AN-ELEC®

RETROFIT HYDRAULIC CRANE CONTROL SYSTEM

ELECTROTECHNICS

project / realization / service

CERTIFIED LR VCA**

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MGMT. SYS. RvA C 010

CERTIFIED LR ISO 9001

RETROFIT HYDRAULIC CRANE CONTROL SYSTEM

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Introduction

More than 20 years of experience

Our company boasts more than 20 years of experience in designing and constructing control systems. Design, construction, installation, startup and maintenance - comprehensive „turnkey" solutions for all projects. Offering high quality and professional service over the years, we have earned a large group of satisfied clients.

In-house production hall and design office

All designs developed by our design office are put into life by our in-house production hall. We are also capable of completing every project based on technical documentation supplied by the client.

For land and offshore industries

Our services are dedicated to the civil engineering and offshore industries. Our hydraulics control system will work perfectly both as part of new projects and within upgraded infrastructure.

The system displayed is designed for controlling the operations of a hydraulic crane. The control system with a switchgear, with a PLC and HMI supplied by ABB as its primary component, was installed, among others, on cranes operating on the board of the Marcos Dias, thus replacing the original control system provided by Liebherr. Both the program and the control switchgear were designed to retain the primary functions of the previous system and, additionally, to ensure the faultless operation of the system and facilitate the diagnostics of possible system malfunctions. The design was developed through reverse engineering, without access to original documentation for the installed crane.

1. General operating principle

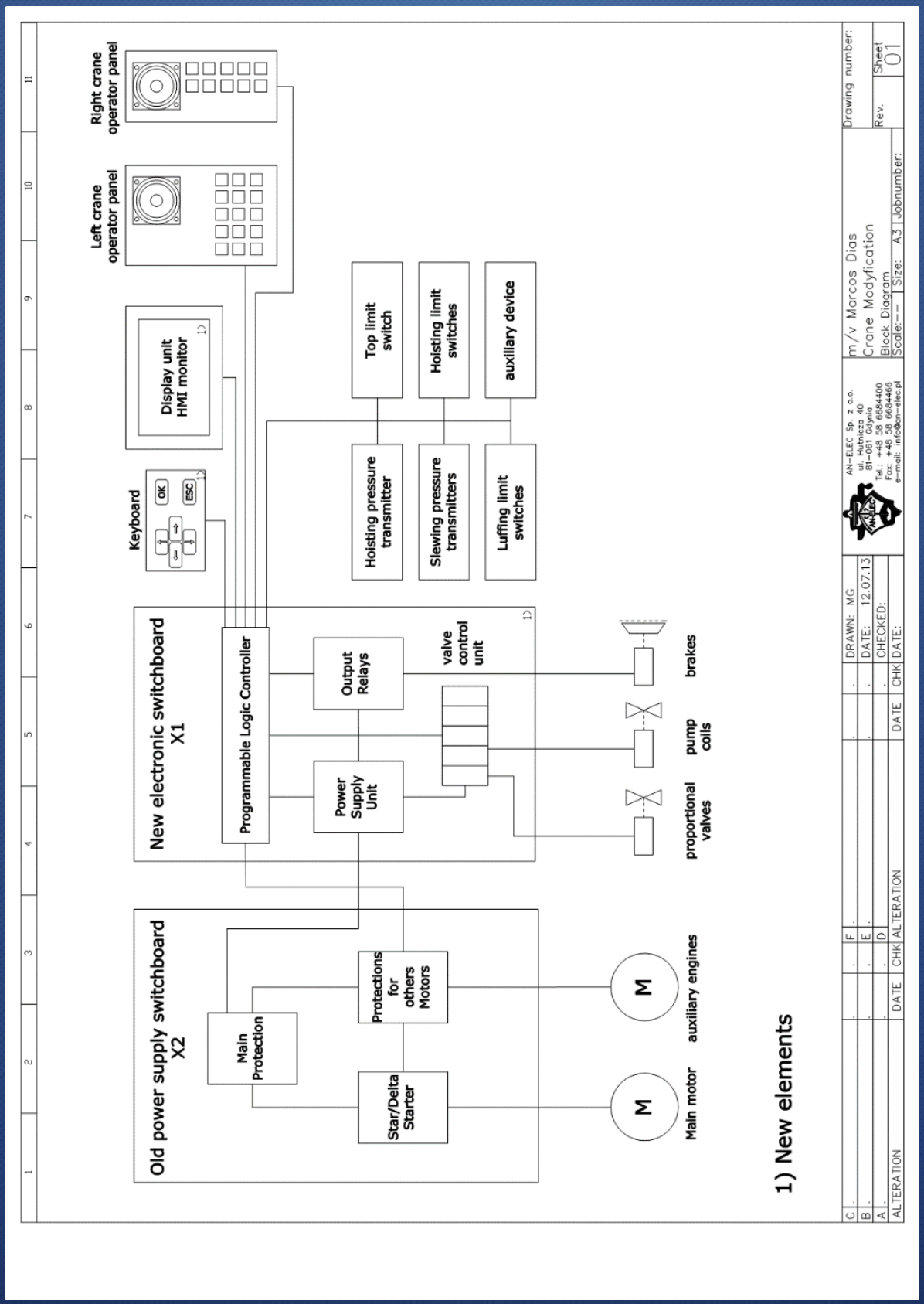
Control of crane movements is carried out by joysticks in the operator's cabin. Crane movements are also limited by the control system, using signals from the sensors.

Crane rotation is executed by two hydraulic motors operating in a closed system, with a variable-capacity pump. The speed of rotation of the crane column is changed by changing the pump output.

