Instruments FOR CONTROL AND AUTOMATIC REGULATION

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Translation

Various instruments for control and automatic regulation of technological processes which were developed and utilized by the food industry can also be used in other industries. These instruments were designed by "TsNIIKIP" (Central Sci. Res. Lab. for Testing & Measuring Inst.) and are being serially produced by the Moscow Experimental Factory for Control-Measuring Instruments (MosKip).

POTENTIOMETERS

Type P-4

Type P-4 potentiometer is used in laboratory work, ~~it is used~~ for determining pH values in acid and alkali solutions from 0 to 13.

Its error, at an ambient temperature of 15-25° and relative humidity of 40-60%, does not exceed ± 1 millivolt, which corresponds to 0.02 pH.

The potentiometer operates on the principle of a difference in potential which depends on the concentration of hydrogen ions on electrodes submerged in the test solution. The balance point ~~of compensation~~ is indicated ~~characterized~~ by the absence of current in the measuring circuit, as shown ~~indicated~~ on a ~~the~~ zero-galvanometer.

The potentiometer's electric system ~~circuit~~ (fig. 1) consists of an adjustment circuit and a measuring circuit.

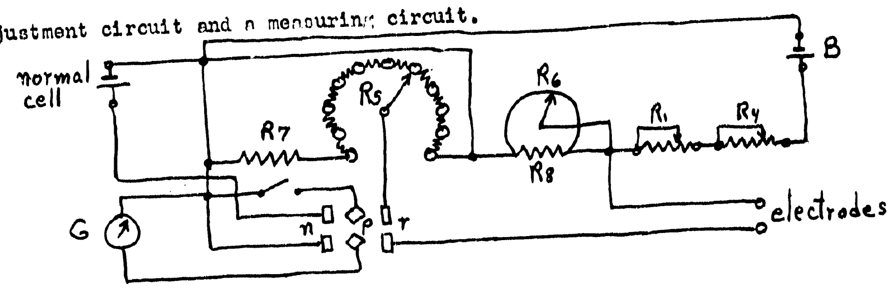

Fig. 1. Electrical Circuit for the P-4 Potentiometer

In the adjustment circuit, the emf of the dry cell B exceeds up to 2 volts the emf of ~~the~~ a standard Weston cell. This excess emf in the battery is reduced by two parallel resistances R_6 (rheochord ~~"reokhord"~~) and R_8 (calibrated shunt resistance) and on rheostats with rough (R_1) and smooth (R_4) adjustments. With the aid of these rheostats, it is possible to balance out both emf's disclosed by absence of a deflection of the galvanometer needle when button (K) is pressed. In the measuring circuit, part of the emf of dry cell B, previously adjusted against the standard cell, is set off against the measured emf. By regulating the resistances of rheostat-switch R_5 until the voltage drop equals 1000 millivolts, and the rheochord R_6 until the voltage drop equals 100 millivolts, the balance point ~~of compensation~~ is obtained.

The scale of the instrument is graduated in millivolts--one division of the rheochord's scale equals 1 millivolt.

The P-4 potentiometer includes: a third-class standard Weston cell; a type GMP galvanometer, sensitivity $1^\circ \cong 1 \times 10^{-6}$ amp, ~~type GMP~~; a set of uncharged electrodes, consisting of a glass electrode container, calomel and platinum electrodes, and four connecting wires.

Charts are provided for converting the potentiometer readings from millivolts into pH values and with further provision for temperature corrections of the test solution.

Type P-5

The Moskip Factory also manufactures a type P-5 potentiometer (pH-meter), intended for direct use in production. The P-5 potentiometer (constructed by N. A. Shibko) consists of a standard cell, battery, and galvanometer mounted in a case 263 x 180 x 118 mm, with additional space for the electrode equipment and connecting cords.

The P-5 instrument permits direct readings on the same scale either in pH units (from 0 to 13 pH) or in millivolts. The total error for the equipment is ± 5 millivolt, which corresponds to 0.1 pH. The potentiometer permits automatic temperature correction for each reading.

The electrical circuit of the P-5 potentiometer (Fig. 2 and 3) consists of ~~five~~ four independent sections: 1) for adjusting the instrument against a standard cell; 2) for measuring pH with a quinhydrone electrode; 3) for measuring pH with an antimony electrode; 4) for measuring in millivolts.

