contact surfaces between layers of solid organic combustible materials of any thickness and solid oxidizing agents. In the present paper we will investigate the analogous phenomenon for the case in which a powdered metal is used as the combustible material.

Combustion in a system consisting of plane or cylindrical layers of the components in contact (a "stratified system") is of interest as a limiting case of the combustion of the more usual random mixture of particles of the same components with large particle dimensions.

Calculation of the Optimal Process in Chemical Reactors by the Method of Dynamic Programming, L. M. Pis'men and I. I. Ioffe, pp. 24–32.

Application of a theoretical solution developed in a previous article on the same subject (Intern. Chem. Eng. **2**, October 1962) is given.

Hydrodynamically, a condition of ideal mixing can be attained, as is known, in liquid-phase reactors with mixers and, under certain conditions, in reactors with a fluidized catalyst bed. The kinetic characteristics of such systems are for the most part unfavorable, due to the hydrodynamic irregularity of the stream and the limited possibilities of purposefully directed action on the process (the small number of degrees of freedom in design and control). In the transition from a single reactor to a chain of reactors with ideal mixing combined in a series, all the technological conveniences of this method of carrying out the process are preserved, and the shortcomings mentioned are to a considerable degree removed. By virtue of this, reactors with ideal mixing combined in series constitute an effective reactor arrangement for many chemical processes. In the following, an analytical method for calculating the optimal process in such reactors is described, based on the theory of dynamic programming.

Application of Burman-Lagrange Series in the Analysis of Transition Processes in Chemical Engineering Equipment, B. N. Devyatov and Yu. N. Kornev, pp. 36–44.

The practical value of the use of these series for the approximation of transcendental transfer functions and the corresponding transition functions is demonstrated by examples.

The determination of transition conditions for a broad range of chemical engineering equipment, in view of its typical presence in countercurrent or direct-flow processes, is related to the analysis of systems of general fundamental equations with partial derivatives.

For such systems, which have distributed parameters, in the majority of cases it is inexpedient to express precise solutions of the equations, since their expressions are either unwieldy or in general do not lend themselves to determination. The corresponding transfer functions are more readily determined, but are transcendental, and their direct analysis is very difficult.

Therefore, indirect methods of constructing the corresponding solutions of the equations for a transfer function in the form of a convergent series, without direct solution of the equations with partial derivatives, acquire a special importance. Burman-Lagrange series can be used very effectively for this purpose. In this case, the selection of one or another concrete form of Burman-Lagrange series is conditioned, on the one hand, by the requirement of very great precision in describing the given part of the transition process, and on the other, by the nature of the transition process itself, and by its nearness to some simple functional dependence.

It is evident from physical considerations and from experimental data that processes which correspond to the general equations for the reaction of moving media in industrial equipment are, in the presence of a gradual disturbance, steady and limited in a majority of cases. The character of the flow in these processes is close to an exponential function.

These peculiarities of a transition function have been taken into consideration in the specific selection of a Burman-Lagrange series, for the purpose of assuring its sufficiently rapid convergence in practice.

It should be noted that the particular form of series adopted by us approximates better the transition functions of systems with nonoscillating limited transitional characteristics, and even better with monotonic. On the other hand, in principle it is possible to construct a Burman-Lagrange series of another type which better approximates oscillating-damping processes, that is, processes typical for automatic control systems. In this sense, the universality of this method of describing transition processes is valuable.

MEASUREMENT TECHNIQUES (Izmeritel'naia Teknika). Published by Instrument Society of America, Pittsburgh, Pa.

Number 3, March 1962

Problems in Measuring Pulsating Flows, N. F. Gonek, L. A. Kirmalov, and B. I. Pilipchuk, pp. 244–246.

Number 4, April 1962

Instrument for Remote Measurement of Temperature of Moving Media, B. L. Gunbin, pp. 288–291.

An instrument for remote temperature measurements of a flow moving with infrasonic velocities is described in this article. The schematic of the instrument (Fig. 1) consists of an unbalanced

