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The Method of Calculation of the Specific Electrical Conductivity of the Soil Obtained be the Information and Technical System of Local Operational Monitoring of the Agrobiological State of Agricultural Land

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Abstract. Modern agriculture foresees the implementation of a particular technological operation, according to the appropriate map-task, which is developed pre-based on diverse information. Knowledge of a certain structure of soil cover variability, obtained using information and technical systems of local operational monitoring of the agrobiological state of agricultural lands, allows us to adopt effective operational decisions for efficient management of agrobiological potential of agricultural lands.

Obviously, under such conditions there is a need for fundamentally new approaches to agricultural production, which is to ensure the proper quality of technological operations. The quality of the implementation of technological operations is an integral indicator of the efficiency of production of agricultural products within the agrobiological field. The necessary quality of implementation of the basic technological processes in plant growing is provided by the integrated information and technical systems of operational monitoring of the agrobiological state of agricultural lands.

This opens new prospects for organic farming using such smart agricultural machines.

In connection with it the task is to obtain reliable data on the agrobiological state of the soil environment by reducing the error in determining the magnitude of the electrical conductive properties of the soil, providing individual stabilization of the working electrodes and the mechanism of lifting / lowering the working electrodes, copying inequalities of the soil environment, reducing the intensity of the destruction of the soil structure , self-cleaning of the working contact of the electrode and ensuring the stability of the electrical contact of the electrode with the soil, by instrument design perfection. The task is achieved by using the information and technical system of operational monitoring of the soil environment of the structure to determine the conductive characteristics of the soil environment.

The purpose of the research is to determine the critical loading at the loss of stability by thin-walled working electrodes made in the form of working electrodes of various shapes (thin-walled solid, three-spit and four-spindle discs with different thickness of the rim). The information and technical system of local-operational monitoring of agrobiological state of soil environment of different configurations with one-side compression. .

Keywords: information and technical system, local operational monitoring, soil, samples, variability, size, research.

Setting of the problem. One of the main approaches in applying precision farming technologies is to optimize yields and ensure the ecological quality of agricultural products, taking into account agricultural management zones. In this aspect the determination of soil electrical conductivity plays an important role in determining the magnitude of profit based on the data of spatial variability and nutrient content in the soil. Knowledge of a certain structure of the variability of soil cover allows us to make effective decisions for managing the agrobiological potential of agricultural lands [1].

The overview of modern literary sources and scientific developments [1] shows that in recent years the process of integration of natural (organic, or biological), biodynamic, extensive, intensive (industrial) and no-till agriculture with the latest technologies, in particular with information and technical systems of local operational monitoring of the condition of agricultural land. At the same time, the latter direction is the most relevant and promising for the conditions in Ukraine.

The modern agricultural production involves the extensive use of automated systems for monitoring the condition of agricultural lands.

The implementation of modern agricultural technologies allows planning the costs of seed, fertilizers, pesticides and other technological materials, including fuel, to determine the overall strategy for managing the agrobiological potential of the field, etc. However, at present, the implementation of these technologies lacks effective systems for collecting and registering (monitoring) localized information (agrobiological and phytosanitary) on the state of agricultural lands in precision farming technologies. Existing ways and means of implementing this process are imperfect [2, 3, 4].

In this sense the development and use of a fundamentally new class of agricultural machines -

information and technical systems of local operational monitoring of the agrobiological state of agricultural lands becomes relevant.

In this regard the important task is to develop and substantiate the modern information and technical system of local operational monitoring of agrobiological state of agricultural lands.

Analysis of recent research and publications. The structure of the soil varies greatly in many agricultural fields. Physical properties of the soil, such as the soil structure, have a direct effect on water capacity, capacity of cation exchange, yield, etc. Nutrients contained in soils are used by the plant and their content in the soil is reduced. The generally accepted characterization of nutrient content in soils is the content of nitrogen, the presence of which in soil largely determines the yield. Cartography of soil electrical conductivity, widely used as an effective means of mapping the soil structure and other soil properties [5]. A quick description of the variability of agricultural land - an important component for zonal management methods [6].

This variation is too important to ignore it and should be taken into account when sampling (Fig. 1).

