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REMOTE CONTROL OF HYDROSTATIC DRIVE MECHANISMS FOR HOISTING MACHINERY AND LOGISTICS CENTERS

Otto GRIGOROV[1], Vsevolod STRYZHAK[2], Daria ZIUBANOVA[3]

[1)] Prof., D.Sc. in engineering, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
[2)] Senior Lecturer, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
[3)] Ph.D. Student, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine

Abstract: *The analysis of the crane or loader travel mechanism construction with hydrostatic drive and low-moment hydraulic motor has been performed. It has been proposed that the electric circuit of pump performance remote control system that meets the requirements applicable to the crane drives control system. The zero-setter design has been developed for hydraulic drive emergency braking in case of an emergency, while the bridge runover on the obstacle when travel limit switches of the traveling mechanism triggered , and also the electric drive motor of the pump and electric control scheme of pump productivity loses power. The hydraulic circuit of the lifting machines mechanism is presented and its operating principle is described. Implementation and testing of remote control system elements are implemented on the travel mechanism experimental stand of the crane with a lifting capacity of 32/5 t that is described in the article.The stand design allows to provide long-term trials in a wide range of static and dynamic loads, to realize implement typical operation cycles and to record the nature of dynamic loads and energy consumption. In consequence of the research it was proved that hydrostatic drive with low-moment hydraulic drive and described remote control system has deep adjustable speed for a given program, softens dynamic load transients, and saves a significant amount of power during acceleration and braking.*

Key words: *hydrostatic drive, travel mechanism, control system, low-moment hydraulic motor, hydraulic motor, servomotor.*

1. INTRODUCTION

Hydrostatic drive with low-moment hydraulic drive is the most advanced of hydrostatic drives, which can be used in the travel mechanisms of hoisting machinery and logistics centers mechanisms. In this case the significant role is played by remote control of the drive.

During the remote control system creation it has been conducted the review and analysis of a large number of publications. We used the author's achievements in this area [1–5].

2. AIM AND PROBLEM STATEMENT

The aim of this work is to create a remote control system of the pump performance that meets the requirements applicable to the crane drives management systems and is able to implement start-up, acceleration, movement with nominal or intermediate speed, braking and reversing of the hydrostatic drive travel mechanism of overhead type crane and also to lifting or lowering at nominal or intermediate speed, braking and reversing of hydrostatic drive lifting mechanism of the overhead type crane.

[*] Corresponding author: 21, Frunze str., 61002, Kharkiv, Ukraine, Tel.: …;
E-mail addresses: *ottow@inbox.ru* (O. Grigorov), *401222@mail.ru* (V. Stryzhak), *daria_ziubanova@yahoo.com* (*D. Ziubanova*).

3. RESULTS

Let us consider the real travel mechanism that can be used in overhead type cranes, stacker cranes, walking cranes (Fig. 1). It consists of a short-circuited electric drive motor 13, pump IID №5 – 11, hydraulic motor PM №5 – 6, security valve blocks 8, running wheel 1, transmission shaft 2, reduction gear 3, coupler 4, 12, hydraulic motor bracket 5, leaking liquid piping 7, main high pressure piping 9, supplementary bowl 10, frame 14. The main elements are energy converters – pump and hydraulic motor.

The most valuable quality of this drive is the ability of smooth, stepless adjustment and positioning accuracy, which is especially valuable in logistics systems. This is achieved with a much greater economic impact than in the mechanical and electrical transmissions.

Hydraulic drive benefits promote its use in handling and transportation machinery and logistics complexes that require smooth speed control over a wide range, particularly in cranes work in the aggressive environments.

Hydraulic motor rotation speed depends on the roller rotation angle of the pump performance remote control (such as IID).

In hoisting machines mechanisms and logistic complexes it can be found the largest electric remote control distribution of the pump capacity.

Figure 2 shows one of the possible remote control electrical schemes that had been tested.

