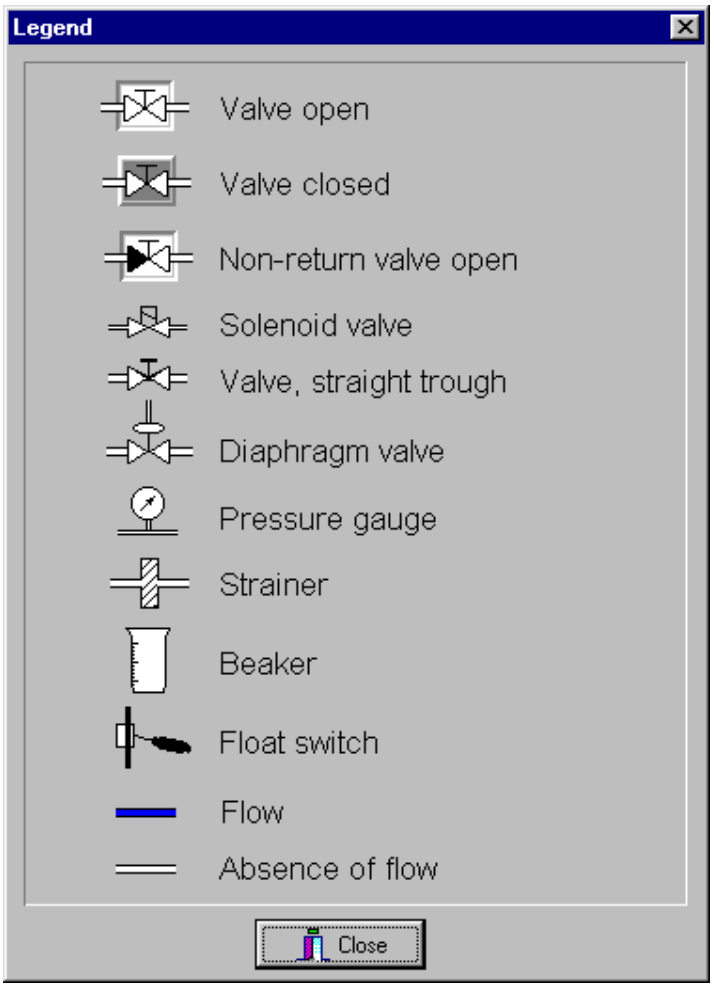

Fig. 2 Legend

Preliminary chamber (I)

The task of the preliminary chamber is to collect sewage supplied for biological treatment. The sewage flows from the ship's sewage system due to gravitation. The preliminary chamber fulfils the function of a storage reservoir and protects the plant against overloading during the period of maximum inflow, as well as against insufficient loading during the period with low sewage formation. The sewage flows to the preliminary chamber through the grate 22, where greater particles are caught. The grate is continuously flushed with the sewage supplied by the circulating pump. Because of this, the size of the particles collected on the grade is reduced. The preliminary chamber is equipped with two float switches: the

lower one 17 and upper one 18. These gauges indicate and control the low and high level of sewage in the preliminary chamber by switching on/off the circulating pump. At the top of the chamber the outlet for plant venting is located.

Activated sludge chamber (II)

The activated sludge chamber – also known as the aerating chamber –constitutes the main element in the chain of the biological processes, taking place in a biological sewage treatment plant.
The sewage is supplied in cycles by the circulating pump from the preliminary chamber through the strainer 23 and a diaphragm valve 24 into to biological treatment chamber. On the bottom of the chamber, aerating nozzles 25 are installed, which are supplied by compressed air from the compressor No1 or No2. Organic substances in the sewage absorb oxygen from the air supplied. Process of reducing the impurities takes place here. Organic substances are absorbed by aerobic bacteria, which in the shape of flocculates are mixed with the sewage by flowing up bubbles of air.

Sedimentation chamber (III)

The sedimentation chamber is composed of an upper, cylindrical shaped part and a conical bottom. In the cylindrical part are located the baffles mounted for minimising the effect of ship rolling on the sedimentation process occurring in this chamber. The solid-state matter settled in the conical part of the chamber is turned back by an ejector 26 into the foregoing activated sludge chamber. The surface scum is collected by a floating funnel 27 and also turned back to the activated sludge chamber. The air necessary to ejector propulsion is supplied by the same compressor that delivers the air to the activated sludge chamber. The inflow as well as the outflow of the sewage into and out of the sedimentation chamber is forced by gravitation.

Chlorinating chamber (IV)

The chlorinating chamber is destined for disinfecting the purified sewage, mainly to reduce Coli titre. The disinfecting of the sewage takes place under the influence of sodium hypochlorite, supplied in definite doses in cycles by the batcher into the chlorinating chamber. A pneumatic system with ejector 28 serves for mixing the disinfecting solution. The chlorinating chamber is provided with three float switches. The switch 20 starts the discharge pump operating .

When the water level in the chamber drops down, the switch 21 switches off the pump.
The highest installed switch 19 indicates too high (emergency) level of sewage in the chlorinating chamber, caused for example by a breakdown of the discharge pump. The chlorinating chamber is equipped with a connector stub by which sanitary (”grey”) sewage can be leaded in this chamber. The overflow connector serves for flowing the sewage out of the plant (to bilge) when the water high in this chamber exceeds the alarm level.

Control panel

The control panel (fig. 3) contains:

- Main switch with control lamp “ Supply”
- Switch “Control mode” (I – Auto, II – Manual)
- Switch “Compressors selection” (I – No1 On, II – No2 On, 0 – Off)
- Switch “Sewage dosage” (this switch is active only with manual control mode)
- Switch “Disinfection” (this switch is active only with manual control mode)
- Push-button “Lamps control”
- Push-button “Alarm confirmation”
- Push-buttons START, STOP – Circulating pump (this buttons are active only with manual control mode)
- Push-buttons START, STOP – Discharge pump (this buttons are active only with manual control mode)
- Alarm lamps: “Chamber I low level”
  “ Chamber I high level”
  “ Chamber IV high level”
  “ Compressed air low pressure”
  “ Batcher low level”
- Control lamps: “ Compressor No1 run”
  “ Compressor No2 run”
  “ Circulating pump run”
  “ Discharge pump run”

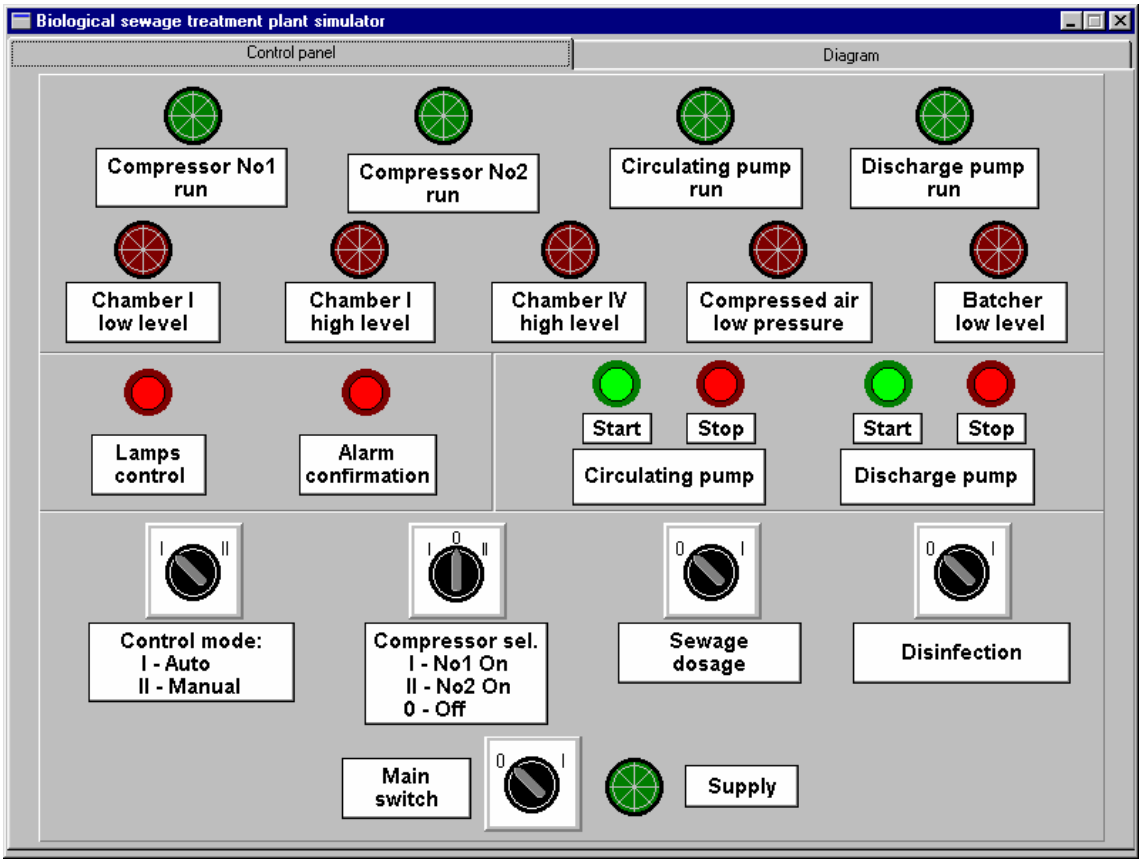

Fig. 3 Control panel

2. Operating instructions

Preparation for starting the plant

1. Open valves 1,2,3,4,5 and 11
   Attention: After the program start the valves 10,12 and 14 are open – faecal and sanitary sewage is leaded directly overboard.
2. Switch „ Control mode" on „ II -Manual"
3. Switch „ Compressors selection" on „0– Off"
4. Switch „ Sewage dosage" on „0"
5. Switch „ Disinfection" on „0"
6. Set „Main switch" on „ I " . The following signal lamp shall now light:
   - „ Supply"

- "Chamber I – low level"
- „ Compressed air – low press"
- „ Batcher – low level"

Push the button „ Alarm confirmation"

7. Push the button „Lamps control" in order to check whether all signal lamps are in good condition.
8. Fill up the chambers with water. For filling up sea water or fresh water can be used. Open valve 9. During the filling up procedure the signal lamp „Chamber I – low level" shall turn-off and then, the lamp „ Chamber I – high level" shall light. In the end of filling-up all chambers shall be the filled with water and "Chamber IV – high level" signal lamp shall light.

   Attention: Do not forget to close valve 9 immediately after the plant is filled up.
9. Fill the container of the batcher with sodium hypochlorite solution (NaOCl) by opening valve 16. Close valve 16 after filling.

Starting the plant

1. Switch „Compressor selection" on „ I – No1 On" or „ II – No2 On"
   The lamp „ Compressed air – low pressure" shall turn-off and manometer on compressed air pipe shall indicate the pressure of aprox. 0.03 Mpa.
2. Switch „ Control mode" on „ I – Auto". At the beginning both pumps are working. After a few minutes the contents of the chlorinating chamber will be drained out. Since then, the discharge pump works with interruptions. The signal lamps „Supply", „Compressor No 1 or No 2 - run" and „ Circulating pump - run" shall light.
3. Lead the faecal sewage into the plant (to preliminary chamber) by opening valve 13 and closing valve 12
4. Lead the sanitary sewage to chlorinating chamber by opening valve 15 and closing valve 14

Automatic control functioning

The plant starts to operate when sewage begins to flow into the plant. Sewage that has to be biologically treated shall be supplied into the preliminary chamber (I). Sewage that shall be only disinfected (i.e. „Grey sewage"), must be delivered by a separate piping system, directly to the chlorinating chamber, omitting other processing stages.
The sewage contained in the preliminary chamber I is all the time circulated by means of the circulating pump . In consequence of the multiple pumping and flowing through the grade 22, semisolid impurities of greater size get disintegrated. The rough filtering strainer 23 and the diaphragm valve 24 are included into the circulating pipe branch. The filtering strainer with the holes of 6 mm secures the pipes and especially the ejectors to get blocked.
The diaphragm valve 24 is controlled by two timers located in the control box. One of them determines the valve opening period (about 40 sec.) and another the duration the valve

closing period (time elapsed between two consecutive valve opening periods) – this time should be set for about 15 minutes.
The diaphragm valve 24 is operated by compressed air – controlled by a three-way solenoid valve 30. When the diaphragm valve is open, sewage enters through the pipeline branch into the activated sludge chamber II.
When the sewage in the preliminary chamber reaches the lowest operating level (float switch 17), the lamp „Chamber I – low level" lights up, and the diaphragm valve 24 remains in the closed state, irrespective of the operating rhythm of the time relays. Sewage will circulate in a closed circuit as long as the level rises, and the float switch 17 switches into the upper position. If the sewage reaches the highest operating level (float switch 18) then the lamp „ Chamber I – high level „ lights up, and the diaphragm valve 24 remains in open position, irrespective of the rhythm of the timers. The sewage is continuously fed into the activated sludge chamber II until the sewage level goes far down and the upper float switch 18 departs down. The timers return automatically back to their normal operating mode.
In the activated sludge chamber II, the biological process takes place. The sewage flow from this chamber into the sedimentation chamber II and further on to the chlorinating chamber is forced by gravitation.
In the sedimentation chamber III the separation of solid matter from the cleaned sewage occurs. After removal of the biological and solid matter impurities, the sewage flows into the chlorinating chamber IV. The sediments and floating scum are returned by ejector back to activated sludge chamber II. The ejectors driven by compressed air operate continuously.
The biologically treated sewage as well as the sanitary sewage is collected in the chlorinating chamber IV. At that moment, when the sewage reaches the upper level in this chamber (float switch 20) the discharge pump is switched on and sewage is pumped outboards. The discharge pump will be automatically stopped when the sewage reaches the lower operating level (float switch 21). At the same time when the discharge pump is switched off, an air driven pump of the disinfecting solution batcher is started delivering approx. 400 ml of the sodium hypochlorite solution into the chlorinating chamber IV. Until the chlorinating chamber IV is completely filled up with sewage, the sewage and chloride are mixed together. In consequence, the sewage gets disinfected. The air pulse for operating the air driven pump of the batcher is supplied through a three-way solenoid valve 31 (the opening period is set for approximately 15 sec.).

Manual control

Changing over the plant operation into manual control mode is made by setting the switch „Control mode" into position „ II – Manual".
In the manual control mode the following actions can be performed:

- starting and stopping both pumps, irrespective of the state of float switches in the preliminary and chlorinating chambers
- sewage feeding into the activated sludge chamber, independent of the state of the timers

- feeding disinfecting solution from the batcher into the chlorinating chamber, irrespective of the actual state of the flow switch 21

For manual starting and stopping the circulating and discharge pumps use the relevant „START" and „STOP" buttons.
Manual feeding of sewage and sodium hypochlorite solution is started by setting the relevant switch („Sewage dosage" and „Disinfection").

Activated sludge control

The activated sludge shall be checked after every month of continuous operation . In order to do it, a sample of the sludge must be collected and tested. Whilst sampling, the plant compressor must be running. Sampling shall be made through the cock into a transparent container – beaker 32 . In the program, the sampling is made by mouse clicking near the beaker 32.
If the amount of deposits exceeds 50% of the beaker capacity, the extra amount of deposit has to be drained out from the plant. If the ship is located actually on waters not restricted by the MARPOL Convention or other regulations, the surplus deposit can be pumped out directly over board.

