The Chord Keyboard Report – Writing Clear Text with the Speed of Speech

Olof Dopping

Contents

(Continued)

Foreword

The word "communication" comes from Latin and means "making common", or "making known". In a modern sense, communication between people means exchange of thoughts, ideas, and opinions – one of the most elementary needs of human beings.

Speech and hearing are the two most important means for such communication. And they are very difficult to replace. But communication is so much more. Our way of using the words, listening to them and interpreting them, also plays an important part. And so also the speed with which we communicate. For how long would you listen to me if I spoke, say, with a speed of ten words a minute?

Several groups of disabled persons are hampered in their communication. People with some form of speech impairment are an obvious case. As are those who are hard of hearing, deaf or deaf-blind. – Speech-impaired persons are in desperate need of some kind of speech prosthesis. And deaf, hard-of-hearing and deaf-blind persons need some kind of service which converts spoken sentences to a medium of theirs, e.g. text on screens or Braille displays. And such devices and services are available. The problem is that – so far, at least – somebody has to transfer the spoken message into written – and sometimes vice versa – via some kind of keyboard. So far, the ordinary typewriter or computer keyboard – called the QWERTY keyboard – is generally used. But it is rather slow in use. So, if some ideas were around for increasing the speed of writing by means of modified keyboards, these keyboards would perhaps do a good job for disabled people.

And such keyboards exist! Indeed, there are several of them. They all have their advantages and disadvantages. But how to choose the best?

Whether this is a straightforward task or not isn't easy to say. But the author of this report – Mr. Olof Dopping – is convinced that one concept is better than the others.

Olof Dopping, M.E., is experienced in this field. He has been working with communication engineering as well as computers, word processing systems and the like for several decades. He is also an experienced pen stenographer, and he has been working with other methods for fast writing. So when he gives us his views we can be sure about at least one thing: he knows what he is talking about!

It is hoped that this report will play an important part in choosing the best solution to the problem of converting speech to print and keyboard input to speech in real time.

The report has been produced within the project called Telematics and Disability. – All statements in the report are the responsibility of the author.

Jan-Ingvar Lindström
Project Manager, Telematics and Disability

1. Introduction and Management Summary

This report is written by Olof Dopping, independent consultant, for The Swedish Institute for the Handicapped. The opinions expressed in the report are mine. They are not necessarily shared by the Institute.

The meaning of "chord keyboard" can be seen in the figures on the next two pages. The main advantages of the chord keyboard are **high typing speed** (up to the speed of speech) and **extra comfortable typing.** By "clear text" I mean ordinary text as opposed to cryptic codes such as pen shorthand signs.

One important **application area** for the chord keyboard is in the area of SDP[1] (Service to Disabled People). In consequence, The Swedish Institute for the Handicapped has been a pioneer in introducing chord keyboards in Sweden.

This report is primarily focussed on SDP applications. However, the SDP area requires chord keyboards to be used also in other areas. Therefore, the report has been designed to be of interest also to people in administration, trade, and industry.

A major application within the SDP area is **text interpretation** for the benefit of deaf (and especially adult-deaf) people. Text interpretation, in its modern sense, means that a human text interpreter continuously presents a written version of a speaker's words, thus enabling deaf persons to follow a speech almost as easily as hearing persons. **Text telephone interpretation** and **meeting interpretation** are two important cases.

Another SDP application serves speech-impaired persons who can use a **key-to-speech system,** producing synthetic speech from keystrokes. With a conventional keyboard (QWERTY), this method is slow, but a chord keyboard will allow the production of keyboard-created synthetic speech with the speed of natural speech, if the user is sufficiently dexterous and has had enough training and practising. (Unfortunately, however, speech impairment is often combined with other disabilities, which may make it difficult or impossible to use a keyboard efficiently.)

Blind persons are often more dependent on keyboards than sighted people. A special section[2] describes the benefits of chord keyboards for blind users.

Chord keyboards are almost as old as the typewriter. Until a few years ago, however, you could not write clear text with a chord keyboard. All you could produce was a sort of mnemonic code that had to be manually transcribed to produce text that could be read by anyone.

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1 The abbreviation, SDP, is not generally used. It has been created for the purpose of this report. And to my knowledge, the expression, Service to Disabled People, is not generally used either.

2 Section 9B4.

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In this respect, using a chord keyboard was similar to using pen shorthand. (Incidentally, I use the words "shorthand" and "stenography" interchangeably.)

In this decade, however, a revolutionary thing has happened to the chord keyboard:

Married
Chord Keyboard, 100 Word Processor, 18 1980's

This marriage has spawned a child:

Born
A Typewriter with Shorthand Speed

Figure 1:1 shows the layout of a modern chord keyboard. Figure 1:2 explains the way to use it.

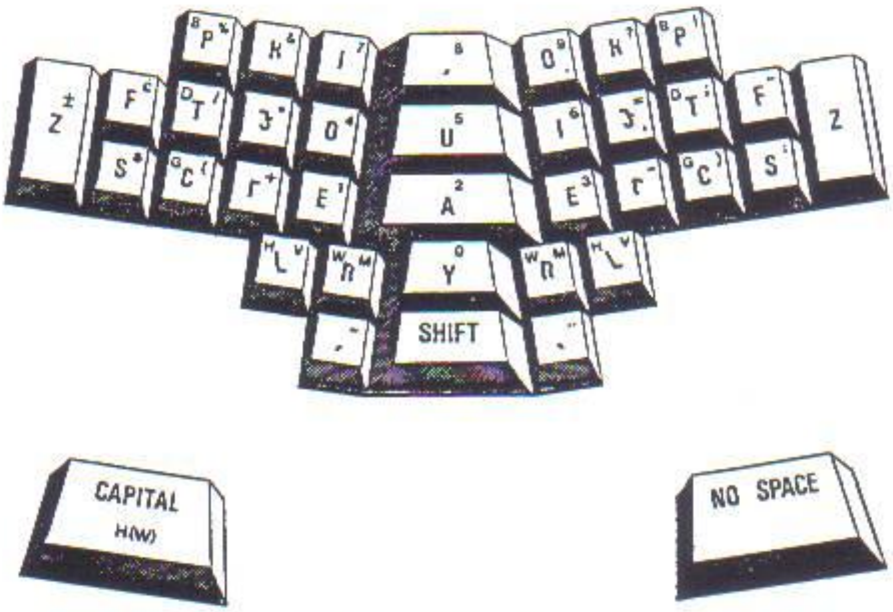


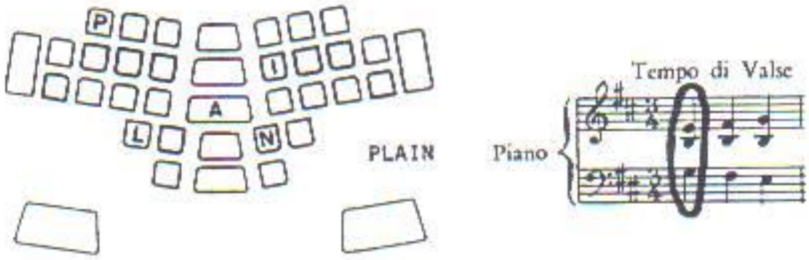
Figure 1:1. Layout of a chord keyboard (Velotype).

A conventional keyboard is called QWERTY.

On such a keyboard, you strike one key at a time.
It can be called a *sequential* keyboard.
You may think this is "the only way to type". **Wrong!**

On a chord keyboard,
you strike several keys simultaneously,
like a pianist striking a chord.
Normally, one chord produces one syllable:

"A chord"



A built-in microprocessor arranges the characters
in the correct sequence, based on rules of phonetics.

Each consonant is represented both to the right and to the left.
You use the left-hand keys for consonants before the vowel(s)
and the right-hand keys for consonants after the vowel(s).

For a letter which does not have any key of its own,
you use a combination of two keys.

On a *modern* chord keyboard
(but not on the old-fashioned ones)
you can also indicate where the inter-word spaces should be,
and you can type punctuation and upper-case characters,
thus producing a graphically perfect printout.

Once you have learned to operate a modern chord keyboard
and practised enough,
you can type much faster and easier
than you can on a QWERTY keyboard.

Figure 1:2. The principle of a chord keyboard.

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However, most chord keyboards can only produce a sort of raw text. Although most words may be correctly spelt, this text has to be "post-edited" by a human operator in order to form a presentable document.

In other words, these keyboards do not completely eliminate human transcription work. All you get is **Computer-AIDED Transcription (CAT)**.

It is an important and little known fact – which it is my ambition to spread via this report – that there are also chord keyboards capable of producing text which needs no post-editing. Thus, they give you ComputerIZED Transcription, not only Computer-AIDED. And they provide for instant presentation of the clear text, which is essential in – among other applications – text interpretation for deaf people.

This feature opens up new application areas, which are for economic reasons inaccessible to users of other chord keyboards.

The Swedish Institute for the Handicapped has made its choice of chord keyboard type – the Dutch **Velotype** – on the basis of this feature, which has a special importance in text interpretation. Swedish organizations which will introduce chord keyboards for uses outside the SDP area – generally in order to save money – will indubitably make the same choice.

This report contains a detailed account of the motives behind the choice of Velotype. It is hoped that this presentation will relieve other user organizations in Sweden and other countries from duplicating the selection process that has already been pursued by the Swedish Institute for the Handicapped.

The report also contains a chapter on host systems.[1] This means the electronic equipment (e.g. a word processing system) to which a chord keyboard must be connected. In most cases, you can "chordize" your word processing system by simply unplugging the original QWERTY keyboard and replacing it with a chord keyboard.

Another chapter[2] covers the necessary training and practising. A special subject in the same chapter is the labour market for **chordists**.[3]

A chapter on Applications[4] begins with a section explaining that the primary justification for using a chord keyboard is not necessarily a need for high speed *per se*. Many user organizations will acquire chord keyboards in order to make radical savings on typing and typesetting costs. Other users will get chord keyboards for ergonomic reasons; it is said that a chord keyboard puts less strain on the operator than a QWERTY keyboard does. – This chapter also contains an account of typical applications both inside and outside the SDP area.

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1 Chapter 7 (Host Systems and Associated Equipment).

2 Chapter 8 (Users, Training, and Practising).

3 I am not aware of anybody else using this term (chordist), which I am now trying to introduce. As the intelligent reader has already guessed, it denotes a user of a chord keyboard.

4 Chapter 9.

There is also a chapter[1] on Costs, Savings, and Benefits. Among other things, it is shown that anyone who runs a typing pool or a typesetting outfit is losing money every day if he sticks to QWERTY instead of switching to Velotype (or any other *suitable* chord keyboard, if there is any).

The main text of the report then ends with chapters on Competition to Chord Keyboards and A Look into the Future.

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1 Chapter 10.

2. Purpose and Target Group

2A. Purpose of this Report

The Swedish Institute for The Handicapped has sponsored a series of studies of questions related to the use of chord keyboards in the SDP area. Some time ago, they decided on choosing the Velotype chord keyboard for this purpose.

Many persons seem to have found this decision a bit daring. "Nobody has done that before." – "Tens of thousands of American court reporters cannot be wrong in their choice of keyboard." – "We have seen that the speed of speech can be reached in English with an American-type chord keyboard, but nobody has seen this done in the same language on the Dutch keyboard."

Therefore, the reasons for choosing Velotype have had to be explained over and over again, as new people have become involved. One purpose of this report is to document the justification for Velotype once and for all.

Another reason is connected with international cooperation. By means of this report, the results of the studies made for the Swedish Institute for the Handicapped are made available to similar organizations in other countries. (Most of this kind of information exchange goes in the other direction, because Swedes can generally read English and often one or more additional foreign languages, while few people outside Scandinavia can read Swedish.)

Apart from the possible advantages to organizations abroad, it may be an advantage for the Swedish SDP if other countries use the same system as Sweden does. This will facilitate future exchange of experience.

2B. Target Group

2B1. Persons in the SDP Area

The primary target group for this report consists of persons involved in SDP. This includes the disabled people who are the *raison d'être* for SDP.

A special group of SDP people which I have in mind consists of persons who are in charge of SDP activities in countries where chord keyboards are not used at all, or not used to any great extent. Thus, I am talking about persons who are in the same situation as the management of the Swedish Institute for the Handicapped was a couple of years ago, when the chord keyboard activities were just beginning.

For this group, I have a special word of caution (assuming that they want to take advantage of the great benefits of chord keyboards for certain groups of disabled people).

You may think – as everyone tends to think in similar situations – that your forthcoming choice of a certain type of chord keyboard only affects a relatively small group of people, mainly consisting of adult-deaf persons and a handful of text interpreters. Especially if you are pioneering the use of chord keyboards in your country or language area, this would be a gross underestimation of the importance of your decision.

This is partly because SDP is just the tip of the iceberg. In a few years the number of chord keyboards will be many times larger outside the SDP area than inside it. This will have a profound effect on the SDP activities, especially because there will be a more or less common labour market for chordists inside and outside SDP.

In such a situation, it is highly desirable that everyone uses the same chord keyboard system. If the others will have another system than you have, the chordists in the SDP area will form an isolated island, and you will have great difficulties in recruiting new personnel.

If you are a pioneer, you will also have a great *de facto* responsibility for the choice of type of chord keyboard. Although the study effort behind this report may seem modest, the vast majority of future chord keyboard users will not have anything like the capacity to carry out studies of a similar depth, and many are likely to just pick the brand a pioneer has selected.

For these reasons, you would be outright narrow-minded if you were looking only at the SDP area in selecting a chord keyboard type. You should keep all application areas in mind. This is the reason for including so much text on non-SDP uses in this report. This also leads me to the next section:

2B2 Persons in Administration, Trade, and Industry

A secondary – but extremely important – target group for this report consists of persons who are, or should be, in a sophisticated way, involved in keyboard activities outside the SDP area. The sophistication may be based on the need for a thrifty and streamlined large-scale operation, e.g. in a typing pool or in a typesetting organization. It can also be founded on the need for efficient "catching of the spoken word", e.g. for verbatim reporting in a parliament. A need for chord keyboards can also be based on ergonomic considerations, which should be of special interest to trade union representatives and people involved with office health care.

The spontaneous distribution of this report will be largely confined to the SDP area, of course. For reasons given above, however, I hope that some of the receivers of the report will order extra copies for some persons they know of in the secondary target group that has been mentioned here.

2C. A Pragmatic Approach

The initial purpose of the chord keyboard study I have made for The Swedish Institute for the Handicapped was not to prepare a report for an international readership. It was just to find out which type of chord keyboard should be used in text interpretation for deaf people in Sweden.

Consequently, it was not my ambition to make a study which would be valid for all countries and all situations. Taking a more pragmatic approach, I concentrated on the alternatives which I found most promising for my customer, and from the point of view of a reader in another country, this report should just be considered as a by-product of my original study.

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This means that I may have missed some alternative that could be of value in another situation and/or another country. Nevertheless, I hope that even readers abroad will find something of value in it.

3. A Short History of fast Writing and Typing

3A. Tiro's Notes and Pen Shorthand

Slavery in the office is not a recent innovation. In ancient Rome, one of Cicero's slaves invented a shorthand system. His name was Marcus Tullius Tiro, and his system was known as Tiro's notes. Tiro trained a number of other slaves to use the system.

The slaves were then put into action, taking down the speeches in the Roman Senate. As a reward for his services, Tiro was set free.

Tiro and his disciples wrote in wax with a stylus. To encourage them to do a good job, their masters told them that their hand would be chopped off if they missed a word.

Later, stylus shorthand evolved into pen shorthand, as pencil shorthand is generally called. It is still a very useful method. I know, because I have been using pen shorthand (Melin's system) for half a century.

Melin's system (1892) is the dominating one in Sweden. In Britain, Pitman's system (1837) plays a similar role, and in the USA, Gregg's system (1888) competes with Pitman's system.

Pen stenography is being squeezed from several directions. Sound recording has taken over big chunks of the market, for dictation and – with limited success – for verbatim reporting. In the era of electronic word processing, many originators prefer to do their own keyboard job, as I do for all small- and medium-scale jobs. For some uses, however, it is a bit hard to outcompete a system using equipment and material which have a negligible price and fit into your pocket.

3B. QWERTY and Other Sequential Keyboards

Very early in the history of the typewriter, keyboards similar to the now ubiquitous QWERTY appeared. It is said that C. L. Sholes, who was the designer of the QWERTY layout, chose the placement of the letter keys so as to make it difficult to type very fast, the reason being that this would diminish the risk of entanglement of the type arms. This was in 1872. Type arm machines are no longer produced, I think, but QWERTY is essentially unthreatened among layout schemes for sequential keyboards.

I don't know if the story behind the QWERTY layout is true, but anyhow it is a well established fact that this layout is far from optimum. As an example, the rather unfrequent letter "J" has the home position of one of the "best" fingers.

Various attempts at putting better layouts on the market have been made over the years. One rather well-known example is the American Dvorak keyboard design in early 'thirties. In the Dvorak layout, the most frequent letters have generally been placed in better positions, and it has been reported that higher speeds can

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be obtained with this keyboard. Some say 3 per cent better, others say 50 per cent.

Despite this clear advantage, the hoped-for breakthrough of the Dvorak keyboard has not (yet?) been seen. However, at least one of the leading manufacturers of word processing equipment offers support for the Dvorak layout.

Another line of development has been to deviate from the sort of "square" design where the keytops form straight horizontal lines, which in turn form a sloping plane. A notable example is the British Maltron keyboard from the 'seventies, where the keytops form two double-curved surfaces, adapted to the natural locations of the fingertips. As far as I know, this nice idea has not had any great impact on the dominance of straight-line keyboards.

However, some inroad has been made by the idea that the keytops do not necessarily have to form straight horizontal lines along the whole width of the keyboard. There are certain keyboards of recent design where each horizontal line is at least broken in the middle, forming a very flat "V" and thus permitting a more natural placement of the hands.

A common feature of almost all these different keyboard layouts is that they are made for sequential keyboards, i.e. keyboards where you strike one key at a time, in the sequence in which the characters are to appear on the paper. The sequential nature is a severe speed-limiting factor because of physiological limitations. It seems that typing with the speed of speech is only possible with simultaneous operations by several fingers on both hands – the chord keyboard idea.

Before leaving QWERTY and its followers, however, let me point out a valuable feature of the traditional keyboard layout that is sometimes nicknamed "dirty QWERTY": its unique character of standard *de facto*. In probably every country in the world, you can find the QWERTY keyboard. There may be some national deviations in details – and in French-speaking countries, not even the "QWERTY" sequence is intact – but still, you will generally be able to use your familiar finger setting and start typing along, whichever country you are visiting. Even in countries where the Latin alphabet is not generally used, you can always find some QWERTY keyboards.

This is an extremely important factor, and when we introduce chord keyboards, we should learn from it. I will revert to that in a later section.[1)]

3C. Mechanical Chord Keyboards

Long before the end of the 19th century, inventors began to design "shorthand machines" based on chord keyboards with one chord per syllable. Most of the features of the chord keyboard principle presented in Figure 1:2 are more than a century old.

Microprocessors were not available at that time, of course. The machines were entirely mechanical.

Therefore, they could not produce *clear text*. Instead, they produced a sort of mnemonic code, consisting of (mainly) letters, on a narrow vertical strip of paper. On this paper, the code corresponding to (generally) one syllable occupied one whole line.

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1 Section 6B (Importance of Uniformity).

An especially successful design was the American *Stenotype* keyboard. Later, keyboards with the same layout have also been produced under other names (Stenograph, Stenoprint). Stenotype was invented by Ward Stone Ireland in 1910 and is still the dominating chord keyboard in the USA and in Canada. (And because chord keyboards are not much used elsewhere, these chord keyboards dominate the whole world.)

In this report, I will sometimes call this type "the American keyboard". The layout of such a keyboard is shown in Figure 3:1.

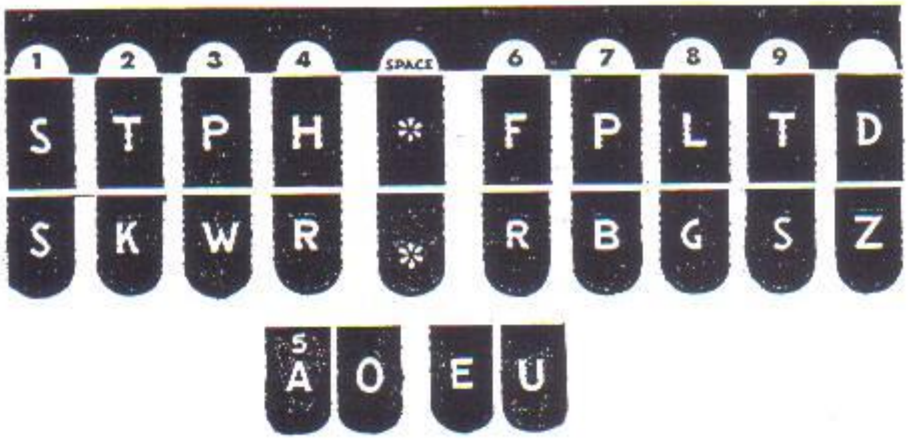

Figure 3:1. The layout of the "American" chord keyboard.

With only 22 characters available, an operator of this kind of keyboard has to replace many characters with combinations of other characters (e.g. "HR" for "L"). Figure 3:2 shows the text on the paper strip corresponding to a simple sentence. As you can see, it is virtually impossible to decipher the text on the strip unless you have been specially trained for it.

