ABSTRACT AND REFERENCES
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ANALYSIS OF INRUSH CURRENTS OF THE UNLOADED TRANSFORMER USING THE CIRCUIT-FIELD MODELLING METHODS (p. 6-11)

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We studied theoretically the transition processes that occur during tests of power transformers in the mode of experimental idling. A circuit-field model of electromagnetic processes is developed, based on a three-dimensional dynamical model of the magnetic field in a three-phase power transformer at idling.

Using a finite element method, we divided the region of field simulation into estimated zones with the magnetic field symmetry conditions for vertical and horizontal cross sections. The number of finite elements and the time for computing was reduced by four times without compromising the accuracy of our results.

It was established that in the circuit of the windings, connected into a triangle, there occurs a transitional levelling current, which fades over the initial switching time. The multiplicity of this current may reach 60–70 % of the multiplicity of the input surge current.

We have developed relations for the approximation of transitional phase currents, which are represented by the aperiodic, periodic components and series with the basis Gaussian functions for phase current discrepancies between the circuit-field and circuit models.

We have proposed and implemented a refined approach for the calculation of input surge current based on the specifications for an idling mode of the transformer and a surge current coefficient, which is characterized by the high efficiency and accuracy of numerical realization.

To determine a functional dependence of the multiplicity coefficient for an input surge current on the input resistances, we applied a method of sorting out specialized functions. The approximation coefficients calculation was carried out based on the method of least squares. This allowed us to significantly reduce the level of error when calculating the multiplicity coefficient of input surge current based on the specifications of the transformer and testing equipment, by 2.1 %.

Using the 3D modeling reduces the calculation error of idling mode current surges by 2.4 % using a simplified procedure that employs specifications of the transformer.

Keywords: circuit-field model, three-phase transformer, idling mode, magnetization inrush currents.

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DESIGNING A COMBINED DEVICE FOR DETERMINING THE PLACE OF ARC DISCHARGE (p. 12-18)

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We determined factors that arise during an arc discharge and detected possibility of their use to accelerate protection against arc closure. This enables creation of a combined device for accurate determination of an arc discharge. In particular, we can expand the spectrum of sensitivity of an optical sensor by the use of ultraviolet radiation without its replacement.

We considered possibility of acceleration of response of protection against arc closure operation due to refusal of its blocking with relay circuits for maximum current protection and reduction of an influence of solar radiation on operation of PAC (protection against arc closure).

We substantiated possibility of development of a more advanced device for protection against arc circuits, which gives possibility to expand the spectrum of the optical sensor in the region of ultraviolet radiation.

We proposed the solution of the problem of increasing of sensitivity of protection against arc closure. This is possible by converting the ultraviolet radiation into a visible part of the optical spectrum, which will expand the spectrum of sensitivity of the optical sensor to the region of ultraviolet radiation and, accordingly, increase its

sensitivity. This is due to the fact that 70 % of an arc discharge radiation falls on the ultraviolet region and only 15 % on the visible and infrared spectra of the optical radiation.

The obtained results give grounds to assert about possibility of realization of a device of combined protection for determination of arc circuits in industrial production, as well as expansion of spectral sensitivity of optical sensors. In addition, we developed a combined device for determination of an arc discharge through a use of an ultrasound system. Known developments devoted to determination of location of an arc discharge by comparing intensity of a signal from a flash at both ends of the ten-meter optical light conductor are characterized by the fact that the maximum difference between the arrival time of signals from a flash point to sensors at the ends of the optical fibers is 5ns. This is a very low temporal level compared to the light conductor length at the velocity of 300,000 km/s.

The system proposed in this study uses the sound velocity, which reaches 342/s, to determine an arc discharge, which simplifies a time measurement device for determination of a short circuit greatly and increases accuracy of time measurement by three orders of magnitude (10^3).

Keywords: protection against arc circuit, protection sensitivity, radiation spectrum, ultraviolet radiation transformation.

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DEVELOPMENT OF DIODE TEMPERATURE SENSORS WITH OPERATING RANGE UP TO 750 K (p. 19-25)

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The problem of expansion of the range of functioning of diode thermosensors in the region of high temperatures is considered and some of the results of the author's research in this area are given. To solve this problem, it is proposed to use diode structures based on wide bandgap semiconductor compounds in the III-V system. The technological method of producing prototypes of high-temperature diode temperature sensors based on GaP is developed. The presented method allows manufacturing samples of diode temperature sensors, the high-temperature limit of which exceeds the limit of functioning of commercial silicon diode temperature sensors by about 200–300 K. The experimental methods of obtaining epitaxial structures of solid solutions of AlGaAs and fabricating diode temperature sensors based on them are developed. It is shown that the approach chosen in this work allows extending the thermometric characteristics of such diodes in the high-temperature region by approximately 150–250 K. The paper presents the methodology for forming InGaN device structures and production of prototype high-temperature diode temperature sensors based on them. This technique with revisions can be used for the manufacture of diode temperature sensors and other devices for high-temperature applications, the entire range of solid solutions in the InN-GaN system. The parameters and characteristics of the obtained diode temperature sensors are investigated. The results of the research can be used by specialists in the field of electronics and optoelectronics in the development and production of semiconductor devices.