In order to pump out the surplus of deposit it is necessary to:

- set switch „Compressor selection" on"0" (both compressors switched off)
- set switch „Control mode" on „ II – Manual"
- close valves 1 and 5
- open valves 6 and 8
- by pressing push-button „START" set the discharge pump operating. As soon as the activated sludge chamber is empty (the indication of the manometer installed on the discharge pipeline drops down), switch off the pump by pressing their „STOP" push-button.
- close valve 8 and open valve 7
- start again the discharge pump, but only for aprox. 1 min. and stop it afterwards
- close valves 6 and 7
- open valves 1 and 5
- fill up the plant with the water (see preparation for starting the plant procedure p.8)
- set switch „Compressor selection" for „I – No 1 On" or „II - No 2 On"
- set switch „Control mode" on „ I – Auto"

AUXILIARY STEAM BOILER INSTALLATION

1. General description

The AUXILIARY STEAM BOILER INSTALLATION – training simulator is designated for learning the essential principles of the marine steam boiler plant maintenance. The program is based on typical marine oil-fired auxiliary boiler – vertical water-tube type.

The program consists of the following three parts:

- control panel
- installation diagram
- fuel nozzle pressure control

The choice of the two first parts of the program is done by mouse clicking at the strip in the upper part of the screen.
The choice of the third part of the program is done by mouse clicking in the field of the appropriate pressure control device / fuel nozzle I or II pressure control / on the installation diagram / fig. 1/.

Application

The main objective for the installation of the plant on the ship is to produce steam for heavy fuel, oil or water heating.
This oil fired auxiliary boiler can be mounted on ship of unlimited cruising area and is running in a full automatic mode.

Main components

The basic elements of the plant are presented on fig. 1.

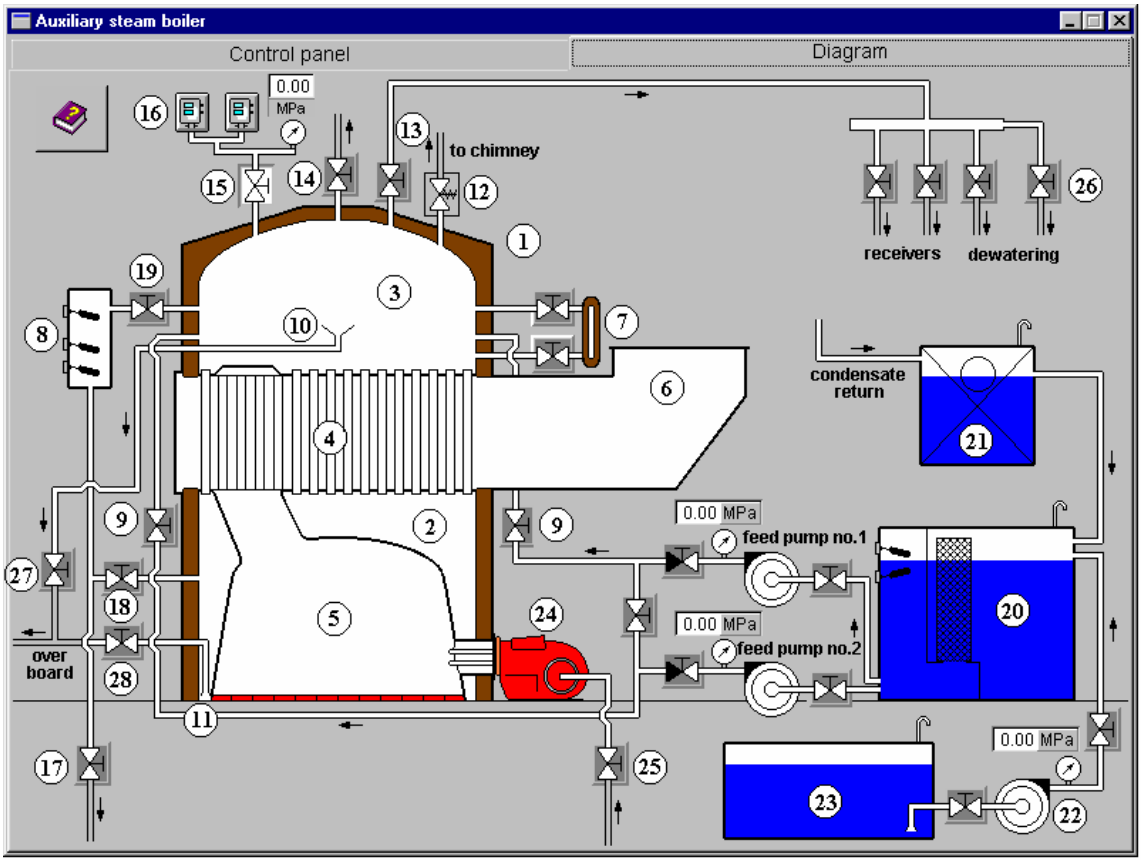

Fig. 1 Auxiliary steam boiler installation

Legend:

1. Steam boiler
2. Water drum
3. Steam drum
4. Row of water tubes
5. Furnace
6. Exhaust gases chamber
7. Water level gauge
8. Float switches chamber
9. Feed valve
10. Scum funnel

11. Bottom blow-off funnel
12. Safety valve
13. Main steam valve
14. Air escape valve
15. Manometer and pressure controls cut-off valve
16. Fuel nozzle pressure controls
17. Float switches chamber blow-off valve
18. Float switches chamber upper valve
19. Float switches chamber lower valve
20. Hot well
21. Condensate observation tank
22. Hot well refilling pump
23. Boiler water tank
24. Burner
25. Fuel supply valve
26. Drain (dewatering) valve
27. Scum valve
28. Blow down valve

Graphic symbols which are used at installation diagram are described in the legend (fig.2)

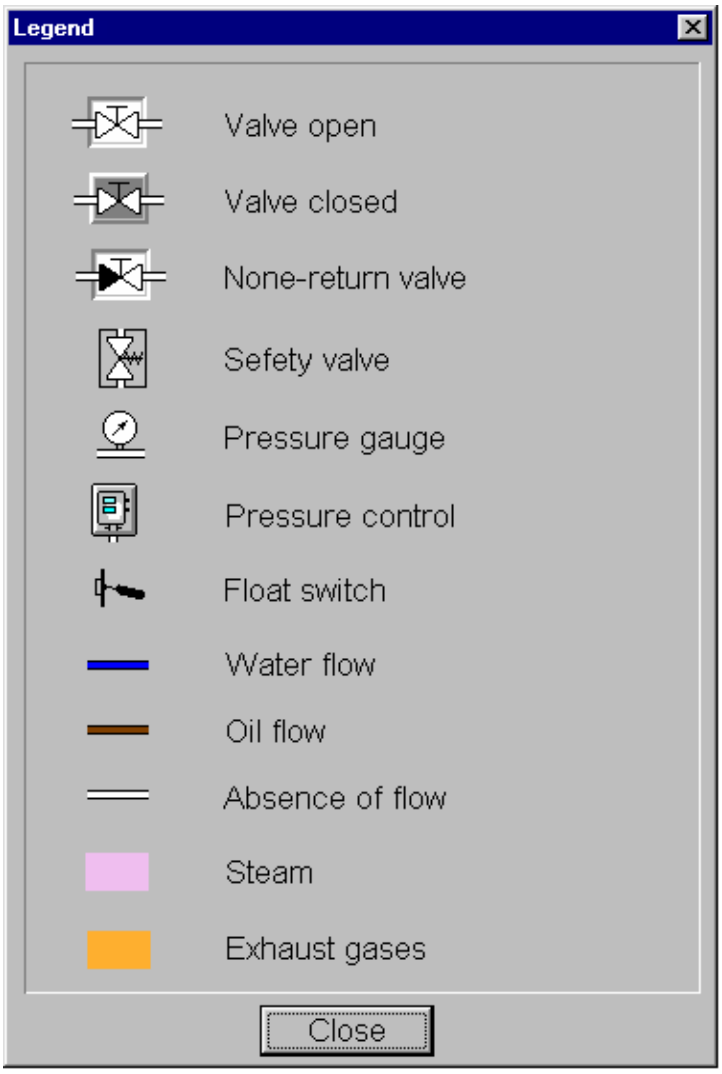

Fig. 2 Legend

Control panel

The control panel (fig. 3) contains the following blocks:

1. Boiler oil-firing block with:
   - Switch " Burner" (I – nozzle I, II – nozzle I+II, 0 – off)

- Switch " Boiler control mode" (I – manual, II – auto, 0 - off)
- Push-button "Spark – manual"
- Push-buttons "Reset"
- Control lamps: " Nozzle I"
  " Nozzle I + II "
  " Blower "
- Alarm lamps: " Flame failure "
  " Burner interlock "

2. Boiler feed water block with:
   - Main switch with control lamp " Supply"
   - Switch "Feed pump selection" (I – pump no.1, II – pump no.2)
   - Switch "Feed pump control mode" (I – manual, II – auto, 0 – off)
   - Push-buttons " Feed pump – START, STOP"(active in manual control mode only)
   - Control lamps: " High water level "
     " Service water level "
     " Low water level "
     " Feed pump run "
   - Alarm lamps: " Low alarm level "
     " Feed pump failure "

3. Hot well with control lamp " Hot well pump run "

4. Main switch with control lamp " Supply "
   - Push-button "Lamps control"
   - Push-button "Alarm confirmation"

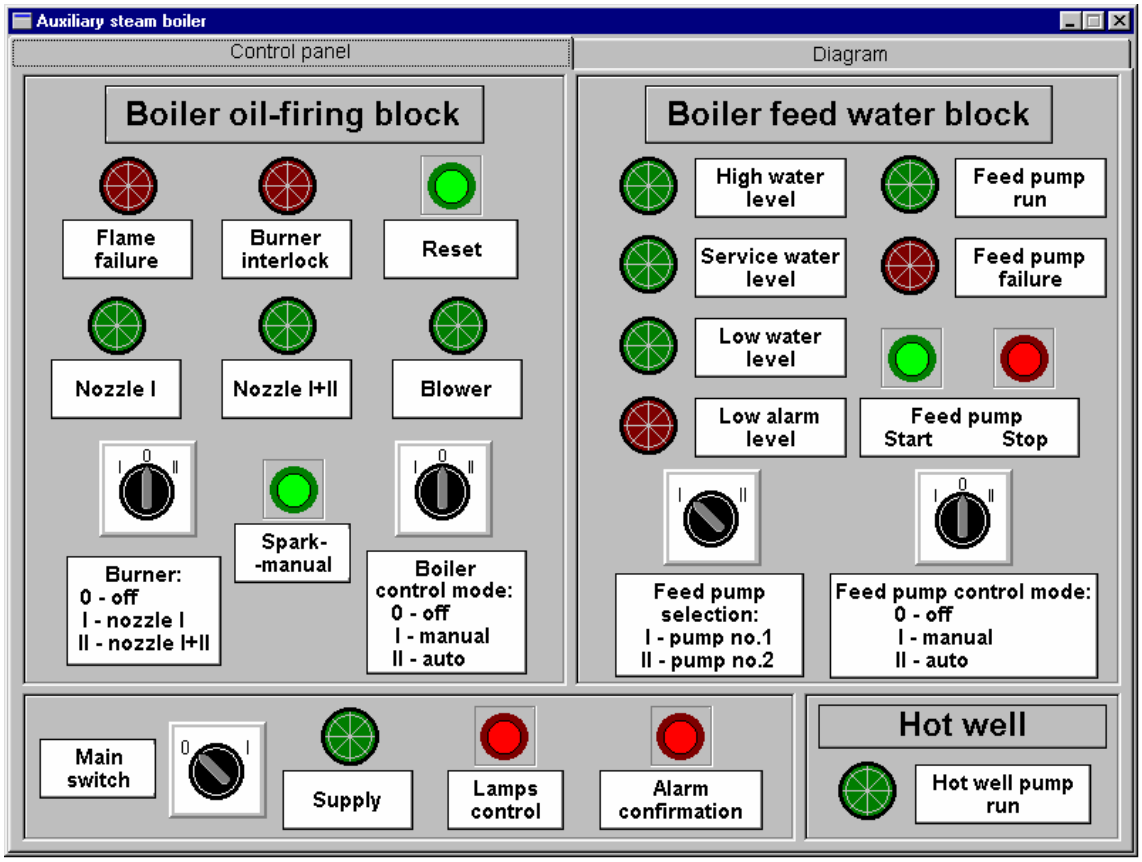

Fig. 3 Control panel

2. Operating instructions

Starting the plant

After the program starting all valves are closed and the water drum is empty.
The boiler starting procedure is divided into three stages. Normally each of those stages takes aprox. 0.5 hour.

I stage:

1. Close main steam valve 13
2. Open air escape valve 14
3. Open manometer and pressure control cut-off valve 15
4. Close scum 27 and blown down 28 valves
5. Open water gauge valves 7
6. Open float switches chamber valves 18 and 19
7. Close float switches chamber blow-off valve 17
8. Open one of feed valves 9
9. Select one of the feed pumps (set I or II switch position on „ Feed pump selection")
10. Open suction and discharge valve of selected feed pump
11. Open suction and discharge valves of hot well refilling pump 22
12. Set switch" Feed pump control mode" on I – manual" position
13. Set „Main switch" on „ I " . The following signal lamp shall now light:
    - „ Supply"
    - " Low alarm level" on Boiler feed water block

    Push the button „ Alarm confirmation"
14. Push the button „Lamps control" in order to check whether all signal lamps are in good condition.
15. Press push-button „ Feed pump - Start"
16. Feel the water drum with water till the low level (lamp „Low water level will light)
17. Stop feed pump.
18. Set „Boiler control mode" on „I – manual" – The blower will start automatically.
19. Set „ Burner" on „I – nozzle I"
20. Open fuel supply valve 25
21. After furnace blowing press push-button „Spark-manual"
    Heat boiler gradually, periodically stopping, until the moment the steam is created (pink colour in the steam drum)

Attention: Danger of blow outs ! Before every ignition vent flues sufficiently

22. Close air escape valve 14

II stage:

1. Set „Boiler control mode" on „ II – auto"
2. Set switch "Feed pump control mode" on „II – auto " (feed pump will start at float switch low level and stop at float switch service level)
3. When the steam pressure achieves more than 0.1 MPa open scum 27 and blown down 28 valves (control proper water level)
4. Blow-off float switches chamber by opening valve 17 (at steam pressure 0.2 MPa)

5. Check safety valve 12 functioning by manual opening.

III stage:

1. By continuous boiler heating increase the steam pressure till 0.5 MPa .
2. Open drain valve 26
3. Open main steam valve 13
4. Close drain valve 26
5. Open steam receiver's valves

Stopping the plant

1. Close steam receiver's valves
2 Close main steam valve 13
3 Set „Burner" switch on „0 – off"
4 Close fuel supply valve 25
5 Set „Feed pomp control mode" on „0 – off "

Pressure control description

The fuel nozzle pressure control is presented on fig. 4.

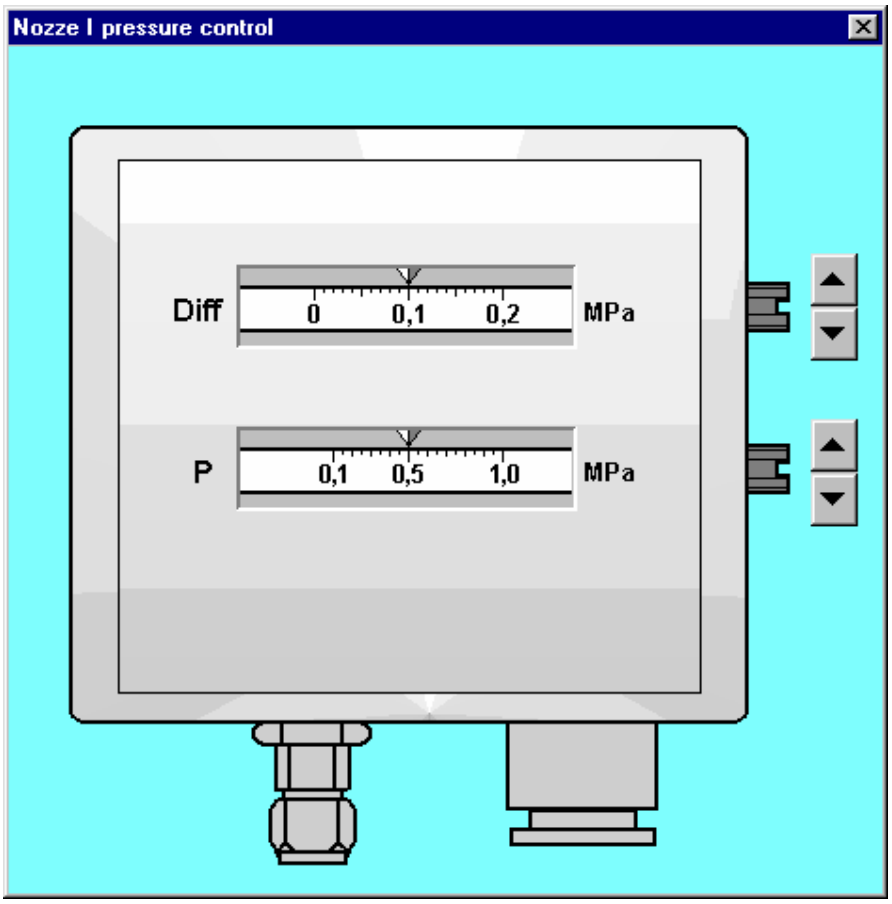

Fig. 4 Fuel nozzle pressure control.

