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(56) Documents Cited
GB 2286035 A GB 1480243 A WO 89/12858 A1
US 5444462 A US 4613139 A

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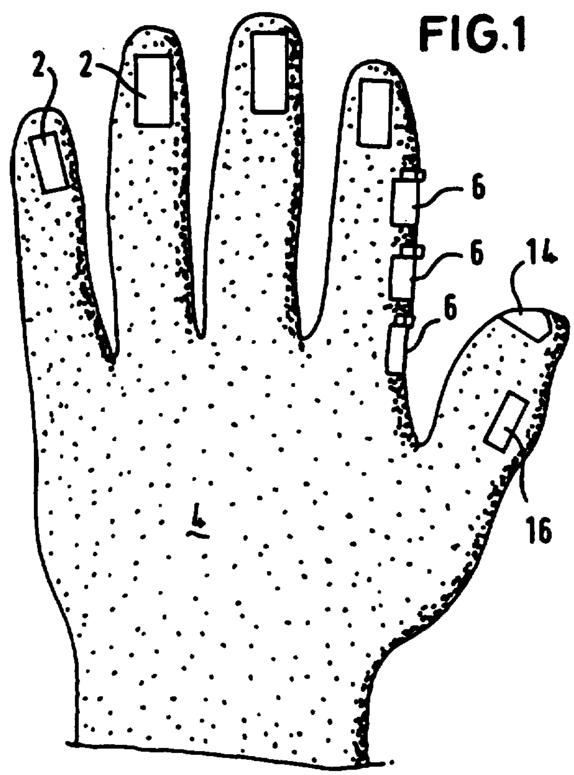
(54) A keyboard glove

(57) A data input device adapted to replace a conventional keyboard is in the form of a glove having pressure sensors 2 at each finger tip, shift buttons 6, function keys (8, figure 2) on the back of the glove, and LEDs (10, 12) for indicating the status of shift and function keys, and two sensors 14, 16 on the thumb, Pressing a finger or a predetermined combination of fingers on any surface, with or without operation of a shift button, produces a corresponding keystroke. Each finger sensor comprises a pair of copper contact plates biased apart by springs (24, figure 5), or alternatively may comprise piezo-electric sensors. The glove may be adapted to provide cursor control by movement of the index finger, and the buttons on the side of the index finger can be used as mouse buttons.

