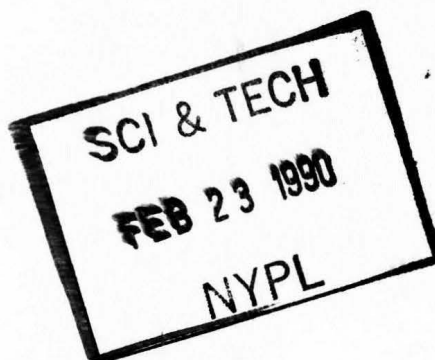




Technical Disclosure Bulletin



vol.32 no.9B February 1990

Volume 32 Number 9B February 1990

IBM Technical Disclosure Bulletin is published monthly by International Business Machines Corporation, Armonk, New York 10504. Officers: John F. Akers, Chairman of the Board; Robert M. Ripp, Treasurer; William W.K. Rich, Secretary.

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MOUSE BALL-ACTUATING DEVICE WITH FORCE AND TACTILE FEEDBACK

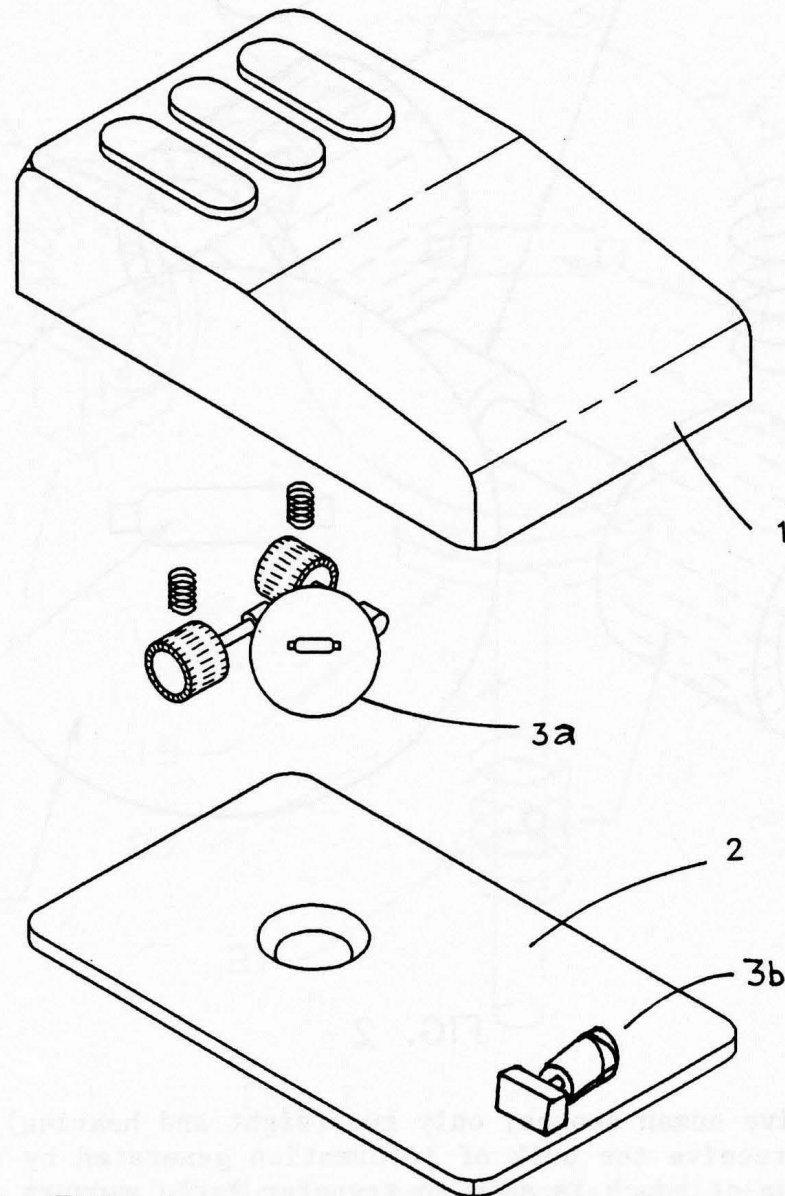


FIG. 1

A technique is described whereby a mouse ball-actuating device, used with personal computers to actuate a cursor, provides orthogonal movement so as to allow variations in resistive force and tactile feedback to the user.