Lower scale „ P ” (0.1 – 1.0 MPa) is designated for pressure adjustment at which nozzle will turn off.
Upper scale „ Diff ” – different (0.0 – 0.2 MPa) serves for fuel nozzle start adjustment (nozzle starts at pressure equal to difference between P – Diff)
Pressure setting is realised by mouse clicking on the adjustment screw arrows (on the right side)
Example: lower scale “ P ” set on 0.5 MPa
upper scale „ Diff “ set on 0.1 MPa
means: starting nozzle pressure P – Diff = 0.5 – 0.1 = 0.4 MPa
stopping nozzle pressure P = 0.5 MPa
Regulator’s setting while starting the program:

- fuel nozzle I : on - 0.40 MPa
  off - 0.50 MPa
- fuel nozzle II : on - 0.30 MPa
  off - 0.45 MPa

MARINE DIESEL ENGINE MONITORING SYTEMS

1. General description

The MARINE DIESEL ENGINE MONITORING SYSTEM program describes the diagnostic systems destinated for the analysis of Diesel engine combustion and injection process.
The program includes the presentation of both stationary and portable monitoring systems for continuous and periodical application.

The program presents the solutions regarding monitoring systems being actually used on ships.

The program consists of a general introduction and description of the following systems:

1) AUTRONICA NK5
2) AUTRONICA NK100
3) ABB CYLDET
4) DIGITEC DIESELTUNE III
5) ICON DOCTOR DK2
6) MALIN 3000
7) MAN B&W PMI SYSTEM
8) KISTLER 2057A
9) KISTLER 9149Q
10) KISTLER C- SENSORS
11) KYMA KDA
12) UNITEST 203

The parts related to the systems AUTRONICA NK5, AUTRONICA NK100, DIGITEC DIESELTUNE III includes examples of faults on combustion and injection pressure.

UNITEST –203 contains the demo of the diagnostic system operation.

FUEL OIL TREATMENT PLANT

1. General description

The FUEL OIL TREATMENT PLANT – training simulators is designated for learning the essential principles of the marine fuel oil treatment plant maintenance.
The program is based on high speed centrifugal separators with self-cleaning bowls type OSA - produced by GEA Westfalia Separator AG and designed for unsupervised operation conform to the regulation of the classification societies.

The program consists of three parts, as follows:

- control panel
- installation diagram
- timing unit

The choice of the appropriate part of the program is done by mouse clicking at the strip in the upper part of the screen.

Application

Centrifugal separators (centrifuges) OSA type are used for the separation of liquid mixtures or for the separation of solids out of liquids or liquid mixtures.

Fuel treatment plant consists of two centrifuges:

- centrifuge 1 - UNITROL system for purification
- centrifuge 2 - SECUTROL system for clarification

Centrifuge UNITROL can work on single or series operation (two-stage separation UNITROL -SECUTROL).

Working principle

Under the influence of the high centrifugal forces (produced in the rotating bowl), separation of the liquid mixture and/or removal of the solid particles takes place rapidly. The sedimentation effect in the settling tank was replaced in the centrifuges by the influence of centrifugal acceleration. In the centrifuge, a conical disc stack is applied in order to increase the separating surface. The centrifugal forces depend mainly on the bowl diameter and speed.
Due to the centrifugal forces, the components with higher specific gravity (solid particles and water) are displaced to bowl periphery, whereas the components with lower specific gravity (clean fuel oil) are displaced towards the centre of the bowl – to the bowl spindle.
The centrifugal separation efficiency is affected by several factors such as density, viscosity, temperature and flow rate of the fuel oil. The decrease in fuel oil viscosity will cause the increase of separation efficiency.

"*Clarification*" is the process of removing the solid particles from the liquid.

" *Purification*" is the process of separation of the liquid mixture composed of two liquids with simultaneous removal of the solid particles contained in the liquids.

The centrifuges OSA type are equipped with a self-cleaning disc-type bowl and can be alternatively used for clarification of liquids or the separation of liquid mixtures - purification.
The solid particles separated out in the disc stack slide down into the solid holding space and are ejected periodically at full bowl speed.
A sliding piston at the periphery of the double-conical solids holding space is hydraulically opened and closed and the solid particles are ejected instantaneously.
The light liquid phase is discharged by a centripetal pump, whereas the heavy liquid phase discharges freely into the hood.

Centrifuge 1 – UNITROL system's description (fig. 1)

This centrifuge is equipped with a self-cleaning disc-type bowl and a conductivity sensor for water contamination control.
The fuel oil is fed to the centrifuge by the separate supply pump to the centrifuge.
The clean oil is discharged under pressure by means of centripetal pump (9).
The bowl is opened and closed automatically for sludge discharge at full bowl speed by means of a remote-controlled solenoid valve in the operating-water line (17). The solenoid valve is opened for a period of 10 sec.
The small volume of liquid flow (7) which is branched off via the separating disc (12) and the sensing liquid pump (8) is monitored by a conductivity sensor (5).
If the sensor (5) detects water, the solenoid valve (10) opens and the solenoid valve (6) closes. Then, the water flows-off through the dirty water discharge (14). As soon as the sensor detects a change in conductivity brought about by an increased proportion of fuel oil, the solenoid valve (10) closes and the solenoid valve (6) opens intermittently. The sensing liquid flow (7) is recycled into the feed (1).

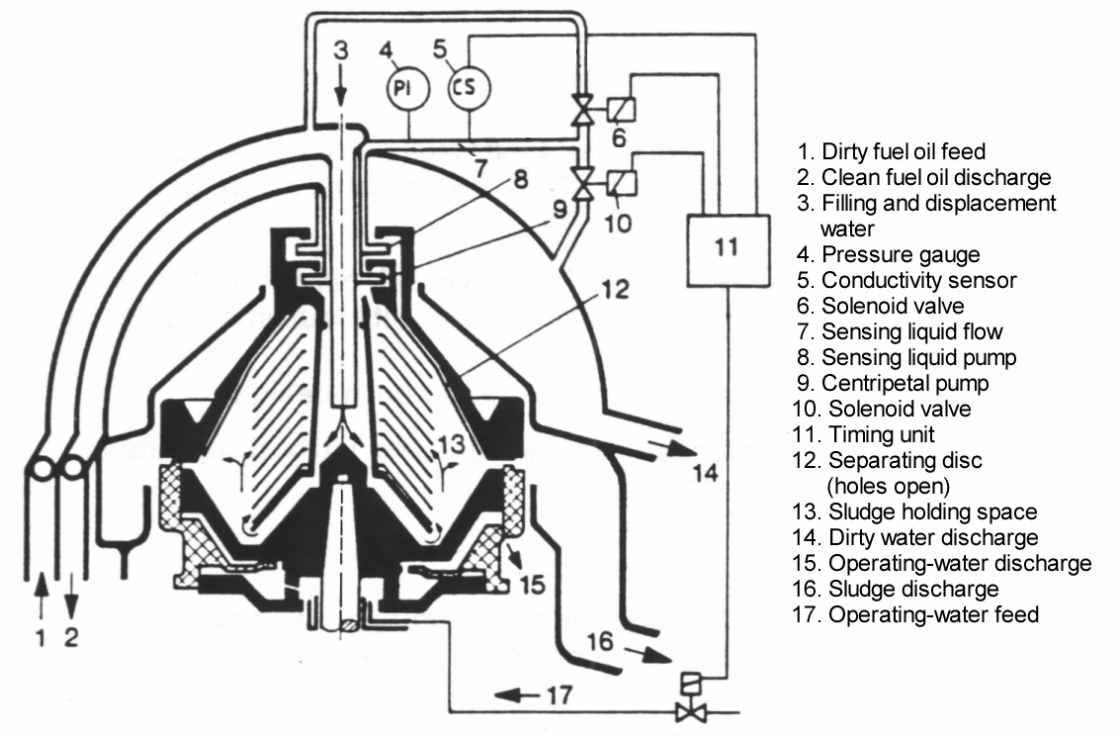

Fig. 1 UNITROL system's description

Centrifuge 2 – SECUTROL system's description (fig. 2)

The SECUTROL system is applied as a second separation stage – clarifier in the series operation UNITROL – SECUTROL.
This centrifuge is equipped with a self-cleaning bowl and with the "self-thinker" sludge discharge system. The fuel oil is conveyed to the clarifier by the centripetal pump of the upstream purifier.
The clean fuel oil is discharged under pressure by centripetal pump (8).
The bowl is opened and closed automatically for sludge discharge at full bowl speed by means of a remote-controlled solenoid valve in the operating- water line (15). The solenoid valve is opened for 10 sec.
A small amount of product -sensing liquid (6) is diverted via a separating disc (10). It is conveyed by the sensing liquid pump (7) through the pressure switch (5) and back into the dirty fuel oil feed (1).
If this flow of sensing liquid is interrupted by solids or water accumulated in the sludge holding space (11), the pressure switch (5) passes an impulse to the timing unit (9) that initiates an automatic total sludge discharge. The "self-thinker" control system thus monitors the whole fuel treatment plant.

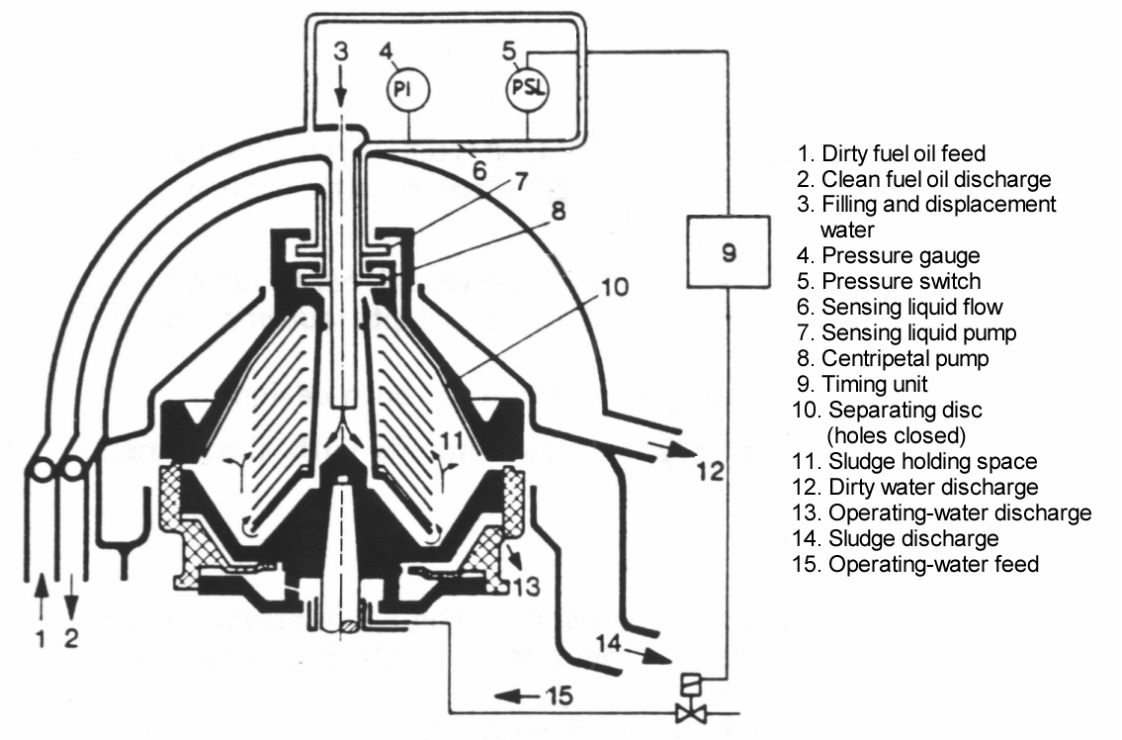

Fig. 2 SECUTROL system's description

2. Fuel oil treatment plant description – fig. 3

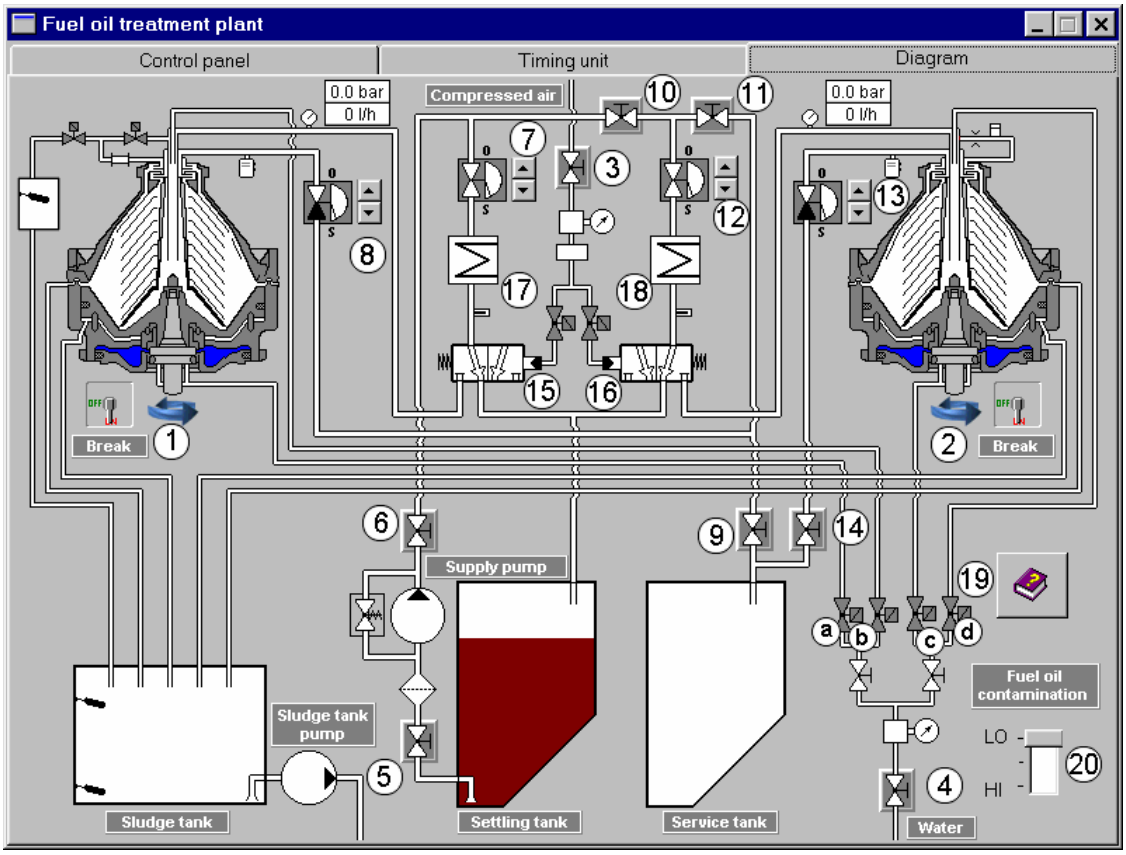

Fig. 3 Fuel oil treatment plant installation diagram

1. Centrifuge 1 – UNITROL system
2. Centrifuge 2 – SECUTROL system
3. Compressed air cut-off valve
4. Operating and filling water cut-off valve
5. Fuel oil cut-off valve before supply pump
6. Fuel oil cut-off valve behind supply pump
7. Fuel oil regulating valve before centrifuge 1
8. Fuel oil regulating valve behind centrifuge 1
9. Fuel oil cut-off valve before service tank
10. Centrifuge 1 by-pass valve
11. Fuel cut-off valve before centrifuge 2
12. Fuel oil regulating valve before centrifuge 2
13. Fuel oil regulating valve behind centrifuge 2