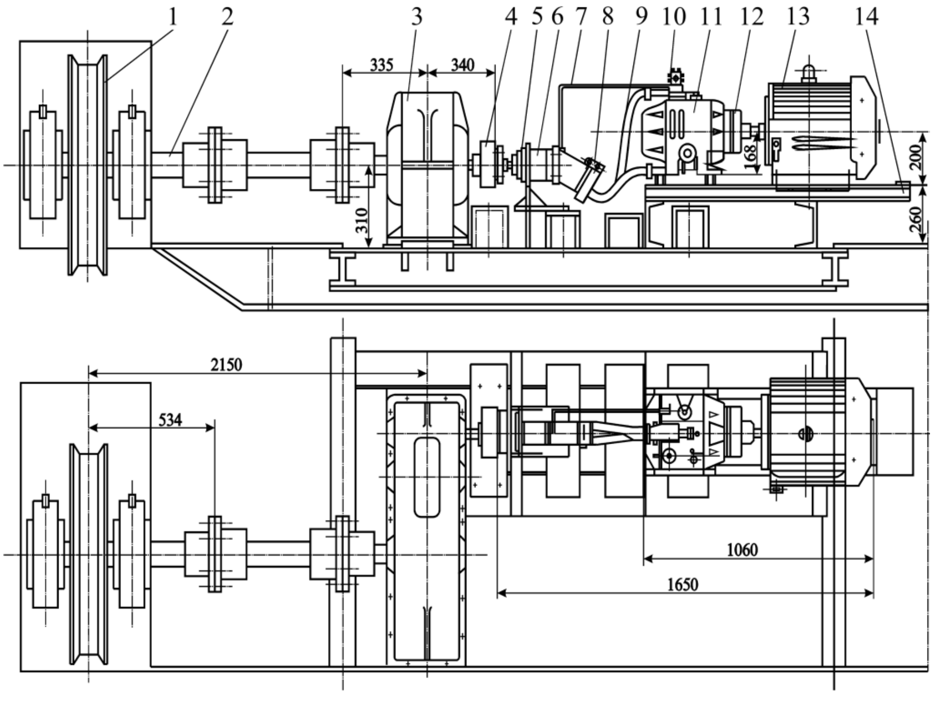

Fig. 1. Variable hydraulic power drive of travel mechanism.