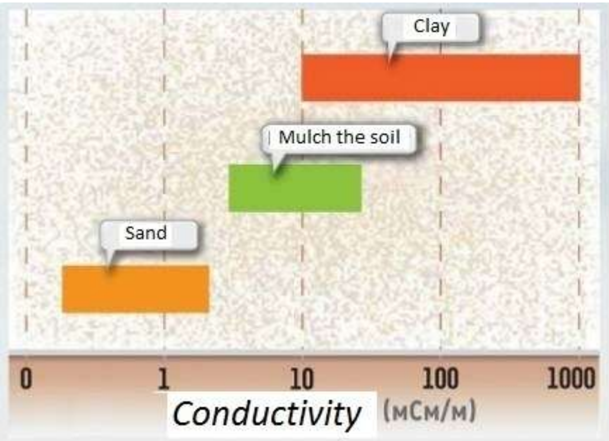

Fig. 1. Electrical conductivity of soil

Ground conductivity maps provides getting cartograms:

- variable rates of introduction of technological material (seeds and mineral fertilizers) on the basis of the expected yield on each individual site, calculated on the basis of the electrical conductivity.

- variable norms for seeding on the basis of the depth data of the upper (arable) layer of soil.

- variable norms of introduction into the soil of herbicides based on data on organic matter, soil structure and electrical conductivity.

- variable rates of introduction of lime based on data on the agrobiological state of the soil environment in accordance with the levels of electrical conductivity.

To map the soil with the EU device, the Veris 3100 uses an off-road vehicle equipped with an on-board computer with parallel driving technology, a GPS receiver (Fig. 2) and a trailer unit with discs (located in disks electrodes). In carrying out measurements, the unit moves in a field with submerged discs to a depth of 2-5 cm, one pair of isolated electrodes enters the electric current into the soil, other electrodes measure the current, which varies depending on the resistance of the soil [4].

The Veris trailer unit extends along the field, one pair of isolated electrodes enters the electric current into the ground, and the other pair measures the voltage drop, which will be different - for example, the clay conducts current better than silt or sand. Measurements of electrical conductivity are combined with GPS data and are clearly displayed as a map. The Veris 3100 uses two electrical conductivity rays to map two depths of soil (0-30.5 cm and 0-91.5 cm) at the same time.

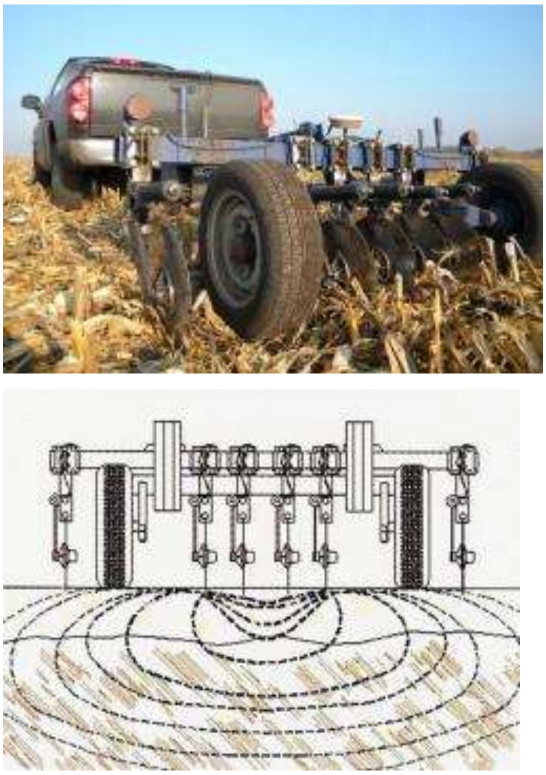

Fig. 2. The equipment EC Veris 3100

Veris 3100 forms two sets of cards - a map of the surface layer (30.5 cm) and a map of an exciting root zone (91.5 cm). The top layer map is often used to select sampling points, and a deeper map to determine the fertilizer application rate (especially nitrogen) [5].

These devices are too costly and give a significant measurement error, which creates the conditions for further study of these systems.

The purpose of this research is the development of an effective information and technical system for operational monitoring of the condition the farmland of the construction made by Oleksandr Brovarets.

Results of the main content of the research. Measurement of conductive properties of the soil environment.

Conductivity is the property of the material to transmit (conduct) electric current, measured in Sims per meter (Sm / m) or millisymens per meter (mS / m).