14. Fuel oil cut-off valve before service tank
15. Three/two-way piston valve for dirty oil feed to centrifuge 1
16. Three/two-way piston valve for dirty oil feed to centrifuge 2
17. Centrifuge 1 pre-heater
18. Centrifuge 2 pre-heater
19. Solenoid valves:
    a. Centrifuge 1 operating-water valve
    b. Centrifuge 1 filling and displacement water valve
    c. Centrifuge 2 operating-water valve
    d. Centrifuge 2 filling and displacement water valve
20. Fuel oil contamination slide-switch (LO-low, Hi-high)

The fuel oil treatment plant comprises the following parts :

- one purifier (UNITROL – system) – centrifuge 1
- one clarifier with self-thinker system (SECUTROL - system) – centrifuge 2
- one feed pump (gear type)
- two pre-strainers
- two pre-heaters
- one control panel and timing unit

Water system consists of:

- cut-off valves
- pressure reducing valve with manometer
- solenoid valves

Air system consists of:

- cut-off valve
- pressure reducing valve with manometer,
- safety valve,
- solenoid valves

Graphic symbols used on the installation diagram are described in legend – fig. 4

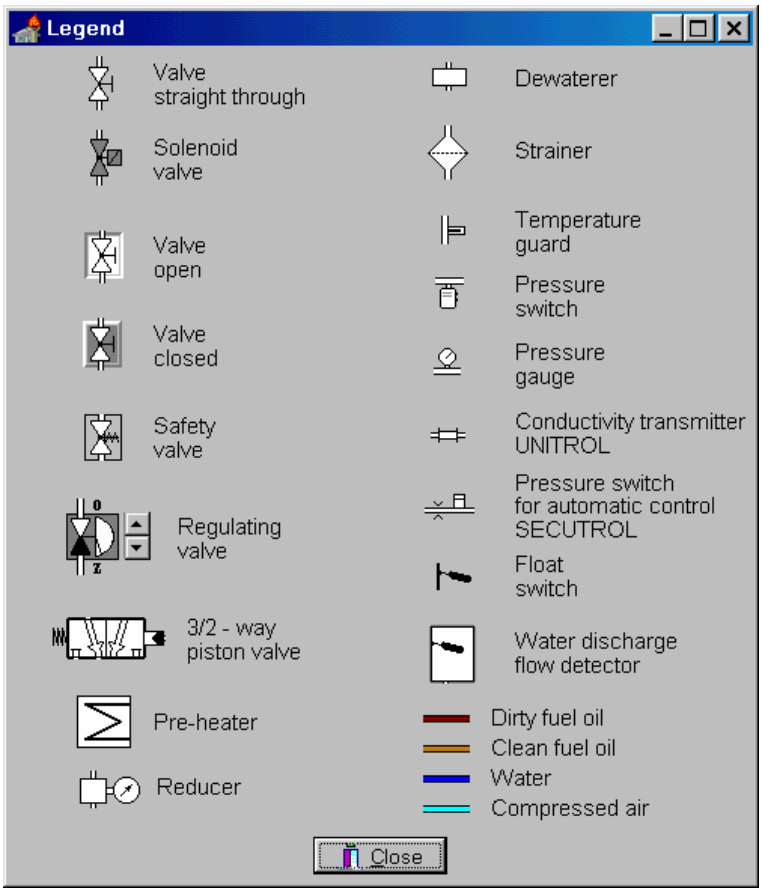

Fig. 4 Legend

3. Control panel description (fig. 5)

Control panel consists of:

- "Pre-heater 1" switch (0-off, I-on),
- "Pre-heater 2" switch (0-off, I-on),
- "Supply pump" switch (0-off, I-on),
- "Sludge tank pump" switch (0-off, I-on, II - auto),
- Push-button „Alarm confirmation"
- Push-button "Lamps control",

- Alarm lamps:
  - "Pre-heater 1 failure"
  - "Pre-heater 2 failure"
  - "Supply pump failure"
  - "High level alarm in sludge tank"
- Control lamps:
  - "Pre-heater 1 run"
  - "Pre-heater 2 run"
  - "Supply pump run"
  - "Sludge tank pump run"

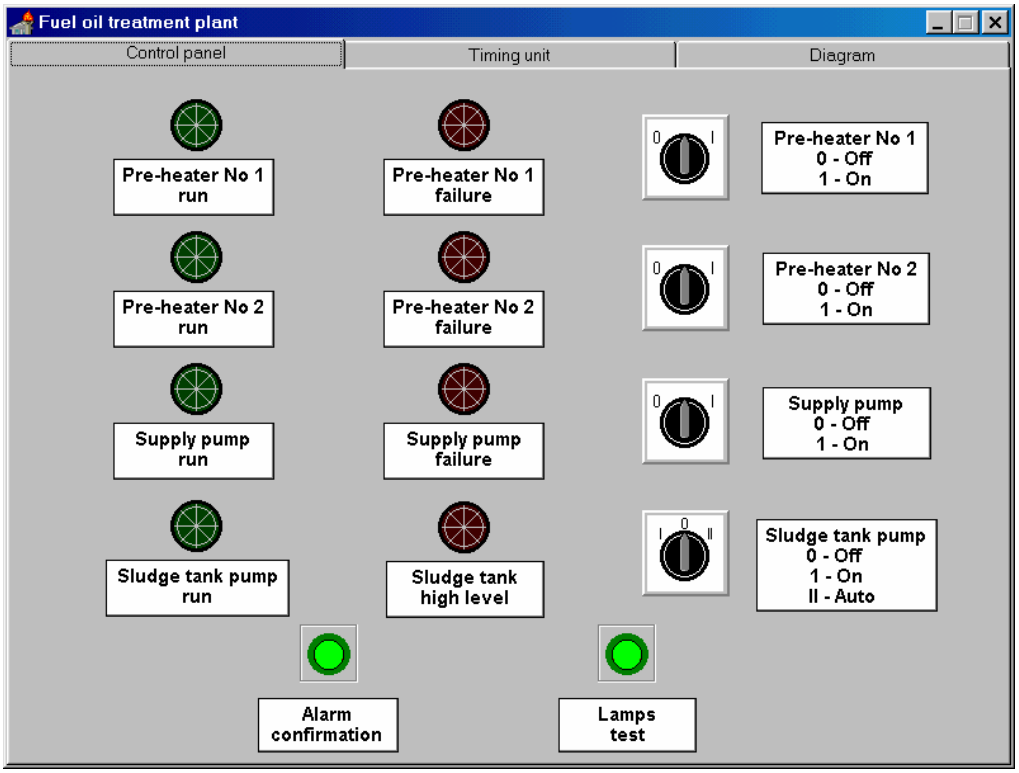

Fig. 5 Control panel

4. Timing unit (fig. 6)

Timing unit contains the following elements:

- "Centrifuge 1 " switch (0-stop, I-start)

- "Centrifuge 2 " switch (0-stop, I-start)
- "Displacement " switch (0-off, I-on)
- "Flushing "switch (0-off, I-on)
- "Centrifuge program " (0-off, I-on)
- "Purifier/Clarifier" switch (P,CL)
- "Automatic control" switch (0-off, I-on),
- "Main switch" (0-off, I-on),
- Push – buttons:
  - "Alarm confirmation"
  - "Lamp control"
  - "Emergency stop"
- Alarm lamp
- Current gauges (Centrifuge 1 and 2)

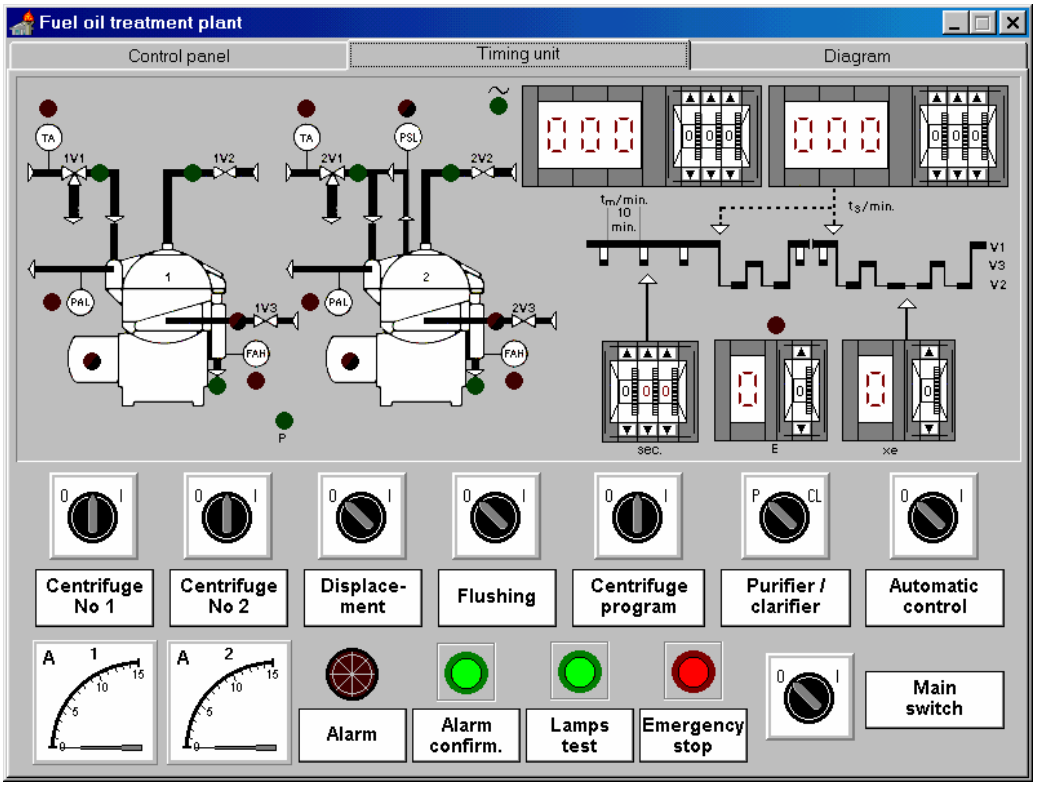

Fig. 6 Timing unit

Timing unit symbols description:

t_m – monitoring time for automatic control (regarding only SECUTROL system activity)
t_s – separation time interval between total sludge discharges (independent of the SECUTROL system action)
sec – impulse transmitter (control impulse) – operating- water feed time lapse (filling of bowl closing chamber)
E – total number of sludge discharges after which an alarm (red LED flashing) is triggered within monitoring time - t_m
x_e – total number of sludge discharges after which flushing is to be carried out – this counter registers sludge discharges connected with the set t_s time as well as the sludge discharges resulting from the SECUTROL system operation;

Alarm LEDs :

TA – Temperature Alarm (fuel oil temperature too high / too low)
PAL – Pressure Alarm Low (clean fuel oil discharge pressure too low)
FAH – Flow Alarm High (discharge on water side too high)
PSL – Pressure Switch Low (control pressure too low) – UNITROL system

LEDs signalling opening of valves:

1V1- three/ two-way piston valve for dirty fuel oil feed (centrifuge 1)
2V1- three /two-way piston valve for dirty fuel oil feed (centrifuge 2)
1V2- solenoid valve for displacement and flushing water (centrifuge 1)
2V2- solenoid valve for displacement and flushing water (centrifuge 2)
1V3- solenoid valve for operating water and sludge discharging monitoring (centrifuge 1)
2V3- solenoid valve for operating water and sludge discharging monitoring (centrifuge 2)

Timing unit consists also of V1, V2, V3 - opening valve diagram.

Additional LEDs:

P – sludge discharging process activation (green light)
~ - centrifuge program operation (continuous green light)

5. Operating instruction

Preparation for starting a single separator – centrifuge 1 UNITROL system

Attention: Operation of the single centrifuge is possible only at low level of fuel contamination.

On the separator diagram:

1. Open the valve 3, 4, 5, 6, 7, 8, 9 (close valves 10, 11, 13, 14)
   Attention : regulating valves 7 and 8 should be totally open
2. Release brake of centrifuge 1 (off position)

On the panel control:

3. Set the "Supply pump" switch to position **I**,
4. Set "Sludge tank pump" to position **Auto**

On the timing unit:

5. Set " Main switch" to position **I**
6. Push the button „Lamp control" in order to check whether all signal lamps are in proper condition.
7. "Centrifuge 1 " switch on position **I**
   Attention : LED - TA lights indicating low fuel oil temperature – press push-button "Alarm confirmation"

On the panel control:

8. Set "Pre-heater 1" on position **I**,
   Attention: It is possible to turn on the pre-heater only when centrifuge is running.

On the timing unit :

9. Switch "Purifier/Clarifier" to position P,
10. Switch "Automatic control" to position **0**
11. Set t_s separation time interval between total sludge discharges (depends on the level of fuel oil contamination) - for example: 10 min
12. Set sec time within the adjustment range: 0.01-1.00 seconds
    for example: 0,50 sec (the bowl may open in case the time set is too long)
13. Set x_e counter for selection of the total number of sludge discharges after which flushing is to be carried out (1 – 9), for example: 4
14. Switch on "Displacement" to position **0**

15. Once the bowl revolution has been attained (check current gauge indicator – current should drop to about 7 A) turn switch "Centrifuge program " to position **I** (confirmed by LED - ~ continuous green light)
    Attention: Centrifuge program may be switched on after reaching proper fuel oil temperature – signalled by LED TA turning off)
16. After centrifuge program initiation the centrifuge is automatically discharged (LED P will light confirming discharge process realisation)
17. Switch on "Displacement" to position **I** (fuel oil displacement is applied for the purpose of fuel oil discharge from the bowl before sludge discharge takes place – fuel oil returns to the settling tank – it is not directed to the sludge tank)
18. Set "Flushing" to position **I** (this option is applied for additional bowl flushing with water after a determined number of sludge discharges - x_e)

On the diagram:

19. Set fuel regulating valves 7 and 8 for required flow and pressure value (pressure equal to about 0,3 bars – flow capacity equals to about 500 l/h)

Preparation for starting a single separator – centrifuge 2 SECUTROL system

Attention: Operation of the single centrifuge 2 is possible only in emergency situations (break-down of separator 1)

On the separator diagram:

1. Open the valve 3, 4, 5, 6, 10, 12, 13, 14 (close valves 7, 8, 9, 11)
   Attention : regulating valves 12 and 13 should be totally open
2. Release brake of centrifuge 2 (off position)

On the panel control:

3. Set the "Supply pump" switch to position **I**,
4. Set "Sludge tank pump" to position **Auto**

On the timing unit:

5. Set " Main switch" to position **I**
6. Push the button „Lamp control" in order to check whether all signal lamps are in proper condition.
7. "Centrifuge 2 " switch on position **I**

Attention : LED - TA lights indicating low fuel oil temperature – press push-button “Alarm confirmation”

On the panel control:

8. Set “Pre-heater 2” on position **I**,
   Attention: It is possible to turn on the pre-heater only when centrifuge is running.