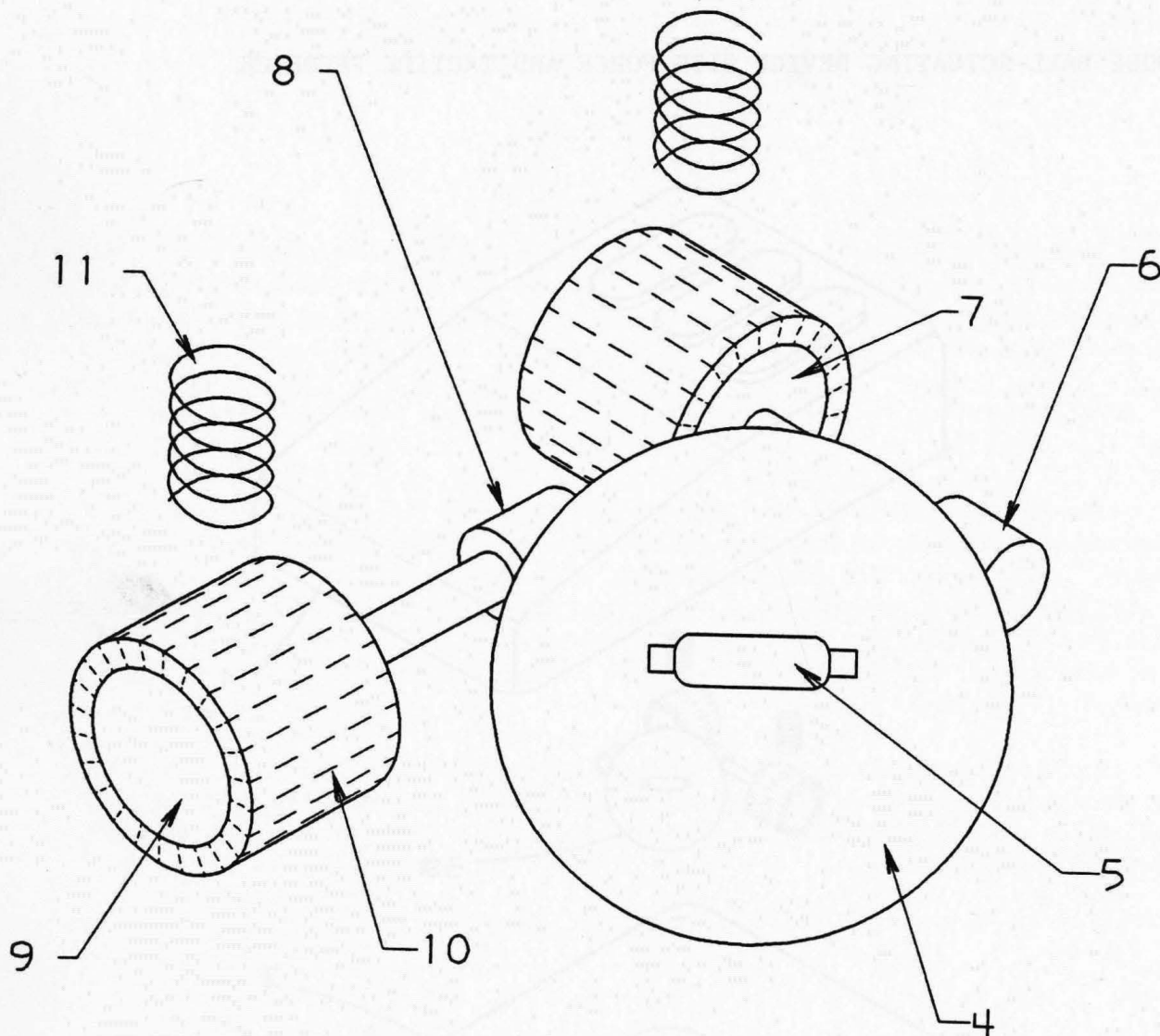


FIG. 2

Of the five human senses, only two (sight and hearing) are generally used to receive the bulk of information generated by a computer. The human sense of touch is able to transfer large amounts of information to the brain, as exemplified by the Braille system. The concept described herein attempts to include the sense of touch to the human computer interface relationship, specifically used within mouse designs. Two primary implementations of this concept are described herein: resistive force feedback and tactile feedback. These implementations may be used individually or in combination.

To provide resistive force feedback, the mouse utilizes a ball that rotates (rubs against) two shafts orthogonal to each other. One