The Scope of the device for determining the conductive properties of the soil environment made by Oleksandr Brovarets.

The information and technical system of operational monitoring of the soil environment of the design of Alexander Brovarya - a device for determining the conductive properties of the soil environment of the design can work with manual devices, placed on high-speed vehicles, placed on agricultural and energy vehicles, which carry out a technological operation that allows to receive operative data on the agrobiological state of the soil environment and make operational decisions on the management tion rule making process inputs (seeds, fertilizers, etc.).

All previously declared elements of such technologies of precision (controlled) agriculture (laboratory analysis (one sample of 5-10 hectares), yield) did not allow for such an accurate approach. This system makes it possible to obtain reliable information on the agrobiological state of the soil environment per square meter of agricultural field.

Such precision does not yet have any technology presented on the market ranging from laboratory testing (one test for 5-10 hectares) and ending with satellite monitoring (accuracy up to 10 m2). In addition, it is necessary to take into account the cost of these technologies, since the cost per test varies within 1-10 $, satellite monitoring - from 20 $, while the cost of such a test using the proposed design of the technical monitoring system is less than 0.1 $ per m2 (Table 1).

The device for determining the conductive properties of the soil environment makes possible quickly determine the parameters of the agrobiological state environment provides an "individual" approach to each elemental field of the field using the data of the conductive properties of the soil environment(Fig. 3).

The device for determining the conductive properties of the soil environment is applied before using the technological operation, simultaneously with the execution of the technological operation (seed, fertilizer application, etc.); or during the growing season and after harvesting.

This opens new prospects for organic farming using such "smart" agricultural machines.

The general view of the technical system of operational monitoring of the condition of the soil environment (see above), Fig. 4 - a general view of the technical system of operational monitoring of the soil environment (side view) is shown.

