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Problem

Certain types of studies of driving performance require mobile equipment for use in making objective measurements of behavior under actual traffic conditions. Due to the inherent dangers of stationary apparatus being used on the highway it becomes important that satisfactory portable and mobile equipment be used to facilitate objective measurements of drivers in traffic, highway and driving research.

Several types of such apparatus are needed for objective measurements, the most important may be listed as follows:

1. Adequate measuring devices for determining reaction time, braking time, perceptual and judgment time.
2. Suitable manual, mechanical and electronic keys for starting and stopping the chronoscope used.
3. A special radio-relay key for remote control of the chronoscope from other vehicles or stations.
4. A complete two-way communication system for interchange of information and signals to render economical use of time in securing observations.
5. Sound recording units for securing protocols and subjective data supplementary to objective observations.
6. Machine-gun cameras for graphic recording of behavior of the driver at the wheel, as well as the behavior of cars following or being followed by the control or experimental vehicle.
7. Spacing equipment such as range finders, radar and other electronic spacing devices.
8. A tachistoscopic or quick exposure device for presenting stimuli under driving conditions.

It is the purpose of this paper to describe certain units of this equipment which are not available in commercial form and which were needed in studies of night driving being conducted at Iowa State College similar to the study being reported by Hoppe (1950). The specific purpose of this paper is to describe the certain essential features of apparatus numbered 1, 2, 3, 4, and 7 respectively. Numbers 5 and 7 involve standard commercial devices readily available and number 8 will be described by Hoppe (ibid.).

Description of the Apparatus

The following equipment has been designed and assembled for the type of problems mentioned and will be discussed in categorical order.

Time Measuring Devices and Control. The primary control unit consists of a simple series electrical circuit. Four means of closing this circuit and two means of opening the circuit are provided. A Springfield S-1 Time Clock with a six-volt Bodine motor using a six-volt clutch is used to measure time intervals desired. This clock or chronoscope has an accuracy of plus or minus five milliseconds. Two push buttons (p) are provided — one for test purposes, the other to start the timer with the closing of a pair of relay contacts. The radio controlled relay provides a means of starting or stopping the chonoscope from a distance by wireless. A six-volt relay controlled by a micro-switch provides local control of the time clock. Another relay is connected to the stop-light circuit of the test car and is designed to stop the time clock when the brake pedal is depressed, or at any point desired according to the design of the particular experiment. This relay requires manual resetting. A specially designed control is provided for the operation of the tachistoscope. One contact being provided at the presentation of the stimulus and another at the response of the driver.

The chronoscope requires ten amperes of current at the instant of starting and eight amperes during continuous operation. The cable from the battery to the timing motor has a 6400 circular mil area of copper in each conductor to avoid voltage drop at the motor.

The relays used in the control unit are 28-volt d.c. relays, the coils of which are rewound with No. 26 cotton-covered copper wire. These relays will operate on two volts. The armatures are light and are closely spaced to the core of the electromagnets. No measurable delay can be found in the relay operation. In other words it is less than the accuracy of the time clock used.* This unit is suitable for measuring perceptual and judgment time since they are appreciably longer than any type of reaction time.

Principal Features of the Electronic Voice Key Used. This unit is provided to time the response of a driver when presented with a road-problem stimulus requiring a decision and a verbal response such as described by Hoppe (ibid.). A class B audio amplifier using 49-type tubes with a relay in the Class B stage high

* For laboratory purposes a more refined chronoscope should be used.

voltage lead converts the verbal response to relay action thus stopping the time clock. The driver stage of this amplifier has a negative bias of 33 volts. The final stage draws five milliamperes with no voice input to the microphone. The verbal response of the subject into the microphone causes the Class B stage to draw 30 milliamperes of current. This increase in current operates an 8000 ohm plate-type relay closing two normally open relay contacts. A ten-microfarad condenser wired in parallel with the relay coil provides a one-second delay in the opening of relay contacts. This is necessary to permit accurate reading of the time clock. The power for this unit is provided by a six-volt genomotor with an output of 130 volts at 30 milliamperes. This unit may be used to either start or stop the time clock as the design of the experiment may require.

