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On the Prehistory of QWERTY

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Abstract

QWERTY keyboard is widely used for information processing nowadays in Japan, United States, and other countries. And the most frequently asked question about the keyboard is: "Why are the letters of the keyboard arranged the way they are?" Several papers in the field of information processing answer the question like this: "To slow down the operator." It's nonsense.

In this paper we reveal the prehistory of QWERTY keyboard along the history of telegraph apparatus: Morse, Hughes-Phelps, and Teletype. The early keyboard of Type-Writer was derived from Hughes-Phelps Printing Telegraph, and it was developed for Morse receivers. The keyboard arrangement very often changed during the development, and accidentally grew into QWERTY among the different requirements. QWERTY was adopted by Teletype in the 1910's, and Teletype was widely used as a computer terminal later.

1. Introduction

On February 1980 issue of Journal of Information Processing, Prof. Hisao Yamada of the University of Tokyo contributed an invited paper titled "A Historical Study of Typewriters and Typing Methods."[1] The paper was an excellent survey of the history of keyboard arrangements on typewriters and computers, so it has been referred by hundreds of papers and books for these 30 years. But the paper included a few misunderstandings, especially about the prehistory of QWERTY keyboard:

> *Hence the original keyboard arrangement of 1873 was experimentally arrived at by Sholes in part by arranging the typebars for some frequent digrams in the English*

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language at opposite locations across the round basket. At the same time, in the empirical process, the keyboard arrangement was unintentionally made more difficult to type fast on.

The misunderstanding has been spread, exaggerated, and repeatedly told in so many papers and books just as follows:[2]

Historians of typewriter design agree, the current QWERTY arrangement was arrived at by Sholes and his associates to satisfy mechanical restraints, and was intended to slow down the operator so that type bars would not jam.

We don't agree it. Christopher Latham Sholes, the father of "Type-Writer," did not arrange the typebars in such way. And he never intended to slow down the operator.

In this paper we describe the prehistory of QWERTY keyboard. We also mention about our recent research on Type-Writers made in the 1870's. Then we debunk several urban legends about QWERTY.

2. Prehistory of QWERTY

In November, 1868, Sholes and his colleagues, Carlos Glidden, Samuel Willard Soulé, and James Densmore, in Milwaukee shipped out their first Type-Writer to Chicago.[3] Their first customer was Edward Payson Porter, the principal of Porter's Telegraph College, Chicago. The keyboard of Type-Writer at that time consisted of 28 keys, looked like a piano, and resembled Hughes-Phelps Printing Telegraph (Fig. 1) that was used in Porter's College. The arrangement of keyboard was in alphabetical order, A to N in left-to-right and O to Z in right-to-left.

In order to receive Morse telegraph and to write it down, Porter required numerals on Type-Writer. In April, 1870, helped by Matthias Schwalbach, Sholes completed new Type-Writer with 38 keys, which consisted of capitals, numerals 2 to 9, hyphen, comma, period, and question mark. According to typewritten letters and patents of Sholes, the keyboard consisted of four rows, nearly in alphabetical order, but U was next to O. It puzzled us.

In the result we found a presumable arrangement shown in Fig. 2. We derived it from Fig. 1, moving vowels, A, E, I, O, U, and Y, to the upper row. We placed numerals and hyphen at the top row as we see nowadays.

In September, 1870, Sholes and Densmore visited New York to meet George

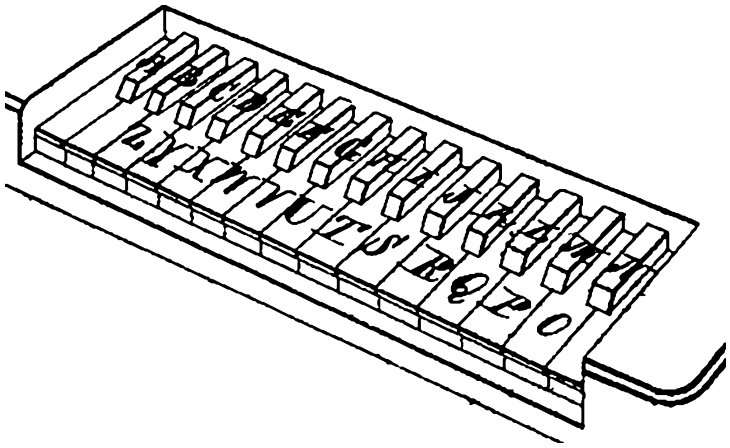

Fig. 1. Keyboard of Hughes-Phelps Printing Telegraph [4]