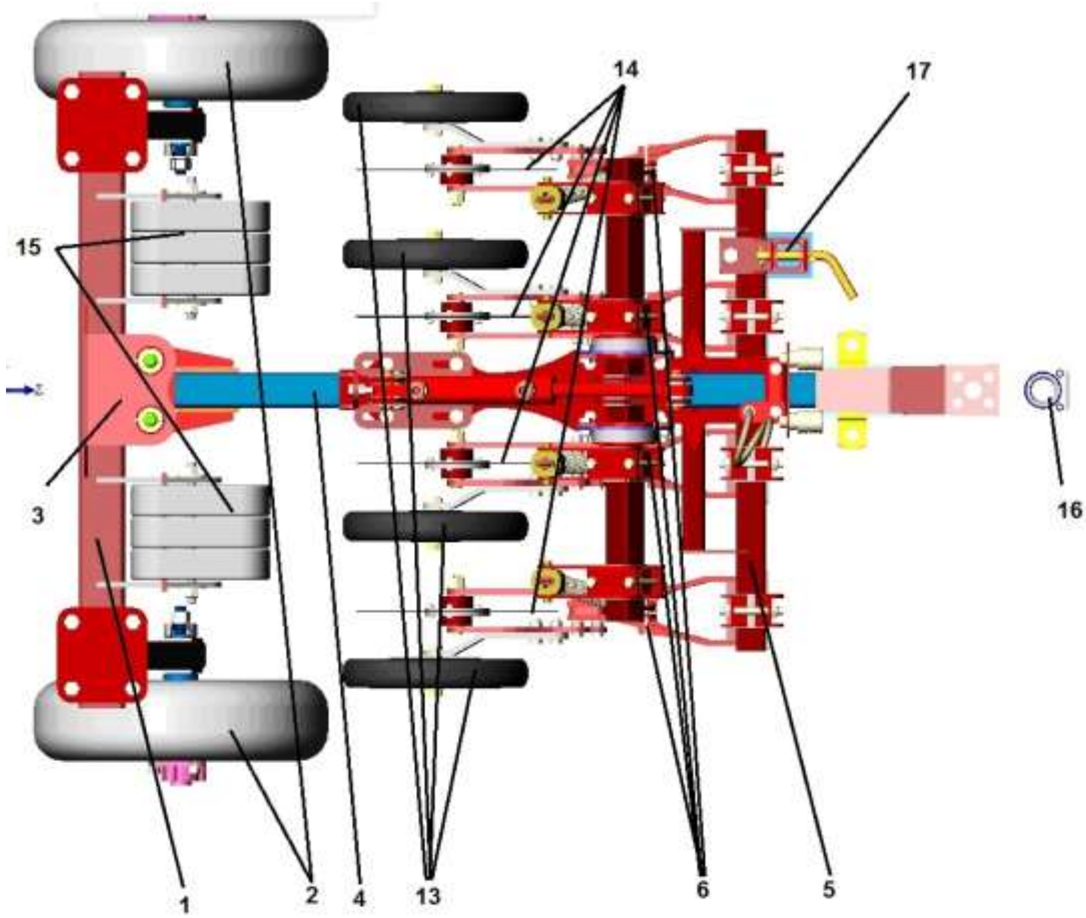

Fig. 3. General view of the information and technical system of local operational monitoring the state of the soil environment

Table 1. Methods of monitoring the agrobiological state of the soil environment of agricultural land

№	Methods of monitoring the state of agrobiological conditions	Density of sampling of soil per 100 hectares	The size of the site from which the fence is made, m2	Cost of one sample (shot), $, mind. unit	The cost of a sample (shot) per 100 hectares, $, UM. unit
1	*Laboratory method*	10-15	10 000*1000	1-10	100-1000
2	*Satellite monitoring*	1 знімок роздільною здатністю до 10 м	100*100	10-100	100-1000
3	*Technical system of operational monitoring of agricultural lands*	1000	10*10	0,1	100
4	*Technical system of operational monitoring of agricultural lands*	10000	1*1	0,1	1000

This technological solution will provide an opportunity to ensure optimal control of the seed rate, seed, fertilizer, etc., taking into account the agrobiological state of the soil environment.

Technical system of operational monitoring of the soil environment of the design consists of (fig. 4) from the support wheels 1, P-shaped frame 2, anchorage 3, longitudinal frame 4, transverse frame 5, hinges 6, levers 7, springs 8, bracket 9, rotary shaft 10, hydro cylinder 11, bracket mount 12, copying wheels 13, working electrodes 14, ballast 15, tow 16 and stand 17.