On the timing unit :

9. Switch “Purifier/Clarifier” to position **Cl**
10. Switch “Automatic control” to position **0**
11. Set t_s separation time interval between total sludge discharges (depends on the level of fuel oil contamination) - for example: 10 min
12. Set sec time within the adjustment range: 0.01-1.00 seconds
    for example: 0,50 sec (the bowl may open in case the time set is too long)
13. Set x_e counter for selection of the total number of sludge discharges after which flushing is to be carried out (1 – 9), for example: 4
14. Switch on “Displacement” to position **0**
15. Once the bowl revolution has been attained (check current gauge indicator – current should drop to about 7 A) turn switch “Centrifuge program ” to position **I** (confirmed by LED - ~ continuous green light)
    Attention: Centrifuge program may be switched on after reaching proper fuel oil temperature – signalled by LED TA turning off)
16. After centrifuge program initiation the centrifuge is automatically discharged (LED P will light confirming discharge process realisation)
17. Switch on “Displacement” to position **I** (fuel oil displacement is applied for the purpose of fuel oil discharge from the bowl before sludge discharge takes place – fuel oil returns to the settling tank – it is not directed to the sludge tank)
18. Set “Flushing” to position **I** (this option is applied for additional bowl flushing with water after a determined number of sludge discharges - x_e)

On the diagram:

19. Set fuel regulating valves 12 and 13 for required flow and pressure value (pressure equal to about 0,3 bars – flow capacity equals to about 500 l/h)

Preparation for starting the series operation – UNITROL/SECUTROL

On the diagram:

1. Open the valve 3, 4, 5, 6, 7, 8, 11, 12, 13, 14 (close valves 9 and 10)
   Attention: regulating valves 7, 8, 12 and 13 should be totally open
2. Release brakes of separator 1 and 2 (off position)

On the control panel

3. Set "Supply pump" switch to position **I**,
4. Set "Sludge tank pump" to position **Auto**

On the timing unit:

5. Set "Main switch" to position **I**
6. Push the button „Lamp control" in order to check whether all signal lamps are in proper condition
7. Set "Centrifuge 1" switch to position **I**,
8. Set "Centrifuge 2" switch to position **I**,
   Attention : low fuel oil temperature is indicated by LEDs - TA (red light) – press push-button "Alarm confirmation"

On the control panel:

9. Set "Pre-heater 1" switch on position **I**,

O*n the timing unit:*

11. Set "Purifier/Clarifier" switch to position **CL**,
12. Set "Automatic control" to position **I**,
13. Set t_s separation time interval between total sludge discharges (depends on the level of fuel oil contamination) - for example: 10 min
14. Set monitoring time t_m on about 90% of separation time t_s, for example: 9 min
15. Set sec time within the adjustment range: 0.01-1,00 seconds
    for example: 0,50 sec
16. Set E on 5 (for example)
17. Set x_e counter for selection of the total number of sludge discharges after which flushing is to be carried out (1 – 9), for example: 4
18. Switch on "Displacement" to position **0**

19. Once the bowls' revolutions have been attained (check current gauge indicator – current should drop to about 7 A) turn switch "Centrifuge Program " to position **I** (confirmed by LED - ~ continuous green light)
    Attention: Centrifuge program may be switched on after reaching proper fuel oil temperature – signalled by LED TA turning off)
20. After centrifuge program initiation the centrifuge is automatically discharged (LED P will light confirming discharge process realisation)
21. Set "Pre-heater 2" switch on position **I**,
22. Switch on "Displacement" to position **I**
23. Set "Flushing" to position **I**

On the diagram:

24. Set fuel regulating valves 7, 8, 12 and 13 for required flow and pressure value after centrifuge 2 (pressure equal to about 0,3 bars – flow capacity equals to about 500 l/h)

Stopping the plant

On the timing unit

1. Set "Automatic control" to position **0**
2. Set "Flushing" switch to position **I**
3. Set x_e counter on position **1**
4. Set "Centrifuge program " on position **I** (one discharge with flushing is carried out)
5. Immediately after discharge (LED P turns off), set switch "Centrifuge program " on position **0** (not allowing the bowl to be filled with fuel again)
6. Switch off centrifuge 1
7. Switch off centrifuge 2
8. Set "Main switch" on position **0**

On the control panel

9. Switch off the pre-heaters
10. Switch off supply pump
11. Switch off sludge tank pump

On the diagram

12. Tighten brakes of centrifuges 1 and 2 (on position **ON**)
13. Close all valves

Automatic control functioning description –series UNITROL/SECUTROL operation (fig.3)

The contaminated fuel oil (during heating process) is transmitted via the supply pump from the settling tank through pre-heater (17) and three/two-way piston valve (15) and returns again to the settling tank. After attaining proper bowls' revolution and fuel oil temperature and as soon as the centrifuge program is turned on, the centrifuge bowl is automatically discharged. Subsequently, the fuel is fed by three/two-way piston valve (15) to the centrifuge. After the fuel oil separating process begins, the LED - PAL flashes during a few seconds – indicating low pressure at the clean fuel oil discharge. Once the LED – PAL turns off, the clean fuel oil is transferred to the service tank.
The cleaning process is automatically controlled (in case the switch "Automatic control" is set on position I). After the time lapse t_s , sludge discharge occurs. Three/two-way piston valve (15) returns to the primary position and the fuel oil is transmitted back to the settling tank. The fuel oil remaining in the centrifuge 1 is displaced by the water to the settling tank, and the clean fuel oil from the centrifuge 2 is displaced to the service tank, as presented on Fig. 7 (in case the switch "Displacement" is set on position I).
Subsequently, the centrifuge bowl is opened by the operating-water valve actuation and the remaining fuel oil together with the solid particles is ejected to the sludge tank (as presented on Fig. 8). After a determined period of time (10 sec.), the bowl is closed and the separation process starts again. The time counter t_s is reset – it counts the time lapse since the beginning. If the "Flushing" switch is set on position I, the counter x_e changes its value by 1. These cycles will repeat until the value of x_e reaches the set value. As soon as the x_e value is achieved and after the self-cleaning process of the bowl occurs, the bowl is filled with water for the purpose of additional discharge with flushing (see Fig. 9). Subsequently, the bowl is discharged . After this operation, the counter x_e is set on a zero position.
In case the x_e counter is set on a zero value, the flushing process following the sludge discharge is repeated over and over again.
In case the time counter t_s is set for a period longer than 10 minutes, the operating water will fill the bowl closing chamber after the time lapse of ten minutes (since the beginning of the separating program).The time of this operation is set on impulse transmitter sec. The filling of the bowl closing chamber is realised each time after sludge discharge (before the dirty fuel oil is fed to the centrifuge). The time t_s, as proposed in the operating instructions, has been lowered due to didactic reasons. In normal exploitation conditions the t_s time is considerably longer and equals ca. 240 min.
If the time t_s is set on a zero value, the sludge discharge occurs and the centrifuge program is frozen in this position. Each modification of t_s resets the centrifuge program and causes t_s counting since the beginning.

Apart from automatic control operation set on the timing unit, automatic control of the fuel oil contamination functions in the system (UNITROL/SECUTROL).
The UNITROL system controls water contamination in fuel oil. This control is independent of the set operating mode (on the control unit) and does not require any adjustments. In case the centrifuge ejects too much dirty water, the flow detector registers it – LED FAH lights and the centrifuge program is turned off.
The SECUTROL system controls the level of solids particles impurities in fuel oil. This system is active only in series centrifuges operation and when switch "Automatic control" is set on position I. If the solids level in the bowl sludge chamber reaches the edge of separating disc, the pressure drops in the sensing liquid flow and the pressure switch will send the impulse for activating sludge discharge. In case the number of sludge discharges during t_m time is higher than the number indicated on the counter E, the red LED (situated in upper part of the counter E) turns on.
The beginning of the sludge discharge process of centrifuge 2 – SECUTROL will automatically initiate sludge discharge process of centrifuge 1 – UNITROL.
In case of emergency operation of centrifuge 2 (when centrifuge 1 broke down) the SECUTROL system automatic control remains inactive and the sludge discharge process is operated manually, for e.g. by resetting the centrifuge program.
When the level in the sludge tank reaches the upper float switch, the sludge tank pump automatically turns on (in case the switch "Sludge tank pump" is set on position "Auto"). The sludge pump stops once the level drops below the lower float switch.
The fuel oil pre-heater can be switched on only once the centrifuge is turned on and the flow of fuel oil occurs in the pre-heater. During the sludge discharge process the pre-heater is automatically turned off. If the TA – low fuel oil temperature alarm (centrifuge 1) is active, it is not possible to switch on the centrifuge program.