FIG.1



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

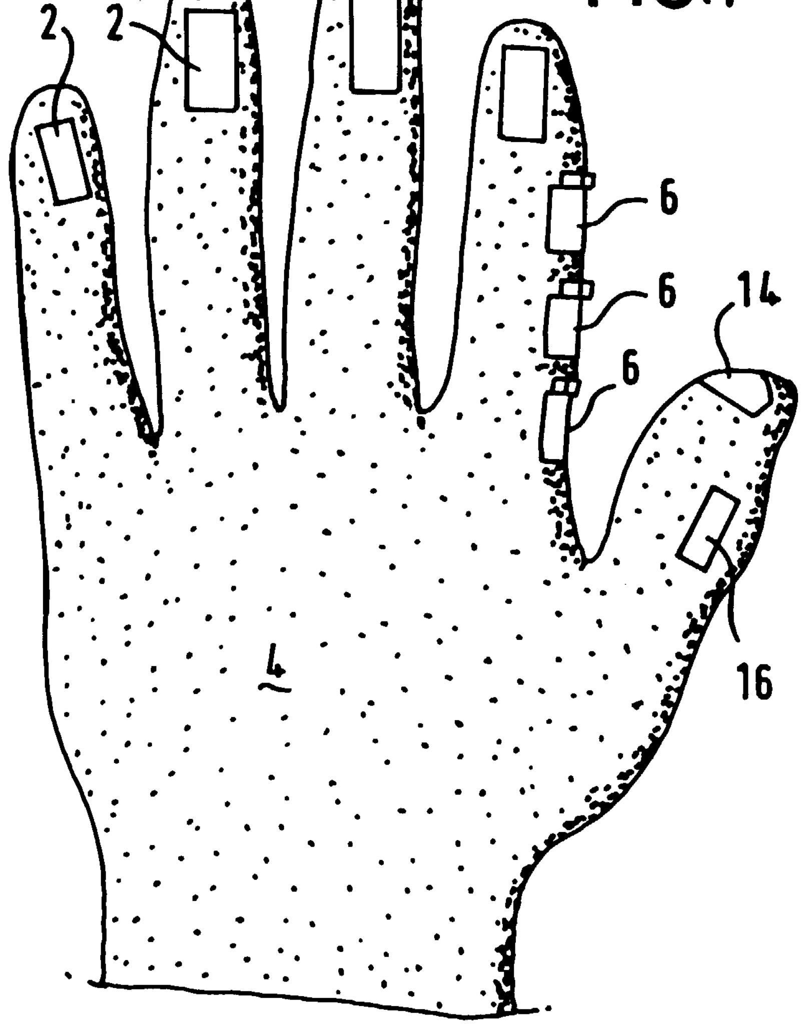

FIG.1

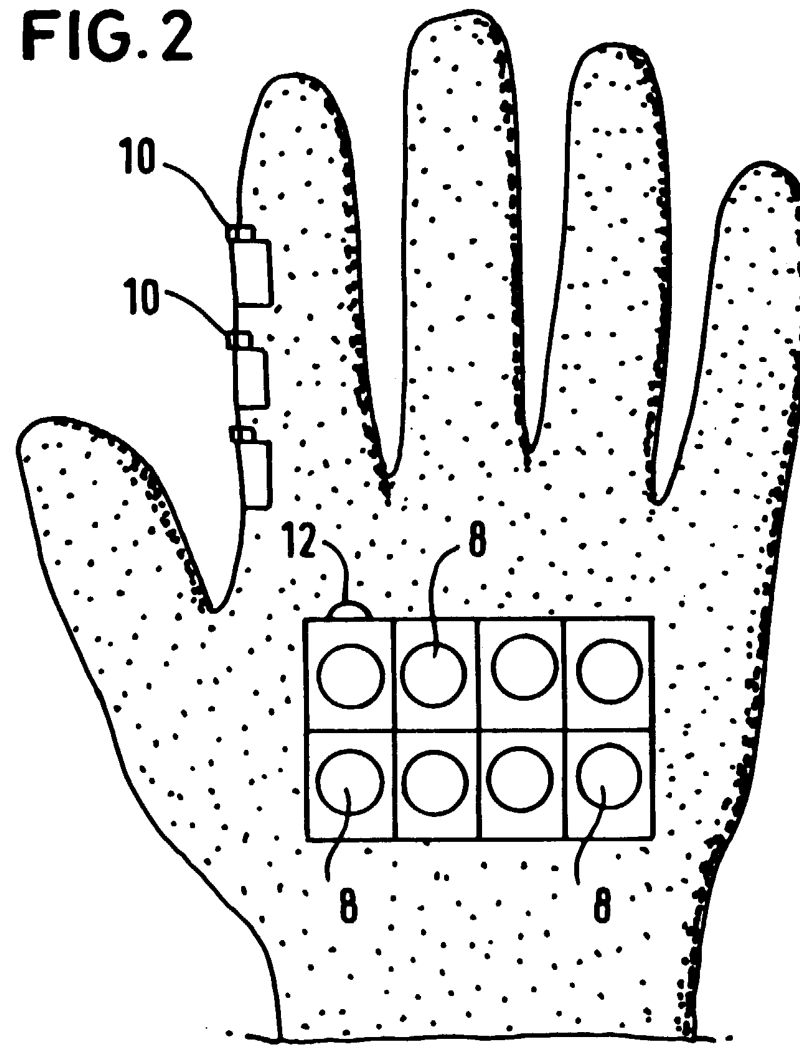

FIG.2

FIG.3

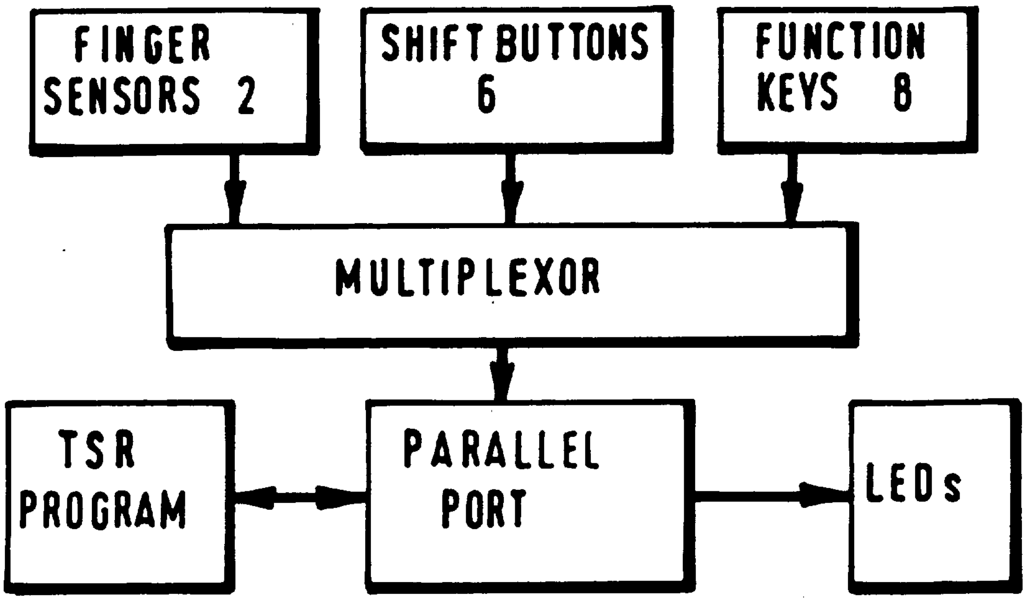
FINGER SENSORS 2
SHIFT BUTTONS 6
FUNCTION KEYS 8
MULTIPLEXOR
TSR PROGRAM
PARALLEL PORT
LEDs