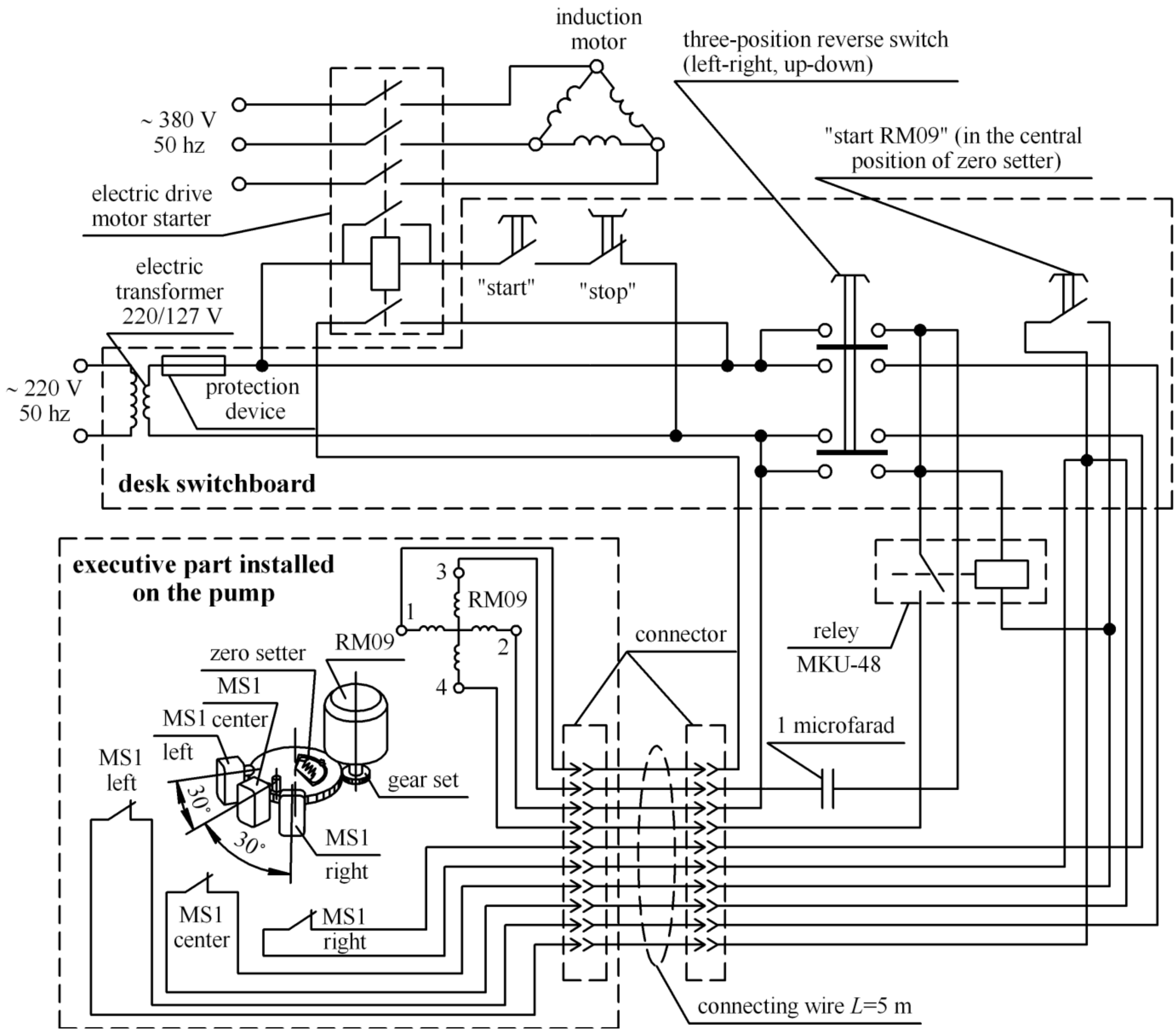

Fig. 2. Electrical scheme of remote control of hydraulic drive speed by switching time

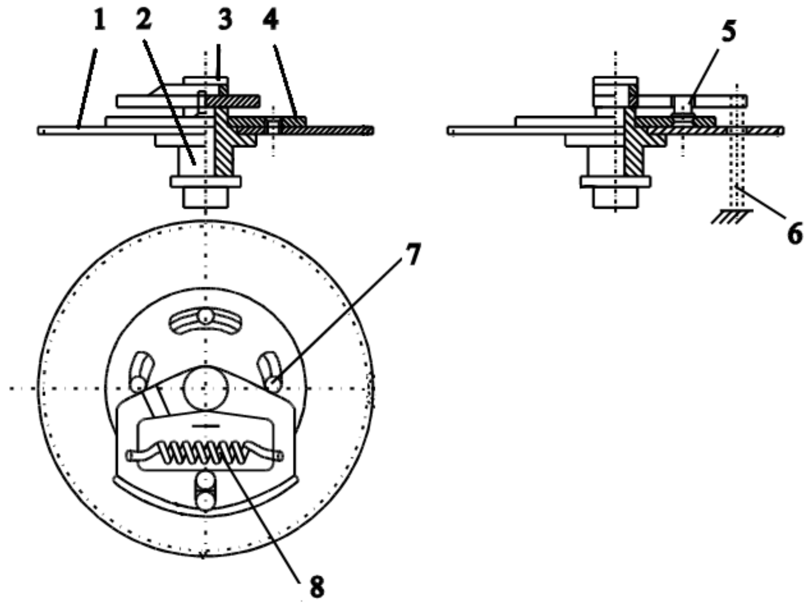

Fig. 3. Zerosetter.

The most difficult is the executive system, which consists of the servomotor RM-09 (or SM-54), gear set, zero setter, microswitch complexes MS-1. The desk switchboard consists of buttons "start", "stop", transformer 220/127 V, three position reverse switch, buttons "start RM-09" (with central location of zero setter). The relay MKU-48 is designed to run one of the winding servomotor.