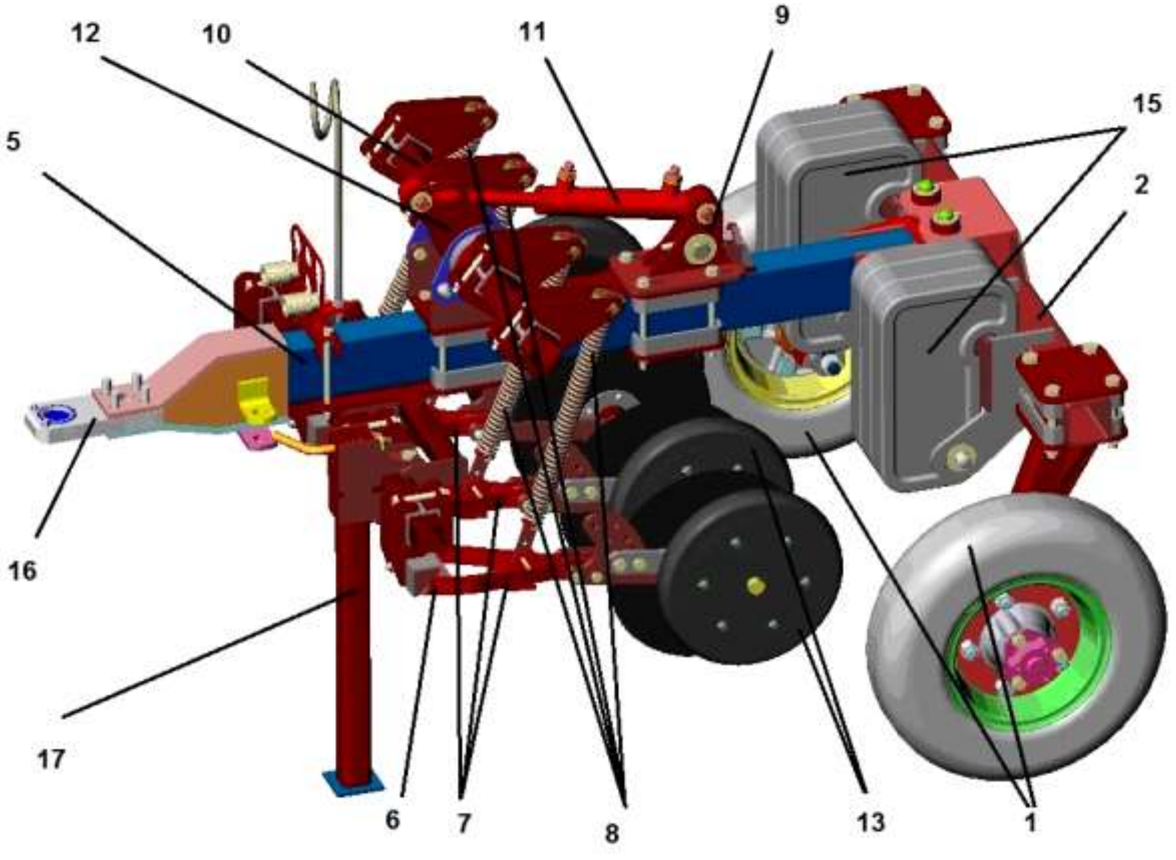

Fig. 4. The general view of the information and technical system of local operational monitoring of the agrobiological state of the soil environment**.**

While using the device, there is a significant error in determining which due to the fact that during the work process the stability of the contact of the disk electrode with the ground is disturbed due to the transverse deviations of the working disk electrodes relative to the straight line of motion due to the construction of the device, the lack of copying the surface roughness fields of disk electrodes. This changes the contact area of the disk electrode with the soil, because in the case of transverse oscillations, flat disks electrodes with one side may not contact the soil at all.

An important parameter in measuring the conductive characteristics of the soil environment is to provide a stable contact area of the working electrodes with the soil. The existing designs do not fully fulfill the specified conditions, which negatively affects the reliability of the information received. In connection with this, there was a need to develop a design that would ensure the stability of the working electrodes with the soil during the measurement of the conductive properties of the soil environment.

To illustrate the drawbacks of the existing design and the advantages of the design, their diagrams are shown Pic 5.1, Fig. 5.2, Fig. 6

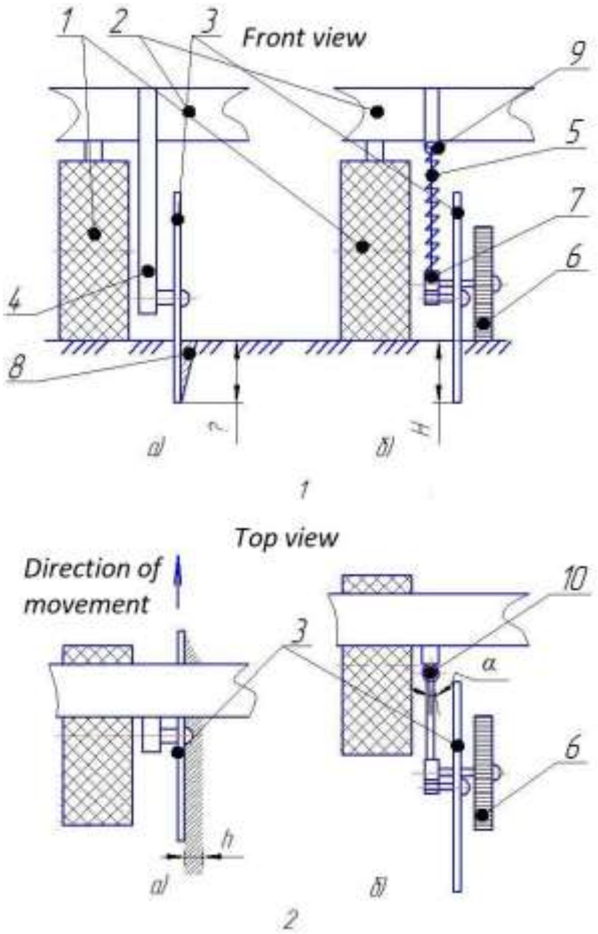

Fig. 5. Comparative scheme of the device for determining the conductivity characteristics of the soil environment (front view, top view):

a) available construction; b) the design is developed;

1 - support wheel; 2 - frame; 3 - working electrode; 4 - stand;

