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Sensor For Measuring The Temperature And Humidity Of Solid And Fluid Mineral Materials

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Abstract: The amount of moisture a mineral can absorb depends on the shape, size, and location of the capillaries, as well as the water's affinity for the mineral. The different binding of moisture to the mineral matter affects its physical characteristics in different ways, and it is difficult to determine this binding. Therefore, measuring the moisture content of solid and dispersible mineral substances is difficult and leads to inadequate graded characteristics.

Basic phrases. Humidity, absolute humidity, relative humidity, humidity of gases, humidity, high frequency, ultra high frequency, dielectric constant.

Methods for measuring the moisture content of solid and dispersed mineral substances are conditionally divided into two groups: 1) direct methods that allow determining the mass of wet or dry matter in a sample (drying, extraction and chemical methods); 2) indirect methods (conductometric, dielcometric, ultra-high frequency, optical, nuclear magnetic resonance, thermovacuum, thermophysical methods) that determine humidity by measuring its dependent parameter. Direct methods are distinguished by high measurement accuracy and long duration (up to 10-15 hours). Indirect methods are characterized by very low measurement accuracy, which is carried out at a very high speed. Technical measurements almost always use indirect methods. Conductometric, dielectric (capacitive), ultra-high frequency and optical methods are widespread among indirect methods. Most of the minerals commonly used in industry are capillary-porous rocks in which they are stored in wet pores. The amount of moisture that a mineral can absorb depends on the shape, size, and location of the capillaries, as well as the water's affinity for the mineral. [1]. The different binding of moisture to the mineral matter affects its physical characteristics in different ways, and the determination of this binding is subject to considerable difficulties. Therefore, measuring the moisture content of solid and dispersible mineral substances is difficult and leads to inadequate graded characteristics. Capillary-porous mineral substances have a specific resistance of 10^{8} Ohm when dry. Dielectric materials of m and above are considered. Specific resistance when capillary-porous mineral substances are wetted is 10^{4} Ohm. can become conductors with m. Conductometric moisture meters are widely used to measure the moisture content of solid and dispersed mineral substances. The conductometric method is based on the relationship between the moisture content of a substance and its electrical resistance. [2]. This connection is expressed as follows: where R is the resistance of the mineral substance, Ohm: S is a constant value depending on the nature of the mineral substance; W — moisture content of the mineral substance, %; *p is* a degree indicator depending on the structure and nature of the investigated mineral substance (it varies within wide limits for different mineral substances). *S* is a constant, and the exponent *is p.* It is determined experimentally for any mineral substance. The ratio of the degree of resistance to moisture indicates the high sensitivity of the method of determining the moisture of capillary-porous mineral substances by the conductometric method. The complex dependence of Lekii resistance on other factors (temperature, mineral content, density, chemical composition, presence of electrolytes, etc.) makes this method unsuitable for automatic continuous measurement of humidity. Therefore, the use of conductometric moisture meters is limited. Transducers of conductometric moisture meters consist of two electrodes made in the form of flat plates, cylindrical tubes, rollers, etc. The readings of conductometric moisture meters are restored only when the weights are pressed, therefore, most of the transducers designed for dispersive mineral substances are provided with devices that press the weights between the electrodes.[3].

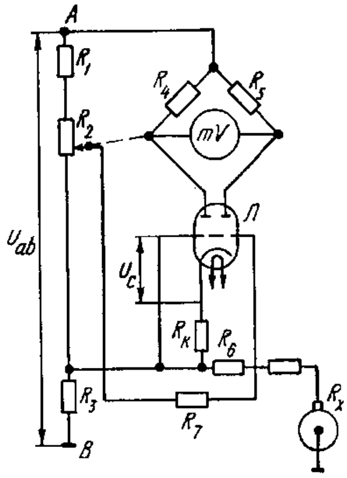

Figure 16.1. Automatic humidity measurement with a K- bridge circuit.

