

AN AUTOMATIC TRAFFIC SPEED RECORDER*

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The Photo-Velaxometer, an automatic traffic speed recorder, is designed to measure accurately and to record small time intervals, or a sequence of small time intervals. It has been built primarily to measure and record a series of successive time intervals that give an acceleration pattern of an automobile as it progresses along the "speed trap," and to determine "spot speeds."

PRELIMINARY INVESTIGATIONS

Early in April, 1940, definite preliminary steps were taken to develop an economical speed recorder that would give acceleration patterns of successive speed traps, and at the same time measure spot speeds. In the preliminary work, the possibility of photographing the moving hands of a precision clock that was driven by a synchronous motor was investigated. In order to obtain various amounts of light for the experimental photographs, capacitors of various sizes were charged from a constant voltage supply and discharged through a strobotron tube. The discharges were initiated by means of a trigger circuit. The results showed that capacitance values of 10 micro-farads or higher were sufficient to provide adequate light for photographing the moving hands. The clock dial was painted a dull gray-black and the hands were painted white.

DESCRIPTION

The main unit of the apparatus consists of a light-tight box in which are mounted an electric clock of special design, two cold-cathode gas discharge tubes that act as a light source, an electrically-operated counter, and a photoelectric cell. The lens of a 35-millimeter camera is arranged in the light-tight compartment so that the clock face and the counter can be photographed by means of the light produced by a flash of the gas-discharge or strobotron tubes. The 35-millimeter camera is mounted so that it is an integral part of the light-tight compartment. The lens of the camera is projected within the light-tight compartment. The mounting of the camera is rigid, and the camera is so placed that it is in fixed focus. The shutter of the camera is permanently fixed at the F. 4.5 opening. On the outside of the light-tight compartment are mounted eight fast-acting relays, a vibrator-type, high-voltage power

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supply operated from a 12-volt battery, the control apparatus for the gas-discharge tubes, a gas-filled tetrode used in conjunction with the photoelectric cell, a signal bell, and various other circuit components.

On the control panel of the unit are mounted all the necessary control switches, the checking voltmeter, and all the signal lights. Provision is also made on this panel for plugging in the source of voltage used to supply the necessary power for operation of the unit. The power supply consists of three 6-volt storage batteries. These are used as power sources because portability is a factor in the usefulness of the unit.

The auxiliary apparatus consists of eight air-operated electric switches of special design but similar in character to those used by the Public Roads Administration.* These switches are air-compression operated and actuated by the passage of a vehicle across a rubber tube. The switches are connected to the unit by means of two shielded, five-wire, rubber-insulated cables. One wire in each cable serves as a common return for the four switches. Leads, which consist of a common wire and a separate lead wire, are tapped off at one-hundred-foot intervals on each lead cable. These leads are attached to the several switches. Two five-wire cables are attached to their respective receptacles when the Photo-Veloximeter is in operation.

The operation of the apparatus can best be explained by describing the procedure for making an acceleration record of one vehicle.

Pneumatic tubes, with switches and switch cables attached, are placed along the highway at one-hundred-foot intervals. The cables are then attached to the proper receptacles on the panel board of the unit. The several operating switches are thrown to the "on" position to energize the various control circuits. This starts the clock motor, but not the hands of the clock, as they are clutch-operated. However, provision has been made by means of a control switch to permit the hands to rotate continuously while the clock motor is operating. When a car crosses the first tube, road switch No. 1 is closed (see Fig. 1). This in turn causes the first relay (Relay No. 1) to operate. This relay is energized by means of an impulse of energy received from the high-voltage power supply through the road switch. After the relay is energized, it is held in a closed position by the energy supplied from the twelve-volt power supply (Bulletins A and B). It will be noted that the original impulse comes from the high-voltage source, and a momentary impulse of current, provided as the capacitor (C), essentially short circuits the current-limiting resistor for an instant after the road switch is closed.

* "New Techniques in Traffic Behavior Studies," *Public Roads*, Vol. 21, No. 2, April, 1940, pp. 29-45.

