Any bending of the sample will turn levers 7 through unequal angles, thus causing a rotation of rocker 8, automatically eliminating the effect of bending, and making the indicator read the deformation of the sample axis. Rocker 8 at one end rests on balls 14 and 15, and at the other on ball 16.

The ball at the end of the measuring stem is replaced by a flat cap which rests against ball 17 pressed into the midpoint of the averaging rocker. This change is made in order to keep the magnification factor of the instrument constant for changing turning angles of levers 7 produced by large deformations of the sample.

The upper and lower holders should be separated from each other after the strain gauge has been secured to the sample. For this purpose locknuts 18 are unscrewed a few turns and rods 3 screwed out of the upper holder and left suspended on the lower holder by nuts 18.

**Valve-Type Transducer for Indicating Pumping Strokes of an Internal Combustion Engine**

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In order to trace pumping strokes of a supercharged engine with counterpressure at its output by means of an electropneumatic indicator we used a valve-type transducer (Fig. 1) characterized by its great reliability as compared with the frequently used diaphragm transducers.

Valve-guide 2 insulated by textolite bushings 8 and 9 is fitted in casing 1 which has thread M18 × 1.5 at its lower end for connecting to an indicator channel and a water-cooled jacket 12. Stainless steel valve 4 (diameter 9 mm, mass 1 - 1.5 g) is provided with a reliable electrical contact with a guide by means of helical brass conductors 6 (0.1 - 0.15 mm wire). One of its ends is hard-soldered to the valve and the other soft-soldered to the upper part of guide 2. The lower 3 and upper 5 seats of the valve and distance bushing 7 are made of stainless steel.

The effective stroke of the valve (0.08 - 0.1 mm) is set by selecting a distance ring 13 of the required thickness. All the separate parts of the transducer are braced together by coupling nut 10 whose connecting tube serves to feed the air from the pneumatic system of the indicator.

The current is taken off the valve guide through collector 11. The transducer cavity is sealed by careful grinding of the faces of the casing bottom, of the upper and lower valve seats, and of the distance ring and bushing. These joints should provide hermetic sealing of the cavity at a pressure of 100 kg/cm².

The main advantages of this valve transducer consists of: its small size, making it suitable for use in any place; the location of the valve directly at the lower end of the casing; the use of stainless steel for making the lower and upper valve seats; reliable connection of the valve to the conductor; constant static calibration; and the possibility of obtaining diagrams without an indicator tap by mounting the transducer valve directly on the surface of the combustion chamber.

The transducer operates reliably for 4 - 5 h even under boosted operation conditions of the engine.

The indicator diagrams obtained by means of this transducer, with its sensing element placed at the surface of the combustion chamber, are free of errors due to the finite speed of pressure propagation in the indicator channel. Indicator diagrams obtained by means of long channels have a lag with respect to the upper dead-center mark. The delay time amounts to

\[ \tau = \frac{t}{W}, \]  

(1)
where $l$ is the length of the indicator channel, $m$, $W$ is the speed of air in the given medium, m/sec.

$$W = \sqrt{\frac{kgRT}{g}}.$$  

\[ (2) \]

where $k$ is the adiabatic index of the given gas; $R$ is the characteristic gas constant of the given gas, kg·m/kg·deg; $T$ is the gas temperature in the channel at the given instant, °K; $g = 9.81$ is the acceleration due to gravity, m/sec$^2$.

It will be seen from (1) that the delay time (for a constant length of the indicator channel) depends on the value of $W$, which in turn is affected mainly by temperature (throughout the cycle the temperature varies by a factor 8 - 10). The values of $k$ and $R$ depend on the gas composition, which varies during the cycle, but to a smaller extent than $T$. Since the value of $T$ varies throughout the operating cycle, each point on the indicator diagram is displaced by a different amount. It is therefore very difficult to correct the displacement of the indicator diagram due to the presence of an indicator channel.

The diagrams were recorded by means of a manometric device of the electropneumatic indicator MAI-2.

The electronic pulse generator ($f = 30$ kc) developed by the V. I. Lenin Khar'kov Polytechnical Institute was used to obtain high-tension pulses in the electric system of the indicator.

The main advantage of an electronic pulse generator as compared to a thyratron high-tension pulse generator consists of its higher speed of operation (higher by a factor of 100).

The high-tension pulse generator comprises the following units (Fig. 2):

1) a half-wave kenotron 5Ts4 rectifier and RC-filter providing a 700-V dc voltage;
2) master oscillator providing signals at 70 - 100 V and 30 kc;
3) an output power stage providing 12 kV pulses at a repetition frequency of 100 cps;
4) a 100 cps saw-tooth relaxation oscillator for blocking the output power stage.

The high-tension pulse generator operates in the following manner. In passing from one seat to the other the transducer valve disconnects the control circuit of the high-tension pulse generator, thus unblocking the control grid of the output power tube 1. At this instant the recording mechanism of the indicator sparks over, puncturing the indicator chart paper. When the transducer valve makes contact with one of its seats the grid of the output tube is grounded and the generation of the high voltage stops. Tube 1 is fed with a 30 kc voltage from the master oscillator which consists of tube 2 and transformer 3 (line transformer from television set "Rubin"-102). A relaxation oscillator which blocks the output tube periodically at the rate of 100 cps is provided in the circuit in order to prevent the chart from catching fire. The relaxation oscillator consists of an RC network and neon tube 5.