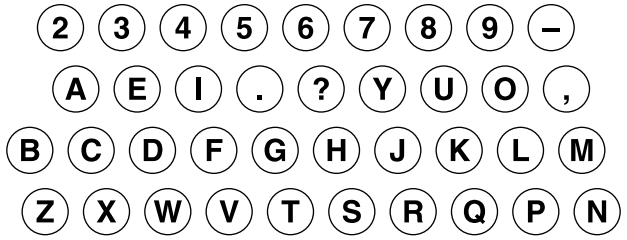

Fig. 2. Presumable keyboard arrangement in April, 1870

Harrington and Daniel Hutchins Craig of the American Telegraph Works. Sholes and Densmore demonstrated Type-Writer, then severely criticized by one of Harrington's partners, Thomas Alva Edison, as follows:[5]

> *"This typewriter proved a difficult thing," says Edison, "to make commercial. The alignment of the letters was awful. One letter would be one-sixteenth of an inch above the others; and all the letters wanted to wander out of line.*

But Harrington and Craig promised to purchase several Type-Writers, while they required many improvements including the change of keyboard arrangement. At least, in our opinion, T, the most frequently-used consonant,

should have moved to the center of keyboard, W, the other semivowel, to the upper row, Q, less frequently-used letter, to the edge, and I, also used for the numeral 1, near by 8 to type "1870" or "1871" rapidly. S should have moved in between Z and E because of the ambiguity of American Morse Code (Fig. 3). The code represents Z as "· · · ·" which is often confused with the digram SE, more frequently-used than Z. Sometimes Morse receivers in United States cannot determine whether Z or SE is applicable, especially in the first letter(s) of a word, before they receive following letters. Thus S ought to be placed near by both Z and E on the keyboard for Morse receivers to type them quickly.[1]

On August 10, 1872, Scientific American featured Type-Writer on the front page [8] with a big engraving that enabled us to see the keytops (Fig. 4). At that time Type-Writer had 42 keys, which consisted of capitals, numerals 2 to 9, hyphen, comma, apostrophe, period, underline, ampersand, question mark, and semicolon. Compared to Fig. 2, half of the letters, D, E, F, G, H, J, K, L, M, O, U, V, and Z, remained in their positions, but other letters were moved by the requirements of Harrington and Craig.

The Type-Writer article on Scientific American claimed that anyone could become able to write from 60 to 80 words per minute. It seems an overstatement, in fact they could reach 30 words per minute when receiving Morse telegraph. In the autumn of 1872, Densmore and Porter demonstrated Type-Writer to Gen. Anson Stager, the president of the Western Union Telegraph Company, Chicago, as follows:[9]

Porter attached the "sounder" to the typewriter, and cried out: "Ready, General!"

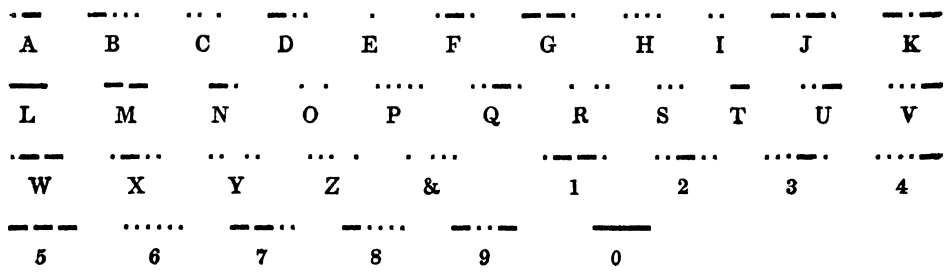

Fig. 3. American Morse Code [6]

