Chassis with Installed Hydraulics for Multifunctional Vehicles Intended for Public Utility Works

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Abstract: *The article presents a solution for the hydrofication of a small capacity truck chassis (total authorized mass of max 7.5 tonnes), i.e. equipping it with a hydraulic system (installation, aggregates, components, electrical control devices, etc.), to actuate various pieces of mechanical-hydraulic equipment (plow, snow cutter, salt spreader, sweeping brush, mower, etc.), intended for carrying out public utility works (snow removal, street sweeping, mowing of the roadsides, etc.).*

Keywords: *Hydrostatic transmission, utility vehicle, interchangeable pieces of work equipment, low fuel consumption*

1. Introduction

The utility vehicles intended for carrying out various works of public utility, such as: snow removal, street sweeping, mowing of the roadsides, etc., have been developed in two stages.
In the first stage, these vehicles were made by mounting a piece of equipment (plow or snow cutter, salt spreader, rotating brush for sweeping, tank with installation for street spraying, etc.), in front of or behind the vehicle operated by a hydraulic installation dedicated to each type of equipment [1].

Fig. 1. Utility vehicles [2]

In the current stage of development, the utility vehicles intended for carrying out public utility works are equipped with interchangeable work equipment, which offers flexibility when using the vehicle carrying various pieces of equipment, so that the same chassis is equipped, for example, in summer, with a rotating brush for sweeping and a street spraying installation, and in winter, with a snow plow or blower and salt spreader.
Fig. 1 shows a utility vehicle designed to perform public utility works, on which interchangeable work equipment pieces - mowers, sprinklers, snow blade and salt spreader - were mounted [2].

2. The structure of the chassis with installed hydraulics

The chassis proposed for being equipped with hydraulics parts has a total authorized mass of 7.5 tonnes.
The capacity of the chassis was limited to max. 7.5 tonnes of the total authorized mass, for reasons of overall size, so that it has access to small spaces or narrow streets.
The small capacity chassis, max. 7.5 tonnes, are manufactured with the motor rear axle and the steered front axle. The work equipment that is mounted in front of the vehicle "unloads" the rear axle, traction, which reduces the grip of the rear wheels especially when the road is slippery. For this reason, it is necessary to modify the front axle and turn it into a steering axle and motors with the possibility of decoupling when it does not need to be used.
Fig. 2 shows the structure of a utility vehicle made on a 7.5 tonne chassis, equipped with a blade for removing snow in front and with a salt spreader for spreading the anti-skid material in the back.

1. Hydraulic system for the operation of the interchangeable work equipment;
2. Salt spreader for spreading anti-skid material;
3. Blade for snow removal;
4. Front axle steering and decoupled motors;
5. 4x2/4x4 Chassis;
6. Rear axle motors.

Fig. 2. The structure of the chassis with installed hydraulics [2]

The power required for the hydraulic system implemented on the chassis is provided by its heat engine, through the power take-off (PTO) and the transfer case.
The chassis with installed hydraulics proposed for the development of the utility vehicles for carrying out public utility works, brings the following innovative elements:

- It offers the possibility to use the vehicle carrying interchangeable work equipment pieces to its maximum potential throughout the year, in summer with equipment specific to this season and in winter with snow equipment;
- It uses a single hydraulic drive system to operate all interchangeable work equipment;
- The power required for the hydraulic drive system of the interchangeable work equipment is provided by the heat engine of the chassis. The fact that there is no second heat engine dedicated to the hydraulic system for operating the interchangeable work equipment leads to the following advantages:
  - The cost price of the entire vehicle is reduced;
  - The fuel consumption is reduced when carrying out the public utility works, because a single heat engine is used;
  - The polluting emissions are lower, since there is no pollution caused by a potential second heat engine.

- The hydraulic system for operating the interchangeable work equipment has high energy efficiency, which is achieved by:

- Implementing hydraulic drive schematic diagrams that reduce the energy losses produced by the throttling of the working fluid to a minimum;
- Storing the energy during the inactive phases in pneumo-hydraulic accumulators, and supplying it during the working phases of the equipment.