The circuit switching is accomplished by two type I switches.

The electric system of the instrument includes the following apparatus:

1) standard cell;

2) zero galvanometer G;

3) switch type I, No 2, to switch the potentiometer circuit for adjusting against the standard cell, and placing ~~it~~ the instrument into operation.

4) push button K for switching the zero galvanometer into the measuring circuit;

5) switch type I, No 1, which permits the instrument to measure pH solutions with antimony or quinhydrone electrodes, or to give readings in millivolts;

6) rheostats of rough (R_1) and smooth (R_2) adjustment, to be used for adjusting the potentiometer circuit against the standard cell;

7) rheostat R_3, for making temperature connections;

8) rheostat R_4, pH corrector for the antimony electrode, intended for applying the correction of the constant for the antimony-calomel circuit to the pH scale;

9) rheostat R_5, rheochord, for balancing out the difference in potentials between the instrument and the measured emf;

10) matching resistances R_6, R_7, R_8, and R_9 for regulating the circuits of the instrument;

11) carbon resistance R_{10} in circuit of standard cell, to protect the standard cell from damage during switching.

The instrument ~~has~~ An antimony electrode is enclosed with

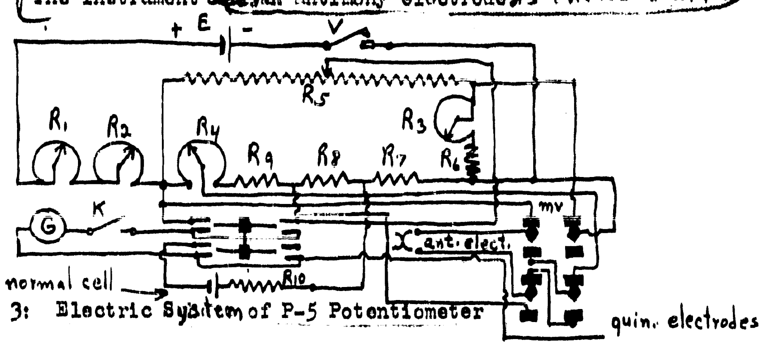

Fig. 3: Electric System of P-5 Potentiometer

The possibility of determining acidity an alkalinity with this instrument, directly in pH values, using an antimony electrode, is an extremely important advantage over other types for the following reasons: a) an antimony electrode makes possible the determination of pH within the range of 0 - 13; b) it replaces expensive platinum electrodes; c) the procedure does not require addition of quinhydrone, hydrogen, or any other substance into the test solution; d) it can be utilized for determining pH in those solutions in which a platinum electrode is subjected to "poisoning", and e) it possesses great durability in contrast to platinum.

Glass electrodes are used in cases where measuring pH values with platinum (quinhydrone) and antimony electrodes is impossible, due to their poisoning by the analyzed being medium, ~~and~~ also where it is necessary to perform exact measurements in media with high resistance in current carrying solutions.

Type LP-3

Vacuum tube potentiometers of type LP-3 with glass electrodes (by N. A. Shibko) operate with a 0.00002 ma. current in the electrode circuit, thus preventing electrode polarization. A two-tube DC amplifier, with a directly heated pentode, and a triode, amplify the current.

The vacuum tube potentiometer is a universal device which makes it possible to perform measurements of pH values in all solutions with glass, antimony, platinum, hydrogen and quinhydrone electrodes. Measurements are ~~made~~ read on the same scale in millivolts as well as directly in pH values, with automatic temperature correction for the test solution.

The vacuum tube potentiometer, during measurements from 0 to 1300 millivolts for from 0 to 13 pH, gives a maximum error of ± 0.1 pH, while errors for readings up to 8 pH do not exceed 0.03 pH.

The electrical circuit of the LP-3 is composed of a potentiometer section and a tube amplifier (Fig. 4).

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Fig. 4 Electrical Circuit for LP-3 Potentiometer.

The potentiometer part consists of adjust~~ment~~ing circuits for balancing ~~against~~ the standard cell, and measuring~~s~~ circuits for three types of measurements of hydrogen-ion concentration: in + millivolts, in — millivolts, and in pH.

The switching over for measuring is done by switch I_1; the switching for adjust~~ment~~ing against the standard cell, and for operating and disconnecting the system, by switch I_2.

