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The Construction and Operation of a Reaction Time Machine

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REACTION TIME MACHINE

THE CONSTRUCTION AND OPERATION OF A REACTION TIME MACHINE

BY
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FOREWORD

Dr. A. B. Carlile of the Education Department, Butler University, suggested that a reaction time machine might be constructed using a spark to puncture a moving paper as a means of recording reaction time.

Since such a machine seemed both worthwhile and feasible, and because of a natural interest in this type of work, the project was attempted with the results described in the following pages.

Grateful acknowledgement is given Dr. Carlile for his original suggestion.

Thanks are also due Herbert Thompson, Leigh Smith, Clarence Eckert and George Harrison of Versailles for help and advice; to the Mallory Coil Co., Detroit for their cooperation; to my wife and family for much forbearance and constant encouragement.

A. T. F.

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CHAPTER I

INTRODUCTION

The Encyclopedia Britannica states that "One of the cardinal problems of psychophysics is the measurement of the duration of the mental processes".

To accomplish this purpose it is necessary to have a chronograph or chronoscope measuring in small fractions of a second with connections suitable to the experiment.

One of the first machines used for this purpose was the Hipp Chronoscope perfected by M. Hipp, of Reutlinger, about 1850. This device was operated by clockwork and its recording pointers were set in motion and stopped by magnets.

Following the work of Hipp, machines were constructed for this purpose by P. P. Wundt, 1893; A. d'Arsonval, 1896; J. Mc K. Cattell, 1900; and subsequently a large number of such machines have been made.

The history of the reaction time experiment is divided roughly into four periods.[1] They are known as "the astronomical period", from 1796 to 1865; "the physiological period", 1863 to 1880; "the psychophysical period", from 1865 to the present; and "the psychological period", from 1893 to the present.

From the foregoing it will be seen that the reaction experiment has been known for about 140 years, and serious work on it has been in progress since the construction of the Hipp Chronoscope more than eighty-five years ago.

Practically all of the devices used in the past for measuring reaction time have been some form of clockwork in which a cog or pointer could be engaged and disengaged at will, usually by means of a magnet, the engagement corresponding with a stimulus, the disengagement with the response, the motion of the pointer thus providing a means for measuring the time required to complete the reaction. Most of these machines used a tuning fork to control their rate of motion.

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[1] E. B. Titchner, Experimental Psychology

The electrical systems employed provided for a "making" of the circuit at one end of the experiment and a "break" at the other end. This one feature seems to introduce a source of error since a "make" and a "break" are not likely to consume the same amount of time. Further, the cogs and clockwork employed in the past seem to admit of improvement.

Concepts of reaction time may be typified by the following citation from William James who states that reaction time is not the measure of the velocity of thought but the "total duration of certain reactions upon stimuli...."[2] He continues:

> The method is essentially the same in all these investigations. A signal of some sort is communicated to the subject, and at the same instant records itself on a time-registering apparatus. The subject then makes a muscular movement of some sort, which is the 'reaction', and which also records itself automatically.

Referring to the reaction itself,[3] James likens it to a reflex.

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[2]William James, <u>Principles of Psychology</u>, Vol. I, P. 86.

[3]Ibid., P. 91.

The early experimenters really set out to measure the "velocity of thought" and much of their work was publicised under that heading. The modern conception, however, is in accord with the statement from William James.