The scheme consists of several modular groups:

- Electric drive motor starter of high power;
- Desk switchboard;
- Executive system installed on the pump.

Microswitches MS-1 has normally closed contacts. Switch on 4 chains in three positions; third position – neutral. Button at three positions: with the fixation of switching mechanism, in a neutral position and without fixation in two extreme positions.

Executive servomotor – RM-09. It has a built-in gear. The electric motor RM-09 is attached to special brackets installed directly on the pump IID №5. On the output shaft of the electric motor the gear wheel are implanted. It has coupling engagement with a gear wheel mounted on the remote control roll of pump performance. Gear wheel bears the cam, which influences the microswitches MS-1.

The electrical scheme meets the conditions that may occur during start-up, acceleration, movement of nominal or intermediate speed, braking and reversing of hydrostatic drive travel mechanism of the overhead type crane, as well as lifting or lowering of cargo with nominal and intermediate speed, braking and reversing of hydrostatic drive mechanism of the overhead crane hoisting.

This scheme satisfies the requirements of the emergency brake, for example, while the bridge run over on the obstacle when travel limit switches of the travelling mechanism triggered and the work included zerosetter.

In this case, the electric drive motor of the pump and electric control scheme of pump productivity loses power.

For emergency breaking the special mechanical zero setter are made. Its design is shown in Fig. 3.

Zero setter built-in gear wheel 1, which transmits rotation on remote control roll through the sleeve 2. Zero setter consists of two staples 7 levied with spring 8. To adjustment disk 4 the pin 5 is attached. A similar pin 6 is attached to the pump casing. Staples 7 is sitting on a sliding landing on axis 3, pressed in bushing 2.

Fig. 3 shows the neutral position of all zero setter elements when the performance of the pump is equal to zero.

If the pump performance is different from zero, then under the influence of gear wheel 1 through pin 5 motion passed to one of the levers 7 (depending on the direction of crane movement), while the other lever 7 is still there, pressed against the spring pin 6. The spring 8 is tensed while this is stretching. When the electrical control scheme loses control voltage, under the springs 8 whole system quickly (1–2 seconds, depending on the spring force) is set to the starting position. During this hydraulic drive is braking hard to zero speed. Zero setter displays remote control swath in zero position, while the servomotor RM-09 shows no opposition, because it lacks power. Roller of servomotor RM-09 is working only under the work of gear wheel the certain angle that corresponds to the crane travel speed with which he moved to actuation road limit switch.

Fig. 4 shows the hydraulic scheme of hoisting machine mechanism.

To control drive mechanism or hoisting mechanism the engine 3 should be started, which drives the pump IID. Along with the main motor launch the voltage is applied to the system.

To move the crane driver puts the switch in one of the extreme positions and simultaneously press the button. Relay MKU-48 is action, contacts close and open, voltage is applied to the windings 3–4 (see Fig. 2) of servomotor RM-09 through the condenser, the motor starts to rotate.