During the adjustments, in all three cases, the voltage of a dry cell (1.5 volts) is set against the voltage of a standard cell. The excess voltage of the cell is balanced out by rheostat R_1, resist~~ances~~ors GR, R_2 and PL (smooth), and ~~constant~~ fixed resist~~ances~~ors. Complete balance of ~~both~~ the voltages is thus obtained. This is disclosed by the absence of a deflection of the galvanometer connected in the potentiometer circuit through the amplifier.

Button K is in a free position during adjustments and permanently connects the galvanometer, through the instrument ~~housing~~ frame, to the potentiometer circuit.

During voltage measurements across the electrodes Kl and St, the voltage of the dry cell ~~to the standard cell~~, previously adjusted to the standard cell, is set aginst the electrode voltage. Regulating the value of rheochord R_3, a balance is achieved if the galvanometer remains at zero when button K is pressed.

In measuring pH values, rheostats are used for temperature compensation and corrector R_2 for asymmetry of the glass electrodes.

The remaining resist~~ances~~ors of the potentiometer circuit are ~~constant~~ fixed.

A 3 volt battery of type 3-S1-30 supplies the ~~tube~~ amplifier, a 15 volt battery is the filament supply, while 22 volt and 16 volt batteries supply the plate voltages. Rheostat R_7 (rough and smooth adjustment) sets the grid bias on the pentode grid for the purpose of zeroing the galvanometer.

The instrument is supplied with calomel electrodes for large and small volumes in pairs with platinum and glass electrodes, and also with combined electrodes which contain glass and calomel electrodes for small volumes. The electrodes are clamped in special holders which are placed in a side compartment of the case. The thickness of the glass electrode bulbs is 0.03-0.05 mm, which requires special care in using them.

"DIEL'KOMETERS"

The ~~Moscow~~ Moskip Factory manufactures electical dielkometer instruments for rapid measur~~ing~~ment of moisture content which operate on the principle of the large differences between dielectric coefficients of dry substances and water.

The moisture content of a substance is determined indirectly by measuring the capacitance of a condenser whose dielectric is the substance.

Hygrometer VM-2

Hygrometer VM-2 (Fig. 5) is used for determining the moisture content of free-flowing, but not powdery, food products (groats, grain) not containing salts and electrolytes in the range 5-15%.

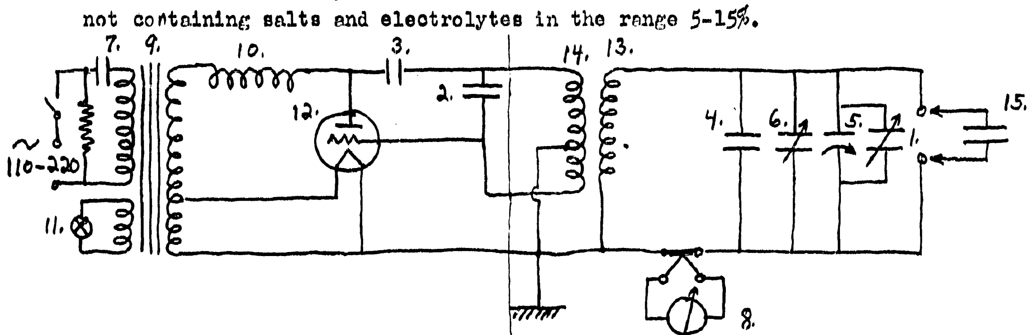

Fig. 5. Electrical Circuit for Hygrometer VM-2 (OMI): 1 – compensating C, 2 – C for oscillator circuit, 3 – isolating C, 4 – supplementary C with trimmer 5, 6 – measuring C, 7 – stabilizer C, 8 – hot-wire milliammeter, 9 – stabilizer transformer, 10 – choke, 11 – indicator lamp, 12 – YO-186 tube, 13 – measuring circuit coil, 14 – oscillator circuit coil, 15 – condenser-transmitter.

The maximum error of the measurements do not exceed ± 1% in comparison with the moisture content determined by the method of drying to a constant weight.

The instrument consists of a high frequency oscillator, supplied by a 110 or 220 volt circuit through a stabilizer, and an inductively-coupled resonant receiving circuit.