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STKPWHRAO*EUFRPBLGTSDZ

           *EU                 I
     HR    *E     B G          LIKE
 T         *E                  TEA
S   W       E       L  S       AS WELL AS
  K       O   F                COFF-
           *E                  EE
```

Figure 3:2. A simple sentence, as it can appear on a paper strip from an American shorthand machine. The clear text is shown to the right of the strip. The line above the paper strip shows where on the line the various characters are placed.

The printing mechanism contains 22 different characters. Each character has its own position on the printing line, which accounts for the queer character spacing that can be seen in the figure.

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The shorthand machines equipped with this kind of keyboard allow a very high speed. They are widely used in courts in the USA and Canada. Most readers have probably seen some American courtroom films where the camera sometimes zooms in on the court reporter, using a shorthand machine for recording every word of the proceedings.

Stenotype and similar keyboards are intended for *phonetic* writing. In other words, the code for a syllable corresponds to its pronunciation, not necessarily to its spelling. For instance, "nose" and "knows" are generally written in the same way. In contrast, *orthographic* writing means a system where a chord reflects the correct spelling rather than the pronunciation. The important question of phonetic writing will be further discussed in a later section.[1]

Many other mechanical shorthand machines with more or less similar chord keyboards have been designed. Some of them are Grandjean (France), Palantype (UK), and Silma (SILbenMAschine, Germany).

The Italian Michela machine stands in a class by itself. Its keyboard layout resembles that of a piano. Under each hand, it has six white and four black keys.

There are probably still many purely mechanical shorthand machines around. In recent years, however, manufacturers have provided the keys with electrical switches or equivalent components for connecting the machines to electronic computing equipment. This leads us over to the next section.

3D. "Electronified" Keyboards

When electric lighting began, it was common practice to "electrify" old kerosene lamps. In the same way, manufacturers of mechanical shorthand machines have, so to speak, "electronified" their chord keyboards in order to provide for computer processing of the text that is being keyed in.

In the "electronification" process, they have not removed the printing mechanism. Thus, an "electronified" chord keyboard can still print hard-to-understand codes on a paper strip, in addition to delivering digital signals to a computer system that may present more or less clear text.

As a motive for this queer practice, it has been said that American courts still consider the paper strip as the official record of the proceedings, even if the system simultaneously produces a printout in something that comes rather close to clear text. With present-day technology, if you feel the need for instant printout on paper, you could use a printer that would be connected to the computer system and produce a far more readable text. It would not be difficult to make the printer effectively noiseless.

When an "electronified" chord keyboard is attached to a suitably programmed computer system, equipped with a huge dictionary in its memory, the computer can interpret almost all the queer codes that have been exemplified in Figure 3:2 and convert them to clear text. This clear text can be stored in a computer memory – e.g. on diskettes or a fixed disk – and/or printed on paper.

Because (purely) phonetic chord keyboard systems cannot correctly interpret all syllable codes, however, further manual work is

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1 Section 4C (Orthographic and Phonetic Systems).

required before a presentable document can be produced. Again, this question will be discussed in a later section.

If I am correctly informed, most of the court reporters in America now use this kind of "electronified" chord keyboards, attached to computer systems. As earlier mentioned, this system is called CAT (Computer-Aided Transcription).

3E. The Modern Chord Keyboard

The most recently developed chord keyboards are electronic from the outset. They are revolutionary because they are designed in a way that provides for full utilization of the computer's resources.

One consequence of their all-electronic design is the absence of an obsolete printing mechanism. What makes them revolutionary, however, is not this detail, but a new keyboard layout and – above all – the abandonment of the phonetic principle in favour of the *orthographic* principle. Again, I refer to a later section.[1]

I have probably made it sound as if there were a whole bunch of such modern chord keyboards around. In fact, I know only two brands that are in production and correspond exactly to the description given above, and for reasons to be presented later,[2] I consider only one of these to be a valid alternative.

I am referring to *Velotype*. This chord keyboard was invented by two Dutchmen, Nicolas M. Berkelmans and Marius Den Outer. In their international patent application, they claim priority from June 13, 1980.

Dr. Berkelmans is a linguist and a polyglot. He chose a keyboard layout that would be suitable for all languages using the Latin alphabet. (A discussion of language independence will be presented in a later section.)[3]

However, there may be more keyboards in production, exactly answering the description above. If so, I would be very much interested to know all about them. I can be contacted via The Swedish Institute for the Handicapped, with address and telecommunication numbers on the cover of this report.

3F. QWERTY Replacement

For decades, the only strong point of chord keyboards in comparison with QWERTY keyboards has been the usefulness for taking notes faster. Because these notes had to be transcribed in order to become readable to everyone, only QWERTY could be used for producing directly readable documents.

With the really modern chord keyboards, the situation has changed. They enable you to produce flawless documents at more than twice the QWERTY speed. Because the costs for typing (and modern typesetting) are almost entirely labour costs, chord keyboards can be used for ordinary typing and typesetting, providing for great economic savings.

For full effect, this increase in profitability calls for an orthographic system, and in the mouth of a proponent for old-fashioned phonetic chord keyboards, "QWERTY replacement" may sound a bit

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1 Section 4C (Orthographic and Phonetic Systems).

2 Section 6D4.

3 Section 5H.

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scornful. In fact, however, this opening up of new areas of application may be the best that has happened to chord keyboards in the last hundred years.

In terms of volume, QWERTY replacement is many times bigger than the traditional application areas of chord keyboards. In the long run, this means lower equipment costs and a much better supply of trained chord keyboard operators. The QWERTY replacement possibility can thus be expected to cause a boom in the chord keyboard market.

3G. "Chord Keyboards"

for One Chord per Character

In all other sections of this report, "chord keyboard" means a keyboard where you strike (generally) one chord per syllable. This section deals with a class of keyboards where you also use chords but where you need one chord for each character. These are not usually called chord keyboards. Hence the quotation marks in the heading above.

In a one-chord-per-character keyboard, the number of keys can be very small, e.g. six or seven, because the number of combinations can still be sufficient for producing all character values. Therefore, the keyboards can be small.

With such a layout, a finger will in most cases be used for one key only. So, the finger moves in one direction only, up and down, and not sideways.

Some proponents of keyboards in this class say that this effect enables the operator to type faster than with a QWERTY keyboard. But these keyboards can clearly not come near the speed of a one-chord-per-syllable keyboard, and their application areas are therefore different.

One example is Microwriter, introduced on the market by Microwriter Ltd., London, in 1982. It is used with one hand only and has six keys, two for the thumb and one for each of the other fingers. A pocket-size Microwriter, equipped with a single-line display, can be used not only for input to a word processing system but also as a self-contained "electronic notepad", where text can be stored temporarily for later input to such a system.

In the SDP area, there is a special application for a Microwriter. A person with only one usable hand should find this keyboard handier than QWERTY.

Another example is the Braille keyboard, which originated in the SDP are. A Braille keyboard is operated with both hands and has (usually) seven keys, one for each of of the six dot positions of a standard Braille character and one for the inter-word space.

Originally, the Braille keyboard could only be used for embossing Braille characters. Nowadays, there are also Braille keyboards that can be attached to word processing systems. Such a system can have both a Braille embosser and an ordinary black-on-white printer attached, thus enabling a blind person to produce both types of output with the same keyboard (which does not, incidentally, *have to* be a Braille keyboard.)

4. Chord Keyboards: Principle

A short account of the principle of (most) chord keyboards has already been presented in Figure 1:2. In the present chapter, more details are given. The text refers to a system where a microprocessor is provided for interpretation of the chords.

The principle described here applies to most chord keyboards. A notable exception is the Bulgarian chord keyboard Isot, known in the West as Stenokey. The Stenokey principle is described in Appendix 1.

4A. The Three Character Groups: C1, V, and C2

A syllable, in the usual sense of the word, always comprises either a single vowel or two adjacent vowels. I call this the Vowel group, denoted V.

V can be preceded by one or more consonants. I call this consonant (or group of consonants) C1. In analogy, a consonant or consonant group after the vowel(s) is denoted C2.

On almost all chord keyboards, you are supposed to use your left hand for C1 and your right hand for C2. This enables an attached computer to know whether a consonant is to be placed before or after the vowel(s) in the printout. (All consonants are represented – in one way or another – on both sides of the keyboard.) Vowel keys are situated in the middle of the keyboard.

The order between the letters in each of the three groups is nearly always unambiguously determined by the characteristics of our speaking organs, and to some extent by the language we speak. Therefore, a computer can arrange them into the right order.

In English, for example, "flow" and "gulf" are real words, but "lfow" abd "gufl" are impossible. "Part" and "trap" are OK, but "patr" and "rtap" are not.

In this respect, there are some differences between languages. For instance, we have all seen some Russian names ending in -tr.

Very often, an acceptable consonant sequence in C1 is the reverse of an acceptable sequence in C2, as in all the examples above. This phenomenon is reflected, literally, in the mirror symmetry that you can observe in Figure 1:1.

In a few cases, two different sequences are allowed on the same side of the vowel(s). For instance, you can say both "gust" and "guts". For distinguishing between these two syllables, the operator must apply an exception rule, which must of course also be reflected in the computer program. In the example, "z" can be substituted for "s" in one of the two cases.

Even this rule fails when you have to write "gusts". In this case, I suppose it is necessary to strike a second "chord" – consisting of only one letter – to indicate the final "s".

As you can see, the chord keyboard operator has to obey more rules than the ones – previously mentioned – that are caused by the need for representing a letter which has no key of its own.

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The complexity of these rules must clearly be especially high if the number of keys is small, as in the American chord keyboards.

4B. What is Meant by "Simultaneous Keystrokes"?

Absolute simultaneity between the keystrokes which together constitute a chord is in practice not possible, of course. It is not necessary either. The following description – referred to a Velotype keyboard – tells why.

When no key is down, the built-in microprocessor in the keyboard is in a state which can be called "keys up". As soon as any key is pressed, it changes to another state ("key down"). The transition to "key down" tells the microprocessor that another chord is coming.

While in the "key down" state, the microprocessor stores all keystrokes temporarily in its memory. As soon as all keys are up again, the microprocessor takes this as a signal that this chord is finished. Therefore, it processes the characters that were temporarily stored and sends the appropriate characters to the host equipment in the right sequence.

4C. Orthographic and Phonetic Systems

As mentioned earlier, most chord keyboards are made for phonetic writing, meaning that the key combination that forms a chord will have to reflect the pronunciation of a syllable rather than the spelling, while other chord keyboards are used with orthographic writing.

The difference between phonetic and orthographic writing is of paramount importance to the usefulness of a chord keyboard. For this reason, I am going to spend a considerable amount of paper and ink on this question.

In the old days, when human transcription was the only way to render a chord keyboard record readable, phonetic writing was OK. I know this because I have been using a phonetic pen shorthand system for 50 years. A human transcriber is not in the least bothered by having to translate from phonetic shorthand text into orthographic typing.

With the advent of computer-aided (and computerized!) transcription, this has changed radically. Phonetic writing has become a very great burden to chord keyboard systems.

One reason is the occurrence of homophones which are not homographs. (Homophones = different words – or syllables – which sound alike, homographs = different words – or syllables – which are spelt alike.) Example: Mr. Ryte, a wright, cannot write "rite" right.

For a computer, it is in most cases impossible to tell such words apart if they are written phonetically. On the other hand, when a stenographer hears a word that has such a homophone, he will almost invariably know from the context which word the speaker means. This is normally a completely unconscious and completely successful process.

In many cases, the homophone problem forces a transcribing computer to present alternatives: "(THERE/THEIR) is (NO/KNOW) evidence against the (COLONEL/KERNEL)." This necessitates human post-editing, which takes time.

The need for post-editing, caused by a phonetic system, can destroy the profitability of a QWERTY replacement application. This is because the labour cost for post-editing may eliminate the savings which are due to faster keyboard input.

Another important disadvantage of a phonetic system in the computer era is the need for a huge computerized dictionary, in principle covering the whole vocabulary of the language (and useless if the operator must quote a phrase in a foreign language). Because there is (especially in English) no simple relationship between pronunciation and spelling, the computer has no other way to arrive at the correct spelling than to look up each word in a computerized dictionary, arranged for retrieval on the basis of phonetic spelling.

The reader might want to point out that the burden of having a computerized dictionary is not as heavy with present computer technology as it used to be. But (i) it is an unnecessary burden, and (ii) a dictionary can never be complete, even apart from the occurrence of names and words in foreign languages.

Let me quote some figures in support of this statement. They are taken from Part 1 of Nusvensk frekvensordbok - Frequency Dictionary of Present-Day Swedish - edited by Sture Allén (Gothenburg, 1970). This book is based on a computer analysis of just over a million words, derived from typesetting tapes used by a number of Swedish newspapers.

The analysis shows that 103,416 words were represented in 1,000,669 word instances. But a vocabulary of 103,416 words does not cover the whole language. If you take a bigger sample than this million of words, you will find a still higher number of different words.

Among the 103,416 words, no less than 59 per cent occurred only once. These figures show that there is a long way to go before one comes near a plateau.

Whatever the number of words in your dictionary may be, thus, it will never be enough. For example, do you think that the words "electronified" and "electronification" - used in Section 3D of this report - are in any CAT dictionary? Nobody may have used these words before, but such additions to the vocabulary are produced every day, and not only by report writers who write in another language than their own. And proper names - geographical and others - are a special tumbling-stone for CAT in phonetic systems.

Some people would probably say that phonetic writing is easier to learn, based on the notion that a phonetic system "requires no spelling rules". But it does. All it amounts to is the need for learning and applying a second set of spelling rules, in addition to the one you learned at school.

I can say this on the basis of some experience. Although I am a computer engineer, I had a part-time job as a parliament stenographer for about 1/8 of a century in the 'forties and 'fifties. I am using a phonetic pen shorthand system (Melin's).

Phonetic spelling would be very easy if the stenographer were a machine for translation of sounds into written symbols, but he is not. As an example, let me assume that a Swedish speaker uses the word "fotboll", meaning just what you guess. If a Melin stenographer were really using phonetic spelling - as he was told to do when he learned stenography - he would write "fopoll", because this is the way most Swedes pronounce the word. But he writes the word as if the speaker had pronounced "tb" instead of "p".

This, in my view, proves that the brain has no direct path between hearing and writing. The sound arriving at the stenographer's ear is sent to some language centre in the brain. There, the sound of a word is identified with some word in the vocabulary

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that is stored in the brain, and nerve signals for muscular movements are not sent to the hand until the identification has been successful. If the stenographer cannot identify the word at all, he may become paralyzed unless he consciously decides to take down something that gives an approximate indication of the sounds of the unidentified word.

Normally, thus, the sounds have already been forgotten when the brain orders the hand to write the word. The spelling comes from this linguistic centre in the brain, not directly from any hearing centre.

With an orthographic system, the homophone problem is hardly noticeable. When the stenographer hears something that sounds like "ryte", he will immediately identify this sound with the appropriate word, be it "wright", "write", "rite", or "right". The identification is based on the context, and in almost all cases, the stenographer is not even aware of having made a choice.

It does happen that the correct identification of the homophone is not finalized until the stenographer has heard a few words more. In such rare cases, he may already have written an incorrect word before he realizes what the correct interpretation is. If he is too much pressed for time to correct the error immediately, some post-editing will be required, but in any case, the amount of post-editing is much smaller in an orthographic system than in a phonetic one.

It is important to realize that the difference between phonetic and orthographic systems is not irrevocably built into the keyboard hardware. The main difference lies in the rules that the operator has to follow and in the program of the microprocessor. By modification in these two respects, a phonetic chord keyboard could in principle be converted into an orthographic one.

Stenotype Italia SRL has made use of this fact. They have designed a system for Italian, using a Stenotype keyboard similar to the keyboard shown in Figure 3:1, but they have assigned other letters to almost all the keys, thereby producing a system which is, as I understand it, orthographic (Fig. 4:1).

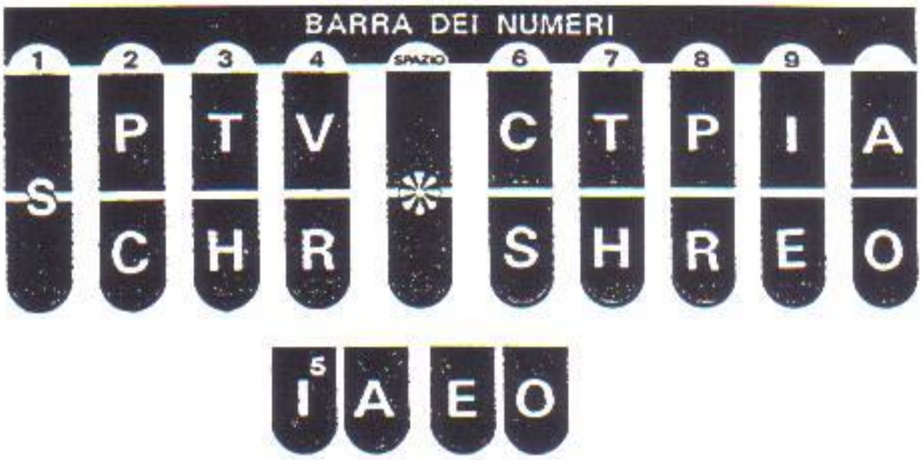

Figure 4:1. The keyboard offered by Stenotype Italia SRL.

There is one obstacle for turning a phonetic keyboard into an orthographic one, however. This obstacle will be revealed in the next section, where also a few words more will be said about the keyboard from Stenotype Italia.

4D. Indication of Inter-Word Spaces

In the days when only human transcription existed, indication of inter-word spaces was considered as an unnecessary luxury. The paper strip from a chord keyboard just showed a sequence of symbol groups, mostly corresponding to syllables, and it was up to the human transcriber to decide which syllables should be combined into words.

A computer has no possibility whatsoever to solve this problem without recourse to a full-vocabulary dictionary. And even with a dictionary, it cannot decide correctly between "key board" and "keyboard".

To avoid the problems of having a big – and unfortunately never sufficiently big – computer-stored dictionary, you *must* use a keyboard which enables you to indicate an inter-word space (or, alternatively, the absence of a space) together with *any* syllable. The Dutch Velotype chord keyboard has a "NO SPACE" key that is operated with the ball of the right hand, as can be seen in Fig. 1:1.

The very widespread American chord keyboard has no key which has been originally intended for this purpose, and because it has few keys, it is not easy to free one of them by re-assignment of other keys. And it should be a separate key because it must be possible to strike it together with any combination of the other keys.

Stenotype Italia SRL, which was mentioned in the previous section, has reached an almost perfect solution of the space problem in their keyboard layout for the Italian language. They have taken advantage of the fact that almost every Italian word ends with a vowel.

As shown in Figure 4:1, they have assigned vowels to the four rightmost keys. (Other vowels than these four can be indicated by means of combinations.)

These four keys are used only for ending vowels, and they can be included in the same chord as the characters of the penultimate syllable. When such an ending vowel is indicated, the attached computer will automatically generate a space after it. For indicating a space after a word ending with a consonant, however, an extra chord will generally be needed.

Explicit indication of inter-word spaces may seem to be of minor importance. But it does away with the need for a full-vocabulary dictionary without introducing a need for extra post-editing. That is important.

4E. Character Repertoire

Old-fashioned chord keyboards, in general, can only produce the upper-case letters of the alphabet (and often only the English alphabet) plus an asterisk. However, special chords can be used for indicating punctuation.

An attached computer can help the situation further by means of programming. For instance, the computer can be programmed to produce lower-case letters generally but use upper case for the first character after the end of a sentence. While this method is

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not infallible, it makes for a considerable reduction in the need for post-editing.

There is always a possibility to add more characters by letting them be represented by special chords which an attached computer can identify. Evidently, this method is easier to apply on the 37-key Velotype keyboard than on the 22-key American keyboard.

4F. Valuable "Nonsense" Chords

The designers of the Velotype chord keyboard have provided an extra feature for assigning special meanings to some chords. If you strike a chord that has at least one left-hand consonant and at least one right-hand consonant but no vowel, the built-in micro-processor of the keyboard will recognize this as a "special" chord and "flag" it by means of inserting an extra character before and after it.

Because of this trick, the attached computer does not have to look for all possible special chords all the time. All it needs to do all the time is look out for the special flag character.

The detailed interpretation of the flagged chords is normally left for the host computer, but at least one such chord has been standardized, "CR-RC". This chord, meaning "CoRReCtion", is interpreted by the chord keyboard processor itself and causes it to strike out the last chord for correction. The chord to be corrected will normally have been sent to the host computer already, but the chord keyboard will then send a series of characters that will erase the erroneous characters from the memory of the host.

4G. Function Chords

In many word processing systems, a hideous number of commands to the system must be given by means of function keys, i.e. keys which are outside the "alphanumeric" part of the keyboard. One widely used word processing system, when applied to an IBM-compatible personal computer with a normal QWERTY keyboard, uses about 30 different function keys. Because many commands require a combination of two or more such keys, they are used for about a hundred different commands.

For a trained keyboard user, who normally uses the touch method of typing, the time taken to operate a function key is many times longer than the time to strike a letter key. This is because he will have to look at the keytops or even a special keyboard template to find the right function key and then move his hand outside the normal working area and back. In addition, even a frequently used command will in many cases require the operation of more than one function key. Especially in a heavy editing job, the operation of the function keys may need much more time than all other tasks combined.

With a chord keyboard and a suitably programmed host processor, the well-trained operator can avoid this function key misery. Every function key and every relevant combination of function keys can be assigned to a "function chord", e.g. of the type described in the previous section.

In such a system, the operator can keep his hands over the normal areas of his chord keyboard all the time. With a single chord, which he can strike in a fraction of a second, he can obtain the same effect as with a much lengthier function key operation.

Likewise, one single chord can in some cases be made equivalent to a whole series of function key operations.

The benefits of such a system can be reaped only by a well-trained operator, however. This is because he needs to know at least the most frequently used function chords by heart if he is to save time.

The extensive use of function chords will open up a new application area for chord keyboards. Without them, a person working with a heavy editing job is not much better off with a chord keyboard than he would be with an old-fashioned QWERTY keyboard because actual text input only stands for a small part of the workload, but function chords will give him a considerable speed advantage over a QWERTY user even in this application.

4H. Use of Abbreviations

The chordist can save time by using a single chord for either a polysyllabic word or a group of two or more words. Naturally, the program of the host computer should be capable of recognizing the chords that form abbreviations and blow up the text to the full word or word group.

Such abbreviations are widely used e.g. by American court reporters. "Under" can thus be input with a single chord. An example of an abbreviated word group ("as well as") has been shown in Figure 3:2.

One of the inventors of the Velotype chord keyboard is opposed to the use of abbreviations because it upsets the rhythm of chord keyboarding, which normally corresponds to one chord per syllable. This may be a valid argument if a person does not have to become a really fast chordist, but when high speed is needed, there is no doubt in my mind that the value of abbreviations is sufficiently high to compensate for disturbances in the rhythm.

I base this opinion on many years' experience of using abbreviations in pen shorthand. Every debate stenographer gets pressed for time now and then, and it is a relief when a speaker uses a stereotyped expression – e.g. "in this case" – for which there is a good abbreviation.

A further argument in favour of using abbreviations in debate shorthand is that stereotyped expressions are sometimes pronounced extremely fast. If a certain speaker is a member of "The Committee for Health and Welfare", he is likely to pronounce the long and familiar name of this committee so fast that the stenographer simply cannot possibly write it in full without lagging too much behind the speaker. The question of abbreviations is further discussed in a later section[1] in connection with the choice of a chord keyboard type.

Even when you use a keyboard with a built-in microprocessor that converts all "normal" chords to clear text (such as Velotype), blow-up of abbreviations is a matter for the host computer program. This problem will be dealt with in a later section.[2]

Abbreviations will require a sort of dictionary in the host computer. The size of such a dictionary will only be a fraction of the size of a full-vocabulary dictionary, however.

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1 Section 6C2 (Attainable Speed).

2 Section 7A1 (Distribution of Tasks between Keyboard and Computer).

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4I. The Natural Way to Type?

It has been said that the chord keyboard provides for a more natural way to type than a sequential keyboard like QWERTY. One reason would be that division into syllables is more natural than division into individual characters. Another reason would be the fact that the sequence of a leading consonant group, a vowel group, and a trailing consonant group is "mirrored" by the physical positions of the keys into a left-hand group, a middle group, and a right-hand group.

5. Chord Keyboards: Requirements

5A. OWESI – Orthographic Writing, Explicit Space Indication

As indicated earlier,[1] a phonetic system without explicit indication of inter-word spaces causes a lot of unnecessary complications in the era of computerized transcription. Especially in a language area where chord keyboards have not yet been introduced on a large scale, it would be very unwise to adopt such a system.

This is the reason for a basic requirement which will be mentioned many times in this report. In order to express it concisely, I will use an acronym for it: OWESI, or Orthographic Writing, Explicit Space Indication.

5B. Speed Requirements

5B1. Measuring Units for Speed

Speed of speech and speed of writing can be measured in four different units:

- cpm (characters per minute)
- ppm (phonemes per minute)
- spm (syllables per minute)
- wpm (words per minute).

A more exact unit name than "**characters per minute**" would be "equivalent QWERTY keystrokes per minute". This would more clearly indicate that an inter-word space is counted as a character.

The count should also include one character (or keystroke) after the last word on a line. In this position, a QWERTY operator has to hit either the space key or the "New line" key.

In fact, an isolated upper-case character should be counted as at least two keystrokes, because the shift key has to be operated. In the queer language used by most authors of word processing manuals, production of a "K" calls for "simultaneous" depression of the shift key and the K key, but especially in an electronic system, you cannot really strike them simultaneously. If you tried, you might hit the K key a millisecond before the shift key, thus producing a "k" instead of a "K". Therefore, the shift key must be hit before the K key. In addition, it must be released before the next character key is hit, if this is to be a lower-case character.