CHAPTER II

CONSTRUCTION OF THE MACHINE

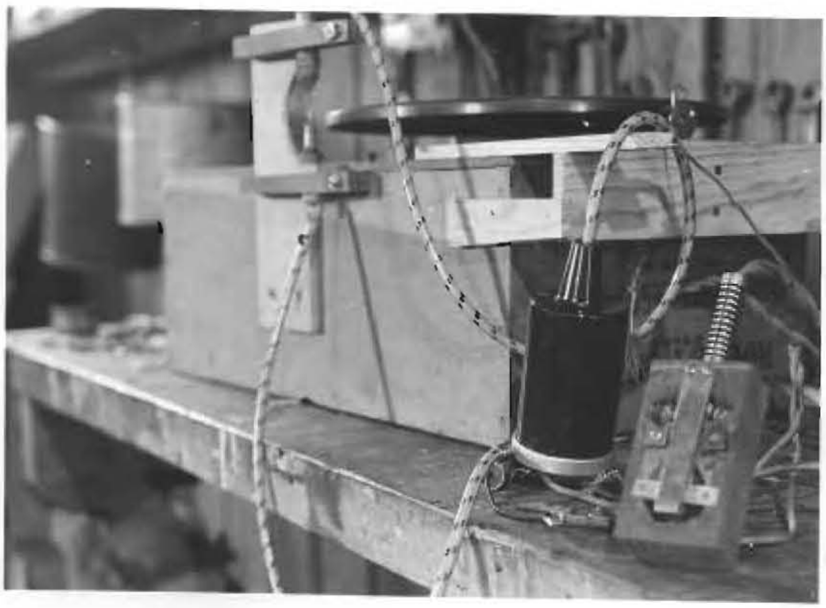
About 1935 Prof. A. B. Carlile of Butler University suggested that a spark type chronograph might be built in which a spark from a strong induction coil could be made to puncture a moving paper tape. If the tape were caused to move at a fixed, measurable speed, the distance between two spark punctures would constitute a measurable time interval. This type of chronograph seemed particularly adapted to the reaction time experiment, and I undertook to build such a machine as a part of my work for the Master's degree in Education.

Early studies convinced us that to employ a moving tape presented many complications. The peripheral speed of the drive pulley would have to be carefully calculated and slippage prevented. Then there would have to be some means to differentiate the initial spark from the second one. Idler pulleys and guides would have to be provided. After much study and experimentation the tape idea was discarded in favor of a disc revolving on and at the same speed as the drive wheel.

This change in structure simplified the machine considerably and a crude but workable model was built from an old phonograph.

The success of this trial construction provided enough encouragement to go ahead with the plans for a more compact instrument. A synchronous motor was obtained from the Radio Corporation of America as the first step in the procedure. The motor used is the same as employed in the low priced R. C. A. Record Player. It is simple in construction and as constant in speed as the alternations of the 60 cycle, 110-v light circuit employed to run it, and since the introduction of the electric clock these alternations have been made remarkably regular at the source of current supply. A personal "check-up" of this condition was made at Norris Dam where the practice is substantially the same as in all modern plants throughout this country. Variations there were found to be so small as to be negligible.

The speed of the motor used was calculated from the number of poles in the armature (92) and the number of alternations of current per second (120) according to the formula $R.\ P.\ M. = \frac{120 \times \text{frequency}}{\text{No. of poles}}$. This gives a speed of 78.26 R. P. M. Figuring further, one revolution