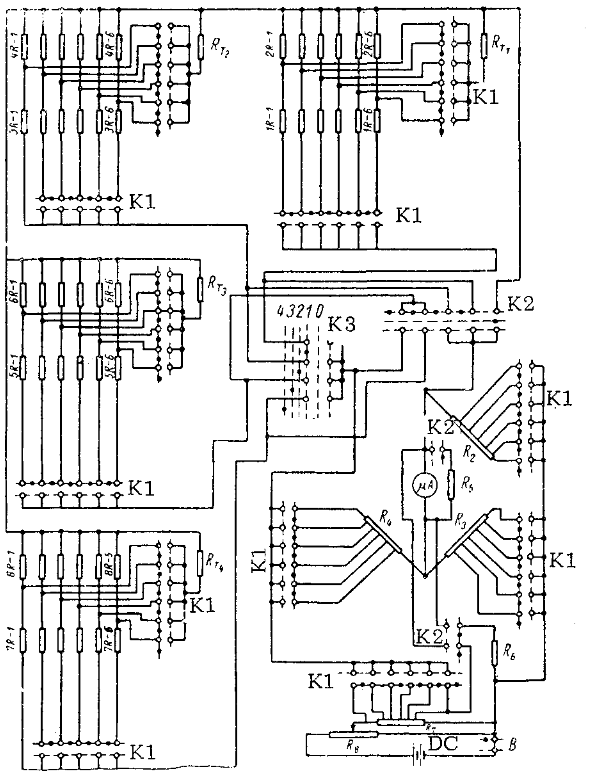

Fig. 1 R_{T1}–R_{T4} are microthermistors type MT-54; K1 are roller switches type KTROI 15-31/5-15; K2 is a roller switch type KTROI 7-17/7-17; K3 is a switch type PMT-4; R_2–R_8 are manganin resistors; 1R-1 to 1R-6, 3R-1 to 3R-6, 5R-1 to 5R-6, 7R-1 to 7R-6 are manganin resistors; 2R-1 to 2R-6, 4R-1 to 4R-6, 6R-1 to 6R-6, 8R-1 to 8R-6 are resistors type VS or MPT; B is a switch type TP1-2; μ A is a microammeter type M91 with a range of 10 μ a; DC are dry cells type ZsL-30.

bridge with a thermistor connected to one of its arms. The instrument has four transducers which are switched-in consecutively. Its temperature range is 0° to 100°C.

Number 5, May 1962

Calorimetric Equipment for Determining the Enthalpy and Thermal Capacity of Substances, E. N. Fomichev, V. V. Kandyba, and P. B. Kantor, pp. 376–380.

The calorimetric equipment of the KhGIMIP (Khar'kov State Institute of Measures and Measuring Instruments), which is described in this article, is intended for measuring the enthalpy of substances in a condensed phase over a wide temperature range of 500° to 3000°K with an accuracy of 0.3 to 1%.

Selection of Optimum Parameters for a Filter at the Output of a Transducer, V. F. Dmitriev and Ya. A. Kupershmidt, pp. 404–408.

The majority of transducers used in industry operate on currents of a standard frequency (50 or 400 cps). Transducers are sometimes provided with an output rectifier and a low-pass filter to facilitate their coupling to other components of various measuring systems. In designing filters only their smoothing effect is taken into consideration for reducing the ripple. The drop in the filter frequency characteristic in the range of the measured variable spectrum, which leads to an error in the reproduction of that variable, is ignored. A rise in the filter time constant increases that error, while at the same time it reduces the ripple. We shall describe a method for selecting optimum parameters of a filter which provides a minimum total effect due to the sum of the foregoing errors. It is assumed that these errors are random and independent of each other.

Number 6, June 1962

Application of Thermal Detectors at Infrasonic Frequencies, O. N. Gravin, O. P. Galakhova, and E. D. Koltik, pp. 486–489.

Currents at infrasonic frequencies are being increasingly used in science and technology, in particular when testing the stability of automatic control systems. In this connection, it becomes necessary to measure various electrical quantities at these frequencies. A detailed investigation of thermoelectrical elements down to frequencies of 0.5 cps is provided in another paper; however, the use of thermal detectors at lower frequencies has as yet received little attention. In the present work, possibilities are examined of using thermal detectors at frequencies below 0.5 cps for measuring the effective and amplitude values of current (voltage), and for indicating the phase-angle difference (0, 90, 180, and 270°).

Certain Dynamic Problems in Photocompensated Amplifiers, S. G. Rabinovich, pp. 491–497.

In designing photocompensated amplifiers, it is often difficult to provide an appropriate damping of transient processes. These difficulties normally arise when the compensator galvanometer has no reserve of sensitivity and it is impossible to shunt it for the purpose of raising its damping. In this case, the problem can be solved by connecting to the compensator circuit appropriate differentiating networks. Differentiating networks are now widely used in galvanometric amplifiers. However, only certain questions of their theory have, so far, been dealt with in the literature. The present article deals with an analysis of the dynamics of galvanometric compensators whose damping is provided by means of circuit arrangements.

Conclusions: The effect of a differentiating network on the transient process in a galvanometric compensator depends to a great extent on the place where this network is connected. A differentiating network connected into the direct amplifying channel raises the damping of the system. But, in this case, the transient process depends not only on the degree of damping, but also on the extent to which the damping is due to magnetic induction and to the differentiating network. The operating speed of the system rises with an increasing effect of the differentiating network; however, usually its sensitivity to noise also rises.

When a differentiating network is connected into the feedback channel, the system's transient processes remain identical to those produced by magnetic induction damping provided by the galvanometer coil or frame. The relationships cited in the article provide the possibility for computing parameters of differentiating networks for a given degree of damping.

Number 7, July 1962

Thermoelectric Anemometer for Measuring Air Flow Speeds, V. M. Maevskaya and A. D. Morozov, pp. 556–558.

In view of the fact that existing instruments for measuring the speed of air flows do not cover low speeds, V. M. Maevskaya and A. A. Sviridonov of the Eastern Scientific Research Institute for safety precautions in the mining industry have developed a miniature portable thermoelectric anemometer ATÊ-1 for measuring air speeds over a wide range from 0.001 to 20 m/sec. The operation of the instrument is based on the cooling by the air flow of the heater of a thermal detector. The thermo-anemometer consists of the following basic units: a transducer with a thermal detector, a measuring instrument, a supply battery, and a circuit with switches and a controlling rheostat.