~~The instrument~~ It is assembled on an ebonite panel placed in a wooden box (Fig. 6).

At the right side of the box there are two compartments, one for the transmitting element, and the second for the cords with prongs.

In the upper left corner of the panel there is a metallic grid protecting the tube container. A tumbler switch is located below the grid for disconnecting the circuit and the lens of the indicator lamp.

A cord is attached to the instrument, with two plugs for connecting it to the power network.

The condenser-transmitter consists of two concentrically-placed cylinders whose intervening gap is the working space of the condenser. Both cylinders are held by insulated mountings, and each one is connected to a shaft through which the condenser-transmitter is brought into the circuit.

The determination of the moisture content of any substance requires the prior construction of a calibrated curve obtained from ~~by determining the~~ readings of the instrument for several samples whose moisture content is known beforehand.

Hygrometer VM-3

Hygrometer VM-3 (designed by S. A. Tsvetnov) is also used for measuring the moisture content of free-flowing substances in the limits 5-25% moisture content with an accuracy of ± 0.5%.

This apparatus (Fig. 7) operates on the principle of voltage resonance, using half of the resonance curve. It has a voltage stabilizer which eliminates voltage fluctuations in the 100-240 volt range.

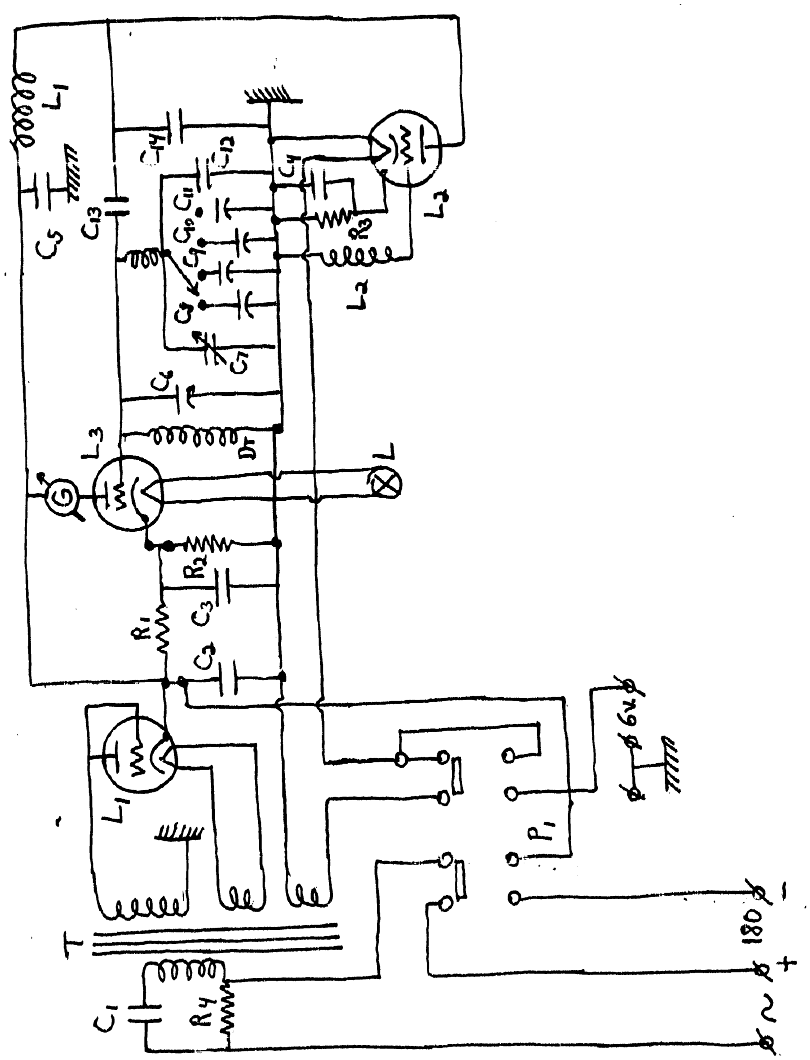

Fig. 7 Electrical Circuit for Hygrometer VM-3

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In order to increase the accuracy of the readings and to obtain the same sensitivity for all points on the scale, the total range is divided into 3 parts.

