

**PEN COMPUTER**

The invention relates to a handheld computer, more particularly to a pen computer that can be used as a calculator, a telephone directory manager, and as an electronic dictionary.

Presently, address books and organizers are available to enable someone to write down contact information of clients and acquaintances. However, unless data were written in a neat and orderly manner, the search for desired contact information cannot be facilitated with the use of the conventional address books and organizers.

Most electronic dictionaries and personal digital assistants (PDA) currently incorporate numerous added functions, such as calculating functions, schedule organizing functions, and telephone directory managing functions, thereby increasing their utility. However, these electronic devices are still relatively bulky and heavy, thereby resulting in some inconvenience when carrying the same.

Therefore, the main object of the present invention is to provide a pen computer that can be used as a calculator, a telephone directory manager, and as an electronic dictionary, and that can overcome the aforesaid drawbacks commonly associated with conventional electronic dictionaries and personal digital assistants.

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According to the present invention, a pen computer comprises an elongated pen barrel, first and second encoding assemblies, and character recognition means. The pen barrel has a writing end provided with a rotatable ball bearing that serves as a ballpoint writing tip. The pen barrel is adapted to be held on one hand for forming characters on a writing surface via the ball bearing. The first encoding assembly, which is mounted on the writing end of the pen barrel, encodes movement of the ball bearing along an X-direction, and generates X-axis drive signals corresponding to encoded movement of the ball bearing along the X-direction. The second encoding assembly, which is mounted on the writing end of the pen barrel, encodes movement of the ball bearing along a Y-direction, and generates Y-axis drive signals corresponding to encoded movement of the ball bearing along the Y-direction. The character recognition means is disposed in the pen barrel and is connected electrically to the first and second encoding assemblies to receive the X-axis and Y-axis drive signals therefrom. The character recognition means identifies the characters formed on the writing surface via the ball bearing from the X-axis and Y-axis drive signals, and generates computer codes that are assigned to the characters identified thereby.

Preferably, the pen computer further comprises calculating means disposed in the pen barrel and associated with the character recognition means. In the event that the characters formed on the writing surface correspond to an arithmetic expression, the calculating means can be operated so as to process the computer codes that are assigned to the characters identified by the character recognition means in order to compute a result of the arithmetic expression.

More preferably, the pen computer further comprises a dictionary database disposed in the pen barrel for storing information about the words of a language, and dictionary searching means disposed in the pen barrel and associated with the character recognition means and the dictionary database. The dictionary searching means can be operated so as to process the computer codes that are assigned to the characters identified by the character recognition means in order to determine a word corresponding to the computer codes, and so as to retrieve the information corresponding to the word determined thereby from the dictionary database.

More preferably, the pen computer further comprises a directory storage unit disposed in the pen barrel for storing a telephone directory database therein, and telephone directory managing means disposed in the pen barrel and associated with the character recognition means and the directory storage unit. In the event that

the characters formed on the writing surface correspond to a name and a contact number associated with the name, the telephone directory managing means can be operated in a directory building mode so as to process the computer codes that are assigned to the characters identified by the character recognition means in order to determine the name and the contact number corresponding to the computer codes, and so as to store the name and the contact number determined thereby in the directory storage unit.

Other features and advantages of the present invention will become apparent in the following detailed description of the preferred embodiments with reference to the accompanying drawings, of which:

Figure 1 is a fragmentary schematic view illustrating a writing tip of the first preferred embodiment of a pen computer according to the present invention;

Figure 2 is a schematic view illustrating an encoding assembly of the first preferred embodiment;

Figure 3 is a schematic view illustrating the position relationship among encoding assemblies and a ball bearing of the first preferred embodiment;

Figure 4 is a schematic view illustrating a rotary member and a sensing unit of the encoding assembly of the first preferred embodiment;

Figure 5 illustrates the relationship among drive signals from the encoding assemblies and direction of movement of the ball bearing according to the first preferred embodiment;

5        Figure 6 is a timing diagram illustrating the drive signals from the encoding assemblies of the first preferred embodiment when movement of the ball bearing occurs only in a +Y-direction;

10        Figure 7 is a timing diagram illustrating the drive signals from the encoding assemblies of the first preferred embodiment when movement of the ball bearing occurs in both a -Y-direction and a +X-direction;

15        Figure 8 is a timing diagram illustrating the drive signals from the encoding assemblies of the first preferred embodiment when movement of the ball bearing occurs only in a +X-direction;