FIG. 5

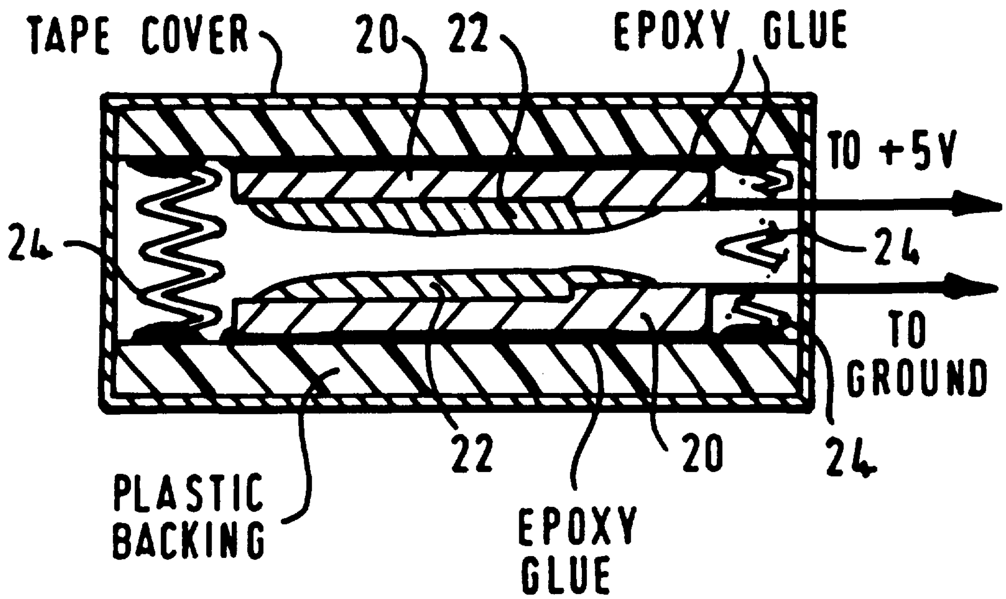
TAPE COVER
20
22
EPOXY GLUE
TO +5V
24
24
TO GROUND
22
20
24
PLASTIC BACKING
EPOXY GLUE

FIG.4

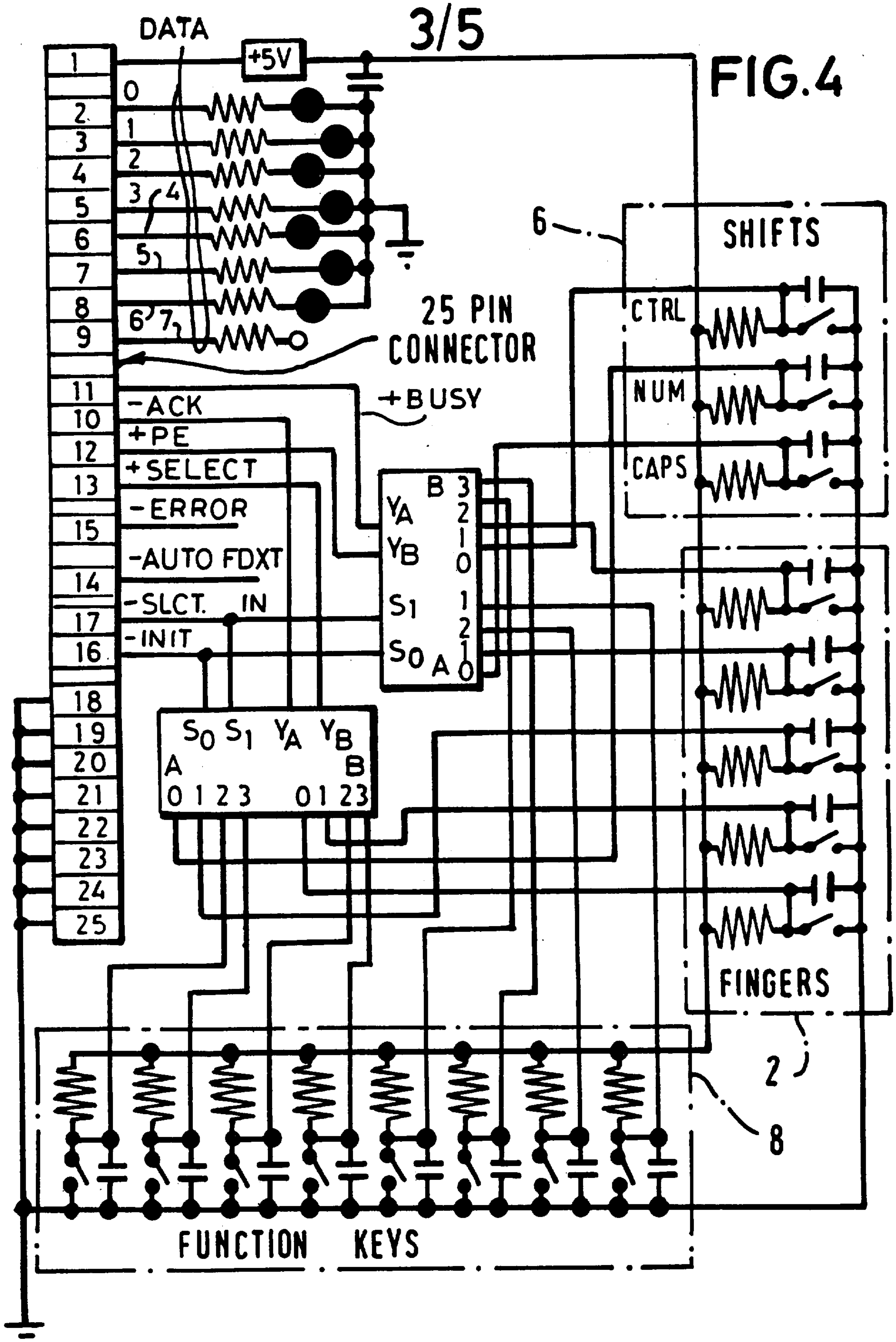
DATA
+5V
0
1
2
3
4
5
6
7
25 PIN
CONNECTOR
-ACK
+PE
+SELECT
-ERROR
-AUTO FDXT
-SLCT. IN
-INIT
+BUSY
SHIFTS
CTRL
NUM
CAPS
FINGERS
FUNCTION KEYS
6
2
8

