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APPARATUS NOTES

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Mechanical start-stop gates for air tracks

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A need frequency arises for a simple and reliable switch system which can be used to time an event in the order of 1 sec or so, such as the timing of the motion of a vehicle on an air track. In some experiments, the "time of flight" of the vehicle could be somewhat less than 1 sec, and such a time interval is not easily measured using a manually controlled timer such as a stop watch. Various photogates are available commercially which could perform the same function, but the proposed design, besides being more economical, might even be more convenient in some instances.

The proposed design consists of two identical switches, one for the beginning, and the other for the end, of the event. These switches, in turn, control a relay, which in turn controls whatever timing device is already available in the laboratory. Hence, the proposed system simply provides a nonmanual control of an already existing timing device. In our laboratory, there are a number of motor-driven timers which are activated by shorting two of the available contacts, so that the normally open (NO) relay contacts in the system under discussion are used to control the motor-driven timer.

The relatively novel feature of the system described in this note is that the switches (or gates) require only a negligible amount of force for their operation, thereby introducing no significant retarding acceleration into the vehicle's motion.

Each switch consists of a common metal pin supported by two metal screws in such a way that the pin forms an electrical path between the two screws. The pin is supported by the screws in such a way that it can be easily pushed off, thereby breaking the electrical path between the screws, as shown in Fig. 1. Wires run from each screw to the box containing the appropriate electrical circuit, as shown in Fig. 2. In our design, the screws are imbedded in wooden dowels for mechanical support, but any insulating material should be satisfactory. The two screws of each gate are separated by about 2 cm, so that a pin or sewing needle will reach from one screw to the other. This assembly is positioned over the air track in such a way that a flag on the vehicle will dislodge the pin (or needle) with minimum disturbance to the vehicle's motion.

To understand the operation of the circuit, consider that both the "start" (S_1) and "stop" (S_2) switches are closed;

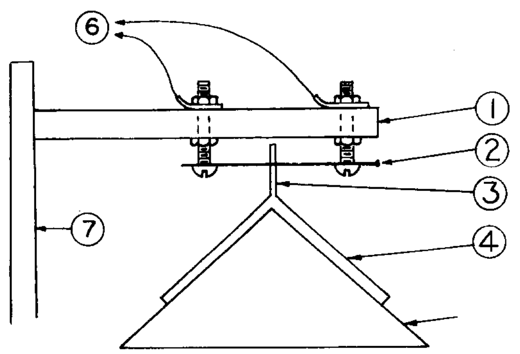

Fig. 1. End view showing air track and a switch: (1) wooden dowel; (2) common pin or piece of wire; (3) "flag" attached to air track vehicle; (4) air track vehicle; (5) air track; (6) wires leading to the box containing the rest of the electrical circuit (see Fig. 2); (7) support stand.

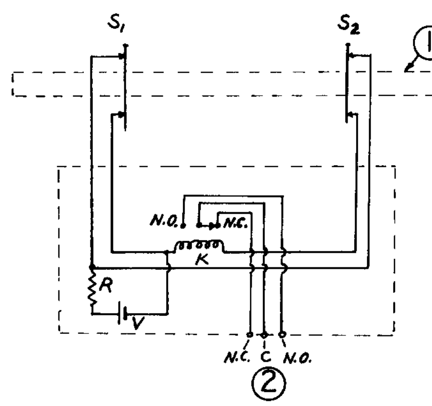

Fig. 2. Electrical circuit, showing pins making contact on switches S_1 and S_2. S_1: start switch; S_2: stop switch; R: current limiting resistor (see text); V: dc power supply to operate the relay K; K: relay, with a relatively short response timer. NO, C, NC signify normally open, common, and normally closed, respectively.

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that is, their contacts are bridged by a piece of metal wire or pin. This means that the relay coil is shorted out by S_1, and consequently that the timer is not running. When the vehicle is released, S_1 opens, removing the short across the relay coil, consequently allowing the timer to run. When the vehicle reaches S_2 and opens it, then the voltage across the relay coil drops to zero, stopping the timer. The value of R is chosen so that the current being delivered by the power supply V while the switches are closed does not exceed the current capacity of the power supply. On the other hand, R must be small enough so that the relay coil can be sufficiently energized during a "run."

In a typical "Fletcher's trolley" experiment, in which the time of flight was in the neighborhood of 1 sec, the difference between the "expected" and "observed" values for the time of flight was less than 5% for any given single run.

A magnetic personality

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We have designed a magnetic induction demonstration that adds some theatrical clout to the conventional one.

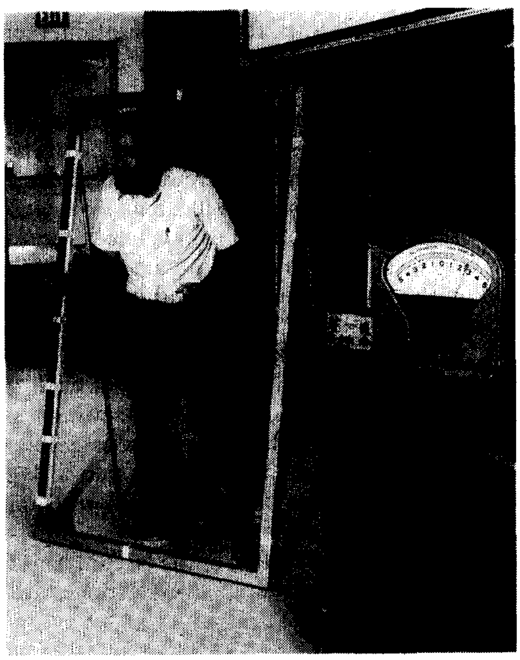

Fig. 1. Author's true personality coming through.

Most of us are familiar with the standard induction demonstration which involves thrusting a hand-held magnet through a multiturned loop of wire connected to a galvanometer. As we all know, the demonstration is not only useful in illustrating induced currents, but also serves to show their dependence on the polarity of the magnet, the angle of the loop and the relative speed of the thrust. Furthermore, alternating currents can be induced with spinning magnets. Mutual induction can be demonstrated by bringing another current loop, carrying a variable current, nearby.

We have simply scaled up this old demonstration. As shown in the photograph of Fig. 1, our "loop" is a 100 × 175-cm rectangular aluminum frame wound with 100 turns of 24 gauge wire. The loop is connected through a current amplifier[1] to a standard demonstration-type galvanometer.[2] Our loop can be used to illustrate the same aspects of the phenomena that the smaller demonstration can illustrate plus one more: the magnetic personality of the instructor. While the teacher can run through the loop, spin inside the loop, lunge back and forth in the loop, or just move by the loop and induce currents, the "average" student cannot. The explanation or model is up to you and your class.

[1]Current Amplifier, Cat. No. 2694, Sargent-Welch Scientific Company, Skokie, Illinois 60076.

[2]Galvanometer Volt-Ammeter, Cat. No. 2692, Sargent-Welch Scientific Company, Skokie, Illinois 60076.

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