3. The structure of the hydraulic equipment of the chassis with installed hydraulics

The structure of the hydraulic equipment of the chassis with installed hydraulics is shown in Fig. 3. The equipment [3, 4] consists of six subassemblies: Pumping group A; Pumping group B; Distribution subassemblies 1, 2 and 3; equipped basin to which the pipes that connect the components of the equipment are added; connection elements (joints, nipples, fittings, etc.) and fastening and assembly elements (clamps, bridles, etc.).
Pumping group A provides the necessary flow rate for the positioning of interchangeable work equipment (snow plough, mowers, etc.).
Pumping group B ensures the flow rate required to drive the equipment (snow cutter, rotating brush, etc.).
Distribution subassembly 1 and Distribution subassembly 2 direct the flow rate of pumping group A, for the positioning of the equipment.
Distribution subassembly 3 directs the flow rate of pumping group B, for driving the work equipment.

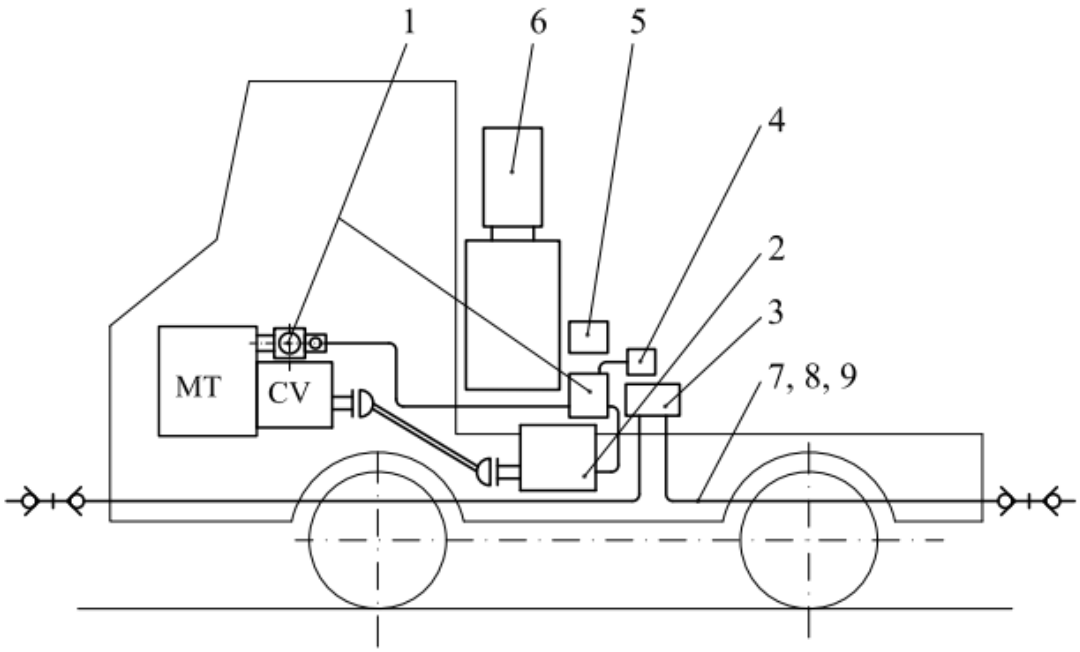
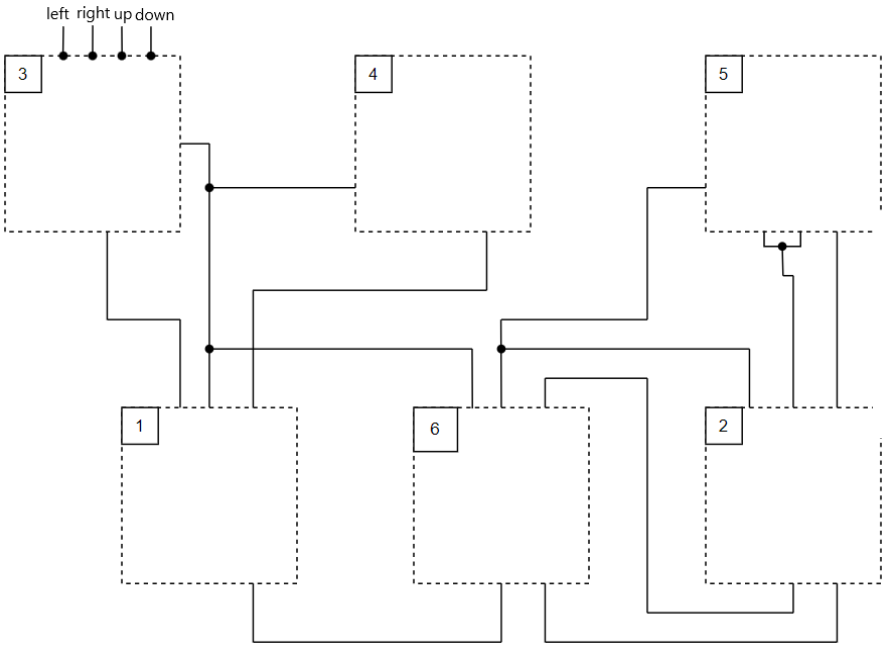


