DESIGN AND CONSTRUCTION OF AN APPARATUS TO MEASURE REACTION TIME

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ABSTRACT

An instrument for measuring the Reaction Time (RT) of individual has been developed. It is a direct reading instrument, the deflection of a galvanometer being proportional to the Reaction Time being measured.

A motor controlled switch also assembled at this laboratory provides visual or auditory stimuli of short duration.

The response can be given either by tapping a morse key or by speaking into microphone. In the latter case, a correction factor of 110 ms. has to be applied to the value of the RT as measured with the galvanometer for getting the true RT.

Simple RT, discrimination RT, discrimination and choice RT and serial RT can be measured.

Introduction

The frequent reference to the speed of performance of individuals suggests the need for the measurement of sensori-motor activity in terms of the reaction time. The interval of time measured from the beginning of the stimulus to the beginning of the response is called the R. T. The work of anti-submarine patrol illustrates the importance of this measurement. When an echo is obtained from a submarine, the operator has to report it quickly in order that effective action could be taken. The Sonar Operational Research Unit at Cochin, working on the problem of categorization of T.D. rates in T.A.S. School, needed an apparatus to measure the R.T.

Presentation of the Stimulus

The stimulus can be either visual or auditory, depending upon whether the visual or auditory R.T. is being measured. For producing visual stimuli, eight neon lamps arranged on a wooden panel as shown in Fig 2 are so adjusted that one of them will be lit up during the short time when any of the six sharp points on the brass piece A touches the phosphor bronze strip B. The bulb which has actually been lit up will depend upon which one of the brass strips marked  is touching the pointer P at that instant. This lighting up of the bulb gives the visual stimulus to the subject under test and he will be asked to respond as soon as he sees the light in any one of the eight bulbs on the panel.

For producing auditory stimuli, the neon lamps, shown in fig. 2, are disconnected at the junction box from the break and make contacts of the motor assembly. The eight points marked 1 to 8 are shorted and then connected to the live terminal of an audio-frequency signal generator through a pair of headphones. The frequency of the generator output can be adjusted to be anywhere in the audio region, but preferably at about 1000 cycles. Whenever A touches B, a ping is heard over the ear-phones and the subject gets the auditory stimulus, to which he is required to respond.

The set up described above is intended for automatic presentation of stimuli. Individual stimuli can also be presented by the experimenter with the help of a morse key.

Method of response

The response given by the subject can be in either of two different ways. He can either tap a morse key or speak into a throat microphone. In the former case, the switch SW (shown in fig. 1) in the equipment measuring RT should be in its off (or TAP KEY) position. The second method is particularly useful when it is intended to measure the discrimination or choice RT. The response from the throat microphone can be recorded on a tape recorder, so that the experimenter can at a later stage verify whether the response was correct or not.

The recording of the RT

A precision galvanometer is connected across the output terminal (marked G in fig. 1) of the RT measuring equipment. As soon as a stimulus is applied and the response has been given, the spot of light on the galvanometer gives a kick, the maximum extent of the kick being a measure of the actual reaction time. For calibrating the instrument, a chronotron manufactured by the Electronic Instruments Co., U.K. was used. While measuring the visual RT of an individual, the input terminals of the chronotron were connected across the relay coil A_1 (fig 1) so that it will correctly measure the period for which this relay was kept energised. As described in a later section, this period is the same as the RT being measured. It was found by this method that a deflection of the galvanometer by one division on its scale corresponded to a time period of 15 milli seconds.

If a chronotron or chronoscope is available, its input terminals can be connected to the relay contacts and the time during which the relay contacts remain closed can then be directly read on the instrument. This is the same as the RT being measured.

The Timing of Mental Processes

It is possible with this apparatus to measure the different mental acts, such as (1) simple reaction (2) discrimination and choice (3) discrimination alone (4) serial reactions.

In measuring simple RT, the subject can be presented a single stimulus and react with the same kind of response. In measuring discrimination and choice RT, the subject could be presented two or more stimuli and he has to respond with the corresponding response key or syllable, after discriminating between the stimuli and making a choice of the response. In measuring discrimination, RT, the subject could be given two or more stimuli in succession, out of which he should make the response only when a particular type of stimulus appears either by tapping the key or uttering the syllable assigned to the particular stimulus. In measuring serial RT, the subject could be presented with one stimulus and he was to make response, which may involve a chain of unitary responses. The difference between the serial RT and other types of mental acts is that in the latter, a "READY" signal is given by the experimenter before the presentation of each individual stimulus, whereas, in the former, the stimuli are presented in serial order without any "READY" signal between the stimuli.

It is also possible with this apparatus, to measure the effect of the length of fore-period upon reaction time. This could be achieved, by systematically varying the time interval between the presentation of two successive stimuli.

