A MECHANICAL DEVICE FOR THE GRAPHIC MEASUREMENT OF CERTAIN TECHNIQUES IN TYPEWRITING

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

Within recent years teachers and research workers in the field of typewriting have intensified their efforts toward increasing the productivity of students learning to type. Various instruments have been used to find specific weaknesses of the typist.

Research workers have made use of the motion picture camera and projector for studying motions. Rhythm has been taught by phonograph records and by type pacers. These, and other instruments, indicate a need for more adequate teaching aids that will enable the teacher to know the weak points in the student's efforts toward learning to typewrite. Stuart says:

> Typewriting teachers should study trends in education to find suggestions for improving basic instruction in typewriting and trends in business affecting the skills and standards in vocational typewriting.[1]

One of the recent trends toward improving basic instruction in typewriting has been to study the motions of the typist. Tate emphasizes the importance of motion studies by saying:

> Because motion study involves the division of a task into its fundamental elements, it is valuable in skill training. In performing a task, motion study points out all the separate movements that are necessary. . . . Since motion study indicates correct technique, it is a great aid to the teacher who is training students for jobs similar to those which have been analyzed.[2]

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1. Esta Ross Stuart, "Revamping the Teaching of Typewriting to Conform to the Modern Trends in Education and Business," Fourteenth Yearbook of the Eastern Commercial Teachers Association, 1941, p. 82.

2. Meriam Tate, "Visual-Sensory Aids in Typewriting," Typewriting News, 11:7, Spring, 1941.

The desired outcome is greater productivity in the early stages of learning to typewrite. More specifically, motion studies are for the purpose of securing more strokes per second, faster carriage returns, quicker and more accurate shifting, and fast paper change. To speed up the whole sum of productivity the gains must be made in one or more of these.

The gain could be made by faster stroking, or faster carriage return or any one of the other basic operations. Efforts toward measuring typewriting with timed tests indicate production as a whole but do not point out the learner's weaknesses. Gains might be more quickly made if the point of greatest weakness in basic technique could be ascertained and remedial work started to decrease the time used in that particular operation. A beginner could, for example, have a high stroking speed for short intervals and yet lose much time from slow-downs or complete stops caused by letters not completely mastered, and yet have a high productivity record in so far as other operations are concerned. Rhythm of stroking, speed of stroking, and shift key operation might possibly be well developed, yet through faulty or slow carriage returns many strokes would never be made and the whole productivity decrease.

The classroom teacher is handicapped for lack of an accurate, simple test of basic operations that would indicate which techniques to stress. A test that would allow the beginner to compare his stroking with more expert typists might assist him greatly in forming more correct habits and help him to increase his speed and accuracy.

Purpose of the Study

It was the purpose of this study to devise a mechanical instrument to measure in typewriting first, the intervals between strokes; second, the time used in making each stroke; third, the amount of time used in returning the carriage; fourth, the time used in the paper change operation and in shifting, capitalizing, and punctuating.

Definitions of Terms Used

Devise. Devise is defined by Webster[3] to mean to form in the mind by a new combination of ideas, new application of principles or a new arrangement of parts.

Instrument. In this study the term "instrument" will be used as meaning "a tool by which work is performed or anything is effected."[4]

Measure. The word "measure" is defined to mean to ascertain the extent or quantity of time.[5]

Test. The word "test" is here defined as that portion of a measuring device by which the pupil's performance is secured.[6]

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3. Noah Webster, Twentieth-Century Dictionary, (New York: Publishers Guild, Inc., 1936), p. 464.

4. Ibid., p. 880

5. Ibid., p. 1020.

6. Harry A. Greene and Albert N. Jorgensen, The Use and Interpretation of High School Tests (New York: Longmans, Green and Co., 1937), p. 606.

CHAPTER II

REVIEW OF THE LITERATURE

The literature pertaining to this problem was divided into two parts. The first part reviews the literature on the acquisition and testing of skill in typewriting. The second part is a summary of certain methods of graphic testing.

Literature on learning to typewrite. A search of the literature on typewriting reveals that teachers in the field and research workers are not satisfied with the progress that has been made. Although the largest gains in the skill of typewriting are made during the first few weeks[1] they feel that even greater economies of time used in basic skill development can be effected. This is reflected in the statement of Clem who writes:

> New ideas and new methods in teaching may double and even triple the results obtained from old methods. It is this constant experimenting and seeking after the new that keeps interest alive in our profession.[2]

A trend in typewriting in recent years has been to apply the scientific methods of motion study to the typist. Motion pictures of typists in action reveal that unnecessary movements reduce production. When it is considered that a typist of reasonable speed will make four to six strokes per second and that champions make up to eleven strokes per second then the value of each second lost takes on new meaning.

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1. William F. Book, Learning to Typewrite (New York: The Gregg Publishing Company, 1925), p. 270.

2. Jane E. Clem, "New Trends in the Teaching of Typewriting." The Business Education World, 19:631, April, 1939.

There are four general classes of time studies according to Haynes.[3] They are: first, time studies that reveal the most economical use of methods and equipment; second, motion studies that divide the work into its minute parts so that certain elements can be studied; third, studies of fundamental elements such as motions too short in duration to be measured by ordinary methods; and fourth, job analyses, used to determine the elements involved in performing a certain piece of work.

Motion studies applied to typewriting by existing methods reveal a large proportion of waste motion in even the most advanced typists. Wasted motions found by using the slow motion camera showed the hand traveling an irregular path while returning the carriage,[4] excess motions while changing paper,[5] excessive finger movements in stroking,[6] and head, arm and body motions that were not needed.[7]

Gilbreth was one of the first to study motions of workers and he says:

> The determination of the path which will result in the greatest economy of motion and the greatest increase of output is a subject for the closest investigation and the most scientific investigation.[8]

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3. Benjamin R. Haynes, "Adapting Scientific Methods to the Everyday Classroom Activities of Teachers of Business," National Business Education Quarterly, 8:10, May, 1940.

4. August Dvorak, Nellie L. Merrick, William L. Dealey, and Gertrude Catherine Ford, Typewriting Behavior (New York: American Book Company, 1936), p. 272.

5. Ibid., p. 250.

6. Ibid., p. 269.

7. Ibid., p. 272.

8. Frank B. Gilbreth, Motion Study (New York: D. Nostrand Company, 1911), p. 82.

Graphic motion study is the natural follow-up of motion study. The chief difference lies in the time of the study. The movie machine recorded the actions of the typist and showed ineffective motions. Graphic motion study would test the results of those actions and measure their duration.

This could be illustrated from Gilbreth. While visiting the New York Exposition he saw a champion wrapping boxes of shoe polish. With stop watch in hand he observed the operation and his eyes told him that certain changes would reduce the time. Those changes were made and the corrected technique timed with the stop watch. The time was reduced from forty seconds to twenty seconds for doing twenty-four packages.[9]

Graphic motion study shows that area which the stop watch measured after the changes had been made. It also represents the result by means of a line on a moving tape. The tape indicates the speed with which each stroke is made, from a pre-set point, as the type travels toward the platen, until it returns to that point. The action, is measured graphically and the results are available for immediate study.

Book indicates the need for such measurement by saying:

> The most helpful method of measurement that could be devised for use by those who direct learners of this subject would, therefore, be a test that would measure the progress which learners are making in dealing with each problem. . .[10]

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9. Ibid., p. xxi.