[1] By the same reason C ought to be placed near by IE. But, in fact, C was more often confused with S.[7]

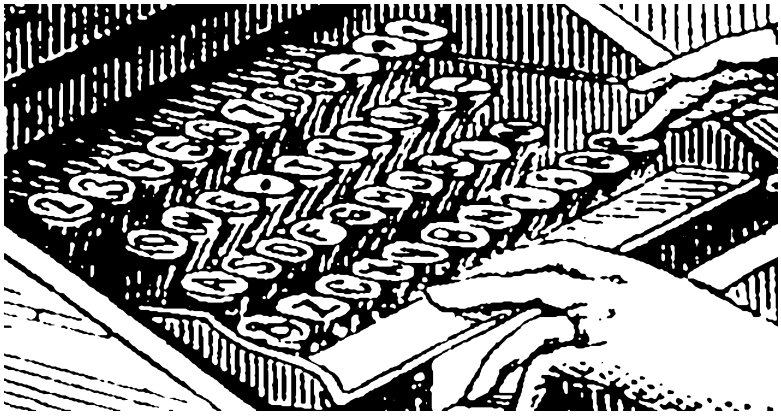

Fig. 4. Keyboard arrangement in July, 1872

The general began to "send" very slowly, as if sure that Porter would be unable to "receive" unless he did so; but before the first line was written; Porter called out: "Faster, General!" The general then sent faster, but immediately Porter again cried out: "Faster, General!" The general then "put in his best licks," but Porter directly again cried out: "Faster, General!" Then the general stopped, and struck his page-bell. When the page appeared, the general said to him: "Send Smith down here."

In February, 1873, Densmore and his partner, George Washington Newton Yost, visited E. Remington & Sons, Ilion, New York. They carried Type-Writer with 43 keys (Fig. 5) to be examined by four Remington people: Philo Remington, Henry Harper Benedict, William McKendree Jenne, and Jefferson Moody Clough. On March 1, 1873, Densmore and Remington signed a contract for manufacture. In May, 1873, Sholes visited Remington, and they decided the brand name as "Sholes & Glidden Type-Writer."[10]

Jenne and Clough perfected a trial model of Sholes & Glidden Type-Writer in the autumn of 1873. It looked like a sewing machine with a foot pedal for carriage return.[11] The keyboard was arranged as shown in Fig. 6, where period was moved near by semicolon, and O, also used for the numeral 0, near by I and 9. "⁝" was added at the left edge of keyboard to indicate "paragraph separator" ("– – – –" in Morse Code of the Western Union Telegraph Company) that was often used when receiving newspaper articles. Sholes was unsatisfied with the arrangement, and demanded to move Y to the center. As a result Y

