A REVISED KEYBOARD

FOR THE

TYPEWRITER

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by

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INTRODUCTION

Chapter I

Suppose there were two weights, one of ten pounds and the other of two pounds, to be carried a distance of three blocks. For this job a man and a small boy about ten years old were available. The question now resolves itself into, Would you want the man to carry the heavier load due to his greater strength? Or, would you want the boy to carry the heavier load because it would be good practice and experience for him in overcoming fatigue and in assuming future heavier loads?

In answer to this question I believe you would take a logical point of view and select the man to carry the heavier of the two loads due to his greater strength.

Now let us take a similar case in the field of typewriting. Suppose you first determine from common word scales that the letter 'a' is one of very high frequency of occurrence in the English language, and also established the fact that the fourth finger of the left hand, which is used to strike the letter 'a', is the weakest of all fingers. Would you in view of these findings want the weakest finger to be used in striking a letter of high frequency?

Furthermore, if you determine from reliable investigations that the right hand is slightly stronger than the left hand, would it not be logical to distribute the work on the typewriter in accordance with the relative strength of the two hands? No doubt, in these cases, you would want the strongest finger to be used in striking a letter which occurs most frequently and you would also distribute the work on the keyboard in accordance with the relative

total finger strength of the left and right hands.

These illustrations will serve to introduce the subject or problem of this thesis, namely A REVISED KEYBOARD FOR THE TYPEWRITER.

The scope of this problem will be limited solely to the letters of the alphabet and will not take into account the numerals and special characters on the keyboard since typewriting is essentially a matter of the use of the letters of the alphabet.

The writer is also fully aware of the difficulties and limitations which this new proposed letter arrangement would entail:

(1) Confusion in the commercial world due to the fact that the standard keyboard is used by thousands of touch operators who would have to start learning the new revised keyboard.

(2) Employers would be reluctant in purchasing a new typewriter equipped with the revised keyboard for their typists and stenographers who were originally taught on the standard keyboard.

(3) Preparation of textbooks or manuals for schools teaching the revised keyboard.

(4) Educating the typewriter manufacturing companies in the advantages of a revised keyboard. Part of this process has already been accomplished since some of the typewriter manufacturers have expressed a willingness to arrange the letters in any order desired by the purchaser.

(5) Reservation is also made with respect to whether a right hand move is more rapid than a left hand move; or, whether a vertical move is more rapid than a horizontal move.

(c) Importance of the Typewriter

The first practical writing machine is about fifty-five years old. During this short space of time the typewriter has become such an essential factor in modern life that the world can hardly be conceived without it.

Since the advent of the typewriter an incalculable amount of time and labor has been saved: the world has been freed from tedious pen slavery. It may justly be said that the enormous growth of modern business has been rendered possible by the time saving and labor saving service of the writing machine.

In addition to this, the typewriter has been partly responsible for the emancipation of women by throwing the doors of business life open to them. In fact, part of our system of education has been changed. Human thought and language have felt its influence.

The striking feature is that all these changes are so comparatively recent that they actually belong to our own times. Many of our big business men well remember when the writing machine first became a factor in commercial life.

The invention of the printing press is one of the salient marks in the progress of civilization, but the latest phase of this story is the invention of the typewriter. It is interesting to note that with the coming of the writing machine, its influence on the art of printing was almost immediate, many improvements in typesetting devices having been directly

Suggested and inspired by the writing machine.

We often hear people speak of the high efficiency of the present-day business man as compared with the business man of seventy-five or one hundred years ago. It is just at this point that we must not fail to give credit for part of this increased efficiency to the writing machine. The typewriter has freed the busy executive from pen slavery and thus preserves his time and energy for the brain work. The twin arts of shorthand and typewriting have helped to free the executive of writing details so that he may devote himself more to the expansion of his business.

The typewriter conserves both mental and physical energy. Not only are many people employed in its production and distribution but it also gives employment to millions of people either directly or indirectly.

There is hardly a business today into which the typewriter does not enter in some form or other. It has extended the scope of one's ability far beyond former limitations. If the typewriter were to become suddenly lost in the business world for one day it would well nigh cause a calamity. The writing machine has very properly been called an invention for the promotion of peace and progress.

The history of the typewriter reads like a good piece of fiction. At first, like most inventions, it was regarded merely as a luxury for the idle rich. A little later it was looked

upon as a convenience for the man of large business interests; today it is universally conceded to be an absolute necessity for all types of commercial, legal, and literary pursuits.

(d) Historical Development of the Typewriter**

The first authentic attempt to invent a writing machine is found in the British Patent Office which shows that a patent was granted on January 7, 1714 by Queen Anne to Henry Mill, an engineer for the New River Water Company.

An examination of these patent papers shows that "Henry Mill hath by great paines and expence brought to perfection an artificial machine for the impressing or transcribing of letters singly or progressively one after another, as in writing, whereby all writings whatsoever may be engrossed in paper or parchment so neat and exact as not to be distinguished from print."

This initial effort on the part of Mills seems, however, to have been only an idea. No model or drawings of the machine exist, nor is there a record to show that they ever did exist.

During the remainder of the eighteenth century we find a few attempts being made in Germany to develop this idea. In 1784 a Frenchman of Marseilles invented a machine which was principally intended for the blind as the characters were embossed. Such a machine had a very limited field. The main idea, however, was the association of the typewriter with the blind and reviving the possibility of writing by printed letters.