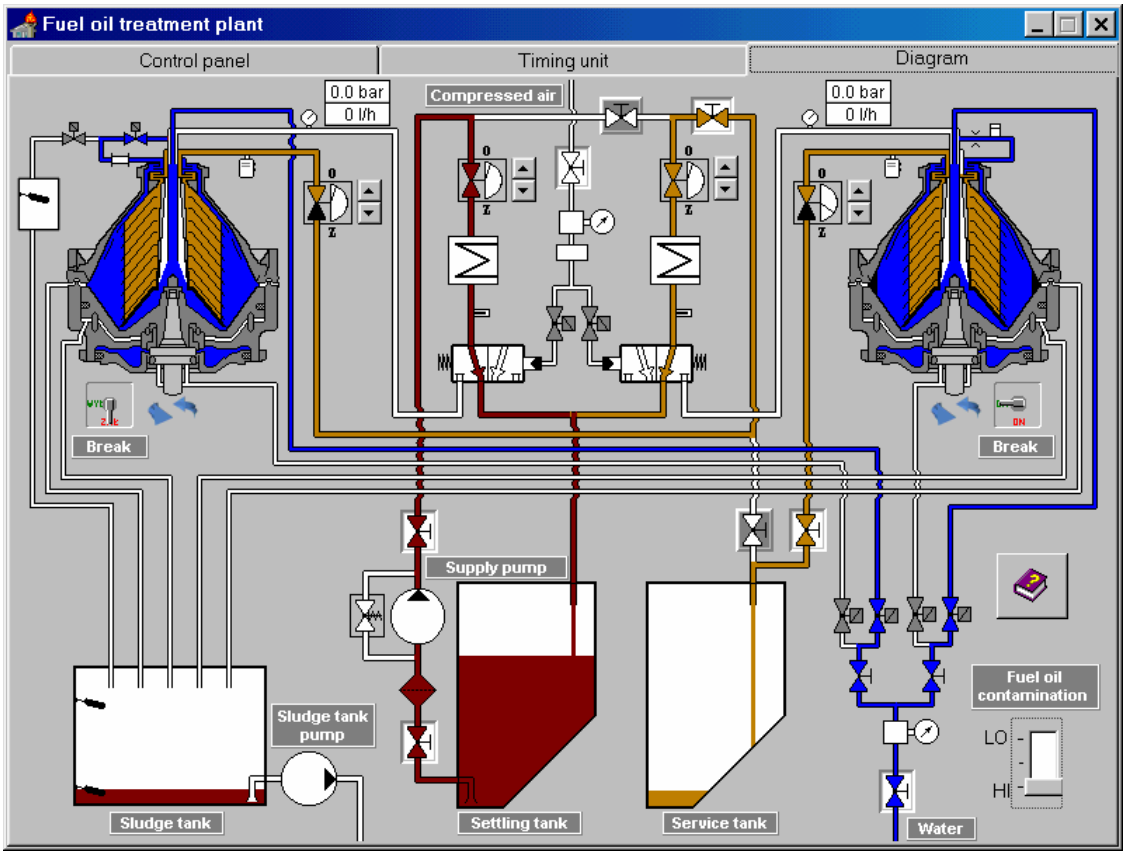

Fig. 7 Fuel oil displacement operation

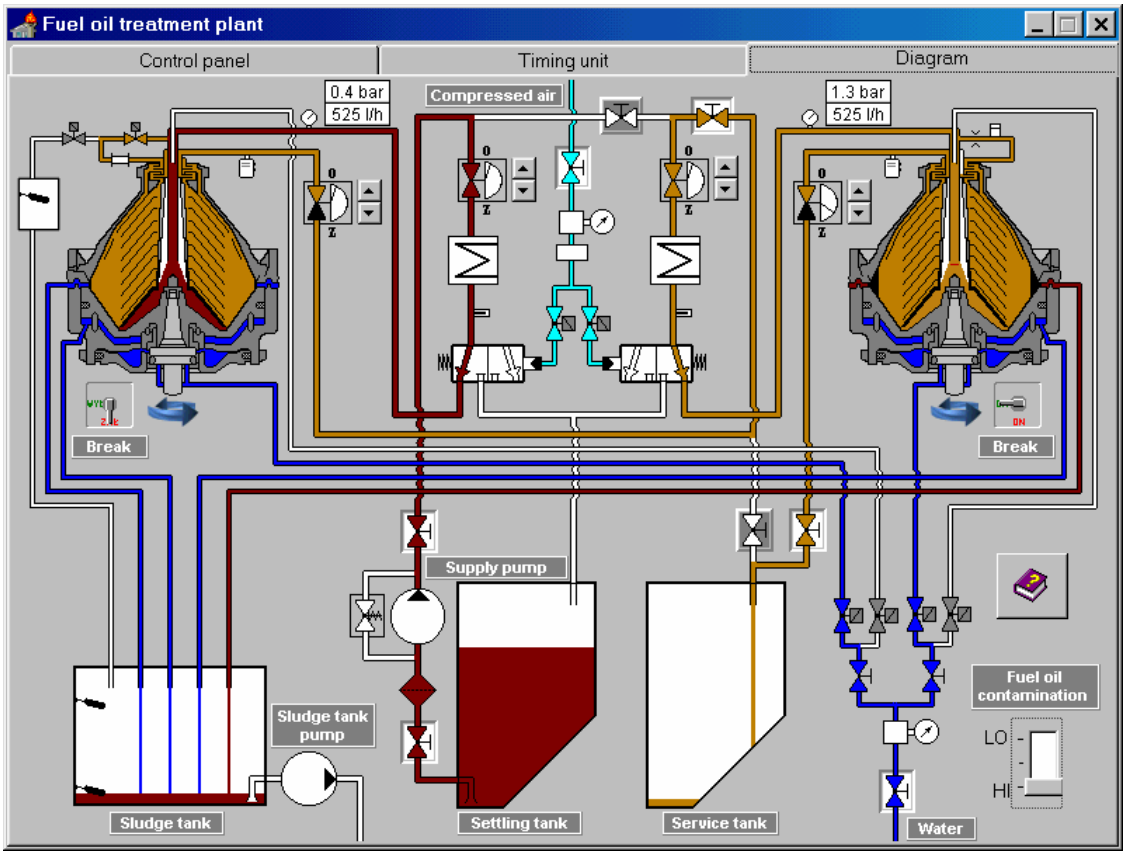

Fig. 8 Sludge discharge process

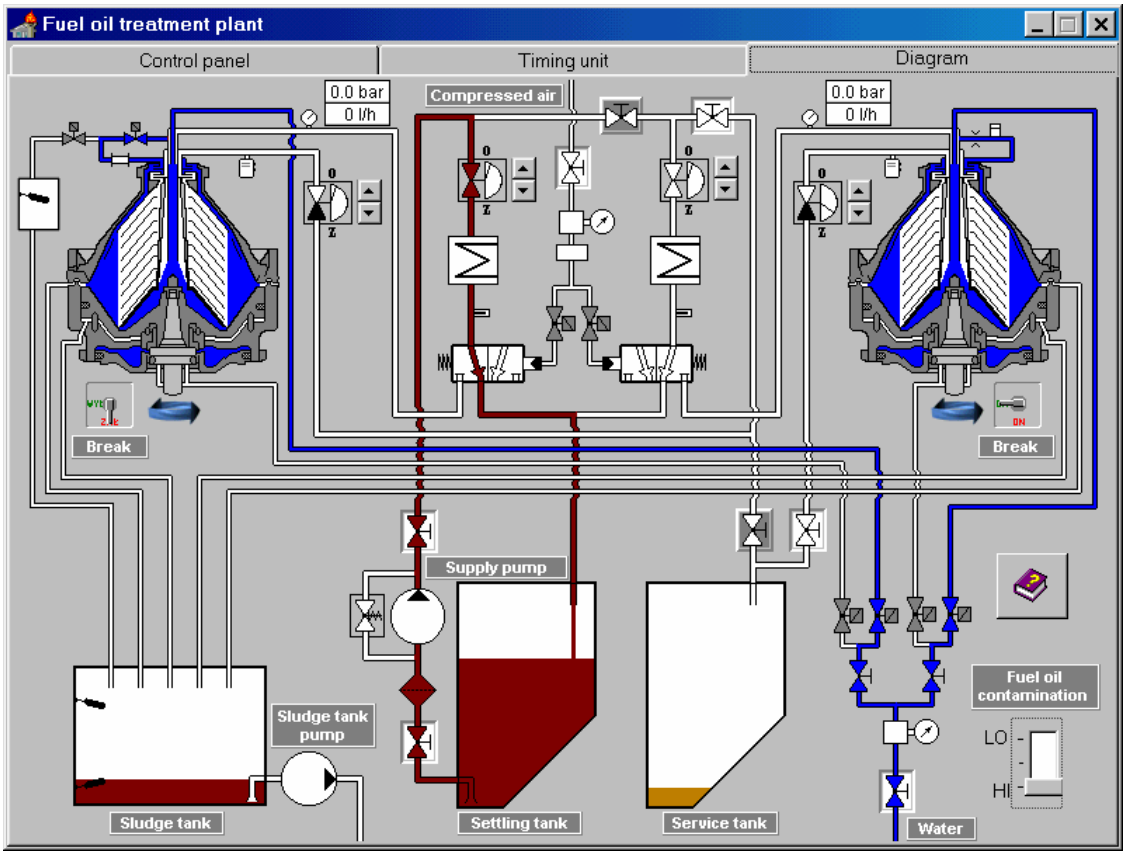

Fig. 9 Flushing operation

CONTROLLABLE PITCH PROPELLER INSTALLATION SIMULATOR

I General description

The educational program CONTROLLABLE PITCH PROPELLER INSTALLATION SIMULATOR is intended for teaching the basic principles of how to operate a typical C.P. propeller installation, that is being presently used on ships. This simulator is based on the C.P. propeller PH-RK type, produced by ABB Zamech Marine Ltd. in Elbląg, Poland .

The program consists of the following 3 parts:

- C.P. Propeller installation diagram
- Pump Aggregates Panel in Engine Control Room (ECR)
- Pump Aggregates Local Control panel

After programme starting, the control panel ECR is shown on the computer screen. The choice of the other panels is done by means of mouse clicking on the field of the appropriate panel (single mouse clicking of the left button).

II C.P. propeller installation description - Fig. 1

C.P. propeller installation performs the following two basic tasks :

- adjustment of pitch propeller by means of proper devices that are placed in hub, in order to secure the propeller's operation efficiency in different navigation conditions

- enables the use of non- reversible engines since the ship's movement AHEAD –ASTERN can be realised by proper pitch adjustment.

C.P. propeller installation system includes the following main units:

- C.P. propeller PH type
- Propeller shaft unit
- Propeller coupling
- Oil distribution box RK type
- Oil system
- Remote control unit

C.P. propeller installation main units description

1. C.P. propeller

The propeller consists of a hub (Fig.1) with an inner mechanism and of blades together with hydraulic cylinder /servo- motor/ placed in the rear part of hub. The rotational movement of the blades is obtained through the transmission of reciprocating movement of the piston through the guide rod and guide assembly to the crank disc. There is a slide block placed on the crank disc pin, which moves in suitable recess of the guide assembly. There is a possibility of setting the blades in optional position from the demanded AHEAD through ZERO to full pitch ASTERN. The servomotor cylinder is screwed to the hub body by means of screws. There is a blocking valve in the piston guide rod. It keeps the blade pitch in case of lack of pressure in the servo oil system. The inner mechanism is lubricated by oil that is inside the hub. The hub possesses two non-return valves. One of them fills up the propeller hub (due to oil pressure in gravity tank). In case of lack of gravity lubrication pressure the valve shuts and the hub remains filled with oil. The second non-return valve protects the hub against over-rising of the oil pressure (for e.g. due to the oil leak from the servomotor cylinder).

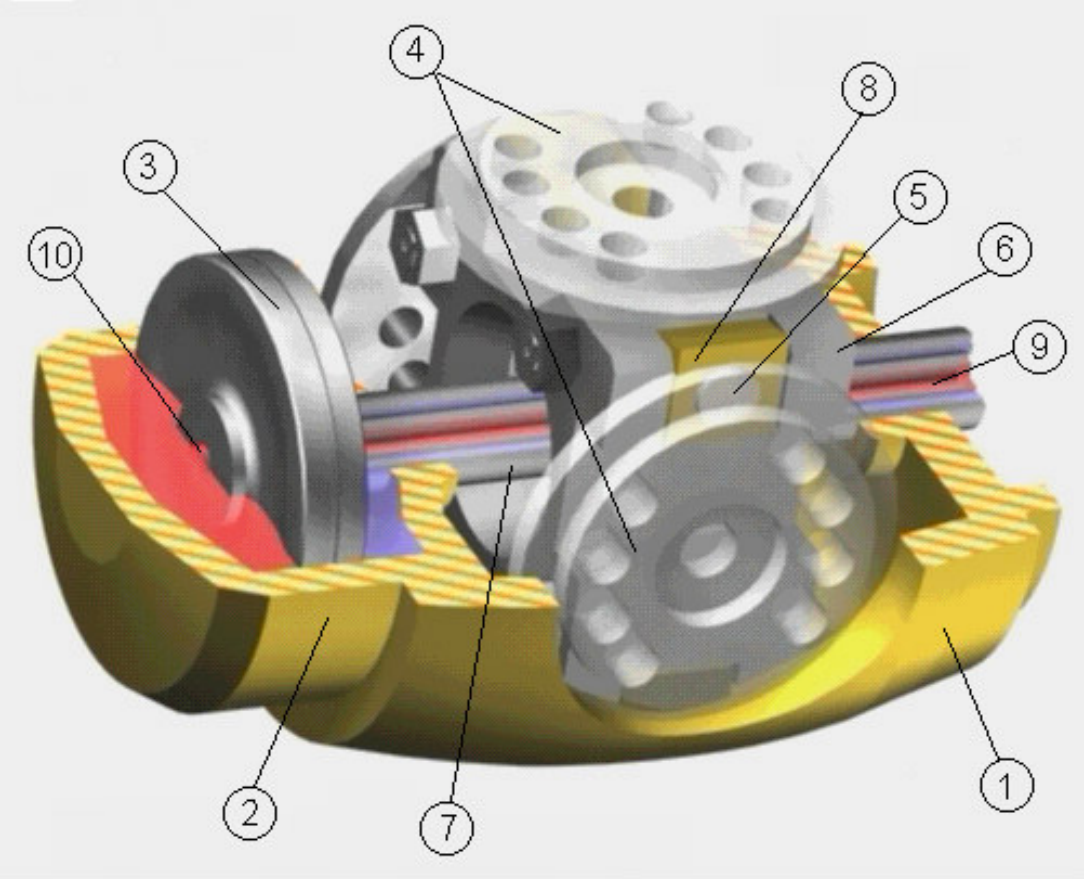

Fig. 1 C.P. propeller hub

Legend:

1. C.P. propeller hub body
2. Servomotor cylinder
3. Servomotor piston
4. Crank disc
5. Crank disc pin
6. Guide assembly
7. Piston guide rod
8. Slide block
9. Telescopic pipes unit
10. Blocking valve

1.1 Blocking valve - Fig. 2

The blocking valve is designated for automatic closing of the oil outlet from Chamber A – AHEAD of the C.P. propeller servomotor in case of a drop down of the servo oil pressure. Thus the servomotor piston remains in the same position as it had before the servo oil pressure has dropped down.

a) blocking valve construction
The valve head is guided in the cover. A small piston is fixed on the valve head rod by means of two snap rings.

b) operation
During normal operation of C.P. propeller servomotor, when the pitch is adjusted, the oil passes to chamber A –AHEAD or B –ASTERN of the servomotor cylinder. The oil supplied to chamber A acts on the bottom of the valve head and keeps the valve in open position. If oil is supplied to chamber B it acts on the piston and keeps the valve in open position (oil is supplied to the chamber from the right side of the valve's piston). When the pressure in servo oil system drops down in chambers A and B or in case of a failure of the main pump operation, the lubricating oil (due to pressure from the gravity tank) acts on the valve's piston. The oil that acts on the valve's piston is supplied from Lubricating Oil Chamber C. In this case the valve's piston together with the valve head will move on the right and the blocking valve will be closed.
During normal operation of the C.P. propeller the oil pressure supplied to chambers A and B is always higher than the oil pressure in lubricating Oil Chamber C. Thus, the blocking valve during normal operation (pitch adjustment) remains open.

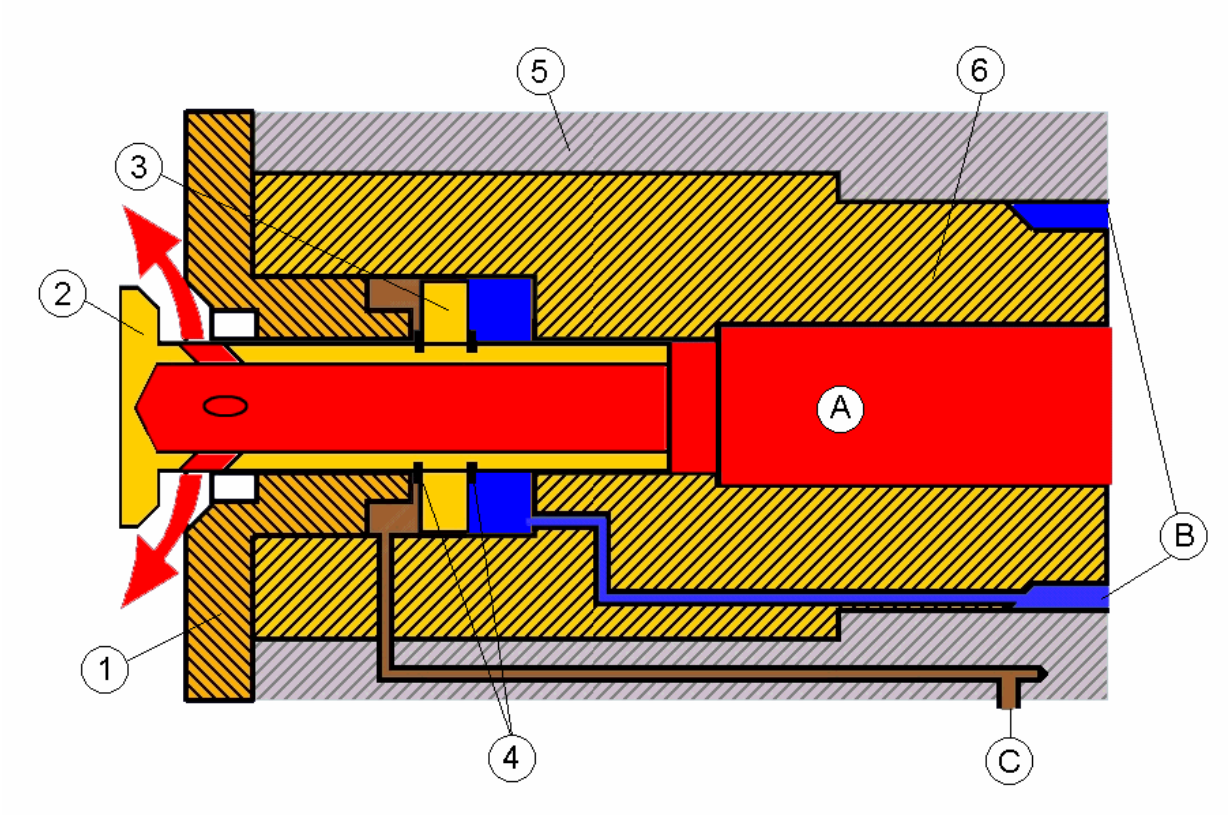

Fig. 2 Blocking valve

Legend:

1. Cover
2. Valve head
3. Piston
4. Snap rings
5. Piston guide rod
6. Telescopic pipe unit

A. AHEAD chamber
B. ASTERN chamber
C. Lubricating oil chamber

2. Propeller shaft unit

The propeller shaft unit is supported in the stern bearing. The stern bearing is lubricated with oil from separate installation. The propeller shaft has the central hollow bore in which two concentrical telescopic pipes are mounted. These pipes deliver servo oil to the cylinder to either for or aft side of the piston.

3. Propeller shaft coupling

The coupling purpose is to connect the propeller shaft with the reduction gear shaft. Coupling body is fitted hydraulically on the conical sleeve on the front end of the propeller shaft.

4. Oil distribution box - Fig. 3 and Fig. 4

The oil distribution box is fastened to the front part of the reduction gear by means of flange. The pitch control block B2S and valve block BZ are fitted on the side faces of the oil distribution box casing. The servo oil is supplied from main pump aggregate to block BZ and further through the hole in the casing to the oil control sliding valve of block B2S. Depending on the slide valve position, the oil is supplied from block B2S, through the bores in the casing, to the channel AHEAD or ASTERN and next through the telescopic pipe unit on the front or aft side of the piston in the propeller hub. The sliding valve position in block B2S is controlled with oil supplied from distributors block BR. The real movement of servomotor piston is transmitted through the propeller hub, propeller shaft and reduction gear shaft pipe units to sliding ring. Next, the movement of servomotor piston is transmitted through the feed back lever of block B2S to the given rotary potentiometers which are placed in the block. The potentiometers send the electric signal of real propeller pitch position and signal of feed back to pitch control unit (CONTROL UNIT).
Moreover, the oil distribution box is equipped with emergency control valve which enables the optional pitch setting AHEAD in emergency situations of propeller hydraulic system.