5 - vertical suspension of suspension; 6 - copier wheel;

7 - adjustment mechanism of the depth of the wheel; 8 - furrow formed by a working electrode; 9 - upper hinge; 10 - lower hinge

It is worth to say that the design of the systems has a number of common elements available and developed (Fig. 5.1, Fig. 5.2, Fig. 6), in particular the common elements are: 1 reference wheel, 2 frame, 3 working electrode. Further, the existing system consists of 4 risers, which are rigidly connected to the frame, so when moving with agricultural land, such a system can form fissures of width h, due to the appearance of angles of the roll, delent and rusting due to non-linear movement of the aggregates due to their deviation or rotation. In turn, this contributes to the measurement error of the conductive parameters of the soil environment, since one side of the disk does not contact the soil at all (Fig. 5.2, a).

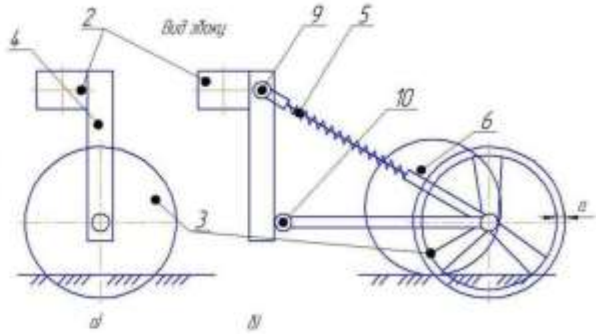

Fig. 6. Comparative scheme of the device for determining the conductivity characteristics of the soil environment (side view):

a) available construction; b) the design is developed;

2 - frame; 3 - working electrode; 4 - stand; 6 - support wheel; 5 - vertical suspension of suspension; 9 - upper hinge; 10 - lower hinge

In the developed design, this problem is eliminated due to the compensation of such angles partly due to the suspension, and in part - the upper and lower suspension hinges of the designed design, which allow compensating the transverse deflection α within 15-20 degrees, while maintaining a stable contact of the electrodes with the soil. With the use of copying wheels 6 (Pic 4.1, 4.2, Fig. 5), the existing structure clearly provides the depth H of the motion of the working electrodes in the soil. In the existing structure (Fig. 4.1, Fig. 4.2, Fig. 5), it changes due to the corners of the deferent, due to oscillations and lateral displacement of the structure of the system during movement of the field surface irregularities.

The general principal differences of the information and technical system of local operational monitoring of the agrobiological state of the soil environment - a device for determining the conductive properties of the soil environment are:

1. Presence of a copier wheel, which determines the depth of the working electrode in the soil H.

2. Suspension of the bearing wheel and working electrodes.

3. Three-spoke thin-walled metal disk with a rim to provide a stable area of contact of electrodes with soil.

4. Articulation of the lever suspension of working electrodes with soil to compensate for the angles of the roll, delent and rotation caused by the movement of the machine-tractor unit by the information and technical system of operational monitoring of the agrobiological state of the soil environment of the design

made by Oleksandr Brovarets and ensuring the stable contact of the working electrodes with the soil.

<u>Method of calculation the specific electrical conductivity of soil () with stationary contact method.</u>

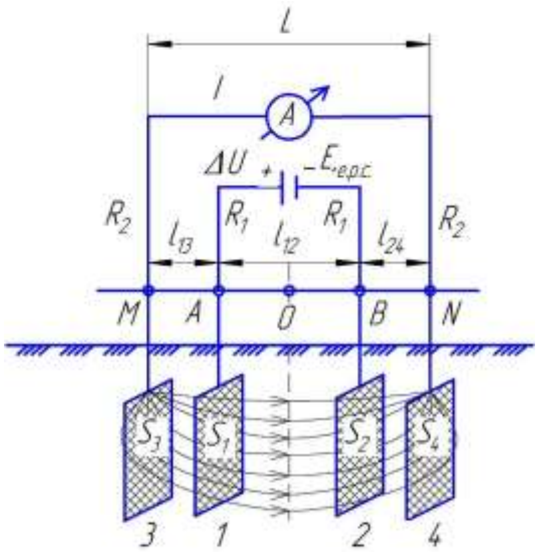

Fig. 7. The calculation scheme of measurement of the specific conductivity of the soil environment of agricultural lands using the information and technology system of local operational monitoring of the agrobiological state of agricultural lands of the soil environment.