In 1829 the first American patent on a typewriter was granted to William Austin Burt of Detroit. The model of this machine was destroyed by a fire in the Washington Patent Office in 1836. This machine carried the type on the segment of a

** 5, Herkimer County Historical Society, 'The Story of the Typewriter 1873 - 1923.'

circle, thus making it the forerunner of the modern type-wheel machine.

In 1833 a French patent was granted to Xavier Projean of Marseilles for a device which he describes as a "Ktypographic" machine. This machine had the type bars arranged in a circle, each type striking downward upon a common center. Thus we find that the present-day principles of the typewriter were embodied in the early devices of Burt's of 1829 and Projean's of 1833.

A very important step was taken by Charles Thurber of Worcester, Mass. to whom a patent was granted in 1843-5. This machine made a notable contribution toward typewriter construction; the letter spacing was accomplished by a longitudinal motion of the cylinder, a principle which is used in our modern machines. It is said that Thurber's machine did actual work but for the want of capital and no demand on the part of the public for such a machine it was never put on the market.

Between this time and the time of the arrival of the first practical typewriter we see many efforts being made to construct a typewriter. Numerous people, both in Europe and in America, tried their hand at this enterprise and took out patents. Among these may be mentioned:

Pierre Foucault, France 1849
Oliver T. Eddy, Baltimore 1850
J. M. Jones, Clyde, New York, 1852
R. S. Thomas, Wilmington, N. C. 1854
A. Ely Beach, New York, 1856
Dr. Samuel W. Francis, New York 1857
F. A. DeMay, New York, 1863
Abner Peeler, Webster City, Iowa, 1866
John Pratt, Centre, Alabama, 1866.

As shown by the above, practically every year patents were granted but with no real success. They only served as stepping-

stones to the succeeding inventor. Each inventor, however, tried to eliminate the bad features and retain the good features of his predecessors, and taken all in all, each is entitled to credit.

During the winter of 1866-67 Christopher Latham Sholes of Milwaukee, Wisconsin was engaged in developing a machine for numbering serially the pages of blank books. Just at this time an article appeared in the Scientific American describing a writing machine invented by John Pratt. It seems this article inspired Sholes to set working on inventing a typewriter. In this work he was assisted by Carlos Glidden and Samuel W. Soule. In June 1868 they had completed and taken out a patent on their first machine. This machine had a great many defects and was very crude in design and construction. A number of letters were written with it by Sholes and fortunately one of these letters fell into the hands of James Densmore, a wealthy iron dealer of Meadville, Pa. Densmore immediately became interested and bought an interest in the new machine before even having seen it. When he finally did see the machine he declared it to be of no value except that the principle involved was feasable. Numerous models were made, about thirty in all, and submitted for trial to practical users, but each one was pronounced a failure. Soule and Glidden at this point became discouraged and dropped out of the enterprise. It was due to the constant help and encouragement of Densmore that Sholes continued in his work.

As Sholes turned out his various models they were sent to James Ogilvie Clephane for practical testing. Clephane was an official shorthand reporter in Washington, D. C., and gladly

tried out one model after another sent to him by Sholes. He was severe in his criticism but that was just what was needed to reveal the weak point of the various models. It seems that Clephane was so critical, so exacting and severe in his criticisms of these models that Sholes came near giving up in despair. Densmore kept assuring Sholes that such fault-finding was exactly what was needed now rather than later once manufacture of the machine has started.

Charles E. Weller, a professional shorthand reporter of LaPorte, Indiana, also tried out the various models as they were turned out by Sholes. Each of the models was sent back by Weller and Clephane who pointed out their shortcomings and suggested various improvements. Densmore insisted that it was absolutely necessary to have outsiders point out the defects of the various models so that the machine might be improved.

The refining process extended over a period of about five years and the total output reached at least fifty or more machines which was produced at an average cost of more than $250.00. At this time they determined to challenge the judgment of the best expert mechanics and so they called in George W. N. Yost of Milwaukee to inspect the machine. After carefully investigating it in every detail he expressed the opinion that what the machine needed most was accuracy in manufacture.

It was late in the month of February, 1873 that Densmore and Yost came to the Remington Works at Ilion, New York, bringing with them the precious model. The Remingtons immediately recognized the possibility of the machine and proposed purchasing the patents, which was duly arranged, together with the consent

of Sholes and Densmore that the machine should be given the name of its manufacturers. Densmore at the time when ownership passed to the Remingtons accepted a royalty, while Sholes, it is said, sold out his royalty rights for $12,000.00 as the amount in full for his share of the patents.

In 1880 we find the first Hammond patents taken out, and the machine was shortly thereafter placed on the market. The Hammond was the first practical type-wheel machine and is today the leading machine of this class.

Soon after the advent of the Hammond there arose the issue of single versus double keyboard. The first double keyboard machine was the Caligraph placed on the market in 1883. The Caligraph was devised principally by a skilled German mechanic named Franz X. Wagner who later gained prominence as the inventor of the Underwood Typewriter. The Underwood typewriter was placed on the market in 1897 by John T. Underwood who had long been connected with the writing machine industry as a pioneer manufacturer of typewriter ribbons and carbon papers.

The L. C. Smith machine was brought out in 1905; the Monarch made its appearance the same year.