Radio Control Relay Used for Remote Control of the Chronoscope. The radio controlled relay is a part of a Beacon Receiver BC-1023A. It has been coverted to operate at a frequency of 53-thousand kilocycles, and to rectify the tone modulation of a transmitter on the same frequency located at a distance of one-half mile away. This rectified current in the final audio stage operates a sensitive relay closing contacts which are normally open. This relay can be used either to start or stop the chronoscope as desired.

The transmitter used with this receiver, and located in the second test vehicle, consists of a tritet oscillator in which the grid circuit is controlled by a 26,500 kilocycle quartz crystal and a plate circuit tuned to twice this frequency (53,000 kc). This transmitter is tone modulated with an audio frequency. Keying the tone modulation controls the operation of the BC-1023A receiver. The power needed for the transmitter is six volts for the tube filaments and 275 volts for the plate circuit of the transmitter. The power is provided by a 12-volt genomotor. The use of this radio control relay combination makes it possible to present a stimulus or road problem to the driver of the test car from the control car or master station some distance away.

Units for Communication between Vehicles. Two low powered FM transmitters provide the means of communication between the mobile units. Two BC 620 receiver-transmitter combinations with PE 120 power packs are used for this purpose. This unit is tuned to a frequency of 27,200 kilocycles in the 11-meter amateur radio band. It has an effective range of five miles. Power to this unit is furnished by a six-volt battery. The antenna consists of an

Figure I. Showing location of Chronoscope Control Unit in the test car.

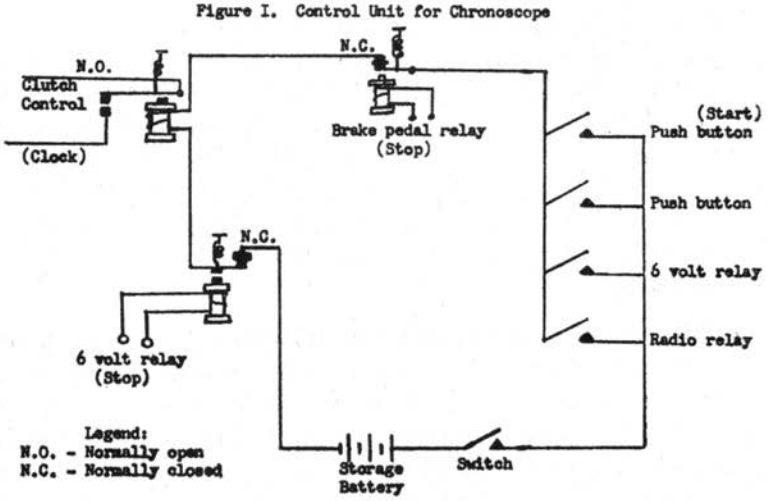
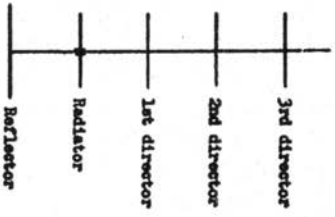


Figure II. The test car and control car showing radio control and communication antennas.

Figure II. Design of Antennas used to Focus Beam (443-447,000 Kilocycles)



MS 48-mounting base with three antenna sections MS 53-52-51 making a total length of nine feet.

To comply with the regulation of the Federal Communications Commission, this equipment must be operated by licensed amateur radio operators. A log of all transmissions must be kept by these operators. The transmitters and receivers are crystal controlled and operate on one fixed frequency and cannot be retuned by the operators. This provision is important and eliminates breaks in communications while a test is underway. The operators use their station calls while operating this equipment.

The communication unit is installed in the luggage compartment of the car and the antenna mounted on the rear bumper as shown in Figure II. Extensions on the TS 13 handset will allow operation from the rear seat with only the handset needed for the control of the transmitter and receiver.