Fig. 3. The structure of the hydraulic equipment of the chassis with installed hydraulics [3, 4]

1. Pumping group A; 2. Pumping group B; 3. Distribution subassembly 1; 4. Distribution subassembly 2; 5. Distribution subassembly 3; 6. Equipped basin; 7. Pipelines; 8. Connection elements; 9. Fastening and assembly elements.

4. Operation of the hydraulic equipment of the chassis with installed hydraulics

The operation of the hydraulic equipment of the chassis with installed hydraulics is presented in accordance with the hydraulic block diagram in Fig. 4 and the hydraulic diagrams of the component subassemblies.

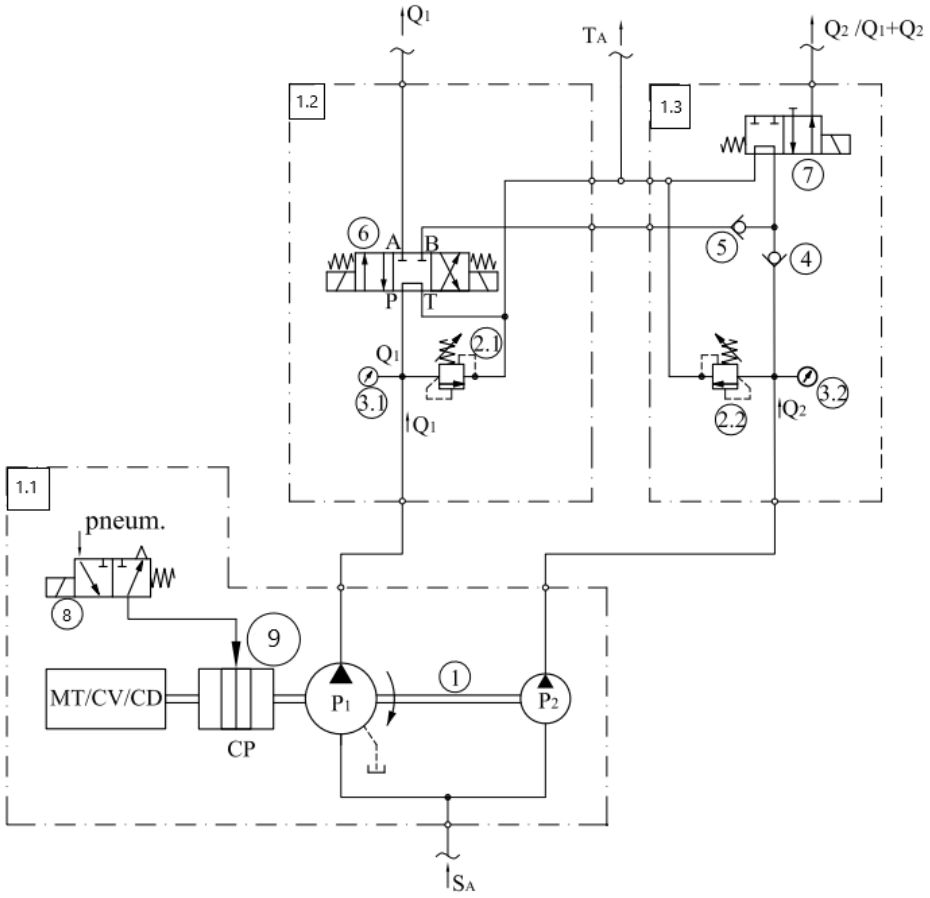


1. Pumping group A;