In 1908, after a great deal of controversy on visible writing among the various manufacturers of machines, we find a complete revolution in typewriter manufacturing and all machines came out with the front stroke visible writing idea originated by the Underwood.

In 1927, after a great many years of futile experimentation, a typewriter for the Chinese language has at last been perfected,

and oddly enough, by an American inventor, Robert M. Jones, of Stony Point, New York. The thing which made possible the building of such a typewriter was the new alphabet introduced in China recently, called 'Chu Yin Tzu-mu,' or national phonetic alphabet, now being taught in all the Chinese schools.

This alphabet was devised by a council of learned men from all sections of the country. It consists of forty symbols which represent elementary signs, modifiable by tone marks. The Chinese typewriter has a keyboard of 48 characters, comprising all the phonetic symbols, 21 compound signs, Chinese numerals, tone marks, a symbol indicating emphasis, parenthesis marks and a period.

Inasmuch as the writing in the new alphabet is to be read from right to left in true Chinese fashion, and in columns beginning at the right hand upper corner of the sheet and proceeding column by column toward the left, the characters of the keyboard are set sidewise, with the tops of the characters toward the left. Thus, when the sheet has been written, it is necessary only to turn it quarter way around in order to read it in the Chinese manner.

The latest achievement in typewriter construction, according to the Literary Digest of November 26, 1927, is the radio typewriter whereby wireless messages may be sent by the manipulation of a typewriter keyboard and received at a distant point automatically in printed form.

With reference to this new radio typewriter, a writer in the Boston 'Globe' says: "Successful experiments have been

conducted between the Bureau of Standards at Washington and the Naval Research Laboratory, wherein a radio transmitter on the ground was controlled by a modified teletype, and messages issuing therefrom were automatically copied by means of receiving apparatus operating on an airplane in flight."

"This demonstration is responsible for a recent suggestion that this new radiotelegraph system be installed in the Arlington, Virginia, Naval Radio Station for the purpose of sending market reports and similar informative material in typewritten form, and receiving stations equipped with a combination of teletypes and radio receivers could receive these messages in printed form."

"This and other similar uses in the application of the mechanism employed in the automatic transmission and reception of telegrams by land line to the sending of messages by radio are foreshadowed. The apparatus consisting of both sending and receiving units, comprises a base scarcely larger than that of a standard typewriter, and contains a keyboard closely resembling this office utility."

(e) Origin of the Standard or Universal Keyboard

An examination of the keyboard of the first practical typewriter shows that the arrangement of the letters is essentially the same as that of the present-day machine. It is, therefore, appropriate at this particular time to ask, Who invented the universal keyboard?--meaning the present universal arrangement of the letters on the typewriter keys. Of all the questions concerning the origin of the typewriter or any of its features, this is the one most frequently asked. Herbert Etheridge in his book 'Dictionary of Typewriting' says: "Practically every typewriter is fitted with what is known as the 'universal' keyboard, based on the arrangement of the printer's type case of many years ago."

Some believe that the universal keyboard was invented by Alexander Davidson, a mechanic and surveyor of West Virginia, who was also one of the pioneers in the field of commercial education. It is known that Davidson, in the later seventies, made a special study of the subject of scientific keyboard arrangement. But there is no evidence that Davidson ever saw a typewriter before the year 1875, at which time the keyboard had already assumed its present form.

It is positively known that Densmore and Sholes, laboring together, worked out the universal arrangement of the letter keys. Just how they happened to arrive at this arrangement, however, is a point on which there has always been much speculation. It must be remembered that both of these men were

printers by trade, a most important point in this connection. The usual a b c arrangement of letters, which would naturally suggest itself to the ordinary layman, means nothing to a printer, who is more familiar with the arrangement of the type in the printer's case. Here, however, we encounter the fact that the arrangement of the letters on the universal keyboard is nothing like the arrangement of the type in the printer's case.

The truth seems to be that the arrangement of the universal keyboard was mainly influenced by the mechanical difficulties under which Sholes labored. The tendency of the type bars on all the Sholes models was to collide and 'stick fast' at the printing point, and it would have been natural for Sholes to resort to any arrangement of the letters which would tend to diminish this trouble.

CHAPTER II

METHOD OF ATTACK

(a) The first step in this plan of work will be to determine the order of frequency of occurrence of letters of the English alphabet based upon representative vocabulary studies. The following vocabulary scales have been chosen:

(1) Ayres' Spelling Scale

(2) Printers' Scale

(3) Horn's '3009 Commonest Words.'

The Ayres' Scale is probably well known to most teachers and educators. It is the result of a vocabulary investigation covering approximately 368,000 words found in business letters, personal letters, newspaper articles, the Bible, and several English authors. This list is one of the most comprehensive investigations ever made of frequently occurring words in our language.

The Printers' Scale is a list given in Chamber's Encyclopedia under the article 'Printing' and is the result of an investigation made to determine the number of type of each letter to be found in a large printer's font.

Horn's '3009 Commonest Words' is the result of an investigation made in 1923 and published by the National Education Association of the United States, Washington, D. C. in the Fourth Year Book, 1926. This list comprises vocabulary studies of over fifteen million words covering the following sources:

(1) The vocabulary of letters of 26 different types of business.

(2) The vocabulary of personal letters from every state in the Union.

(3) An extensive sampling of the letters of eight noted American writers and eight noted English writers.

(4) The vocabulary of a single individual over a period of eight years.

(5) The vocabulary of letters printed in magazines and metropolitan newspapers.