Figure 9 is a fragmentary schematic sectional view of a pen barrel of the first preferred embodiment;

20        Figure 10 is a schematic circuit block diagram of a control unit of the first preferred embodiment;

Figure 10A is a functional block diagram of a memory device of the control unit of Figure 10;

Figure 10B is a functional block diagram of a processor of the control unit of Figure 10;

25        Figure 11 is a flowchart illustrating the operation of the first preferred embodiment;

Figure 12 is a flowchart illustrating the operation of the processor of the first preferred embodiment in a calculating mode;

5 Figure 13 is a schematic view illustrating a rotary member and a sensing unit of an encoding assembly of the second preferred embodiment of a pen computer according to the present invention; and

10 Figure 14 is a schematic view illustrating a rotary member and a sensing unit of an encoding assembly of the third preferred embodiment of a pen computer according to the present invention.

Referring to Figure 1, the first preferred embodiment of a pen computer 1 according to the present invention is shown to comprise an elongated pen barrel 10 having a writing end formed with an axial opening 11 and a pair of orthogonal radial chambers that are communicated with the opening 11 via cut-outs 12, 13. A rotatable ball bearing 15 extends outwardly of the pen barrel 10 at the axial opening 11 to serve as a ballpoint writing tip 16. An ink supplying unit 14, in the form of an ink core, is disposed in the pen barrel 10 and supplies ink to the ball bearing 15. In the preferred embodiment, the ball bearing 15 is retained rotatably on one end of the ink supplying unit 14. First and second encoding assemblies 2, 2' are mounted 25 respectively in the radial chambers at the writing end of the pen barrel 10. The first encoding assembly 2

encodes movement of the ball bearing 15 along an X-direction, and generates X-drive signals corresponding to encoded movement of the ball bearing 15 along the X-direction. The second encoding assembly 2' encodes  
5 movement of the ball bearing 15 along a Y-direction, and generates Y-drive signals corresponding to encoded movement of the ball bearing 15 along the Y-direction.

Referring to Figures 1 through 4, each of the first and second encoding assemblies 2, 2' includes a frame  
10 member 22 mounted securely in the respective radial chamber at the writing end of the pen barrel 10. A rotary shaft 220 is mounted rotatably on the frame member 22. A contact member 20, 21, in the form of a ball, is mounted securely on the rotary shaft 220 and extends into the  
15 pen barrel 10 via the cut-outs 12, 13 for contacting the ball bearing 15 such that rotation of the ball bearing 15 in a certain direction can drive rotation of the rotary shaft 220. The contact members 20, 21 contact the ball bearing 15 at orthogonal locations,  
20 as best shown in Figure 3. A rotary member 23 is mounted securely on the rotary shaft 220 for co-rotation therewith. A sensing unit 24 is mounted securely on the frame member 22 for generating the drive signals in response to detected movement of the rotary member 23.

25 As such, when the pen barrel 10 is held on one hand for forming characters on a writing surface via the ball bearing 15, the contact members 20, 21 rotate according

to the direction of movement of the ball bearing 15 to drive rotation of the respective rotary shaft 220 and the associated rotary member 23. The X-axis and Y-axis drive signals are subsequently and respectively generated by the sensing units 24 of the first and second encoding assemblies 2, 2' in response to detected movement of the corresponding rotary member 23.

In the first preferred embodiment, the rotary member 23 is formed as a conductive member having a central mounting portion 232 mounted securely on the rotary shaft 220, and a plurality of equally spaced contact arms 230 that extend radially and outwardly from the central mounting portion 232. The rotary member 23 is connected electrically to a first voltage source, such as the ground terminal of a power supply unit. The sensing unit 24 includes an insulator substrate 241 mounted on the frame member 22 proximate to the rotary member 23, and front and rear conductor plates 240, 242 mounted respectively on front and rear sides of the insulator substrate 241. The front and rear conductor plates 240, 242 are connected electrically to a second voltage source, such as the positive (or Vcc) terminal of a power supply unit. When the contact members 20, 21 rotate in a corresponding first direction due to movement of the ball bearing 15, the contact arms 230 contact successively the front conductor plate 240 to result in +X-axis and +Y-axis drive signals.

Accordingly, when the contact members 20, 21 rotate in a corresponding opposite second direction due to movement of the ball bearing 15, the contact arms 230 contact successively the rear conductor plate 242 to  
 5 result in -X-axis and -Y-axis drive signals.