10. Ibid., p. 317.

> Such a learning test for typewriting should for example, give reliable quantitative information about the amount of progress that is being made: (1) In forming and fixing the necessary finger habits required to locate accurately each successive key by the method that should be used at that level of skill; (2) in forming and fixing the habits which enable learners to initiate and control the correct sequence of the various letter-making movements. . . . (4) in acquiring more ready and accurate identification of the important sources of improvement. . . .[11]

In a later paragraph Book summarizes with the statement:

> . . . They will aid them in selecting the more favorable responses accidentally originated in the course of the learning because these could be more easily recognized. . . .[12]

Such technical drill might well be faster stroking, practice in light stroking pressure, faster recoil action of the fingers, drills in making fast carriage returns and others that could be tested and the results shown graphically. The following illustrates the value of a knowledge of results:

> When all is said and done about incentives the last word on rapid improvement comes from competition against your own record. This competing against yourself is known as "knowledge of results." No matter what your fingers are doing, the more you know about the records being made, the higher your efficiency mounts.[13]

Some of the methods used by Dvorak, Merrick, Dealey and Ford to motivate work are bar charts, for line production output, progress charts showing the curve of errors, gross scores, and net scores.[14] Such graphic presentation has very desirable results in stimulating learning. They sum up with the statement:

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11. Book, op. cit., p. 317.
12. Ibid., p. 319.
13. Dvorak, op. cit., p. 67.
14. Ibid., p. 446-457.

> In self-directed practice, individual charting of the consequences becomes a spur to desired changes.[15]

The device offered in this study would furnish the student with graphic evidence of actual performance in developing the techniques of stroking, carriage return, shifting for capital letters, and changing paper.

At the present there are no instruments in general use that permit the classroom teacher to illustrate visually certain techniques in typewriting. Such elements as those mentioned in the preceding paragraph are usually taught by audible instruction. They are measured by the student's sense of touch, which is untrained, and the teacher's observation, which is limited by her inability to form a correct mental picture of fast motion.

Any device that would measure those elements graphically would economize the teacher's time and have a tendency to speed up the learning process by giving more objective, detailed information to the student. Ettinger points out that eighty-three per cent of our learning reaches us through the eye, and he goes on to say that such visual aids tends to eliminate verbalism and to create interest by isolating and emphasizing detail.[16]

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15. Ibid., p. 458.

16. Clifford Ettinger, "The Selection of Visual Aids for Business Education," Fourteenth Yearbook of the Eastern Commercial Teachers Association, 1941, p. 323.

"No student should be permitted to continue from day to day without knowing the status of his work," says Lessenberry,[17] and a device that would place more complete information at hand for students who are learning to typewrite would be a help in motivating the learning process.

Book's studies of the learning process in typewriting revealed motivation to be a powerful factor in speeding up learning. He says:

> Another factor which has marked effect on the improvement which a learner can make, is the ease with which he can be made satisfied with the things which really bring him success and displeased with the things which retard his progress.[18]

Later he adds:

> Learners often object to certain technical drills in music and typewriting because they do not see that such practice is needed. But they can be shown that this is a necessary step in lifting them onto a higher plane of skill.[19]

Psychologists indicate that instruction in the early stages of typewriting must, more and more, take into account the factor of starting pupils correctly. Each new habit should be formed as nearly correct as possible from the very start. Of the formation of habits Gates says:

> Learn the act in the way it is to function in actual life.[20]

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17. D. D. Lessenberry, Methods of Teaching Typewriting, Monograph 36 (Cincinnati: South-Western Publishing Company), p. 12.

18. Book, op. cit., p. 306.

19. Ibid., p. 307.

20. Arthur I. Gates, Psychology for Students of Education (New York: The MacMillan Company, 1925), p. 283.

Greater economy of learning is also accomplished if the student understands the purpose of the practice and the goal he is trying to reach. Gray says:

> All learning, regardless of types, takes place through exercise and is facilitated by understanding. To do and to understand why, are fundamental in all forms of effective learning. The amount of exercise and the amount of understanding both vary with the nature of the learning situation. Also they are interdependent. The amount of exercise necessary is reduced by increasing the amount of understanding and vice versa. Exercise and understanding may truly be considered the laws of learning.[21]

Once the act is learned continued practice of the right kind should be kept up until the act becomes automatic. Such fundamental habits in typewriting as stroking and carriage return are usually demonstrated to the student to get the first attempts correctly made. Stuart states that:

> After one of these typing skills has once been demonstrated, it should be practised regularly until the student becomes expert in it. It should be tested regularly thereafter to make sure that a skill which is once acquired is not lost.[22]

It is not only necessary that right responses be set up and made permanent, but also that wrong responses be cast out. Trial and error learning, according to Gates,[23] consists of making the reaction, eliminating the reactions that are unsuccessful and annoying, strength-

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21. Stanley J. Gray, "Basic Principles of Learning," Lesson Plans and Classroom Techniques, Second Yearbook of the National Commercial Teachers Federation, 1936, p. 30.

22. Esta Ross Stuart, "Revamping the Teaching of Typewriting to Conform to the Modern Trends in Education and Business," Fourteenth Yearbook of the Eastern Commercial Teachers Association, 1941, p. 79.

23. Gates, op. cit., p. 241.

ening the reactions that are satisfying because they further the learner's progress, and the final linking together of the various successful reactions.

Literature on methods of graphic testing. A study of the methods used for graphic recording and presentation of data concerning body movements reveals many different types of apparatus. The underlying method of recording, however, generally falls into two classes, those that are operated mechanically, and those that use an electromagnet for moving a stylus. In all of those reviewed the purpose was to record objectively the actions of the subject being tested.

Associated voluntary movements were studied by Collier[24] by using a stylus that marked on a drum held in a vertical position.

Beebe-Center and Stevens[25] studied cardiac acceleration by means of recording the path of a stylus moved by an electromagnet.

Van Dusen[26] used a micromotion camera and a time clock in a study of work methods. He mentioned that the values of motion study have probably been neglected in education and have only been used to their fullest extent by factories and business houses.

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24. Madison Collier, "A Technique for the Kymographic Registration of Certain Associated Voluntary Movements," Journal of Experimental Psychology, 21:181-193, August, 1937.

25. J. G. Beebe-Center and S. S. Stevens, "Cardiac Acceleration in Emotional Situations," Journal of Experimental Psychology, 21:72, July, 1937.

26. A. C. Van Dusen, "Work Methods and Learning," Journal of Experimental Psychology, 29:22-27, September, 1941.

Reaction time was the subject of the studies of Seashore, Starman, Kendall, and Helnick.[27] The apparatus used consisted of electrical contacts that started and stopped a time clock.

Bugelski[28] describes the apparatus he used in making a study of individual differences as follows, "The work curves were traced directly on wax-coated stylograph paper by means of a pointed lever. . . . "

Jasper and Shagass[29] describe their experimental equipment as follows, "For manual response, a push button connected to an electromagnetic marker was employed."

Bobbit used communications equipment and a magnetically driven stylus writing on stylographic paper. She mentions its value by saying:

> (The). . . apparatus has the advantages of. . . . furnishing a record, not merely of the onset of the verbal response and its reaction time, but of the form and structure of this response.[30]

Warren and Clark[31] also used a method of drum marking to record reaction time.

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27. Robert H. Seashore, Raymond Starman, William E. Kendall, and John S. Helnick, "Group Factors in Simple and Cremenative Reaction Times," Journal of Experimental Psychology, 29:347, October, 1941.

28. B. R. Bugelski, "The Consistency of Individual Differences in the Pattern of Work Decrement," Journal of Experimental Psychology, 29:329, May, 1941.

29. Herbert Jasper and Charles Shagass, "Conditioning the Occipital Alpha Rhythm in Man," Journal of Experimental Psychology, 29:374, May, 1941.

30. Ruth A. Bobbit, "A New Apparatus for the Luria Experiment," Journal of Experimental Psychology, 27:580, November, 1940.

31. Neil Warren and Brant Clark, "Blocking in Mental and Motor Tasks During a 65-hour Vigil," Journal of Experimental Psychology, 21:97, July, 1937.

Two psychological studies were found that had used graphic recording for making experiments in typewriting. The earliest of these was made by Lahy in Paris.[32] The work was started in 1912 and, after an interruption caused by the war, was continued until about 1923.