(6) A comparison of the words thus obtained with the Thorndike list.

Accepting these 3009 words as the most common it would appear that by counting the frequency with which the various letters of the alphabet occur, we should obtain a close approximation to their frequency in the English language, and in the work done on typewriters.

These three tables represent a total of 131,133 letters. The letters of each scale will be placed on a comparable basis in order that an average of the three scales may be obtained, thus making the order of frequency more exact. (See Tables I, II, III, and IV)

At this particular point the writer wishes to call the attention of the reader to the following limitation:

The one thousand common words listed in the Ayres' Scale and the 3009 common words listed in Horn's Scale are only accounted for once for each word, whereas in the Printers' Scale the letters are based not only upon letter frequency but also upon word frequency. An illustration will perhaps serve to make this point a little clearer. In the Ayres' Scale the word of highest frequency at the top of the list is "THE" with a

frequency of 6393. Therefore the letters T, H, and E should be computed each on the basis of 6393. The total of 5433 letters for the Ayres' Scale means a total letter frequency for the one thousand words without regarding word frequency.**

** The writer will carry out this point in a doctorate thesis involving approximately 16,000,000 letters.

(b) Since typewriting is a matter entirely of the use of the hands it will be necessary to make an investigation of the relative total finger strength of the right and left hands.

(c) Since touch typewriting makes demands upon all eight fingers it is necessary to determine the relative strength or ability of the individual fingers.

(d) After the order of frequency of the letters of the English alphabet, the relative total finger strength or ability of the left and right hands, and the relative strength of the individual fingers has been determined, it will be necessary to analyze the present standard or universal keyboard and answer the following questions:

(1) Are the letters on the standard or universal keyboard arranged in such order that the letters which occur most frequently in the scale struck with the strongest fingers? Also, are the weakest fingers used to strike those letters which occur least in the scale of frequency?

(2) Are the letters of the alphabet distributed on the standard or universal keyboard in accordance with the relative total finger strength of the left and right hands?

CHAPTER III

Analysis, Organization and Summary of Data

(a) What is the order of frequency of occurrence of letters of the alphabet in the English language?

TABLE I

Frequency of Occurrence of Letters in the Ayres' Spelling Scale

Letters	Frequency	Raised to 1000
E	734	1000
T	440	599
R	434	591
A	419	571
O	385	524
N	373	508
I	366	498
S	308	419
L	254	346
C	219	298
D	193	263
U	171	233
H	170	232
P	161	219
M	154	210
G	114	155
F	113	154
Y	107	146
B	97	132
W	90	123
V	60	82
K	36	49
J	14	19
X	13	18
Z	5	7
Q	3	4
Totals	5433	7400

The above table shows in the first column the letters arranged in the order of their frequency; in the second column the number of times that each letter occurred in the 5433 letters of this scale. The third column is secured by raising the letter 'E' to 1000 and then multiplying the number of occurrences of each letter by 1.362. The reason for this is to put the individual letters on a suitable basis for later comparison with other tables.

TABLE II

Frequency of Occurrence of Letters in the Printers' Scale

Letters	Frequency	Raised to 1000 in terms of Hundreds
E	12,000	1000
T	9,000	750
A	8,500	708
S	8,000	667
I	8,000	667
O	8,000	667
N	8,000	667
H	6,400	533
R	6,300	525
D	4,400	367
L	4,000	333
U	3,400	283
C	3,000	250
M	3,000	250
F	2,500	208
W	2,000	167
Y	2,000	167
P	1,700	142
G	1,700	142
B	1,600	133
V	1,200	100
K	800	67
Q	500	42
J	400	33
X	400	33
Z	200	17
Totals	107,000	8918

The above table shows in the first column the letters of the alphabet arranged in the order of their frequency found in a large printer's font; in the second column the number of times that each letter occurs out of a total of 107,000 letters. The third column is obtained by raising the letter 'E' to 1000 and then multiplying the frequency of each letter by 8.333. The figures in the last column are expressed in terms of hundreds so that comparison with other tables can be made.

TABLE III

Frequency of Occurrence of Letters in Horn's Common Word List

Letters	Frequency	Raised to 1000
E	2457	1000
A	1497	609
T	1403	571
I	1393	567
R	1356	552
S	1246	507
O	1170	476
L	1019	415
U	865	352
N	855	348
D	808	329
C	790	322
P	582	237
M	533	217
G	524	213
H	450	183
F	360	147
Y	323	131
B	266	108
V	266	108
W	239	97
K	147	60
X	60	24
Q	40	16
J	38	15
Z	13	5
Totals	18,700	7609

The table given above shows in the first column the letters of the alphabet arranged in the order of their frequency: the second column gives the number of times each letter occurs in this list of 3009 words comprising 18,700 letters. The third column is obtained by raising the letter 'E' to 1000 and then multiplying the number of occurrences of each letter by .407 in order to establish a basis for comparing these results with the results obtained in Tables I and II.

An examination of the data given in the preceding three tables will disclose a striking similarity in the order or rank of the various letters of the alphabet. In order to make this study of letter frequency more exact Table IV gives the final order of the letters as a result of averaging the three previous letter scales. Each letter was averaged in terms of 'E' raised to 1000. This was done so that we may get an average which represents a fair basis for determining the letters of the alphabet in the order of their frequency of occurrence.