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1 Section 4C (Orthographic and Phonetic Systems), and 4D (Indication of Inter-word Spaces).

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So, an operation of the shift key may contribute even more to the time used for typing than a character key does. But because typesetting companies have traditionally made no difference between upper-case and lower-case characters in their accounting procedures, I think we should accept this practice although it is in principle wrong.

In speed measurements, the use of punctuation affects the results differently for QWERTY and chord keyboards. When using QWERTY, a period or a comma requires one keystroke. In the chord keyboard case, it requires one chord, which is otherwise equivalent to several QWERTY keystrokes (in Swedish, 3.2). In quoting speed figures, therefore, it is fair to mention whether or not full punctuation has been used.

In speech speed comparisons between different languages, the number of **phonemes per minute** would probably be the most "fair" measuring unit. A phoneme (loosely: a speech sound) is defined as the smallest element of speech that serves to distinguish between two different words. (As you already know, a definition is something that you already know, expressed in a way that you don't understand.)

The assumed "fairness" of phoneme counting is based on the fact that the average number of characters per phoneme varies between languages, while the maximum number of phonemes per minute might be reasonably similar in different languages. The English word "through", for instance, has only three phonemes, although it has (with British spelling) seven characters.

Even if phonemes per minute may thus be the best measuring unit in principle, I do not suggest that we should quote speed-of-speech figures in phonemes per minute at present, but I have mentioned this matter just to point out that the number of characters per minute is affected by spelling rules, not only by the "physiological" speed of speaking.

The number of **words per minute** is widely used in English-speaking countries. The average length of an English word is about four characters, and together with the space after it, you get five. Therefore, 200 wpm in English is approximately the same as 1,000 cpm.

In some other languages, the average word length is different. In Swedish newspaper text, for instance, the average word length according to Frequency Dictionary of Present-Day Swedish[1)] is 5.4 characters, making 6.4 when you include the inter-word space. (And if you add one punctuation character for every ten words, you arrive at 6.5.)

The difference between English and Swedish in this respect is at least partly caused by differences in the use of composite words. When an Englishman says milk bottle, a Swede uses only one word: mjölkflaska.

Thus, a speed comparison based on the number of wpm is only useful within one language. For comparisons between writing speeds in English and Swedish, for instance, it would be misleading. (And even within a single language, the average word length will undoubtedly be different for different styles, such as the styles of the sports pages in a newspaper and an academic dissertation.)

The number of **syllables per minute** is used e.g. in the international shorthand contests that are arranged every two years by the Intersteno organization. Italians and Bulgarians tend to have great success in these contests. In their languages, the average

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1 Also mentioned in Section 4B.

number of characters per syllable is rather low, and so, the Italians and Bulgarians would be a little less successful if the speed comparisons were based on the number of cpm rather than the number of spm.

In Swedish, the average number of syllables per word – in newspaper text, at least – is approximately 2. Thus, you should multiply the number of words per minute in Swedish by 2 to get the number of syllables per minute and by 6.4 to get the number of characters per minute, if punctuation is not counted.

In English, you have approximately 1.4 syllables per word and 3.55 characters per syllable (including a share of the inter-word space). This gives us, as before, 5 characters per word, including the space.

To me, it seems obvious that the number of cpm is the most suitable practical measuring unit for writing speed (and speaking speed, too). With this unit, comparisons between writing speeds in different languages must be considered more fair than if words or syllables are counted.

5B2. How Fast Do We Speak?

Because the purpose of many chord keyboard systems is to catch the spoken word, it is important to know how fast people speak. There is no simple answer, of course.

Obviously, the speaking speed varies from one person to another and from one situation to another. For instance, people seem to speak faster in small meetings than they do before a large audience, and priests tend to speak slowly, perhaps because they are used to speaking in echoing churches. And speed varies over time even during the same speech.

The statistical distribution of speaking speeds, when illustrated graphically, can safely be assumed to be similar to the well-known Gaussian curve shown in Figure 5:1. In such a distribution, the average value of the variable under consideration – speed, in this case – is exactly defined, but there is no defined maximum value. The only reasonable way to give an indication of the right-hand part of the curve is to quote the variable value which is not exceeded in more than p % of the cases, and here, the number p must be specified, of course.

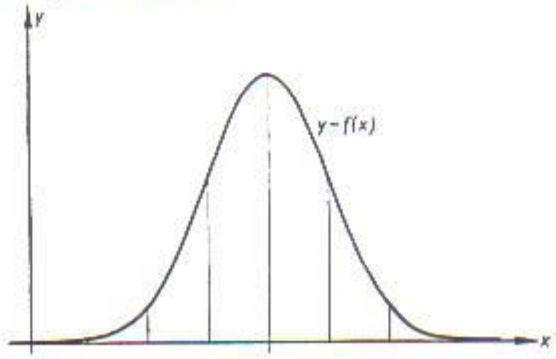

Figure 5:1. A frequency curve for speed may look something like this. There is no maximum speed, but we can give an idea of the rightmost part of the curve by quoting a pair of numbers (s and p), indicating the speed (s) that is not exceeded in more than p per cent of the cases.

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When a speed figure is given, it should be accompanied by information on the duration of the measurement. The one-hour average may be considerably lower than the average speed in a half-minute interval during which the speaker is talking extra fast. In fact, if you quote a certain person's top speed, the speed figure will generally be higher the shorter measuring interval you use, down to a certain threshold beyond which it is not meaningful to go.

The threshold is determined by the capacity of the chordist's short-term acoustic memory, which acts as a buffer. Speed variations within the time interval covered by this short-term memory are automatically and unconsciously levelled out. The chordist's writing can lag behind the speech by an amount that is covered by this buffer memory.

So much for the ambiguities in quoting the speed of speech. Now for the actual speed figure.

One indication is the volume of a verbatim printout. In my own experience as a debate stenographer, I have found that one hour's discussion in a parliamentary situation yields about 40,000 characters. This gives us a one-hour average of a little less than 700 cpm. (40,000/60 = 667.)

This figure is for a printout produced after a sometimes very radical editing. It is hard to say whether the editing has made the text longer or shorter, on the average. – It should be added that this figure obviously tells us nothing about the top speed during a typical hour.

Another indication of speaking speed comes from the examination rules followed in tests for admitting shorthand reporters to courts. Here, I will quote a passage from a paper presented by Nancy Patterson, USA, at the 35th Intersteno Conference (Luzern, Switzerland, 1983):

Court reporting in the United States

In many states licenses are required before a court reporter can practice. A speed test is administered demanding 95 percent accuracy or better. In California it is 97.5 percent. These test vary from state to state. A test may consist of ten minutes of four-voice testimony – the judge, two attorneys, and a witness; or it may consist of three five-minute tests on different types of material: jury charge, testimony, and literary.

In those states which do not have a licensing examination of their own, applicants for positions are usually expected to hold a certificate of proficiency from the National Shorthand Reporters Association. This examination, requiring 95 percent accuracy, consists of a five-minute test on literary material at 180 WPM, a five-minute test on jury instructions at 200 WPM, and a five-minute test on testimony at 225 WPM. The certificate of proficiency examination also requires the applicant to pass a written knowledge test covering English, legal and medical terminology, and reporting procedures.

The above figures for five-minute tests correspond to speeds of 900, 1,000, and 1,125 cpm. Obviously, the accuracy requirements are very modest while the speed requirements are high.

According to some information given during a conversation, courts in the USA require 220 wpm, while British courts only require 180 wpm. These figures – corresponding to 1,100 and 900 cpm, respectively – were not accompanied by any information on the duration of the tests for these speeds, or on the accuracy that is required.

The dispersion of these figures reflects the fact that "top speed of speech" is not a well-defined concept. To make it unambiguous, one would have to sacrifice a part of the generality of this concept. For instance, one could define a certain speed S like this: "S is the moving one-minute average speed, in characters per minute, which was not exceeded for more than 1 per cent of the time during all official speeches held in the Swedish Parliament during March, 1988." Although this definition is not very general, the speed thus defined will probably not vary much for one March to another.

In the future, when chord keyboards are extensively used for verbatim reporting, linguists will easily get such speed information by means of computers. Unfortunately, however, we can hardly hope to get such information now, when it would be a great help in our choice of chord keyboard type.

Figures on maximum speaking speed do not easily travel across the boundaries between different language areas. If you compare the speeds of an English and an Italian speaker who seem to speak with the same speed – each in his own language – you might find that the Englishman produces more characters per minute while the Italian produces more syllables per minute, for example.

For practical purposes, however, we need to establish a speed standard against which we can decide whether or not a certain chordist can be considered to meet the requirements for a certain type of job. The standard should also specify the required level of accuracy in non-ambiguous terms. The most stringent demands, obviously, must correspond to a speed which is of the order of 1,000 cpm during a constant-speed test of at least five minutes' duration. I will revert to this question in a later section.[1]

5B3. Measuring the Speed of Writing

The speed of chord keyboard operation can be measured in a number of different ways. The results will depend on the way of measuring.

One way is to measure the time it takes to copy a manuscript. This test is easy to perform, but it will not give a complete picture of a person's ability to catch the spoken word.

Another way is to use a sound tape, dictated at a rather high speed, and let the chordist start and stop the tape e.g. by means of pedals. For a fair test, the person in question must have had an opportunity to try the start-stop system long enough to operate it efficiently.

Still another method is to let a person dictate a text at a predetermined, constant speed. If a chordist manages to write the text essentially without errors, a higher speed should be tried until he fails.

For consistency in the test results, the type of text should be well defined. A text with many proper names and many complex scientific terms is clearly extra difficult, and this type of text should generally be avoided in testing situations because it is not easy to keep the level of difficulty constant from one test to another.

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1 Section 8A (Necessary Qualifications) with Sub-Sections.

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A computer program for speed measurement has been developed for Velotype. In the course of using the keyboard for practising, the program can present a dynamically varying graph on the screen of an attached host computer.

5B4. How Fast is QWERTY?

In a QWERTY replacement application, the requirements on chord keyboard speed depend on the speed of the QWERTY job that is replaced. Here, we have the same definition difficulties as for speed of speech, which was illustrated in Figure 5:1.

An indication of upper-end extremes can be taken from the results of the latest Intersteno World Championships in Typing (Florence, Italy, July 1987). The contests were held in six separate classes as shown in the result list below. There was a 30-minute speed test and a 10-minute accuracy test, where the penalty for mistakes was many times higher than in the speed test.

In the speed test, the six world champions obtained the following results:

Speed cpm	Mistakes	Class
479	1 in 1,597	Mechanical typewriters, juniors
493	1 in 4,926	Mechanical typewriters, seniors
573	1 in 419	El. typewr. without corr. possib., juniors
691	1 in 797	El. typewr. without corr. possib., seniors
721	1 in 3,605	El. typewr. with correction possib., juniors
634	1 in 6,340	El. typewr. with correction possib., seniors

Naturally, it must be kept in mind that these results were obtained by an elite taken from a population of scores of millions of (in most cases) professional typists.

A more typical speed of a very qualified QWERTY typist seems to be 300 cpm, measured over one or several hours. Part of the basis for this statement consists of interviews with a small number of teachers who are themselves engaged in typing championships and therefore more interested than most other people in keeping an eye on the general performance level. And my own favourite free-lance secretary, whom I considered to be extremely competent, types at this speed as an average over half a day or so when transcribing dictated tapes.

It must be observed, however, that these speed figures are referred to the time actually spent at the keyboard. Even a person who is considered to work as a full-time typist will not generally spend the whole day typing new material. A significant percentage of the working time will normally be devoted to other jobs. Some of them will be related to typing, such as proofreading, corrections, copying, and dispatching. Therefore, if you ask how many characters are produced in an 8-hour day by a competent QWERTY typist or typesetter, you may hear figures like 60,000 characters, corresponding to an average of about 125 characters per minute.

Another indication of QWERTY typing speeds is based on training results in one type of school where the pupils have typing during a two-year period at the ages of 17 and 18 – altogether about 150 lessons of about 45 minutes each. They will typically reach an average speed of about 100 cpm in a final 15-minute test. They will normally get the highest grade if they reach about 140 cpm.

5C. Instant Presentation

Certain applications, such as text interpretation for deaf people, call for what I would call instant presentation. In such an application, we cannot accept any noticeable delay between the chord keyboard input and the presentation.

Velotype allows the text on a presentation screen to appear syllable by syllable. Among the systems that need a computer-stored dictionary, some do not allow instant presentation at all.

5D. Requirements on Ease of Learning

The most severe obstacle for the introduction of chord keyboards is the need for special training and practising. In this respect, there are significant differences between the various chord keyboard brands.

To become a court reporter in America, using chord keyboards of the American type, a person generally has to take a two-year course. Including practising, the students are occupied full time during these two years, but they do not learn machine shorthand only. The course also includes other subjects such as Legal Procedures, Jurisprudence, and Psychology.

In spite of this massive training, it has been reported that only a fraction of the students will ever reach the skill that is required of a certified court reporter. The percentage of success is said to be typically about 10 per cent or even less.

One particular company has reported a very high success rate (approaching 100 per cent) in training on the American keyboard. Later it was revealed, however, that this figure was referred to a course in which all the participants were experienced pen stenographers, capable of following the spoken word with their pen shorthand system. Therefore, this success figure is not at all compatible with the figures for students who start from scratch.

Generally speaking, the Velotype chord keyboard does not by far impose such hard requirements on training. The theory of using the chord keyboard is generally taught in a two-week course, which includes about 20 hours of practising. After this course, they do not necessarily have to go to class again. All that is required is practising.

Even a Velotype operator needs a lot of practising if he is to reach high speed, of course. Some typical data in this respect will be presented later.[1]

It may seem almost incredible that the difference in training requirements can be so great. There are, however, some factors that account for a great difference.

One such factor is the number of keys. The fact that the American keyboards have very few keys means that the students

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1 Section 8C (Typical Curves over Speed vs Time).

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must learn quite complex rules in order to be able to produce all possible syllables. Velotype, with a considerable greater number of keys, provides for writing of all syllables with much fewer rules.

Another reason is connected with abbreviations. In the American schools for court reporters, the students must devote considerable time to learning numerous abbreviations for common phrases. As an example, a certain American textbook for court reporters contains single-chord abbreviations for nine phrases containing the same verb: I can't recollect, I don't recollect, they recollect, what you recollect, that you recollect, which you recollect, what I recollect, which I recollect, could you recollect.

In the Velotype course, no abbreviations are taught. This does not mean, however, that users of American keyboards have a greater need for abbreviations than Velotype users have. Therefore, a certain amount of training time for abbreviations should be added to the figures for Velotype in order for these figures to be compatible with the figures for American keyboards.

In terms of net training costs, the difference in favour of Velotype is very much greater than can be derived from the number of training and practising hours. This is because the Velotype students, working with a keyboard that is well suited for QWERTY replacement, can earn a living on their keyboard job very soon after the end of their two-week course. It will not be long before they can type faster than a fully trained QWERTY typist, and from that point in time, their speed advantage will grow from one day to another.

5E. Requirements on Ergonomics and Ease of Operation

It is not unreasonable to believe that there are differences between the various keyboard types in terms of ergonomics and ease of operation, and a proponent of a certain type of keyboard will probably claim that his particular type is superior in this respect.

Advocates of the American chord keyboards will perhaps point out that these keyboards, having few keys, do not require the finger tips to move so far. On the other hand, advocates of Velotype may point to the fact that its deviation from the straight-line arrangement of the keys means a better adaptation to the natural way to hold the fingers. They may also point out that "straddling" positions, in which one finger must press two keys simultaneously, are more frequently required when the American chord keyboards are used.

Personally, I cannot judge between them in this respect.
Nevertheless, I have found it important to point out that there is in principle a requirement for the greatest possible ease of operation.

5F. Requirements on Freedom from Post-Editing

If a text, produced with a chord keyboard, is not in all respects perfect from the beginning, it obviously has to be post-edited. Although the ease of editing increased enormously when electronic word processing came, editing still takes time, and it is an obvious requirement that post-editing can be avoided or at least kept to a minimum.

When you look at a raw print-out that has been provided with proofreading signs, editing may seem a trifle if the characters to be affected are few. Based on a massive experience of editing on word processing systems, however, I can testify that editing takes much more time than an unexperienced person may think. Much improvement in this respect is generally possible, because word processing programs are not always as editor-friendly as one would wish, but even so, post-editing remains a problem.

In this respect, Velotype is very much superior to the American chord keyboards, for reasons that have been explained earlier.[1] Especially in QWERTY replacement, which is quite cost-sensitive, the cost for post-editing can easily eliminate the profitability of an American chord keyboard.

5G. Compatibility Requirements

It is obviously desirable that one can combine a chord keyboard with many different types of host equipment. It is not a difficult engineering problem to provide such a compatibility, but some chord keyboard manufacturers have done it more extensively than others.

Even here, Velotype seems to be superior. The manufacturer can supply Velotype keyboards equipped with interfaces for a large number of host systems, including the personal computers that are now the most common vehicles for word processing, "desk top publishing", etc. The keyboard is generally made "plug compatible" with the original QWERTY keyboard of the host system, enabling even a non-technical user to change from QWERTY to chord.

5H. Requirements on Language Independence

Especially outside the English language area, many keyboard operators have to use different languages at different times. A change of language may need equipment changes in addition to some changes of operating rules.

In the Velotype keyboard, the writing rules are a bit different for different languages. These differences are reflected as language-dependent differences in the data stored in the Read-Only-Memory (ROM)[2] associated with the microprocessor that is built into the keyboard.

However, the ROM has room for several language modules, most of which are optional. The user can change between the various language modules by means of easy keyboard operations.

For writing just a few words in a different language, it is not always worthwhile to change language module, however. As an example, a Swedish typist who has to type a few words of English in a text which is otherwise in Swedish can do this using the Swedish language module, but if a longer text has to be written in English it is better to switch to the English module, which permits more "genuinely English" chords.

At present (first quarter of 1988) Velotype has language modules for (at least) Dutch, English, French, German, and Swedish. Other language modules are under way.

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1 Section 4C (Orthographic and Phonetic Systems).

2 The designation ROM is here taken to include the variations that are sometimes indicated by prefixes to ROM, e.g. in PROM (Programmable ROM).

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With the American keyboards, the translation from chords to clear text is generally done in a host system having a full-vocabulary dictionary of the language to be used. In such a system, it is not practical to try to write in another language than the one(s) in the dictionary, and because a dictionary requires very much memory space,[1] users may be reluctant to have dictionaries for several languages.

5I. Economic Requirements

Holding down the costs is an obvious requirement. In the case of chord keyboards, we can distinguish between hardware costs, training costs, and operating costs. (Costs for expendable material is generally rather low in relation to the other costs, and it will not be taken into consideration here.)

When it comes to **hardware costs,** all such costs must obviously be taken into consideration to the extent that they are different for different types of chord keyboards. In other words, it is not enough to consider the costs for the chord keyboard itself if one chord keyboard needs a more expensive host system than another. American chord keyboards will generally require a more expensive host system, mainly because this system needs a huge dictionary.

I will not try to give any detailed price comparisons between the various types of chord keyboards and associated equipment. To give an indication of the order of magnitude, however, I will mention that a Velotype keyboard costs something in the order of 5,000 Dutch Florins in the Netherlands excluding Value-Added Tax (VAT). (The exact amount depends on such factors as the number of language modules and which host equipment the chord keyboard is to be interfaced to.)

Because Velotype's built-in microprocessor takes care of the interpretation of all normal chords, this chord keyboard does not necessarily require a more expensive host computer than a traditional QWERTY keyboard does. However, some additional programs will be necessary if the host computer is to interpret special function chords and abbreviations.[2]

The hardware costs per year (including interest and mortgage on initial expenditure) are rather independent of the degree of utilization. Electronic equipment is not subject to wear to any great extent, and even the mechanical parts can be kept in good shape for many years. Naturally, however, a certain yearly percentage has to be set aside for maintenance.

Training costs (including any costs for practising time) are of very great importance. These costs include tuition fees, costs for the hardware required for practising, and production loss.

Especially for people who have otherwise finished their education and are in production, the last-mentioned factor may be quite heavy. As pointed out elsewhere[3] Velotype seems to be the best solution in this respect, both because of shorter training time and because the students can be productive as typists during the major part of their practising period.

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1 Section 4C (Orthographic and Phonetic Systems).

2 Sections 4G (Functions Chords) and 4H (Use of Abbreviations), respectively.

3 Sections 5D (Requirements on Ease of Learning) and 8C (Typical Curves over Speed vs. Time).

Operating costs are dominated by labour costs. The hourly operator cost for input of new text will probably not depend much on the type of chord keyboard, when training costs have already been taken into account in a separate calculation, but because of varying need for post-editing, the differences in total operating costs may be important and even decisive for the choice of brand.

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6. Chord Keyboards: Choice of Type

In this chapter, I present an account of arguments for and against the various brands or types of chord keyboards. The main emphasis is on the American chord keyboards and on Velotype. The American keyboards are in focus because of their present strong situation on the world's biggest chord keyboard market – the one in North America – and the reason for my special interest in Velotype is that I have found it clearly superior to the American brands, especially due to its OWESI characteristics.[1)]

Other chord keyboards than the ones I have just mentioned are discussed more superficially in this report. I apologize for this limitation, which is a consequence of my pragmatic approach; I cannot afford to devote too much time to detailed studies of a brand that does not seem to stand a good chance of coming out as the winner.

6A. Importance of Choice of Keyboard Layout

At least if you are in a country like Sweden, where chord keyboards have not been used to any significant extent earlier, your choice of chord keyboard can have a profound effect. As soon as a chord keyboard has become established on the market and trained chordists are appearing on the labour market it will be extremely hard to change over to a keyboard with a different layout.

And although your choice of keyboard may seem to affect only a small number of people, this will be changed. When the characteristics of chord keyboards become generally known, a few courageous people will start using them for QWERTY replacement, and after some time, the use of chord keyboards will be taught in schools.

After a few years, chord keyboards will be everywhere, and chances are that they will have the keyboard layout picked by the first serious user. Therefore, the original choice had better be good.

6B. Importance of Uniformity

To "let a hundred flowers blossom" may seem attractive, but it would be a disaster if a rich flora of different chord keyboard layouts would spread over your country. **It is highly desirable to have chord keyboard layout standardized in each language area.** (Uniformity between different language areas may also be of value, but it is much less important than the intra-country standardization

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1 Section 5A.

because there is generally not much migration of personnel across language boundaries anyhow, in relation to the whole work force.)

This kind of standardization is so important primarily because it affects *people*. Standardization of such things as a bicycle tire is important "only" for economic reasons, but contrary to what many people might think, standardization of chord keyboard layout will actually influence the quality of life of many people. You must pardon me for these solemn words, but I mean them, and I will explain why.

If Company X is the only one using chord keyboards with layout Y, chordists working for Company X are effectively locked-in. If they want to go to another company and use their precious ability to write on a chord keyboard, they will have to re-learn, adjusting to another layout. This may be almost like starting from scratch again, which might be outright prohibitive.

Compare this with the situation of a QWERTY typist. When he moves to another company, he will take it for granted that he can immediately use any typewriter in the new office. It should be like that even for chordists!

However, what must be standardized is just the chord keyboard layout and the writing rules that the layout entails. It is by no means necessary to standardize on one particular brand or even one particular way of designing the interior parts of the chord keyboard. Nevertheless, we will probably have to stick to one single brand for some years to come because no OWESI chord keyboard is offered by more than one supplier.

Standardization must always be used with care because it is a potential obstacle for progress. But the advantages of standardization are generally important enough to compensate for the absence of *small* improvements. One reason for the difficulties that the Dvorak keyboard[1] has had for more than half a century is that its improvement over QWERTY is not big enough to overcome the huge inertia presented by the countless existing QWERTY keyboards and keyboard users in the world.

Even chord keyboards have to fight the QWERTY inertia. But the advantages of the OWESI chord keyboard are so great that these keyboards will overcome some day.

6C. Criteria

6C1. Factors A Priori and A Posteriori

Because "the proof of the pudding is in the eating", it would be desirable if we could base our choice of keyboard entirely on results which have actually been achieved. This would give us a *posteriori* knowledge of their characteristics.

However, absolute adherence to a need for *a posteriori* knowledge would put an end to progress. The American keyboards have been extensively used for many decades, and tens of thousands of qualified chordists can prove their usefulness. OWESI keyboards, on the other hand, have only been around for a short time, and they would probably fail in every speed comparison with the American keyboard.

