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DEPARTMENT OF MINES AND
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by

J. D. KEYS AND G. E. ALEXANDER

MINERAL SCIENCES DIVISION

(REPRODUCED FROM ELECTRONICS,
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A GATED OSCILLATOR CIRCUIT FOR THE MEASUREMENT OF SHORT TIME INTERVALS

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J.D. Keys* and G.E. Alexander**

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ABSTRACT

A transistor gate circuit has been developed to control the output from an oscillator which is used to measure time intervals of the order of a few milliseconds in radioactive tracer applications. The cycle is started by an initiating pulse and concluded by a pulse originating in a gated detector, which in this case is a Geiger tube. The effect of background activity is allowed for in the detecting circuit and there is sufficient flexibility to permit use over a wide range of time intervals in the presence of moderate background.

RÉSUMÉ

On a mis au point un circuit de déclenchements à transistors pour commander le signal de sortie d'un oscillateur servant à mesurer des intervalles de temps de l'ordre de quelques millisecondes dans les applications de radioindicateurs. Une impulsion initiale amorce le cycle qui se termine par une impulsion partant d'un appareil de détection à déclenchements, en l'occurrence un tube de compteur Geiger. En matière de circuit de détection on tient compte de l'effet du bruit de fond (background) et l'appareil est assez souple pour qu'on puisse l'utiliser dans une large gamme d'intervalles de temps quand le bruit de fond est modéré.

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Radioactive Tracers Find

Simultaneous gating of oscillator and radiation detector permits recording of flow rate of jet fuel containing radioactive tracer. Reliable transistor circuit can be used for other time-interval measurements

By J. D. KEYS and G. E. ALEXANDER, Department of Mines and Technical Surveys, Ottawa, Ontario, Canada

DURING THE COURSE of investigations using radioactive tracers to measure flow rates of liquids, a circuit was required to measure time intervals of about 25 milliseconds. The particular application involved is the measurement of the rate of flow of fuel to a jet engine. Previous methods used to measure flow rates[1, 2] are considered unsuitable either from the instrumentation point of view, or, in the case of the total-count method, the flow rates encountered are too great.

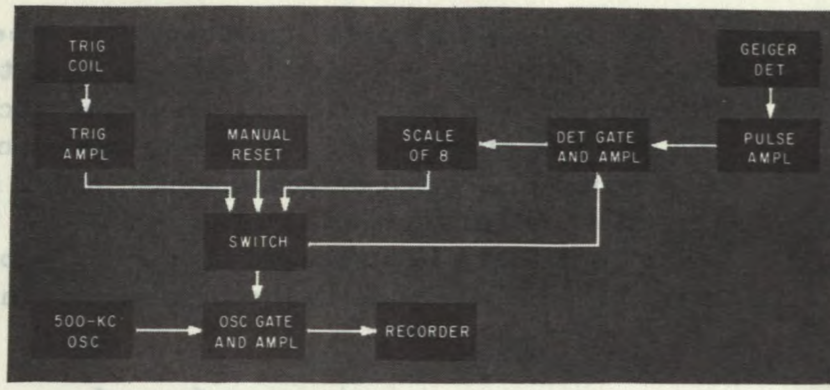

FIG. 1—Switch opens gates for detector and oscillator outputs

The circuit developed for this purpose uses a Geiger tube as the detecting element. A transistor switch circuit is operated by an initiating pulse, and it controls gate circuits for the oscillator and Geiger amplifier circuits.

The first gate permits output from an oscillator to be recorded, and the second gate permits output from the Geiger tube to pass to a scaling circuit. After a predetermined number of pulses, the scaling circuit feeds back its output to the switch circuit to close the two gates. Time interval is derived from the recorder based on the known oscillator frequency.

Operating Principle

A block diagram of the overall circuit is shown in Fig. 1. The operating cycle is initiated by a trigger pulse that is amplified by the trigger amplifier and applied to the switch circuit. The switch circuit performs two simultaneous functions. The first is to open the gate for the crystal-controlled oscillator, permitting oscillator output to be applied to the recorder. The second is to open the gate controlling the detector amplifier, permitting output from the Geiger tube to pass into the scaling circuit, which is of conventional design.[3]

Output from the scaling circuit is fed back to the switch circuit, which closes the two gates previously opened. The time elapsed between the initiating trigger and the closing pulse from the scaling circuit is read out from the recording device. Thus, the time interval depends upon the pulse rate delivered by the Geiger tube, which depends in turn on the fuel flow rate.

The scaling circuit acts as a discriminator against random background. Depending on the time interval to be measured, scales of 2, 4 or 8 may be used to prevent spurious radiation from closing the gates prematurely. When the radioactive tracer passes the detector, the rapidly increased count rate is sufficient to create an output pulse from the last binary stage of the scaler. This output actuates the switch circuit.

A manual reset is incorporated into the circuit for use in applications where the time interval is terminated mechanically rather than by pulses from a Geiger tube.

Switch and Gates

The switch circuit consists of a bistable flip-flop circuit, which is shown in Fig. 2. With the circuit in the ready condition, no current flows to the collector of Q_1, which is at a potential of -5 v. In this state, point A, which is coupled to the detector and oscillator gates, is at -2.6 v. This voltage is sufficient to keep the gates closed. In this case, the gates are closed when Q_3 and Q_5 are conducting and shunting the signals applied to their collectors to the zero line.