Keywords: diode temperature sensors, diode thermometry, thermometric characteristic, thermal sensitivity, liquid-phase epitaxy.

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DEVELOPMENT OF A MINIATURE MICROWAVE RADIOTHERMOGRAPH FOR MONITORING THE INTERNAL BRAIN TEMPERATURE (p. 26-36)

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To improve efficiency of non-invasive monitoring of the internal brain temperature, a small-size single-channel microwave radiothermograph consisting of a miniature radiometer and a radiometric sensor based on a printed antenna was developed. Such solution is necessary to provide physicians with a system of non-invasive monitoring of diagnosis and treatment processes. Mathematical modeling and experimental verification of the technical solutions obtained are described in this paper. A miniature radiothermograph was developed. It is a balance modulation radiometer designed on the basis of the R. H. Dicke's circuit with two loads. Taking into account the requirements of miniaturization, a radiometric sensor was developed by means of numerical simulation. As a result of calculations, optimum antenna dimensions were determined (the

total size: Ø30 mm, the size of the foil dielectric substrate: Ø23 mm, dimensions of the emitter slot: 16 mm×2 mm). According to the mathematical modeling, the depth of detection of thermal anomalies was not less than 20 mm for the printed antenna which is practically the same as for the waveguide antenna successfully used at present in brain radiometry.

The standing wave coefficient was determined for various head regions: frontal, temporal, parietal, occipital and the transient between the occipital and parietal regions. Experimental tests of the radiothermograph on water phantoms and biological objects have been carried out. A very good coincidence between the data of numerical simulation and the physical SWR experiment in a range of 1.04–1.8 was obtained. As a result of the study, it has been found that the radiothermograph with a printed slot antenna enabled measurement of internal brain temperature with an acceptable accuracy (±0.2 °C). This will ensure control of craniocerebral hypothermia in patients with brain stroke and allow doctors to promptly change the hypothermia tactics. Small size of the created unit will make it possible to combine it with medical robotic systems to improve treatment effectiveness.

Keywords: microwave radiometry, temperature monitoring, printed antenna, medical radiothermograph, brightness temperature, medical robotics.

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ANALYSIS OF CONDITIONS FOR THE PROPAGATION OF INTERNAL WAVES IN A THREELAYER FINITE-DEPTH LIQUID (p. 37-46)

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The problem of propagation of internal waves for an ideal incompressible fluid was considered. The hydrodynamic system consisted of three layers of a finite thickness that did not mix and were bounded with a solid cover from above and a solid bottom from below. The surface tension force acted on the interfaces of liquid media.

The problem was formulated in a dimensionless form. The nonlinearity coefficient equal to the ratio of the characteristic amplitude to the characteristic wavelength was used as a small parameter.

Solutions of the linear problem were sought in the form of progressive waves. On the basis of these solutions, the dispersion relation was obtained as a condition of solvability of the system of linear differential equations. Existence of two characteristic modes (the real roots of the dispersion relation) was revealed. The graphs of the roots of the dispersion relation were analyzed depending on various physical and geometric parameters of the system. It has been established that thickness of the layers did not affect dispersion of the waves while the change of the surface tension and the ratio of densities had a significant effect on the wave propagation conditions. Wave packets were considered in a linear formulation which was a superposition of harmonic waves of close lengths. It was found that amplitude of the envelope of the wave packet on the lower contact surface remained sinusoidal while it varied on the upper contact surface according to a more complicated law.

The problem of propagation of internal waves along the surface of three liquid layers can simulate a strongly stratified thermocline in the ocean. The study of influence of surface tension can also be used to develop new technologies associated with the use of three liquid layers that do not mix.

Keywords: ideal incompressible fluid, internal waves, three-layer hydrodynamic system, dispersion relation.

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EXPERIMENTAL INVESTIGATION OF THE FIRE-EXTINGUISHING SYSTEM WITH A GASDETONATION CHARGE FOR FLUID ACCELERATION (p. 47-54)

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To improve the parameters of pulsed fire-extinguishing plants for long-range and mass and dimensional indicators, it was proposed to replace the pneumatic propellant charge with the gas-detonation charge. The charge is formed based on the technical propane-butane mixture with oxygen, and detonation combustion of the mixture was achieved through the application of the electric discharge system of detonation initiation.