Under the present circumstances, a speed comparison on an *a posteriori* basis is not conclusive in terms of *potential speed*. For a "fair" comparison on an *a posteriori* basis, we would need a

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1 Section 3B (QWERTY and Other Sequential Keyboards).

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great number of pairs of identical twins. In each pair, one should learn to use one keyboard, the other, a different one. When the twins in each pair had had (identical) opportunities to learn and practise for a sufficient number of years, we could test them and see which keyboard was best. I would not suggest such a study at present, however.

There is a serious factor behind this joke. What we can measure in an *a posteriori* comparison between two chord keyboards is not so much a difference between the keyboards as a difference between their users. Equipment differences will be completely hidden behind personal variations under most conditions.

Unfortunately, thus, we have to resort also to some *a priori* information in our judgement of the keyboards. For instance, the superiority of an OWESI keyboard in QWERTY replacement efficiency can be objectively stated *a priori*, on the basis of undisputed facts and logical reasoning.

Some other *a priori* factors cannot be *objectively* assessed. They should not be discarded for this reason, however. We must not confuse measurability with importance. A subjective factor can be very important, even if it is disputable.

6C2. Attainable Speed

Because the main *raison d'être* for a chord keyboard is its speed, the attainable speed is one obvious criterion for the choice of chord keyboard type. In order to test a chord keyboard against this criterion, we must take two things into account:

- Which speed do we need?
- Which chord keyboards will enable us to attain this speed?

The first question does not have one single answer, of course. The speed requirements depend on the applications, which will be discussed in a later chapter.[1] In the days when chord keyboards still required manual transcription, only speed-of-speech writing could justify them, and they were worthless in the hands of a person who could not attain that speed. In the era of QWERTY replacement, the picture is different.

Now, a chord keyboard can be economically justified in a QWERTY replacement application even if its user cannot attain a speed approaching the speed of speech. This will happen even at a rather modest speed increase in comparison with QWERTY. Details of a calculation of this effect will be found in a later chapter.[2]

When it comes to attainable speed, we need no further proof that the **American chord keyboards** are excellent. Many decades of successful operation is enough.

We also know that the **Bulgarian Isot keyboard, or Stenokey,** allows very high speeds. At Intersteno 87, the World Championship in Shorthand was won by a Bulgarian lady using this machine. Probably, however, nobody in the West knows how much training and practise has been required for reaching the glorious speed of 497 syllables per minute. With 2.4 characters per syllable in Bulgarian, this means almost 1,200 characters per minute.

For **Velotype,** only medium speeds are well documented. With

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1 Chapter 9.

2 Chapter 10 (Costs, Savings, and Benefits).

regard to top speed, the situation is not very clear, and I have to base my opinion on an incomplete material.

I cannot present any *a posteriori* proof that very high speeds can be attained with Velotype. But this does not prove that high speeds cannot be attained. I think they can.

Because Velotype has such excellent characteristics in many other respects, I will go to some length in arguing that its potential for high speed is adequate. It would be a disaster to discard this keyboard for lack of evidence of high-speed possibilities.

First, I will present some reasoning on an *a priori* basis. Here, I will have to separate two factors which together determine the speed:

– factor a: attainable number of chords per minute, and

– factor b: average number of chords per syllable.

When factor a is studied on an *a priori* basis, it is conceivable that someone will find arguments for saying that there are some differences between the various chord keyboard types. Some possible differences have been discussed in the section on ergonomic requirements.[1]

A proponent for a phonetic system might argue that an orthographic system causes delays because the operator could possibly have some difficulties in recalling the right spelling of a word. But I don't think this is the case, not even for English with its queer spelling.

In support, I can point to American experiences with "close captioning" using Digitext, a system which will be described in a later section.[2] This system has been used by some American TV stations for instant presentation of the speaker text in writing during live news transmissions.

While Digitext is not really an orthographic system, it requires the operator to obey certain rules for eliminating the ambiguities ("conflicts") that would otherwise be caused by homophones.[3] For example, the homophones "hire" and "higher" are written differently in the Digitext system.

Thus, Digitext lays approximately the same "spelling burden" on the chordist as an orthographic system does. In my opinion, the successful operation of this system proves that non-phonetic spelling does not necessarily slow down chord keyboard operations.

As I see it, these *a priori* factors, related to factor a (attainable number of chords per minute), do not indicate any *significant* difference between the chord keyboard layouts in present use. If there is any difference at all, I cannot tell which type is superior with respect to these factors.

Instead, I think the maximum value of a is determined by physiological factors which limit the number of precise finger movements we can perform in a second. In fact, the speed superiority of the chord keyboards in comparison with QWERTY is explained by this limitation. We cannot increase the QWERTY speed further by producing still faster finger movements. The chord keyboard does not require faster movements by any muscle, but it makes use of our ability to move a greater number of muscles simultaneously.

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1 Section 5E.

2 Section 6D2.

3 Section 4C (Orthographic and Phonetic Systems).

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Now for a discussion of factor b, the average number of chords per syllable. This factor can be changed by means of abbreviations.[1)]

In a system without abbreviations, factor b will be perhaps 1.002. The deviation from 1 is because a syllable will in some rare cases need two chords instead of one.)

The speed, in syllables per minute, equals a/b. Abbreviations – which are not used at present in Velotype systems – will reduce b. Thus, they will increase the speed (unless they should bring about a significant reduction of a by causing hesitation).

The amount of reduction of factor b caused by a given set of abbreviations can be calculated with high accuracy on the basis of language statistics. For Swedish, at least, excellent language statistics are available.

There is no *a priori* reason to believe that the use of abbreviations will reduce factor a in the long run. (It will obviously increase the required time for training and practising, but this is a disadvantage that the user has to accept if he wants to reach a really high speed.)

As mentioned earlier, the Velotype manufacturer has been opposed to the use of abbreviations. But there is no *a priori* reason to believe that the need for abbreviations will be lower in a Velotype system than in other chord keyboard systems, in which decades of experience has proven their necessity.

If adherence to a one-chord-per-syllable rhythm were of value in attaining high speed with Velotype, the same would apply to e.g. the American chord keyboards. Surely, someone would have discovered this effect in the course of time if it existed.

My *a priori* reasoning about the speed of Velotype can be summed up as follows.

- The attainable number of chords per minute should be approximately the same as for e.g. the American chord keyboards.

- Introduction of abbreviations in the Velotype system will obviously reduce factor b and thus increase the attainable speed, but the extra speed will require extra time for training and practising.

- The highest Velotype speed reached so far – whatever it is – can be exceeded by means of abbreviations. This increase comes on top of any increase that can be caused by intensified training and practising activities.

Now for the scanty *a posteriori* material on Velotype speeds.

For one thing, I saw a successful demonstration of Velotype in October, 1986. A 19-year-old Dutchman provided instant presentation of a lecture, held in English at a normal speech rate.

According to a document issued by the Velotype manufacturer, the same young man was the winner of the Dutch Intersteno typing championships in 1986, using Velotype. He produced 22,856 characters in 30 minutes with an error rate of less than 0.1 per cent. This corresponds to 762 cpm. (The fastest QWERTY typist had 439 cpm.)

This result was obtained in copying a manuscript. In general, it can be assumed that higher speeds can be attained in dictation

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1 Section 4H.

tests, in the same way as an athlete on a sports arena can run faster if he has a "hare" in front of him.

During a visit to Holland in January, 1988, I had an opportunity to test two Velotype operators. I gave them a text from a Dutch newspaper and asked them, one after the other, to copy it, using a Velotype keyboard attached to a personal computer with a word processing program in it. Afterwards, the resulting texts were copied to a diskette, which is now in my possession. This text, with a length of 2,583 characters, was input with 728 cpm by one of them and with 712 by the other.

I have been told of much more impressive results obtained on other occasions, but I will not quote these results here. I prefer to restrict my account to results which are either officially recorded or seen with my own eyes, as above.

These results are not too impressive in comparison with results obtained with other chord keyboards. Above, I have shown that one factor behind this is the lack of an abbreviation system. However, there is also another factor which can help to explain the relative mediocrity of the results.

I am referring to the low age of Velotype and the scarcity of really professional operators. The first Velotype keyboards, in a "0 series" of 100, were produced as late as 1984. Not very many persons have been trained on Velotype, and the manufacturer has lost contact with most of them after the course. If some of them have developed into very fast chordists, the manufacturer does not know, and the persons who are available for speed tests are mostly bright young students who have chord keyboard operation as a sideline.

In contrast, the American chord keyboards are used by tens of thousands of persons whose profession is to write at the speed of speech on a daily basis. Most of them have been doing this for many years, and recruitment is stimulated by handsome salaries.

Personally , I have come to the conclusion that speed limitations will not be a problem for Velotype in the long run. But I am sure that many others will take a more sceptical view. The Velotype supplier must do something to convince potential customers that Velotype is well suited also for applications where the ultimate in speed is required.

I think they must encourage some bright young persons to really go in for serious Velotype training, aiming at a professional career in fast writing. They must also produce objective evidence of good speed results.

In addition, an abbreviation system must be designed, to be used by chordists who want to reach top speed. Because no abbreviations have been used till now, we have an excellent opportunity to create a system which is well designed from the beginning.

Although the abbreviation system must be language-dependent, there are great similarities between languages in abbreviation possibilities, and a cooperation between specialists from different language areas is highly desirable, not only for efficiency in the system design, but also for obtaining a certain degree of inter-language uniformity, which will be valuable for operators who have to write in more than one language.

If these or equivalent measures are not taken, the competitors of Velotype can continue to point to the lack of documented top speed results. This should be the most serious threat to the survival of Velotype, notwithstanding that the QWERTY replacement applications are quite profitable even at the moderate speeds for which we have objective proof of attainability.

Summing up the material on attainable speed, it is not difficult to find keyboards which are excellent in this respect, but if one

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adds some other important requirements, the number of eligible candidates will shrink very much. Because Velotype seems to be clearly the best candidate in so many other respects, I have analyzed its top speed potential in great detail. For scarcity of *a posteriori* data, I have been forced to resort to *a priori* reasoning to a great extent. My conclusion is that the top speed attainable with Velotype will in the long run be approximately the same as with other chord keyboards.

6C3. The OWESI Criterion

As pointed out earlier, OWESI[1] characteristics are important for successful QWERTY replacement applications. Because it would be unpractical to use different chord keyboard layouts in different sectors of the market, all keyboards, irrespective of intended application, should be of the OWESI type.

6C4. Ergonomic Criteria

Proponents of Velotype claim that their chord keyboards are better than QWERTY from an ergonomic point of view. Some of the arguments are based on statistics over such things as the travelling distances of the fingers.

I do not know of any independent studies having been made in the field of chord keyboard ergonomics. Therefore, much of the judgement in this respect has to be based on *a priori* factors.

Some proponents of the American type of chord keyboard have claimed that the lower number of keys is an advantage because the finger-moving distances are small and the demand for accurate finger positioning is not very hard. On the other hand, I have been told that the operator at an American keyboard has to use a very great proportion of straddling keystrokes, i.e. keystrokes where one finger presses two adjacent keys. Such a keystroke should require a higher finger-positioning accuracy than a single-key stroke. Straddling keystrokes are used much less by Velotype operators.

The Velotype manufacturer also points to the fact that the key positions in Velotype have been chosen to suit the geometry of the human hands. The American keyboards, on the other hand, got their "rectangular" design at a time when the restrictions of early mechanical technology excluded other possibilities.

6C5. Capability for Instant Presentation

Some CAT systems – phonetic in nature – do not allow instant presentation, even apart from the deficiencies caused by ambiguities ("conflicts"). In these systems, the (nearly) clear text can only be produced in what is called a batch run of the host computer. For practical reasons, batch runs can only be made at rather long intervals. Capability for instant presentation is mandatory in certain applications, e.g. text interpretation for deaf people.

6C6. Economic Characteristics

In terms of costs, the difference between the two main contenders is great. The price difference between the chord keyboards themselves – Velotype or American – may not be of any great impor-

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1 Section 5A.

tance, but the choice between them entails differences in two other respects.

One is connected with the host equipment. Velotype can be interfaced e.g. to an ordinary personal computer, and the electronic gear for interpretation of the chords is built into the keyboard. The American keyboards, on the other hand, will in general require a powerful computer comprising a full-vocabulary dictionary.

Another important difference is in the cost for training and practising. This question has been covered in an earlier section.[1] And, as pointed out earlier, operating costs are strongly influenced by any need for post-editing.

6C7. Stability of the Manufacturing Company

Competitors of Velotype have stressed their financial stamina and expressed doubts about Velotype in this respect. And it is true that the Velotype manufacturer - Special Systems Industry BV (SSI), in The Netherlands - has not been very successful in the past when it comes to grabbing a large market share.

I am not a company analyst, and I leave it for others to judge the important question of the stability of SSI. But the superiority of the Velotype idea has convinced me that it will not go under. If any outside help should be required for necessary expansion, I am sure it can be provided because of good chances for long-term profitability, based on patents.

6D. Candidates and Candidate Groups

In the following sub-sections I will discuss various brands of chord keyboards and explain the reasons for my position to them. As mentioned earlier, I have taken a pragmatic approach, meaning that I have not studied all brands in detail. If I have thereby been unfair to any brand, I can only say that this report might be of help in making the situation clear.

6D1. Phonetic Systems

As pointed out earlier, systems which do not meet the OWESI criterion are not competitive in the commercially important QWERTY replacement applications. This, in my view, is a decisive argument against them for any application because it would be unpractical to have more than one chord keyboard layout in a country where such duplication can be avoided.

In countries where there are a great number of chord keyboard operators who are already fully trained in the use of a phonetic system, this is a clear argument in favour of such a system - in the short perspective. When it comes to training another generation of chordists, the situation may be different.

Thereby I have eliminated the American chord keyboard in its ordinary versions. I will revert to variations of this keyboard in the following two sub-sections.

If I am correctly informed, the French Grandjean keyboard and the British Palantype keyboard can be eliminated on the same grounds. As for the Italian Michela keyboard, the text it produces needs extensive human editing, at least in the version I saw demonstrated at the Intersteno 87 exhibition in Florence last year.

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1 Section 5D (Requirements on Ease of Learning).

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To the extent that I know the names and addresses of suppliers of the above-mentioned chord keyboards, they are indicated below.

Stenograph Corporation, 7300 Niles Center Road,
Skokie, IL 60077-3889, USA; +1 312-675-1600 and 800-323-4247;

Stenograph in Europe: Oyez Services, 24 Gray's Inn Road,
London WC1X 8HR, UK; +44 1 831 2285.

Michela: Data Management spa, Viale Eginardo, 29,
20149 Milano, Italy; +39 2 4993.1.

Transcriptor™ X (based on the "American" type of keyboard:
BaronData, 1700 Marina Boulevard, San Leandro, CA 94577, USA;
+1 415 352-8101 and 800 227-1764.

6D2. Digitext – a Quasi-Phonetic System

Digitext is a system which is based on a keyboard layout similar to, if not identical with, the Stenotype layout. But it uses a different "writing theory" and consequently a special CAT program.

This "writing theory," i.e. the set of rules that an operator has to follow for inputting syllables, is largely phonetic, but it differs from the usual American phonetic system in some respects. As I understand it, Digitext provides for better discrimination between words which have similar, but not identical, pronunciation. This should eliminate many of the ambiguities ("conflicts") which plague the conventional American systems.

In addition, it prescribes deviations from the phonetic principle for distinguishing between exact homophones such as "cell" and "sell". In other words, Digitext has certain features in common with an orthographic system. Because it is mainly phonetic, however, I would call it "quasi-phonetic".

With Digitext, almost all ambiguities seem to have been eliminated, in exchange for a complex "writing theory". But one type of ambiguity remains, based on the absence of an explicit indication of spaces. The system cannot distinguish between e.g. "counterpart" and "counter part".

This deficiency is bad enough in English. It would become still worse, however, if the system were applied to a language in which composite words are more common, such as Swedish or German.

Like the more conventional American chord keyboard systems, Digitext requires a full-vocabulary dictionary. This is needed both for spelling and for (imperfect) placement of inter-word spaces.

I have devoted many words to Digitext because someone might think that it is an OWESI system. It is not, and the text above should have proven that Velotype is superior to Digitext.

6D3. The Italian Stenotype System

The system offered by Stenotype Italia SRL has been mentioned earlier.[1] This comes close to an OWESI system, although explicit indication of an inter-word space needs an extra chord when the previous word ends with a consonant. And the user does not have to sacrifice a chord on the vowel that ends most Italian words.

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1 Section 4C (Orthographic and Phonetic Systems) and 4D (Indication of Inter-Word Spaces).

This system, thus, offers significant advantages over the conventional Stenotype system. However, it can only be applied to Italian.

Stenotype Italia SRL: Via Francesco Baracca, 209, 50127 Firenze, Italy; +39 55 37 16 38.

6D4. Stenokey: Orthographic Principle but Complex Operation

The Bulgarian Stenokey meets the OWESI requirements. Nevertheless, I have not taken it into serious consideration. Its operation seems very complex. For every chord, the operator has to obey a series of rather abstract rules, very different from the conceptual simplicity of other chord keyboards.

I admit that this is a subjective judgement, but I think that most readers will share my view after studying Appendix 1, which describes the operation. With due permission, Appendix 1 has been copied from a report written by Richard D. Steele, Ph.D., of the Rehabilitation Research and Development Center, VA Medical Center, Palo Alto, California, USA. The report was prepared for Baron*Data*, USA.[1)]

Stenokey, export: Isotimpex Foreign Trade Organization, 51 Chapaev St., Sofia, Bulgaria; +359 2 70-72-41/5, Telex 022731.

6D5. Velotype

Velotype meets the OWESI criterion and is thus capable of instant presentation of clear text. Essentially no post-editing is required, apart from correction of operator errors. It does not need a full-vocabulary dictionary. Its training requirements seem modest, although some time has to be added to the required training and practising time for those who want to become really fast writers, because abbreviations will have to be introduced.

Clearly, the weakest point of Velotype is lack of objectively documented top speed performance. As indicated in Section 6C2, however, I have come to the conclusion that this is just lack of proof, not lack of potential top speed.

Special Systems Industry BV, 69 Delftweg, 2289 BA Rijswijk (ZH), The Netherlands; +31 15 12 28 88, 12 28 89.

6E. The Swedish Decision

Some time ago, the Swedish Institute for the Handicapped decided to choose Velotype for text interpretation purposes. Similar decisions were taken by Swedish Text TV and a private company in the graphic industry. A modest sum was paid to SSI in Holland for developing a program module for the Swedish language.

A first course in Sweden was held in November, 1987. A second one was held in February, 1988. Some of the participants were young people with the intention to try to become skilled chordists, while others were administrators, seeking concrete knowledge of the new technique. In the first-mentioned group, the majority are people who are or will be active in text interpretation for deaf people, either in meetings or in Text TV.

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1 The address of BaronData is indicated in Section 6D1.

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The chordists *in spe*, with possibilities for extensive practising, have succeeded to get speed results above expectations, according to the company that is acting as a Swedish agent. Further details will be given in a later section.[1]

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1 Section 8C (Typical Curves over Speed vs. Time).

7. Host Systems and Associated Facilities

In general, a chord keyboard must be connected to a *host* system. The host can be a dedicated word processor, but nowadays it is more common to use a personal computer, equipped with a word processing system. The system includes a computer program, but an equally important part of it consists of rules for using it, text-books, etc.

In an office where many people do word processing work simultaneously, an alternative to using a number of separate personal computers is to have one central computer, more powerful than personal computers usually are, and let the users have some equipment which is connected to the central computer all the time. (Even the equipment on the users' desks may consist of personal computers, but in this case, the central computer takes over certain tasks from the personal computers.) In the present state of technology, such multi-user systems may be competitive in cases where many users need access to a common set of text files.

7A. Personal Computers and Similar Equipment

Personal computers come in a large number of varieties. However, a few classes of them have crystallized as being generally more viable than the others.

A certain degree of uniformity between personal computers is of great value to the users. One of the advantages is that the collections of operating programs – the software – can be standardized and thus very cheap.

Three classes of personal computers are generally more in focus than others are:

- IBM PC (Personal Computer) and the many computers that are compatible with it,

- Apple Macintosh, and

- IBM PS/2 (Personal System/2).

The group of IBM-compatible personal computers includes IBM PC in a number of varieties plus a number of "clones", i.e. computers made by other manufacturers and designed in a way that makes their characteristics identical with those of IBM PC in all important respects. One advantage of the IBM-compatible computers is that the user is not dependent on a single manufacturer. Software for these computers is abundant and cheap.

The price competition between the manufacturers of "clones" has been very effective in lowering the prices. IBM has now discontinued the production of IBM PC, but the clones are delivering computers in very great numbers.

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IBM is now promoting the more advanced PS/2 family instead of IBM PC. A user of IBM PC can move up to PS/2 and still use the same programs, but in order to make full use of the higher performance of PS/2 he should make some changes.

As far as I can see, the additional performance of PS/2 is hardly of any value in chord keyboard applications because the performance of the IBM-compatible personal computers is quite sufficient. And a user of PS/2 is essentially dependent on a single manufacturer because the PS/2 world – so far, at least – does not show a clone situation similar to the one in the IBM PC world.

Macintosh, supplied by Apple, has had a sufficiently large "niche" to hold a strong position as an alternative to the IBM-compatible personal computers for some years. Recently, Apple has made some moves to provide a sort of compatibility bridge between Macintosh and the IBM-compatible personal computers, enabling Macintosh users to exchange data with users of IBM-compatible personal computers on diskettes.

Before this happened, a user's decision to "go Macintosh" or "go IBM PC" would mean that he was cut off from one of the two worlds. With the new compatibility bridge, the consequences of this choice have become less dramatic because he can now have a compatibility with both the Macintosh world and the world of IBM-compatible personal computers. The "language" on the IBM diskettes has become a *lingua franca* "spoken" in the two most important sectors of the personal computer market.

Within the IBM PC world, there are some important variations in capacity. One is related to fixed disk memory and the other to processor speed.

The original IBM PC had only diskette stations for secondary storage. (A diskette is a type of magnetic storage medium that can be exchanged in seconds.) With the advent of a computer called IBM PC/XT, a fixed disk (called hard disk by most other manufacturers) was introduced. While a diskette originally had "only" room for about 360,000 bytes, a hard disk has typically room for 10 million bytes or a multiple thereof, and it has an access time that is just a fraction of what a diskette has.

Clone manufacturers were fast to imitate this improvement. In many respects, an "XT compatible" personal computer is more valuable than a PC with only diskette storage. Therefore, we can expect to see many personal computers with fixed disk, or hard disk, in installations with chord keyboards.

Another performance enhancement was made when IBM PC/AT was introduced. Here, the original microprocessor (Intel 8086) had been replaced with a much faster one (Intel 80286).

Even in this case, clone manufacturers followed the example. The "AT" designation is trade mark protected, and clones with the faster microprocessor are often identified by means of a model designation comprising the number "286".

While many word processing systems show an acceptable performance with the slower microprocessor, the "286" model performs better in many jobs, especially when "desk top publishing" is involved. Therefore, many chord keyboards will probably be attached to "286" computers.

7A1. Distribution of Tasks between Keyboard and Host

Typically, a chord keyboard will be connected to a host which has some sort of word processing system. This system is normally designed for a computer with a QWERTY keyboard. When a chord keyboard is used, some additional functions will have to be performed, requiring extra computer programs. One such function is to transform a chord, corresponding to a group of characters which are not completely ordered, into (in general) a syllable in clear text.

In Velotype, the program for this purpose works in a special microprocessor which is included in the chord keyboard. Therefore, the host receives exactly the same signals as if the same text had been input on a conventional QWERTY keyboard, although the signals come in a more rapid succession.

This means that the host does not necessarily need any special program for a Velotype chord keyboard. A standard word processing program can do the job.

Most other chord keyboards cannot produce clear text on their own. Therefore, the host needs an extra program for transforming the chords into words. And if a keyboard for phonetic writing is used, the host must also have access to a full-vocabulary dictionary, designed in a way that allows syllables and words to be found when the "key" consists of a set of phonetic codes.

This dictionary must be stored in a big memory, usually consisting of a hard disk. And if the chord keyboard is to be used for instant presentation,[1] the computer's primary storage must be big enough to contain a copy of the whole dictionary all the time. (For "primary storage", other names are sometimes used, such as "main memory".)

Earlier in this section, it was pointed out that the host of a Velotype chord keyboard does not "necessarily" need any special program. But a small special program will be desirable – in certain applications, at least – for two reasons.

One of them is connected with abbreviations.[2] An abbreviation, in this case, is a special code that must be blown up to a polysyllabic word or a group of words.