Crane jib movement (change of outreach) is executed by two actuators (powered from a fixed-capacity pump). Their lifting and lowering speed is regulated by proportional valves. Two hydraulic motors powering the winch drum, operating in parallel, in a closed system with two variable-capacity hydraulic pumps are responsible for lifting and lowering the crane hook. Similarly to change in rotations, changing the pump output causes the rope winding/unwinding speed to increase or decrease.

All of the aforementioned pumps, including auxiliary pumps and circulation, are powered by a single electric motor through a transmission system.

2. Block diagram of the designed system



3. Crane operator panel

The crane cabin was furnished with a panel (HMI monitor) and functional buttons used for displaying the information saved in the panel.
One of the primary functions of the HMI panel (displayed on the first "screen") is displaying information about the current load of the hook winch, and the value of oil temperature, as well as active alarms and notifications. The event history can be further browsed by selecting the history tab using the functional buttons.

List of information displayed on the panel:

a) crane operation alarms:
- the emergency stop was pressed;
- engine overload;
- motor temperature high;
- oil temperature high;
- oil temperature low;
- oil level low;
- transmission oil temperature high;
- winch drum oil temperature high;
- hook winch overload (load too heavy or brake failure);
- 6 bar pressure not reached (leak);
- crane safeties disabled;
- oil cooler malfunction;

b) system alarms:
- rotation joystick error;
- outreach joystick error;
- hook joystick error;
- oil temperature measurement out of range;
- hook system pressure measurement out of range;
- left turn pressure measurement out of range;
- right turn pressure measurement out of range;
- internal controller error;
- top limit switch sensor failure;
- lower jib position sensor failure;
- upper jib position sensor failure;

- jib parking position sensor failure;
- upper jib release sensor failure;
- lower jib release sensor failure;

c) displayed values:
- load on the hook winch;
- oil temperature;
- current maximum and preset hook winch capacity;

4. Function of the PLC automation system

The crane function control system is based on a PLC which has the following, basic functional units:

- crane rotation unit;
- jib tilt unit;
- hook movement unit;
- alarm unit;
- main engine and radiator motor control unit;

4.1 Crane rotation control unit

The primary purpose of this unit is to develop a control signal for the card which adjusts the rotation pump capacity, and a brake release signal. In addition, the unit checks the statuses of its inputs, notifying the operator of any prohibited values - alarm unit.

From the joystick, the rotation signal is fed to the potentiometer interference filter. Next, the signal is shaped and the correctness of input rotation signals is verified. Further on, the control signal is made dependent on the signals from pressure transducers (pressure values are also filtered) and the power is limited to prevent the available pump power to be surpassed. In emergencies, the control signal is cut off from the card to protect it from any unpredictable effects.

The last part of this unit consists in a system which produces a signal required for releasing the rotation brake. The brake is released when the pump capacity control signal is present and when the joystick is pushed.

4.2. Jib angle control unit

The role of the jib angle control unit is to obtain a control signal for the proportional valve card controlling the jib lifting piston, to control the brake valve and to release the brake when lowering the jib. In addition, the unit checks the statuses of its inputs, notifying the operator of any prohibited values - alarm unit.

Similarly to rotation control, the signal generated by the joystick is filtered and shaped,

depending on the signals received from the sensors (speed reduction in top and bottom deceleration areas, engaging the parking mode, limits). The correctness of signals generated by the joystick and the limit switches is also verified. In emergencies, the control signal is cut off from the card to protect it from any unpredictable effects.

The brake system is an important element of the unit, since when the proportional valve is set to lowering, the brake unlocks the brake valve and, depending on the weight of the load, adequately adjusts the setting of this valve.

4.3. Hook movement control unit

The primary purpose of the hook movement control unit is to develop a control signal for the card which adjusts the hook pump capacity, and a brake release signal. In addition, the unit checks the statuses of its inputs, notifying the operator of any prohibited values - alarm unit.

From the joystick, the hook movement signal is fed to the potentiometer interference filter. Next, the signal is shaped and the correctness of input signals is verified. At the same time, the hook winch line signal is filtered and fed to the pump power limiter system, the pressure memory system (the weight of the load being lifted) and the pump leak compensation system.

In emergencies, the control signal is cut off from the card to protect it from any unpredictable effects.

The last part of this unit consists in a system which produces a signal required for releasing the hook winch brake. The brake is released when the pump capacity control signal is present and when the joystick is pushed.

4.4. Alarm unit

The purpose of the alarm unit is to gather all information about PLC errors, incorrect input signals and crane failure. The system transmits information about events to the HMI panel, to warning lamps inside the crane cabin, and to the buzzer.

4.5. Main engine and radiator motor control unit

The primary drive engine is started after the engine start signal is fed to the controller. It is stopped when the signal is discontinued. The star-triangle startup is performed in the X2 switchgear and is not modified in any way.

In order for the main engine to be started, a series of conditions must be fulfilled, among others:

- the engine start button in the operator's cabin must be pressed;
- no signals on the crane movement control coils;
- transmission oil temperature not exceeded;
- main engine overload signal not present;
- main engine temperature below upper threshold;
- correct oil level in the tank;
- correct oil temperature in the tank;

The main engine is stopped when:

- the engine stop button in the operator's cabin must be pressed;
- transmission oil temperature is exceeded;
- main engine overload;
- main engine temperature above upper threshold;
- oil level low;
- the emergency stop was pressed.

The hook winch radiator motor is started when the temperature in its drum exceeds 55 degrees Celsius and when its thermal protection is engaged. In turn, the main oil cooler motors are started when oil temperature in the tank exceeds 50 degrees Celsius and no issued with motor safeties occur.

5. Summary

Our proprietary hydraulic crane control system is an all-purpose system which can be be retrofit in crane systems offered by other manufacturers. All of our control system modifications are always accepted by a representative of a classification society, such as BV.

In our headquarters, you will find a fully operational crane model with original software.

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