When relay No. 1 closes, it causes the clock clutch to be energized. This connects the hands of the clock to the motor, thereby starting the clock in motion. The closing of the relay also provides momentary (make-before-break) contact, which actuates the gas-discharge tubes. These tubes discharge the energy of capacitors (C_2) through themselves, producing an almost instantaneous flash of light. This instantaneous illumination enables the camera to photograph the position of the hands of the clock at the instant of the flash. Relay No. 1 also closes the circuit for the coil of relay No. 2 so that it will be ready for operation before the vehicle closes road switch No. 2. The circuit is arranged in this manner in order that a record

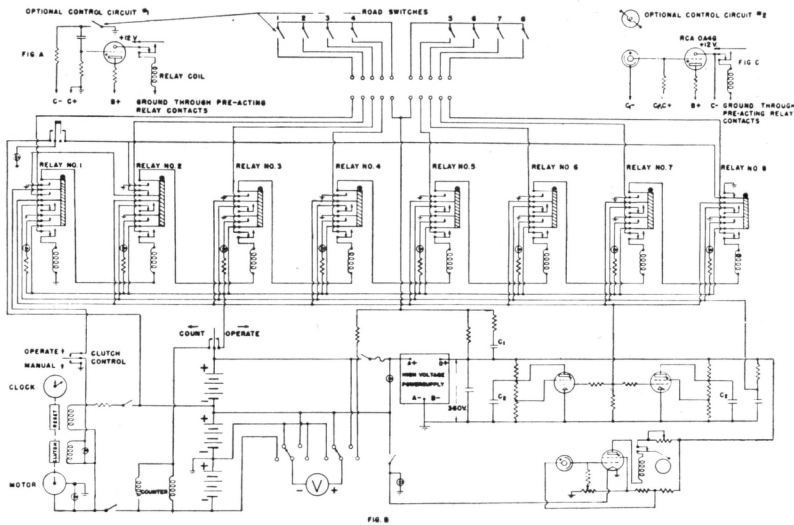


Fig. 1. Photo-Velometer—wiring diagram.

may be made of only one car as it passes through the “speed trap,” even though this car may be preceded or followed by other vehicles. The sequence of operation is much the same for the succeeding relays until No. 8 is reached. When this relay is operated, it stops the clock hands by disengaging the clock clutch.

The hands may now be reset to zero by pressing the reset push button. This procedure as outlined permits relay No. 1 to operate the clock clutch. Some error is induced because the starting of the clock hands requires about one hundredth of a second. This error is overcome if the clock is allowed to run continuously.

The record obtained on the film is a multiple exposure of eight different positions of the clock hands. Since the sweep-hand of the clock completes one revolution per second and the other hand requires 25 seconds per revolution, it is not difficult

to interpret the time intervals between successive flashes. The photographic record is read by projecting an image on a small screen.

If spot speeds are recorded photographically, there are but two positions of the clock hands. The action of the photographing unit is dependent upon two road switches only. The actuating relays in this case are No. 1 and No. 2, and they perform the same functions as relays No. 1 and No. 8 if the control switch is placed in the "two switch" position. In general, it is much easier and more economical to read the spot speeds direct from the clock hands. An experienced operator can read about 300 spot-speed records per hour.

The field operation of the machine for making one complete record, after the road cables are in position, involves turning the camera one frame, pushing the reset button if the operator desires to have a zero position on the record, pushing the operate-count switch to "count" and then back to "operate." This operation must be done for each observation.

Several checking features are provided as an aid in obtaining complete records. The operation of each relay is indicated on the control panel by a pilot light. Other pilot lights are used to indicate when certain units are functioning properly. These are on the control panel. In order that the flashing of the gas-discharge tubes within the light-tight compartment may be checked, a photoelectric cell used in conjunction with a gas-filled tetrode rings a bell with each flash. The two solenoid-operated counters are synchronized: one is mounted on the control panel; the other is placed so that it will be photographed. The photographed reading of the counter becomes a permanent part of the record. The operator records the exterior counter reading on his traffic log. The voltage of each battery and the high-voltage power supply may be checked at any time by means of the voltmeter mounted on the control panel.

CALIBRATION OF THE INSTRUMENT

Checking the time interval required to close the relays, after an impulse had been placed upon the road switch, involved a special circuit using a cathode-ray oscillograph as a time indicator. The slowest time required to close the relays was $1/240$ of a second. Therefore, the closing time of the relays had little effect upon the time interval, as the clock is calibrated in $1/100$ -of-a-second intervals.

Field checks were dependent upon the time required for a car to pass between two points varying from one hundred feet to seven hundred feet apart. As a check, a test car was driven at various constant speeds over the courses and clocked by means of a stop-watch and by means of the Photo-Velaxometer. There was some difference between the reading of the stop-watch and the unit when short speed traps were used, but when

the long speed traps were used, there was no appreciable difference (less than one per cent). It is probable that the Photo-Velaxometer is more accurate than timing with a stop-watch, as the human element has been eliminated.