The transducer (Fig. 1) consists of a hollow texolite cylinder 1 with ebonite handle 2. The cylinder has a diameter of 55 mm, is 20 mm long and has a wall thickness of 2.5 mm. Along its circumference the cylinder carries 25 series-connected thermocouples made of 0.3 mm constantan and steel wire. The thermocouple junctions protrude inside the cylinder in two rows, one of which is formed by the cold junctions 3 and the other by the hot junctions 4. The protruding ends of the cold junctions are 10 mm long, and the hot junctions 15 mm long. The hot junctions are heated by means of nichrome wires glued to them with bakelite lacquer. Several coats of the bakelite lacquer over the junctions prevent any possibility of short circuits. The conductors to the supply and measuring circuits are taken out through the bakelite handle.

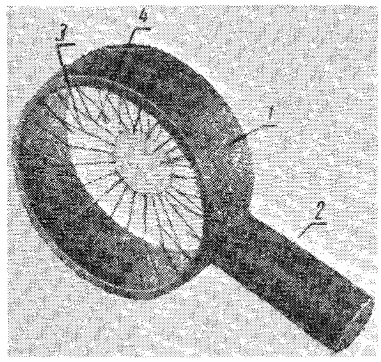

Fig. 1

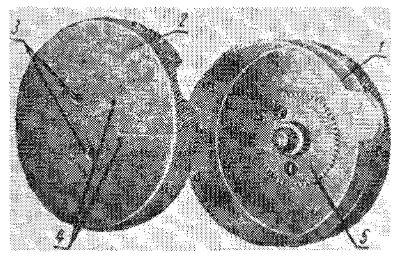

Fig. 2

Conclusions: The thermoelectric anemometer was tested under mining conditions for measuring the speed of air along underground workings. The tests have shown that the instrument is more accurate than existing impeller or cup-type anemometers and is suitable for measuring low air speeds. It is also possible to measure air depressions by means of this instrument, thus providing depression surveys by means of one instrument instead of two, namely, a microammeter and an anemometer which are normally used in mines. The instrument has three ranges: 0.001–0.3; 0.1–6 and 1–20 m/sec; its error is 1.5% and its over-all dimensions are 90 × 110 × 130 mm, with a weight of 1.2 kg.

New Method of Designing Filters for Measuring Devices, M. A. Zemel'man, pp. 559–564.

It is often necessary, in designing measuring apparatus, to produce devices for separating the constant component from a voltage of any waveform. The simplest example of such an instance consists in the separation of the constant component after half- or full-wave rectification of a sinusoidal voltage. Sometimes it is necessary to separate the constant component of a train of pulses, etc. Often such smoothing devices must provide a very small ripple at the output, i.e., a very small alternating voltage component at the output, and yet possess the required speed of operation. Such a problem may arise, in particular, when high-speed digital measuring instruments are being developed for measuring alternating voltages which are first rectified. Such instruments do not measure the mean but the instantaneous rectified voltage. Hence, the ripple at the output of the filter connected after the rectifier must be at any rate smaller than the tolerated error of the instrument.

The requirements of a small ripple at the output and high speed of operation are contradictory for normal filters. The time constant must be raised in order to reduce the ripple, but it must be lowered to raise the speed of operation. For instance, in a single-section RC filter for a ripple not exceeding 0.1% of the d.c. voltage, the settling time of this voltage to 99.9% of its stable-state value after a sudden change in the input voltage amounts to 6000 T (T is the period of the a.c. components). For a frequency of 100 cps this time amounts to 60 sec. The foregoing contradiction is a fundamental obstacle to the use of ordinary inertial systems in high-speed filters with a very small ripple.

Under certain conditions this fundamental contradiction can be reconciled to a considerable extent by using, for smoothing filters, a system which consists of a narrow-band d.c. amplifier with a negative feedback. Moreover, in a direct transmission channel the d.c. component of the input voltage will be amplified, but the basic component whose frequency is outside the passband of the amplifier will be attenuated. The duration of the transient process in the d.c. component will be reduced by the feedback effect.

Number 8, August 1962

High-Speed Self-Checking Digital Voltmeter, V. N. Khlistunov and G. G. Zhivilov, pp. 677–679.

The most important requirement facing measurement technology consists in the automation of measurements and connecting measuring instruments (channels) to digital computers as the most suitable devices for the automation of complex processes. The high-speed digital voltmeter described here is intended for use in systems of centralized control and for subsequent treatment and use of measurement results in conjunction with digital computers. The operation of this voltmeter is based on time-to-pulse conversion of the input signal in a discrete form. The principle of operation of such instruments and their systematic errors are described in other papers.

In the instrument described the duration of voltage measurements up to 20 v does not exceed 2 msec; its input resistance is 10 MΩ and its error is 0.2%. The instrument is provided with a four-digit display by means of IN-1 tubes. The tube of the highest order is provided with two digits only. Moreover, each digital indication unit has three projection-type indicators for registering the number of the measured parameter and its dimensions. The instrument is made in 5 units suitable for rack mounting, consisting of the digital converter unit, the self-control unit, two digital display units, and a supply unit.

Microscope for Measuring Small Diameter Holes and Their Concentricity, S. L. Gondik, pp. 648–651.