The battery drain with a six-volt storage battery is 3.25 amperes. The transmitter power output is listed as 1.12-1.5 watts. The unit requires a vacuum-tube volt meter for alignment and tuning purposes. The frequency of the quartz crystal needed for this unit may be found by the following formula:

$$\text{Crystal frequency} = \frac{\text{transmitter frequency} - 2880}{3} \text{ **}$$

The crystals for this unit are mounted in the FT 243-type of crystal holders. A BA 41 internal bias battery is needed for proper operation of this equipment. The gear used in this unit can be secured from the surplus market and identification numbers are U. S. Signal Corps designations.

Radio Altimeter Spacing Units. The spacing of the test cars on the highway is determined by a simple radar set. The radio-type altimeter that uses the echo principle, but not the pulse principle, provides a simple means of measuring short distances. The RT-7APN-1 altimeter now available on the surplus market provides a satisfactory unit for this purpose. It operates on a frequency range of 418-462 megacycles and can be tuned to the amateur band of 420-450 megacycles. This frequency will be located by using the third harmonic of a crystal-controlled transmitter operating on a frequency of 144,140 kilocycles.

This unit operates on 24-volt direct current which is provided by four six-volt storage batteries. The operation of the unit requires approximately 2.8 amperes of current. Two dipole antennas were

** All frequencies are given in kilocycles.

used in plane operation of this altimeter. In measuring horizontal distances these dipoles are rebuilt into beam antennas to concentrate the radio beam to points directly in front of the car. This beam antenna consists of a dipole, reflector and three directors. Its use eliminates reflections from objects on the side of the road. A metal target is mounted on top of the test car as shown in Figure II to provide maximum reflections. This target consists of a metallic screen, the mesh of which are approximately one-quarter inch square. This unit is located in a control vehicle ahead of the test car. An accuracy of plus or minus 40 feet at the distances ordinarily used can be expected in the use of this equipment. A range-limit switch provides a light flash when a predetermined distance between cars is reached. This may also be set to operate automatically. The equipment is provided with a keying circuit for identification purposes and must be operated by licensed amateur operators.

Summary

Five units of an eight-unit set of apparatus designed to facilitate objective measurements of driving behavior on the highway are described. The equipment is particularly useful as a new tool for studies of night-time driving and other conditions of low visibility. It is also adaptable to a variety of types of driving and traffic studies.

Mobile Equipment for Traffic Studies

The following units of equipment and apparatus are needed for the study of certain psychological studies of highway and traffic driving:

1. Adequate measuring devices for determining reaction time, braking time, perceptual and judgment time.
2. Suitable manual, mechanical and electronic keys for starting and stopping the chronoscope or timing device used.
3. A special radio-relay key for remote control of the chronoscope from other vehicles or stations.
4. A complete two-way communication system for interchange of information and signals to render economical use of time in securing observations.
5. Sound recording units for securing protocols and subjective data supplementary to objective observations.
6. Machine-gun cameras for graphic recording of driver behavior at the wheel, as well as the behavior of cars following, or being followed, by the control or experimental vehicle.
7. Spacing devices such as range finders, radar and other spacing devices.
8. A tachistoscopic or short-time exposure device for presenting stimuli or situations under ordinary driving conditions.

Numbers 5 and 7 are standard commercial devices which are readily available and may easily be adapted to such use. It is usually necessary

to have one or both vehicles equipped with 110-115 volt convertor in order to provide current for standard equipment.

The present paper deals only with the construction and assembly of units 1, 2, 3, 4 and 7 of the above. A paper by Mr. Hoppe given later on this program will cover one type of apparatus listed as No. 8.

Please note attached diagram for general layout of the main control circuit. A schematic diagram of the beam antenna is also shown at the bottom of the page of drawings.

References

1. Frequency Modulation Handbook, Holabird Signal Depot, Baltimore, Md., 1944.
2. Handbook of Maintenance Instructions for Radio Sets, AN-APN/1. Aircraft Altimeter Equipment (AN-08-10-189).
3. Handbook of Operating Instructions for Radio Sets AN-APN/1. (AN-08-10-265).
4. Instruction Book for Operation and Maintenance of Radio Receiver BC-1023-A (Technical order Number 08-10-150) Army Air Forces.
5. "Simplicity on Six," p. 40, OST, August, 1949.