FIG.6

CHORD					SHIFTS			
Thumb	Index	Middle	Ring	Little	DEFAULT	CAPS	NUM.	CAPS + NUM.
●	●	○	○	○	a	A	5	&
●	●	○	●	○	b	B	*	
●	●	●	●	○	c	C	0	%
●	○	●	●	○	d	D	/	\
○	○	○	●	○	e	E	3	!
●	○	○	●	●	f	F	Tab	
○	○	●	●	○	g	G	)	>
○	○	●	○	○	h	H	2	@
○	○	○	○	●	i	I	4	?
●	●	●	○	●	j	J		
○	●	●	●	●	k	K	^	^
○	●	●	●	●	l	L	=	<
○	●	●	●	○	m	M	-	_
○	●	●	○	○	n	N	(	"
●	○	○	●	○	o	O	7	1
○	●	○	●	○	p	P	+	#
○	●	●	○	●	q	Q	?	
●	●	●	○	○	r	R	9	'
●	○	●	○	○	s	S	6	$
○	●	○	○	○	t	T	1	'
○	●	○	○	●	u	U	[	{
○	●	○	●	●	v	V	ESCAPE	
●	●	○	○	●	w	W	]	}
●	●	○	●	●	x	X	*	
●	○	○	○	●	y	Y	8	~
●	○	●	○	●	z	Z		
●	○	●	●	●	, (comma)			;
○	○	●	●	●	. (period)			:
●	○	○	○	○	SPACE			
○	○	○	●	●	BACKSPACE			
●	●	●	●	●	RETURN			

FIG.7

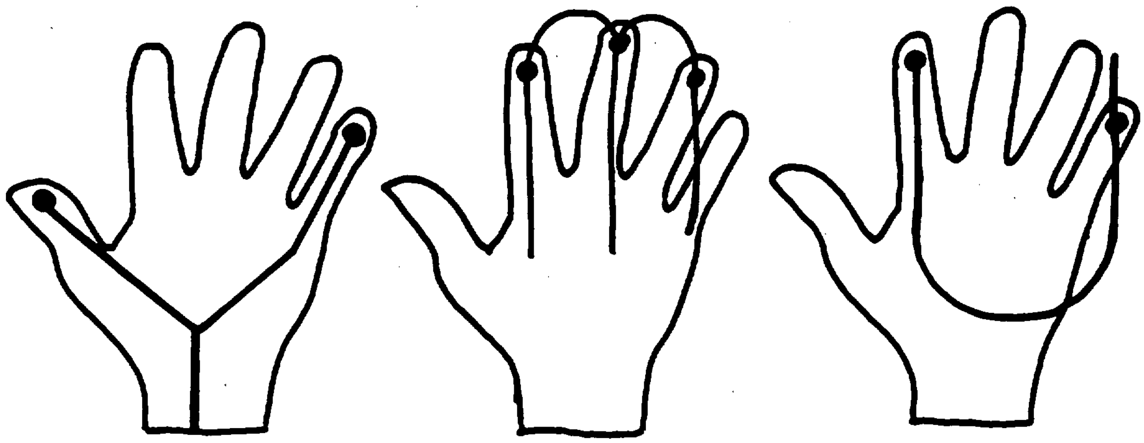

FIG.8

<table>
<tr><td></td><td>INDEX</td><td>MIDDLE</td><td>RING</td><td>LITTLE</td></tr>
<tr><td>NO THUMB</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td rowspan="4">THUMB</td><td>5</td><td>6</td><td rowspan="2">7</td><td rowspan="3">8</td></tr>
<tr><td colspan="2">9</td></tr>
<tr><td colspan="3">0</td></tr>
<tr><td colspan="4">RETURN</td></tr>
</table>