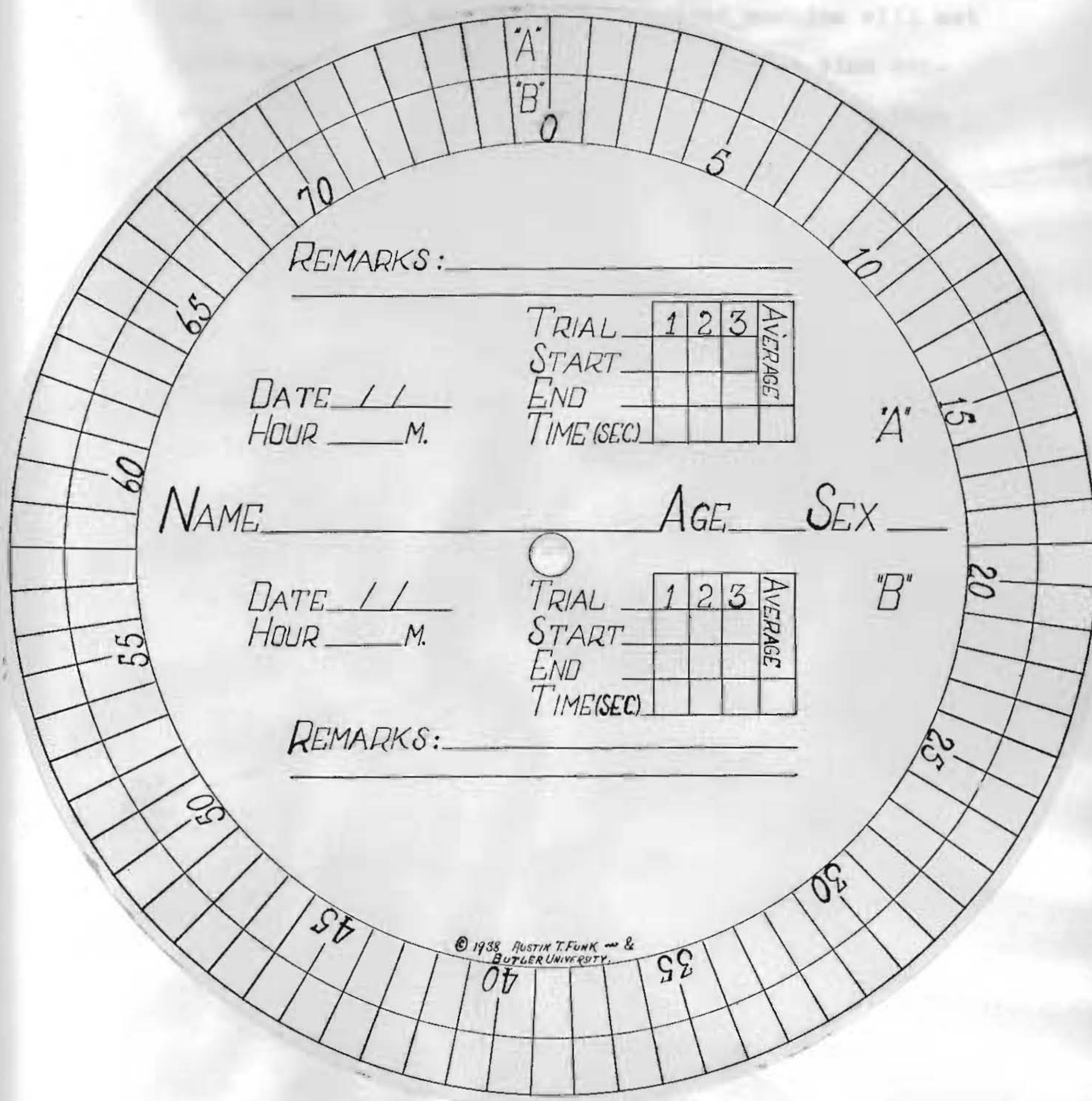
TRIAL MODEL - REACTION TIME MACHINE

will take place in 92/120 seconds or .76 2/3 seconds. Therefore the disc was divided into 77 equal parts so that the time interval per division is 0.009956 seconds. This is close enough to say that each division represents 0.01 seconds, for all practical purposes, or the error of -0.000044 seconds can be allowed for, if thought necessary.

The disc was made large enough that 0.1 of a division could be estimated quite easily so that the machine may be said to measure to the thousandth of a second. A sample of the disc is included here.

In order that the initial spark puncture might be distinguished from the second, or response puncture, means were provided to produce the initial spark automatically by the machine; it therefore occurs at a fixed point on the rotor for such experiment. It is only necessary then to locate the zero point of the disc at this point on the rotor and the initial spark is definitely located. In practice, no attempt is made to locate the zero point exactly since slight variations in location will be accounted for in recording thd time.