The technical result, which is achieved using the information and technical system of local operational monitoring of the agrobiological state of the soil, is:

1. Ensure a stable contact of the electrodes with the soil: due to the compensation of the angles of the roll, delent and the risk caused by the movement of the technical system.

2. Determination of the depth of entry of the working electrode into the ground using a copier wheel.

3. Decrease in area growth per unit depth / entry into the soil of the working electrode due to the construction of a three-spoke thin-walled metal disk with a rim in the design.

4. The absence of the formation of a groove by working electrodes due to compensation of the angle of rotation of the upper and lower hinges of the suspension of the angle α.

The device for determining the conductive properties of the soil environment makes it possible to quickly identify the zones of variability of the agrobiological state of the soil environment, provide an "individual" approach to each elementary field of the field using the data of the conductive properties of the soil environment and identify them with further laboratory analysis.

<u>Such a technological solution will provide</u> an opportunity to ensure optimal control of the seed rate, seed, fertilizer, etc., taking into account the agrobiological state of the soil environment.

Let us deduce the formula for determining the specific electrical conductivity. We design the equivalent of the calculation scheme of the information and technical system of local operational monitoring of the agrobiological state of agricultural lands of the soil environment (Fig. 1).

It will be accepted the scheme $S_4 = S_3$ $S_2 = S_1$.

Maybe it will be right $S_3 = S_4$, $S_1 = S_2$.

We reduce a formula for determining the specific conductivity, when the measurement of specific conductivity is carried out according to the scheme

We design the equivalent of the calculation scheme of the information and technical system of local operational monitoring of the agrobiological state of agricultural lands of the soil environment (Fig.8)

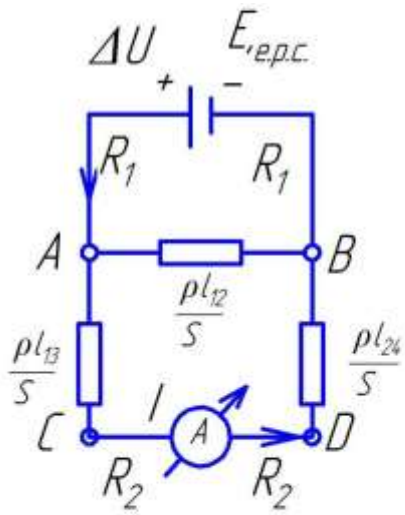

Fig. 8 The equivalent calculation scheme of the information and technical system of local operational monitoring of the agrobiological state of agricultural lands of the soil environment.

$$I = \frac{E_{e.p.c.}}{R_{пов} + r} = \frac{E_{e.p.c.}}{R_{AB} + 2R_1 + r}; \quad (1)$$

$$R_{AB} = \frac{\frac{\rho \cdot l_{12}}{S} \cdot \left(\frac{\rho \cdot l_{13}}{S} + \frac{\rho \cdot l_{24}}{S} + 2 \cdot R_2 + R_{АМП} \right)}{\left(\frac{\rho \cdot l_{12}}{S} + \frac{\rho \cdot l_{13}}{S} + \frac{\rho \cdot l_{24}}{S} + 2 \cdot R_2 + R_{АМП} \right)}; \quad (2)$$

$$U_{AB} = E_{e.p.c.} - I \cdot 2 \cdot R_1 - I \cdot r = E_{e.p.c.} - I \cdot (2 \cdot R_1 + r). \quad (3)$$

$$I_A = \frac{U_{AB}}{2 \cdot R_2 + \frac{\rho}{S} \cdot (l_{13} + l_{24})} =$$

$$\frac{E_{e.p.c.} - I \cdot (2 \cdot R_1 + r)}{2 \cdot R_2 + \frac{\rho}{S} \cdot (l_{13} + l_{24})} = \frac{E_{e.p.c.} - \frac{E_{e.p.c.} \cdot (2 \cdot R_1 + r)}{R_{AB} + 2 \cdot R_1 + r}}{2 \cdot R_2 + \frac{\rho}{S} \cdot (l_{13} + l_{24})}; \quad (4)$$

$$I_A = \frac{E_{e.p.c.} \cdot \left(1 - \frac{2 \cdot R_1 + r}{R_{AB} + 2 \cdot R_1 + r}\right)}{\left(2 \cdot R_2 + \frac{\rho}{S} \cdot (l_{13} + l_{24})\right)}; \qquad (5)$$

$$I_A \cdot \left(2 \cdot R_2 + \frac{\rho}{S} \cdot (l_{13} + l_{24})\right) = E_{e.p.c.} \cdot \left(1 - \frac{2 \cdot R_1 + r}{R_{AB} + 2 \cdot R_1 + r}\right); \quad (6)$$