The switch is triggered into the opposite state by a negative pulse of at least -2.8 v applied to the collector of Q_1. When transistor Q_1 is

Jet Fuel Flow Rates

conducting, the potential on its collector rises to −0.5 v, and the collector of Q_2 is cut off.

With the switch in this state, the potential at point A falls to −4.8 v. This drop in potential is applied to the bases of gate transistors Q_3 and Q_5, cutting them off.

The circuit remains in this condition until a positive pulse from the scaling circuit is applied to the base of transistor Q_1. This increase in the potential on the base of Q_1 cuts this transistor off again. Collector potential falls to − 5 v and transistor Q_2 again conducts. The drop in collector potential is again coupled to the bases of gate transistors Q_3 and Q_5, causing them to conduct which effectively closes the gates again. Since the scaling circuit gate is closed, pulses from the Geiger tube are shunted through Q_5 and no longer arrive at the scaling circuit. Therefore, the scaling circuit remains in the ready or reset condition.

The switch circuit is very stable and its operation is relatively independent of the pulse shape with one exception. The leading edge of the pulse must be sharp. Some overshoot can be tolerated because a positive pulse appearing on the collector of transistor Q_1 has no effect on the operation of the circuit.

The circuits of the oscillator and detector gates are also shown in Fig. 2. In the ready condition, the base of transistor Q_3 is at a potential of +0.53 v. Because transistor Q_3 is conducting under these conditions, the potential on its collector is zero volts and output from the oscillator remains shunted to the zero line.

When the switch circuit is triggered to its ON state, voltage at the base of Q_3 falls to +0.50 v. This slight drop in base voltage is sufficient to cut Q_3 off. Voltage on the collector of Q_3 rises to +1.8 v, raising voltage on the base of Q_4 to the same level. Therefore, oscillator output appearing at the base of Q_4 is amplified and fed to the recorder.

The pulse transformer in the collector circuit of Q_4 serves two purposes. The first function is to increase the output to the level necessary to actuate the recording instrument, which is a commercial scaling unit with a 1-μs input strip. The second purpose served by the pulse transformer is to provide isolation for the recorder.

The operation of the detector gate is exactly the same as that of the oscillator gate. However, an additional feature is incorporated in the detector gate—the insertion of a 10,000-ohm tapped resistor from the collector of gate transistor Q_5 to the zero line, rather than the fixed resistor used with the oscillator gate. Use of a tapped resistor permits some control over pulse height appearing at the base of detector amplifier Q_6.

Performance

The circuit described has been in operation for several months, both in and out of the laboratory. Its performance has proved to be very reliable. The particular application in connection with measuring flow rates of jet fuel with radioactive tracers is only one of many for which the circuit is suitable.

The contribution of G. G. Eichholz, in the form of many discussions during development of the circuit, is gratefully acknowledged.

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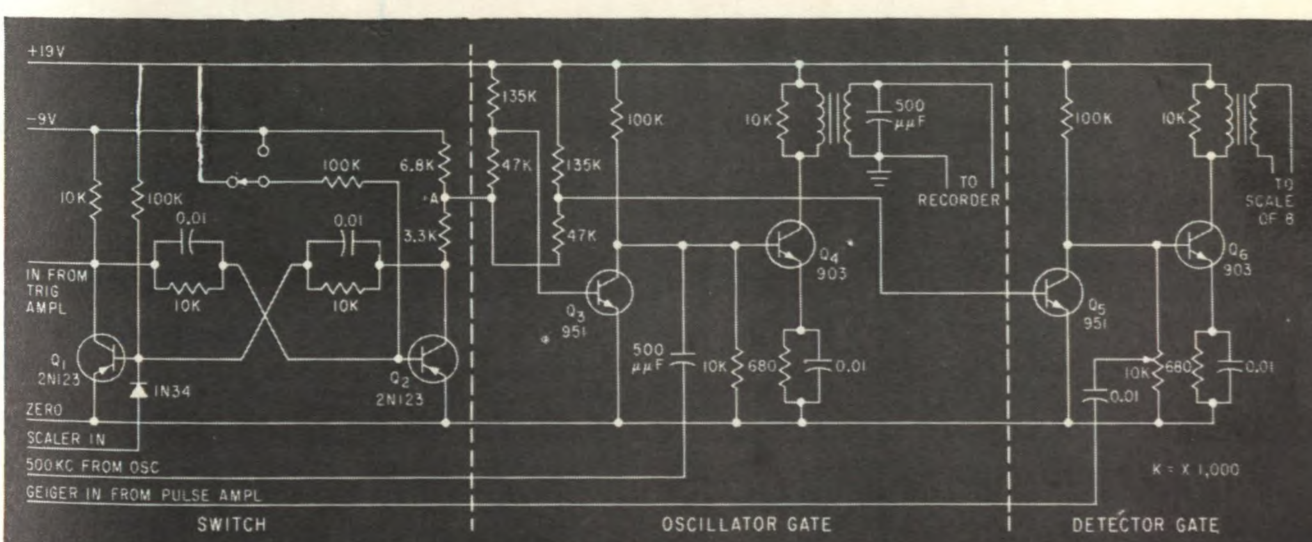

FIG. 2—When multivibrator is switched ON, Q_3 and Q_5 are switched off so that oscillator and Geiger tube inputs are amplified