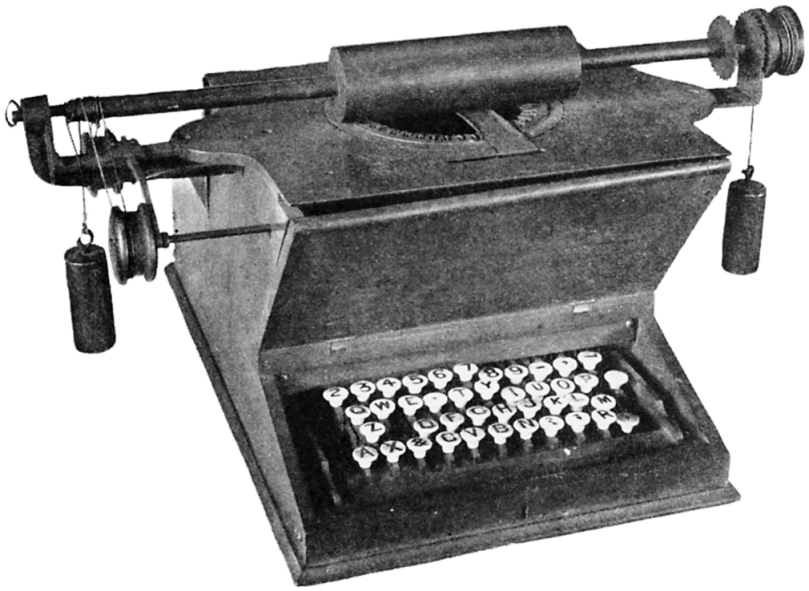

Fig. 5. Type-Writer, brought to Ilion in February, 1873

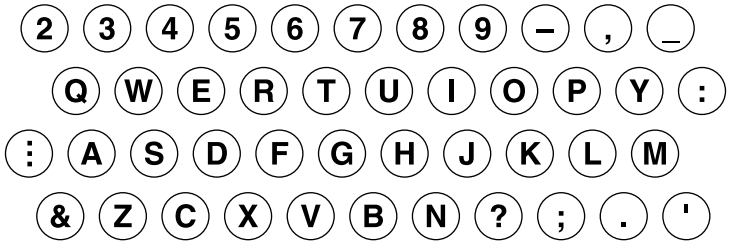

Fig. 6. Keyboard arrangement in the autumn of 1873

was moved next to T on the keyboard of Sholes & Glidden Type-Writer (Fig. 7) and the keyboard arrangement was patented by Sholes.[12] E. Remington & Sons released Sholes & Glidden Type-Writer in April, 1874, and shipped out "Serial No. 1" to Stager.

On December 28, 1874, Yost and Densmore founded the Type Writer Company to secure Type-Writer patents. Densmore assigned patents of Sholes, Glidden, Schwalbach, Jenne, and Clough to the Type Writer Company. In

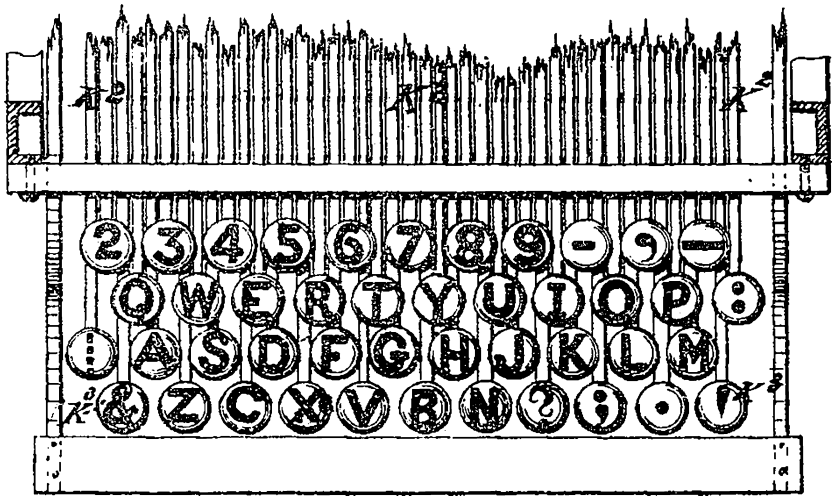

Fig. 7. Keyboard of Sholes & Glidden Type-Writer

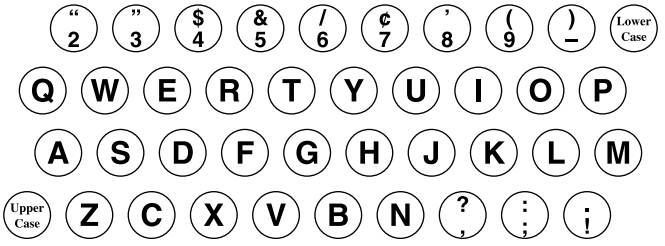

Fig. 8. Keyboard arrangement of Remington Type-Writer No. 2

December, 1875, Yost visited Byron Alden Brooks, who invented the platen-shift mechanism.[13] With the machanism Type-Writer could print capital and small letters with the same key. Brooks sold the idea to E. Remington & Sons, then Jenne and Benedict began to develop new Type-Writer.

In January, 1878, E. Remington & Sons released Remington Type-Writer No. 2.[14] It had 40 keys with the arrangement as shown in Fig. 8. When the "Upper Case" key pressed down, the platen moved forward, then typebars typed capital letters and punctuations. When the "Lower Case" key pressed down, the platen moved backward, then typebars typed small letters, numerals,

hyphen, comma, semicolon, and exclamation mark.