The instrument is supplied from a 110-220 volt AC source through transformer T. The voltage on the secondary winding is rectified by a kenotron rectifier using a 6C5 tube. In the event that batteries are used, the transformer is excluded from the circuit.

The system utilizes a self-excited BFO (beat frequency oscillator) ~~The heterodyne is achieved by a self-excited circuit~~ with a 6C5 triode; coils L_1 and L_2, inductively coupled, comprise ~~a~~ plate--grid oscillator circuit.

Resistor R_3 creates a negative bias on the tube grid. Condenser C_4 short-circuits the tube to the chassis for high frequencies. Condenser C_5 filters out the high frequency from the plate supply circuit.

The high frequency voltage taken off the plate of the oscillator is applied to the measuring circuit which is designed on the principle of voltage resonance.

The measuring circuit consists of an inductance L_3 connected in series and the following elements connected in parallel: condenser-transmitter C_{12}, condenser C_7, calibrating condenser C_8, and the condensers which set the measuring range, C_9, C_{10}, and C_{11}.

~~The coupling of~~ The measuring circuit and the beat frequency oscillator ~~heterodyne circuit~~ are coupled through ~~is achieved by~~ C_{13}.

Condenser C_{14} shunts the BFO ~~heterodyne~~ output.

The measuring circuit is adjusted to a frequency close to the beat ~~heterodyne~~ frequency in such a manner that, during changes in capacitance of the condenser-transmitter when filled up with the tested substance,

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the voltage in the circuit changes along a linear portion of the resonance curve.

The voltage from this circuit is applied to the grid of the vacuum tube voltmeter, which also uses a 6C5 tube. Coil Dr is the leakage path; condenser C_6 is the high frequency shunt for the voltmeter.

In order to minimize the effect of the supply voltage on the instrument's operation, a feedback circuit is used in the voltmeter. It consists of resistances R_1, R_2, and condenser C_3.

When the instrument is switched on, the BFO generates a voltage in the measuring circuit with an amplitude which increases as the natural frequency of the circuit approaches the frequency generated.

The voltage from this circuit is applied to the grid of the voltmeter. On this same grid a negative bias is applied through resistor R_2 which cuts off the tube.

The voltage taken from the measuring circuit when the condenser-transmitter is empty is insufficient to cause the tube to conduct; therefore the plate current is zero.

With an increase in the capacitance of the transmitter, the natural frequency of the circuit will be closer to resonance, and the voltage of the circuit will now be large enough to cause a current to appear in the plate circuit. This current will increase as the frequency of the circuit approaches resonance; i.e. as the capacitance of the transmitter increases.

Since the capacitance of the transmitter is directly proportional to the moisture content of the substance which is placed into it, the moisture content can be measured by the plate current readings.

Hygrometer VM-1

Hygrometer VM-1 is designed for measuring, under laboratory conditions, the moisture content of free-flowing substances in the range 10-19% by their electrical resistance.

The instrument (Fig. 8 and 9) was set up for measuring the moisture content of macaroni products.

In units of electrical resistance, the instrument's range is from 1500 ohms to 15-16 megohms. It can be used for determining the moisture content of various free-flowing substances which have a well-defined relationship between their electrical resistance and moisture content.

~~The characteristic feature of~~ The instrument operates by admitting the test substance through a gap (0.5 to 2-3 mm.) between two metallic rollers and ~~subsequent~~ measuring the resistance of this material which is crushed and pressed by them. In this way, the reading of the instrument is independent of the granular composition or weighted portion used.

The resistance of the material between the rollers is measured by an ohmmeter with d.c. supply, which indicates the resistance values on a galvanometer scale.