2. Pumping group B;
3. Distribution subassembly 1;
4. Distribution subassembly 2;
5. Distribution subassembly 3;
6. Equipped basin.

Fig. 4. Operating mode of the equipment - block diagram

4.1 Pumping group A – Fig. 5

Pumping group A consists of a double gear pump 1-P_1+P_2 driven from heat engine-MT, gearbox-CV, distribution box-CD via pneumatic clutch 9, controlled with the help of pneumatic directional control valve 8.



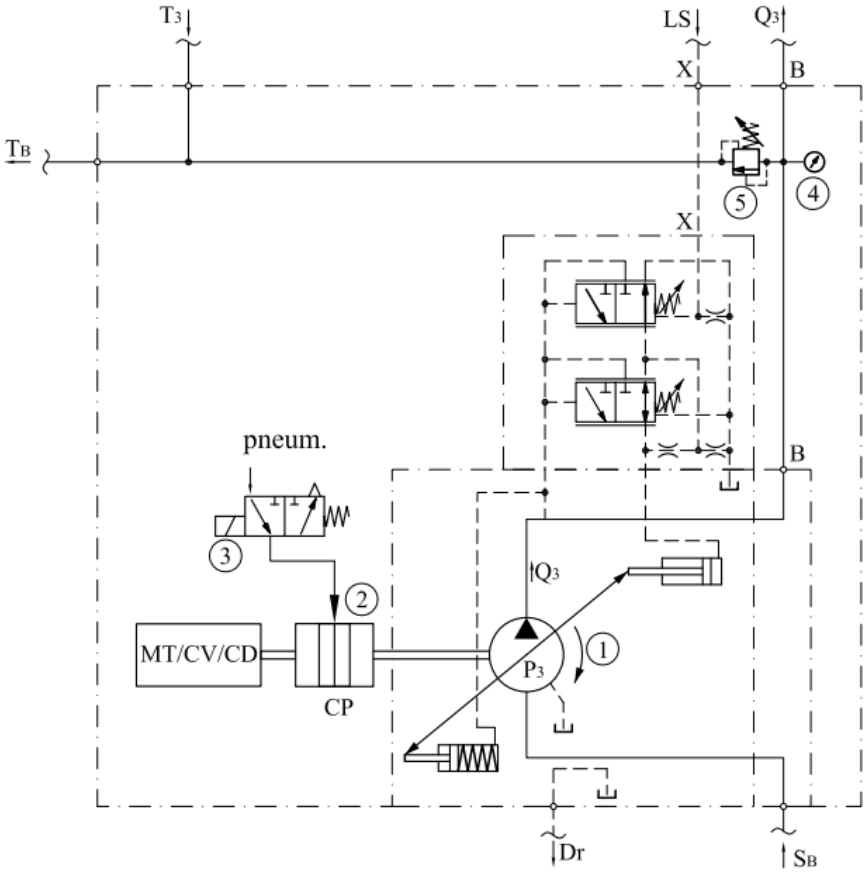
1. Double gear pump;
2. Safety valve;
3. Pressure gauge;
4. Check valve;
5. Check valve;
6. 4/3 Directional control valve;
7. 4/2 Directional control valve;
8. Pneumatic directional control valve;
9. Pneumatic coupling.

