A SUMMING TWO-CHANNEL STRAIN-GAUGE DEVICE FOR MASS MEASUREMENT

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Various leverless weighing systems are widely used in industry, as they work reliably under considerable dynamic loading and are readily incorporated in automatic control systems. Systems employing wire strain gauges are the most widely used, but not all plants employ them, since this would necessitate machine modification without interrupting the flow of production, which is not always possible. It is desirable to replace existing beam systems with leverless ones in such cases. The automation laboratory at the Chemical Machines Research Institute has performed this replacement without major cost at various plants owned by the Ministry of Chemical and Petroleum Machine Production. Long experience with these devices has shown them to be very reliable.

As several components may have to be weighed successively on one weigher (e.g., materials for casting compositions), we developed a summing two-scale strain-gauge system. The first scale, 0-500 kg, is intended for weighing individual components, while the 0-3000 kg scale is used for summing the masses.

The two-range system greatly facilitates operation and tends to reduce subjective errors; it also improves the accuracy by a factor 1.5-2 for the components and allows each component to be measured from zero, which is a major advantage over a single-range system.

The parts are as follows: strain gauges, secondary instrument (electronic potentiometer), and coupling links. The load acts on an elastic element, which alters the resistance of the gauges and so produces an output proportional to the load within the accuracy of the gauges.

Type S gauges are used, which are meant for long-term use under dusty humid conditions in the presence of vibration. These retain their characteristics between -30 and +50°C at relative humidities between 30 and 80%. There is no loss of accuracy if a 50-Hz supply is used.

The secondary instrument uses a balancing circuit (the bridge voltage is compared with a standard voltage), and the difference is amplified by a phase-sensitive amplifier, which controls the balancing system.

This is an analog device and can use automatic potentiometers such as the EPV-2, EPD, EPP-09, PPR4, etc. Standard electronic potentiometers make this a relatively cheap design. Flexible screened cables link the strain gauges to the secondary instruments.

Figure 1 shows the block diagram, in which 1 denotes elements in range 1 and 2 those in range 2. Elements common to both ranges have neither figure.

Figure 2 shows the theoretical circuit. The strain gauges 1T-4T are fed from the secondaries of transformer Tr, as well as the zero-set systems ZS1 and ZS2, the balancing circuits SB1 and SB2, and the control circuits.

Phase shifts are balanced out by an RC network (resistor Rp and capacitor Cp). ZS1 (ZS2) uses $R_0$ ($R_4$) with $R_2$ ($R_3$) and $R_{11}$ ($R_{12}$) to compensate for the mass of the pan or any zero drift that may occur on prolonged use.

SB1 (SB2) uses a bridge formed by $R_1$ ($R_3$), $R_C$ ($R_D$), and $R_0$ ($R_4$), $R_I$ ($R_I$), and $R_s$ ($R_s$) (slidewires). $R_d$ ($R_d$) sets the working current, while $R_{SC}$ ($R'_SC$) and $r_{SC}$ ($r'_{SC}$) set the scale.

The amplifier A works into the motors M1 and M2. The amplifier is taken from one of these potentiometers, less the chopper, standard cell, supply battery, and input filter, since this system works only in ac.
Fig. 1. P) Part to be weighed; SG) strain-gauge unit; ZS1 and ZS2) zero-set devices for the two ranges; SB1 and SB2) signal-balance systems; M1 and M2) motors driving needles and balancing resistors; S) switching unit; I1 and I2) mass indicators; A) amplifier.

The nominal gain of the amplifier is set for the first range. Resistor $R_3$ (10-30 Ω) is connected in parallel with the input via the normally open contacts 2RP2 to prevent change on the other range.

The control circuit consists of the rectifier PPD, filter capacitor C, the dc relays 1RP and 2RP, pushbuttons K and KC, and signal lamps 1LS and 2LS. The control circuits have to be supplied by dc because 1RP and 2RP were type RMUG miniature sealed relays, which work only on dc.

Relay 2RP operates when the circuit is switched on. The normally-open contacts 2RP1 and 2RP2 connect the measuring circuit for the second range to the amplifier, while the normally-closed 2RP3 disconnects the circuit for the first range. If the needle for the first range is not at zero at that instant, M1 is activated via normally closed 1RP4 to drive it to the zero position. The rate of return is adjusted via $R_4$. 

Fig. 2