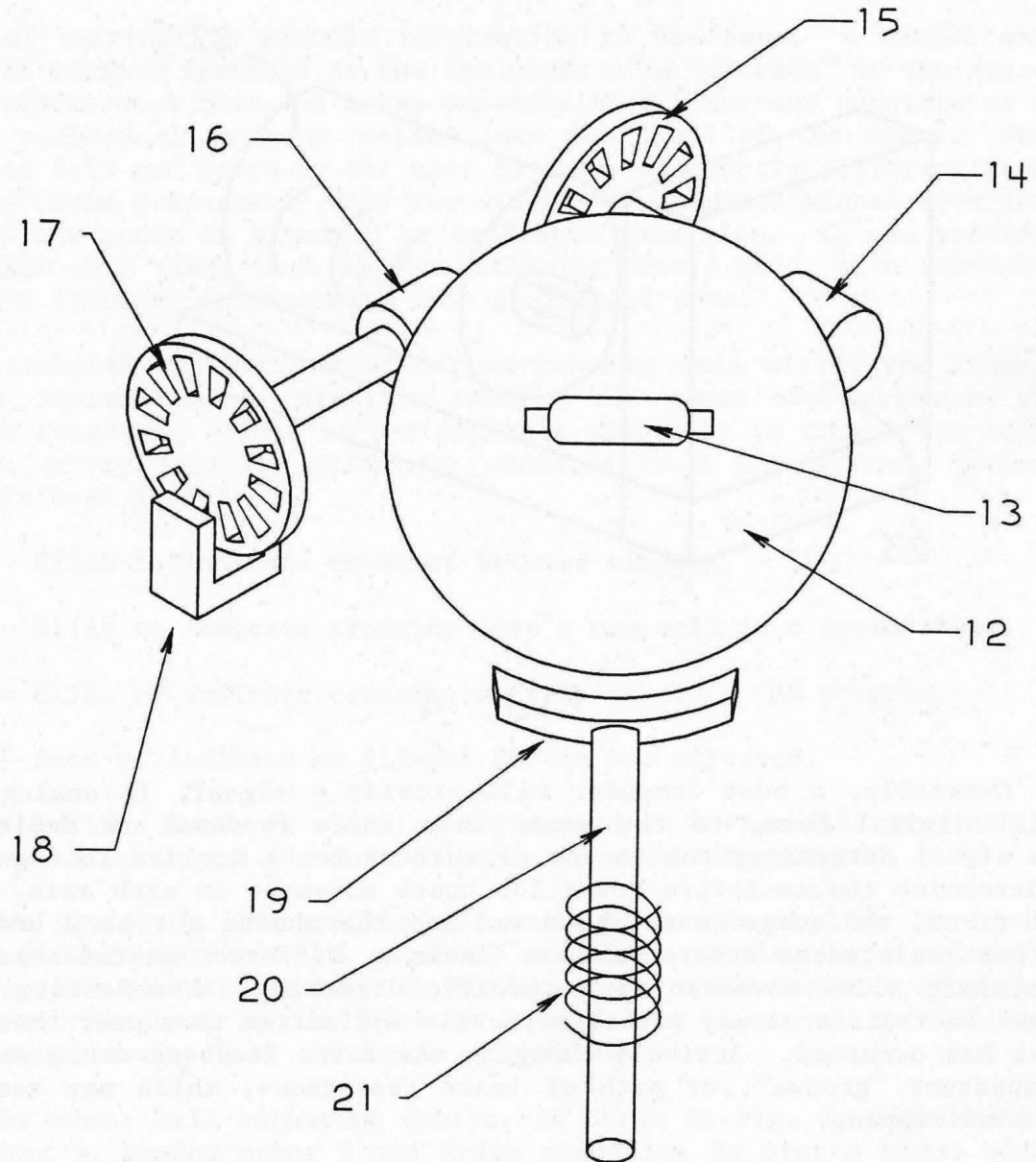


FIG. 3

shaft rotates in the "X" direction and the other shaft rotates in the "Y" direction. Each shaft is attached to a disk with magnets along its perimeter and is used for both position sensing and force feedback. Two electromagnets are used to provide force feedback. The force feedback shafts are independent of the motion-sensing rollers in the mouse.

With the mouse utilizing two balls, it is considered practical to apply the feedback to the second ball, leaving the primary sensing ball "free rolling". A feedback ball added to an optical mouse utilizes this same idea.

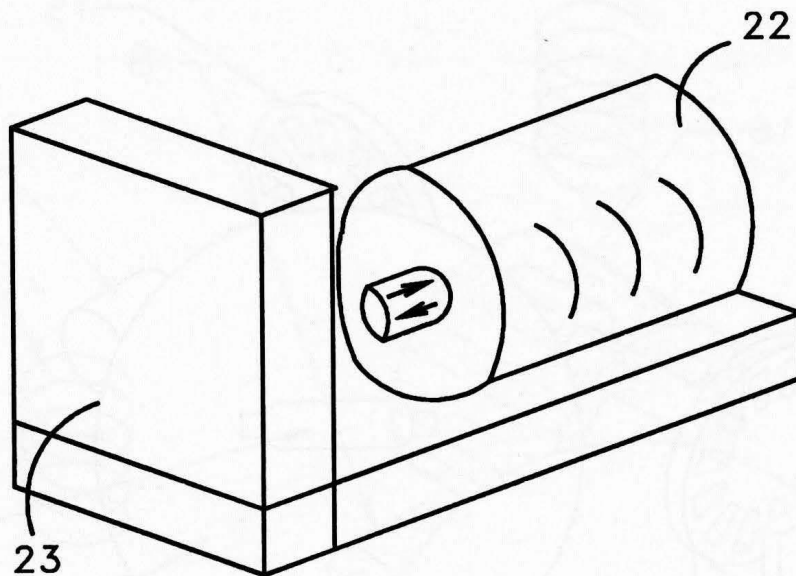


FIG. 4

Generally, a host computer will provide a signal, in analog or serial digital form, to the mouse when force feedback is desired. This signal determines the amount of current to be applied to magnets to determine the resistive force for mouse movement in each axis. At full force, the mouse cannot be moved and the shafts act as a brake. Smaller resistances create various "feels". Different resistances on each shaft allow movement in a specific direction. A momentary increase in resistance may act as a tactile indication to a user that an event has occurred. Actively changing the force feedback can provide an apparent "groove", or path of least resistance, which may assist the handicapped.

The possible uses of the device include:

- Keeping the mouse inside of an area or path.
- Adding resistance to adjust the mouse "feel" to provide stability to the hand.
- Providing a "path of least resistance" to ease selection or tracing of a line in computer automated design (CAD) applications, or making a detent at a window border on a screen, pulling the mouse over to a cell in a spread sheet or in a menu or over to a position in a dexterity teaching system.

Tactile feedback, unlike force feedback which changes the mouse movement "feel", uses the sense of touch (sometimes combined with the

sense of hearing) to provide information to the user. A simple example of tactile feedback is the inclusion of a "clicker" in the mouse which clicks each time the mouse passes a step point and consists of a simple mechanical movement molded into the shell of the mouse. The click is felt and heard by the user in a way distinctly different from a "beep" from a speaker. Only the single-bit feedback signal from the host to the mouse is required to implement this idea. It can provide one click at a time, such as when stepping over a grid, or a continuous buzz (indicating movement) into an illegal zone.

A complex clicker, or vibration-inducing unit within the mouse, can be implemented to simulate rolling the mouse over surfaces of various roughness. This is particularly adaptable to categorize menu options or to indicate different surfaces in a CAD system. Other possible uses include:

- Click to indicate movement between windows.
- Click to indicate crossing into a new cell in a spreadsheet.
- Click to indicate crossing over a line in a CAD program.
- Buzz to indicate an illegal button was actuated.
- Various rates of clicking correspond to motion will give an indication of the current scale in a drawing program.

The device is designed to allow the user the ability to input graphical information to a personal computer, similar to a standard mouse unit. However, it has the ability to receive feedback from the computer. Feedback to the user is provided by means of controlling the ease of movement of the mouse on a table.

The mouse ball actuating device, as shown in Fig. 1, consists of top cover 1, bottom cover 2 and drive mechanism 3a (for a mouse with force feedback), and tactile feedback unit 3b. Drive mechanism 3a, as shown in Fig. 2, consists of mouse ball 4 which rotates about the "X" and "Y" axes when the mouse unit is moved on a hard surface. Roller pin 5 keeps the mouse ball in position. "X" axis roller 6 rotates the "X" axis input cylinder 7. "Y" axis roller 8 rotates the "Y" axis input cylinder 9. Roller pin 5, "X" axis roller 6 and "Y" axis roller 8 produce three points of contact for the mouse ball. They keep it in position so that movement from the bottom of the mouse ball on a hard surface will produce motion in "X" axis input cylinder 7 and "Y" axis input cylinder 9. The two relative motions conform to the motion of the mouse unit on the hard surface.

Dashed lines 10 on input cylinders 7 and 9 represent alternating North and South poles of a magnet that is similar to the magnets used in standard stepper motors. The rotary motion of the alternating

poles produce a sinusoidal current through electromagnetic coils 11. This output current is sent back to the circuitry and converted to a binary input at the personal computer to indicate the motion of the mouse unit.

Feedback to the user is produced by applying an external current through the "X" or "Y" electromagnet. This current attracts like poles and repels unlike poles of the input cylinders, thereby causing a resistance to the movement of the mouse ball. The user feels a higher resistance to movement when current is applied. The degree and direction of resistance to movement is controlled by the amount of current applied to the "X" and "Y" electromagnets.

Alternatively, Fig. 3 illustrates a means of achieving a similar effect. Mouse ball 12 and roller pin 13 remain the same as in Fig. 2. However, "X" axis roller 14 rotates the "X" LED/PTX wheel 15 and "Y" axis roller 16 rotates the "Y" LED/PTX wheel 17. The wheels 15 and 17 are read by the LED/PTX 18, similar to that used in a standard mouse.

Brake shoe 19 is used to exert a controlled pressure on mouse ball 12 to induce pressure on the movement of the mouse device. Brake shoe 19 is attached to plunger 20 which is controlled by electromagnet 21. When current is applied through electromagnet 21, brake shoe 19 pushes against mouse ball 12 to provide braking action.

Tactile feedback unit 3b is shown in detail in Fig. 4. It consists of solenoid 22 and click plate 23. Signals from the host computer cause solenoid 22 to fire. This produces a tactile "click".

In general, the mouse can provide resistance to, and manual guidance of, mouse movement, as well as straightforward tactile feedback. A mouse can produce vibrations and has the ability to make detents and can move a person's hand to a specific location. The mouse can have favored areas of movement ("detent"), somewhat like a discontinuous-position knob in stereo units, or the part of a watch that detains a wheel when moved in one direction but releases it on its return excursion. Possible uses of the mouse detent include spreadsheet fields, where the mouse "jumps" the user between fields, text editors, where the mouse has a tendency to jump to the head of paragraphs, and other menu-based systems where the cursor placement is important. In these applications, productivity is significantly enhanced.