TABLE IV

Final Order of Frequency of Letters as Result of Averages of Tables I, II, and III

Letters	Raised to 1000
E	1000
T	640
A	629
I	577
R	556
O	556
S	531
N	508
L	365
D	320
H	316
C	290
U	289
M	226
P	199
G	170
F	170
Y	148
W	129
B	124
V	97
K	59
X	25
J	22
Q	21
Z	10
Total	7977

(b) What is the relative total finger strength or finger ability of the left and right hands in typewriting?

Roy E. Hoke in his study on 'The Improvement of Speed and Accuracy in Typewriting' conducted certain tests to establish the relative total finger strength of the left and right hands used in typewriting.

These tests consisted of tapping with each of the eight fingers for thirty seconds and then counting the number of taps made. Three of such tests were conducted as follows:

(1) 50 High Schools Girls,
(2) 46 High School Boys,
(3) 54 College Girls.

Upon examining the results of these tests we find as follows:

TABLE V

Relative Total Finger Strength in Typewriting

	Number of Recorded Taps		
	Left Hand	Right Hand	Total
High School Girls	447	489	936
High School Boys	549	635	1184
College Girls	469	511	980

Using the results of this investigation as a basis of relative total finger strength of the two hands the writer will now give these results in a summary in terms of percentage together with an average:

Summary

	Left Hand	Right Hand
High School Girls	47.7%	52.3%
High School Boys	46.4%	53.6%
College Girls	47.8%	52.2%
AVERAGE	47.3%	52.7%

As a further experiment the writer made the following study with reference to relative total finger strength of the left and right hands:

A class of 18 high school students (10 boys and 8 girls) who had six weeks instruction in typewriting were chosen. The entire keyboard had been covered during that time. Each student was instructed to take the proper position with fingers on the guide keys and the thumbs resting lightly on the space bar. With each finger the proper key on the guide row was struck for 15 seconds and the number of impressions were counted. The number of impressions made by each of the four fingers of the left hand were then totalled. The same procedure was maintained for the right hand.

TABLE VI

Tapping Test on Typewriter -- High School Pupils

Showing total number of impressions made by fingers of left and right hands in 15 seconds

Pupil	Left Hand	Right Hand
1	228	260
2	260	275
3	183	184
4	247	264
5	225	233
6	281	284
7	271	285
8	126	150
9	267	279
10	206	225
11	225	259
12	240	303
13	262	276
14	267	307
15	196	221
16	264	301
17	209	268
18	234	265
Totals	4191	4639

Summary

Hand	Number of Strokes	Percentage
Left	4191	47.46
Right	4639	52.54

An examination of the above results shows the right hand to be slightly stronger than the left hand. The right hand is approximately 53% and the left hand approximately 47%.

(c) What is the relative strength or ability of the individual fingers since touch typewriting makes demands upon all eight fingers?

William W. Nelson in an article published in Science Progress, October 1921, entitled 'Typewriter Reforms--The Combinational Keyboard' states as follows:

> "The really capable or effective fingers are the first and second fingers of each hand. The little finger is the most ineffectual of each hand, especially of the left hand."

As far back as 1891 Elias Longley in 'National Typewriter Instructor' sets up the following premises:

> "(1) The first and second fingers of each hand are certainly the most easily and forcibly used in the manipulation of the keys."
>
> "(2) The third and fourth fingers of the left hand are the weakest and least serviceable of all the eight fingers."

In the Preface of 'Expert Typewriting' by Fritz-Eldridge, Revised Edition, 1921, the following statement is found:

> "The little fingers are naturally weak."

In 'Typewriting by the Project Method' by Emily Manning, published in 1926, we find the following statements:

> "The third finger of each hand is a <u>weak</u> finger." (Page 25)
>
> "The fourth finger of each hand is a <u>very weak</u> finger." (Page 26)

In order to determine the relative strength or abilities of the eight fingers used in touch typewriting the writer made the following study:

A class of high school pupils (10 boys and 8 girls) who had six weeks instruction in typewriting were chosen. The entire

keyboard had been covered during that time. Each student was instructed to take the proper position with fingers resting on the guide keys and the thumbs touching lightly on the space bar. With each finger the proper key on the guide row was struck for fifteen seconds and the number of impressions were then counted.

TABLE VII

Number of Impressions made by each Finger Striking the Typewriter Keys for 15 Seconds

	Left Hand				Right Hand			
Pupil	f 1	d 2	s 3	a 4	j 1	k 2	l 3	; 4
1	61	60	57	50	71	68	60	61
2	75	64	64	57	74	73	66	62
3	46	51	47	39	48	47	45	44
4	68	64	64	51	70	70	64	60
5	62	59	54	50	61	60	58	54
6	80	79	63	59	82	78	64	60
7	73	74	69	55	75	78	70	62
8	34	32	33	27	44	41	33	32
9	74	73	67	53	76	77	69	57
10	67	53	50	36	67	68	49	41
11	64	65	53	43	75	65	63	56
12	63	72	53	52	77	73	80	73
13	75	70	62	55	76	75	64	61
14	78	74	63	52	81	79	75	72
15	61	57	43	35	62	64	49	46
16	76	63	68	57	78	80	78	65
17	58	57	50	44	69	72	66	61
18	67	66	59	42	78	76	64	47
Totals	1182	1133	1019	857	1264	1244	1117	1014
Average	66	63	57	48	70	69	62	56

An examination of the above table reveals the fact that the strongest fingers are the first and second fingers of each hand. The weakest fingers of each hand are the fourth fingers, especially of the left hand.