Fig. 5. Hydraulic diagram of pumping group A

Safety valves 2.1 and 2.2 limit the pressure on the discharge circuit of the gear pumps P_1 and P_2. Gauges 3.1 and 3.2 indicate the pressure on the discharge circuits of pumps P_1 and P_2. The check valves 4 and 5 allow the flow rate of the pumps to circulate in one direction only - from the double gear pump to the consumers. The directional control valve 6 directs the flow rate of pump P_1 to the distribution subassembly 1 or the distribution subassembly 2.

4.2 Pumping group B – Fig. 6

Pumping group B ensures the working flow rate for the multifunctional equipment and consists of variable flow pump 1-P_3, pneumatic clutch 2-HP, pneumatic distributor 3, pressure gauge 4 and safety valve 5.
Pump 1 is equipped with LS flow regulator and pressure regulator [5]. It is driven from heat engine-MT, gearbox-CV, distribution box-CD, through pneumatic coupling 2-HP led with the help of pneumatic directional control valve 3.
Pressure gauge 4 indicates the pressure on the pump discharge circuit, and safety valve 5 limits the pressure on the pump discharge circuit.

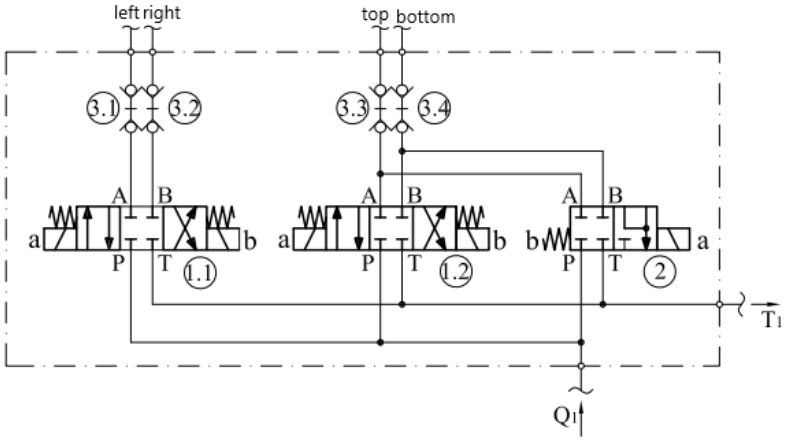


1. Variable flow pump;
2. Pneumatic clutch;
3. Pneumatic 3/2 directional control valve;
4. Pressure gauge with glycerin;
5. Safety valve.

Fig. 6. Hydraulic diagram of pumping group B [5]

4.3 Distribution subassembly 1 – Fig. 7

Distribution subassembly 1 is dedicated to the positioning of the snow plough equipment and consists of 4/3 directional control valves, items 1.1 and 1.2, and 4/2 directional control valve, item 2.
Directional control valve 1.1 directs the plow to remove snow on the left or right side of the utility vehicle.
Directional control valve 1.2 lifts or lowers the snow plow.
Directional control valve 2 provides the "flat-out" position of the snow plow if the electromagnet is electrically powered.