Keyboard Glove

This invention relates to data input devices for computers, and particularly to devices adapted to replace conventional keyboards.

In the near future, computers will be small enough to put in a pocket or mount on a belt. The theoretical minimum size of computers is limited by the keyboard. The current accepted value for the smallest usable key is 19mm square. This clearly limits the size of computers to approximately their current size. The computer can be made only as small as the keyboard.

The keyboard also poses a portability problem. To work, the keyboard must rest on some surface, whether it is a desk, lap or hand. This makes the keyboard only usable while sitting, or with using one hand. In a virtual reality system, the user is often standing. Using a keyboard to input text in this environment would be difficult at best. This is a major factor preventing the use of a text input device in virtual reality.

There is a way to avoid the size limit. The user interface does not have to be a standard keyboard. One solution to this problem is a chord keyboard. Chord keyboards use the idea that multiple keys can be pressed simultaneously to give more possible characters. Most current chord keyboards have between 6 and 16 keys, either for one or both hands. Research has shown that people learn chord keyboards faster than a standard QWERTY. Also, novices tend to type faster on a chord keyboard.

Chord Keyboards

Most keyboard alternatives are just modified versions of the standard keyboard. A character is made by pressing one key, or one key and one shift key simultaneously. This layout allows any number of characters, as long as there is room on the keyboard. To reduce the number of keys, consequentially the size of the keyboard, there must be more shift keys. Using this method, each key would have several characters associated with it. A chord keyboard is the logical conclusion to this process. There is a limited number of keys, usually one for each finger. Pressing a key by itself makes one character, like a normal keyboard. Pressing two or more keys simultaneously also makes a character. Pressing combinations of keys in this way is called chording.

Chord keyboards were first used by the US Post Office in the 1960's for entering numbers for mail sorting. Most early research on chord keyboards concentrated on limited applications. In the 1980's chord keyboards were reevaluated and applied towards a general text keyboard. The major disadvantage to using a chord keyboard for general text entry is the limited number of keys. A one handed chord keyboard has only five keys. This translates to 31 possible combinations. This is enough for all the letters, with room for a few more characters, like space and return. There are numerous solutions to this problem. Below are just some of the possible solutions:

Two handed chording:

A ten key chord keyboard has 1023 possible characters. This more than enough. Most two-handed keyboard do not use all combinations, but uses each hand separately to type faster. This is done by overlap. Overlap is enterin a chord with one hand before the other hand is finished with the last chord. This is what is usually done on a standard keyboard. Users of two-handed chord keyboards tend to type 17% faster than users of one-handed keyboards. Most chord keyboards are made for two hands.

Thumb keys:

One or more extra keys can be added in reach of the thumb. Sixteen more characters are added per thumb key. Mor combinations are possible if the thumb keys can be pressed simultaneously. This is the a common solution and is often used in addition to two-handed chording.

Sticky shift keys:

A sticky shift, when pressed once, acts on the next one chord made. When double-pressed (like double-clicking a mouse) it acts on all chords until the shift is hit again. For each shift, the number of possible characters doubles.

Multiple state keys:

Instead of an on/off key like most keyboards, it is possible to have a three or more state key. A three state keyboard uses keys which can be pushed up, down, or not at all. This gives 243 combinations for one hand.

Additional finger keys:

It is possible to have more than one key per finger, such as an extra row, above or below the base row. This is effectively the same as having one multiple state key per finger.

By using one or more of these combinations it is possible to create all the same characters that can be made on a standard keyboard. With this problem removed, it is possible to use a chord keyboard as a general text input device.

The following is how chord keyboards rate on the text input design criteria:

1. Input speed: beginner: 30-35wpm, novice: 60wpm[Go88]], disabled: 12wpm[Ki86]

2. Error rate: 9.88%[Se62], 1%-2%[Go88]]

3. Learning rate: normal use chords: 1 hour [BAT] typing: novice: 20h, expert 60h [Go88] disabled use chords: 5 hours [Ki86] typing: novice: 11h

4. Fatigue: Low amounts of finger use.

5. Muscle strain: can rest the wrist on the keyboard. Arm can be held comfortably. Hand is held flat causing shoulder stress.