Customers of Remington Type-Writer No. 2 were not telegraphers, but mostly shorthanders. As soon as No. 2 released, William Ozmun Wyckoff of Ithaca, New York, began to teach his six-finger typing method, using first to third fingers of both hands, to his shorthand pupils at Phonographic Institute. Wyckoff provided several examples of his fingering as follows:[15]

3 2 3 1	1 2 1	1 3 2 2 1	3 1 2 1	3 1 3 2 1 3 2 1 2	1 1 2 2	2 3 1	1 2 1
away	can	house	much	supersede	this	was	you
L L L R	L L R	R R R L L	R R L R	L R R L L L L L L	L R R L	L L L	L R R

On August 1, 1882, E. Remington & Sons entered into an exclusive selling agreement of Type-Writer with Wyckoff and Benedict, and they established a new company "Wyckoff, Seamans & Benedict" with Clarence Walker Seamans of New York. WS&B released a new model, Remington Standard Type-Writer No. 2. In order to evade the patents that were assigned to the Type Writer Company, WS&B slightly changed the design of No. 2 including the keyboard arrangement (Fig. 9), where M was moved next to N, and C was exchanged with X. It was the QWERTY keyboard arrangement as seen nowadays.

On August 31, 1882, Elizabeth Margaret Vater Longley[2] presented her eight-finger typing method, using first to fourth fingers of both hands, at the First Annual International Congress of Shorthand Writers held in Cincinnati.[16] Then she started to teach her typing method at her own school, the Cincinnati Shorthand and Type-Writer Institute. To compare with Wyckoff's

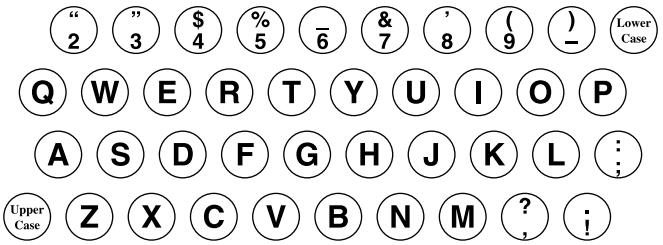

Fig. 9. Keyboard arrangement of Remington Standard Type-Writer No. 2

[2] Prof. Yamada [1] wrote her name as "Mrs. L. V. Longley" by mistake. Prof. Yamada also mistook Wyckoff for "Wycoff" and Louis Traub of Longley's Institute for "Louis Taub."

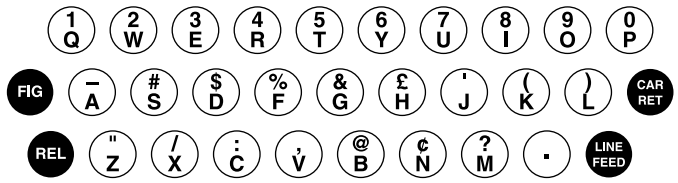

Fig. 10. Keyboard arrangement of early Teletype

method, here we show some examples of her fingering:[17]

4 3 4 1	2 4 1	1 3 2 3 2	2 1 2 1	3 2 1 1 2 1 1 2 3	1 1 2 3	3 4 3	1 3 2
away	can	house	much	submitted	this	was	you
L L L R	L L R	R R R L L	R R L R	L R L R R L L L L	L R R L	L L L	R R R

Of course, fingering of "can" or "much" was much different between Wyckoff's and Longley's, because C and M (and X) were moved in the new model.

On March 30, 1893, WS&B and their partner, Charles Newell Fowler of the Equitable Mortgage Company, founded the Union Typewriter Company as the shareholder of five leading typewriter companies, Remington, Caligraph, Yost, Densmore, and Smith-Premier, to form the Typewriter Trust.[18] As the five companies adopted QWERTY on their typewriters, by June, 1898, QWERTY became de facto standard.