Description of the Equipment

(*a*) *Motor controlled make break switch*

The presentation of short-duration stimuli is achieved with the arrangement shown in Fig. 2. A wooden drum W, 3″ in diameter and 5″ in length, can be rotated by means of a motor M about the axis AD, the brass collars CC being rigidly fixed to the drum and to the iron rods A & D by means of screws. A number of brass strips, each $\frac{1}{2}''/\frac{3}{8}''$ in dimensions and marked ⊠ in the figure are fixed along the circumference of the drum in three separate rows, insulating gap between two neighbouring strips being made as small as possible. These strips are electrically connected in a random manner to the eight pins in the junction box through eight slip rings which have been arranged four on each and of the drum and shown shaded at the extreme ends of W in the figure. Thus during the short interval when one of the six sharp points projecting out of A touches the strip B, the electrical circuit will be completed as follows through one of the neon lamps

—110V·DC—neon lamp—brass strip on W (which is touching P at that time)—strip P — strip B—Out terminal (fig. 2)—IN terminal (fig. 1)—resistance R2 (fig. 1)—Earth (110V) negative). Thus the neon lamp corresponding to the strip just above P will glow for a short duration, the time of glow being controlled by the time for which A & B are in contact. Since the brass strips on W are connected randomly to the neon bulbs, the bulbs will light up in a random manner, but after six such stimuli have been presented, the process will repeat itself, unless the experimenter manipulates the handle H so that the point P now touches another row of contact strips. When the motor is running at its fastest speed *i.e.* when there is no resistance in rheostat R of fig. 2, stimuli will be automatically presented once in every two seconds. But this period can be increased slightly by introducing a resistance in series with the motor so that its speed of rotation is reduced.

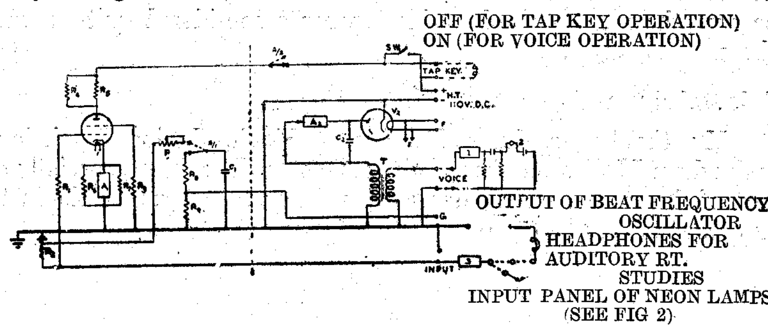
When it is intended to present auditory stimuli, the neon lamps are disconnected from the rest of the assembly at the junction box and the points 1 to 8 are shorted and connected to the live terminal of an audio frequency oscillator through a pair of head phones. Whenever B touches A, the electrical circuit is complete and a "ping" is heard on the phones, the frequency of which is controlled by the oscillator setting. By manipulating this frequency, auditory stimuli of different types can be presented.

In both the above cases, the electric current which produces the light in the neon lamp or the sound in the headphones is passing through resistance R_2 in the RT measuring equipment of fig. 1, thus driving the grid of valve V_1 positive for a short time. By this method the striking of this thyratron is synchronised to the beginning of the stimulus.

(b) R. T. Measuring Equipment

Fig. 1 shows the details of the RT meter constructed. It works on the principle of the charging and discharging of the condenser marked C_1. V_1 is a gas triode (type 2051) whose control grid is kept at a negative bias of 1·5 volts. Therefore normally there is no current passing through it. The terminal marked "INPUT" in fig. 1 is always kept connected to the terminal marked "OUT" in fig. 2 so that a current passes through R_2, whenever a neon lamp glows or when a ping is heard over the earphones. Thus, as shown in the previous paragraph, whenever a stimulus is presented, the control grid of V_1 goes positive and the valve begins to conduct. The resistances R_4, R_5, R_6 and R_7 are suitably adjusted for the plate current to be 25 milliamperes and the current through relay A_1 to be just sufficient for energising it. Due to the special properties of the thyratron, it will continue to conduct until the D. C. plate voltage is switched off either by means of the tap key or (in the case of voice operation) when the subject talks into the microphone. In the latter case, the output of the microphone is amplified by a commercial A. F. amplifier, whose output is fed across the terminals marked "VOICE". The resultant A. C. signal from the transformer T, is rectified by the diode V_2 and energises relay A_2, which in turn breaks the plate supply of V_1 at the contacts A_1. Thus V_1 remains conducting from the beginning of the stimulus to the beginning of the response, or, in other words, the relay A_1 is kept energised for a period equal to the RT being measured. During this period, condenser C_1 is being charged through potentiometer P. The potential to which this condenser is actually charged will be nearly proportional to the time of charging, if this time is negligibly small compared to the RC value of the charging circuit. Since in this case, RC is of the order of 12 and the reaction time will be in the region 100 to 500 milliseconds, this condition is always satisfied. When the contacts A/1 return to their normal position after the charging period is over, C_1 discharges through galvanometer G, the deflection of which will be proportional to the voltage to which C_1 was originally charged and hence to time for which A_1 was kept energised. Thus the deflection on the galvanometer is a direct measure of the RT. A resistance R_8 has been provided in series with the galvanometer, so that the discharge of C_1 is not too rapid. It is made sufficiently slow for the galvanometer to record the current through it. Another resistance R_9 is always put as a shunt across G so that the galvanometer returns quickly to its zero position after each discharge. The value of this resistance should be equal to the critical damping resistance for the galvanometer used.