Hence

$$R_{AB} = \frac{\frac{\rho \cdot l_{12}}{S} \cdot \left(\frac{\rho}{S} \cdot (l_{13} + l_{24}) + 2 \cdot R_2 + R_{AM\Pi}\right)}{\left(\frac{\rho \cdot l_{12}}{S} \cdot (l_{13} + l_{24} + l_{24}) + 2 \cdot R_2 + R_{AM\Pi}\right)}; \quad (7)$$

$$I_A \cdot \left(2 \cdot R_2 + \frac{\rho}{S} \cdot (l_{13} + l_{24})\right) = \frac{E_{e.p.c.} \cdot R_{AB}}{R_{AB} + 2 \cdot R_1 + r}; \quad (8)$$

$$I_A \cdot \left(2 \cdot R_2 + \frac{\rho}{S} \cdot (l_{13} + l_{24})\right) \cdot (R_{AB} + 2 \cdot R_1 + r) = E_{e.p.c.} \cdot R_{AB}; \quad (9)$$

To simplify the solution of the equation (9) considering $(R_1, R_2, r) \prec\prec \left(\frac{\rho \cdot l_{12}}{S}, \frac{\rho \cdot l_{24}}{S}, \frac{\rho \cdot l_{13}}{S}\right)$, so the resistance of the internal battery, the resistance of the wires (R_1, R_2) and $R_{AM\Pi}$ (idial) $\rightarrow 0$.

That is, the task is greatly simplified.

$$R^*_{AB} = \frac{\frac{\rho \cdot l_{12}}{S} \cdot (l_{13} + l_{24})}{(l_{12} + l_{13} + l_{24})} \qquad (10)$$

The equation is becoming:

$$I_A \cdot \left(\frac{\rho}{S} \cdot (l_{13} + l_{24})\right) \cdot R^*_{AB} = E_{e.p.c.} \cdot R^*_{AB}; \quad 11)$$

$$\frac{\rho}{S} \cdot (l_{13} + l_{24}) = \frac{E_{e.p.c.}}{I_A}; \qquad (12)$$

$$\rho = \frac{E_{e.p.c.} \cdot S}{I_A \cdot (l_{13} + l_{24})}. \qquad (13)$$

The specific conductivity of the soil is determined according to the formula:

$$\sigma = \frac{1}{\rho}. \qquad (14)$$

Unit of measurement:

$$[\sigma] = \frac{Сімен}{м}, \ [E_{e.p.c.}] = B, \ [I_{A.}] = A, \ [l_{13}, l_{24}] = м, \ [S] = м^2.$$

Then

$$\sigma = \frac{I_A \cdot (l_{13} + l_{24})}{E_{e.p.c.} \cdot S}. \qquad (15)$$

Knowing l_{13}, l_{24}, S, $E_{e.p.c.}$ batteries and measuring I_A finding σ electrical conductivity of the soil.

CONCLUSIONS

The proposed method for calculating the specific electrical conductivity of the agrobiological ground environment by the stationary contact method of the working electrodes of the information and technical system of the local operational monitoring will allow obtaining reliable data on the state of the soil environment by reducing the error in determining the magnitude of the electrical conductive properties of the soil, providing individual stabilization of the working electrodes and the mechanism of lifting / lowering the working electrodes , copying of irregularities of ground sier reduction of the intensity of destruction of the soil structure, self-cleaning of the working contact of the electrode, and the stability of the electrical contact of the electrode with the soil, by improving the design of the device, using the proposed methodology.

The result of using the device to determine the electrical conductive properties of the soil environment is to obtain a 20-30% increase in profits by optimizing the seed rate of the technological material, taking into account the agrobiological state of agricultural lands.

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