The design of a microscope for measuring small diameter holes and determining the concentricity of two-hole diameters in the

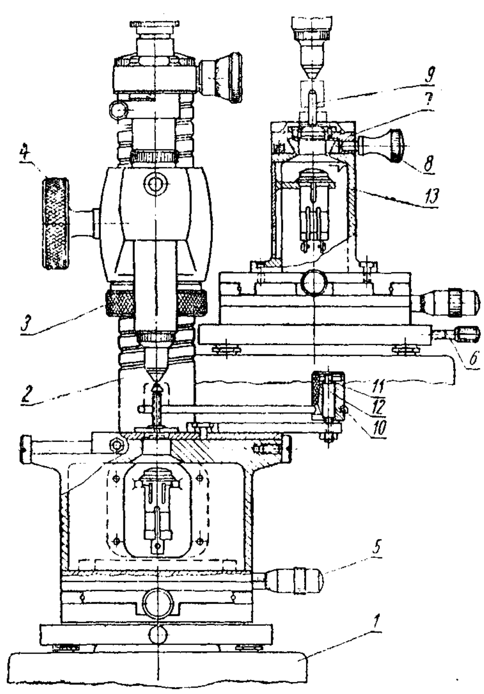

Fig. 2

body of a tractor jet atomizer (Fig. 1) has been developed at the Khar'kov tractor plant. The general view of the microscope is shown in Fig. 2.

Number 9, September 1962

High-Speed Multirange Instruments for Measuring and Recording Pressure, V. I. Korotich, pp. 739–741.

In studying an agglomeration process it is necessary to measure static gas pressure at various sections of the sintered layer. Such measurements are usually made in practical experiments by means of the simplest water-filled U-shaped manometers, thus requiring an operator for recurrent measurements and recording of results. This work is difficult, requires concentrated attention, and does not eliminate the possibility of errors. The instruments produced by our industry for measuring and recording pressure, consisting of recording circular differential pressure gages DKSV, can hardly be used for agglomeration research for two reasons: These instruments have a single channel and, therefore, as many instruments as measuring points will be required for continuous measurement of pressure and, what is even more important, these instruments have a considerable inertia (owing to the large capacity of the air ring), which is comparable to the time taken by pressure variations at the measured point, i.e., they produce a large error. This error increases if thin feed tubes are used or the instrument is moved away from the sintering installation.

The metallurgical department of the S. M. Kirov Ural Polytechnic Institute has developed an instrument which measures pressure simultaneously at several points and records the results on a single chart of a recording electronic potentiometer. The pressure is measured by means of wire-wound strain-gage transducers. The device consists of a measuring box, an adjusting box, a multichannel recording electronic potentiometer ÉPP-09, a dry cell (of 1–2 v), a milliammeter or voltmeter, connecting leads, and feed tubes.

We made no special tests to determine the dynamic error of the instrument. However, it was established with precision that the diaphragm with its measuring strips and transducers, following a sudden change in pressure, returned to its balanced position in under 3 sec, which equals the spacing between the consecutive potentiometer measurements. For the purpose of using this instrument in testing sintering processes such a "dynamic" sensitivity is quite satisfactory.

Calibration of Electronic Paramagnetic Resonance Transducers for Magnetometers, A. V. Kubarev, pp. 768–773.

The application of electronic paramagnetic resonance (EPR) transducers containing stable free radicals with a narrow absorption line has great possibilities for precision measurements of weak magnetic field strength. The relative accuracy of measurements in the range of 1 to 10 oe may then amount to 0.02–0.05%. However, there exist numerous data indicating the possible instability of the basic characteristics of such transducers, depending on the conditions of their manufacture and application, thus limiting considerably the accuracy of field-strength measurements in each given case. Hence, it is very important to make a detailed study of the metrological characteristics of the utilized samples and, probably, to calibrate each batch of radicals for the transducers.

Effect of the Duty Factor of a Square-Wave Controlling Voltage on the Operation of a Synchronous Detector, G. A. Shtamberger, pp. 774–776.

Synchronous detectors, because of their phase sensitivity and high selectivity, are being widely used in various measuring instruments and automatic, tracking, and control devices. Synchronous detectors comprise the main components in circuits for measuring very weak harmonic signals over a wide frequency range. The most widely used detectors employ a circuit similar to that of a balanced ring modulator. These devices can be provided with excellent metrological characteristics when electronic synchronous detectors are used in a keying operating condition controlled by a square-wave voltage. In the majority of cases the square-wave voltage is formed by means of double-sided amplitude limiters, or generators of a multivibrator type synchronized by the voltage of a given frequency.

It is advisable to study the effect of switching voltage duty factor variations on the operation of the detector, since the reading of the instrument connected to the output of a synchronous detector is proportional to the product of the switching and measured voltages. However, various causes, of which the most important are variations in the amplitude of the limited signal, nonlinearity of the volt-ampere characteristic, changes with time of the circuit element parameters, hysteresis, and other causes, may considerably change the duty factor of the switching voltage, thus producing an additional error.

