Electrical control scheme of the machine for isolation of toxic ergot from rye grain

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Abstract. The grain heap contains, in addition to high-grade grain, various impurities, which include ergot toxic sclerotia. Poisonous ergot sclerotia most often affects rye grains. The duration of flowering and the structural features of its flowers explain the strong susceptibility of rye to ergot. The use of various machines for cleaning grain does not give positive results in the isolation of toxic ergot from rye grain due to the proximity of its properties and the properties of the crop being cleaned. Purification of seeds from ergot sclerotia, having a density lower than the density of rye grain, is possible in an aqueous solution of salt. To mechanize the release of ergot from rye grain by density in an aqueous salt solution, the development of an appropriate device is an urgent issue. When creating a machine for the allocation of toxic ergot, simple in design and maintenance, the question arises of developing an electrical circuit for controlling the working bodies. To drive the working bodies of such a machine, a simple single-phase electrical circuit for controlling a three-phase electric motor has been developed. The developed electrical control circuit made it possible to ensure reliable and trouble-free operation of the electric drive of the working bodies of the machine for the extraction of toxic ergot from rye grain during experimental studies. The installation of the control circuit has an electrically safe design, convenient for operation, and the protection elements of the circuit exclude a person from electric shock and fire.

1. Introduction
The main raw material for the production of the most important food products for people and animal feed is the grain of the main cereal crops, such as rye, wheat, barley and oats.

However, the listed main crops, especially winter rye, are often affected by ergot [1, 2]. Therefore, after threshing the grain mass with combine harvesters [3, 4, 5], grain heaps contain poisonous ergot sclerotia in addition to grain, organic and mineral impurities [6, 7, 8].

Therefore, to obtain grain suitable for food, technical and seed purposes, it is necessary to clean the grain heap, the task of which is to isolate all impurities, especially toxic ergot. The use of various and rather sophisticated grain cleaning machines does not give positive results when cleaning grain from these impurities due to the proximity of their physical and mechanical properties in terms of speed in the air flow and linear dimensions (width, thickness and length) [9-19].

However, the grains of the main grain crops (rye, wheat, barley and oats) have a larger specific gravity \( \rho_g = (1.2...1.5) \times 10^3 \text{ kg/m}^3 \) than ergot sclerotia \( \rho_s = (0.9...1.15) \times 10^3 \text{ kg/m}^3 \). Therefore, almost 100% purification of seeds from ergot sclerotia, which differ in density from grain, is possible in aqueous solutions of various inorganic salts [20].

This circumstance requires the creation of a less energy-intensive and more effective machine for the extraction of ergot sclerotia from the seed material, which has the most simple, convenient to set
up and maintain the main working bodies [21].

One way to solve this issue is to create a machine for the separation of ergot sclerotia from grain, consisting of a bath, seed and waste conveyors (ergot sclerotia), a hopper with a feeder, the wall of which is immersed in a salt solution and separates the bath cavity with a seed withdrawal conveyor from the waste conveyor [22].

These machines, like any grain and seed cleaning machines, contain electric drive devices by working bodies, that is, they incorporate common industrial electric motors single-phase or the most used three-phase. A variety of control schemes are used to control these electric motors. However, when creating a poisonous ergot isolation machine, simple in design and maintenance, the most preference, in our opinion, is a simple single-phase control circuit for a three-phase electric drive of the working bodies.

2. Materials and methods

To solve the stated goal of research and development of an electric circuit for controlling the working bodies of a machine for separating toxic ergot from rye grain by density in an aqueous solution of salt, information resources have been used that form the basis of the entire information support system for scientists and agricultural engineers. In the analysis of electrical circuits of the drive of working bodies used to clean grain material from impurities by density in an aqueous solution of salt, scientific articles, monographs, study guides, as well as special types of technical documentation and literature, which include patent documentation, standards and catalogs, were used.

In carrying out this scientific work, standard and particular methods using physical modeling and certified instruments were used, a general view of which is shown in Figure 1.

![Figure 1](image)

**Figure 1.** General view of the devices used in the installation and configuration of the electrical control circuit of the working bodies of the machine for the separation of toxic ergot from rye grain by density in an aqueous solution of salt.

When installing and setting up the electrical control circuit for the working bodies of the rye grain poisonous ergot extraction machine, the TT-1 «ammeter-voltmeter-ohmmeter» combined electric meter, DT830B digital multimeter, TDM screwdriver-indicator (probe), linear voltmeter (phase probe) were used, a set of electrical measuring instruments K-505.

The tester TT-1 in the ohmmeter mode was used to test various sections of the circuit's electrical circuits, as well as wires for an open or short circuit. In the «AC voltmeter» mode, the tester TT-1 was used to measure AC voltage in various parts of the circuit's electrical circuits. The digital multimeter DT830B was used for operational checks of sections of the electrical circuits of a circuit whose...
Measurement processes are similar to the TT-1 tester. An indicator screwdriver (probe) TDM was used to determine the presence of voltage (phase presence indication) in the conductor, which ensured the safety of work and the correct connection of the equipment to the electrical network. To check the voltage between the phases, a linear voltmeter with an operating voltage of 90 to 500V (phase probe) was used. In the process of setting up the experiments, to measure the parameters of a three-phase electric network connected to the drive motor, a set of K-505 electrical measuring instruments was used. The rotational speed of the motor shaft and the drive shafts of the conveyors was measured with a tachometer ТЧ-10Р.