The relationship among drive signals from the first and second encoding assemblies 2, 2' and the direction of movement of the ball bearing 15 is shown in Figure 5. The following are three sample conditions to  
 10 illustrate the operation of the encoding assemblies 2, 2':

1. In the (+Y>X=0) state of Figure 5, movement of the ball bearing 15 only occurs in the +Y-direction. As such, the contact member 20 is stationary, while the  
 15 contact member 21 rotates in the first direction. Figure 6 shows the X-axis and Y-axis drive signals generated by the first and second encoding assemblies 2, 2' under the (+Y>X=0) state. As shown, with further reference to Figure 6, because the contact member 20  
 20 is stationary, the associated rotary member 23 does not rotate, thereby maintaining the front and rear conductor plates 240, 242 at the high logic state due to connection of the latter with the positive (or Vcc) terminal of a power supply unit. On the other hand,  
 25 because the contact member 21 rotates in the first direction, the associated rotary member 23 rotates such that the contact arms 230 contact successively the

front conductor plate 240. Since the rotary member 23 is connected electrically to the ground terminal of a power supply unit, the logic state of the front conductor plate 240 changes from high to low at the instant one of the contact arms 230 makes contact therewith. Thus, due to rotation of the rotary member 23 with the contact member 21 in the first direction, the +Y-axis drive signal from the second encoding assembly 2' is generated in the form of a pulse train having equidistant pulses at this time.

In the example of Figure 6, the +Y-axis drive signal from the second encoding assembly 2' is formed of nine consecutive pulses. The number of pulses in the +Y-axis drive signal from the second encoding assembly 2' depends upon the speed of movement of the ball bearing 15 in the +Y-direction. The faster the movement of the ball bearing 15 in the +Y-direction, the pulses in the +Y-axis drive signal from the second encoding assembly 2' will be narrower, and the number of pulses in the +Y-axis drive signal will be greater.

The speed of rotation of the contact members 20, 21 depends upon the vectorial angle component of the movement of the ball bearing 15 that acts on the corresponding contact member 20, 21. For example, when the vectorial angle components acting on the contact members 20, 21 are equal, the contact members 20, 21 rotate at the same speed. When the vectorial angle

component acting on the contact member 20 is greater than that acting on the contact member 21, the contact member 20 rotates at a faster speed as compared to the contact member 21. Accordingly, when the vectorial  
5 angle component acting on the contact member 20 is smaller than that acting on the contact member 21, the contact member 20 rotates at a slower speed as compared to the contact member 21.

2. In the  $(-Y=+X)$  state of Figure 5, movement of the  
10 ball bearing 15 occurs in both the  $-Y$ -direction and the  $+X$ -direction. As such, the contact member 20 rotates in the first direction, whereas the contact member 21 rotates in the second direction. Figure 7 shows the  $X$ -axis and  $Y$ -axis drive signals generated by the first  
15 and second encoding assemblies 2, 2' under the  $(-Y=+X)$  state. As shown, both the  $+X$ -axis drive signal and the  $-Y$ -axis drive signal from the first and second encoding assemblies 2, 2' are in the form of pulse trains. However, because the vectorial angle components of the  
20 movement of the ball bearing 15 that act on the contact members 20, 21 are equal, assuming that the ball bearing 15 moves at the same speed as in the example of Figure 6, the contact members 20, 21 rotate at a slower speed as compared to the example of Figure 6, thereby  
25 resulting in wider pulses for the  $+X$ -axis and the  $-Y$ -axis drive signals.

3. In the  $(+Y=0<X)$  state of Figure 5, movement of the ball bearing 15 only occurs in the +X-direction. As such, the contact member 21 is stationary, while the contact member 20 rotates in the first direction. Figure 8 shows the X-axis and Y-axis drive signals generated by the first and second encoding assemblies 2, 2' under the  $(+Y=0<X)$  state. As shown, the Y-axis drive signal from the second encoding assembly 2' is maintained at the high logic state, whereas the +X-axis drive signal from the first encoding assembly 2 is in the form of a pulse train.

Referring to Figure 9, the pen barrel 10 is further formed with a mounting hole 17. A positioning frame portion 18 projects inwardly and integrally from the pen barrel 10 adjacent to the mounting hole 17. A circuit board 37 is mounted on the positioning frame 18, and has a control unit 3 provided thereon.