6. Portability: one-handed is much smaller than a standard keyboard, but it still needs a surface to rest on.

7. User preferences: no negative QWERTY transfer. Impossible to use without some training/practice.

Given the above, how does a chord keyboard compare with a standard or alternative one? The expert typists can type faster on a standard keyboard, but, novice typists can type faster with less training. It is not possible to type without training on a chord keyboard, as it is on a standard one. On the other hand, learning to type on a chord keyboard is easier because the chord shapes can have some physical correspondence to the letter being typed [Go88].

For example, holding out only the thumb and little finger makes a Y shape. If the chord for Y is made with the thumb and little finger, it becomes much easier to remember. In addition, learning to type on a chord keyboard does not have any effect on the ability to type on a standard one. A person can switch back and forth without any problem. This is an advantage over keyboards with different layouts.

Touch-typing on a standard keyboard is difficult because the large number of keys and movements make it easy to miss. This is alleviated much by most alternative keyboards. With a chord keyboard it is impossible. Each finger uses only one key. Since almost no movement is involved, it is impossible to miss, this is especially useful in blind, or otherwise disabled users. This is reflected in the smaller error rates for chord keyboards. Another problem with excessive hand motion is that with most normal keyboards, the hand must constantly move from the keyboard to the mouse. Since a one-handed chord keyboard is not much larger than a mouse, the entire device can be used as a pointing device. This would alleviate much unnecessary motion.

A chord keyboard is not, however, an ideal solution. Chord keyboards simply have less keys than a standard keyboard, reducing the required area. Most chord keyboards are designed such that the wrists rest on the base and the keys are spread radially about the palm of each hand. This leaves empty, unused space under the palms and wrists. This makes the keyboard the size of one or both hands, which, for a two-handed chord keyboard, is not much smaller than a standard keyboard. Since the hands must rest on the keyboard, this is not a solution to the portability problem, either.

The present invention seeks to provide a solution to both the size and portability problems. According to the present invention there is provided a data input device comprising a glove having pressure sensors at each finger tip whereby pressing a predetermined combination of fingers on any surface produces a corresponding keystroke. Since there are only 31 possible combinations of five fingers, which is much less than number of upper and lower case letters, numbers, punctuation characters, and so forth, the number of characters may be increased by the use of shift keys. Preferably, sensors are arranged on the side on the index finger so as to be pressed easily by the thumb. For example, pressing the shift button with the thumb would make the next one combination be a capital letter. There may be an analogous key for typing numbers, and a third key may be provided to put the glove in "caps" or "num" lock.

In order to tell the state of each shift, sub-miniature LEDs are preferably placed next to the shift buttons, red for operation on the next character, and green for locked. In order to have easy to press, rarely used buttons, such as escape, pause, help, etc., additional control buttons (with LED indicators, as necessary) are placed on the back of the hand. These buttons are in easy reach of the other hand.

In this way it is possible to increase the number of possible characters to include upper and lower case letters, punctuation, numbers, and special keys. Since the glove can be worn just like any item of clothing it is completely portable and has effectively zero size.

The glove may also be adapted to provide a graphic interface, so that movement of the index finger, up, down, left, or right, can control a pointer. Extending the index finger and curling up the other fingers may be arranged to toggle a pointer mode. The arrangement may also be such that the buttons on the side of the index finger can be operated by the thumb as mouse buttons. This gives the glove all the benefits of being a mouse and a keyboard, without needing to move between the two.

Alternatively, the glove can be modified for use in a virtual environment i.e. for "virtual reality" applications. This would expand the uses of immersive virtual reality to include all text aspects of modern desktop computers. This would allow one to program, write E-mail, and interface aspects that are difficult to represent graphically, without having to change computers.

The glove solves several problems of modern interfaces. As opposed to the QWERTY, the chords are arranged to maximise, not minimise speed. Also, the user car arrange their hands to be in whatever comfortable position they want, and even vary the positions, thus reducing keyboarding injuries. As opposed to other keyboards, the glove frees the use of one hand for other tasks. The glove takes up effectively zero space, making it very portable. Additionally, the glove does not place a limit on the size of the computer, making it ideal for portable computers.

Most keyboards are separate from the pointing device, requiring the user to physically move between the two. If the glove is combined with a pointer, both unit are combined and can be switched by fingers movements. Text input in virtual reality systems is limited to voice recognition systems, which are currently not very accurate, especially in a noisy environment. This would be ideal for a VR text input device because it can be used as graphical interface as well.

This arrangement provides all the advantages of a normal chord keyboard, and more. The advantages are as follows:

Frees one hand:

Since this can used by only one hand, the other hand is freed to perform other tasks.

Reduces injuries:

Since the device enables typing on any surface, the hand can be held horizontally, vertically, or whatever the user feels comfortable with. The user can type in a variety of different ways in one sitting. This helps to avoid repetitive motion injuries.