In principle, a Velotype chord keyboard could have the interpretation of a set of abbreviations done by a program in the built-in microprocessor. But the abbreviation program should have some flexibility, and this is easier to achieve in the host. Among other things, a user may want to add abbreviations for certain names or technical terms.

The other reason for special programming in a Velotype installation is connected with function chords.[3] Even here, some flexibility is desirable, making this job suitable for the host. This is especially because a certain command is in many cases expressed differently in different word processing systems.

The special host functions which are necessary or desirable in a system with a chord keyboard do not generally require any special kind of hardware, apart from the keyboard itself. But the required memory sizes will be affected, and in the case of a phonetic keyboard, the necessary extra memory capacity will be substantial. – The software questions will be further discussed in a separate section.[4]

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1 Section 5C.

2 Section 4H.

3 Section 4G.

4 Section 7D.

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7A2. Printers

In most cases, chord keyboards do not impose any extra requirements on the printers which are to be used for text output. There is one possible exception, however, connected with certain types of instant presentation.

Instant presentation at a meeting will generally mean presentation on a screen ("soft copy"). However, some organizations may find it desirable to produce text on paper ("hard copy"). For instance, if a person has been absent from a congress for a few hours or minutes, such a system will enable him, at a glance, to get a picture of what has been and is going on.

The speed requirements for such "real-time printout" are not hard to meet. Almost all printers in use at present have a printing speed which is faster than the speed of speech. But a printer for this purpose should preferably produce visible text with negligible delay. This rules out "page printers" (e.g. laser printers) which do not produce anything that can be seen until the text for a full page has been received from the host computer.

7A3. Presentation Equipment

Instant presentation[1] for a single person – e.g. a deaf meeting participant – can be produced on a normal computer screen. In some cases, the deaf person can look at the same screen as the chord keyboard operator who does the text interpretation, but otherwise, the deaf person should have a separate slave screen. Some systems have infra-red (IR) connection to slave screens, which relieves the user of the slave screen from handling cables.

As alternatives to a CRT screen (Cathode Ray Tube, or "TV tube") some other types can be used. One of them is the LCD screen (Liquid Chrystal Device), using the same principle as most digital watches. Another one is the plasma screen, or gas panel, containing a flat glow lamp with a very large number of tiny electrodes which can be individually made to glow, forming visible characters.

The screen of a personal computer normally presents about 24 lines of 80 characters each. In text interpretation, it may be better to have bigger characters, e.g. with 40 characters per line and 12 lines, or even 20 characters and 6 lines. Provision of such presentation is not always as easy as it might appear, but it can be done.

Undoubtedly, there will be requirements for presentation to a larger audience. The speaker may want to check that the text interpreter has understood him correctly, but even apart from that, people will soon find out that text presentation is of value even to hearing persons. Some reasons for this will be given in a final chapter.[2]

One way of presenting text to a large audience is to use a flat, transparent LCD screen of a type that can be placed on an overhead projector. Another, more recent type of transparent LCD screen is small enough to fit in a slide projector. The last-men-

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1 Section 5C.

2 Chapter 12 (A Look into the Future).

tioned type is more expensive, but on the other hand, it is said to enable a larger audience to read the text.

7A4. Other Ancillary Equipment

While instant presentation of a speaker's text is a recent achievement, verbatim reporting with subsequent printout has been with us since Tiro's days. The combination of a chord keyboard and a text-processing computer will make such verbatim reporting easier and more attractive in the future. For this application, however, some extra equipment – and some special programs – are desirable for maximum efficiency.

One reason for extra equipment is connected with the use of sound recording as the stenographer's safety net. The art of sound recording may seem to have reached a high degree of maturity, but much remains to be done in this field when it is applied to a verbatim reporting situation. This is largely a question of using certain digital techniques, not only for the sound recording as such, but also for the coordination between sound recording and text recording.

Another reason has to do with editing of the text. In court reporting, it may be essentially forbidden to edit the text, but in reporting from a parliament session, editing is essential. In verbatim reporting in edited form, the dominant cost is for editing, not for taking down the text in written form. Therefore, much is to be gained by use of a system that makes life easier for the editor, and there is much that can be done in this field by means of special ancillary equipment and programs.

A full account of the possibilities will not be given here. I have only wanted to point out that verbatim reporting is still an underdeveloped part of chord keyboard applications.

7B. Self-Contained Keyboards

In certain applications, a chord keyboard does not need a host all the time. If it is used for taking down notes for subsequent printout, the text can be temporarily stored in a memory contained in the keyboard itself. The chord keyboard is then a self-contained unit. With a battery-powered keyboard, chords can be recorded without cords.

Such a text memory can be installed in a Velotype keyboard. The capacity can be up to 32,000 characters, which corresponds to something between 30 and 60 minutes of unintrupted speech. Before the text memory becomes full, its contents must be copied to some host equipment.

7C. Speech Synthesizers

Certain groups of speech-impaired people can have use for a speech synthesizer of the key-to-speech type. When a text is input over a keyboard, the speech synthesizer can read it aloud.

This technique is now well established. Although the sound does not have much of a personal touch, its intelligibility can be good.

This method of communication is not suitable for *all* speech-impaired people. Speech-impairment is often combined with other disabilities, which make it difficult or even impossible to handle a keyboard. For others, key-to-speech systems must be of great value.

When a QWERTY keyboard is used, however, such a system has an irritating slowness. With a chord keyboard, this can be helped, if the user has good control of his hands. When the user has a Velotype keyboard, which requires no host computer for producing the right character sequences, it should be possible to attach a speech synthesizer having a volume of the same order of magnitude as the volume of the chord keyboard itself.

7D. Software

Because a modern keyboard is essentially a tool for word processing, the host computer can in many cases use one of the commercially available word processing programs. For certain applications, however, some additions to such a program are desirable. The additions may affect either the text input side or the text output side.

On the input side, interpretation of abbreviations and function chords[1] have to be interpreted by a special interpretation program. If you use a single chord like "MC" for "Mr. Chairman", you will want this special program to remove "MC" from the character stream emanating from the chord keyboard and send a longer strong of characters along to the word processing program, making this program "believe" that you have actually typed "Mr. Chairman" on a QWERTY keyboard. And when you strike a function chord, you want the special interpretation program to deliver the same character code or codes as a conventional keyboard would deliver if you had operated some function key(s).

On the output side, you may need an extra presentation program if you are using instant presentation. An ordinary word processing program produces codes which identify characters to be presented on a screen, but if you want extra big characters, you may need a presentation program for translating the character codes into another form, which is otherwise used for producing graphics, i.e. pictures, rather than strings of standard-size characters.

Neither the interpretation program nor the presentation program will be difficult to produce, but it may be a problem to combine them with a standard word processing program. The interpretation program has to be "inserted" between the keyboard and the word processing program, and the presentation program has to be "inserted" between the word processing program and the screen.

If I am correctly informed, the degree of difficulty of this insertion depends on whether or not the word processing program uses a standard method for input and output. In an IBM-compatible personal computer, input and output are normally handled by a program module called BIOS (Basic Input-Output System). If the word processing system makes use of BIOS, insertion of an interpretation and/or presentation program should not be difficult, but unfortunately, some word processing systems are said to contain "own" input/output parts instead. This may make the insertion difficult, unless one can get cooperation from the organization that has created the word processing system. In selecting software for a system with chord keyboards, these factors should thus be taken into account.

Another factor is the speed of the word processing program. The programmer has normally only had QWERTY speed in mind, and it has been reported that certain word processing programs

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1 Sections 4H and 4G, respectively.

cannot cope with the more intensive stream of characters that a chord keyboard can deliver. This is probably a bit unusual, however. Especially, you are not likely to get into such difficulties if your host computer is equipped with a fast microprocessor such as the 80286.[1]

1 Section 7A (Personal Computers and Similar Equipment).

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8. Users, Training, and Practising

To the extent that the contents of this chapter are dependent on the type of chord keyboard, I will concentrate on Velotype. This is because I have found its superiority clearly established.

8A. Necessary Qualifications

8A1. Speed

For ages, few professions were open to women, and if a young girl wanted a white-collar job, one of her few possibilities was to become a secretary or office clerk. Among those who chose these professions, there were many highly talented persons.

But there were many who sought such jobs and accepted a low salary. This has probably been an important factor in holding down the esteem for such skills as shorthand and typing. However, especially shorthand with very high speed requires a rather rare talent for this special task.

I have no statistical proof of this statement, but in the days when I went to voluntary evening class for shorthand training – in the early 'forties – I could observe how few of my comrades could reach really high speed. Sooner or later, everyone reaches a plateau in his speed development, a level which cannot be exceeded regardless of the amount of training. This plateau turned out to be clearly below the speed of speech for most people in the class, although every participant in the fast training classes had come because they had shown good promise as beginners. And in those days, when parliament stenographers were still unthreatened by sound recording and consequently well paid, the motivation to reach the speed of speech could be very strong in a young student.

This subjective observation is not the only support for my thesis, that fast shorthand requires special talent. Let me remind you of the examination results in American schools for court reporters, where 90 per cent or more fail to get the desired certificate.

I have tacitly assumed that talent for pen shorthand and talent for chord keyboarding are more or less identical. If you are in doubt about this, I will remind you of the astonishing success of one chord keyboard school which I wrote about in Section 5D. I could not believe that almost 100 per cent of the participants passed the tests until I heard that they were all very fast pen stenographers when they began the course. In other words, they were all among the few who remained after most of their comrades in their pen shorthand training must have failed.

Shorthand talent is intellectual, not physical. When a fast stenographer fails to follow a fast speaker, it is not because his fingers cannot obey the orders from his brain. It is because the brain cannot issue the orders fast enough. This, too, is a subjective experience, but I think that all fast stenographers can testify that this is the case. I admit that physical pain in the muscles of the hand can be a limiting factor for a beginner, but a fast stenographer's narrow section is in his nervous system, not in his hand.

It seems that the upper speed limit is generally higher for chordists than it is for pen stenographers. In Intersteno's World Championships in shorthand, held every two years, users of chord keyboards are consistently getting the best results. So, the general speed level can be assumed to be higher among students of chord keyboarding, but the spread in results within that group should be largely the same as for pen shorthand. The Gaussian curve in Figure 5:1 can probably be applied to shorthand talent, too.

8A2. Accuracy

Freedom from uncorrected errors is obviously of great importance. And even if the stenographer notices his errors and immediately corrects them, the corrections will of course reduce his average speed. It is recommended that students of chord keyboarding should never neglect the accuracy requirements in their efforts to gain speed fast during the practising period.

In QWERTY replacement jobs, it has been reported that users of chord keyboards make fewer mistakes per page than QWERTY typists. The main factor behind this effect is probably in sequence errors. One of the most frequent error types in QWERTY typing is a reversal of the order between two adjacent letters, but such errors can hardly ever occur in a chord keyboard system because the order is controlled by a microprocessor, not by a human operator.

In pen shorthand, which anyhow needs human transcription, the accuracy requirements are relatively low. I know from experience that a stenographer's signs can sometimes be used without much difficulty even if they are horribly deformed, because it is the stenographer himself who reads them.

When chord keyboards are used, the situation is a little different. You cannot produce deformed characters, but characters can be erroneously added, exchanged, or omitted.

Still, many such mistakes can be coped with as long as the text is read by a person who knows how to operate a chord keyboard. But instant presentation requires high accuracy. The reader has generally no detail knowledge of chord keyboard operation, and even very small mistakes can render a part of the text unintelligible.

8A3. Linguistic Ability and Editing Skill

It is a wide-spread misconception that a debate stenographer is a robot who produces a sort of mechanical recording of the sounds he hears and that a good transcription of a speech should be truly verbatim. This is wrong both on the input and output side.

On the input side, the stenographer must identify each word. This may appear to be simple, but especially in ambient noise or otherwise difficult acoustical conditions, we do not really hear every word that a speaker says, even if we think we do.

In fact, we fill in many words on the grounds of context. To do this right, we need a wide vocabulary and a good command of the language. If you have seen speeches that have been typed from tape recordings, you will probably have seen horrible misinterpretations of words because such printout jobs are often delegated to people who have neither talent nor motivation for this task. When we are just listening, we are not bothered too much by some uncertainties about words, but if a person is supposed to

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transcribe the spoken words on paper, he had better get every word right, on the "input side" of his job.

On the output side, if we produce a truly verbatim printout, this will often be both ugly and hard to understand. This is partly because the spoken language contains much non-verbal information which is important for listening but gets lost in a verbatim transcription. This information consists of such signals as pauses and tone variations. Also, the listener is generally much more tolerant with respect to violations of the laws of grammar and syntax than the reader is.

A good transcription should make the same impression on the reader as the speech made on the listener. For this goal to be reached, wording will often have to be changed rather radically, and especially the order between words. It takes great linguistic skill to edit a speech in such a way that the absence of the non-verbal information is compensated by means of changes in the wording while the speaker does not notice any appreciable deviations from what he thinks he has said.

The American court reporters do not have this problem. They are forbidden to change the wording of a witness, for example, and the readers have to bear this in mind. But the reputation of the Swedish parliament members would be very bad if their utterances had not been improved by the stenographers.

For these reasons, some chordist jobs – but not all – require linguistic skills in addition to the ability to write fast. It should not be difficult to produce tests for measuring the ability to identify spoken words and to edit verbatim printouts of speeches.

I think there is, luckily, a high correlation between talent for fast writing and linguistic talent. This is a purely subjective opinion, without statistical support, but you may admit that it is quite plausible because a faculty for fast writing is clearly related with our ability to handle the language.

8B. Courses and Practising

As indicated in the beginning of this chapter, I am not going to dwell on the American two-year courses for chordists. Instead, I will concentrate on Velotype.

The principles of using Velotype are normally taught in a two-week course. Including practising hours, the course takes full time during these two weeks.

At the end of the course, the students can use the chord keyboard for producing any text, but their writing speed is low at this stage. As earlier mentioned, no abbreviations are taught in the Velotype courses at present.

During the course, each student must have a chord keyboard. The present models of Velotype have a small built-in display that shows the last forty characters, and with such a model, no host equipment is needed during the course except for perhaps one keyboard in the classroom.

For picking up speed, the student needs a lot of practising. Because Velotype is well suited for QWERTY replacement, the practising can consist of productive typing work. This is not only of economic importance. It makes practising more interesting (hopefully) than pure exercises.

It has been said that automatism is normally achieved in about 400 hours of practising. This is an important milestone. But even beyond this point, further practising will normally mean further speed increase.

Normally, young students – say, below 30 – are reported to show the fastest speed increase. There are, however, also a few success stories about older students.

8C. Typical Curves over Speed vs. Time

Naturally, it is desirable to know which speed can generally be attained after a given number of practising hours. Unfortunately, the available information regarding Velotype is not very exact in this respect. A set of "typical" curves was produced at an early stage, but later, the time scale of the curves was revised to present a less optimistic view.

The revised curves – shown in Figure 8:1 – may be a bit on the pessimistic side instead, at least in part. – The originator of the diagram has pointed out that practising time here means the time that is actually spent on using the keyboard for input, excluding time for breaks of all kinds.

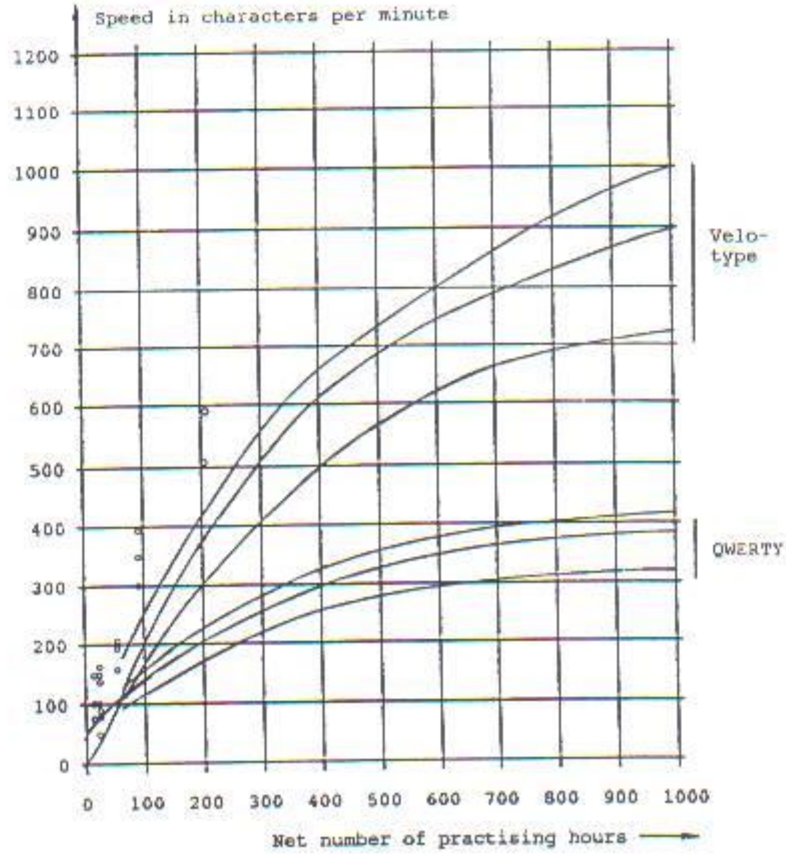

Figure 8:1. Typical curves over speed vs. training and practising time for Velotype operators according to the manufacturer. See text for the meaning of the small circles.

The small circles in the lower left-hand part of the diagram indicate speeds that some of the students in the first Swedish Velotype course reached – according to the company that is acting as a Swedish agent for Velotype – within the first few months after the course. This two-week course ended on November 27, 1987, and the last tests indicated in this diagram were held on March 29, 1988.

Each test lasted for three minutes. No speed deduction was made for typing errors. As you can see in the diagram, the highest speed attained – after 204 net hours of practising – was nearly 600 characters per minute.

Generally speaking, the highest speeds were reached – naturally – by the young students who were there to become chordists, while the participants who were administrators, seeking general knowledge, could not write with the same speed. The circles seem to indicate that the curves for Velotype at least do not exaggerate the speed that can be reached in the first few months, which is the only period for which Swedish data are available.

The results obtained by these Swedish students are not necessarily typical. These students were selected from a large number of applicants, and if the selection criteria were relevant, the admitted students may have above-average talents for fast writing.

When the curves in Figure 8:1 were first drawn, they were based on material from the Dutch Association for Stenography, Typewriting and Office Practisers (Associatie SMK). The information came from chord keyboard teachers who had kept a more or less accurate record of their own advances and the advances of their students. It was admitted that especially the important right-hand part of the Velotype curve was rather uncertain because the number of students who had had an opportunity for a large number of practising hours was very small at that time.

Even now, neither the Velotype manufacturer (SSI) nor anybody else seems to have a very accurate picture. The SSI people explain the lack of a solid statistical material by pointing out that they are seldom in a position to observe Velotype students for long after the course. Most of them get a job immediately after the course – if they did not have one before – and they will hardly ever report back about their speed increase.

We have to accept this uncertainty about the average rate of performance improvement. I would be very worried by this if the margins for success would seem to be narrow.

Fortunately, they are quite wide. Results can be much inferior to what is shown in the curves and still be very good.

Although I feel uncertain about which percentage of the students will ever reach the speed of speech, I get some consolation from the fact that speed-of-speech chordists are not required in very great numbers, and it is evident that the average Velotype user can reach a speed which is very much higher than the speed of experienced QWERTY typists. In fact, they may attain speeds in the region of what the world champions in QWERTY typing can achieve. I will revert to this in a later chapter.[1]

8D. Labour Market for Chordists

As will be shown in the next chapter (Applications), there is a wide spectrum of jobs where chord keyboard operation is necessary or desirable. This provides for a passage through progressively higher positions during the practising period after the course.

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1 Chapter 10 (Costs, Savings, and Benefits).

Initial jobs are mainly in QWERTY replacement, where a chordist should be able to earn a good living based on the high productivity.

The high productivity of a chordist is best utilized in jobs where input of large quantities of text is needed. Such jobs are found e.g. in typing pools and in typesetting offices. Some persons will undoubtedly like to become self-employed and set up their own small typing bureaus.

Those who reach the highest speeds can go to speed-of-speech jobs such as text interpretation for deaf people and verbatim reporting at congresses and other parliamentary gatherings. The jobs in this sector are rather few at the present, but the possibility for instant presentation and very fast production of printed proceedings will make employers more positive to this kind of activities.

Many of the jobs in the speed-of-speech area are of an *ad hoc* nature. A trade union may need a handful of fast stenographers for a one-week congress every four years or so, and a deaf person will occasionally need a meeting interpreter. For this reason, free lance chordists may find a good market. And when no speed-of-speech jobs are available, they can fill their time with profitable QWERTY replacement tasks.

In addition to people who have chord keyboarding as their chief task, chord keyboarding will be an important sideline in many professions. In some journalist jobs, for instance, fast writing can be of great value, especially for taking notes but also for writing articles (although one should not overestimate the value of fast writing in this case).

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9. Applications

9A. Classes of Applications

A natural way to classify applications is by purpose. This system is used in most of this chapter. In the following two sub-sections, however, classifications on other grounds are presented as a contribution to the overview of the field.

9A1. Applications Justified by Speed, Savings, and Ergonomics

When chord keyboards were invented, their only purpose was to enable the user to take notes with high **speed.** At that time – and for a century thereafter – machine shorthand was just an alternative to pen shorthand.

For catching the spoken word, both forms of shorthand are now facing competition from sound recording. In American courtrooms, shorthand reporters – almost all of them using machine shorthand – have kept their positions against assaults from sound recording, perhaps because a shorthand reporter can immediately read back a recent statement from his paper if he is asked to. A playback system for the same purpose in sound recording would be a bit complicated, although it would clearly be feasible.

With the advent of the most modern chord keyboard techniques, machine shorthand has gained a very important advantage over sound recording because of the possibilities for instant presentation. Never before has it been possible to show an utterance in clear text in practically the same moment as it has been pronounced in a "live" performance.

The instant presentation capability is actually quite revolutionary, but this has not yet been noticed by many. Among those who have are people in the Swedish Institute for the Handicapped, planning to use instant presentation in text interpretation for the deaf.

Many wonder why stenography is still used e.g. in parliaments, when typists could transcribe recorded sound tapes instead. And if you want an unedited printout, the sound recording method may be quite competitive, provided that the transcription is made by sufficiently qualified people.

But it is entirely impossible to edit the text in a satisfactory manner during transcription from sound tape to typing, because the typist does not have an overview of sufficiently long parts of the text. On the other hand, when a stenographer meets a passage which has to be edited, he can look at the preceding and following words and perform the editing in the course of his transcription work, while a sound tape transcription will have to be edited – and often completely retyped – in a separate operation after the raw printout.

For this reason, even a relatively well-paid debate stenographer – using either pen shorthand or machine shorthand – can produce an edited printout both faster and cheaper than a typist and an editor, working from sound tapes. This leads me over to the next form of justification: **savings.**

Especially in QWERTY replacement applications, great savings can be obtained by using chord keyboards. Some quantitative examples will be given in a later chapter.[1] This should be the primary justification for most QWERTY replacement jobs.

Even in such applications, though, speed as such contributes a little to the justification. A typesetting company, for instance, becomes more competitive when it can produce a given text volume in a shorter time, even apart from the savings in labour costs.

Ergonomic considerations can provide further justification for chord keyboards. The Velotype manufacturer claims that Velotype causes much less stress and strain than the QWERTY keyboard, not only for a given text input volume, but also per hour of work. Very much shorter finger movements are one important ergonomic factor in this respect. Another one is that the geometry of the Velotype layout is better adapted to the anatomy of the hand than a conventional QWERTY keyboard.

The ergonomic advantages of a chord keyboard are much harder to prove than speed and cost advantages. But organizations active in the ergonomic field, such as Arbetarskyddsstyrelsen in Sweden, should study this question and publish the results, for ergonomic factors are very important, affecting the well-being of people. (In addition, ergonomic improvements will often cause economic savings.)

9A2. Real-time Applications and Batch Applications

Another important classification is based on synchronization with outside events. In a **real-time** chord keyboard application, the chordist's work has to be synchronized with the utterances of a speaker who could not care less about the stress that the chordist may feel because of the high speed of the speech. In a **batch** operation, on the other hand, the chordist can work at his own pace, e.g. when he is typesetting a book from a manuscript or from a dictated tape that he can start and stop at will. Clearly, a real-time chord keyboard job is much more difficult and stressing than a batch job.

There is a grey area between real-time and batch jobs. One example is text telephone interpretation between a hearing person and a deaf text telephone user. Here, the text interpreter should ideally follow the hearing person's speech, enabling the deaf person to see every word almost immediately after it has been pronounced. But if the text interpreter cannot write with the speed of speech, the consequences are not catastrophic. If the situation becomes really bad, he can ask the hearing person to wait a little, and if it is not quite that bad, all that happens is that the conversation is slowed down a little.

A grey-area situation can also exist in a meeting of a relatively small number of persons. Here, a text interpreter has a certain chance to make the hearing participants speak a bit slowly, and if the text is displayed in a way that enables everybody to see it, the speakers may even spontaneously adjust their speaking speed when they observe that the text interpreter is lagging too much behind. In a big gathering such as a parliament meeting, on the other hand, the shorthand reporting is traditionally handled a bit more

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1 Chapter 10 (Costs, Savings, and Benefits).

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discreetly, and there is no question of making the speaker slow down because the reporter cannot write fast enough.

The "real-time" and "batch" concepts can also be used in a slightly different sense, focusing on the timing of whole jobs rather than individual parts such as spoken words or sentences. This aspect will be discussed in a later section.[1]

9B. Applications in the SDP Area

9B1. Text Interpretation for Deaf People