Lahy says:

> The method employed for analyzing touch was to record the movements of the keys of a typewriter when struck by typists of all grades of skill; these movements are measured by the graphic method usually employed in physiological laboratories. Three methods of transmitting the movements of the keys to a recording cylinder were employed. . . .[33]

The three methods mentioned were pneumatic recording,[34] electric recording,[35] and a combination of pneumatic and electric recording.[36]

The graphs were drawn on a prepared paper by means of a stylus. The cylinder was approximately eighteen inches in diameter and possibly twenty-four inches long and was mounted on a work table apart from the typewriter. A gearing system moved the stylus continually over to a new track.

Three Deprez markers were used by Book for recording on a kymograph drum.[37] The general make-up of the apparatus was similar

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32. J. M. Lahy, Motion Study in Typewriting, (International Labour Office Studies and Reports, Series J, No. 3, Geneva: 1924), p. 11.

33. Loc. cit.,

34. Ibid., p. 12.

35. Ibid., p. 13.

36. Ibid., p. 16-19.

37. William Frederick Book, The Psychology of Skill (Chicago: Gregg Publishing Company, 1925), p. 5.

to that used by Lahy. The Deprez marker is an electromagnetic device with a stylus attached for marking on stylograph paper. A metalic arm holds it in position.

Summary

The literature on learning to typewrite indicates that achievement in the early stages of skill development can be increased. Scientific motion studies indicate economical motions that are swift and sure. There is a need, however, for an adequate, practical means of testing certain techniques of the typist.

A test that would measure the learner's progress and tell him immediately of his success or failure would motivate learning to typewrite. Psychologists and writers in the field of Business Education point out that skill could be developed more quickly if the learner were aware of his progress in the formation of each habit. Visual information is indicated as being efficient and helpful for eliminating unsuccessful responses.

Apparatus in use in physiological laboratories suggests a means of testing in typewriting that would give the teacher the tool suggested above. It would let the learner see his own progress in the development of certain basic techniques by measuring the time used in stroking, carriage return, shifting, and in changing paper.

CHAPTER III

CONSTRUCTION OF A WORKING MODEL

Analysis of the review presented in the preceding chapter reveals that each of the testing devices was set up for a specific purpose. For that reason each of them varied in construction details and even in basic principles.

Dvorak's[1] students imposed certain conditions for him to meet when he developed the Type-Pacer. His list was used as a guide for developing the requirements that follow:

(1) It must be low in initial cost.

(2) It must be easy to operate.

(3) It must need few, simple adjustments.

(4) It should show comparable results for different typewriters.

(5) Speed should be constant and operating conditions standardized.

(6) It should be easily attached. There should be little if any mechanical change in the typewriter for this purpose.

(7) Results should be available for immediate study.

(8) It should be inexpensive to operate.

Power supply and stylus motivation. From the first it was accepted that the movement of the stylus or pen should be made by electrical means rather than by direct mechanical connections. The latter would have had obvious disadvantages. Vibration of the

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1. Dvorak, op. cit., p. 317.