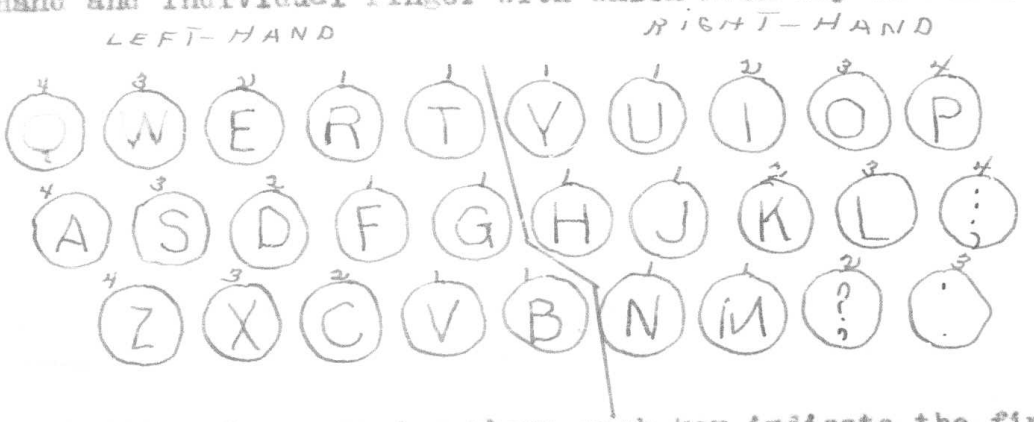
(d) Having examined the order of frequency of occurrence of letters of the English alphabet as shown in Tables I, II, III and IV, and also having determined the relative total finger strength or abilities of the left and right hands (Table VI), as well as the relative strength of the individual fingers (Table VII) it is now necessary to analyze the present standard or universal keyboard and answer the following questions:

(1) Are the letters of highest frequency of occurrence struck with the strongest fingers; are the letters which occur lowest in the scale of frequency struck with the weakest fingers?

(2) Are the letters on the standard keyboard distributed in accordance with the relative total finger strength of the left and right hands?

Figure 1

Diagram of Standard Keyboard Showing Individual Hand and Individual Finger With Which Each Key is Struck



The numerals appearing above each key indicate the finger with which each key is struck. This method of fingering is taken from "A Practical Course in Touch Typewriting" by Charles E. Smith, (Complete High School Edition, Isaac Pitman & Sons, New York, 1927). This book appears on the Purchase List of the Board of Education, New York City, and is in use in many high schools of New York City.

TABLE VIII

Showing Letters Arranged in Order of Frequency (taken from Table IV) Together with Hand and Individual Finger with which each Key is Struck on the Standard Keyboard

Key	Finger and Hand
E	L 2
T	L 1
A	L 4
I	R 2
R	L 1
O	R 3
S	L 3
N	R 1
L	R 3
D	L 2
H	R 1
C	L 2
U	R 1
M	R 1
P	R 4
G	L 1
F	L 1
Y	R 1
W	L 3
B	L 1
V	L 1
K	R 2
X	L 3
J	R 1
Q	L 4
Z	L 4

Table VIII also reveals the fact that 15 letters are struck with the left hand while 11 letters are struck with the right hand. Figure 1 on the preceding page makes this fact more apparent.

TABLE IX

Hand and Individual Finger Load
of the Standard Typewriter

Left Hand	Ayres	Printers	Horn	Average
Q	3	500	40	21
W	90	2000	239	129
E	734	12000	2457	1000
R	434	6300	1356	556
T	440	9000	1403	640
A	419	8500	1497	629
S	308	8000	1246	531
D	193	4400	808	320
F	113	2500	360	170
G	114	1700	524	170
Z	5	200	13	10
X	13	400	60	25
C	219	3000	790	290
V	60	1200	266	97
B	97	1600	266	124
Totals	3242	61,300	11,325	4712
Right Hand				
Y	107	2000	323	148
U	171	3400	865	289
I	366	8000	1393	577
O	385	8000	1170	556
P	161	1700	582	199
H	170	6400	450	316
J	14	400	38	22
K	36	800	147	59
L	254	4000	1019	365
N	373	8000	855	508
M	154	3000	533	226
Totals	2191	45,700	7375	3265

TABLE X

Composite Table Showing Hand Load of
Standard or Universal Typewriter Keyboard Taken From
Table IX Expressed in Percentage

	Left Hand	Right Hand
Ayres'	60%	40%
Printers	57%	43%
Horn	60%	40%
AVERAGE	59%	41%

TABLE XI

Individual Finger Load of Standard Keyboard

R 1		R 2		R 3		R 4	
Y	148	I	577	O	556	P	199
H	316	K	59	L	365		
N	508						
U	289						
J	22						
M	226						
	1509		636		921		199

L 1		L 2		L 3		L 4	
R	556	E	1000	W	129	Q	21
F	170	D	320	S	531	A	629
V	97	C	290	X	25	Z	10
T	640						
G	170						
B	124						
	1757		1610		685		660

In the above table the figures following each key indicate the letter frequency as found in Table IV. R 1 means the first finger of the right hand; L 1 means the first finger of the left hand, etc.