Since a spark coil operates only at the "break" of the primary circuit and since one "break" will occupy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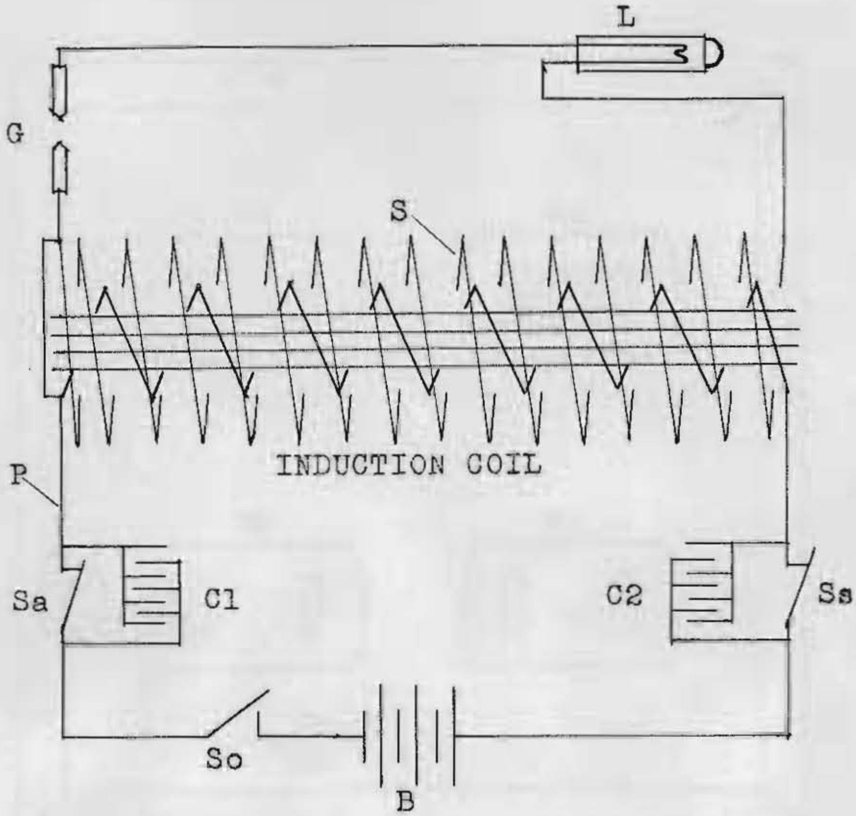
THE DISC

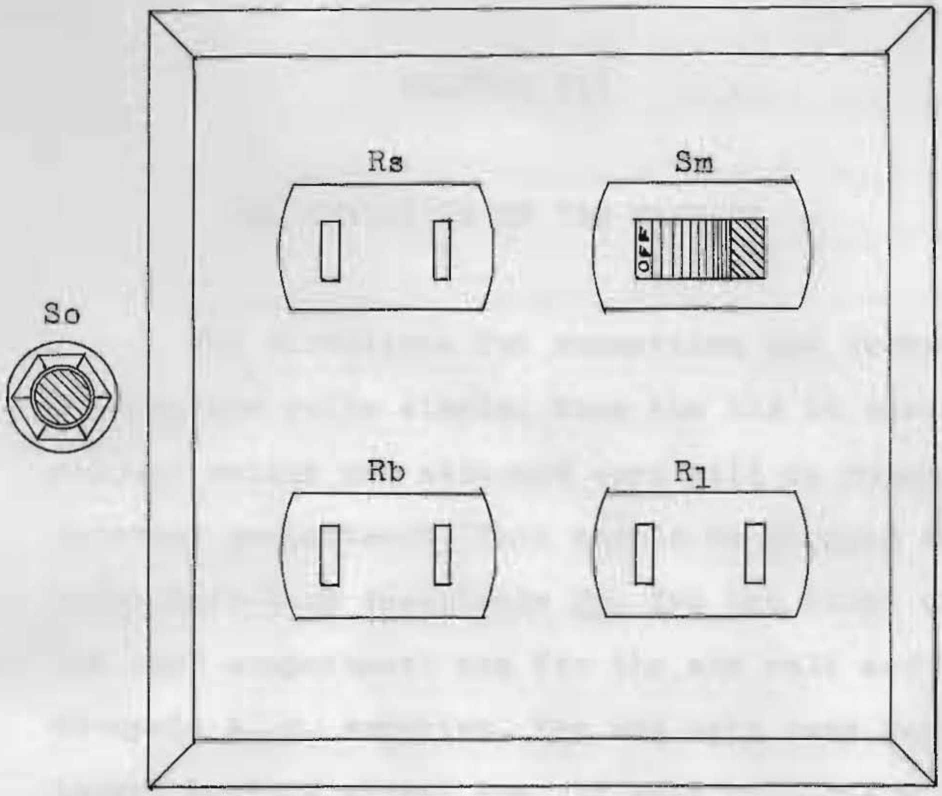
the same time as another, this type of machine will not show the errors caused by the difference in time consumed for a "make" and a "break", hence its advantage over the older type of magnetically controlled clockwork. Also, for all practical purposes, a circuit can be broken instantly, while it may consume an appreciable time to set it up.