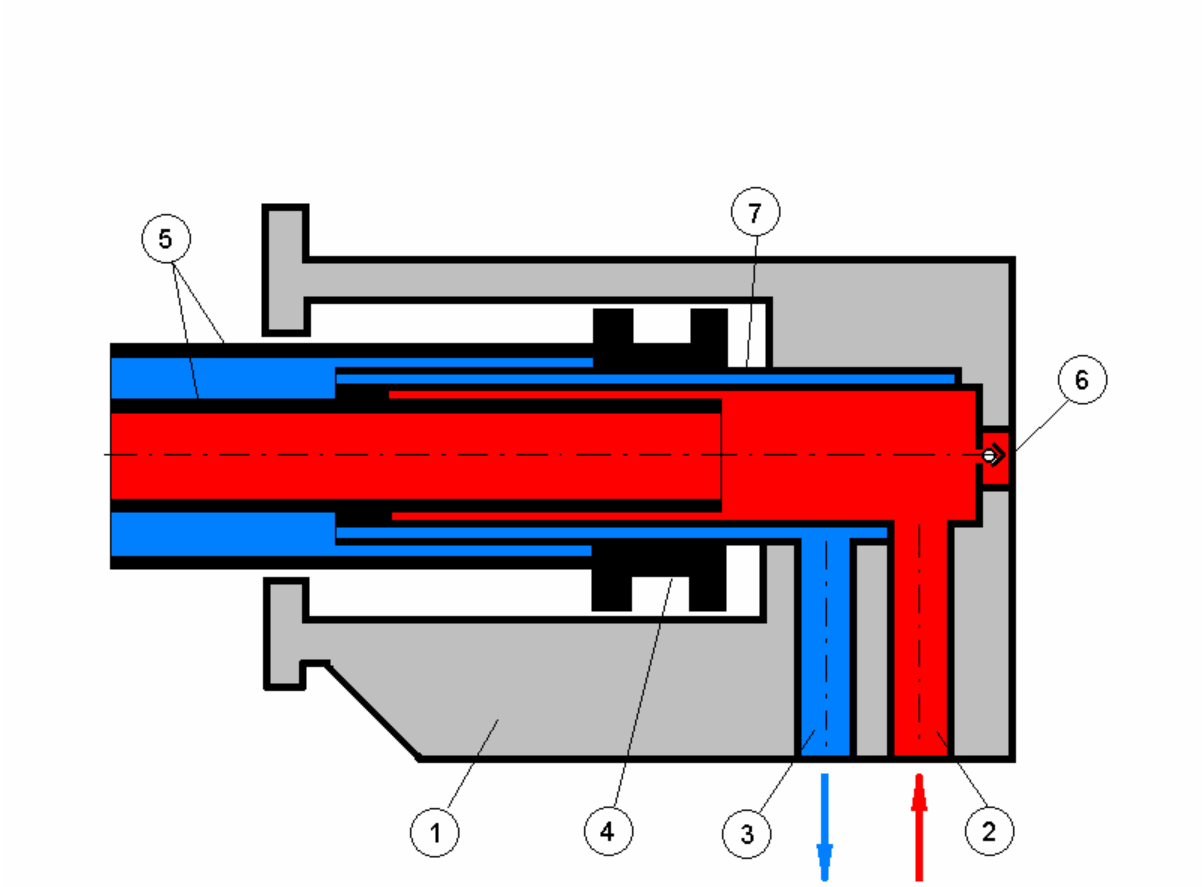

Fig .3 Oil distribution box

Legend :

1. Casing
2. Channel AHEAD
3. Channel ASTERN
4. Sliding ring
5. Telescopic pipe unit
6. Emergency pitch setting AHEAD control valve
7. Inner pipe

The oil distribution box purpose is to direct servo oil to the hub through the telescopic pipe unit that goes inside the gear shaft and inside the hollowed propeller shaft. The oil distribution box also maintains pitch adjustment set by the manoeuvring stand. In case of setting device failure there is a possibility of propeller pitch setting in optional position for AHEAD by means of an appropriate installation .

5. Oil system - Fig. 4

a) Servo oil system
The C.P. propeller possesses a separate main oil tank of big capacity (depends on the propeller size) placed under the oil distribution box. From the tank through the filters the oil is sucked by one of the Main pump aggregates No.1 or No. 2. Then, the oil is pressed further to valve block BZ and to pitch control block B2S which is fitted on the oil distribution box casing. In the valve block BZ, there are plate non- return valves, one for each pump, and a distribution valve and a safety valve. The oil is delivered from the valve block BZ to the side valve which is placed in the pitch control block B2S. Further, it is delivered by means of channels in distribution box casing and telescopic pipe unit to the hydraulic servo-motor in the propeller hub. The back –flowing oil flows through inner chamber of oil distribution box and cools the unit . Next it flows to valve block BZ and further through the flexible hose by means of a pipeline, to the cooler. The oil is delivered from the cooler to the oil tank by means of a pipeline. If the valve is closed or the flow through the cooler is limited, the back –flowing oil flows into the tank through the non –return valve. During vessel stay, the non- return valve keeps the oil distribution box and the cooler filled with oil. There is a temperature sensor placed on a draining pipeline. This sensor transmits the alarm signal at temperatures higher than the permissible temp. of 60° C. The normal servo oil temperature which ranges from 35 ° C to 50 °C is kept by means of valve which establishes corresponding quantity of cooling water flowing through the cooler. Reserve pump aggregate is automatically activated in case of a lack of pressure from the pump previously switched on. For automatic starting the reserve pump aggregate, one of the three pressure safety cut-out is used while the two others are used to transmit alarm signals.

b) control oil system

The control oil system is designated for hydraulic control of the slide valve pitch control block B2S. The oil to the control system is supplied from valve block BZ. Next, the oil flows through the filter to the distributors block BR. The distributors block BR consists a set of electrohydraulic distributors having different functions in the pitch adjustment control unit. The following elements appear here:

- three-position distributor connected to electric remote control by means of two push buttons (non-follow up operation);
- three-position distributor (of the proportional valve type) connected to follow-up control by means of pitch control lever;
- two-position distributors fulfilling auxiliary functions;

In the BR block casing there is also a reduction valve which stabilises the pressure of control oil that is delivered to the proportional valve and to distributor, making them independent of the servo oil pressure changes . The three –position distributors of block BR are equipped with push buttons on the electromagnetic coils that enable the manual setting of the valves' position.

c) lubricating system

The lubricating system contains a gravity tank and the Lubricating pump aggregate that automatically fills the oil in this tank up to an appropriate level .This system is used during vessel stay when the Main pump aggregate does not work, to secure the proper oil pressure inside the propeller hub. The Lubricating pump aggregate is used also for emergency setting of propeller pitch. The lubricating system also contains: a non-return valve on the discharge side of the Lubricating pump aggregate, a throttle non-return valve and manual two-position distribution valve. During the operation of the Main pump aggregate, the pressure inside the propeller hub as well as oil level in gravity tank is secured automatically by means of the inner hydraulic system. The oil surplus in gravity tank is directed to the main tank by means of overflow pipeline . During vessel stay the pressure in the propeller hub is secured by the gravity tank which is automatically filled with oil by means of Lubricating pump aggregate. Then the oil from the gravity tank fills the inside of distribution box by means of a throttle non-return valve and a two-position distributor valve. Further, the oil flows inside the propeller hub by means of through bore in the reduction gear shaft and propeller shaft. The multi- position level sensor that is placed in the gravity tank serves for automatic switching Lubricating pump aggregate on and off and to transmit the alarm signal of low oil level in the gravity tank to the control unit.

6. The remote control system (Fig. 4)

The servomechanism of C.P. propeller enables to control the pitch in following ways:

a) local control by means of mechanical lever connected to the pitch control block B2S. In simulator conditions this type of control is possible by means of mechanical levers placed on both ends of pitch control block B2S (Fig. 4 Pos. 7).

b) non-follow up remote control by means of push buttons located on the bridge or ECR manoeuvring unit. (Fig. 4 Pos. 14). Both the local control and the remote non – follow up control by means of push-buttons are treated as emergency control modes. In case such emergency control mode is used, a three-position distributor is also applied (Fig.4 Pos. 10). However, the main engine load control system does not function in this control mode.

c) follow up remote control by means of a pitch control lever located on the bridge or ECR manoeuvring unit. The follow – up remote control is the basic method for pitch propeller adjustment. A three-position distributor (proportional valve) is applied in the
follow up remote control method. This three-position distributor processes the electric signal from the remote control system controller and transforms it into the hydraulic signal with the pressure proportional to the control current value. When the control signal from the bridge is directed at one or another of the electromagnetic coils, the control oil is delivered to one of the pitch control block B2S chambers. The remote control system enables the realisation of necessary functions such as pitch control adjustment, main engine load adjustment, switching control and signalling units.

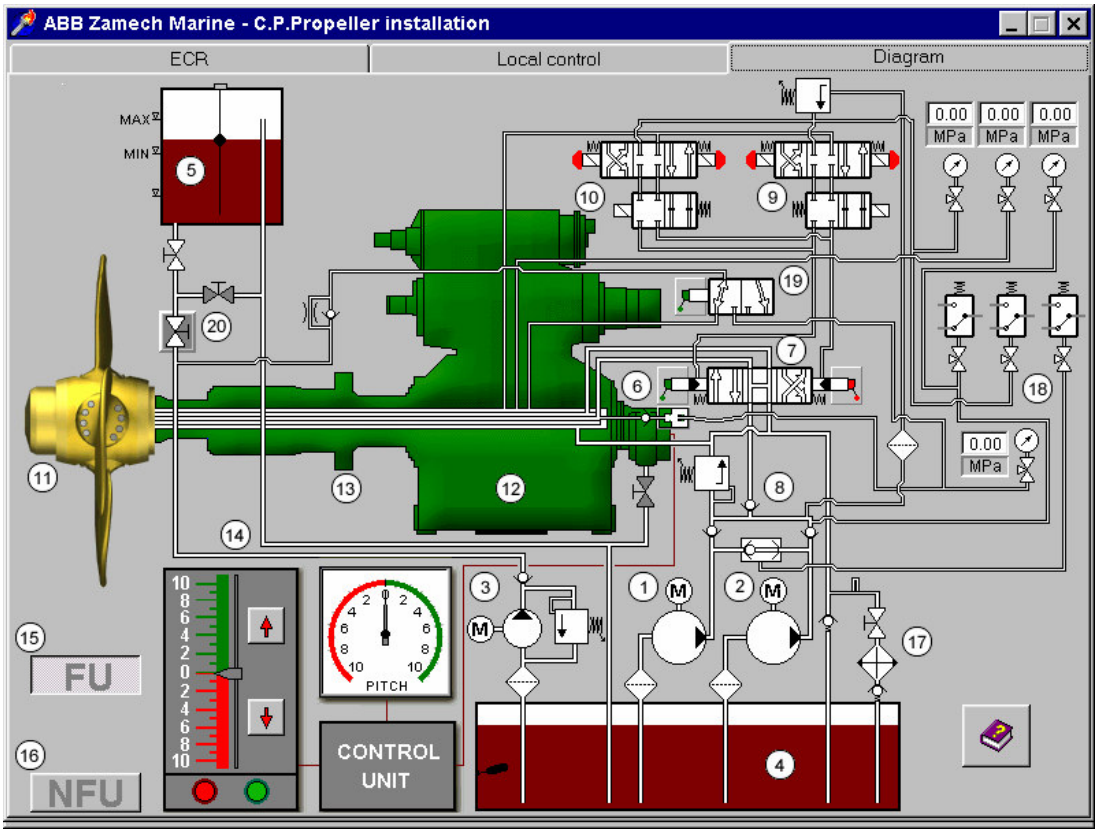

Fig. 4 C.P. propeller installation diagram

Legend:

1. Main pump aggregate No 1
2. Main pump aggregate No 2
3. Lubricating pump aggregate
4. Oil main tank
5. Oil gravity tank
6. Oil distribution box
7. Pitch control block B2S with three-way valve slide valve
8. Valve block BZ
9. Distributors block BR / for follow-up control /
10. Distributors block BR / for non follow-up control /
11. C.P. propeller
12. Reduction gear

13. Propeller shaft coupling
14. C.P. propeller pitch control system and pitch gauge
15. Follow-up control push-button
16. Non follow-up control push-button
17. Oil cooler
18. Pressure safety cut-out unit
19. Manual two-position distribution valve
20. Shut-off valve

The graphic symbols which are used at the C.P. propeller installation diagram are described on Fig. 5.

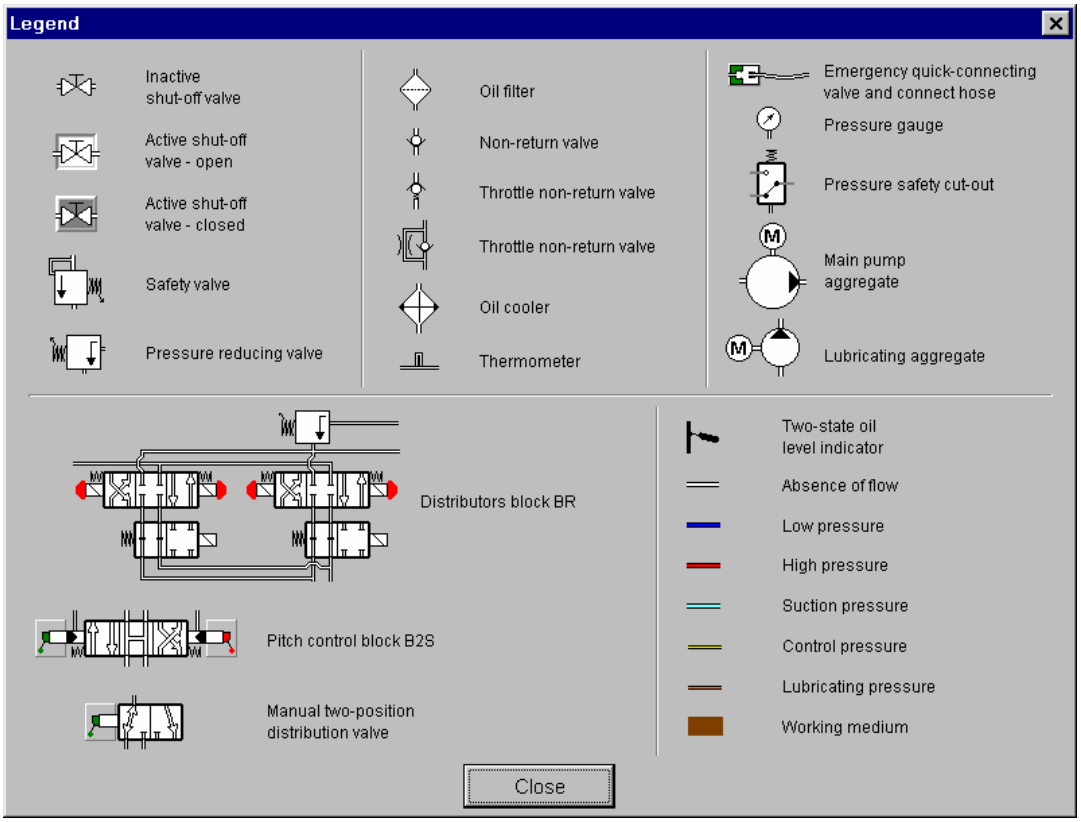

Fig. 5 Legend

III. Hydraulic System Control panel's description

C.P. propeller installation consists of two control panels. One is in Engine Control Room – ECR (Fig. 6) the second one is for local control and is near the C.P. propeller installation (Fig .7) .

Attention:

In this simulator does not include the control units located on the bridge and the bridge wings.