Among the measurement schemes, the most effective are the bridge schemes. Bridge measuring circuits have high sensitivity and are used for measuring average and high (5...25%) humidity. Figure 16.1 shows the schematic diagram of an automatic moisture meter with a bridge measuring circuit. The mineral substance to be tested is passed between the roller and the shaft (the roller is isolated from the shaft). The main element of the circuit is the bridge, the shoulders R_4 and $R_{5 \text{ of the bridge}}$ are constant resistances, and the other two shoulders are the internal resistances of the triode (the circuit has two additional resistances R_1 and R_3. A millivoltmeter humidity meter is connected diagonally across the bridge. *U on the grid of the left half of the lamp s*, the negative voltage is determined by the voltage drop in the resistor *Rx* and it is constant. Therefore, the resistance in the left half of the triode is also constant. The negative voltage of the right triode type differs from *Us* by IR $_6$ magnitude. And the current J is the resistance *Rx of the mineral substance being built* and R_2 depending on the state of the rheochord slider. When the rheochord slider deviates from the zero position of the millivoltmeter needle (the bridge is out of balance) , the voltage drop in R_2 is balanced by the voltage drop in R_6 and R_7. When the displacement voltages on both halves of the triode are the same , the bridge balance With the change of moisture and, consequently, the resistance of the mineral substance Rx , a current is generated in the resistance R_1, the balance of the bridge is disturbed, as a result, the slider R_2 moves to the appropriate value. Each humidity value corresponds to a specific state of *the rheochord slider* R_2. As mentioned above, the resistance of the converter also depends on factors other than the moisture content of the mineral substance. Therefore, the character of the curves describing the ratio between resistance and humidity, even if they are the same, do not correspond to different substances (for each substance, a graded curve or calculation tables are needed). The dielcometric method is based on the fact that the change in the humidity of capillary-porous bodies greatly changes their dielectric absorption. In dry bodies, the dielectric constant is $\varepsilon = 1.6$, and that of water is $\varepsilon = 81$. As a result of the change in the moisture content of the mineral substance, the change in dielectric absorption is usually determined by the change in the capacitance of the capacitor between the layers of the analyzed mineral substance. The converter of the dielectric moisture meter is made in the form of two flat plates or two concentric cylinders, between which the mineral substance being analyzed is filled. The geometric dimensions of the known capacitor capacity are found by a special formula. The connection of a capacitive transducer to a high-frequency oscillation circuit allows the use of resonant circuits of tube or semiconductor devices to measure the capacitance of the transducer and, accordingly, the moisture content of the mineral substance. Capacitive converters are less sensitive to the composition of the mineral substance, its structure, and the contact resistance between the electrode and the mineral substance. Since the dielectric constant of most mineral substances depends on temperature, the automatic correction of temperature changes in industrial devices is kept in autumn. The error of capacitive moisture meters can be 0.2..0.5%. However, the sampling method (filling between the capacitor plates with a mineral substance) can affect the measurement results. For example, even changes in the particles of the mineral being analyzed can greatly affect the readings of the moisture meter. For this reason, capacitive moisture meters that measure the

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moisture content of solid and dispersed bodies are rarely used in technical measurements. The difficulty of measuring the moisture content of solid, dispersed, as well as fibrous mineral substances is that when the sensor interacts with the mineral substance, its structure, density and other factors change, and they can greatly increase the error of the instrument. Therefore, non-contact measurement methods are mainly used in the industry: in ultra-high frequency and optical methods, high-frequency (UUuCh) moisture meters use the fact that the electrical properties of water and dry matter differ greatly (tens of times) . Moisture concentration is measured by the attenuation of high-frequency radiation passing through the analyzed mineral layer. The ultra-high frequency (UUuCh) method is based on the fact that the electrical properties of mineral substances in the field of ultra-short centimeter radio waves (3000 . 10 000 MHz) depend on their moisture content . The structural scheme of UYuCh moisture meters is depicted in Fig. 16.2.

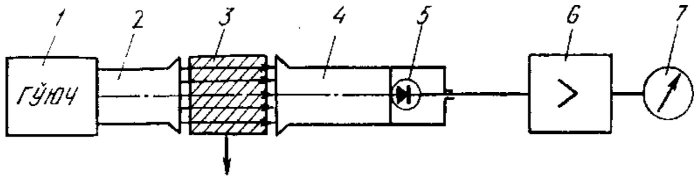
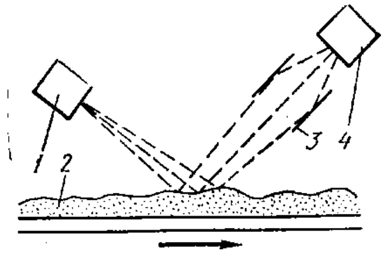


Figure 2. Structure diagram of ultra high frequency moisture meter. The tested mineral substance *3* passes between the transmitting antenna *2* and the receiving antenna *4 supplied from the UYuCh generator 1.* The receiving antenna has a detector *5 that receives a weakened signal of UV radiation. This signal, amplified by* the amplifier *6* , comes to the measuring instrument 7. The UVC method is non-contact and inertial, and is less sensitive to the existing electrolytes and to the uneven distribution of moisture in the mineral substance than to electrical methods. The main disadvantage of UYU moisture meters is the complexity of the device formation. [3,4]. In addition, these tools require information on the constant density or density of the mineral being monitored. Humidity meters with UYuCh 0 . It allows to measure humidity with high accuracy in a wide range of 100%. Optical moisture meters use the relationship between the moisture content of a substance



and the radiation reflected from it . To achieve the greatest sensitivity, radiation in the infrared part of the spectrum is used. It is produced by source 1 (Fig. 6). The light stream returned from the analyzed mineral substance *2 is sent to the receiver 4 using the* focusing device *3* . The higher the moisture content of the mineral substance , the better it absorbs infrared rays and the lower the amount of return current.
Figure 16.3. Optical moisture meter. Since this method can measure the moisture content of only a thin layer (5...30 mm), the moisture meter is usually used for loose mineral substances transported on conveyor belts. "Bereg" type optical moisture meters allow analysis of mineral substances with a moisture content of up to 80%.

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