Although the charging period of C_1 and the deflection of the galvanometer should be directly proportional to the RT being measured, a few errors due to the time taken by relays A_1, and A_2 to get energised have to be eliminated. There are three corrections—(1) for time δ_1, taken by relay contacts A/1 to close after the energising current has started to flow through A_1, (2) time δ_2 taken by same contacts to open after the energising current has ceased to flow, (3) time δ_3 for contacts A/2 to open after current starts to flow through coil A_2. If the charging period of C_1 (as measured by the galvanometer kick during the discharge) is found to be T_1, then the real $RT = T_1 + (\delta_1 - \delta_2 - \delta_3)$ the quantity within the brackets being a correction factor. By actual measurement using a chronotron, it was found that $\delta_1 = 25$ milliseconds, $\delta_2 = 23$ milliseconds; $\delta_3 = 110$ milliseconds. Thus the factor $(\delta_1 - \delta_2)$ can be neglected. If the response of the subject is by tapping the key, relay A_2 is not being used. In that case, the charging time of C_1 will be identical to the RT under test. If the response is, however, by "VOICE" operation, to get the actual RT, a quantity equal to δ_3 (110 msec) has to be substracted from the value of the charging time as obtained by measurement of the galvanometer deflection. As described in an earlier section, the galvanometer deflection is calibrated in respect of time periods (ms) by using a calibrated chronotron.

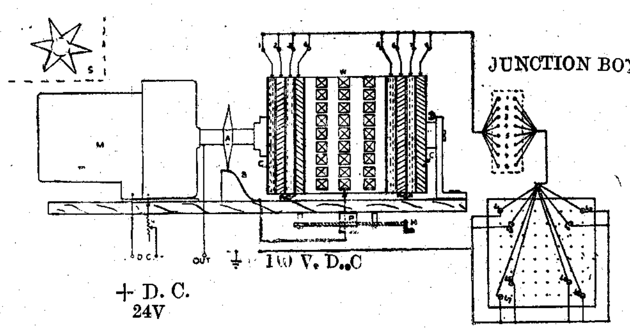


R_1 R_3 — 100 K. ½ W.
R_2 — 5 K. ½ W.
R_4 R_5 — 4 K. 5 W.
R_6, R_7 — 1·5 K. ½ W.
R_8 — 10 K. ½ W.
R_9 — 1 K. ½ W.

P — POTENTIOMETER CARBON 1 MEGOHM.
C_1 — 12μF 450V.
C_2 — 8μF. 50V.
A_1 — RELAY COIL OF No. 1 (A/1 Contacts for same)
A_2 — „ „ „ No. 2 (A/2 „ „ „)
T — INTERSTAGE TRANSFORMER (1 : 3)
SW_1 — S.P.S.T. SWITCH.
V_1 — VALVE TYPE 205, V_2 VALVE TYPE-6H6.,

1.. A. F. AMPLIFIER
2.. THROAT MIKE
3.. MAKE BREAK SWITCH CONTROLLED BY MOTOR (SEE FIG 2)

FIG 1



M D. C. MOTOR 24V 1.3 AMPS. 5 R.P.M.
W WOODEN DRUM 3 DIA., 5" LENGTH.
A AXLE OF MOTOR TO WHICH W IS FIXED (CROSS SECTION VIEW IN INSECT).
BRASS STRIPS (½"×⅜") FIXED OVER CIRCUMFERENCE OF W.
B, P. CONTACT STRIPS OF PHOSPHOR BRONZE
R W W RESISTANCE 25 OHMS.

C .. BRASS COLLERS FIXED AT ENDS OF W
D .. AXLE AND SUPPORT OF IRON TO GUIDE DIRECTION OF ROTATION OF W.
H .. RACK AND PINION FOR MOVING P LEFT AND RIGHT.
$L_1 L_2 L_4$ NEON LAMPS FIXED ON WOODEN PANEL
S .. CROSS SECTIONAL VIEW OF A ALONG AXIS.

FIG 2

Limitations of the instrument

This instrument, although versatile and capable of being put to use for various measurements, has serious limitations when rapid observations are to be made. When successive stimuli appear at a very fast rate (say, more than one in 2 secs) the observer may not be able to keep pace with the galvanometer deflections and his own personal error may influence the observations. Ink-recording arrangements were considered for the purpose but were found relatively unsatisfactory due to the inertia of the recording stylus. However, improvements along this line are being attempted. The instant at which the stimulus is presented and that at which the subject responds, can be indicated by means of "pips" on a cathode ray oscillograph screen and cine recording of this screen seems to be the correct answer. But this instrument being quite expensive, the one described in this paper was considered quite satisfactory for the work at hand.

Acknowledgements

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