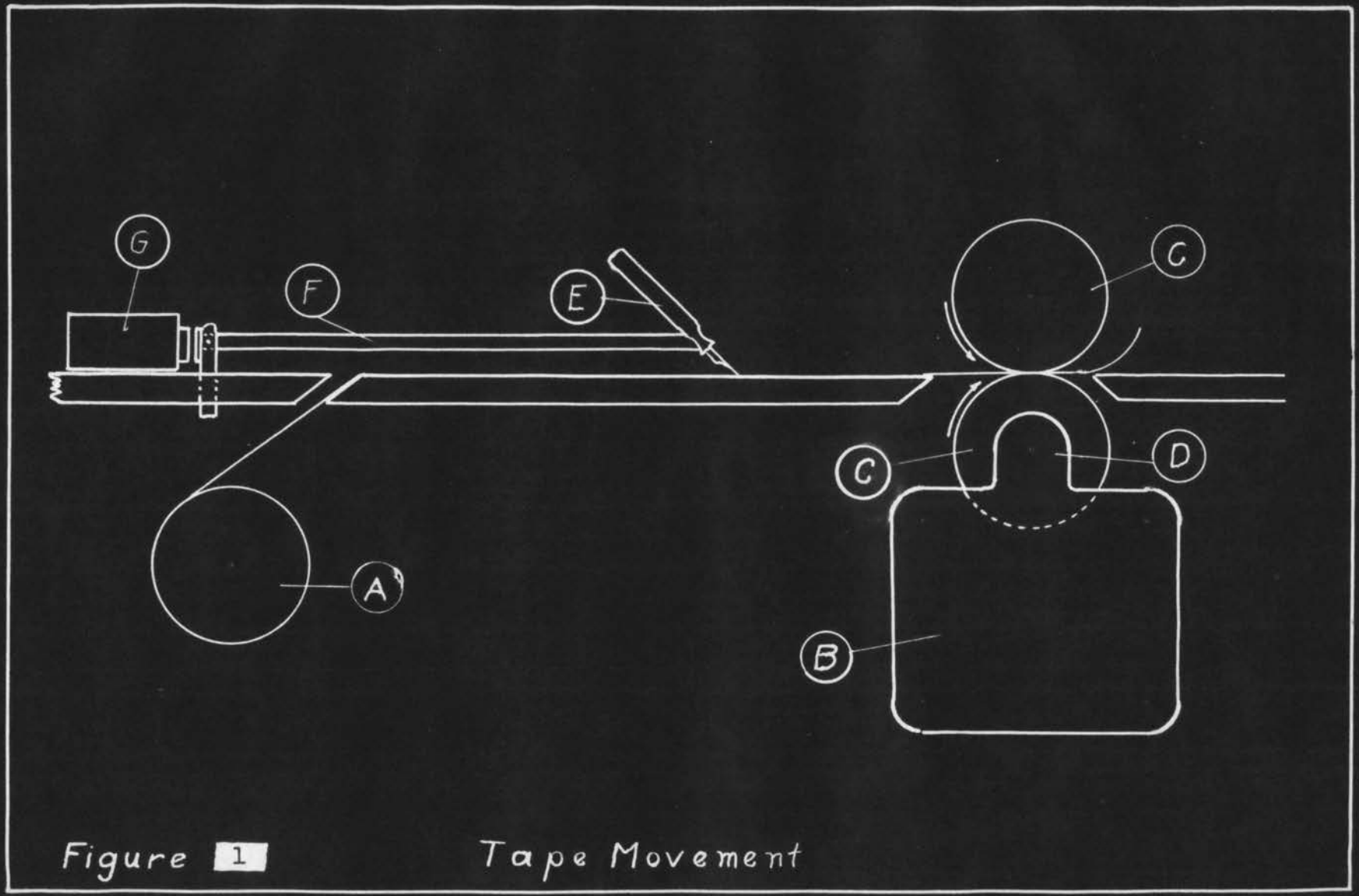

Figure 1 Tape Movement

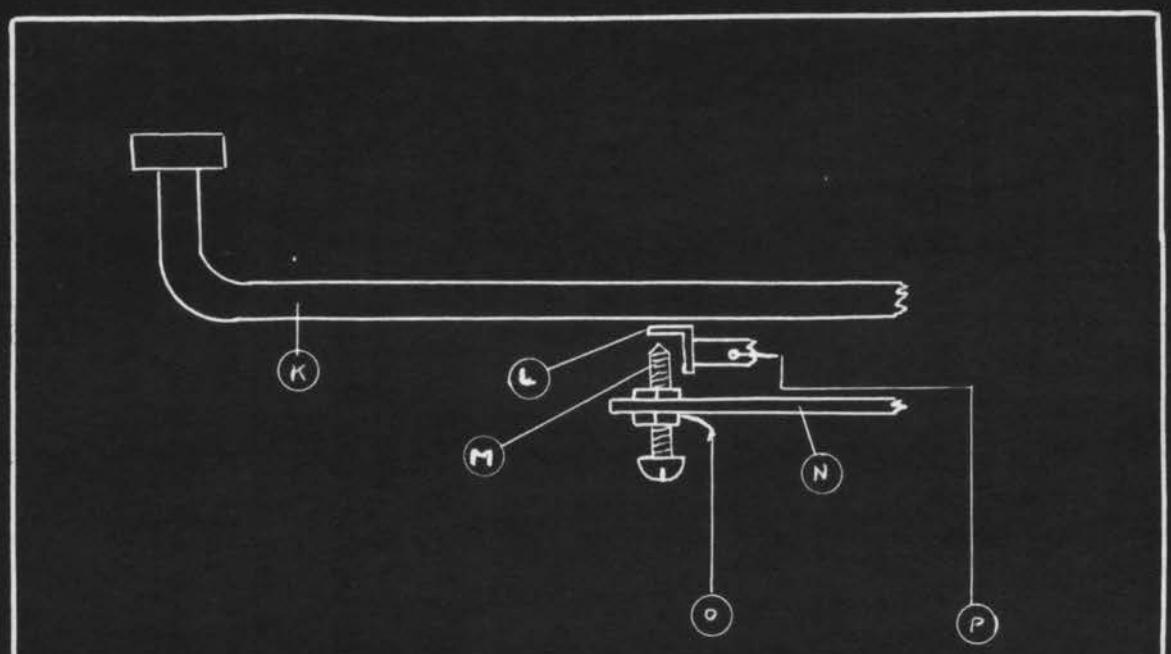

Figure 2 Keyboard Contact

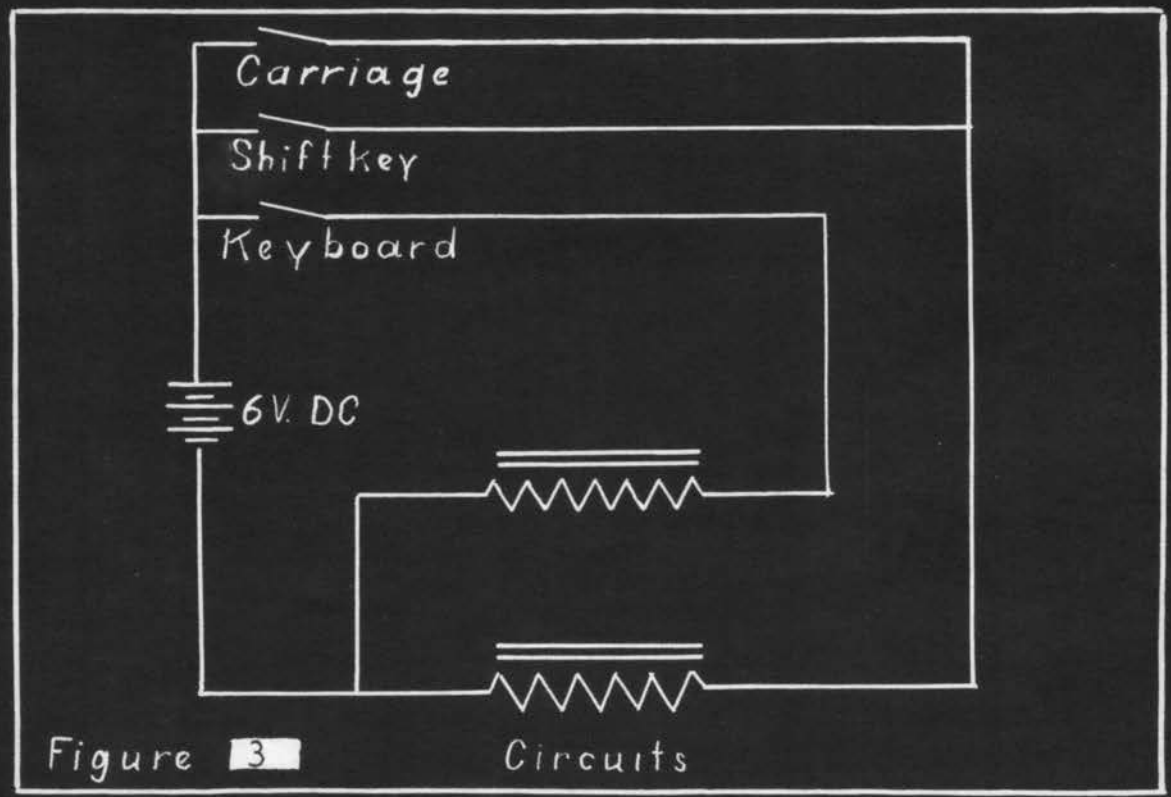

Figure 3 Circuits

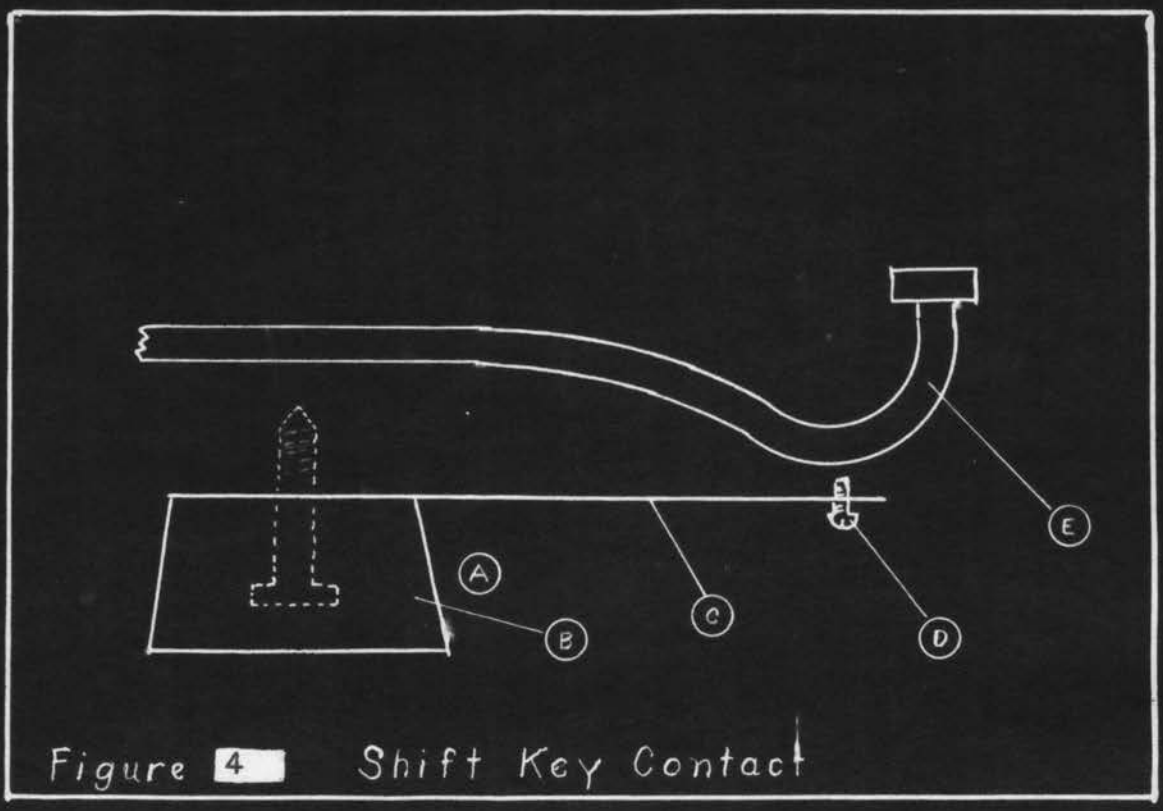

Figure 4 Shift Key Contact

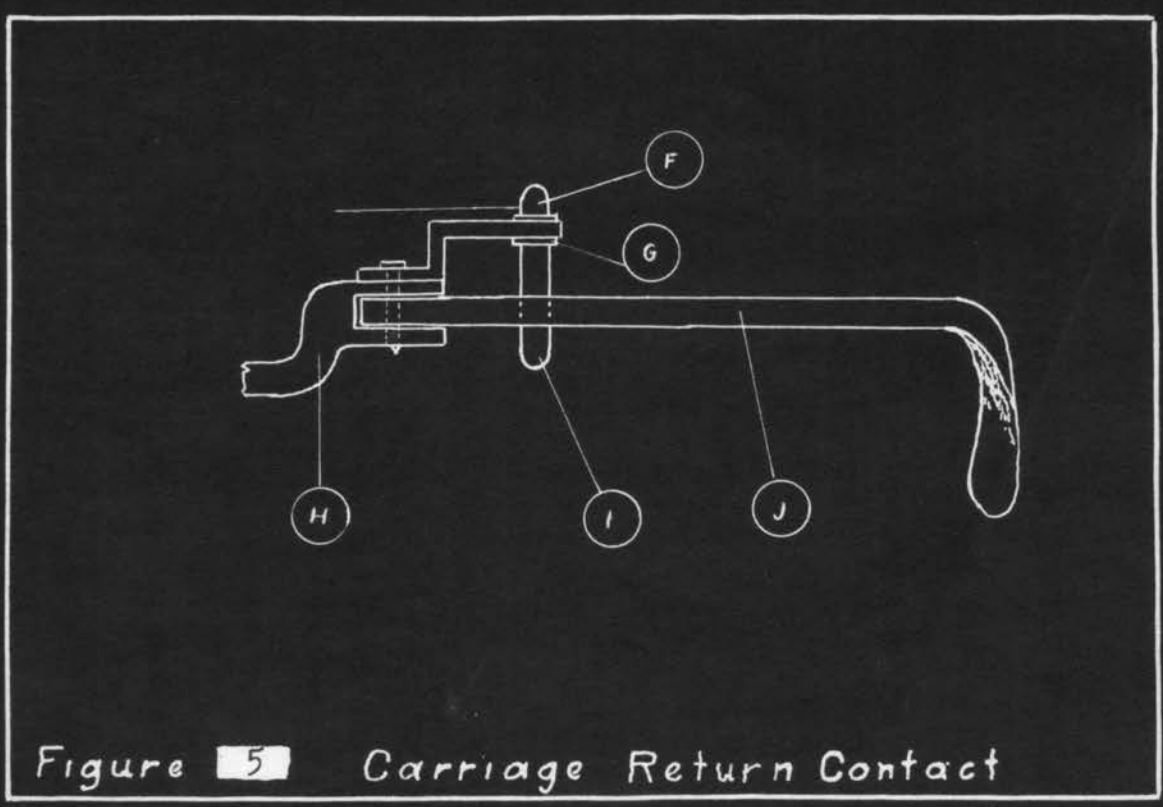

Figure 5 Carriage Return Contact

typewriter would cause a lesser degree of accuracy. Mechanical connections would become more complicated and more changes would be needed on the typewriter.

By using an electrical circuit the measuring device could be placed anywhere in the room and wires used for making connection with the typewriter. Vibration of the typewriter would not affect the test results.

The principle of electromagnetism was selected to furnish motive power for moving the recording pens. It is described as follows:

> When a piece of iron is placed inside of a solenoid, it becomes magnetized and thus produces an electromagnet. . . . The iron core loses much of its magnetism as soon as the current is removed from the coil. Under the action of the current, the minute molecular magnets are more or less oriented in one direction. When the current ceases to flow, this directive force is removed and these molecular magnets again face in various directions.[2]

The stylus arm consisted of a piece of soft iron in the shape of an "L" and the pen was located at the long end of the "L." The short end of the "L" faced the electromagnet. Figure 1-G shows the general location of the magnet used for measuring strokes. The stylus arm is at point "F" in Figure 1.

Method of making contacts. Several methods of making contacts on the typewriter for closing the circuit on the electromagnet were tested. The first was a spring across the machine just in front of the platen. This method showed accurately the rhythm of stroking sequence and the carriage return time but would not show the time used in making the stroke. Some students were distracted by the small spark caused by the contact.

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2. Alpheus W. Smith, The Elements of Physics (New York: McGraw-Hill Book Company, Inc., 1938), p. 437.

The escapement was tried next. Stroking time was partially indicated but, since the space bar made a contact, it was very difficult to assign letters to the graphs after they were made.

While studying the typewriter for a better method it was found that a bar underneath the machine was moved when the key was struck but not when the space bar was struck. The amount of the movement was determined by the key movement. A contact was placed under it and found to be satisfactory. (See Figure 2).

A screw adjustment was arranged to be used in standardization of results. A greater portion of the stroke could be measured by narrowing the gap between the contact points (Figure 2, L-M). Graphs in Figures 5, 6, 7, and 8 were made with the contacts set to allow the maximum of key overlapping without the keys hanging on each other.

Point "P" in Figure 2 is a ground wire for the circuit and may be connected to any convenient part of the typewriter. Point "O" furnishes the return line when a contact is made between "L" and "M" as the typist makes a stroke. Point "K" is the typewriter key and "N" is a small piece of flexible plastic that is attached to the leg of the typewriter.