While pre-lingually deaf people generally prefer sign language, many adult-deaf people have never learned this language, or have not learned it well enough. On the other hand, they can usually read well, and so, text interpretation is of great value to this group. (In certain situations, a deaf person who is a good lip reader can also be helped by a mouth-hand system, where an interpreter makes lip movements in accordance with the speaker's words and supports lip-reading by means of hand movements for sounds that are otherwise hard to distinguish from other sounds.)

9B1A. Text Interpretation in Meetings

In Sweden – and in many other countries, I presume – there is an organization for providing text interpretation for deaf persons in meetings, including such bilateral meetings as visits to a doctor. Text interpreters will be sent to such meetings, where they will use some suitable equipment for this purpose.

Today, the interpreter's equipment is normally a text telephone, which is in this case not connected to the telephone network. The interpreter inputs the spoken words on the keyboard, and the text is presented on a screen within the deaf person's sight.

At present, QWERTY keyboards are used. The slowness is quite irritating to all parties, of course, and a change to chord keyboards (Velotype) is now under way. A small number of text interpreters have now had a two-week Velotype course, but at the time of writing this report, these interpreters may not yet have gained a chord keyboarding speed in excess of the speed of a fast QWERTY typist.

A Velotype keyboard cannot at present be interfaced to the text telephones used in Sweden. Therefore, text interpreters for meetings will have to change to some sort of personal computer, preferably portable, if they are to use chord keyboards.

There have been complaints that some deaf people cannot follow the pace of the text that appears on a screen during a meeting even when the text interpreter uses a slow QWERTY keyboard. Consequently, there has been some concern over what will happen to these deaf people when chord keyboards are introduced.

However, it seems reasonable to believe that the reported reading speed problems are not really caused by a too fast presentation of the text. I base this theory on having observed that QWERTY text interpreters are often forced to try to perform some "instant editing" because they cannot type fast enough. This editing will often consist in omitting words and punctuation in a way that makes the text impossible to understand.

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1 Section 10D (The Solution to the Queuing Problem).

With a chord keyboard, a skilled text interpreter will be able to write every word. This will improve the intelligibility of the text, and I think this will cure much of the problems which have been ascribed to a too high writing speed.

Another reduction of what appears to be reading speed problems can be made if we can provide the screens with *smooth scrolling*, also called soft scrolling. When the bottom line on the screen is full or nearly full, the text lines have to been moved ("scrolled") one step upwards to leave one line empty. In a system with smooth scrolling, the scrolling is continuous and relatively slow, allowing the viewer to go on reading the text during the upward movement.

Most systems have discontinuous scrolling, meaning that the upward movement appears to be instantaneous. This may not bother a person who can read every word immediately, for he will already have finished reading the last line when it is moved upward. But a person who is reading in the middle of a line will easily lose his orientation when a completely different text appears where he is looking.

Therefore, smooth scrolling should be used in text interpretation systems. – Some other questions in connection with text presentation during meetings have been covered in an earlier section.[1)]

9B1B. Text Telephone Interpretation

Many deaf people have text telephones, enabling them to communicate with other telephone users via the telephone network. A text telephone is like a data terminal, with a keyboard and a screen where the user can read both his own text and the text that the other party writes.

When a text telephone user wants to use the telephone for communicating with a hearing person who has no text telephone, he can use a text telephone interpretation service. In Sweden, such a service is provided by Swedish Telecom.

For using this service, the calling subscriber dials a special number (0010, not preceded by any area code) which brings him in contact with a text telephone interpreter who has a text telephone, in addition to a sound telephone. The hearing subscriber speaks to the interpreter, who relays his words to the deaf subscriber via the text telephone.

At present, the text telephone interpreters use QWERTY keyboards. Naturally, this is a slow method. And although the interpretation service is fully paid by the government, the subscribers have to pay for the calls at the same price per minute as for ordinary telephone calls over the same distance. Therefore, the slowness of QWERTY causes extra costs for the calling subscriber, to say nothing of the irritation.

Therefore, a change to chord keyboards on the desks of text telephone interpreters is being discussed. In addition to the savings that such a reform would give the subscribers because of a shorter average call duration, a many times larger saving could be obtained on the government side. This is because the hourly costs for the text interpretation is many times higher than the subscriber's average hourly cost for a call.

Nevertheless, a change to chord keyboards may not have first priority among reforms in the area of text telephone interpretation in Sweden. Some other reforms, which are also of great value both to the subscribers and the government, will be easier to carry out,

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1 Section 7A3 (Presentation Equipment).

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and they should perhaps be implemented before any significant resources are used on the introduction of chord keyboards in this application area.

One of the reasons for this opinion of mine is mainly quantitative. A few hundred persons spend part of their working time on text telephone interpretation, and thus, re-training of these persons needs big resources. In addition, providing meaningful work for these persons during a long practising period, before they have acquired a chord keyboard speed which is higher than their present QWERTY speed, is a bit of an organizational problem. A further difficulty lies in the fact that some of the text telephone interpreters are not very young, which means that some of them may have extra difficulties to become skilled chordists.

In spite of such obstacles, it is reasonable to believe that chord keyboards will some day become standard equipment for text telephone interpreters.

Among the deaf text telephone users, on the other hand, few can be expected to acquire chord keyboards. One obvious reason is in the cost for a chord keyboard and, still more important, the cost and time for a chord keyboard course and the practising that is required for high-speed work.

In addition, many deaf persons have little use for a keyboard when they communicate with hearing persons. Some hearing persons have acquired text telephones in order to communicate with deaf relatives or friends, and other hearing persons can communicate with deaf text telephone subscribers via the text telephone interpretation service.

In such communication situations, many deaf people can talk to the other party instead of using the keyboard. Using a suitable communication procedure, the two parties can easily switch from text transmission to speech transmission every time the deaf person has something to say. At present, alternating text transmission and speech meets certain technical difficulties in the Swedish text telephone system, but these difficulties will hopefully soon be eliminated.

9B1C. Problems with Slower Text Telephone Systems

In some text telephone systems, the use of chord keyboards can be hampered by speed limitations in the communication system itself. This is not the case in Sweden, though, because the Swedish text telephones use a speed of 300 bits per second, corresponding to nearly 27 characters per second. A speaking speed of 900 cpm, which is relatively fast, corresponds to 15 characters per second.

The transmission system used for text telephony in Sweden and some other countries is denoted as CCITT[1)] V.21, or just V.21. In some countries, also using the V.21 system, the speed is only 110 bits per second. This is more than adequate for QWERTY speed, but not for the full speed of speech.

Some other countries use what is called the DTMF (Dual-Tone Multi-Frequency) system instead of V.21. This system is still slower, as will be explained in more detail below.

This does not mean that chord keyboards cannot be used at all in such systems. If suitable measures are taken, the system can cope with the chord keyboard speed at least part of the time, and

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1 CCITT stands for Comité Consultatif Télégraphique et Téléphonique, an international standardization organization.

the system can be designed to warn the chordist when this is no longer possible.

One such measure is to provide the apparatus on the sending side with a suitably arranged *buffer memory*. (Some or all text telephones in the countries in question may already have such buffer memories of sufficient capacity.) When the input speed *temporarily* exceeds the maximum transmission speed, the excess characters are stored in the buffer, from which they are automatically transmitted on a first-in, first-out basis as fast as the transmission system allows.

With such a system, no characters are lost as long as the buffer capacity is sufficient. They are only delayed. And if the buffer should become full, the system can issue a warning, e.g. a "beep", to inform the chordist that he has to wait a little.

A buffer system should enable a 110-bits-per second V.21 system to provide a reasonably satisfactory text telephone interpretation service with chord keyboards. It will allow an *average* speed which is at least twice the normal QWERTY speed, and *temporarily* more, due to the levelling-out effect of the buffer memory.

Even in a DTMF system, a buffer memory will be of value, but here, it may not be enough, due to the still lower speed of DTMF. For this case, a method for further improvement is suggested at the end of this section.

The DTMF system – used in Denmark and The Netherlands – is in certain respects compatible with the system used for dialling in modern telephone systems, where the rotary dial has been replaced with a set of pushbuttons. This is an important advantage because it enables a user of an ordinary telephone to communicate with deaf text telephone users in these countries if the deaf persons can speak, which almost all adult-deaf and many pre-lingually deaf persons can. The hearing person uses the pushbuttons on his telephone to send characters, which can be seen in clear text on the deaf person's text telephone.

When a button on a telephone is depressed, the telephone sends a pair of tones over the line. The number of different characters that can be identified by pushing a button is limited to 16. Such a character is called a *hexadecimal digit*.

In general, only 12 of the 16 possible hexadecimal digits are used in a telephone system. They correspond to the ten decimal digits (0...9) plus "*" and "#".

In a text telephone system based on DTMF, an *alphanumeric character* – e.g. a letter of the alphabet – is generally sent either as one hexadecimal digit or as two such digits, one after the other. In some national alphabets, such as the Swedish one, certain characters require three hexadecimal digits each. The average number of hexadecimal digits per alphanumeric character is approximately 1.7.

With DTMF, the maximum number of hexadecimal digits that can be sent and received in a second varies a little from one country to another. In the telephone dialling system, it can be as low as 8 and as high as 10.6. Even with 10.6 hexadecimal digits per second, the maximum number of alphanumeric characters per second is limited to approximately (10.6/1.7 =) 6.2.

The question is, however, to which extent the speed limitation in DTMF is absolute. The above information on DTMF transmission speeds has been derived from CCITT Recommendation Q.24, which explicitly deals with the use of dual tones for dialling, but another CCITT recommendation (V.19) seems to indicate that the above-mentioned speed limitation is not inherent in the dual-tone system as such. The V.19 recommendation covers a system where a much higher number of hexadecimal digits per second can be transmitted,

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although the tone combinations are exactly the same as they are according to the recommendations that cover DTMF dialling.

If there is an interest in using chord keyboards in the Danish and Dutch text telephone systems, therefore, it might be a good idea to check if the transmission speed can be substantially increased without abandoning the DTMF system. Existing text telephones might have to be modified if they are to receive text at chord keyboard speed, but new text telephones could be designed for the higher speed at the outset, and they would be fully compatible with the old text telephones when used at QWERTY speed.

9B2. Live Subtitling in (Text) TV

When subtitles are used either in Text TV or as video-transmitted text, they are normally prepared in advance. Especially for deaf people (but also for some others, e.g. immigrants with limited knowledge of the language in their new country) it would be valuable if subtitles could be provided for *live* TV transmissions as well.

QWERTY is evidently too slow for such an application. Use of chord keyboards is the obvious solution.

Even if very fast chordists are available, it is a matter for discussion whether the subtitles should contain all spoken words or a condensed version. Transmitting the full text may keep the viewer so busy reading the text that he has no time for the picture. Many persons will even be entirely unable to read all the text before it vanishes from the screen.

If a condensed version of e.g. a speaker text is to be produced with a chord keyboard during a live TV transmission, it is generally considered impossible for one person to do both the required editing and the chord keyboard work. A more reasonable arrangement is to have one editor, who listens to the speaker text, edits it into a condensed version, and reads this version aloud to a second person, who handles the keyboard.

It is recognized, however, that the editor's task is quite difficult because he has to do three jobs simultaneously. While listening to the speaker's words, he must edit a previous speaker passage in his mind and read the edited version aloud to the keyboard operator.

The situation with respect to text transmission speed would be much different if the subtitles could be presented with smooth scrolling.[1] This would facilitate reading very much, in comparison with a system where the text suddenly vanishes and new text pops up in its place.

For video-transmitted subtitles – i.e. subtitles that are shown on all TV receivers – smooth scrolling will require changes only on the transmitter side. In text TV, on the other hand, the transmitter only sends codes that identify characters, and the translation to visible characters is performed by electronic circuits in each receiver (if it has text TV capability and the user has activated the text TV function). Therefore, there seems to be no possibility to introduce smooth scrolling in text TV in the nearest few years.

In Sweden, Text TV has sent some new employees to a Velotype course in early 1988. The intention is to start live subtitling with Velotype when some of these persons have gained sufficient speed.

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1 Section 9B1A (Text Interpretation in Meetings).

9B3. Synthetic Speech for Speech-Impaired People

Some questions related to synthetic speech have been discussed earlier.[1] Below, a few words on telephone communication for speech-impaired persons will be added.

A few speech-impaired persons have acquired text telephones, enabling them to communicate with other text telephone users and, via the text telephone interpretation service, with users of ordinary telephones ("sound telephones"). At least some of them can be expected to change from ordinary text telephones to personal computers with speech synthesizers.

With such equipment, a speech-impaired user can communicate with users of sound telephones without text telephone interpretation (unless his speech impairment is combined with deafness). Avoiding the intervention of a text interpreter protects the privacy of the communicating persons. Nevertheless, some speech-impaired people might resent this solution because of the impersonal nature of synthetic speech.

A few of the speech-impaired users of speech synthesizers will probably want to acquire chord keyboards. A typical case might be a young and active person who has had a laryngectomy operation. He might consider chord-keyboard-controlled speech synthesis as a good way of restoring his capability for speech communication, both with and without the telephone.

9B4. Use by Blind People

Keyboards are among the tools that a blind person can operate with almost the same ease as a sighted person. And a further incentive to use a keyboard is in the many advantages that a blind person can get with a personal computer.

While a personal computer is now considered as a necessity for many sighted persons, a blind person may have still more applications for it. He can use a personal computer not only for such things as computer conferencing, electronic mail, and word processing, but also – and this may be still more important – for getting more easy access to literature. Instead of handling very big and heavy books in Braille, he can use diskettes or optical disks, or he can get text from remote text banks via the telephone network.

The blind person can use this machine-readable text by means of synthetic speech. If he finds a certain part of the text worth storing in Braille on paper, he can tell his personal computer to output this text to his Braille embosser.

A speech synthesizer, installed in his personal computer, will also mean a radical improvement of his possibilities to use the keyboard. This is because synthetic speech provides an efficient method for immediate checking of what he has written ("feedback") when he feels a need for it.

For these and other reasons, a keyboard plays a more important role to many blind persons than it does to sighted persons. This is one argument for providing blind persons with the best possible equipment of this kind – chord keyboards.

To a blind person, a chord keyboard should also be easier to use than a QWERTY keyboard, after the training period. The "home" positions of the fingers can be easily identified with his fingertips, and no key has to be located by means of the eyes.

This is especially important with respect to function keys. With a QWERTY keyboard, blind people can have difficulties in utilizing

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1 Section 7C.

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some of the most advanced word processing systems, for instance, because the advanced functions often require the use of function keys which are hard to locate without sight. With a suitably programmed personal computer and a chord keyboard, the use of function keys can be replaced with function chords, as earlier explained.[1]

Even before the era of personal computers and synthetic speech, many blind persons were very competitive for keyboard jobs such as transcription of dictated tapes. The chord keyboard will make many blind persons still better equipped for such jobs.

This is no fantasy. A blind young lady in Holland has learned to use a Velotype keyboard, and she has become very proficient. She uses it professionally and is very happy with it. The chord keyboard enables her to perform even better than her sighted colleagues, who use QWERTY keyboards.

9C. Other Applications

As pointed out earlier, the successful use of a chord keyboard in the SDP area must be supported by applications outside this area.

9C1. Typing and Typesetting

"Typing and typesetting", in this context, can be considered equivalent with "QWERTY replacement applications". Their potential economic importance is great, due to the large volumes of labour in this field.

Not very many years ago, typesetting was a job exclusively for a group of blue-collar workers having had long training exclusively for this work. They were operating huge electro-mechanical machines. In the era of word processing, photo typesetting and – in the last few years – "desktop publishing", it can be done in ordinary offices. (The "typesetting"of this report, for instance, is performed with a personal computer and a laser printer.) Thus, typing and typesetting are now very similar with respect to the usefulness of chord keyboards.

If typing and typesetting are based on manuscripts, the keyboard operator does not even have to know the language, in principle, provided that the manuscript is clear and correct. (Much typesetting has been done in countries with cheap labour, by persons who have had no idea of the meaning of the text. This may seem inhuman, but some people who are threatened with unemployment may take another view.)

Dictated tapes are a bit harder to use. The chordist must have a reasonably broad vocabulary and be a good speller.

Transcription of tapes recorded in meetings are still a bit worse. While a person at a dictating machine hopefully tries to speak clearly and perhaps explains difficult words, a speaker in a meeting does not normally think of the transcriber's difficulties. In addition, microphone arrangements are often unsatisfactory, making some words hard to hear. In this application, the qualification requirements are similar to those of a debate stenographer, apart from speed, of course.

Real-time dictation is a working method that can be of great

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1 Section 4G.

value. It has been little used till now, but the advent of chord keyboards will make it more attractive.

By real-time dictation, I mean a dictation where every word is immediately displayed in front of the originator. During conventional dictation – either for a stenographer or on a dictating machine – the originator cannot see the text that he has already dictated. This factor, which probably has made millions of originators write manuscripts instead of using dictation, is completely eliminated in real-time dictation. Preferably, the originator should have a slave screen, showing the same text as the keyboard operator's screen.

Remote real-time dictation brings further refinement. For instance, a trained chord keyboard operator can set up a typing bureau, offering real-time dictation to customers all over the country. He can sign contracts with some customers who are willing to use his services now and then and to acquire a slave screen plus an extra telephone line.

For real-time dictation, two telephone calls are set up. One is used for voice communication, the other for text to be sent to the slave screen on the originator's desk.[1] When the text is finished, the typing bureau can either print it and send it to the customer or use the telephone network for transmitting it to a word processing system in the customer's office.

9C2. Real-time Keyboarding during (Big) Meetings

During big meetings, e.g. parliamentary assemblies, the debate stenographer's role can be played by a qualified chord keyboard operator.

With respect to equipment requirements, the least demanding case is when a written record of the discussions is to be produced some time after the meeting, leaving time for editing. The editing is done on a normal word processing system. Preferably, a chord keyboard should be used even in the editing process, and the computer in the system should be programmed to understand function chords,[2] which will provide for high editing efficiency. Sound recording should be available as a safety net for the chordist.

Instant presentation has already been discussed in connection with applications in SDP.[3] I am sure this application will become popular even in audiences where all people have normal hearing, when a sufficient number of people have made contact with instant presentation. Even hearing people can sometimes have difficulties in catching every word, especially under bad acoustic conditions, and it will be a relief to be able to glance at a real-time text display when needed.

In this connection, I want to point out a synergetic effect of special value to people who are deaf or hard of hearing. For a meeting, a chordist can be hired for three purposes:

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1 In the forthcoming ISBN telecommunication system, it could perhaps be arranged for both the voice and the text communication to be handled with a single call.

2 Section 4G.

3 Section 9B1A.

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- to produce a verbatim printout after the meeting,

- to provide instant presentation for the benefit of a hearing-impaired participant, and

- to provide instant presentation in a form that can be seen by all participants.

Even if none of these purposes in itself should be considered as enough for hiring a chordist, two or three of them together might be sufficient. This might make it easier for deaf persons to get text interpretation.

10. Costs, Savings and Benefits

10A. Only Differences Calculated

At the risk of saying too obvious things, I want to point out that a calculation of the profitability of using a chord keyboard should only take differences into account. By how much is the cost and the income changed when you change from your present system to a system involving chord keyboards?

Especially, this affects the way costs for a word processing system are calculated. (The following reasoning is based on the assumption that your organization has some large-volume typing or typesetting workload. Otherwise, you would probably not consider chord keyboards at all.) If you are not using an electronic word processing system today, you should clearly acquire one even if you are not going to use chord keyboards.

This is because a word processing system itself, even with QWERTY, is very profitable in all places where reasonably heavy typing jobs are to be performed. This should now be common knowledge, and I am sure it is not necessary to prove it again.

Although a chord keyboard, in practice, requires a word processing system, the costs for this system should thus not be charged to the balance account of the chord keyboard. Nor should the chord keyboard be credited with that part of the resulting efficiency gain that comes from the word processing system *per se*. If you have to acquire a word processing system, this should have its own balance account, and this account should undoubtedly show a profit in itself.

10B. The Precision of the Calculations

High precision in profitability calculations may be hard to reach, especially if the calculations have to cover a wide range of situations. But high precision is not always needed.

In this case, the purpose of the calculations is just to prove that the profitability is positive. And because I am going to prove that this condition is fulfilled with very wide margins, I can allow myself to make some very sweeping assumptions instead of going into detail everywhere. Although some of my assumptions may be uncertain by dozens of percent, these uncertainties are not large enough to threaten my conclusion – which I am now anticipating – that chord keyboards are very profitable in situations where a person spends a considerable part of his working day inputting words.

This anticipated conclusion is valid, in one way or the other, both for speed-justified and savings-justified applications. I am going to discuss these two cases separately aafter the section that follows this one.

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10C. Recurrent Costs and One-Time Costs

In a profitability calculation for introducing a new system, you will normally have both one-time costs – or an *investment* – and *recurrent costs*. If you compare a new system with your present system, you will typically find that the new system causes certain one-time costs in the beginning, while it causes the recurrent costs to become lower, and we need a system to compare these initially incompatible types of costs.

This is done either by replacing the investment with equivalent recurrent costs in the calculation or doing the opposite. I will choose the first-mentioned method.

The recurrent cost that is equivalent with a certain one-time cost consists of two factors, which should be added together. They are interest and mortgage.

The interest, or the "cost of money", will vary widely from one situation to another. For instance, it may correspond to the interest that an organization has to pay for borrowed money, or to the interest the organization would earn by depositing the money in a bank instead of buying something for it. In my calculations, I am going to assume an interest rate of *10 % per year*.

Soon after a one-time cost is paid, thus, the organization will have to pay a yearly 10 % in interest on it. But at the end of the mortgage period, the capital on which interest is calculated will have been reduced to zero. Therefore, I calculate the *average* yearly interest as 10 % of *half* the investment.

The yearly mortgage sum is what you get by dividing the one-time cost by a certain number of years, the calculated lifetime of the investment. The question is which lifetime should be assumed for the investments caused by a changeover to chord keyboards.

I guess the physical lifetime of a chord keyboard should be something like four years, at least. This is the figure I am going to use in my calculations.

The "lifetime" of an investment in a person's training, as seen from the employer's point of view, corresponds to the time this person will stay in the organization. Obviously, this will not only be variable, but also very difficult to predict. More or less arbitrarily, I am going to use four years in my calculations even at this point.

Using the assumptions above, we will find that the yearly cost corresponding to the purchase of a chord keyboard should be of the order of 5,000 SEK.[1] In principle, a yearly maintenance cost should be added, but this cost will fall within the uncertainty margin, and so, I will use 5,000 SEK per year as the hardware cost in my calculations.

If the chordist's salary is 120,000 SEK per year, for instance, the employer's costs for this person are at least 240,000 SEK per year. This proves that the cost of the keyboard plays an almost negligible part in comparison with the personnel costs. – Similar calculations for other cost elements will be given in later sections.

All the assumptions above are a matter for discussion. However, we will see that the weight of the yearly costs caused by an investment in chord keyboards is not very large in comparison with the recurrent costs and the savings. Therefore, the uncertainties

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1 In the beginning of March, 1988, 1 Swedish Krona (SEK) is equivalent to 0.094 Pounds Sterling.

of the assumptions do not affect the result of the calculations very much.

10D. Economy of Speed-Justified Applications

In one type of speed-justified applications, there is an alternative with which the costs of a chord keyboard system can be compared. This is real-time keyboarding during meetings for subsequent print-out, such as the work done by parliament stenographers. Here, the same end product can be produced with pen shorthand.

Documenting a cost comparison between pen shorthand and machine shorthand in this application would require a separate book, however, and it would not be too interesting because the real obstacle to replacing pen shorthand with chord keyboarding in parliaments etc. is probably conservatism and lack of development resources rather than doubts about the economic profitability.

For text interpretation in meetings, an alternative to using chord keyboards would in principle be to stay with QWERTY. Here, however, the profitability of chord keyboards is overwhelming, especially from the point of view of national economy. In a meeting with text interpretation with QWERTY, everybody (except the deaf person himself, if he is the only one who cannot hear) must speak with less than half the normal speed, which means that the meeting takes about twice as long as a similar meeting with no need for text interpretation, if other factors are equal.