Combines with a pointer:

It is possible to combine the glove with a glove-based pointing device, like a DataGlove or Power Glove. This allows switching between text and graphics input with a minimum of unnecessary movement.

Portable:

The glove takes up practically no space, and since it worn, is uncumbersome. This allows it to be taken anywhere. Since this can type on any surface, including the body, it can also be used anywhere. Combining the glove with glove-based pointer, a small portable computer, and a small head-mounted display (like the Private Eye), give a computer that is completely uncumbersome and ideal for fieldwork where a computer may be needed.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is plan view of the palm side of a keyboard according to the invention;

Figure 2 is a plan view of the back of the glove of Figure 1;

Figure 3 is a schematic diagram of the main parts of the glove and its computer interface;

Figure 4 is a circuit diagram of the glove hardware; and

Figure 5 is a cross-section through a finger sensor.

Figure 6 illustrate a chord keymap for the glove;

Figure 7 shows chords which resemble letters which they make; and

Figure 8 shows a chord pattern for numbers.

Referring to Figure 1, finger sensors 2 are sewn onto the palm side of each fingertip of the glove 4. They detect when a finger is pressed against something. Shift buttons 6 are located on the side of the index finger. Pressing one changes a shift state, allowing more possible chords.

Function keys 8 are located on the back of the glove, Figure 2. These are seldom used keys which must be pressed by the other hand.

LEDs 10, 12 are located on the side of the index finger and on the back of the hand respectively, to indicate the status of the shifts and the AutoCaps mode (automatic capitalisation at beginning of sentences).

In operation, each finger press is detected by a finger sensor. The thumb has two sensors 14,16 to detect presses on the finger tip and on the side, just above the knuckle, respectively. The sensor that is used depends on how the hand is being held. When the hand is horizontal, the side of the thumb is usually used. When the hand is vertical, the tip is usually used.

The shift buttons 6 are located on the side of the index finger. One button is in the middle segment and two are in the bottom segment. They are used to change each of the shift states -- caps, number, and control. When pressed the shift operates on the next one character. When double pressed ("sticky shift") the shift operates on all characters until pressed again.

The function keys (8) are seldom used keys that are meant to be easily accessible. This is why they are located on the back of the hand, in easy reach of the other hand. These keys are pressed individually and each has its own function. These include the following functions:

Pause:

This will cause all finger sensors to be ignored until this key is pressed again. This is to allow the hand to perform other actions without unintentionally typing.

Escape:

This has the same effect as the Escape key on a normal keyboard.

Help:

This is intended to call whatever help is necessary for the application. Currently this is used to pop up a window displaying the keymapping.

AutoCaps Toggle:

This turns on or off the AutoCaps feature (automatic capitalisation after full stop). There is an LED (12) associated with this button which shows the AutoCaps state.

The function keys have the same design as the shift keys. The six shift indicator LEDs (6) are in three groups of two. Each shift has a red and a green LED next to it. When the shift is off, no LED is on. When the shift is on, the red LED is lit and the green is off. When the shift is locked, the green LED is lit and the red is off.

The LEDs are powered directly by the computer through the parallel port. The LEDs are independent of each other and their use can be changed in software to fit specific applications.

Each finger sensor (Figure 5) or shift key comprises a pair of plastic support members inside an insulating tape covering (20) carrying copper contact plates, and connected by a pair of compression springs (24). A connecting wire is soldered to each copper plate so that the circuit is made when the assembly is compressed. As shown a Figure 4, a resistor (56kΩ) is connected in series with each sensor and a capacitor (22pF) in parallel which acts as a low pass filter, preventing noise.

Instead of fabricated metal contact switches, it is also possible to utilise other devices such as piezo-electric sensors, which can now be fabricated as thin flexible films (see for example, US 5230921) or laminated strips (US 4883271).

The bulk of the hardware (Figure 4) is mounted on a board which is sewn to the glove, just below the wrist. All of the glove hardware is connected to the board to be converted to/from computer I/O. The digital finger sensor signals and the signals from the shift buttons and function keys (sixteen signals) are multiplexed to connect to the four inputs on the parallel port (see Figure 3).

Software:

The parallel port is read every clock tick (18.2 times per second). The input in converted into chords, shifts, and function keys. If a function key is made, it is converted into a normal, appropriate key press. If a shift is pressed, the corresponding LED is turned on or off. When a chord is made, the chord is converted into a key code and output into the keyboard buffer.

There are two kinds of function keys, those which control glove functions, and those which act as normal keys. When a function key that mimics a normal key (like Escape) is pressed, the appropriate key is entered into the keyboard buffer. When the key is released, nothing happens. When a key which controls a glove function key is pressed, the effect depends on the key.

AutoCaps toggle: If AutoCaps is on, it is turned off. If off, it is turned on. The AutoCaps indicator LED is set on or off as well.

Help: When pressed, the help window pops up. When the button is released, the help window closes.