In order to provide a stimulus at the same instant as the initial spark a neon light is inserted in the secondary circuit. This type of light responds instantly to the current flow, hence introduces no time lag. The particular lamp used employs a conderser lens and is quite visible under all usual conditions.



PRIMARY AND SECONDARY CIRCUIT

G - Spark Gap
S - Secondary Windings
L - Neon Lamp
P - Primary Windings
Sa - Automatic switch operated by motor; normal position closed-opened once each revolution
So - Operator's switch; normal position open-closed at will to set up the circuit for the automatic stimulus
Ss - Subject switch; normal position closed-opened by subject on receiving stimulus
B - 6 volt batter
C1-C2 - Condensers



SWITCH PANEL

Rs - Receptacle for switch plug
Rb - Receptacle for 6 V supply plug
Rl - Receptacle for 110 V, 60 cycle A.C. supply plug
Sm - Motor switch
So - Operator's switch

CHAPTER III

THE OPERATION OF THE MACHINE

The directions for connecting and operating the machine are quite simple. When the lid is opened, the subject switch and attached cord will be found in an interior compartment. This should be plugged in at the upper left-hand receptacle Rs. The two other cords in the cord compartment are for the six volt and 110 volt, 60-cycle A. C. supplies. The six volt cord has two attached battery clips; the 110 volt cord has a plug on either end, one of which should be plugged into the machine, lower right receptacle Rv first, and then into the source of supply. The motor switch directly above the 110-v plug is marked "on" and "off". The 6-v supply cord should be plugged in just below the subject switch cord at Rb and then connected to the terminals of a 6-v battery.

Discs also will be found in a compartment in the machine and the next step is to prepare one for use by filling in the name, age and sex of the subject, the date and hour of the trial. The disc is then placed on the turntable of the machine with the zero point of the disc at or slightly to the left of the zero mark on the turntable. The wood disc-holder should be placed on top of the disc to hold it in place. The spark gap G may then be adjusted so that it has the disc between the terminals and it should be centered over the outside, or A circle.

The machine should be started by spinning the turntable counter clockwise, taking care not to slip the disc by a sudden motion. A slight effort will cause the motor to turn faster than its normal speed after which the motor switch Sm should be turned on. The motor will slow up to and maintain synchronous speed at once.

The subject should be seated in a comfortable position some six to ten feet from the machine with the subject switch Ss at hand, facing the neon lamp L in the back of the machine. Each experimenter will doubtless choose to word his own instructions to the subject in keeping with his particular experiment, so none are given here. However, it should be kept in mind that when using the type of subject switch accompanying the machine a sharp push is required to produce a satisfactory spark.

The stimulus is given by pressing the small button So to the left of the switch plate on the front of the machine. The spark will jump and the lamp light within a fraction of a revolution. The subject, when pressing his switch Ss should hold it down momentarily while the operator should release his switch So just after the response is made, after which the subject may release his switch. It is all quite simple after becoming familiar with the machine.

After a trial is completed, the disc holder should be removed and the disc slipped from the turntable; the motor is then turned off. The time is read by holding the disc to a light and recording the position of the spark holes on the disc. The hole representing the stimulus will be found near the zero point of the disc. A subtraction gives elapsed time in hundredths of a second. For example, if the first spark puncture is found to be at 0.7 and the second at 24.2 the difference is 23.5 or 23.5 hundredths of a second which is 235 thousandths of a second.

To make succeeding trials on the same disc, replace it on the machine with "5" or "10" at the zero point on the turntable. After three trials, move the spark gap toward the center of the turntable so that the succeeding three trials will register in the "B" circle. By this procedure six trials may be made on one disc.

From the work of other experimenters times for reaction to the stimulus of a light are from .150 to .225 seconds. Results as obtained so far with this new spark type machine give comparative times of from ,132 to .255 seconds.

It must be remembered that this is the first model of a new device; hence it is far from perfect. Much more refinement is possible; much more work and testing should be done. Particularly should the subject switch be improved to speed up its action. We do claim, however, that the principle involved is sound, and we expect this type of machine eventually to take its place in the psychology laboratory as a worthwhile instrument.