QWERTY was adopted by Teletype (Fig. 10) in the 1910's.[19] Teletype was widely used as a computer terminal from 1940's to 1970's in United States, United Kingdom, and Japan. As a result computer keyboards have become QWERTY there, even now.

3. Debunking QWERTY Legends

Tracing the prehistory of QWERTY, we have investigated Type-Writers made in the 1870's. We found several Sholes & Glidden Type-Writers at Milwaukee Public Museum, Smithsonian Institution, Nagoya Sangyo University, and other places. Against Prof. Yamada [1] we realized that the typebar basket of Sholes & Glidden Type-Writer (Fig. 11) did not mathematically correspond to the keyboard arrangement shown in Fig. 7. Somewhat ad hoc. For example, almost all numerals were located on every two typebars in the basket, but the numerals 3 and 4 were next to one another.

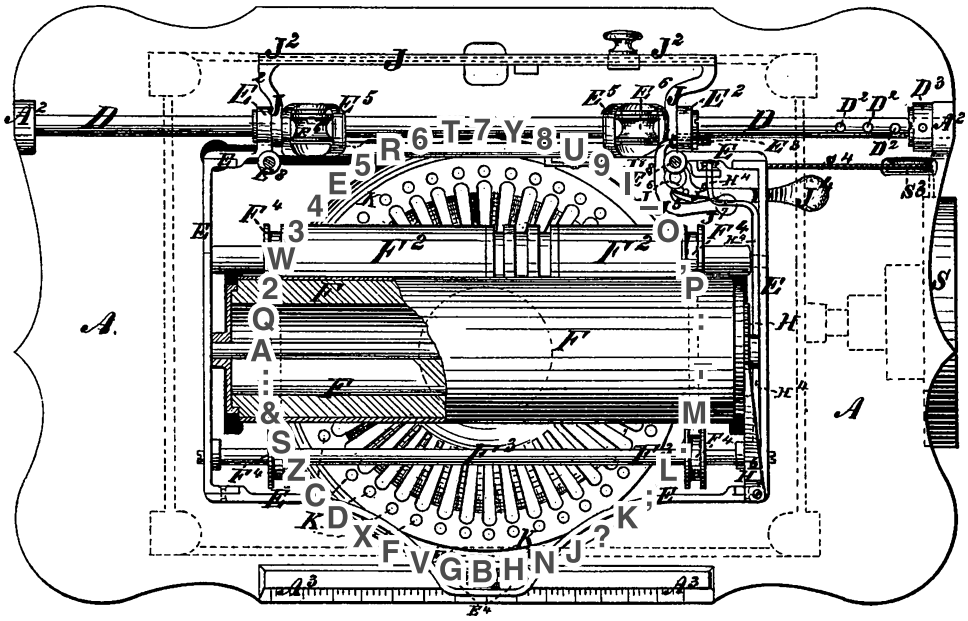

Fig. 11. Typebar basket of Sholes & Glidden Type-Writer (top view)

In Table 1 we show frequently-used digrams in English with their typebar distances in the basket of Sholes & Glidden Type-Writer. Surely the most frequently-used digram, TH + HT, was placed in opposite locations across the basket. But the second one, ER + RE, was placed adjacently in the basket. Considering the fact that Jenne and Clough intentionally moved R near by E in place of period, we argue against Prof. Yamada about the typebar locations of E and R. So as other frequently-used digrams: A and N, I and T, and so on.

Now we consider whether QWERTY "was intended to slow down the operator." It's false. As described in Section 2, early customers of Type-Writer were Morse receivers. The speed of Morse receiver should be equal to the Morse sender, of course. If Sholes really arranged the keyboard to slow down the operator, the operator became unable to catch up the Morse sender. We don't believe that Sholes had such a nonsense intention during his development of Type-Writer.