The control panel in ECR includes :

1. The signalling and alarm lamps:

   - **Oil gravity tank low level**
   - **Oil main tank low level**
   - **Servo oil low pressure**
   - **Control oil low pressure**
   - **Servo oil high temperature**
   - **Control signalling**

2. Main and Lubricating pumps panel consist of:

   - Control mode signalling lamps : **Local – Remote**
   - Signalling lamp: **Pump run**
   - Reserve pump signalling lamp: **St –by** (this lamp is not included on the Lubricating pump aggregate panel)
   - Push-buttons: **Start - Stop**
   - Switch **Pump operation** mode (**0 –off , I – manual , II – auto**)
   - Switch **Supply** switch with signalling lamp

3. Switch **Main pump aggregates st-by selection** (**0 – off, I – pump No 2 st-by, II – pump No 1 st-by)**
4. Push-buttons : **Alarm confirmation**
   Lamps test

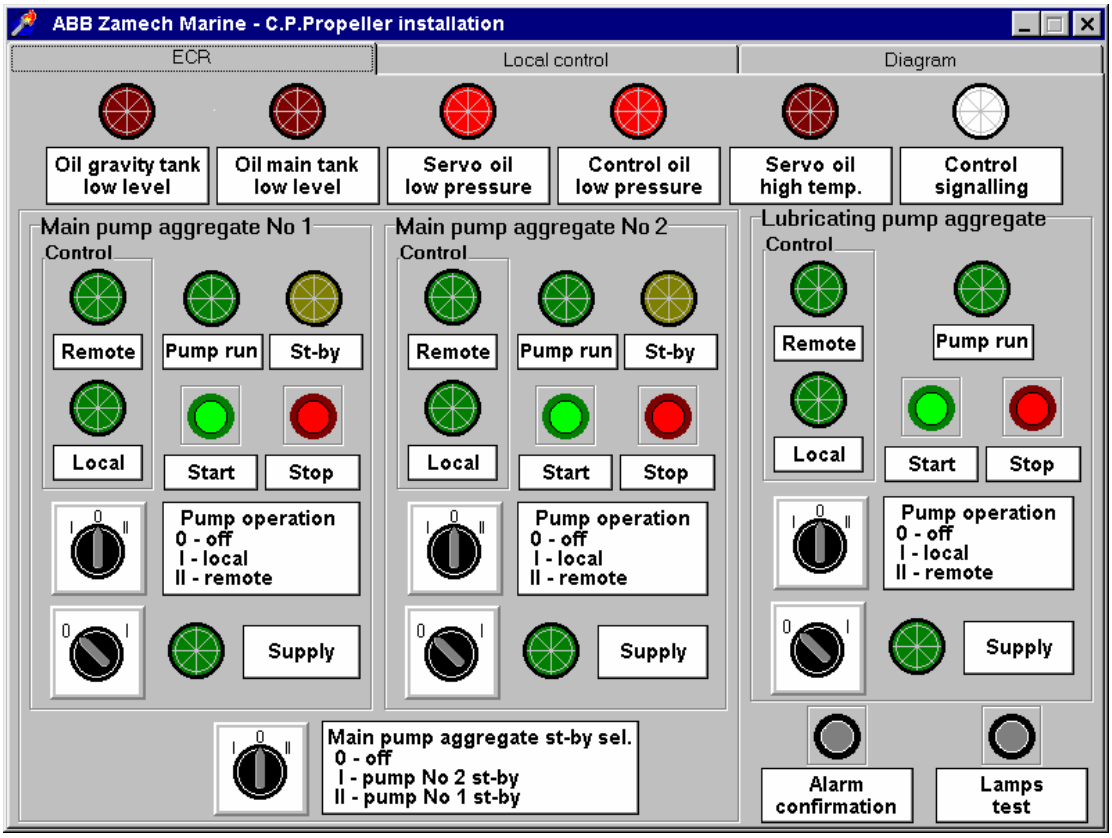

Fig . 6 Engine Control Room panel - ECR

The local control panel includes three fields of pump aggregates (No 1, No 2 and Lubricating pump aggregate)
Each of these fields consists of :

- Signalling lamp: **Pump run**
- Switch **Pump operation** mode (**0 – off , I – local , II – remote**)
- Push-buttons : **Start – Stop**

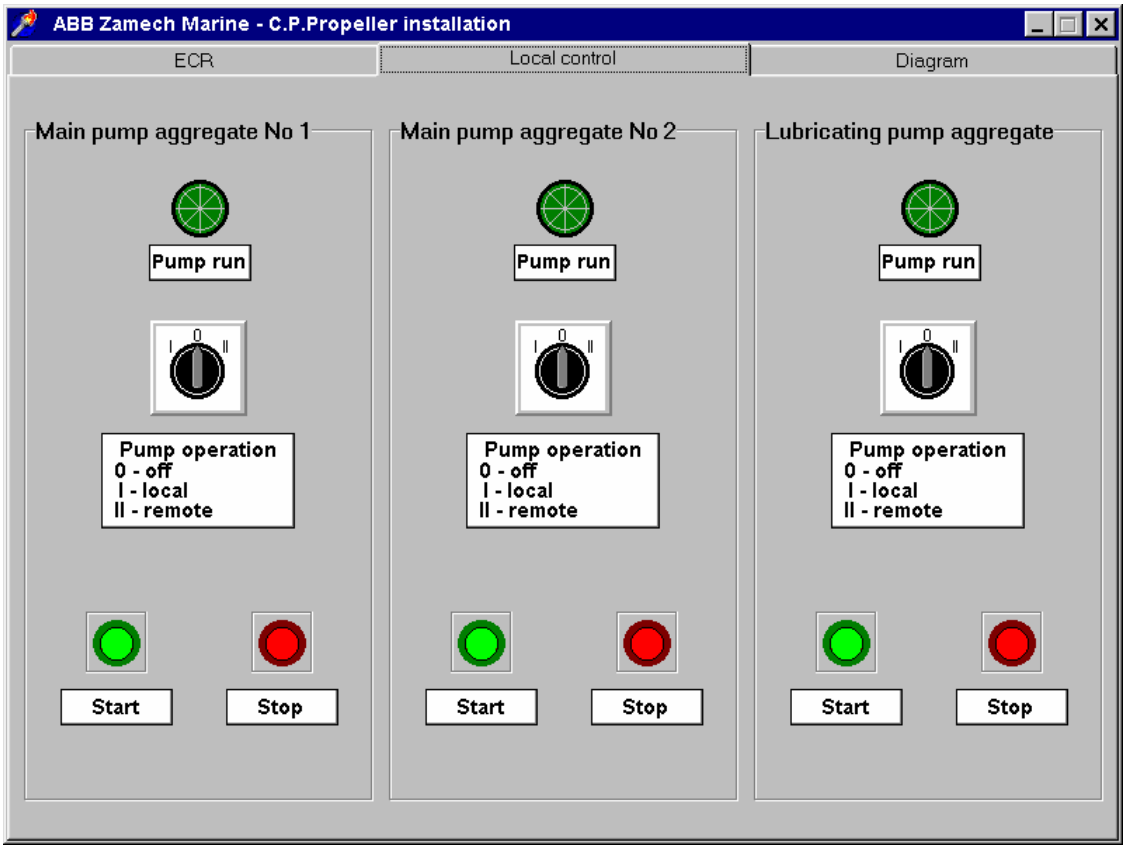

Fig.7 Local control panel

C.P. propeller operating modes

C.P. propeller installation may operate in one of the following operation modes during its exploitation:

- *Basic operation* : one of the main pump aggregates works with remote pitch propeller control from the bridge (follow-up or non follow-up).

Attention:

Simultaneous operation of two main pump aggregates is not permissible

- *Emergency operation* at which one of the main pump aggregate works with local control. The pitch propeller control is done by acting manually on the sliding valve position of pitch control block B2S by means of the lever unit.

- *Emergency operation* at which main pump aggregates do not work and the pitch propeller control in AHEAD direction is done by means of the Lubricating pump aggregate.

C.P. Propeller starting procedure

Attention:
After programme starting, two alarm lamps turn on : **Servo oil low pressure** and **Control oil low pressure**, and the alarm signal simultaneously turns on. After pressing the push-button **Alarm confirmation** the alarm signal switches off.

1. At basic operation mode with remote control the following operations should be performed:
   a) open the shut-off valve at the installation diagram (Fig . 4, Pos. 20)
   b) on local control panel set up the three –position switch **Pump Operation** on all fields **/ Main pump aggregates No 1 and No 2** and '**Lubricating pump aggregate' /** into position **II – remote** control.
   c) on Pump Aggregate control panel in ECR:
      - set up the three-position switch **Pump Operation** of all Pump Aggregates into Position **I – Manual**
      - switch on supply of all pump aggregates - set up two-position switches into position **I** – supply activation will be confirmed by turning on of the **Supply** lamps. After turning on the supply, in each of the pump aggregates' fields, **Remote** lamps will turn on confirming remote control mode.
      - Switch on the Main pump aggregate (For e.g. No.1} by pressing the push-button **Start** (the lamp **Pump run** will turn on and simultaneously the alarm lamps **Servo oil low pressure** and **Control oil low pressure** will switch off).
      - Set up the second Main pump aggregate on stand –by mode by setting the switch **Pump operation** into position **II- auto** and by setting switch **Main pump aggregate st-by sel.** (selection) into position **I - Pump No. 2 st-by** 2. Stand-by operation mode of the second Main pump aggregate will be confirmed by turning on the **St-by** lamp. This means that in the event of a lack of discharge oil pressure of Main pump aggregate No. 1 (for e.g. due

to system failure or absence of supply) Main pump aggregate No 2 will automatically turn on. A check out of proper functioning of the stand-by system may be done by switching off operating Main pump aggregate, (in this case Main pump aggregate No 1) by pressing the push-button **Stop,** and verifying whether Main pump aggregate being on stand-by mode turns on automatically. The signal on switching on the St-by aggregate should be transmitted to the ECR alarm unit.

- On Lubricating pump aggregate block set switch **Pump operation** into position **II – auto** control. This means that, depending on the oil level in the gravity tank, the Lubricating pump aggregate will turn on and off. Lubricating pump aggregate will turn on at minimum oil level MIN and will turn off at maximum oil level MAX.

d) Pitch propeller remote control mode may be set up as <u>follow-up control</u> by pressing the push button **FU** (Fig. 4 Pos. 15). Once the follow – up mode is set, it is possible to adjust the propeller pitch by mouse clicking on the arrow field AHEAD - marked with green colour on lever's scale or ASTERN - marked with red colour on lever's scale .
Pitch propeller remote control mode may also be set up as <u>non- follow-up</u> control (regarded as emergency mode in case of follow-up system failure) by pressing push button **NFU** (Fig .4 Pos. 16). In case of non follow-up operation, pitch adjustment is done by pressing push buttons - green button AHEAD or red button ASTERN. Actual propeller blades position on the 0 up to 10 scale AHEAD – ASTERN is indicated on PITCH gauge.
At follow-up operation, control signal originates from pitch lever control unit, located on manoeuvring stand on the bridge. Once the signal is amplified it reaches CONTROL UNIT that constitutes a comparison element. Depending on demanded pitch propeller setting, control signal is delivered to electromagnetic coil of distributors block BR (Fig. 4 Pos. 9) .
In consequence, control oil is supplied on either the fore or aft side of three-way slide valve of pitch control block B2S. By changing the slide valve of pitch control block B2S, the oil from Main aggregate pump is delivered to servo motor cylinder. In consequence, the propeller blades adjustment changes . A change in the propeller blades adjustment activates the feed-back device. The feed back device sends to the comparison element an information about actual propeller blades position. At follow-up control mode, supply of oil for servo motor cylinder will cease when feed-back device directs to the comparison element a signal indicating that demanded propeller adjustment has been achieved. At non follow-up control mode, electrical signal from push button AHEAD or ASTERN is directly transmitted to electromagnetic coils of the distributor block BR (Fig. 4 Pos. 10). The blades' displacement continues as long as the push button AHEAD or ASTERN is pressed.

Attention:

At non-follow up control mode it is necessary to observe the PITCH gauge in order not to exceed the maximum pitch value determined during sea trials as nominal value, as otherwise it will lead to main engine overload .

2. At emergency operation mode (in case of control signal from bridge failure) when one of the Main pump aggregates functions and the control mode is local, the following operations have to be carried out :
   a) on ECR control panel:
      - set three-position switch **Pump operation** of Main pump aggregates into position **0** - **off**
      - turn on supply of the Main pump aggregates. After turning on the supply on the fields of Main pump aggregate, the **Supply** lamp will turn on.
      - turn on supply of Lubricating pump aggregate and set switch **Pump operation** into position **II- auto (**see 'Basic Operation Mode' procedure)
   b) on local control panel set switch **Pump operation** of the Main pump aggregates into position **I- local** control. Set Lubricating pump aggregate switch **Pump operation** into position **II – remote** control. The appropriate lamps on the ECR panel will turn on.

   Attention:
   Setting the whole remote control mode as manual means that remote control from the bridge and from ECR (either follow-up or non follow–up control operation) does not function. In real conditions on board, in order to set the operation mode as local it is necessary to use a separate independent switch placed on the Local Control Panel. At this operation mode it is also not possible to turn on Main pump aggregates on ECR control panel.

   c) on local control panel, start chosen Main pump aggregate by pressing push button **Start.**

   d) local control of pitch propeller adjustment is done by acting manually on three - ways slide valve of block B2S – in simulator conditions this it is achieved by mouse clicking on field of green lever AHEAD or on field red lever ASTERN (Fig. 4 Pos. 7)

   Attention :

   1. At emergency local control mode it is necessary to observe the PITCH gauge in order not to exceed the maximum pitch value determined during sea trials as nominal value, as otherwise it will lead to main engine overload.
   2. At local control mode, it is possible to perform a trial of opening of safety valve in BZ block. This should be undertaken when the Main Engine is

stopped. Once the pitch propeller achieves maximum deflection value, resulting from the piston movement in the cylinder (the piston lays against the cylinder wall), the safety valve BZ opens. A similar trial may be effectuated at non-follow up remote control.

3. At emergency control mode (in case of a failure of Main pump aggregates) when the Lubricating pump aggregate functions and the control mode is local, the following operations have to be carried out:

   a) on ECR control panel
      - switch off the Main pump aggregates' supply
      - in the fields of Main pump aggregates set three-position switch **Pump operation** into position **0 – off**
      - switch on Lubricating pump aggregate supply. Once the supply is turned on, control lamp **Supply** turns on.

   b) on local control panel :
      - set three – position switches **Pump operation** of both Main pump aggregates into position **0 – off**
      - set three position switch **Pump operation** of Lubricating pump aggregate into position **I – local** control. On ECR panel, the lamp **Local** will turn on in the field of Lubricating Pump Aggregate.

   c) on the installation diagram :
      - close shut-off valve (Fig.4 Pos. 20)
      - set manual two – position distribution valve (Fig. 4 Pos. 19) for emergency oil distribution block supply (by mouse clicking on field of valve lever)
      - connect emergency quick connecting valve with connecting hose (by mouse clicking on field of oil distribution box connecting hose (Fig.4 Pos. 6)

Emergency control of pitch propeller (only AHEAD) is possible by turning on Lubricating pump aggregate, by pressing **Start** push button on local control panel. Once the demanded propeller adjustment is achieved (only AHEAD), Lubricating pump aggregate has to be stopped. As a next step, manual two -position distribution valve has to be set (Fig. 4 Pos. 19), as for normal lubrication operation (by mouse clicking on field of valve lever) and Lubricating pump aggregate has to be turned on again on local control panel. At emergency operation mode of this type, shut-off valve (Fig. 4 Pos. 20) remains closed in order to improve the conditions of lubrication and cooling of oil distribution box.

Attention :

In case of servo oil supply system failure of Main pump aggregates, automatic blockage of pitch propeller occurs. Such state allows for further emergency operation of pitch propeller, at previously set adjustment (it is not necessary to change pitch propeller adjustment by applying the emergency mode described above). In this situation, it is only necessary to turn on Lubricating pump aggregate into continuous operation and to close shut-off valve (Fig. 4 Pos. 20) in order to improve the conditions of lubrication and cooling of oil distribution box.

It is also possible to set the pitch propeller at emergency mode AHEAD in case of failure of all pump aggregates. This is done by means of an additional, manually operated pump. This situation is not simulated within the program. The pitch propeller manufacturer also enabled emergency pitch propeller operation by means of emergency oil supply from Lubricating pump aggregate directly to valve block BZ. This possibility is not simulated within the program.

C.P. propeller stopping procedure

Stopping procedure of pitch propeller installation once the manoeuvres are finished (during stay in ports) requires the performance of the following tasks:

a) on ECR control panel:
   - set switch **Main pump aggregate st-by sel.** into position **0- off** - **St-by** lamp of pump aggregate being on stand by mode turns off
   - set switch **Pump operation** of pump aggregate that previously was on stand-by mode into position **0- off**
   - switch off working Main pump aggregate by pressing **Stop** push button and set switch **Pump operation** into position **0- off**
   - switch off Main pump aggregates supply
   - Lubricating pump aggregate supply should remain turned on and **Pump operation** switch should be in position **II - Auto**.

b) on installation diagram check whether shut-off valve (Fig .4 Pos. 20) is open.