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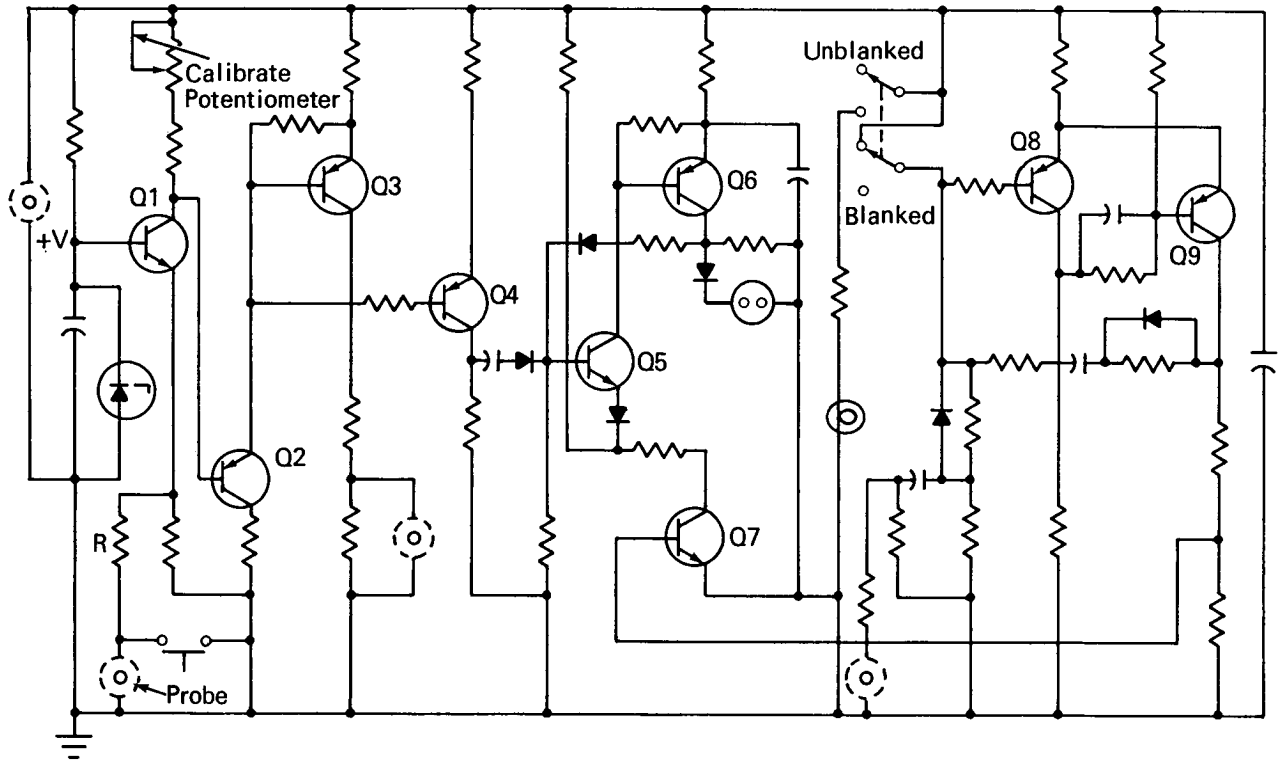
Electrical Instrument Measures Position and Velocity of Shock Waves

The problem:

To design a miniature, rugged instrument for measuring the position and velocity of compression and rarefaction waves in shock tubes. The instrument should have a rise time on the order of 1 microsecond and should produce a strong, noise-free signal that can be interpreted without ambiguity.



The solution:

An instrument employing a sensor consisting of a twin-electrode probe mounted in the wall of a shock tube, with a small dc voltage impressed across the electrodes. A simple power supply, amplifier, and gate pulse generator complete the system. The output is a sensitive microsecond response to changes in the electrical impedance of the gas stream flowing across the sensor. The instrument is suitable for any type of shock tube apparatus operating at shock speeds ranging from Mach 6 to 20 or greater in air. It provides data for the construction of wave diagrams, as well as a measurement of shock velocity.

(continued overleaf)

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How it's done:

The electronics system incorporates an amplifier section, a pulse-generating section, and a blanking section. The sensing electrodes in the probe consist of two small alloy (glass-sealing) rods sealed in glass within a tube of the same alloy. The probe is mounted in a shock tube port, with the tips of the electrodes flush with the inner tube wall.

The amplifier, conposed of Q1, Q2, Q3, and Q4, has a bandwidth extending from dc to approximately 3 MHz, and provides a voltage output that varies with the electrical impedance between the probe electrodes.

The open-circuit voltage between the probe electrodes is typically 11.5 volts, and is applied in series with a 500 ohm resistor R. When the probe electrodes are short circuited, the amplifier output signal, which can be varied by the "calibrate" potentiometer, is nominally 5 volts into a 93 ohm external load resistor. With infinite impedance between the probe electrodes, a small dc offset voltage is present at the output of the amplifier (typically 0.2V with a 93 ohm external load), and this is considered as the baseline voltage for all measurements.

The blanking section, consisting of Q7, Q8, and Q9, controls the condition of the pulse generator and prevents pretriggering of the pulse generator by externally generated rf noise. A "blanked-unblanked" switch determines the mode of operation of this section. When the switch is in the unblanked position, the pulse generator can produce an output pulse whenever the probe impedance drops to 10,000 ohms or less. When this switch is in the blanked position, the pulse generator cannot produce an output pulse until an externally generated unblanking pulse is received. The unblanking pulse should be a minimum of +40 volts and should have a duration of approximately 5 to 10 microseconds. After receipt of the unblanking pulse, the generator is ready to function for approximately 30 milliseconds, when it returns to the blanked condition and remains there until another unblanking pulse is received.

The pulse generator section consists of transistors Q5 and Q6. In the unblanked condition, it produces an output pulse of +45 volts, with a rise time of 0.1 microsecond, into a 50 ohm load whenever the probe impedance is reduced at the instant the shock wave reaches the probe. The output pulse is used to stop a counter. Simultaneously and independently, an output voltage inversely proportional to the stream impedance is displayed on an oscilloscope.

Reference:

Dannenberg, R.E.; and Humphry, D.E.: Microsecond Response System for Measuring Shock Arrival by Changes in Stream Electrical Impedance in a Shock Tube. Rev. Sci. Instr., 39, 1692 (1968).

Note:

Requests for further information may be directed to:

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Patent status:

No patent action is contemplated by NASA.

Source: D. E. Humphry and R. E. Dannenberg
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