The method of making the contact for measuring carriage return time is similar to that of the key contact. The return lever (Figure 5-J) furnishes one of the points and the contact is made with a thin piece of flexible metal (Point I). "J" is grounded and point "P" is connected to an electromagnet as shown in Figure 3. "G" insulates the metal strip from the typewriter. "H" is the return lever bracket.

Operation of the shift key was measured by means of a contact placed under it as illustrated in Figure 4. The circuit is closed by contact between "D" and "E." Point "C" is a flexible plastic or plywood and "B" is one of the front legs of the typewriter. Point "E" is grounded to the typewriter. "D" is connected according to the circuit diagram in Figure 3.

The batteries shown in Figure 3 are dry cell telephone type and are connected in series as shown in the circuit diagram. The electromagnets are similar to those used in doorbells.

The carriage and shift key measurements are made through the same magnetically operated pen and are therefore connected as shown in the circuit diagram in Figure 3.

Method of moving paper tape. Motive power for moving the paper recording tape was accomplished by means of a small electric motor. It was arranged in such a manner as to pull the tape under the pens at a constant rate of speed.

To accomplish this, and to meet the mechanical requirements set up on page 19, the following criteria were used in selecting the motor:

(1) The retail price of such a motor had to be low. A top price of six dollars was arbitrarily set.

(2) The motor had to be light in weight. Its weight would account for the greatest percentage of the overall weight of the finished model.

(3) Operating cost had to be low, or somewhere in the range of a house lightbulb.

(4) It had to have sufficient power to assure smooth operation without being overloaded.

(5) Its speed had to be constant when not overloaded.

(6) It must be built in such a manner as to permit convenient speed reduction to the rate of speed desired for the tape.

A small motor of the type used in oscillating electric fans was found to meet all requirements. It was a constant speed squirrel-cage induction type motor.[3] The weight was less than ten pounds. It could be purchased new for approximately five dollars. The rated horsepower was one sixteenth at a speed of 1,750 revolutions per minute. It was equipped with a combination of worm gears and a gear train. A rubber roller was attached directly and had a speed of eight and one-half revolutions per minute. A second rubber roller was placed in surface contact. The paper tape was impelled by friction between the two surfaces. The location of the motor, rubber rollers, and the tape are illustrated in Figure 1.

Summary

Three problems are considered in this chapter dealing with the construction of a device for measuring certain techniques in typewriting. Electrical contacts for circuits connecting the typewriter to the device are illustrated by means of blueprints. The electromagnet is discussed as a means of moving a stylus on a paper tape. A suitable type of motor is described and its use in pulling the tape under recording pens is shown.

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3. Lionel S. Marks, Mechanical Engineers' Handbook, Fourth Edition (New York: McGraw-Hill Book Company, Inc., 1941), p. 2018.