Limiter circuits and synchronizing square-wave generators are normally provided with components for setting the initial duty ratio. Moreover, the value of the switching voltage changes in the majority of cases every half-period. If the switching voltage variation for any of the foregoing reasons occurs at a time $T/2 \pm \Delta t$ instead of $T/2$, the duty ratio will not be equal to but greater or smaller than two.

$$Q = \frac{T}{(T/2) \pm \Delta t} = \frac{2}{1 \pm (2\Delta t/T)}$$

If a synchronous detector is used as a null indicator, the voltage at its output will not be equal to zero at a 90°-phase difference, but at some other angle which depends on the duty ratio and can be determined according to another paper from the expression

$$\varphi = \text{arc tan}\ \frac{1 + \cos 2\pi\ (\Delta t/T)}{\sin 2\pi\ (\Delta t/T)} \tag{5}$$

For instance, for $\Delta t/T = 0.02$ we have

$$\varphi = \text{arc tan}\ \frac{1 + \cos 7.2°}{\sin 7.2°} \approx 86°30' \tag{6}$$

Thus, variations in the duty ratio of the switching square-wave voltage can have a substantial effect on the error of measurements carried out by a synchronous detector, and, therefore, it is necessary to pay attention to the duty ratio and stability of the switching voltage.

Number 10, October 1962

Selection of an Optimum Readout Frequency in Digital Measurements, Ya. A. Kupershmidt, pp. 807–814.

A continuous process is reproduced in digital measurements by means of discrete readouts taken at a certain rate. Constant values are maintained between the readouts, which is equivalent to a step-by-step approximation. The mean square of the differences between the approximating function ordinates and those of the initial process determines the quadratic mean error of approximation and decreases with a rising rate of discrete readouts, i.e., the error decreases with a decreasing readout cycle. However, because of the finite speed of a digital converter, which is determined, for instance, in remote measurements by the signal-carrying capacity of the transmission channel and in local digital measurements by the duration of transient processes in various circuit components, a reduction in the readout duration produces a reduction in the number of converter operation cycles during one readout. As a result of this the error of each discrete count is increased.

Thus, a rising readout frequency reduces one of the discrete measurement error components, namely, the discrete approximation, and increases the other, the discrete readout component. The error produced simultaneously by the stepped approximation and discrete readout has a minimum for a certain optimum readout frequency. In this article we find the optimum conditions with respect to the spectrum of the measured process and the speed of digital conversion.

Testing and Calibration of Electronic Ionization Pressure Gages, A. V. Eryukhin, pp. 824–830.

A method for testing measuring units of electronic ionization pressure gages has been described elsewhere; here we deal with the testing and calibration of manometric transducer tubes for ionization manometers.

Summary:

1) The design of a manometric tube for electronic ionization pressure gages must satisfy specified conditions both within the limits in which it is calibrated and tested by means of a reference MacLeod gage and over the required measurement range.

2) The cathode current I_k in the cathode circuit of ionization pressure gages when the latter are being calibrated or tested must not exceed a certain value for which condition (16) holds and hence Eq. (15) is applicable. Systematic errors may otherwise occur, since the pressure in the system may differ considerably from that in the manometric tube.

3) The fulfillment of condition (16) may be checked indirectly by the shape of the curve representing a relationship of the type of (17). Conditions (16) are met over the linear portion of relationship (17). A deviation from linearity with a rising current I^k indicates a departure from conditions (16).

4) The foregoing technique with the use of reference MacLeod gages provides a calibration and testing of ionization pressure gages with a relative quadratic mean error in calculating their sensitivity of the order of 1–2%.

Measurement of a Tube Voltmeter Input Impedance, V. V. Klanberg, pp. 866–867.

The input impedance of the voltmeters is often evaluated by means of an additional resistance and the measurement of two voltages. The essence of this method consists in measuring the voltage across the input of the voltmeter and across a known additional resistor R_1 and calculating the input impedance, if it is purely resistive, from the following formula:

$$R_{\text{in}} = \frac{\dot{U}_2}{\dot{U}_1 - \dot{U}_2} R_1 \tag{1}$$

where voltages U_1 and U_2 are measured by means of the tested voltmeter in question, providing its accuracy is sufficiently high for this measurement. However, the actual input impedance of a voltmeter is always complex and consists of a resistance R_{in} connected in parallel with a capacitance C_{in}. In this case the input impedance is

$$\dot{Z}_{\text{in}} = \frac{\dot{U}_2}{\dot{U}_1 - \dot{U}_2} R_1 \tag{2}$$

In practice the modulus of the input impedance is calculated from the formula

$$Z_{\text{in1}} = \frac{U_2}{U_1 - U_2} R_1 \tag{4}$$

An analysis shows that the value of a tube voltmeter input impedance measured by this method is always larger than its actual value. Hence, the value of the input impedance calculated from Eq. (4) exceeds its actual value by +18%. It is, therefore, always necessary, in evaluating a tube voltmeter input impedance by the additional resistance method, to calculate the measurement error, which in certain instances can be considerable.

Certain Problems in Calibrating Ultrasonic Flowmeters, G. I. Birger, pp. 272–274.

An ultrasonic flowmeter of any type measures the mean speed of liquid along the line of the ultrasonic beam. The rate of flow is determined, however, by the mean speed of flow across its cross section. It is obvious that these two quantities coincide only for a rectangular pipeline and then, strictly speaking, only of an infinite width. The speed of flow measured in a round pipe by means of an ultrasonic flowmeter whose beam passes along a diametrical cross section tends to be larger than the mean speed, with the ratio of these quantities depending on the distribution of velocities along the cross section of the flow. In this connection it is necessary to determine the extent to which the readings of an ultrasonic flowmeter depend on the hydrodynamic characteristics of the flow.