William Hoffer, a Virginia science writer, represented similar legend about

Table 1. Frequently-used digrams and their distances in typebar basket

Digram	Frequency (per mil)[20]	Distance (degree)	Digram	Frequency (per mil)[20]	Distance (degree)
TH + HT	31.28	180	ST + TS	13.84	106
ER + RE	28.63	16	OF + FO	13.23	147
HE + EH	25.75	147	IS + SI	13.21	155
IN + NI	21.67	123	ND + DN	12.18	57
AN + NA	19.61	106	AS + SA	11.46	25
IT + TI	18.49	49	LE + EL	11.34	164
AT + TA	17.93	82	ME + EM	10.71	147
EN + NE	17.86	155	AL + LA	10.64	147
ET + TE	17.79	33	NT + TN	9.65	172
ON + NO	17.49	106	EA + AE	9.57	49
ES + SE	16.73	74	HA + AH	9.35	98
OR + RO	15.30	82	OU + UO	9.29	33
AR + RA	14.67	65	VE + EV	8.96	123
TO + OT	14.01	65	CE + EC	8.84	90
ED + DE	13.92	98	LI + IL	8.83	82

the birth of QWERTY:[21]

> *Sholes carefully devised the QWERTY keyboard. He spread the most common letters—E, T, O, A, N, I—all over the board and ensured that frequent combinations such as "ed" had to be struck by the same finger so that the machine would not jam. In other words, the QWERTY keyboard was invented to slow down typing speed.*

The legend was referred by Prof. James V. Wertsch,[22, 23] a professor of the Department of Psychology, Clark University, then it was regarded as an established theory in the field of psychology. In fact, however, "ed" was struck by different fingers in the words such as "supersede" or "submitted" with Wyckoff's or Longley's method, respectively. "ed" did not need to be struck by the same finger in the 1870's and 1880's, as described in Section 2. And in our opinion, E, T, O, and I were not spread on QWERTY keyboard. They were all placed in the upper row.

Prof. Paul Allan David of Stanford University extended the legend to be

fit to his theory "the economics of QWERTY" as follows:[24]

> *Marketing considerations also may have played some role in Jenne and Clough's final keyboard shuffles; it has been suggested that the main advantage of putting the R into QWERTY was that it thereby gathered into one row all the letters which a salesman would need, to impress customers by rapidly pecking out the brand name: TYPE WRITER.*

The extended legend was instantly quoted by Prof. Stephen Jay Gould of Harvard University and then spread all over the world.[25, 26] In fact the brand name, however, had been decided as "Sholes & Glidden Type-Writer" before Jenne and Clough exchanged R with period. Why wasn't SHOLES on one row? How about GLIDDEN? Where was the hyphen between TYPE and WRITER? Furthermore, as described in Section 2, sales demonstration of Type-Writer was done by receiving Morse telegraph or by dictation. We don't believe that it was enough for impressing customers to peck out TYPE WRITER rapidly.

4. Conclusion

In this paper we have described the prehistory of QWERTY keyboard. We have presented that Type-Writer keyboard was originally derived from Hughes-Phelps Printing Telegraph, and that QWERTY was developed for Morse receivers. The development of QWERTY was a winding road, first by Sholes and others, second by Harrington and Craig, then by Jenne and Clough, again by Sholes, and at last by Wyckoff, Seamans & Benedict. There was no consistent policy towards QWERTY. The keyboard arrangement was incidentally changed into QWERTY, first to receive telegraphs, then to thrash out a compromise between inventors and producers, and at last to evade old patents.

We have also argued in this paper that operators of Type-Writers in the 1870's were telegraphers and shorthanders. There were no professional typists at that time, and the operators typewrote with contemporary typing methods that were different from modern ones.

Nowadays QWERTY keyboard is widely used for information processing in Japan, United States, United Kingdom, and other countries. The origin of QWERTY, however, has not been elucidated, and dubious legends about QWERTY have been widely spread. We wish this paper helps to cast light on the history of QWERTY keyboard. Additionally, at our WWW site

"QWERTY People Archive"
`http://kanji.zinbun.kyoto-u.ac.jp/~yasuoka/QWERTY/`
we are gathering Type-Writer articles in the 19th century including eleven [3, 8–17] of References below. Readers may visit the site to obtain them.

Acknowledgment

We would like to express our deep appreciation to Prof. Hisao Yamada, who encouraged us to write this paper and gave us helpful suggestions.

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