Referring to Figure 10, the control unit 3 includes a power supply unit 31, a memory device 32, a processor 33, an output device 34, an alarm sound generator 35, a switch set 36, and a wireless communications unit 38, such as a conventional infrared communications unit.

The power supply unit 31 can be in the form of series-connected battery cells (not shown), and provides the electrical energy required for operating the control unit 3.

Referring to Figure 10A, the memory device 32 is

configured to include at least a computer code storing region 321, a dictionary database region 322, a directory storage region 323, and a computing region 324. The computer code storing region 321 is used to  
5 store character patterns and associated standard computer codes that are assigned to characters to be formed on a writing surface via the ball bearing 15. One example of a standard computer code is ASCII, which is suitable for encoding alphanumeric characters.  
10 However, in view of the fact that some languages, such as Chinese and Japanese, do not use ASCII for the encoding of their characters, more than one type of character patterns and standard computer codes may be stored in the region 321 to enable operation of the pen  
15 computer 1 under different language formats. The dictionary database region 322 is used to store information about the words of a language. The information can be the meaning of a word, or a translation of the word in another language, e.g.  
20 English to Chinese. Known dictionary databases of the aforementioned type in electronic form are applicable for storage in the dictionary database region 322. The directory storage region 323 is used to store a telephone directory database therein. The format of the  
25 directory storage region 323 can be similar to those found in most conventional handheld electronic devices, such as electronic dictionaries and personal digital

assistants. The computing region 324 is used for temporary storage of data when making calculations, when identifying an input character, when forming an entry for the telephone directory database, etc.

5        In the preferred embodiment, the memory device 32 is implemented using two different kinds of memory units. The first memory unit is a FLASH random access memory having at least the computer code storing region 321, the dictionary database region 322, and the  
10        directory storage region 323. The second memory unit is a static random access memory having at least the computing region 324.

Referring again to Figure 10, the output device 34 is preferably in the form of a liquid crystal display  
15        (LCD) unit that is mounted in the mounting hole 17 of the pen barrel 10. The alarm sound generator 35 is in the form of a speaker, and the switch set 36 is used to control the operating mode of the processor 33, as will be described in greater detail in the succeeding  
20        paragraphs.

As shown in Figures 10 and 10B, the processor 33, such as a microprocessor, is connected to the power supply unit 31, the memory device 32, the output device 34, the alarm sound generator 35, the switch set 36 and  
25        the wireless communications unit 38. The processor 33 is further connected to the first and second encoding assemblies 2, 2' (see Figure 1) so as to receive the

X-axis and Y-axis drive signals therefrom. With reference to Figure 10B, the processor 33 is configured to include a character recognition unit 331, an electronic clock unit 332, a calculating unit 333, a dictionary searching unit 334, a telephone directory managing unit 335, an output driver unit 336, a mouse operation unit 338, and a keyboard operation unit 339.

Figure 11 is a flowchart illustrating the operation of the first preferred embodiment. With additional reference to Figures 1, 10, 10A and 10B, when the power supply 31 is active, the switch set 36 can be operated in a predetermined manner to select the operating mode of the processor 33 and the operating language of the pen computer 1. Once the ball bearing 15 moves to form characters on a writing surface, the first and second encoding assemblies 2, 2' generate the X-axis and Y-axis drive signals corresponding to the detected movement of the ball bearing 15. At this time, the character recognition unit 331 retrieves the appropriate character patterns and standard computer codes from the computer code storing region 321 of the memory device 32, and stores the same in the computing region 324 so that computations and comparisons can be made in order to commence identification of the characters formed on the writing surface, and generation of the computer codes that are assigned to the characters identified thereby. The generated

computer codes for the identified characters are stored in the computing region 324 at this time. The character recognition unit 331 is further associated operably with the output driver unit 336, which enables the  
5 output device 34 to indicate the characters identified by the character recognition unit 331 thereon.

As to how the character recognition unit 331 identifies the characters that are formed on the writing surface via the ball bearing 15, this can be  
10 accomplished using known character recognition techniques, which vary according to the language of the characters to be identified.

When using the pen computer 1 to compute the result of an arithmetic expression, the switch set 36 is  
15 initially operated so as to enable operation of the processor 33 in a calculating mode. When the characters that constitute the arithmetic expression are written down on the writing surface via the ball bearing 15, the character recognition unit 331 proceeds to store  
20 the computer codes for the identified characters in the computing region 324. The calculating unit 333 then processes the computer codes stored by the character recognition unit 331 in order to compute the result of the arithmetic expression. This action can be triggered  
25 upon detection of the computer code for the "=" sign. The calculating unit 333 is further associated operably with the output driver unit 336, which enables the

output device 34 to indicate the result of the arithmetic expression thereon.