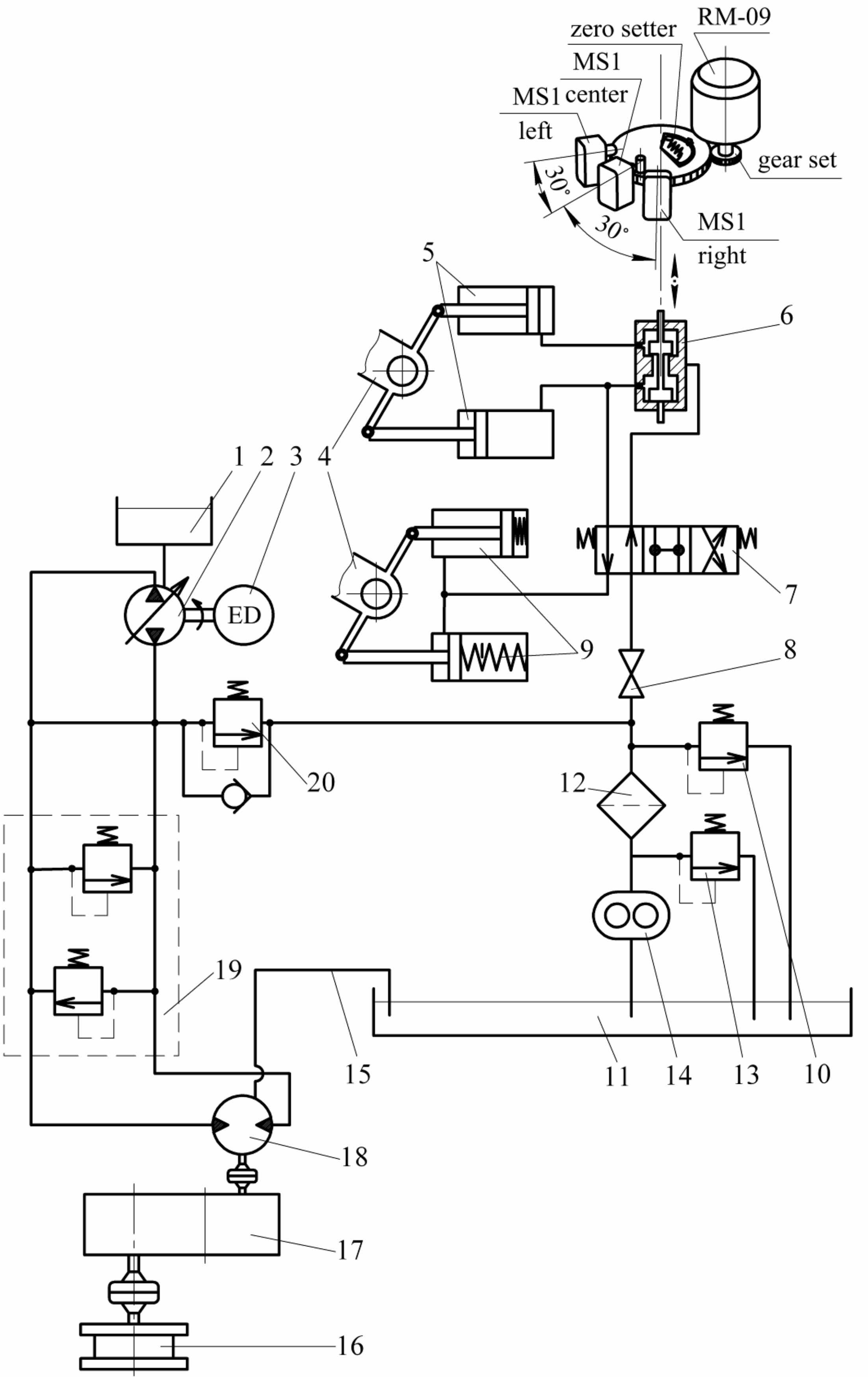

Fig. 4. The hydraulic scheme of travel crane drive mechanism with the installation of devices for speed remote control of hydraulic drive on time: 1 – supplementary bowl; 2 – pump; 3 – electric drive motor; 4 – pusher (cradle pump); 5, 9 – cylinders; 6 – amplifiers valve box; 7 – shifting spool; 8 – changeover cock of the working modes; 10, 13, 19 – security valves; 11 – pump housing; 12 – filter; 14 – gear-type pump; 15 – leakage collection pipeline; 16 – crane wheel; 17 – reduction gear; 18 – hydraulic motor; 20 – replenishing valve.

Cam comes off the microswitch that blocks button and contact MS-1 is closed. Conduction path is opened by passing the button. Hoisting machine accelerates with constant acceleration.

Selection of electric drive reduction and additional gear wheel is made in such a way that the hydraulic motor accelerates to a speed of about 1500 rev/min (corresponding to nominal speed) at the desired time. Meanwhile rollers of remote control of pump productivity turned on about 30°. After turning on 30° cam clicks on one of the limit switches MS-1. The chain is opening. Servomotor stops. Hoisting machine at this time is moving with the nominal speed.