OPTIONAL CONTROLS

There are many other suitable ways for obtaining the impulse provided by the road switch. An experimental circuit, as shown in Figure (C) of the complete wiring diagram (Fig. 1), has been used successfully. Provision is made in an optional circuit for a photoelectric-cell circuit and a light beam that can be interrupted. Whenever the beam is eclipsed, the photo-cell will provide an impulse for a gas-filled tetrode that will produce enough power to close a relay. This circuit would provide an excellent means of obtaining an accurate road switch detector if the apparatus were to be set up permanently. However, there are three disadvantages to this circuit: lack of easy portability, difficulty in obtaining power supply, and ease of detection by motorists.

Some optional circuits could be used for operating the Photo-Velaxometer. A cold-cathode tube as shown in Figure (A) of the complete wiring diagram (Fig. 1) may be used to close a relay. The advantage of this method is that a closure of the detecting or initiating switch need be only in terms of micro-seconds to actuate the gas-filled tube. Also, this contact need not carry an appreciable current. This allows the maintaining of a precise adjustment of the detecting switch contacts.

Further refinement of the apparatus would involve the placing of a cold-cathode gas triode between the road switch and the relay circuit. If the clock were running continuously, then the flashing of the interior gas-discharge tubes would be a function of the time required to fire the gas triode tube and would not depend upon the closing time of the relay. The time involved would be in terms of micro-seconds.

Another refinement that would make the apparatus practically automatic would be to replace the 35-millimeter camera with an 8 mm. or 16 mm. motion picture camera that has a single frame exposure attachment. The attachment could be mechanically operated with an electrical solenoid serving as the power unit to pull one frame at a time. Should the apparatus be used for spot speeds, the second flash of the gas-discharge tube would provide the initial impulse to energize the circuit controlling the solenoid. The eighth flash of the gas discharge tubes could serve as the impulse for energizing the circuit controlling the solenoid in making a blank frame between records if acceleration patterns were being recorded.

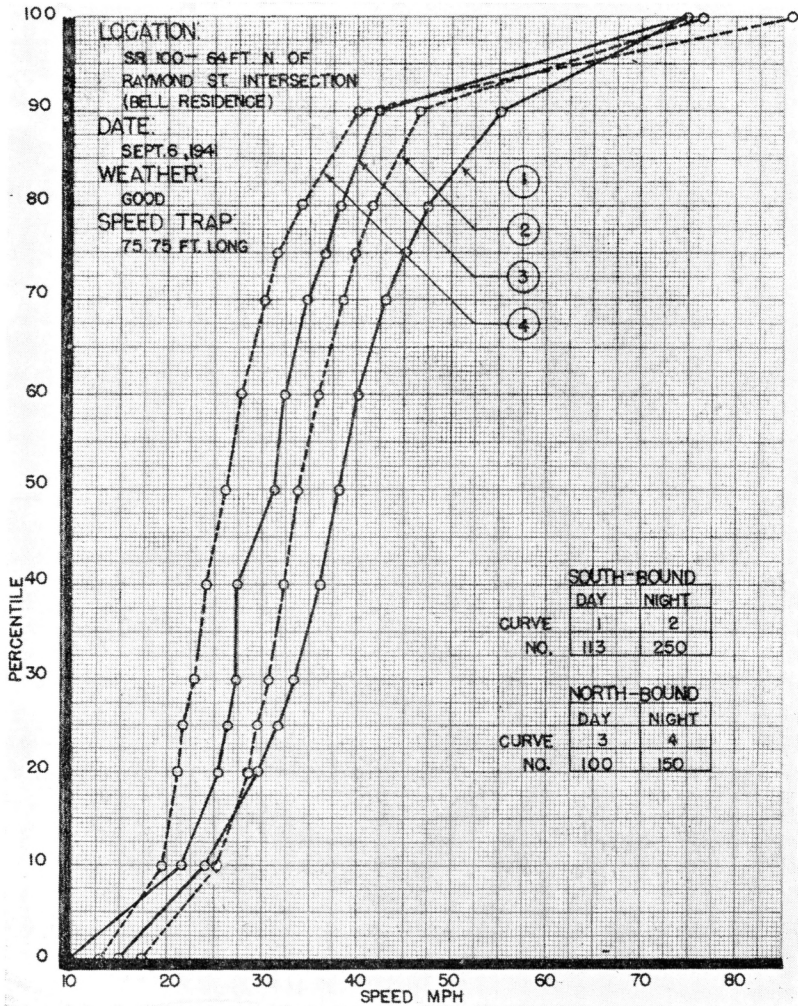


Fig. 2. Typical percentile—spot-speed pattern.

TYPICAL USES

Figure 2 shows the compliance of motorists to a 40 M.P.H. speed zone sign. These data were recorded as "spot speeds" in this study. Note the difference in directional speeds and the difference between day and night speeds. In this particular study, outgoing city traffic moved at a higher rate of speed than incoming traffic. Daylight traffic moves somewhat faster than night traffic.