TABLE XII

Percentage of Work Done By The Fingers Individually With Respect To The Total Work Done By The Right Hand Separately, and Also By The Left Hand Separately

Fingers		1	2	3	4
Right Hand	100%	46%	20%	28%	6%
Left Hand	100%	37%	34%	15%	14%

TABLE XIII

Individual Finger Load of Standard Keyboard Expressed in Percentage With Respect To Total Load Carried By Both Hands

Fingers	1	2	3	4	Total
Right Hand	19%	8%	12%	2%	41%
Left Hand	22%	20%	9%	8%	59%

(e) How should the letters on a typewriter keyboard be arranged in order to bear out the findings in answer to Questions (a), (b), and (c)?

TABLE XIV

Showing Present Method of Operating or Fingering Letters on the Standard Keyboard and Logical Hand and Finger With Which Key Ought To Be Operated According to Individual Finger Strength

Key	Finger and Hand on Standard Keyboard	Logical Finger and Hand	
E	L 2	R 1	
T	L 1	L 1	(No Change)
A	L 4	R 1	
I	R 2	L 1	
R	L 1	R 1	
O	R 3	L 1	
S	L 3	R 1	
N	R 1	L 1	
L	R 3	R 1	
D	L 2	L 1	
H	R 1	R 1	(No Change)
C	L 2	L 1	
U	R 1	R 2	
M	R 1	L 2	
P	R 4	R 2	
G	L 1	L 2	
F	L 1	R 2	
Y	R 1	L 2	
W	L 3	R 3	
B	L 1	L 3	
V	L 1	R 3	
K	R 2	L 3	
X	L 3	R 3	
J	R 1	L 3	
Q	L 4	R 4	
Z	L 4	R 4	

L represents Left Hand
R represents Right Hand
The Number following L or R represents the finger

Table XIV shows in the first column the letters of the alphabet arranged according to order of highest frequency (Table IV). In the second column is given the finger and hand with which the letter is struck on the standard or universal keyboard. In the third or last column is given the finger and hand with which the key should be struck based upon letter frequency and individual finger strength (Table VII). An examination of this table reveals the fact that the keys 'T' and 'H' are the only keys on the standard keyboard which are struck with the proper hand and proper finger.

Figure 2

A Suggested Revised Keyboard

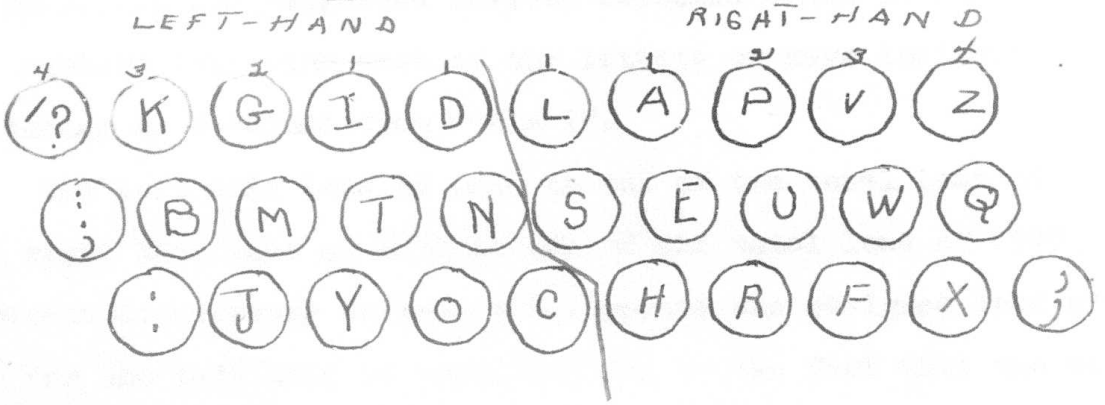


TABLE XV

Hand Loads of Suggested Revised Keyboard

Left Hand		Right Hand	
D	320	L	365
N	508	S	531
C	290	H	316
I	577	A	629
T	640	E	1000
O	556	R	556
G	170	P	199
M	226	U	289
Y	148	F	170
K	59	V	97
B	124	W	129
J	22	X	25
		Z	10
		Q	21
	3640		4337

Table XV shows the individual hand loads or burdens of work in operating the suggested revised keyboard shown in Figure 2. The numbers following each of the letters or keys indicate the frequency as obtained from Table IV.

The left hand load of 3640 is 46% of the total load of 7977; the right hand load of 4337 is 54% of the total load of 7977. The apparent discrepancy between 47% strength and assigned load of 46% for the left hand is accounted for by the fact that the fourth finger of the left hand is solely used for striking punctuation marks and hence does not enter into consideration in figuring on the basis of letters of the alphabet.