If an intermediate movement speed of hoisting machine is needed, the driver upon reaching it puts the switch in the neutral position. Servomotor RM-09 while this stops and will maintains remote control shaft in one of the intermediate (from 0 to 30 °) provisions relevant to required speed.

Thus, we have the dependence of the hoisting machine movement speed on the time switch that is necessary to rotate the remote control roller by 30°. To reduce the hoisting machine speed the switch should be put in the opposite extreme position required for acceleration and bring in a neutral position to achieve the desired reduced speed.

For a complete stop of the crane the switch is left in extreme position until the cam mounted on remote control roller gear that does not break microswitch contacts MS-1 while shunting the button. Remote control roller while this takes a neutral – zero position. The electric motor RM-09 stops. The mechanism will be in place so that the performance of the pump is equal to zero.

Microswitch installation MS-1 that shunts button is needed when mechanism while it stops, doesn't start to move in the opposite direction without special permission (pushing the buttons). The remaining two microswitches MS-1 act as limit switches. After the breaking of the contacts one of these switches the reversing can occurs, with the help of the servomotor RM-09 switch, which will reduce the movement speed of the mechanism to the required size.

When a switch is in neutral position or breakout of normally closed contacts of switches MS-1 for enabled winding switches 3–4 are getting the voltage, by passing capacitor.

This device meets all the conditions of start-up, acceleration, movement of nominal or intermediate speed, braking and reversing of hydrostatic drive mechanism.

The scheme also meets the requirements of emergency braking when hitting an obstacle or at over wind load when the trigger limit switches. In this case, the drive motor of the pump and electric control scheme of the pump performance loses power. Zero-setter pump displays a pipe, and with it the remote control roller in zero position; servomotor RM-09 does not counteract this, since it lacks power. Servomotor roller RD-09 under the influence of wheels turns at an angle corresponding to the movement speed of cranes to final switch operation.