A second typical example of use is shown in Fig. 3. An attempt is being made to determine the effect of bridge widths on both speed and transverse placement of the vehicle. The

acceleration pattern shows the reaction of the motorist (during daylight and darkness) when approaching a narrow bridge that is 19 feet between the parapet walls. The limited data show that passenger cars' acceleration patterns represent faster speeds during daylight hours than at night. The opposite is true for truck speeds. There is very little change in acceleration as the motorist approaches the narrow bridge. Furthermore, about one-third of the drivers changed their lateral position to a position near or across the centerline as they approached the narrow bridge. Thompson in his study "Motor Vehicle Driver Behavior Studied by New Methods"* makes a similar report as follows: "Although no general conclusion can be reached from the data applicable to this one bridge, it is of interest to note that its presence caused no significant change in speed but a pronounced shift of placement toward the center of the roadway".

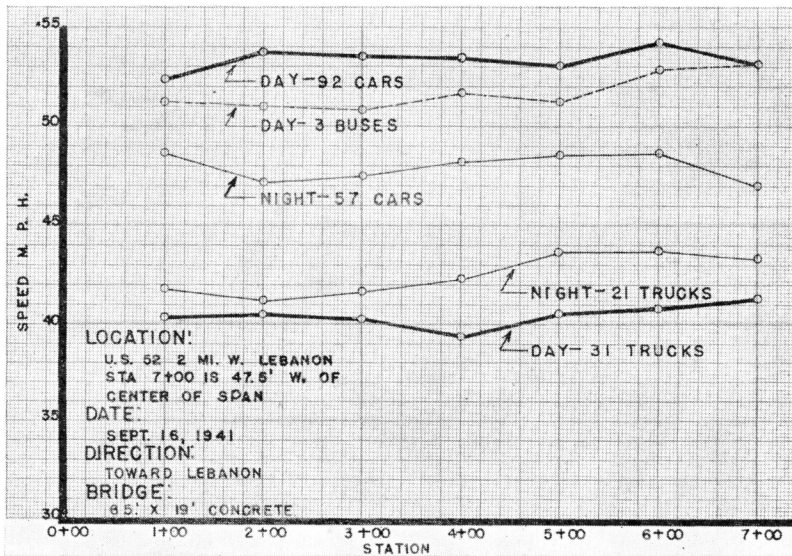


Fig. 3. Acceleration pattern showing the reaction of motorists to a narrow bridge.

SUMMARY

The Photo-Velaxometer that has been described is accurate and reliable. However, some changes in its construction would make it practically automatic. Some of these refinements have been discussed under "Optional Controls". It is believed, however, that the underlying principles of the Photo-Velaxometer provide for an accurate and efficient means of measuring a series of "successive spot speeds" or "spot

* *Civil Engineering*, Vol. 11, No. 10, October, 1941, pp. 589-592.

speeds". The former gives an integrated acceleration-pattern recording. The apparatus is portable and stable in operation and has shown consistency in performance. It would appear that there are several uses for this equipment in the field of traffic research. The apparatus has been used to record acceleration patterns of motorists when approaching narrow bridges, curves, stop signs, speed zone signs, and vehicle performance on hills. It has been used as an economical and accurate means to measure "spot speeds". Many other driver reactions could be studied.

THE USE OF SPEED-RECORDER EQUIPMENT

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The Photo-Velaxometer is designed to measure and record small time intervals and sequences of small time intervals so as to give an acceleration pattern of a moving vehicle as it progresses through a measured distance.

The immediate application of this instrument to highway engineering is its use in studying the following types of traffic problems:

1. To find the maximum, minimum, and average speeds of vehicles at any location on the open highway for speed-limit determinations.
2. To make speed determinations on city streets and in semi-residential areas to discover driver obedience to speed-limit signs.
3. To record both positive and negative acceleration of vehicles approaching and leaving various highway warning signs to determine the effect of the signs on motorists.
4. To discover the effect that highway hazards have on motorists, by measuring positive and negative acceleration of vehicles approaching and leaving highway hazards, such as narrow bridges, sharp curves, steep hills, sudden dips, and highway junctions.
5. To discover differences in driving characteristics on wet, dry, and icy pavements.

These types of highway problems can be further analyzed by obtaining other pertinent data, such as state license, sex of driver, number of passengers, type of vehicle, weather, condition of pavement, and any surrounding characteristics of the location that may influence the driver's reactions.

Since the completion of the Photo-Velaxometer, five studies have been made on some of the above suggested types of traffic problems. These studies are as follows: