Avoiding Repetitive Stress Injuries by using Ergonomically Improved Keyboards

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Avoiding Repetitive Stress Injuries (RSI) by using ergonomically improved keyboards
-A TRIZ based study of 10 inventions

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1. Introduction

Keyboard is the most important input device for a computer. It is quite essential for any type of computer whether desktop, laptop or small handheld computers like palmtops and PDAs. However, most conventional keyboards are designed keeping their technical efficiency in mind and not human comfort or ergonomic aspects. This leads to various physical problems by keyboard users and more seriousness to the prolonged users. There is a need to build ergonomic keyboards to reduce this problem faced by keyboard users.
1.1 Problems caused by prolonged keyboard usage

The major physical problems caused by prolonged keyboard usage can be
categorized as neck pain and stiffness, low back pain and stiffness, and strain of
the wrists. These problems are caused by chairs, computer desks, and keyboard
support stands that are unsuitable for the particular computer user.

Many physicians advise computer users to take off for five minutes or so at each
30 to 60 minutes of working time to move about to relieve their neck, back and
wrist pain symptoms. In most cases the user fails to do so because of the work
pressure. Even if he does so the user productivity is affected.

1.2 Repetitive Stress Injuries (RSI) and Carpal Tunnel Syndrome (CTS)

A primary problem which has been closely associated with the use of the
computer is that of carpal tunnel syndrome (CTS). Carpal tunnel syndrome is a
debilitating injury to the wrist joint which has been frequently attributed to long
term repetitive hand motion activities. A further factor contributing to carpal tunnel
syndrome and its symptoms is the strain on the operator’s wrists due to using a
keyboard that is too high or too low.

The median nerve and flexor tendons of each hand pass through a small opening
in the wrist known as the carpal tunnel. When continuous activities involving
strain on the wrist are combined with finger articulation, swelling in the carpal
area may occur which, in turn, creates pressure on the median nerve. The
resultant pain, tingling and numbness of the fingers are the symptoms typical of
carpal tunnel syndrome.

A carpal tunnel syndrome is generally treated with complete rest and
immobilization of the wrist for a period of several weeks. The worse cases are
treated with surgery. But all these problems may again start when the user starts
using the keyboard again after the treatment.

1.3 Factors causing problem in keyboard usage

- The conventional key layout is not scientifically arranged. This leads to more
  movement of fingers for less work and leads to user fatigue.

- Keyboard is generally positioned on a standard table the height of which is
  not convenient for many users.

- If the keyboard is too far from the operator’s seat the user may have to lean
  forward, which causes uncomfortable sitting position.

- Keyboard is generally kept flat on a table where as human arm would prefer
to operate in an angle.
- As the keyboard is at lower level than the monitor the user has to move his vision from monitor to keyboard time and again which causes strain to the muscles of the neck and of the eyes.
- The keyboards of small computers and PDAs are not comfortable for typing.

1.4 Steps to avoid problems caused by keyboard usage
- It is necessary to adjust the height of the keyboard relative to the level of the operator's wrists and the height and location of the monitor screen.
- The keyboard should be capable of moving forward and backward (even upward, downward and angular) to suit operator’s position.
- The keyboard may have an ergonomic key arrangement for typing comfort.
- The keyboard may have a cushion for armrest to reduce the pain of wrist and arm.
- The gap between keyboard and monitor should be minimum to reduce eye and neck movements.
- The keyboard should be tiltable to suit the angle of the user’s wrist and arm.

2. Inventions on ergonomically improved keyboards

2.1 Arm and hand rest for a keyboard (Patent 5104073)

Background problem
The keyboard operators have been subject to on-the-job medical conditions of carpal tunnel syndrome (CTS) and repetitive strain injuries (RSI), which causes pain in one’s hands and fingers. It is necessary to provide a device that permits the user to rest the joints of the arm and hand in proper position and posture.

Solution provided by the patent
VanBeek et al. provided an arm and hand rest for individuals (Patent 5104073, issued Apr 1992) while using the keyboard so as to prevent problems like CTS and RSI. According to the invention the arm and hand rest is three dimensionally adjustable to permit positioning about the approximate height of the keyboard, and provide for spacing of the wrists and for relaxation of the wrists and arms while the fingers can still poised on the keys.
The most significant aspect of the invention is a padded arm and hand rest that provides support during operating the keyboard. The arm and hand rest is intended for preventing carpal tunnel syndrome and other repetitive strain injuries.

**TRIZ based analysis**

The objective of the invention is to prevent pain and health problems caused by keyboard operation *(Principle-8: Counterweight).*

The apparatus uses three-dimensional adjustment to keep the keyboard at a convenient height and position *(Principle-17: Another dimension).*

The main aspect of the invention is the padded arm and hand rest *(Principle-11: Cushioning).*

**2.2 Computer support system (Patent 5120117)**

**Background problem**

There are several accessories to enhance the efficiency of using a computer and improving the working environment of the computer operator more pleasant and efficient. But a primary problem that is associated with the use of the computer is that of the carpal tunnel syndrome (CTS).

It is necessary to create a computer workstation, which optimizes the positioning of the keyboard and the monitor for the comfort and efficiency of the user.

It is also necessary to create a preformed workstation that may be installed by modifying an existing desk, table or counter.

**Solution provided by the invention**

Williams disclosed a preformed platform (Patent 5120117, assignee-Nil, issued Jun 1992) for the support of the keyboard and monitor components of a computer terminal. The platform comprises two major sections, one to hold the keyboard (called keyboard section) and the other to hold the monitor (called
monitor section). The two sections are positioned according to ergonomic principles to yield maximum comfort of the user.

The base of the keyboard is supported at a level below the ordinary desk height so as to allow typing to be done with the wrists substantially level and straight. A wrist support bar is provided to support the wrists and reduce wrist strain.

The monitor and the keyboard are positioned with their operative centers at similar heights from the floor and at similar distances from the operator for optimum operator comfort and efficiency.

**TRIZ based analysis**

The invention intends to reduce difficulties caused by keyboard operation (Principle-8: Counterweight).

It provides a preformed platform that can be mounted on an existing table or furniture (Principle-7: Nested Doll).

The equipment consists of two sections, viz., a keyboard section and a monitor section, for holding the two devices in an ergonomic angle (Principle-1: Segmentation).

### 2.3 Wrist support for computer keyboard (Patent 5125606)

**Background problem**

Individuals who spend long hours at computer terminals can develop repetitive stress injuries (RSI) and carpal tunnel syndrome (CTS). It is necessary to provide a wrist support to avoid this problem.

**Solution provided by the invention**

Cassano, et al. disclosed a wrist support (Patent 5125606, assignee-Wrist-Eze Products, Inc., issued Jun 1992) for use with a computer keyboard including a longitudinally extending rigid board with a foam layer and a cover to compress the foam to form a cushion. A rubber base is placed on the underside of the board. The cushion is placed near a lower edge of a keyboard for support of the
wrist rests. A flat base can be attached to the underside to form a platform on which to rest the keyboard.

![Diagram of keyboard base](image)

**TRIZ based analysis**

The invention attempts to reduce the physical difficulties to operate the keyboard. The invention uses soft cushion to provide support to the wrists and hands (*Principle-11: Cushioning*).

**2.4 Wrist rest support for a computer user (Patent 5131614)**

**Background problem**

It is necessary to keep the wrists in a neutral or unflexed position and that vibration from typing be deadened in order to avoid stresses that lead to RSI such as CTS and stiffness of the neck and shoulders.

**Solution provide by the invention**

Garcia, et al. disclosed a wrist support (Patent 5131614, issued July 1992) for operating a keyboard and mouse. The invention uses a base pad that is positioned partially under the keyboard and includes a section extending away from the keyboard that has a top surface above the level of the keys for supporting the wrists. The pad features an antistatic fabric laminated to a foam base and, in one embodiment, has a riser section that is separable from a base section when it is desired to substitute another riser section of different dimensions.

![Diagram of wrist support](image)
**TRIZ based analysis**

The invention provides a cushion to the wrist while operating the keyboard and mouse. The base pad comprises foam and is antistatic. *(Principle-11: Cushioning).*

2.5 Adjustable stand for a keyboard (Patent 5868079)

**Background problem**

It is monotonous for the user to sit on a particular position for long time to use the computer. Sometimes a prolonged use may create health problems.

**Solution provided by the invention**

Gad Charny disclosed a flexible stand (Patent 5868079, assigned to Finish Group Ltd, Feb 99) to hold a computer monitor and keyboard so that a human operator may comfortably use the computer in a variety of positions, including sitting in a conventional chair and standing. The invention includes two shelves, one for the monitor and another for the keyboard, which can be adjusted as necessary for the operator’s comfort. Depending on operator’s position, the monitor is held at eye level, while the keyboard is held at the level of the operator's hands.

![Image of adjustable stand](image)

**TRIZ based analysis**

The monitor, keyboard and other devices should be placed in an appropriate position according to user's convenience *(Desired result).*

The invention discloses an adjustable stand to place the keyboard at a desired height that is convenient to the user *(Principle-15: Dynamize).*

The keyboard positions can be adjusted for the user to work on sitting position and on standing position as well *(Principle-15: Dynamize).*
2.6 Adjustable computer keyboard support mechanism (Patent 5878674)

Background problem
There is a need for an improved adjustable support mechanism for a computer keyboard. There are so many methods disclosed by different inventors. Some of these patents describe a support mechanism employing a parallel arm type mechanism that allows adjustment of the keyboard support. But the mechanism needs to be improved.

Solution provided by the invention
An adjustable keyboard support mechanism is disclosed by McConnell (US patent 5037054), which teaches a keyboard support mechanism using nonparallel arms to support the keyboard platform. This mechanism thus has the benefit that when the keyboard platform is stored under the table, the platform is reoriented to provide greater access to the kneehole of a desk.

Allan Scott disclosed a keyboard support assembly (patent 5878674, assigned to Waterloo Furniture Components, March 99) that comprises a platform having one end of the arm pivotally mounted to the platform and the other end pivotally mounted to a mounting bracket which is attached to the underside of a work surface. The platform is moved to and from a storage and use position. This allows the platform to be tilted and locked in a tilted position.

TRIZ based analysis
The keyboard should remain in a position of user’s comfort without blocking useful space (Ideal Final Result).

The invention uses an adjustable keyboard support mechanism to provide flexibility (Principle-15: Dynamize).
2.7 Cushion for keyboard cursor control stick (Patent 5889508)

Background problem
The notebook computers generally come with a control stick as a cursor-pointing device. This control stick is typically mounted between the "G", "H" and "B" keys on a standard QWERTY-type keyboard. When the user puts some horizontal pressure on the stick the cursor moves in the corresponding direction.

Some models of control sticks are hard which become slippery because of perspiration or natural body oils. When the user applies excessive force to control the cursor, it affects the finger and hand muscles to get physically tired, causes irritation, inflammation and bruising of the finger tissues after prolonged use. There is a need to improve this situation.

Solution provided by the invention
Slotta disclosed a method (Patent 5889508, March 99) to attach a cushion to the control stick to take care of this issue. The cushion is flexible enough to prevent tissue damages to the user’s fingers due to repetitive motions. The cushion can be used on an existing control stick by fixing it through adhesive.


TRIZ based analysis
The control stick should be soft and suitable for human skin (Desired result).

The invention uses a cushion on the control stick, which is soft to operate (Principle-11: Cushioning).

The later invention uses gel to provide cushioning effect (Principle-29: Pneumatics and hydraulics).
2.8 Dimensional adjusting device for computer keyboard racks (Patent 5901933)

Background problem
A conventional computer desk includes a retractable drawer for supporting the keyboard. The keyboard is pulled out when used and pushed back under the desk after usage is over. This mechanism gives only one directional motion of the keyboard adjustment, i.e., inward and outward. It does not give upward or downward adjustment, or angular adjustment. It's necessary to position keyboard at a position of convenience according to the height of chair, height of the user and his personal convenience.

Solution provided by the invention
Lin invents (US Patent 5901933, May 99) a fully adjustable rack for computer keyboard. The invention includes a displacement device, a rotary device, an elevation device and a positioning device. All these devices give a complete freedom to position the keyboard plate, facilitating rotation, elevation and horizontal movement.

TRIZ based analysis
The keyboard support plate should be adjustable in all directions to hold the keyboard at any position suitable for the user (Desired result).

The invention uses various devices to make the keyboard support completely adjustable to any direction. The keyboard can move front and back, upward and downward and even rotate as well (Principle-15: Dynamize, Principle-17: Another Dimension).
2.9 Detachable wrist support of keyboard (Patent 5904327)

Background problem
The keyboard manufacturers don’t give emphasis on a hand rest to support user’s wrists. This causes strain on the user’s wrists and may cause damage to the wrists and arms with long-term use of the keyboard. Some keyboards have built in extension for wrist support that increases the size of the keyboard and so inconvenient for storage. There is a need for detachable wrist support for the keyboard.

Solution provided by the invention
Chun-Wel Cheng discloses this method (Patent 5904327, assigned to Behavior Tech Computer Corp, May 99) of connecting a detachable wrist support to the keyboard. The wrist support is connected to the keyboard by means of two connectors. This makes the wrist support attachable and detachable to allow the users to mount the wrist support when required.

TRIZ based analysis
The keyboard should provide a wrist support without taking additional space (desired result).

The invention provides a wrist support that is attachable and detachable as per the need. (Principle-8: Counterweight, Principle-15: Dynamize).

2.10 Keyboard-to-lap holding device (Patent 5927210)

Background problem
Keeping the keyboard on the table is not comfortable as the table is fixed. Even keeping the keyboard on a keyboard drawer is not adaptable to the position of the user when he moves his chair. It is necessary to find out a mechanism to place the keyboard at a comfortable position.
Solution provided by the invention

Hacker invented a solution (patent 5927210, assigned to The Big H Corporation, July 99) to it by designing a keyboard holding device, a leg strap to keep the keyboard on operator’s lap. The leg strap encircles one leg and fixed above the knee of the computer operator. The keyboard is held by two clips, one at the bottom and other at the top of the keyboard.

![Diagram of keyboard and leg strap]

This simple mechanism makes the keyboard completely movable according to the movement of the user. This increases the ease of operation and considered to be an ergonomic device.

TRIZ based analysis

The position of the keyboard should be comfortable irrespective of the position change of the user (desired result).

The invention uses a leg strap so that the position of the keyboard automatically moves according the movement of users legs (Principle-15: Dynamize, Principle-8: Counterweight).

3. Summary and conclusion

During recent days, the manufacturers have changed their focus from the technology to the customer. They have realized that the equipments are made for the user and the user may not accept the equipments unless he feels comfortable in using it.

As the technical aspect of the keyboard mechanism is already matured, there will be very less inventions to improve they keyboard mechanism or layout. The major focus of future inventions will go towards building special keyboards and improving the ergonomic aspect of the keyboards.
4. Reference:


5. 5868079, “Adjustable stand for a keyboard”, Gad Charny, assigned to Finish Group Ltd, Feb 99

6. 5878674, “Adjustable computer keyboard support mechanism”, Allan Scott, assigned to Waterloo Furniture Components, March 99


8. 5901933, “Dimensional adjusting device for computer keyboard racks”, Invented by Lin, May 99


10. 5927210, “Keyboard to lap holding device”, Invented by Douglas Hacker, assigned to The Big H Corporation, July 99