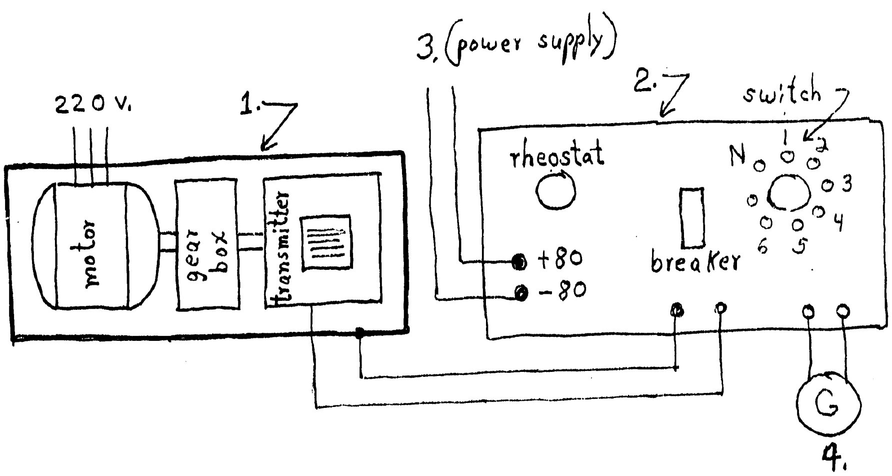

Fig. 8. Circuit for Hygrometer VM-1

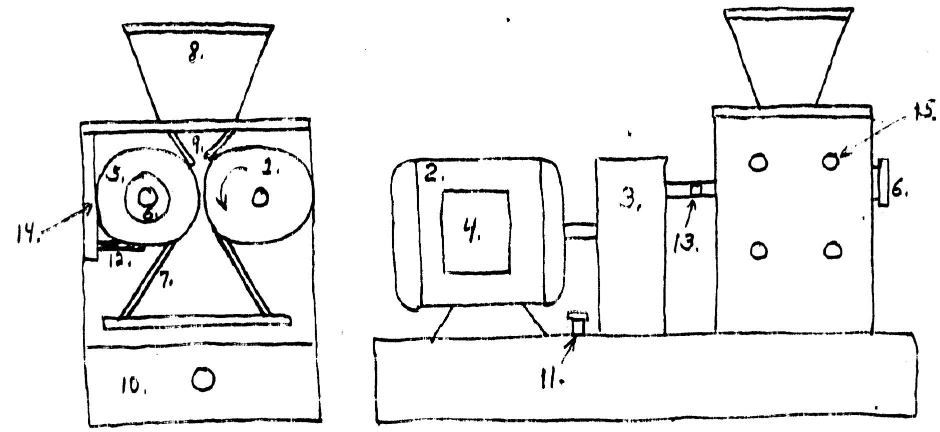

Fig. 9. Transmitter System of Hygrometer VM-1

The hygrometer (Fig. 8) is composed of a transmitting element with rollers 1, electrical measuring instrument 2, power source 3, galvanometer 4 and connecting cords, 6

The transmitter (Fig. 9) is assembled on a cast iron base. The right roll 1 of the transmitter is driven by the electric motor 2 (whose power is not less than 0.25 Kw.) through reduction gears 3.

The reduction unit consists of 3 pairs of cylindrical gears. The shaft rotation is 30-32 rpm.

The motor is started and stopped by buttons of switch 4 with two mechanical interlocking contacts. Pressing the large button switches on the electric motor, while the small button cuts it off.

The second roller 5 is a driven one.

The rollers have grooved surfaces and are equal in size. During measurements, the drive roller revolves CCW while the driven one rotates in the opposit direction. The two rollers are coupled by means of the tested material. If the driven roller does not rotate due to poor cohesion, it is necessary to turn it over by hand. For this purpose the roller is supplied with a handle 6 made of insulated material. Scrapers 7 are located under the rollers for cleaning their surfaces from the adhering material.

The material to be tested is poured into the transmitter's hopper 9 through the wooden inlet hopper 8, which can be removed during the test, and then passes through slit openings into the gap between the rollers. The mashed material passing between the rollers is deposited in wooden drawer 10. Hopper 9 and the upper and side frames of the transmitter are ~~prepared~~ made from organic glass (acrylite) which makes it possible to observe the roller surfaces.

For supplying current, the drive roller is connected to the frame ~~(body)~~ and is placed into the measuring circuit through terminal 11 on the base. The second roller is insulated from the frame by ~~the~~ supports 12, and the current is carried through rubbing contacts to terminal 13.

The gap between the cylinders is determined by strip 14; in order to change it, the 4 bolts (15) must be unscrewed. The instrument is produced with a gap adjustable from 0.60 to 0.65 mm; however, it may be enlarged to 2-3 mm.

The electrical resistance of the material passing through the rollers of the transmitter changes in relation to the moisture content of the material within a wide range--from a few thousand to several million ohms. Therefore, a multiple-step galvanometer shunt is used which makes it possible to divide the range into a number of parts, each of which corresponds to a definite moisture content interval.