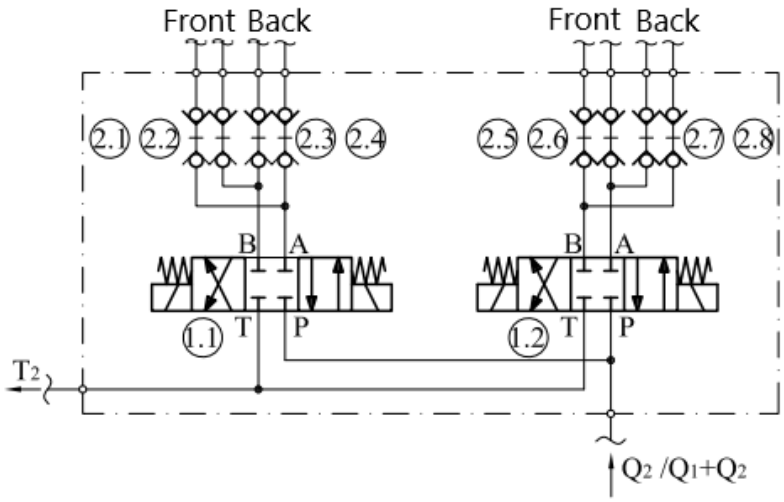
1. 4/3 Directional control valve;
2. 4/2 Directional control valve;
3. Quick couplings.

Fig. 7. Hydraulic diagram of distribution subassembly 1

Quick couplings 3 ensure the rapid hydraulic connection of the interchangeable equipment, the snow plow, in this case, and the hydraulic installation.

4.4 Distribution subassembly 2 – Fig. 8

With the help of distribution subassembly 2, interchangeable equipment positioned in front of or behind the chassis can be positioned / operated.



1. 4/3 Directional control valves;
2. Quick couplings.

Fig. 8. Hydraulic diagram of distribution subassembly 2

The subassembly is composed of two 4/3 directional control valves, items 1.1 and 1.2, and the quick couplings 2.1....2.8, which ensure the fast connection of the interchangeable equipment to the hydraulic installation.

4.5 Distribution subassembly 3 – Fig. 9

Distribution subassembly 3 directs the flow rate provided by pumping group B, for the operation of the interchangeable equipment located in front of or behind the chassis. It consists of monoblock hydraulic directional control valve 1 and quick couplings 2.1……2.6.
The monoblock directional control valve has three work sections, one of which supplies the equipment in front of the chassis, another - the ones on the rear, and the third is the reserve. The monoblock directional control valve sends the LS hydraulic signal to the pump of pumping group B, for the variation of its capacity. The pump flow rate of pumping group B is proportional to the electric signal of 0 ...10V, with which the proportional electromagnets of the monoblock directional control valve are supply. Quick couplings ensure fast connection of the equipment to the hydraulic installations.