Electronic Circuit of a Commercial Electromagnetic Flowmeter, I. R. Linetskii and L. M. Korsunskii, pp. 875–879.

The effective voltage in electromagnetic flowmeters does not normally exceed several millivolts. Specific interference of the same frequency as the useful signal but displaced in phase with respect to it by 90° is characteristic of electromagnetic flowmeters. Normal operation of these flowmeters is impossible without elimination of the interference. Reliable operation of an electromagnetic flowmeter is provided by automatic compensation both of the useful signal and interference emf's by means of a rectangular-coordinate automatic a.c. electronic potentiometer. An electronic circuit of an automatic potentiometer for an electromagnetic flowmeter (Fig. 1) is described in this article.

Current I_b in electromagnet 1 induces in the operating gap a magnetic field with induction B. The emf E in the transducer due to the liquid flowing with velocity v through the pipe placed in the magnetic field is compared with the voltage across the contactless ferrodynamic elements 3 and 4. The excitation circuit of compensating element 3 is fed from amplifier 2, and current I_b flows through the excitation winding of element 4.

The output voltage U_1 of amplifier 2 is fed to winding W_1. Voltage U_{k1} is obtained across the moving coil W_{2k}. The feedback voltage U_β is obtained across the stationary coil $W_{2\beta}$ and is compared to voltage U_R across the resistance R of shunt 5. The input of amplifier 2 is fed by their difference U_R-U_β. Voltage U_{k2} is obtained across the moving coil W_{1k} of the compensating element 4.

The negative feedback across amplifier 2 and compensating element 3 makes voltage U_R coincide in phase with voltage U_{k1}, which is used for balancing the useful signal. Voltage U_{k2} lags with respect to current I_b by approximately 90° and is used for compensating the quadrature interference emf. The phase-sensitive drive consists of reversible servomotors 6 and 8 fed by autocompensation amplifier 7.

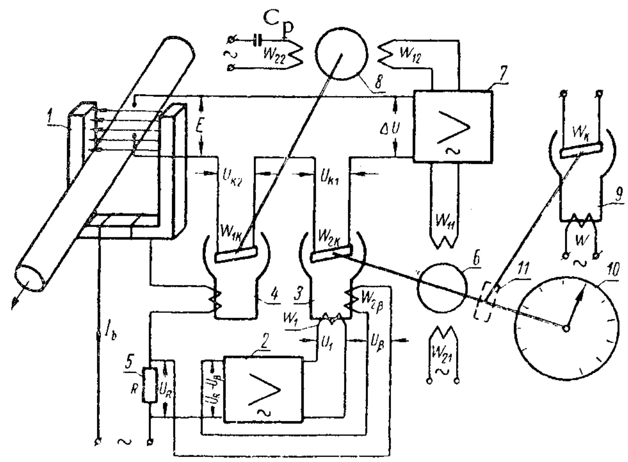

Fig. 1

The difference signal $\Delta U = \dot{E} - \dot{U}_{k1}$-$\dot{U}_{k2}$ is fed after amplification to control windings W_{11} and W_{12} of servomotors 6 and 8, respectively. The excitation voltages fed to servomotors 6 and 8 through windings W_{21} and W_{22} are displaced in phase by 90° owing to phase-shifting capacitor C_p. Servomotor 6 therefore reacts to the useful component of the unbalanced emf, and servomotor 8 to the quadrature interference component. Servomotor 6 operates through reduction gear 11 and moving coil W_{2k} of compensating element 3, as well as the moving coil of the output ferrodynamic converter 9 and the pointer of the counting device 10. Moving coil W_{1k} of interference compensating element 4 is operated by servomotor 8. The excitation circuit of the electromagnet and the excitation windings of the servomotors and of the output converter are fed from the same phase of the 50-*Hz* supply through an isolating transformer, which is not shown on the drawing.

SOVIET ASTRONOMY (*Astronomicheskii Zhurnal*). Published by American Institute of Physics, New York

Volume 6, Number 2, September–October 1962

Some Relations in the Theory of Radiation Scattering, V. V. Sobolev, pp. 178–181.

Very interesting papers by Yamamoto and King appeared several years ago. The first of these dealt with the scattering of light in a plane-parallel layer illuminated by isotropic radiation, and the solution of this problem was expressed in terms of the Hopf function. In the second paper, the Hopf function was expressed in terms of the moments of the Ambartsumyan function. The foregoing papers are of great interest because they suggest that the problem of the scattering of light in a medium of finite optical thickness can be reduced to the problem of the scattering of light in a semi-infinite medium. It is obvious that such a reduction would considerably simplify the theory of radiation scattering.

However, Yamamoto's formula is given without proof, and the derivation of King's formula is based on the former. It is therefore important to establish the validity of Yamamoto's formula. Yamamoto and King's papers contain tables of quantities calculated both from the formulas obtained by them and by other methods. A comparison shows that in general there is agreement to the first two significant figures. Since the calculations were only approximate, it is difficult to decide whether these discrepancies are due to inaccuracies in the formulas or inaccuracies in the calculations.

It is shown in the present paper that Yamamoto and King's formulas unfortunately are not exact. They should be regarded as approximate formulas that may possibly be sufficiently accurate for some applications. First of all we give Yamamoto's formula and examine some of its consequences, then we derive King's formula (as its earlier derivation is not strictly correct), and finally we investigate the accuracy of the forementioned formulas.