CHAPTER IV

GRAPHIC TESTING OF TYPEWRITING

The validity of a graphic test in typewriting can be established mathematically. Green and Jorgensen define validity as being:

> A term used to express the degree to which a measuring instrument measures the thing it purports to measure. . . .[1]

The mechanical device reported here uses two constants from which a third can be established. Two standard measures, time and distance, are the constants. The third element, which is the length of time an electrical contact closes a circuit, can be measured.

By experiment it was determined that the tape moved under the pens at a constant rate of 13.33 millimeters each second. When the circuits were closed for a definite length of time, the length of the variation recorded on the tape could be measured. By comparison it was determined that the measurement give the same length as this formula: T x R = L. "T" represents the time the circuit was closed. "R" is the rate of movement of the tape, and "L" is the length of variation on the recorded line.

The circuit was then closed for ten seconds and the length of the variation on the recorded line measured. The two constants, time and rate of movement, were substituted in the formula as follows:

$$10 \times 13.33 = 133.33$$

The length of the variation on the recorded line should have been and was 133.33 millimeters in length.

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1. Greene, loc. cit.

The formula was then rewritten to read:

$$L \div R = T$$

so as to give the time used in making a portion of one stroke. For illustration the letter "S" in Figure 7 was measured and found to be 6 millimeters in length. All dimensions were multiplied by three when the drawings were made so the letter "S" had an original length of 2 millimeters. The problem then would be:

$$2 \div 13.33 = .153 \text{ seconds},$$

the time used in making that stroke.

The carriage return interval between the ";" and "j" in Figure 7 is 87 millimeters in length, an original length of 29 millimeters. The time used would be:

$$29 \div 13.33 = 2.17 \text{ seconds},$$

the time used between the last stroke of one line and the first stroke of the next line.

The amount of time the hand is actually on the carriage return lever is shown by the lines above the graphs in Figures 6 and 7. It serves to distinguish the operation of the lever from the total time used in returning the carriage and also helps to distinguish between the interval made by returning the carriage and those intervals between letter strokes and words.

The operation of changing paper would create a long interval between strokes and could be measured by the method discussed in the preceding paragraphs.