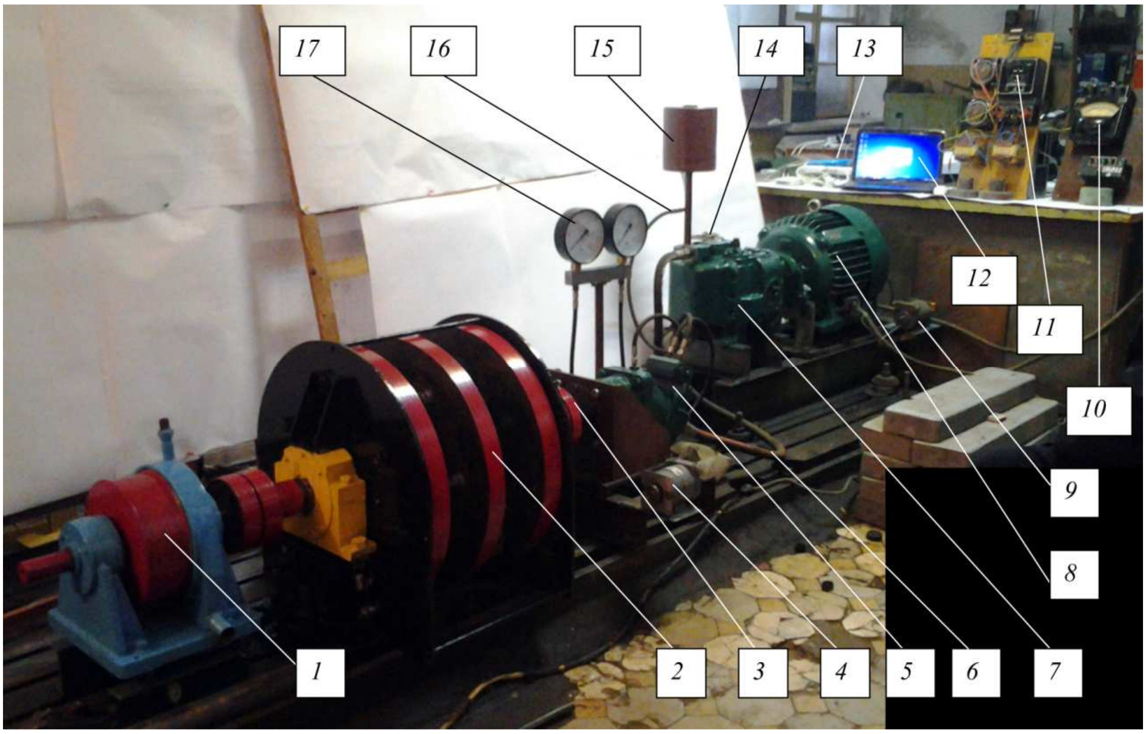

Fig. 5. Stand for testing the mechanisms and logistics systems with hydrostatic variable power drive:
1 – Loader that cooled under running water to simulate the static moment of movement or rotation resistance; 2 – rotating mass to simulate the moment of rotating mass energy (cranes parameters of wide range of capacity are simulated); 3 – tension sensor for the torsional moment transmission to the amplifier and then to the ADC; 4 – tachogenerator TMG-30P for rotation speed recording; 5 – hydraulic motor IIM №5; 6 – high pressure pipelines; 7 – axial piston pump IID №5; 8 – electric motor AO 62-4; 9 – tachogenerator ТМГ 30 П for rotation speed recording of the hydraulic motor and fixing his work in generator mode; 10 – pointer wattmeter; 11 – power converter P004; 12 – notebook; 13 – amplifiers; 14 – performing part of control systems; 15 – supplementary bowl; 16 – drain leakage pipeline; 17 – manometer.

Hydraulic drive operates on the closed scheme of the working fluid circulation. The geared pump 14 (see Fig. 4.) sucks the oil from the crankcase 11 and submits it to the filter 12 where it is cleaned. Then the oil under the pressure of 0.6 MPa comes to fuelling valves 20. If the suction line of axial piston pump 2 pressure is less than 0.6 MPa, valve passes oil from the gear pump until the pressure is back to normal.

Pump productivity and the oil flow direction, and thus the speed and direction of movement changed via servomotor RM-09. Servomotor RM-09 through a series of intermediate gear shifts away from the neutral position spool valve boxes hydroamplifier 6, and thus exempt access to oil power cylinder 5. Cradle 4 of axial piston pump 2 bends the rod of power cylinders. Thus, the pump performance is changing.

Oil under the pressure from the axial-piston hydraulic pump oil enters the hydraulic motor PM №5 - 18, where the pressure drop in pumping and drainage pipes converted to torque that is transmitted through gear 17 to the running wheels 16.

To prevent the overload of the pump IID №5 and hydraulic motor PM №5 the safety valves box 19 is installed.

Disabling the electric drive motor 3 the pipe through the zero setter rods 9 reaches in zero position.

Fluid reservoir 1 is used for filling leaks. The shifting spool of the zero installer 7 serves to supply oil to the hydroamplifier spool box and to the zero setter.

Changeover cock of the working modes 8 (automatic – semi-automatic) is used to switch the pump performance management from the remote mode to hand-operated mode. In our case, the crane is set in "automatic" mode and pump included for use with remote control.

Positions 10, 13 – safety valves of gear pump. Drain pipe 15 assigns the origins of the hydraulic motor into the pump.

Drive with the remote control system has been tested on the stand shown in Fig. 5.

4. CONCLUSIONS

As a research result the following conclusions can be made. Hydrostatic drive with low moment hydraulic drive and described remote control system has deep adjustable speed for a given program, softens dynamic load transients, and saves a significant amount of power during acceleration and braking. In comparison with electric motor drive with the phase-wound rotor the energy cost savings equals 30–40%. The application of hydrostatic drive of travel crane mechanism gives the possibility to automate and implement the remote control. To automate the capacity pumps management as an option the electrical remote control scheme can be applied (shown in Fig. 2).

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