3. Results and Discussion

To drive the working bodies of the machine for isolating toxic ergot from rye grain in density in an aqueous salt solution, an electrical control circuit for controlling a three-phase drive motor is developed and manufactured, which is shown in Figure 1.

![Figure 1](image1.png)

**Figure 1.** The electric control circuit of the electric drive of the working bodies of the machine for the extraction of toxic ergot from rye grain in density in an aqueous solution of salt: SB1 – «STOP» button; SB2 – «START» button; QF – three-phase circuit breaker; QF1 – single-phase circuit breaker; KM1 – magnetic starter; KK – thermal relay; CP – electric motor control board.

A general view of the elements of the control panel is shown in Figure 2. The button station communicates with the control panel of the remote wire with double electrical insulation. For ease of operation and visual observation during research, the front cover of the shield is removed for visual inspection of the internal device.

The control circuit of a three-phase electric motor for driving the working bodies of a machine for the extraction of toxic ergot from rye grain in density in an aqueous solution of salt consists of a control panel (CP) mounted on an arm and mounted on the machine itself. Outside the control panel (CP), a three-pole circuit breaker (QF) and a three-phase 380V AC three-phase asynchronous electric motor (M) with windings connected by a star circuit are separately located.

The control panel (CP) of a three-phase electric motor drive the working bodies of a machine for the separation of toxic ergot from rye grain in density in an aqueous solution of salt includes: a magnetic starter (KM1) with three-pole power contacts (KM1) and a blocking contact (KM1.1); thermal relay (QC); single-pole circuit breaker (QF1); a manual control push-button post with the «STOP» (contact SB1) and «START» (contact SB2) buttons; starter magnetic coil (KM1) – single-phase with a supply voltage of 220V and a frequency of 50Hz.

The control circuit has a classic simple, relatively electrical, convenient for operation and repair reliable design, in accordance with the rules of electrical installations and other state standards. A
single-phase control circuit of a three-phase starter can reduce the cost of the components of the circuit compared, for example, with a two-phase control circuit and is relatively safe due to the use of a lower voltage of 220V. However, if necessary, a single-phase control circuit can be converted into a two-phase a control circuit using a magnetic starter coil for a voltage of 380V. Also, a variant of a circuit with a single-phase electric motor for a voltage of 220V, 50Hz is possible.

The assembled control circuit is equipped with the necessary electrical safety signs. Control circuit elements are commercially available, which leads to quick repair or installation of a new circuit.

The installation of the electrical circuit and its maintenance is only allowed to be carried out by electrical personnel who have qualification clearance of at least the third electrical safety group. The machine for separating toxic ergot from rye grain in density in an aqueous solution of salt can be controlled by service personnel with qualification approval of the first group on electrical safety and having passed relevant instructions on labor protection and safety, as well as fire safety.

The electrical control circuit operates as follows. First, the circuit breakers $QF$ and $QF1$ are turned on. After that, when you press the «START» button (contact $SB2$), a voltage of 220V is applied to the coil of the $KM1$ starter, due to the fact that the coil is turned on between phase $C$ and zero $N$. Due to the magnetic coil, the moving part of the starter is attracted to the fixed and closes the power contacts $KM1$, as well as the interlock contact $KM1.1$. Through the power contacts of $KM1$, voltage is supplied to the electric motor $M$, that is, the electric drive of the machine for extracting toxic ergot from rye grain is turned on. After releasing the «START» button, $SB2$ contacts open, and the $KM1.1$ blocking contact remains closed, providing power to the $KM1$ starter coil.

The working engine $M$ is stopped using the «STOP» button (contact $SB1$). When the «STOP» button is pressed, contacts $SB1$ open, creating a gap in the power circuit of the starter coil $KM1$ and power contacts $KM1$ disconnect the engine $M$ from the mains. Re-starting the engine $M$ is possible only by pressing the «START» button (contact $SB2$).

The locking contact $KM1.1$ of the starter provides protection against spontaneous starting of the engine $M$ in the event of a power failure and its sudden appearance in the network. The thermal relay $KK$ protects the engine $M$ from overloads and, to a certain extent, from phase failure. Circuit breakers $QF$ and $QF1$ provide protection, respectively, of the power circuit and control circuit from short circuits, and also serve to manually disconnect these circuits after the end of the machine.
4. Conclusion
A simple single-phase electrical control circuit has been developed to drive the working bodies of a machine for isolating toxic ergot from grain by density in an aqueous salt solution. The developed electrical control circuit made it possible to ensure reliable and trouble-free operation of a three-phase electric drive motor for transporting seeds from the bath of a prototype of a machine for the extraction of toxic ergot from rye grain in density in an aqueous salt solution during experimental studies. The installation of the control circuit has an electrically safe design, convenient for operation, and the protection elements of the circuit exclude a person from electric shock and fire.

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