TABLE XVI

Individual Finger Load of Revised Keyboard

Right Hand

R 1		R 2		R 3		R 4	
L	365	P	199	V	97	Z	10
S	531	U	289	W	129	Q	21
H	316	F	170	X	25		
A	629						
E	1000						
R	556						
	3397		658		251		31

Total for Right Hand: 4337

Left Hand

L 1		L 2		L 3		L 4	
I	577	G	170	K	59		
T	640	M	226	B	124		
O	556	Y	148	J	22		
D	320						
N	508						
C	290						
	2891		544		205		0

Total for Left Hand: 3640

TABLE XVII

Individual Finger Loads of Revised Keyboard Figured on Basis of Work Done Separately by Left Hand and Right Hand

Fingers	1	2	3	4
Right Hand - 100%	78.3%	15%	6%	.7%
Left Hand - 100%	79%	15%	6%	0%

TABLE XVIII

Individual Finger Loads of Revised Keyboard With Respect to Total Load Carried By Both Hands

Fingers	1	2	3	4
Right Hand - 54%	42.5%	8.2%	3%	.3%
Left Hand - 46%	36%	7%	3%	0%

Additional Factors Governing Construction of Revised Keyboard

(1) Punctuation marks are so placed on the new proposed keyboard that they are struck with the weakest finger. All manuals or textbooks teaching typewriting advise striking these marks with a very light touch in order to prevent their piercing the paper. The writer therefore believes that if these marks are allotted to the weakest fingers this object will be accomplished.

(2) The writer also believes that with the hand and individual finger loads distributed logically according to their relative finger strength a great step will be taken toward rhythm, ease of operation and accuracy.

(3) The new proposed keyboard is so constructed that it can be taught beginning with the strongest fingers from the central portion of the keyboard and proceeding outward toward the weakest fingers. From the very start words can be written by the beginning student. As an illustration, with the first finger of the right hand words can already be written such as, LASH, SHE, HASH, RASH, etc. In order to secure balance the first finger of each hand can be utilized to write such words as LOAD, SOD, TALE, etc. This will secure balance of operation, minimum hand motion and rhythm in writing.

(4) These intensive word drills with the first finger from practically the first day of instruction will inspire the student with enthusiasm and interest. This feature is what makes the proposed new keyboard fundamentally and pedagogically sound.

(5) Another noteworthy feature of this revised keyboard is

the fact that such frequent consonant combinations as TH, ND, CH, LY, NS, MP, SM and also such frequent vowel combinations as OU, AI, EI, OA are written by the use of fingers on opposite sides of the keyboard. This will be an additional step in the direction of balance and freedom of movement.

Summary

(1) The historical development of the typewriter was traced from the first attempt in 1714 at typewriter construction up to the end of 1927. The purpose in the writer's mind was to show whether any attempt had been made to revise or rearrange the letters on the keyboard. This naturally brought up the question as to who invented the present standard keyboard and an effort was made to answer this much propounded question.

(2) A study was then undertaken to determine the order of frequency of letters of the English alphabet. For this purpose three well-known scales were chosen. In an endeavor to get a final order of letter frequency as expressed in Table IV the three scales were averaged and expressed on a common basis.

(3) In order to get at the matter of relative total finger strength of the left and right hands the writer used the results of a study made by Hokes in "The Improvement of Speed and Accuracy in Typewriting" in which it was shown that the total finger strength of the left and right hands is 47.3% and 52.7% respectively(Table V).

(4) The next step was to get at individual finger strength. In this connection the writer quoted well-known authors of typewriting manuals and textbooks and also carried on an experiment of his own. Here it was determined that the first and second fingers of each hand are the strongest, while the fourth fingers are the weakest, especially the fourth finger of the left hand.

(5) The present standard or universal keyboard was then taken to show the method of fingering as taught in many New York City

high schools on the basis of the letters of the alphabet arranged in the order of frequency (Table VIII).

Table X shows that on the standard or universal keyboard the left hand does 59% of the total work and the right hand does 41% of the total work. In other words, the left hand carries approximately three-fifths of the total load and the right hand carries approximately two-fifths of the total load.

Table XIII shows the percentage of work done by the eight individual fingers on the basis of the total work done by both hands on the standard keyboard. The striking feature revealed in this table shows that the first finger of the left hand does a little more than one-fifth of the total work, and the weakest finger, namely the fourth finger of the left hand, does eight per cent of the total work.

(6) The last step was a comparison (shown in Table XIV) between the hand and finger which is used to strike each key on the standard or universal keyboard and the hand and finger which logically ought to be used in accordance with its strength based upon letter frequency.

The revised keyboard is shown in Figure 2 on Page 36. Tables XV and XVI show the individual hand loads and individual finger loads respectively for the proposed keyboard.

CHAPTER IV

Conclusions

As a result of this investigation the following conclusions are drawn:

(1) The present standard or universal keyboard is defective from the standpoint that the letters which occur most frequently are not in the majority of cases struck with the strongest fingers.

(2) The letters which occur lowest in the scale of frequency are not in the majority of cases struck with the weakest finger according to the present arrangement of the letters on the standard or universal keyboard.

(3) The work assigned to the left and right hands in typewriting on the standard or universal keyboard is not in accordance with the relative total finger strength of the individual left and right hands. In Table V it was pointed out that the relative total finger strength of the left hand is 47.3% and the relative total finger strength of the right hand is 52.7%. Furthermore, Table VI (the writer's own experiment) shows also that the relative total finger strength of the left hand is 47.46% and the relative total finger strength of the right hand is 52.54%. In other words, the relative total finger strength of the left hand is approximately 47% and that of the right hand is approximately 53%. In view of these findings, however, the work on the present standard keyboard (Table X) shows that the work is distributed so that the left hand carries 59% of the total load and the right hand carries 41% of the total load.

(4) A keyboard should therefore be devised which will distribute the hand loads more in accordance with the relative total finger strength of the individual hands; also, a distribution of individual finger loads more in accordance with individual finger strength. (Figure 2 and Tables XV, XVI, XVII, and XVIII)

CHAPTER V

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