Radiative Thermal Conductivity of a Fully Ionized Plasma, T. D. Kuznetsova and D. A. Frank-Kamenetskii, pp. 191–197.

Exact calculations of the Rosseland mean opacity and radiative thermal conductivity of ionized hydrogen are given, taking into account electron scattering and bremsstrahlung. The results are compared to the Sommerfeld and Elwert approximations. An interpolation formula is presented for the radiative thermal conductivity of fully ionized hydrogen.

Possible Existence of a Ring of Comets and Meteorites around Jupiter, S. K. Vsekhsvyatskii, pp. 226–235.

1) The various arguments supporting the eruption theory, which provide a basis for the view that cometary and meteoritic masses orbiting around planets exist, are reviewed. These arguments are: impossibility of accounting for the young age and peculiarities in the motion of short-period comets in terms of capture; the existence of asteroids and meteor streams in the central regions of the solar system; the existence of cometary families in association with the planets Saturn, Uranus, and Neptune; the common features of cometary gases and the chemical structure of planetary atmospheres; characteristics of the system of parabolic comets; the presence of ice in comets; data on the structure and chemical composition of meteorites; evidence of volcanic activity on planetary bodies.

2) Significant changes observed in the Saturnian rings are noted, and data compiled by Otto Struve (19th century) and later observations are studied to find the rate of expansion of the rings and the speed with which they approach the surface of the planet. The decrease in the total energy of ring particles is calculated as a minimum of $3 \cdot 10^{36}$ ergs over a 300-year interval. Findings indicate that a rapid evolution, at a faster rate than that predicted by earlier estimates, of the ring must be ascribed to replenishment of the ring material and to collision between components of the ring.

3) The reader's attention is drawn to some conspicuous features of Jupiter's equatorial band, and observations of that band are reviewed.

4) It is shown that a correlation of the periods of best visibility of the Jovian equatorial band and the zenographic position of earth and sun and an examination of the position of the band on the disk furnish a powerful argument for the view that the band constitutes the shadow of a comet-meteorite ring surrounding Jupiter and lying in the plane of the planet's equator.

5) Some special features of a hypothetical ring around Jupiter with an optical thickness several tenths smaller than that of the Saturnian ring are discussed, as well as the possibilities of observing such a ring.

The Ring Encircling Jupiter, I. T. Zotkin, p. 236.

The outer form of the equatorial belt and its position on Jupiter accordingly provide us with no sure grounds as yet, on the basis of available observational data, for assuming it to be shadow of a ring. It cannot be denied, though, that this hypothesis of the existence of rings encircling Jupiter is in and of itself a highly intriguing conjecture.

Volume 6, Number 3, November-December 1962

Amount of Water Available in a Free State on Mars, A. I. Lebedinskii and G. I. Salova, pp. 390–397.

This paper discusses the amount of water available on the planet Mars in the free state. The estimate was arrived at through two different approaches: 1) from the degree of turbidity of the atmosphere; 2) from the rate of evaporation of the polar ice caps. Both approaches produced closely agreeing estimates. The thickness of the snow or cloud layer in the polar ice caps is 0.01 g/cm², and the total quantity of water in the free state on Mars is $2 \cdot 10^{15}$ g. Errors are pointed out in the calculations by de Vaucouleurs and Janesley.

Perturbations in the Translational-Rotational Motion of a Satellite and Planet Caused by Their Oblateness, V. T. Kondurar', pp. 405–411.

The influence of the shape of a celestial body on the motion of its center of mass has not been investigated previously, as it was thought that this effect could be neglected. Up to now this effect has been taken into account only in studies of the rotation of a body around its center of mass. In classical celestial mechanics, when studying the translational motion of a body together with the center of mass, this effect was generally neglected. In 1959, when studying the influence of reoblateness of a satellite in its translational-rotational motion, the author found that this could have a considerable effect not only on the rotational motion of the satellite, but also on its translational motion around the planet. In order to compare the effect due to the oblateness of the satellite with that due to the oblateness of the planet in the rotational-translational motion of the satellite, the problem of the translational-rotational motion of two rigid bodies is studied on the assumption that both have dynamical symmetry.

The differential equations of this problem are essentially nonlinear. For a limited interval of time they can be substituted by linear equations and thus the deviations (from the undisturbed motion) in the radius-vector, applicate, the longitude of the center of mass of the satellite, and the Euler angles of the satellite and planet caused by the oblateness of the planet can be determined. Adopting in our problem for the undisturbed motion, the regular motions considered elsewhere, which correspond to the case when the oblateness of the central body is zero, we can without difficulty deduce new formulas for determining the forementioned deviations (perturbations) due to the oblateness of the planet.

Zemplene Theorem for a Hot Gas in Equilibrium with Radiation, V. S. Imshennik, pp. 426–427.

It is shown that the conditions of the Zemplene theorem are fulfilled for an arbitrary ratio of radiation pressure to gas pressure, i.e., in a hot gas in equilibrium with radiation only compression shock waves are thermodynamically stable.

Volume 6, Number 4, January-February 1963

The Astronomical Unit of Length, A. A. Mikhailov, pp. 449–458.