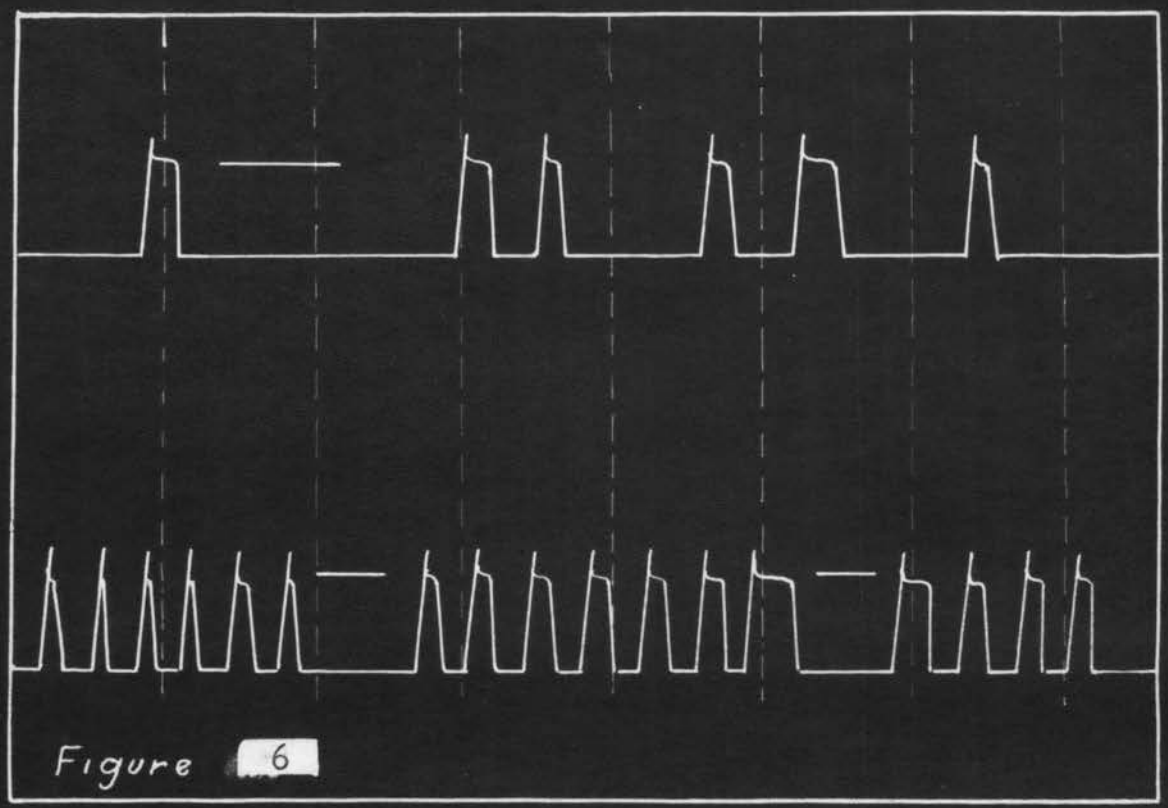

Figure 6

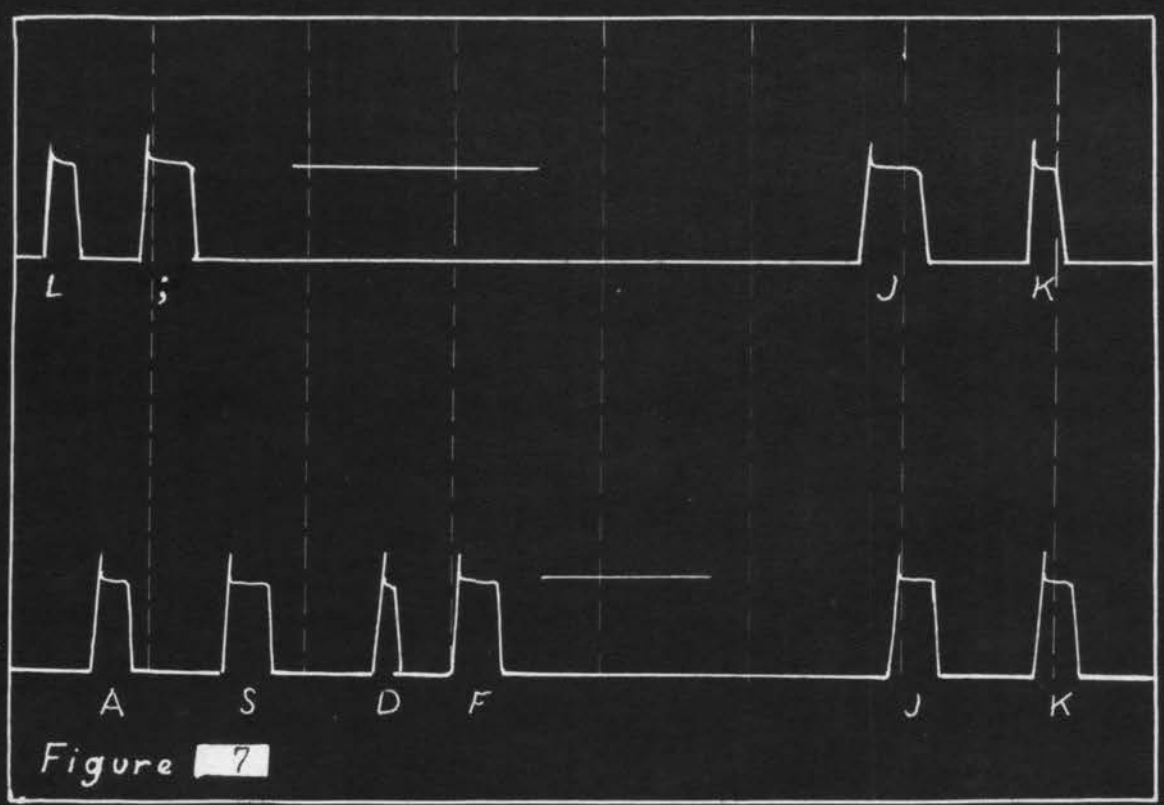

Figure 7

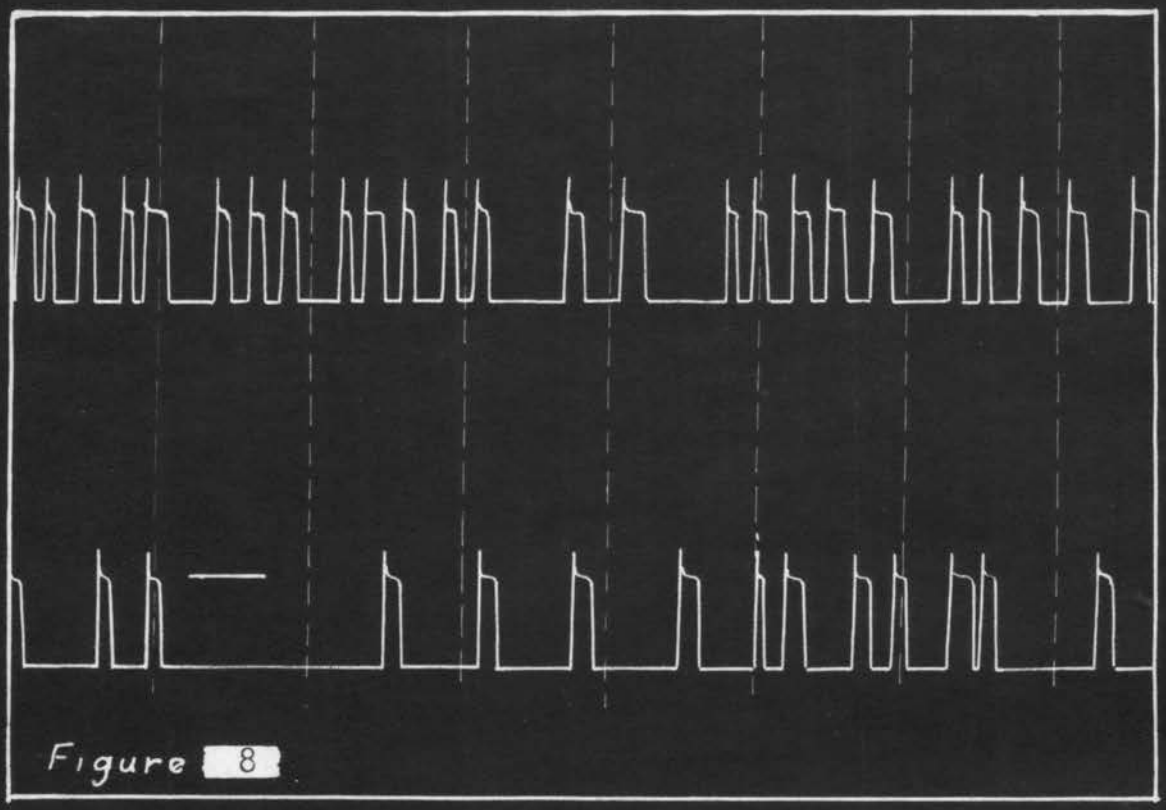

Figure 8

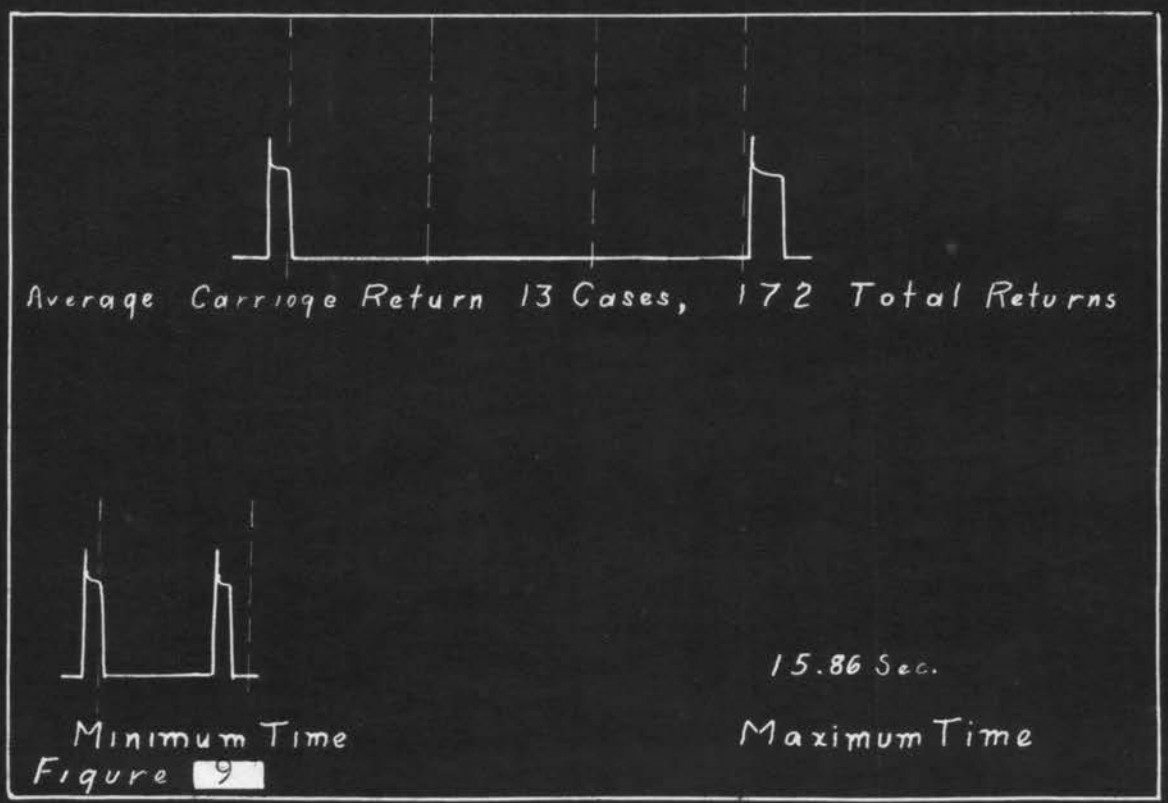

Figure 9

Shifting requires two operations, depressing and releasing the shift key, and making the stroke. A stroke is shown by a variation in the recorded line. Striking and releasing the shift key would move the second pen marking the period of shift key depression with a line over the graph indicating the stroke. Its deviation to the right or left indicates whether the stroke was being made too soon or too late for the letter to be exactly on the line of writing.

Punctuation involves a keyboard stroke and its graph is made in the same manner as the letters of the keyboard.

All of the graphs in the Figures 6, 7, and 8 of this chapter were made with the keyboard contact adjusted to allow a maximum of overlapping of strokes, or that portion of a stroke that would measure from a point where two type bars just pass, on in to the platen, and then back to that point. Greater portions of a stroke could be measured by adjusting the screw shown at "M" in Figure 2.

The finished model met all of the requirements listed in Chapter III with the exception of the fourth. A difference in the mechanics of typewriters of the "standard" and "noiseless" varieties made it difficult to get comparable results. Noiseless typewriters could be adjusted to give uniform results of the type bar action peculiar to these machines.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The need for more skillful teaching in typewriting and more adequate testing devices are pointed out in the first chapter. The purpose, to develop a mechanical test of certain techniques in typewriting, is given and various terms pertinent to the study are defined. Procedures are given for developing a report of the problem.