It was experimentally proved that the use of the gas-detonation charge instead of the pneumatic charge in pulsed fire-extinguishing plants makes it possible to improve their parameters. An increase in long-range of a water jet, which was achieved in the developed plant, decreases the impact of heat radiation on a rescuer, which ensures the feasibility of application of such systems for fighting large-scale fires. A decrease in gas pressure in cylinders due to transition from compression energy to chemical combustion energy ensures a decrease in the equipment weight and an increase in the number of shots with the extinguishing agent with the same dimensions of similar plants with the pneumatic charge. Specifically, in the plant with the gas-detonation charge, effective fire extinguishing distance, depending on the initial pressure of the charge within 0.1÷0.3 MPa was from 8 to 19 meters for the mass of the extinguishing agent of 1 kg and from 5 to 14 meters for the mass of the extinguishing agent of 2 kg.

The parameters of the electric discharge system, which ensure detonation initiation with minimal electricity consumption, were determined. Specifically, in the case of the use of a special spark plug by two synchronized spark discharges, at complete energy of the charge of 15 J and application of the capacitor of 1.75 μF and inductivity of the discharge curciut of 400 nH, detonation occurs in the pipe of the diameter of 73 mm under conditions of the conducted research at the distance of not more than 180 mm.

The obtained results could be used in designing the plants with a gas-detonation charge.

Keywords: pulsed fire-extinguishing plant, extinguishing agent, gas-detonation charge, fire extinguishing distance, dispersion of atomization.

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INVESTIGATION OF THE ELECTROCHROMIC PROPERTIES OF $Ni(OH)_2$ FILMS ON GLASS WITH ITO-Ni BILAYER COATING (p. 55-61)

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Electrochromic films have been deposited onto glass coated with indium-tin oxide (ITO) and glass with ITO and a thin layer of metallic nickel deposited onto it. Nickel was deposited onto the surface of the ITO coating from nickel electroplating solution. The metallic nickel was deposited onto the surface of ITO at the following parameters – cathodic current density 0.5 A/dn^2, deposition time 3 s. Such deposition parameters were chosen, because at longer deposition time and (or) higher current density, the deposited layer of metallic nickel became opaque. The two substrates were then used in the deposition of $Ni(OH)_2$ electrochromic films using the cathodic template synthesis method. As a result, it was revealed that the electrochromic film deposited onto glass with ITO-Ni coating possesses higher specific characteristics than that deposited on bare ITO-coated glass: higher coloration degree and higher oxidation-reduction currents on the cyclic voltamperogram. However, it was also revealed that the film possessing better characteristics, on the contrary, has lower reversibility of the coloration-bleaching process. Based on the obtained data, the mechanism that explains the role of the intermediate metal layer was proposed. The mechanism is that the deposited layer of metallic nickel forms additional contacts between the substrate surface and the electrochromic film. The nickel layer can also assist in securing the electrochromic film, and during film deposition has a positive effect on current distribution. On the other hand, the lower reversibility of the coloration-bleaching process of the film on ITO-Ni coating can be explained by gradual oxidation of metallic nickel in the basic medium. At the same time, it was revealed that deposition of metallic nickel leads to some decrease of the substrate transparency.

Keywords: electrochromism, electrodeposition, thin films, $Ni(OH)_2$, nickel, indium-tin oxide, nickel hydroxide.

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DETERMINIG THE PARAMETERS OF THE ACOUSTIC SYSTEM FOR THE PRIMARY TREATMENT OF WOOL (p. 61-68)

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We have studied the process of primary treatment of wool in order to remove soil and manure contaminants, vegetable impurities, fat, and sweat. The primary treatment of wool performs a key role in retaining the natural properties of wool fiber and makes it possible to obtain high-quality raw materials for textile industry. It was found in the course of research that the intensification of the processes of primary treatment of wool requires the application of

acoustic oscillations. Acoustic oscillations act on the system wool-washing solution. The system wool-washing solution is in between grating conveyors. Conveyors form a grating of metal rods. To determine parameters of the acoustic system for the primary treatment of wool, we performed an analysis of three problems. The problems related to: the scattering of acoustic oscillations on a metal grating, on a layer of wool-washing solution, and combining the solutions to two problems into one using a scattering matrix method. Our study allowed us to define parameters for the system of primary treatment of wool with acoustic oscillations, which makes it possible to achieve greater effectiveness in cleaning wool compared to existing analogues. It was established in the course of theoretical and experimental studies that the washing of wool should be carried out at the following parameters of acoustic oscillations in a washing solution: frequency of the sound field is 1.1±0.1 kHz; the sound intensity is 1.1±0.01 W/cm^2. In this case, the thickness of a layer of wool at the conveyor is 0.06±0.01 m; the motion speed of conveyor is 0.1 m/s; the number of converters per bath is 8±1 pieces.

The application of optimal parameters in process of continuous washing of wool fibers in an aqueous solution makes it possible to obtain the residual fat on wool within 1.5 % of the amount of fat in the unwashed wool while GOST of Ukraine permits up to 2 %.

Keywords: primary treatment of wool, parameters of acoustic oscillations, coefficient of reflection of acoustic wave.

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