For every hour of chord keyboard use, therefore, we save one hour of working time for each one of the persons present. Even in a bilateral meeting between a deaf person and a hearing person plus the text interpreter, every hour of chord keyboarding saves three man-hours, and if more persons are present, the saving becomes proportionately greater.

I need not go into details regarding the cost of the equipment and the training in such an application. It should be clear that these costs are negligible in comparison with the savings.

This does not necessarily mean that the government's costs for text interpretation will go down when chord keyboards have been introduced. (In Sweden, at least, many text interpretation jobs are paid for by society.) The attractiveness of using text interpretation will grow enormously, and the volume increase may have a greater effect on public expenditure than the decrease of cost per meeting. In addition, much of the value of the time saving will not benefit society directly in any measurable way. On the other hand, a volume increase reflects a great improvement in the quality of life of deaf meeting participants, and this should be worth the (possibly) added costs for society.

10E. Profitability of Savings-Justified Applications

As indicated earlier, "savings-justified applications" means approximately the same as "typing and typesetting". Here, the labour cost per 1,000 characters is greatly reduced due to the high speed that can be attained with a chord keyboard. This saving should be balanced against the yearly cost corresponding to the initial investment at the transition from QWERTY to chord.

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10E1. Equipment Costs

The yearly cost of having a chord keyboard has been discussed in an earlier section.[1] There, it was roughly estimated at 5,000 SEK per year. As indicated in another section,[2] the costs of the host equipment does not enter into the calculations of the chord keyboard profitability.

10E2. Tuition Fees

According to a Dutch price list from 1986, the tuition for a normal two-week Velotype course was 1,100 DFL excluding VAT (Value-Added Tax).[3] An "in-house course" on a customer's premises with a maximum of 12 participants cost 5,000 DFL, which means that the price per participant could in principle be pressed to a minimum of 417 DFL excluding VAT.

I am going to base my calculations on 1,100 DFL excluding VAT. With a mortgage of 25 % per year and a 10 % interest on half the investment, this tuition fee corresponds to 330 DFL per year excluding VAT.

10E3. Productivity Change during the First Year

The savings in a typing or typesetting application come from the productivity change, of course. In order to calculate the value of the productivity change, I have to make a number of assumptions, some of which are a bit arbitrary. Therefore, the calculation should be regarded as an example, valid for one particular situation, but the interested reader should have no difficulty in modifying the calculation to suit other conditions.

My first assumption is that a person – let me call him Peter – is going to become a chordist and is already employed in the organization. Peter is already a very good QWERTY typist, with a practical average speed of about 300 cpm. (If I had instead assumed Peter to be a novice, the situation would have been more favourable for the chord keyboard because the QWERTY alternative would have shown a lower productivity.)

Further, I assume that Peter's salary is 120,000 SEK per year and the employer's overhead costs for Peter are also 120,000 SEK per year. These are very round figures. In many cases, the costs are higher, thus increasing the profitability of the time-saving chord keyboard.

Peter is assumed to devote two hours per working day to input of new text. In this text, only a small proportion is assumed to consist of tables, for which the superiority of chord keyboards is questionable.

It is further assumed that this time is not changed at the transition to chord keyboards. In other words, the long-term increase in productivity is used for increasing the text volume, not for decreasing the time spent at the keyboard. This seems to be a reasonable assumption because it makes sense to utilize the increased productivity as much as possible.

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1 Section 10C (Recurrent Costs and One-Time Costs).

2 Section 10A (Only Differences Calculated).

3 In the beginning of March 1988, 1 DFL = 0.297 Pounds Sterling, or 3.155 SEK.

Peter is assumed to work for 1,600 hours per year. In case of an 8-hour day, this corresponds to 200 days per year, or 40 5-day weeks per year.

With these assumptions, every working hour costs the employer (240,000/1,600 =) 150 SEK per hour. (With his original QWERTY speed of 18,000 characters per hour, this gives a cost of 8.33 SEK per 1,000 characters.) The labour cost for Peter's text input (400 hours per year) is thus 60,000 SEK per year.

During the first year, the first two weeks will be lost due to the Velotype course, which includes some 20 hours of practicing. After the course, Peter starts using the chord keyboard for 10 hours a week, and at the end of the first year, he will have accumulated 400 hours at the chord keyboard.

According to figure 8:1, Peter will probably have reached a speed around 600 cpm at the end of the first year, and his average speed during his 38 weeks of production will be around 400 cpm. Instead of 18,000 characters per hour, as he produced on QWERTY, he will therefore on the average produce 24,000 characters per hour on the chord keyboard during the first year. So, during his 80 hours in the course and 380 hours of productive typing, his production is (380 x 24,000 =) 9,120,000 characters. In the same time (460 hours), if he had skipped the Velotype course and stayed on QWERTY, he could have produced (460 x 18,000 =) 8,280,000 characters.

So, in the first year, Peter has produced (9,120,000 − 8,280,000 =) 840,000 characters more than if he had stayed on QWERTY. The added production is worth approximately 7,000 SEK. (840 x 8.33 = 6,997,20.)

This happens to be of the same order of magnitude as one year's mortgage and interest on the initial cost plus the cost for technical maintenance. Therefore, we can say that Peter has in the first year recovered both the cost of having a chord keyboard during this year, the tuition fee, and the cost for the production loss caused by 80 hours spent on the course and by low chord keyboard speed during the first few weeks after the course.

10E4. Productivity Change after the First Year

At the beginning of the second year, Peter's speed should be around 600 cpm, which is twice his QWERTY speed. Let me assume – conservatively – that Peter will never exceed this speed. During his 400 hours of typing per year, he will then produce 36,000 characters per hour, or 14,400,000 characters per year. At 8.33 SEK per 1,000 characters they will be worth about 120,000 SEK.

With QWERTY, he would only have produced half this volume, and so, the extra production is worth about 60,000 SEK per year. After deduction of interest and mortgage on initial cost and the yearly maintenance cost, we will have a net gain of more than 50,000 SEK per year starting at the beginning of the second year. At the end of the fourth year, we have an accumulated net gain of more than 150,000 SEK. (This is the period that I have, somewhat arbitrarily, picked as the lifetime of the investment.)

10E5. Value of "Intangibles"

In the preceding sub-sections, the only benefit taken into account has been an increase in productivity. There are also some "intangible" benefits (and "intangible" disadvantages, too).

One intangible benefit is faster throughput. The time from the start to the finish of a typing or typesetting job will become shorter. This can never be a disadvantage, and sometimes it is an

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important advantage. But it is in general hard to put a price tag on this factor.

Another important factor is ergonomics. As indicated earlier,[1] the Velotype manufacturer claims that his product has ergonomic advantages, and to me, it seems plausible that he is right. Such advantages are obviously good for the well-being of the personnel, and they may also yield direct savings, although these savings are hard to estimate.

10E6. Discussion of the Calculations

The calculations in section 10E and its sub-sections have ended in a production increase worth altogether more than 180,000 SEK over a four-year period and costs – including interest on capital outlay – of less than 30,000 SEK, under the given assumptions. This corresponds to an average yearly net profit of substantially more than 100 % of the total capital outlay.

The question is, however, how reliable these calculations are. In this respect, there are some negative and some positive factors.

One negative factor, from the employer's point of view, is in the salary development. Peter will probably realize that his value to the company has increased considerably, and the employer will probably find it better to give Peter a substantial raise than to lose him. Furthermore, the company may lose Peter before the end of the 4-year period that I have taken into account. On the other hand, he might stay longer, in which case the company can continue to reap the benefits of Peter's talent for fast writing.

The uncertainty of the cost figures is not important for the outcome. This is because the costs are anyhow just a fraction of the value of the production increase.

Some readers will undoubtedly say that the calculated savings are "purely theoretical". They can claim, for instance, that Peter's employer will never be able to reduce his personnel and that the extra capacity will be absorbed by new tasks in accordance with Parkinson's law.

Such objections can be raised against all projects for labour-saving investments. But most of the spectacular material progress in the industrialized countries for the last two centuries has been a result of labour-saving innovations and investments.

The most serious uncertainty in my calculations is the one about Peter's rate of speed increase and final speed. However, I think I have been conservative there. I base this on the performance figures reported about the participants in the first Swedish Velotype course, held in November, 1987, as mentioned in connection with Figure 8:1.

I have further assumed that Peter spends two hours per day on input of new text. This is more than most secretaries do. On the other hand, it should be less than a typesetter generally does.

If Peter spends two hours a day inputting new text, he will probably also spend some time editing and correcting. Even in these activities, his productivity will be increased with the chord keyboard, especially if he can use function chords. But I have not taken this gain into account in my calculations.

It should thus be pointed out again that the generality of my calculations is low. The results are valid only under the assumptions I have indicated.

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1 Sections 5E and 9A1.

Nevertheless, I hope to have convinced the reader that an employer does not stand a great risk of losing money on introducing chord keyboards if there are relatively large volumes of text input in the company's work load. And chances are that he will make a profit.

10F. The Solution to the Queuing Problem

In Section 9A2, real-time and batch applications were discussed. That section dealt exclusively with the characteristics of the job while it was going on. The concepts of real-time and batch applications can also be applied to another question: At what point in time must a job be started?

Certain chord keyboard jobs are of a batch nature in this respect. If a typist gets a one-hour job at 8 o'clock and has to have it finished by 11 o'clock, he is free to start it at any time between 8 and 10. If the time that remains before deadline is longer than the required working time, as in this example, the difference between these periods constitutes a *slack*, which gives some relief in planning the work.

Some other tasks are of a real-time nature in this respect. If a text telephone interpreter gets a request for interpretation, he is not free to choose the starting time. He has to start immediately, if he can.

Unlike requests for text telephone interpretation, requests for text interpretation in meetings are normally booked in advance. Otherwise they are similar; the chordist is not free to choose the starting time.

Real-time jobs – in this sense – are characterized by *random arrival* and, generally, *random duration*. Such situations tend to produce *queuing*, which causes *waiting time*. The queuing is caused by the absence of slack time.

Queue theory can help us calculate such things as average waiting times and standard deviations of waiting times. It can also point to the most effective means for reducing the queuing.

Common sense tells us that one (expensive) way to hold queuing down is to provide over-capacity. Queue theory tells us in quantitative terms which queuing phenomena we can expect as a function of the over-capacity we are willing to provide.

In the case of chord keyboarding service, there is one way in which we can hold queuing down without providing a very high excess capacity. This is to let the same personnel have a mixture of real-time jobs and batch jobs. Because many batch jobs can be postponed within certain limits without ill effects, we can ask the chordists to break any ongoing batch job when a request for a real-time job arrives. In other words, we are using the slack of a batch job to make room for a real-time job when it arrives.

The queuing situation will then be essentially the same as if the chordists were idle in pauses between the real-time jobs. Still, they can be productive even during a great proportion of these pauses.

Naturally, this calls for a certain organizational upheaval. But the advantages may be worth it.

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11. Competition to Chord Keyboards

Before deciding to go in for a revolutionary innovation like the modern chord keyboard, one should try to get an idea of whether or not this innovation will stay competitive for a reasonable time. That is the motive for including this chapter in the report.

11A. Competition from QWERTY Keyboards

The QWERTY keyboard will offer a formidable resistance to the introduction of chord keyboards. It has some very powerful allies such as people's general resistance to change.

But QWERTY has also some real advantages. Everyone knows how to handle a QWERTY keyboard, and everyone will find the familiar QWERTY keyboard everywhere.

For people who have no ambition to become efficient typists, QWERTY has the advantage of being useful to some extent even without any training at all. There are no complex rules to learn and remember.

Such factors will be very effective in limiting the proliferation of chord keyboards except in areas where QWERTY is impossible or where its inferiority is very clear, such as text interpretation in meetings. This situation will change if chord keyboarding will be taught in schools, but this may not happen very soon, except on an experimental scale.

11B. Competition from Sound Recording

For documentation of what has happened during a meeting, sound recording is a useful complement to written proceedings. It reveals certain things that cannot be shown in print, such as intonation, and its contents have not been changed by any editing (we assume).

But the average access time to a passage on a sound tape is unpleasantly long. (An important reduction of the average access time is technically possible, however.)

As mentioned in an earlier section,[1] transcription of recorded sound tapes is a bit less practical than most people think, because a separate editing procedure is generally required, and in many cases complete re-typing. Nevertheless, such transcription has a market.

In this transcription job, which often involves large volumes of text, chord keyboards are very useful. And for this application, the chord keyboard operator does not need speed-of-speech capability. So, even in cases where sound recording is preferred to chord keyboarding at the time of the meeting, this method can actually promote the use of chord keyboards.

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1 Section 9A1.

11C. Competition from Pen Shorthand

In the era of the modern chord keyboard, pen shorthand has one remaining advantage in its extremely light and cheap equipment and material, eminently portable and available everywhere. In spite of this great advantage, however, I think the use of pen shorthand will continue to shrink, as it has been doing for many years.

The overwhelming disadvantage of pen shorthand is in the fact that almost all applications of this method call for a separate transcription process which is tedious, lengthy, error-prone, and often difficult. An additional disadvantage is the lack of precision that is an effect of human imperfection; the shorthand signs will often be deformed. This can cause reading difficulties and misreadings.

Institutions like parliaments with qualified pen stenographers employed may be a stronghold of pen shorthand. This is not only due to general conservatism. Also, a change from pen shorthand to machine shorthand will cause transition problems during a few decades or so of overlapping between the two methods.

11D. Competition from Speech Recognition?

There have been many optimistic forecasts about the voice-controlled typewriter, which will print what we say in a microphone. And if this dream will ever come true, it may mean the end of the chord keyboard, at least in most QWERTY replacement applications.

But that day is a very long time off, probably decades. Although there are already speech recognizers in routine operation in many places, their application possibilities are extremely limited.

The weakest point of the speech recognizers, when it comes to competition with chord keyboards, is their vocabulary limitations. Most of the practical machines of today have a vocabulary of the order of 100 words. Although there are experimental machines with a many times larger vocabulary, it is still not nearly enough for implementing a voice-operated typewriter for general text.

Even a vocabulary of 20,000 words is too small for a practical writing instrument, except perhaps for certain special applications with a more or less stereotyped text. According to the Frequency Dictionary of Present-Day Swedish,[1] the 21,006 most frequent Swedish words stand for only 88.9 % of the word occurrences. With this vocabulary, between one and two words per line in this report would have to be marked as unidentified. (And in addition, we might expect some of the other words to be wrong due to imperfection of the speech recognition system.)

Even a doubling of the vocabulary would not reduce the frequency of unidentified words more than from one in nine to one in sixteen. And because identification difficulties – loosely speaking – rise exponentially when the vocabulary is increased, the problems in getting a vocabulary of acceptable size will be formidable.

An even greater obstacle is what can be called the isolated-utterance requirement. All speech recognition projects with any reasonable degree of realism are based on the assumption that the speaker will make clear pauses between words, relieving the recognition equipment of the burden of identifying word boundaries. This restriction will be acceptable for certain applications, mainly

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1 First mentioned in Section 4B.

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of the QWERTY replacement type, but it can never be accepted in such applications as verbatim reporting during meetings.

Another restriction of present-day speech recognition projects is that the equipment has to be "trained" on each individual speaker's voice and speaking habits. This factor, too, is an obstacle for verbatim reporting, of course.

Summing up, it is entirely safe to say that speech recognition will not be a realistic alternative to using chord keyboards even for dictation and QWERTY replacement within the economic lifetime of the keyboards you can acquire now. And for verbatim reporting at meetings, the threat from speech recognition must at least be decades off.

11E. Competition from "Poor Man's Fast Typing System"

By "poor man's fast typing system", I mean a system which enables a person to save about 20 % of the keystrokes on an ordinary QWERTY keyboard, connected to a word processing system, and still get clear text both on the screen and on paper. The system is based on a set of abbreviations which can be recognized by the word processing system for automatic replacement with the full text.

Such a system is not a direct competitor to the chord keyboard, no more than a wheelbarrow is a direct competitor to a van. The wheelbarrow costs just a fraction of what the van costs, and you need not go to a driving school for learning to use it, but its capacity is also very limited compared to that of the van.

Nevertheless, an abbreviation system might have a place in an application where a chord keyboard, although desirable, cannot be afforded. In the Swedish text telephone interpretation service, for instance, it will be very long before all interpreters have chord keyboards and can operate them efficiently, but an abbreviation system could give at least some speed increase, and for a very low price.

12. A Look into the Future

A decision to introduce chord keyboards will have lasting consequences, and it is essential to think a little of the long-term effects. As it has been said, we always tend to overestimate what can be done in one year and underestimate what can be done in ten.

12A. Why So Few Today?

Because the future begins now, a look into the future should start with the present situation.

Outside North America and perhaps the U.K., few chord keyboards are in use today. Some people might take this as an indication that chord keyboards are no good. But I do not think so. Let me first say something about the market for "catching the spoken word".

The traditional market for chord keyboards is in speed-of-speech applications. One such application is verbatim reporting in parliaments and the like, but in some countries, and especially the USA, the speed-of-speech market is dominated by courtroom reporting and kindred applications.

In some other countries, this market does not even exist. In Sweden, for instance, there are normally no stenographers working in the courts. Sound recording is used, but the sound tapes are not transcribed onto paper unless there is a special reason for it, e.g. an appeal to a higher court.

Probably, the speed-of-speech markets have not grown very rapidly since chord keyboards began to be attached to computers. And the vast majority of the present fast stenographers have been in their profession since the days of manual transcription.

It is no wonder that American court reporters have stuck to the American chord keyboard in spite of the shortcomings that are caused by the phonetic system and the absence of explicit space indication. Most of them may not be aware of the existence of such systems as Velotype, and even if they were, it is quite natural that they are not enthusiastic about re-training.

In countries were chord keyboards have not been used to any significant extent, the speed-of-speech market shows the same kind of conservatism. Experienced shorthand reporters, who have been using pen stenography successfully for many years, are generally not willing to re-learn, and young people who want to go into the shorthand reporter's profession may never even be informed about the existence of chord keyboards.

In Sweden, there has been an additional serious obstacle. Until 1987, there was no chord keyboard that could be used successfully for Swedish. Now there is one (Velotype). And the situation in this respect is similar or worse in certain other language areas.

In another speed-of-speech application – text interpretation for deaf people – there is no such conservative corps of people who think they can do without chord keyboards. There is simply no

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alternative to chord keyboards for instant presentation with the speed of speech. In this area, the only reason for the present scarcity of chord keyboards is that the activities have just begun (in Sweden, at least).

So much for the speed-of-speech market. In the QWERTY replacement field, the American chord keyboards are not very competitive, and the marketing of Velotype has been very passive. There are simply very few people who are aware of the great advantages of a truly modern chord keyboard for ordinary typing and typesetting jobs.

12B. The Ketchup Effect

At present, even the few employers who are aware of the existence of modern chord keyboards may think that purchasing such keyboards is no good because there are not any trained chordists in the market. And if a young person is interested in becoming a chordist, he may think that this is not a good idea because there are no chord keyboards around.

Sooner or later, however, this vicious circle will be broken. Then, the market will grow explosively. It can be compared with what happens when you have shaken your ketchup bottle long enough.

When chord keyboards are produced in really large quantities, the price can be much lower than today. And training will become more easily accessible. Self-tuition will be possible, and electronic training systems of various kinds will be available. All this will contribute further to the ketchup effect.

12C. Further Development

The attractiveness of chord keyboards can be enhanced through further development. Some such possibilities have already been mentioned, e.g. the combination of a chord keyboard and a speech synthesizer. As another example, a truly modern electronic system for verbatim reporting could be developed, with chord keyboards integrated into it.

A portable personal computer with a chord keyboard would probably sell well. Especially, an enthusiastic chord keyboard user might like to bring such a machine along on certain journeys because he would otherwise only have access to QWERTY keyboards on the places he visits. And a typewriter with a chord keyboard could be a very useful tool.

These are just examples. There are many other application areas where chord keyboards can be more effectively applied if some special attachments are developed.

12D. Text Interpretation Even for Hearing People

Because text interpretation at full speed with instant presentation has not been available until now, it is natural that nobody has thought of using such a system for hearing persons. But when people have been accustomed to seeing this kind of presentation in meetings where deaf people are present, even hearing persons will find this technique useful. If you are sitting in an auditorium, listening to a speaker, you will now and then miss an important passage, perhaps because your neighbour has been coughing. You can fill in the missing passage by looking at the screen.

This application may not be considered important enough to warrant hiring of a chordist. But if a chordist is working anyhow, for verbatim reporting, provision of instant presentation will not require much extra resources.

In connection with simultaneous interpretation from one language to another during conferences, instant presentation in writing would be of great value. This goes especially for participants from small language areas, for whom even the interpreter's target language is a foreign language. These persons will often understand the target language better reading than listening.

Instant presentation together with simultaneous translation may at first sight appear too difficult to be practical, because simultaneous interpretation is a very demanding task even in itself. But I am not sure that it is impossible. Chord keyboarding will become automated after a few hundred hours of practising, and so, writing the translated text could become a sort of automatic by-product of reading it aloud, or vice versa. (However, any failures to interpret difficult passages in an acceptable way will be more obvious to the audience than they are in spoken interpretation, where the interpreter can hide some such problems by simply blurring the pronunciation.) – As a further by-product, a raw manuscript for a hard-copy translation of the speaker's words can be accumulated in a computer at very little extra cost.

12E. The Impact in a Longer Perspective

Innovations in the art of writing have always made great impact. Some of the more recent innovations are the typewriter, the carbon paper (now almost obsolete), and the xerographic copier.

Another innovation – the word processing system – may have something to tell us about the chord keyboard. A few years ago, many were reluctant to accept a word processing system, and they could not understand why it was needed because the typewriter is such a useful tool. But nobody wants to go back to the typewriter after having learned to use a word processing system and become accustomed to it.

The chord keyboard is now generally looked at as a tool for a very small group of highly specialized people. But it is clearly a very useful tool for all persons who think they are going to use keyboards sufficiently often to be willing to spend a fortnight on learning how to type. No chord keyboard user will want to go back to QWERTY the day we can find chord keyboards everywhere.

The orthographic chord keyboard with explicit space indication will one day beat all other chord keyboards. It combines the advantages of shorthand and typing, and its appearing on the stage will be considered as one of the most important steps in the evolution of the art of writing.

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13. Svensk sammanfattning

Denna rapport är skriven av Olle Dopping, fristående konsult, på uppdrag av Handikappinstitutet (HI). De åsikter som uttrycks i rapporten är författarens och omfattas inte med säkerhet av Handikappinstitutet.

Rapporten handlar om ackordtangentbord. Hur sådana kan se ut finns exemplifierat bl.a. i kapitel 1 (figur 1:1). De viktigaste fördelarna med ett ackordtangentbord är hög skrivhastighet – upp till talets hastighet – och gynnsamma ergonomiska egenskaper. De modernaste ackordtangentborden kan omedelbart leverera klartext till skillnad från andra system, som åtminstone delvis levererar en kod i stället.

Viktiga användningsområden finns bl.a. inom handikappsektorn. Därför har HI varit en pionjär i införandet av ackordtangentbord i Sverige. I rapportens engelska text betecknas handikappområdet med förkortningen SDP (Service to Disabled People).

Rapporten är i första hand inriktad på användningarna inom handikappområdet. Men dessa användningar kräver i praktiken att ackordtangentbord används även inom övriga sektorer i samhället. Därför är rapporten skriven på ett sådant sätt att den skall vara av intresse också inom förvaltning och näringsliv i allmänhet.

En viktig användning inom handikapområdet är texttolkning för döva, speciellt vuxendöva. I modern utformning innebär texttolkning att en mänsklig tolk kontinuerligt presenterar en skriven version av en talares ord, så att döva kan följa talet nästan lika lätt som hörande. Texttelefontolkning och sammanträdestolkning är två viktiga fall.

En annan handikapptillämpning gäller vissa talskadade personer, som kan använda syntetiskt tal, producerat med hjälp av ett tangentbord. Med ett konventionell tangentbord («QWERTY») går detta långsamt, men ett ackordtangentbord medger produktion av syntetiskt tal med samma hastighet som naturligt tal, förutsatt att användaren har tillräckligt god kontroll över sina fingrar och har haft tillfälle till utbildning och träning. (Tyvärr är emellertid en talskada ofta kombinerad med något annat handikapp, som gör det svårt eller omöjligt att använda ett tangentbord på ett effektivt sätt.)

Blinda är ofta mer beroende av tangentbord än seende personer är. Ett speciellt avsnitt (9B4) handlar om de fördelar som ett ackordtangentbord har för de blinda.

Ackordtangentbordet är nästan lika gammalt som skrivmaskinen. Ända till för några få år sedan kunde emellertid ett sådant inte användas för produktion av någonting som liknade klartext. I stället fick man en mnemoteknisk kod, som måste skrivas om av en människa för att man skulle få en text som vem som helst kunde läsa. Härvidlag var alltså användningen av ackordtangentbord («maskinstenografi») praktiskt taget jämställd med pennstenografi.