The basic principles and results of the determination by the trigonometrical, dynamic, spectroscopic, and radar methods of the astronomical unit of length and the solar parallax are discussed. Some of the sources of uncertainty of these determinations are pointed out and possible errors evaluated. Future possibilities are considered.

Radius of Venus. II, D. Ya. Martynov, pp. 511–517.

A new determination of Venus' radius has been carried out on the basis of occultations of Regulus by the planet, incorporating hitherto unknown observations. Auwers' value of the radius, $8''.41 \approx 6100 \pm 30$ km, was fully confirmed. Some possible corrections to this value are found in Table 3 (the factor 0.6 should also be applied). Some remarks on the possibility of a gap in the cloud layer of Venus, and the diurnal variations of the height of the cloud layer, are left to the summary.

The Gegenschein as an Effect Produced by the Scattering of Light from Particles of Interplanetary Dust, L. M. Gindilis, pp. 540–548.

The optical theory of the Gegenschein is considered. It is shown that the scattering of light by particles of interplanetary dust allows us to explain the main features of the Gegenschein: the observed photometric profile and the energy distribution in the Gegenschein spectrum. The following assumptions are made concerning the properties of the dust:

1) The presence of some dielectric particles, scattering from which is responsible for the brightness at the antisolar point, is necessary.

2) The spatial distribution of dust can correspond to a constant density or to density decreasing according to the law r^{-1} or, finally, to a concentration of dust in the asteroids belt. The latter corresponds best to the observed photometric profile on the Gegenschein at angular distances of 180–160° from the sun.

3) The distribution of particle sizes is $n(a)da = Ca^{-p}da$, where $p = 4$ or $p = 5$. With $p = 4$, it is necessary to assume that besides dielectric particles there are 90–95% absorbing particles with $A \approx 0.1$. With $p = 5$, the Gegenschein can be accounted for by scattering from dielectric particles only. This value of p is in better agreement with the energy distribution in the Gegenschein spectrum. A higher value of p does not yield the observed photometric profile.

4) In the case of constant density decreasing according to r^{-1} the density of particles at the earth's orbit N $(a > 0.6\mu) \approx 5 \cdot 10^{-13}$ cm^{-3}. In the case of dust concentrated in the asteroid belt, the average density in the asteroidal belt is $N \sim 10^{-12}$, whereas the density at the earth's orbit is $N < 10^{-13}$.

The difficulties encountered by the optical theory in explaining some of the observed facts are discussed in the introduction.

Stability of Stellar Rotation, V. V. Porfir'ev, pp. 555–557.

The stability of stellar rotation is considered. It is shown that two types of stable stellar rotation are possible. In the first case the total absence of circulation is assumed, and in the second circulation is so strong and exists for such a long time that momentum transfer is absent. The first case is investigated. It is shown that, with the assumptions adopted, the theoretical law of stellar rotation practically coincides with the observed law of solar rotation.

New Examples of Capture in the Three-Body Problem, V. M. Alekseev, pp. 565–572.

New examples are given of "capture" phenomena in the problem of three mass points moving under mutual Newtonian attraction. Purely qualitative methods are used, and numerical integration is not employed. The examples are more general than in a reference given and contain the maximum number of free parameters.

Volume 6, Number 5, March-April 1963

Theory of Stellar Shock Waves, I. A. Klimishin, pp. 692–695.

Equations are obtained for the shock adiabatic and the parameter discontinuities (pressure, density, temperature) at a stellar shock wave front, i.e., a wave moving in a gas-radiation mixture. It is shown that the ratio of the gas to total pressure behind the shock front decreases sharply with increasing temperature discontinuity at the wave front. The allowance for energy losses of the wave for increasing the radiative energy density leads to an increase in the density discontinuity and a noticeable decrease in the temperature discontinuity. In particular, for a shock wave moving with a velocity of 1000 km/sec in an envelope of a solar-type star, the temperature which sets in behind the wave front is 18.5 times lower than that derived from the theory of ordinary ("classical") shock waves.

Retardation of Stellar Rotation, V. F. Belevich, pp. 696–698.

The law of constancy of the moment of inertia of stellar rotation is considered. Formulas are obtained for the retardation of rotation of a star due to light and corpuscular radiation.

One Case of Central Motion, N. N. Makeev, pp. 718–720.

A special case of central motion of a mass point with variable mass in a very rarefied atmosphere is considered. The resistance of the medium is taken into account. The area integral and the equation of the trajectory are obtained in closed form.

Additional Acceleration in the Motion of Celestial Bodies, R. A. Saakyan, pp. 721–725.

It is shown that additional acceleration appears in the equation for relative motion due to the curvilinear motion of the center of gravity of a binary system. It is expressed by

$$S = 2\left[\frac{d\bar{r}}{dt}\,\bar{\omega}\right] + [\bar{\omega}[\bar{r}\bar{\omega}]] + \left[\bar{r}\,\frac{d\bar{\omega}}{dt}\right]$$

where dr/dt is the angular velocity of motion of the center of gravity, $\bar{\omega}$ is the velocity of relative motion in the rotating system, r is the distance between the components, and [ ] is the vector product.

Until now several problems in astronomy have been solved without allowing for the foregoing acceleration. These include problems on the relaxation of stellar systems and relative motion in binary systems (the motion of planets relative to the sun, tidal phenomena on the earth, etc.). In more precise solutions it is necessary to take the circumstances mentioned into account.