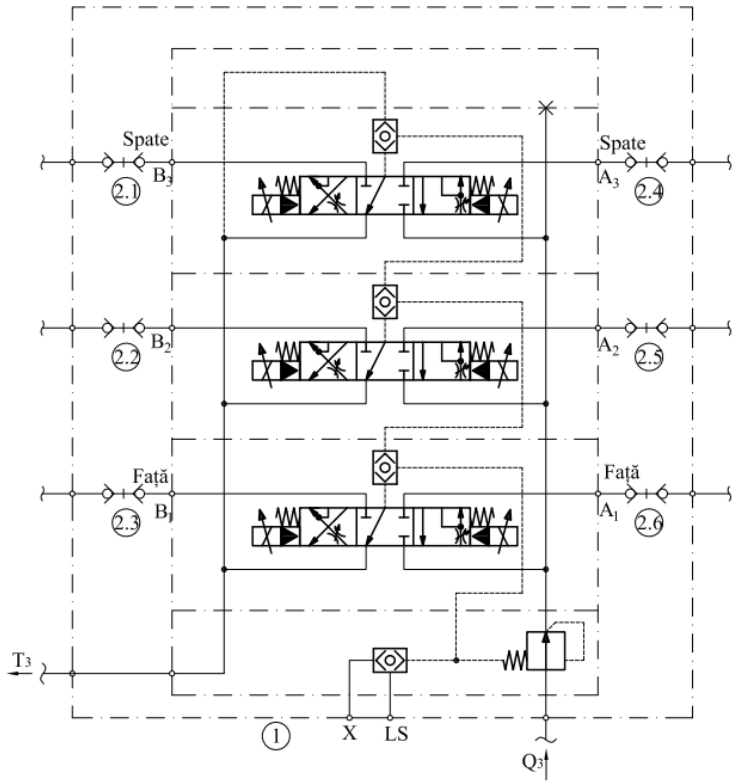
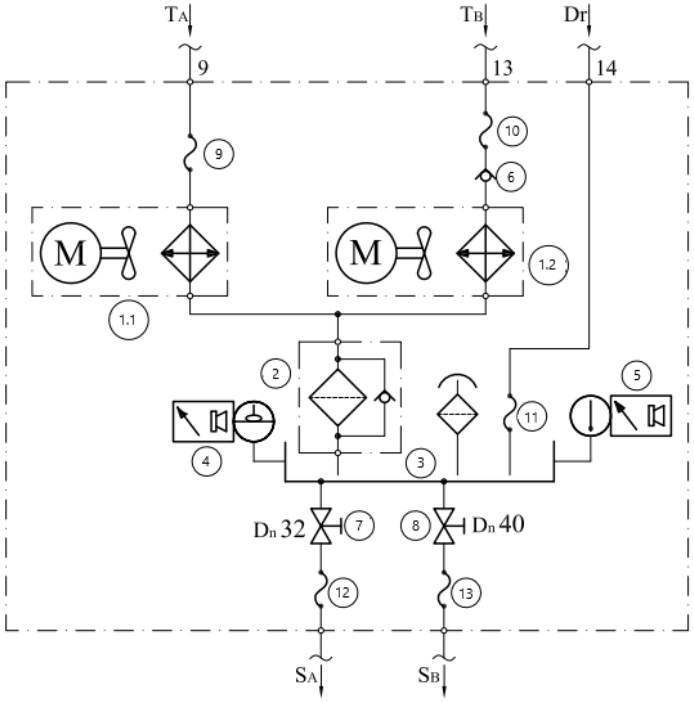


Fig. 9. Hydraulic diagram of distribution subassembly 3

4.6 Equipped basin – Fig. 10

The "Equipped basin" subassembly provides the working fluid necessary for the hydraulic installation, which equips the utility vehicle. The cooling of the hydraulic oil is provided by heat exchanger 1.1, for pumping group A, and heat exchanger 1.2, for pumping group B, and the filtration by return filter 2. Basin 3 has a capacity of 160 liters. Minimum level sensor 4 emits an alarm beep if the oil level drops below the minimum suction value of the pumps.



1. Air-oil heat exchanger;
2. Return filter;
3. Oil tank;
4. Minimum level sensor;
5. Maximum temperature sensor;
6. Check valve;
7. Suction valve A;
8. Suction valve B;
9. Flexible connection D_n 10;
10. Flexible connection D_n 20;
11. Drainage connection D_n 10;
12. Suction connection D_n 32;
13. Suction connection D_n 40.

Fig. 10. Hydraulic diagram of the equipped basin

Temperature sensor 5 turns on the fan of the coolers, if the oil temperature exceeds the value of 50 °C.
Suction valves 7 and 8 isolate the pumps from the oil tank. Flexible connections 8...13 ensure the connection between the basin and the rest of the devices, with the damping of the vibrations produced by the components in rotational motion.

5. Conclusions

The chassis with installed hydraulics presented in this article comes with the following innovative ideas:

- It uses a single hydraulic drive system for all interchangeable pieces of work equipment that equip utility vehicles designed to perform public utility works;
- It offers the possibility to make full use of the vehicle carrying interchangeable work equipment throughout the year, in summer with equipment specific to this season, and in winter with snow equipment;
- The power required for the hydraulic drive system of the interchangeable work equipment is provided by the heat engine of the chassis. The fact that there is no second engine dedicated to the hydraulic system for operating the interchangeable work equipment, leads to the following advantages of the utility vehicle:
  - The cost price of the entire vehicle is reduced;
  - The fuel consumption is reduced when carrying out public utility works, because a single heat engine is used;
  - The polluting emissions are lower, since there is no pollution caused by a potential second heat engine.

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