Under detta årtionde har emellertid en omvälvande förändring skett:

Vigsel
Ackordtangentbordet, 100 Skrivautomaten, 18 1980-talet

Äktenskapet har inte varit barnlöst:

Födda
En skrivmaskin med stenografifart

Den tidigare nämnda figuren 1:1 i kapitel 1 visar utformningen av ett modernt ackordtangentbord. Figur 13:1 på nästa sida förklarar hur det används.

Flertalet ackordtangentbord kan – trots samarbetet med en dator – bara producera en råtext. Även om flertalet ord blir korrekt skrivna måste en människa efterredigera texten för att allt skall bli entydigt och korrekt.

Med sådana ackordtangentbord kan man alltså inte helt eliminera den mänskliga transkriptionen. Vad man får är *datorstödd* transkription (Computer-Aided Transcription.

Det är ett viktigt och föga känt faktum – som det är min ambition att sprida genom denna rapport – att det också finns ackordtangentbord som producerar korrekt klartext och alltså eliminerar behovet av efterredigering (bortsett från rättelse av mänskliga skrivfel). Ett sådant tangentbord åstadkommer alltså datoriserad transkription, inte bara datorstödd. Det möjliggör också ögonblicklig presentation av klartexten, vilket är oundgängligt bl.a. vid texttolkning för döva.

Detta möjliggör nya användningsområden, som av ekonomiska skäl inte står öppna för användare av andra typer av ackordtangentbord.

Handikappinstitutet har grundat sitt val av ackordtangentbord – det holländska Velotype – på möjligheten till ögonblicklig klartextproduktion, som är nödvändig för texttolkning. Svenska myndigheter, företag och organisationer som kommer att införa ackordtangentbord – i många fall huvudsakligen för att spara pengar – kommer otvivelaktigt att göra samma val.

Denna rapport innehåller bl.a. utförliga redogörelser för motiven till valet av Velotype. Förhoppningsvis kommer dessa redogörelser att befria andra från att behöva göra om samma utredning.

Rapporten innehåller ett speciellt kapitel (7) om de *värdsystem* till vilka ett ackordtangentbord kan anslutas. Ett existerande ordbehandlingssystem kan i flertalet fall «velotypiseras» genom att man helt enkelt kopplar ur det ursprungliga QWERTY-tangentbordet och kopplar in ett Velotype-tangentbord i stället.

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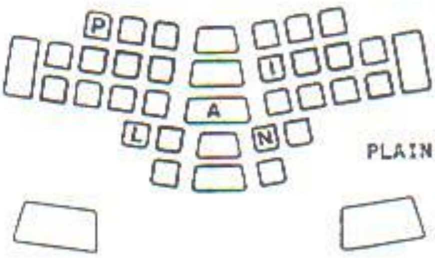
Ett konventionellt tangentbord sägs vara av QWERTY-typ.

På ett sådant tangentbord slår man ned en tangent i taget.
Det kan kallas ett *sekventiellt* tangentbord.
Man kanske kunde tro att detta är den enda möjligheten. **Fel!**

På ett *ackordtangentbord*
slår man ned flera tangenter samtidigt,
som när en pianist slår ett ackord.
Normalt ger varje ackord en stavelse:

Ett ackord



En inbyggd mikroprocessor sorterar tecknen
till rätt ordning på grundval av fonetiska regler.

Varje konsonant har tangenter både till vänster och till höger.
Vänstertangenterna används för konsonanter före vokalen
och högertangenterna för konsonanter efter vokalen.

För en bokstav som inte har någon «egen» tangent
använder man en kombination av två tangenter.

På ett modernt ackordtangentbord
(men bara på ett sådant)
kan man också ange ordmellanrum
liksom skiljetecken och versaler
så att man får en grafiskt perfekt text.

När man har lärt sig använda ett sådant tangentbord
och övat sig tillräckligt
kan man skriva mycket snabbare och lättare
än på ett QWERTY-tangentbord.

Figur 13:1. Principen för (flertalet) ackordtangentbord.

Behovet av utbildning och träning, som är av avgörande betydelse för ackordtangentbordets möjligheter att slå igenom, behandlas i kapitel 8. Det illustreras för Velotype i ett diagram (figur 8:1) som återger Velotype-leverantörens uppgifter om sambandet mellan träningstid och uppnådd hastighet. I samma kapitel diskuteras också arbetsmarknaden för ackordtangentbordsoperatörer.

Kapitel 9 handlar om tillämpningar och inleds med ett avsnitt där det påpekas att den primära anledningen till användning av ackordtangentbord inte behöver vara hastigheten i sig. Många användare kommer primärt att välja göra radikala besparingar genom minskning av arbetstiden för maskinskrivning och/eller sättning, varvid snabbheten bara är ett medel, inte ett mål. Åter andra kan välja ackordtangentbord av ergonomiska skäl; ett ackordtangentbord sägs anstränga användaren mindre än ett QWERTY-tangentbord. – Kapitlet innehåller också en redogörelse för typiska tillämpningar, både inom och utanför handikappområdet.

Kostnader, besparingar och «ovägbara» faktorer behandlas i kapitel 10. Där visas bl.a. att den som driver en maskinskrivningscentral eller ett sätteri förlorar pengar varje dag om han inte går över från QWERTY till Velotype (eller något annat lämpligt ackordtangentbord, om ett sådant finns).

Rapportens engelska del avslutas med ett kapitel om konkurrenter till ackordtangentbordet och ett som ger en blick in i framtiden.

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Appendix 1. The Bulgarian Stenokey

(Partial reprint, with due permission, of:)

THE BULGARIAN "STENOKEY"

A Report Prepared for Baron Data
by
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(Remaining parts of Dr. Steele's report are not reproduced here.)

THE BULGARIAN "STENOKEY" INPUT INTERFACE

A Report for Baron Data, prepared by Richard D. Steele
August 17, 1983

A. INTRODUCTION

According to an article appearing in the June 6, 1979 edition of the English-language newspaper *Sofia News* (a weekly in Bulgaria's capital), work on the STENOKEY electronic keyboard began back in 1975, and was inspired by technical studies of the late Bulgarian linguist, Lyubomir Andreychin. The first reports of the device to appear in the Western press were published in September of 1979, after STENOKEY's debut in the Intersteno Speed Competition, where it captured second place. More recently, STENOKEY has taken top honors in that competition on two subsequent occasions, this year again capturing second – and third – places. It is clearly one of the worlds fastest input interfaces.

What makes the Bulgarian device an object of particular interest, however, is not so much its speed – several chord keyboards operate similarly rapidly – but rather the cleanness of its text output. At 310 syllables per minute (corresponding to approximately 220 words per minute), text emerges from the machine in normal form – that is, without abbreviations, with all words properly spelled, with proper punctuation and proper capitalization, as from a normal typewriter. This differentiates it from all the other devices used in the Intersteno and similar competitions: those others all employ phonic recording methods, producing output that must be translated into normal text before being read by non-specialists. STENOKEY produces that text as its normal output. It is thus not simply fast – it is the world's fastest spelling machine.

On August 11, 1983, STENOKEY was publicly displayed in the United States for the first time. The occasion was the annual meeting of the National Shorthand Reporters Association, held August 10 – 13 in Washington, D.C. At the invitation of Baron Data, I attended this conference to inspect and report on the Bulgarian machine. Over the course of a day and a half, I talked with American stenographers trained in Sofia to use the machine, spoke with the Bulgarians who represented the various interests in manufacturing, licensing and displaying the machine, and logged approximately two uninterrupted hours using it. This report presents my findings from that examination of STENOKEY.

B. DESCRIPTION

The STENOKEY is officially designated the ISOT 6902C, a machine for taking and deciphering stenographic notes. It is a microprocessor-based machine, containing a single printed circuit board of the CM 600 microprocessor family. It has a housing of molded plastic of overall dimensions 14.96" in width, 11.02" in depth, and 4.72" in height at the rear (it slopes down towards the front). STENOKEY weighs 7.72 lbs. It has a power consumption of 50 watts, and is conformed to European electrical standards, 220 volts at 50 Hertz. Along the top rear panel of the housing are located four selector buttons, which specify in which language the STENOKEY is to operate; any single STENOKEY unit may operate in up to four out

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of the sixteen available languages (Bulgarian, Czech, English, Finnish, French, German, Greek, Hungarian, Italian, Japanese, Polish, Rumanian, Russian, Serbo-Croatian, Spanish, Turkish). A STENOKEY unit may communicate with other processors (over an RS 232 C serial interface), with a Diablo printer, with a cassette recorder, and with the IBM typewriter models 82C and 196C, converted into printers. Sales and licensing of the STENOKEY outside of Bulgaria are handled by ISOTIMPEX, 51 Chapaev Street, Sofia, Bulgaria (telephone 74-61-51, telex 022 731 and 022 732).[1]

C. OPERATION

Overview. The STENOKEY is a *spelling machine* – that is, it requires the operator to record explicitly every letter in a word and every space between words. In this regard, it is precisely like a standard typewriter. It differs from the typewriter, however, in allowing the operator to hit clumps, or chords, of keys simultaneously. In this, it is like the stenotype keyboard, another recording device which operates rapidly by allowing keyed inputs in parallel. STENOKEY is unlike either, however, in that it uses processing power to format, or position, letters and spaces relative to one another. On the typewriter, positioning is done temporally (whichever of two keys is struck earlier will be printed first), and on the stenotype machine, positioning is done spatially (whichever key is leftmost on the keyboard will be printed first); on the STENOKEY, positioning is done by the processor, in accordance with control commands that come primarily from the thumb keys. A corollary of this approach is that it is irrelevant just where vowels or consonants are recorded, since they will be re-positioned by the processor; from this flows perhaps the most unusual feature of the STENOKEY keyboard: *all* consonants are recorded by the right hand, and *all* vowels are recorded by the left hand (cf. FIGURE 1 – The STENOKEY Keyboard). This arrangement, in fact, may make sense from the point of view of manual dexterity: most people are right-handed, and positioning the consonants for access by the right hand puts the greatest workload on most people's stronger hand. (Compare, for contrast, the standard QWERTY typewriter keyboard, which requires the left hand do 55% of the work [in Appendix B, An Incredible Legacy].)[2]

Consonants Followed by Wovels. To understand STENOKEY's workings in practice, consider first what happens in the default cases, when only letter keys (say, a consonant key and a vowel key, but no control keys) are depressed. In that instance, the processor prints out the consonant first, followed by the vowel. If there are two consonants, then both the consonants will be printed out before the vowel; if there are two vowels, then both vowels will follow the consonant. This illustrates the default ordering: vowels will follow consonants (unless control instructions dictate otherwise).

The Rank-Orders of Consonant Keys and Vowel Keys. Among the vowel keys, and among the consonant keys, there are also default orderings. These are shown by the rank order of each of the keys

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1 The telephone number in Section 6D4 comes from a more recent publication.

2 Appendix B to Dr. Steele's report is not reproduced here.

in FIGURE 1 (the numbers 1 through 7, written below each of the keys). For either hand, the keys numbered 1 take predence (print out before) over the keys numbered 2, which take predence over the keys numbered 3, etc. Thus, in order to print the sequence "stay", it suffices simply to push the 'S' and the 'T' keys with the right hand, and the 'A' and the 'Y' keys of the left hand. The earlier principle – that consonants print out before vowels – ensures that the 'T' and 'S' will precede the 'Y' and 'A'; the rank ordering within each of those groups causes the 'S' (rank 1) to precede the 'T' (rank 2), and the 'A' (rank 2) to precede the 'Y' (rank 4). The result is the letter sequence "stay".

Spaces Between Words. If "stay" is to represent a separate word – that is, if it is to be followed by a space in the output text – then one hits one of the space keys (of the five designated by "SP" on Figure 1) along with the four 'S', 'T', 'A', and 'Y' keys. When an "SP" key is struck, the space is always printed out as the final element in the character string; it is thus impossible to capture more than one word with a single chordstroke, since the space cannot be interpolated between two letter substrings to indicate an intervening word boundary. If the "SP" key is not struck, then letters of the following chordstroke will be adjoined directly to the letters of the "SP"-less chordstroke; in the present example, this would be appropriate if "stay" were to be the first element in the typed word "staying".

Punctuation. Punctuation other than the space is accessed by striking the special punctuation control key (designated on FIGURE 1 by ⓧ) simultaneously with one of the consonant keys. Striking the "S" key and the punctuation control key together causes a period to be printed out; it also causes the cursor to advance two spaces, and the first letter of the following word to be capitalized automatically. Striking the "N" key and the punctuation control key simultaneously causes a question mark to be printed, the cursor to be advanced two spaces, and the first letter of the following word to be capitalized. In general, striking any of the punctuation keys causes the processor to print out the appropriate character AND to handle anything automatic (e.g. spacing, capitalization).

Level-Control Keys for Consonants. The account so far allows one to access any of the top letters listed on the consonant keys (e.g. the "S" on the "S"-"B"-"C"-key, the "T" on the "T"-"K"-"F"-key). These top letters all belong to the "first level". Accessing the "second level" keys (e.g. "B" and "K") or the "third level" keys (e.g. "C" and "F") requires one to use the "level-control keys", operated by the thumb of the right hand. There are three of these keys, numbered 1 through 3 on FIGURE 1: number 1 designates a letter of the first level, 2 – of the second level, and 3 – of the third level. Suppose, for example, that one wants to print out "sky" (with a following space). To do this, the operator must strike simultaneously six different keys: (1) the "S/B/C" key, (2) the "T/K/F" key, (3) the "SPace" key, (4) the "Y" key, and (5 – 6) "level control keys" numbers 1 and 2. The first level-control key, number 1, specifies that the highest-level letter on the "S/B/C"-key – that is, "S" – is to be printed out; the second level-control key, number 2, specifies that the middle-level letter on the "T/K/F"-key – that is, "K" – is to be printed. There is no confusion as to which consonant key each level-control key refers, as priority of association is established by the same rank order among consonant keys discussed above (using the example

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"stay"); thus, the higher level-control key is associated with the higher consonant rank order key, and the lower control-level key

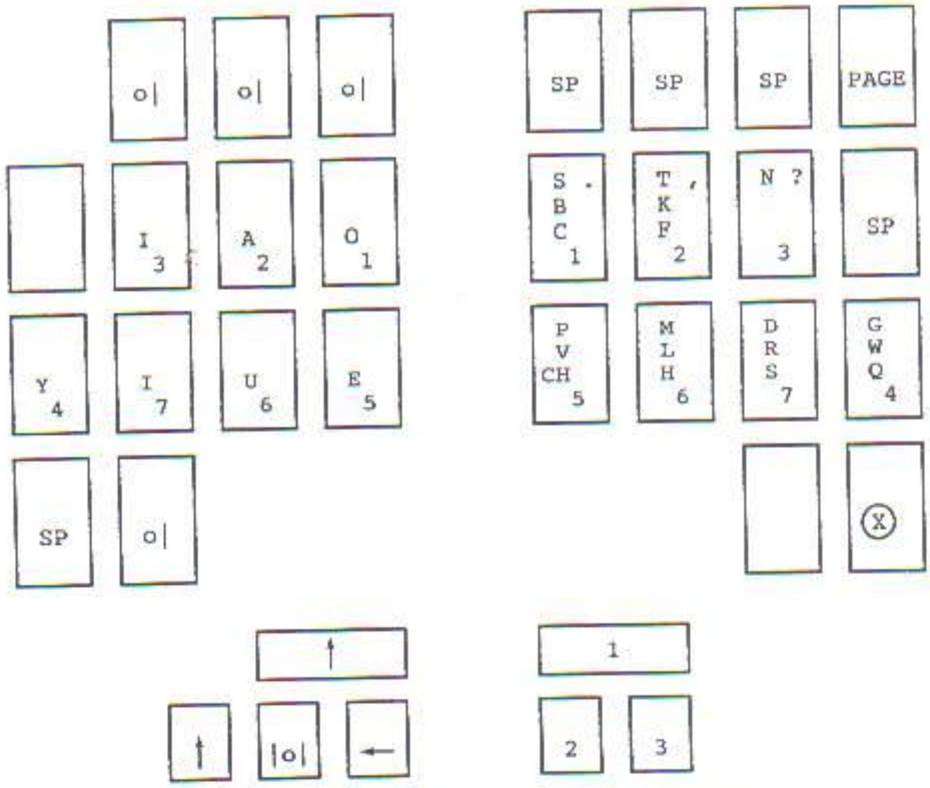

Figure 1 (of Appendix 1). Layout of the Stenokey keyboard. (The version produced for this appendix is just a schematic figure, not showing the right proportions.)

modifies the lower rank order key. Typing "th", then, requires hitting consonant keys number 2 ("T/K/F") and 6 ("M/L/H"), along with level-control keys numbers 1 and 3: this accesses level 1 of key 2 ("T") and level 3 of key 6 ("H").

Reversing Consonant Output Order. This works well as long as the letters are positioned on the keyboard in the desired order. Often they are, but sometimes they are not. In these latter instances, one reverses the order in which the consonants are printed out by pressing – along with everything else – the "letter reversal key", designated by the left-arrow on FIGURE 1. This key is operated by the thumb of the left hand; it is usually necessary for accessing consonant clusters that occur in syllable-final or word-final position, such as "-rk", or "-lp". To access this latter cluster "-lp", for example, one presses five keys simultaneously: (1) consonant key 5 with "P/V/CH", (2) consonant key 6 with "M/L/H"", (3) level-control key 1, (4) level-control key 2, and (5) the "consonant reversal key" with the left thumb. Pressing the "consonant reversal key" specifies that the two letters selected

("P" from key 5, and "L" from key 6) are to be printed out in reverse order, as "-lp".

Level Reversal. Sometimes, the consonants occur on keys in the correct rank order, but occupy levels on those keys in ascending (rather than the desired descending) order. Such is the case with the consonant cluster "cl-" in "clay", for example: "C" occupies level 3 on key 1, "L" occupies level 2 on key 6. Pressing consonant keys 1 and 6 while simultaneously holding down the level-control keys 2 and 3 would cause level 2 from key 1 to be printed out ("B") followed by level 3 of key 6 ("H") – but "bh" is not the desired output. In these instances, the operator presses the level-reversal key, designated by the up-arrow on FIGURE 1. There are two such keys, and they are operated by the thumb of the left hand. This key has the effect of associating the higher consonant level with the consonant key of lower rank order, a reversal of the default operation. In this case, it will cause key 1's third-level consonant to print out ("C"), followed by key 6's second-level consonant ("L"), yielding the desired output consonant cluster, "cl-".

Vowel Pre-positioning Key. Default ordering always places consonants first, vowels second. Sometimes, however, one wants to place a vowel in word-initial position (as in "ask") or in syllable-initial position (as in the second syllable of "poet"). To do this, the operator pushes – along with the desired consonants and vowels – the vowel pre-positioning key, designated by o| on FIGURE 1. This key reverses the default ordering for consonants and vowels, placing the vowels in initial position, followed by the consonants. STENOKEYing the word "ask", therefore, requires that seven keys be pushed simultaneously: (1) consonant key number 1, containing "S/B/C", (2) consonant key number 2, containing "T/K/F", (3-4) level-control keys numbers 1 and 2, (5) the vowel "A", (6) the vowel pre-positioning key above the "A" vowel key, and (7) a "SPace" key, probably one of those over the "S" key or the "K" key. Keys 1-5 assure that the proper letters will be selected, key 6 will place the vowel before the consonants (yielding "ask" rather than the default "ska"), and key 7 will place a space after the last letter of the word.

Vowel-Insertion Key. The most common position for a vowel in an English syllable or word is neither in the final position (STENOKEY's default position) nor in initial position (accessed via the Vowel Pre-positioning key described above), but in the middle of the syllable, sandwiched between consonants. Interconsonantal vowel positioning is accomplished on the STENOKEY by using the vowel-insertion key, designated by |o| on FIGURE 1. This key is operated by the thumb of the left hand. The rules for interconsonantal vowel positioning seem simple: apparently, if the vowel-insertion key is struck, the vowel will be printed out in second position, after the first of the consonants, and other consonants will trail after the vowel. In consequence, producing the word "send" will require that six keys be struck on the STENOKEY keyboard simultaneously: (1) the first-ranked consonant key for "S", (2) the third-ranked consonant key for "N", (3) the seventh-ranked consonant key "D", (4) the fifth-ranked vowel key, "E", (5) the vowel-insertion key, |o|, and (6) a "SPace" key. The vowel-insertion key will position the "E" after the "S" and before the "N", "D", and "SPace", yelding "send". It should be pointed out that positioning the vowel after the first consonant will not always yield the right results: in some cases, the resultant output

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may be a non-word (e.g. "salm" instead of "slam") or it may be the wrong word (e.g. "salt" instead of "slat"). It would be of interest to determine if and how STENOKEY guards against errors of the earlier type: in theory at least, such errors could be prevented in software,.

Syllables of the Form "mom", "did", "pap". Trisegmental syllables of the form "mom", "pop", which contain a single vowel sandwiched between identical initial and final consonants, are produced according to a special convention on the STENOKEY. Keys are struck which specify the initial consonant and the vowel, together with the vowel-insertion key (preceding paragraph). Logically, of course, this makes no sense, since there is only one consonant indicated, and vowel insertion between two consonants requires that two consonants be specified. By convention, however, in this instance STENOKEY will double the indicated consonant, and insert the vowel between the two. This is a convenience which saves a stroke. Thus, to produce the word "wow", one strikes five keys simultaneously: (1) the fourth-ranked consonant key "G/W/Q", (2) the level-control key number two, thus selecting "W", (3) the "O" vowel key, (4) the vowel-insertion key, and (5) a "SPace" key.

Capitalization. In the middle of a sentence (e.g. "... when I was ..."), the first letter of a chord is capitalized by pushing the level-control key number 3 prior to pushing the character chord itself. Thus, "I" (capitalized pronoun) is produced by a two-stroke action: (1) the level-control key 3 is pressed, following which in a separate action (2) a chord composed of the vowel key "I" and a "SPace" key is pressed.

New Line/Paragraph. A new paragraph is begun by pressing a single chord of just two keys, level-control keys number 1 and 3. The action is produced by the thumb of the right hand. Each time this is done, the processor moves the cursor down to a new line and begins a new sentence (i.e. the first letter of the first word recorded is capitalized). Where single spacing is being used, pressing the "new line" chord twice produces a new, non-indented paragraph.

Abbreviations. Although the Bulgarian representatives could provide no details, they did say that the STENOKEY could be programmed to expand previously stored abbreviations automatically in text. They were uncertain as to how this might be done, what effect it might have on device performance, and what quantity of abbreviations might be so stored, given the current memory capacity of the STENOKEY. Nonetheless, it appears to be an intriguing capability, and deserving of further investigation.

Striking Multiple Control-Keys. Any number of control keys may be struck at once, and the processor will generate some interpretation of the intent and output the letters according to that interpretation. Usually the results are understandable, if not entirely expected at first. Learning to use the machine is, to some degree, a process of learning how it will respond to various command combinations. Comments made by the American stenographers trained in Sofia earlier this year indicate that even the Bulgarians are still learning how best to operate the machine in its English incarnation. Almost always, in fact, it is possible to achieve the same output using different letter and command sequences; becoming proficient on the machine is as much a function of knowing how best to achieve a given output as it is a function of gaining skill in keying in those particular command sequences. For the English version of STENOKEY, some of the theoretical problems yet remain for elucidation.

Control Stream vs. Letter Stream. Conceptually, we can see that the processor of the STENOKEY receives two types of information with each chordstroke – characters (including the space), and commands on how those characters are to be positioned relative to one another. In essence, it is a form of typewriter, but one which receives clumps of characters rather than just single characters with each device-recognized act. The clumps themselves are positioned on the paper temporally (just as the individual letters of a typewriter) – that is, all the characters of any given clump will be printed out before any of the characters of the following clump are sent for printing. Such temporal positioning is relatively slow (since it depends on human reaction times), which is why writing on a typewriter is relatively slow. Within the STENOKEY clumps, positioning is done by the processor, in accordance with the formatting commands received either from the control keys or from default positioning rules. Processor-generated character positioning is relatively fast (since it depends on microprocessor response times), which is why writing on a STENOKEY is more efficient than typing on a traditional keyboard (either QWERTY or DVORAK – see Appendix B).[1)]

D. OBSERVATIONS ON STRENGTHS AND WEAKNESSES

What follows is a preliminary evaluation of three aspects of the device – its overall design (from an ergonomic point of view), its keyboard letter distribution (from a linguistic point of view), and its operational demands (from a cognitive point of view). The comments here are meant to be primarily suggestive: the STENOKEY represents such a radical break from past designs and operational principles that it would take considerable time to evaluate the device fully. Nonetheless, for all their cursoriness, I believe the following comments do touch on significant aspects of the device.

Overall Design. Considerable thought has gone into the physical design of the STENOKEY; it attempts to incorporate major insights from the field of ergonomics, and is to a high degree successful. The most obvious feature of the device is the absence of anything that might be called "a keyboard". Rather, it has two keypads, one for each hand. These two keypads are placed approximately four inches apart, and are inclined slightly to form a shallow "V". A person sitting in front of the keyboard can maintain his hands in this position quite comfortably, as it is specifically designed to minimize the fatigue which comes over time from conforming ones arms and hands to a poorly laid-out keyboard. In contrast, standard typewriter and stenotype keyboards were built originally for ease of mechanical construction, rather than for minimizing operator fatigue, and hence the keys form straight lines and rectangles which bespeak a mechanically dictated, rather than ergonomically

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1 Appendix B to Dr. Steele's report is not reproduced here.

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dictated, design. In the present era, these box designs are perpetuated mainly through force of tradition.

The positioning of the keys themselves within the two keypads also shows attention to ergonomic design principles. The "home" keys on each keypad – those numbered 1-4 on FIGURE 1 – are arranged to conform to the relative finger lengths on the two hands. The key for the middle finger is positioned highest, as this is the longest finger; the keys for the index and ring fingers are both positioned slightly lower, as these fingers are generally of the same length, being somewhat shorter than the middle finger; and the key for the little finger is in the next row down, as this finger is distinctly shorter than any of the others, and most comfortably rests below the line defined by the tips of the index and ring fingers. The thumb keys too seem well placed with respect to remaining keys, and in addition are configured to be simple to operate: one pushes a thumb key not with the tip of the thumb, but rather with its side. With this in mind, the Bulgarians have placed all keys which might have to be accessed alone all next to one another, where they can be individually depressed. Keys which will be accessed only in conjunction with other keys reside above those keys, where it is simple to strike them both with the side of the thumb.

This is not to say that the design could not be improved yet further. I believe that it could and should be so improved. In particular, I believe that two additional features should be investigated: the incorporation of some degree of curvature into the keyboard design (the Bulgarian keypads still reside in a flat plane), and the incorporation of slightly wedge-shaped keys (the Bulgarian keys are square), which would allow the keys to "radiate" out from a projected center, as the fingers do when a fist is opened. Having watched the operators record text on the STENOTYPE, I believe that such modifications could improve performance yet further, particularly in accessing keys which are located one above the other (e.g. the "SPace", "T", and "H" keys of the word "the". As it stands now, operators have to contort their fingers to get them to press adequately the column of keys on the flat surface.

Keyboard Letter Distribution. This seems at present to be a weak link in the English version of STENOKEY. Several suggestions for letter distribution improvements can be made immediately, and almost certainly more would come from further performance studies. For vowels, such suggestions would include (1) providing some mechanism for recording with a single stroke the common English digraphs "OO" (e.g. "door") and "EE" (e.g. "deer"), probably through the addition of a "doubling key" next to the vowel keys themselves, (2) providing some mechanism for reversing the order of the vowel digraphs through control keys, such that "AE" could become the common "EA" (e.g. "deal", "eat"), "EU" could become the common "UE" (e.g. "glue", "cue"), and (3) some mechanism for recording the common "Vowel-Cons-e" sequence of English (e.g. "late", "muse", "sine"). For consonants, improvement suggestions would include (1) providing some mechanisms for single-chord recording of such common initial consonant clusters as "STR-" (e.g. "street", "stripe"), "DR-" (e.g. "drip", "drive"), and "SC-" (e.g. "scare", "scoop"), and (2) replacing "CH" on key 5 (it is a redundant here) with "Y" in word-initial or syllable-initial position (at present there is no efficient way of recording "you", for example).

Cognitive Operational Demands. STENOKEY reveals things of interest here. Previous language-oriented manual input interfaces have maintained a close mapping relationship between space and/or time, and the order in which language elements appear on the printed page. For example, on a standard typewriter, temporal priority maps directly into element order: any key which is struck earlier than another key will be printed out to the left of the latter. On the stenotype keyboard, the spatial mapping is as it were "hard-wired" into the device: a syllable-initial "S" can be printed out *only* before a syllable-initial "T" because they are set in that order. (To the extent that this conforms to the phonic regularities of English, it poses no problems; but foreign borrowings which break the rules, such as "tsar", cannot be captured easily.) STENOKEY has developed a system of "software positioning" of elements. Control-key instructions are delivered to the processor along with each packet of characters, and the characters are then arranged in accordance with the processor's interpretation of the control-key instructions.

At first, it seems as though this might be a confusing way to operate. However, the Bulgarian performance on the machine at the Intersteno Speed Competitions suggests otherwise. And, in fact, this is not surprising. What the operator of the STENOKEY device learns, ultimately, is not so very different conceptually from what an American stenotypist learns: that certain frequent phonic patterns correspond to certain characteristic patterns of the hands, and that certain letter combinations are accessed by pressing certain combination of keys. What is particularly new here is that the thumbs are used to generate abstract element positioning instructions. However, these also are patterns with distinct regularities, and the frequent cases will be rehearsed enough to become familiar and automatic to the operator. The most important lesson to be learned is that operators are capable of efficiently extracting and encoding abstract "pattern-oriented" information about words at the same time that they are recording the letters. It is a lesson which might be applied even better.

(Remaining parts of Dr. Steele's report are not reproduced here.)

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