The second chapter reviews two classes of literature pertaining to the study. The first, literature concerned with learning to typewrite, indicates a need for more adequate testing. The second part of the chapter reviews the historical literature concerned with graphic testing in physiology and psychology.

A working model is described in the third chapter and blue prints are offered showing the circuits and general operating principles.

Chapter four graphically illustrates, through the medium of blueprints, actual tests made with the model. The method of establishing the validity of the tests is described. Requirements listed in chapter three as a guide in constructing a practical working model are reviewed and the extent to which they are met is pointed out.

This chapter offers a summary of the work. In it the uses of graphic tests are suggested.

The methods of graphic motion study, used in experimental physiology and psychology, can be applied to the field of typewriting. These methods make possible the study of certain techniques such as stroking,

carriage return, shifting, paper change, and between-stroke intervals as individual parts of the learning process.

The apparatus used for measuring these techniques is inexpensive to build and simple to operate. The results, when it is used in the classroom, can be made immediately available for the learner, as well as the teacher, to study. The extent of the benefits to be gained from such information is not a part of this study, however, a knowledge of progress promotes better learning, as was pointed out in the review of literature.

Peaks of stroking rate can be measured and may be of value in determining the potential typing speed of the student. Figure 8 shows a student had achieved eight key strokes and one space bar stroke in one second. This gave a gross stroking speed that was nearly twice as great as he was able to make on five minute speed tests in first-year typewriting.

All of the graphic motion studies that have been made so far with the device were to test its operation when used with different typewriters and under varying conditions. Conclusions can not be made from these brief case studies. However, certain implications might be pointed out to be developed in other studies.

Students differed greatly in stroking time, not only in advanced stages of learning to typewrite, but in their very first lessons. Could this be one of the elements of prognosis in typewriting?

Between-stroke intervals decreased as the learner acquired greater skill. Between-stroke intervals of two students were found to be greater than those of other students who had a lower gross speed rate.

Other students were found who were achieving a near maximum overlapping of strokes and yet were typing at a lower rate of speed than the average student in the class.

Time used in returning the carriage was decreased to one half of the original within a few days after the device was made available in the classroom. Was this the result of insufficient teaching earlier in the course or a value derived from use of the test?

Between-stroke intervals at the end of words, but before a punctuation mark, were often longer than those intervals between letters of a word. Is this due to placement on the keyboard, a change from the letter sequence of the word, or lack of skill in using these keys?

Problems that could be investigated by means of graphic testing in typewriting.

(1) The effect of graphic testing as a factor in reducing time losses.

(2) The effect of graphic testing as a factor in motivating learning in typewriting.

(3) The effect of hand size and structure on stroking technique.

(4) The effect of piano skill training on stroking technique.

(5) Development of scales of attainment for the several stages of basic skill development such as:

a. Time needed to return the carriage,

b. Time needed for each individual stroke,

c. Time needed for changing paper, and

d. Time used in between-stroke intervals.

(6) Development of scales of attainment showing the stroking rate per second for beginners.

(7) A comparative study of skill development of the left and right hands in typewriting.

(8) Hand fatigue as a limiting factor in typewriting skill.

(9) The continuity of stroking sequence at the several stages of skill development.

(10) A study of time losses after the carriage return.

BIBLIOGRAPHY

Beebe-Center, J. G. and S. S. Stevens. "Cardiac Acceleration in Emotional Situations." Journal of Experimental Psychology, XXI (July, 1937), 72-87.

Bobbit, Ruth A. "A New Apparatus for the Luria Experiment." Journal of Experimental Psychology, XXVII (November, 1940), 578-582.

Book, William Frederick. Learning to Typewrite. New York: The Gregg Publishing Company, 1925, 463 pp.

Book, William Frederick. "How Progress in Learning to Typewrite Should be Measured and Why." The Business Education World, XV (October, 1934), 101-109.

Book, William Frederick. The Psychology of Skill. New York: The Gregg Publishing Company, 1925, 257 pp.

Bugelski, B. R. "The Consistency of Individual Differences in the Pattern of Work Decrement." Journal of Experimental Psychology, XXVIII (May, 1941), 326-339.

Carmichael, Vernal H. "Objective Measurement of Accomplishment in Typewriting." The Balance Sheet, XII (December, 1930) 106-110.

Clem, Jane E. "New Trends in the Teaching of Typewriting." The Business Education World, XIX (April, 1939), 629-631.

Collier, Madison, "A Technique for the Kymographic Registration of Certain Associated Voluntary Movements." Journal of Experimental Psychology, XXI (August, 1937), 181-193.

Dvorak, August, Nellie L. Merrick, William L. Dealey, and Gertrude Catherine Ford. Typewriting Behavior. New York: The American Book Company, 1936, 521 pp.

Ettinger, Clifford. "The Selection of Visual Aids for Business Education." Fourteenth Yearbook of the Eastern Commercial Teachers Association, Somerville: Somerset Press, Inc. (1941), 433 pp.

Gates, Arthur I. Psychology for Students of Education. New York: The MacMillan Company, 1925, 489 pp.

Gilbreth, Frank B. Motion Study. New York: D. Van Nostrand Company, 1911, 116 pp.

Good, Carter V., A. S. Barr and Douglas E. Scates. The Methodology of Educational Research. New York: D. Appleton-Century Company, Inc., 1935, 890 pp.

Gray, Stanley J. "Basic Principles of Learning." Lesson Plans and Classroom Techniques, Second Yearbook of the National Commercial Teachers Federation. Detroit: National Commercial Teachers Federation, 1936, 291 pp.

Greene, Harry A. and Albert N. Jorgensen. The Use and Interpretation of High School Tests, New York: Longmans, Green and Company, 1937, 614 pp.

Haynes, Benjamin R. "Adapting Scientific Methods to the Everyday Classroom Activities of Teachers of Business." National Business Education Quarterly, VII (June, 1940).

Jasper, Herbert, and Charles Shagass. "Conditioning the Occipital Alpha Rhythm in Man." Journal of Experimental Psychology, XXVIII (May, 1941), 373-387.

Lahy, J. M. Motion Study in Typewriting. International Labour Office Studies and Reports, Series J, No. 3, Geneva: 1924, 63 pp.

Lessenberry, D. D. Methods of Teaching Typewriting. Cincinnati: The South-Western Publishing Company (1937), 24 pp.

Marks, Lionel S. Mechanical Engineers' Handbook. Fourth Edition; New York: McGraw-Hill Book Company, Inc., 1941, 2274 pp.

Poorman, Alfred P. Applied Mechanics. Fourth edition; New York: McGraw-Hill Book Company, Inc., 1940, 354 pp.

Schwamb, Peter, Allyne L. Merrill, and Walter H. James. Elements of Mechanism. Fifth edition; New York: John Wiley and Sons, Inc., 1938, 400 pp.

Seashore, Robert H., Raymond Starman, William E. Kendall, and John S. Helmick. "Group Factors in Simple and Cremonative Reaction Times." Journal of Experimental Psychology, XXIX (October, 1941), 346-349.

Smith, Alpheus W. The Elements of Physics. Fourth edition; New York: McGraw-Hill Book Company, Inc., 1938, 790 pp.

Stuart, Esta Ross. "Revamping the Teaching of Typewriting to Conform to the Modern Trends in Education and Business." Fourteenth Yearbook of the Eastern Commercial Teachers Association, Somerville: Somerset Press, Inc., 1941, 433 pp.

Tate, Meriam. "Visual-Sensory Aids in Typewriting." Typewriting News, XI (Spring, 1941), 7.

Van Dusen, A. C. "Work Methods and Learning." Journal of Experimental Psychology, XXIX (September, 1941), 225-235.

Warren, Neil, and Brant Clark. "Blocking in Mental and Motor Tasks During a 65-hour Vigil." Journal of Experimental Psychology, XXI (July, 1937), 97-105.

Webster, Noah, Twentieth-Century Dictionary. New York: Publishers Guild, Inc., 1936, 1956 pp.

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