Since the instrument's reading depends on the constancy of the applied voltage, provision is made for regulating the voltage with a rheostat ~~the voltage used~~ before making ~~any~~ measurements. For this purpose, the switch is placed in position N (see Fig. 8), but in place of the transmitter resistor, a standard resistor is inserted.

The galvanometer needle is set on a definite division, and this position of the rheostat must be the same during subsequent measurements.

The indication of moisture content is given by a suspended needle galvenometer with a 0-100 scale, each division equivalent to $0.2 - 0.4 \times 10^{-6}$ amps.

The supply source for the measuring part of the instrument is a plate dry battery located outside the equipment. The normal supply voltage is 85-90 volts.

The instrument can be supplied from one 90-volt battery (BAS-90), in which case the voltage can be reduced to the proper value with a rheostat while the switch is in the N-position.

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FLUOROMETER VF-1

Fluorometer VF-1 (Fig. 10), now being produced, is a special instrument for determining the intensity of fluorescent radiation.

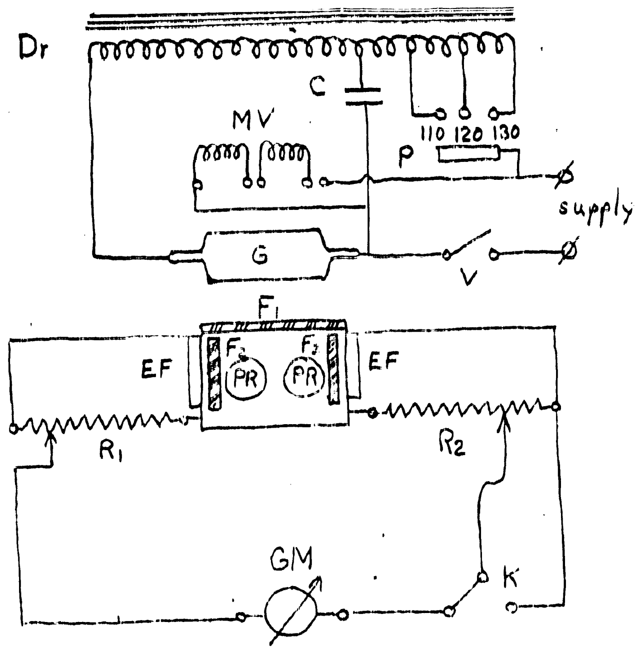

Fig. 10. Principle circuit diagram for fluorometer VF-1: G - light source PRK-4; Dr - coil EMA; C - condenser (0.1 mfd.); MV - blower; P - switch; V - ~~cutout switch~~ breaker; F_1 and F_2 - light filters; PR - vessels; EF - photocells; R_1 - adjusting rheostat; R_2 - rheochord; K - adjusting button; GM - zero galvanometer.

Its principle of operation is based on the measurement of the intensity of fluorescent radiation originating in a liquid medium containing vitamin B_1 or B_2 when it is exposed to a quartz lamp.

The fluorescence of the material being analyzed is found to be in functional relationship ~~with~~ to the concentration of the fluorescent substances.

As can be seen from the diagram, 2 selenium photocells EF transform light energy, i.e. the light radiated by the tested and standard solutions, into electrical energy.

Against this measured emf there is established an equal and opposing emf adjusted by the instrument. The moment of balance is determined by the absence of current in a very sensitive ($1° \approx 0.65 \times 10^{-9}$ amp.) mirror galvanometer. The number of divisions on the disk of rheochord R_2 characterizes the illumination intensity and concentration of the analyzed substance in the solution.

The use of a balancing circuit permits operation without requiring stabilization of the supply voltage for the irradiation source (quartz lamp), since changes in the supply voltage are reflected to an equal extent in both photocells which have the same spectral and integral sensitivity.

Coil Dr has considerable inductive reactance which assures a constant average current and voltage for the quartz light source. Taps on the coil make it possible to use the light source on 220, 127 and 110 volts.

The fluorometer can detect concentrations of vitamins B_1 and B_2 from 0.03 gamma with an accuracy within 0.04% of the actual vitamin content in the medium being analyzed.

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