Pause: When pressed, all chord keys are ignored until Pause is pressed again.

When a shift key is pressed, one of three things will happen:

1. If the shift is off, the shift is turned on and will operate on the next one chord. The red LED is turned on.

2. If the shift has just been pressed, the shift is locked and will operate on all subsequent chords. The red LED is turned off and the green LED is turned on.

3. If the shift is locked or has not been pressed recently, the shift and both LEDs are turned off. Because the shift keys are intended to be pressed by the thumb, when a shift is pressed, any simultaneous press of the thumb is ignored.

A chord can be made any of 5 ways:

1. The keys can be pressed simultaneously and then all are released.

2. The keys can be pressed simultaneously and held longer than a cutoff time.

3. The keys can be pressed and some keys released. The chord made is from all the keys pressed before the first was released.

4. If some keys are released, the computer waits a short time before the new chord is registered. The new chord

is made from whatever keys are pressed when the short time has passed.

5. If the same keys are held beyond a certain cutoff time, the chord is repeated.

When a chord is made, the appropriate key code is sent into the keyboard buffer. This causes the computer to believe an actual key has been pressed, and acts accordingly. If AutoCaps is on, the computer looks for the characters "." (period), "?" (question mark), and "!" (exclamation point). If any are pressed, and no shift is locked, the caps shift is turned on (and the red indicator LED). This will operate on the next one chord, just as if the shift had been pressed manually. This removes the requirement to press caps to capitalise the first letter of a sentence. Note that the period is the same in the caps mode as in the normal mode. This allows ellipses (...) to be entered without a problem.

<u>Chord Keymap</u>

A chord keymap was developed which associates the most frequently used characters with the easiest hand positions. The hand positions were rated by Seibel by measuring Discrimination Reaction Times (DRTs) for each chord. The chords with the fastest DRT are the easiest to make. Five basic mnemonics facilitate memorisation of the keymap:

1. The chord can resemble the character. The finger combination can have some obvious relation to the shape of the character typed. For example, the letters Y, M, and U are all made in such a way that the shape of the fingers

which make the chord resemble the shape of the letters (Fig. 7).

2. A sequence of chords can have some meaning and be easy to make. For example, the common sequence "t h e" is made by a simple sequence of chords: Index - middle - ring; which are easy to make in succession.

3. Sequential characters can be made by following a simple pattern. For example, numbers are made as described in the table of Figure 8.

4. One chord can be based on another chord. For example, the similar characters Comma and Period have similar chords, with only one finger difference between the two (Table 2).

5. A shifted chord can be based on an unshifted chord. For example the chord for exclamation point is a shifted version of the chord for e.

The theoretical input speed for this keymap can be approximated by averaging Seibel's DRTs, and weighing each DRT by the frequency of the associated character. The average speed for this keymap is 305ms/character, or 40 words per minute.

Seibel calculated DRTs by measuring the time it took for a subject to make a chord once asked to do so. The chords were displayed randomly and were not associated with any characters. When using chords for text entry, the following character is known in advance, giving the subject a slight time advantage. This means even faster speeds may be achieved than the theoretical 40 wpm.

CLAIMS

1. A data input device comprising a glove having pressure sensors at each finger tip whereby pressing a finger or a predetermined combination of fingers on any surface produces a corresponding keystroke.

2. A data input device according to claim 1 in which at least one further sensor is arranged on the side of the index finger so that it can be pressed by the thumb, so as to provide "shift", "cap lock" or "num lock" type functions.

3. A data input device according to claim 2 further comprising indicator means adjacent the or each further sensor to indicate its state of operation.

4. A data input device according to any preceding claim further comprising additional sensors on the back of the hand for actuation with the other hand.

5. A data input device according to any preceding claim in which the glove is adapted to control movement of a screen pointer by corresponding movement of the index finger.

6. A data input device according to claim 5 in which the pointer mode is initiated by extending the index finger

while curling up the other fingers.

7. A data input device according to claim 5 or claim 6 further comprising sensors on the side of at least one finger, adapted to operate as mouse buttons.

8. A data input device substantially as herein described with reference to the accompanying drawings.

Application No:	GB 9518900.7	**Examiner:**	Peter Squire
Claims searched:	1-7	**Date of search:**	27 November 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F2Y YCA YCB YTA YTB H1N NAK

Int Cl (Ed.6): G06F 3/00, 02, 023 G06K 11/18 B41J 5/00, 10 A41D 19/00

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2286035 A	(PENDLETON) see e.g. page 7 para. 2	1
X	GB 1480243	(POST OFFICE) see whole document	1
X, Y	WO 89/12858 A1	(KADOTA) see e.g. WPI abstract accession no.90-022675/03	X: 1, 4 Y: 5, 7
Y	US 5444462	(WAMBACH) see e.g. column 3 lines 1-13 and column 4 lines 53-61	5, 7
X	US 4613139	(ROBINSON) see whole document	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.