Figure 12 is a flowchart illustrating the operation of the processor 33 in the calculating mode. Since the  
5 functions associated with the processor 33 when operating in this mode are similar to those found in conventional calculators, a detailed explanation of the flowchart of Figure 12 will be dispensed with herein for the sake of brevity.

10 When using the pen computer 1 to search for information regarding a particular word, the switch set 36 is initially operated so as to enable operation of the processor 33 in a dictionary searching mode. When  
15 the characters that constitute the particular word are written down on the writing surface via the ball bearing 15, the character recognition unit 331 proceeds to store the computer codes for the identified characters in the computing region 324. The dictionary searching unit 334 then processes the computer codes stored by  
20 the character recognition unit 331 in order to determine the word corresponding to the computer codes, and retrieves the information corresponding to the word that was determined thereby from the dictionary database region 322 of the memory device 32. This action  
25 can be triggered upon detection of the computer code for the "?" character, which is appended to the characters of the subject word. The dictionary

searching unit 334 is further associated operably with the output driver unit 336, which enables the output device 34 to indicate the information retrieved by the dictionary searching unit 334 from the dictionary database region 332 thereon.

As is known in the art, the procedure for determining a subject word from computer codes varies according to the selected operating language of the pen computer 1. Since the search routine associated with the dictionary searching unit 334 is commonly found in electronic dictionaries, a detailed description of the same will be dispensed with herein for the sake of brevity.

The switch set 36 can be further operated so as to enable operation of the processor 33 in a directory managing mode. In the directory managing mode, a name and an associated contact number can be added into the directory storage region 323, and the contact number that is associated with an input name can be retrieved from the directory storage region 323. When adding an entry into the directory storage region 323, the characters that constitute the name and the contact number associated with the name are written down on the writing surface via the ball bearing 15. The character recognition unit 331 proceeds to store the computer codes for the identified characters in the computing region 324 as described beforehand. The telephone directory managing unit 335 then processes the computer

codes stored by the character recognition unit 331 in order to determine the name and the contact number corresponding to the computer codes. The telephone directory managing unit 335 is further associated operably with the output driver unit 336, which enables the output device 34 to indicate the name and the contact number determined by the telephone directory managing unit 335 thereon for verification. Upon operation of the switch set 36 to verify accuracy of the information indicated on the output device 34, the telephone directory managing unit 335 stores the name and the contact number as a new entry in the directory storage region 323.

When searching a contact number in the directory storage region 323, the characters that constitute an input name are written down on the writing surface via the ball bearing 15. The character recognition unit 331 proceeds to store the computer codes for the identified characters in the computing region 324, and the telephone directory managing unit 335 then processes the computer codes stored by the character recognition unit 331 in order to determine the input name corresponding to the computer codes. By appending a symbol, such as the "?" character, to the input name, the telephone directory managing unit 335 is enabled upon detection of the symbol to search the directory storage region 323 for the contact number that is

associated with the input name. With the assistance of the output driver unit 336, the output device 34 is enabled so as to indicate the input name and the associated contact number retrieved by the telephone  
5 directory managing unit 335 thereon.

Since known directory building and directory searching techniques found in handheld electronic devices are applicable to the telephone directory managing unit 335, a more detailed description of the  
10 operation of the latter will be dispensed with herein for the sake of brevity.

The switch set 36 can be further operated so as to permit operation of the processor 33 in a clock mode. In the clock mode, the electronic clock unit 332 is  
15 enabled to generate a time output. The electronic clock unit 332 is associated operably with the output driver unit 336 so as to enable the output device 34 to indicate the time output of the electronic clock unit 332 thereon. Like conventional electronic clocks, operation of the  
20 switch set 36 in a predetermined manner while the processor 33 is in the clock mode enables setting of the time output of the electronic clock unit 332 and setting of an alarm time. In addition, upon determination by the electronic clock unit 332 that the  
25 time output has reached the preset alarm time, the electronic clock unit 332 activates the alarm sound generator 35 in a known manner to generate an alarm sound

output.

The switch set 36 can be further operated so as to enable operation of the processor 33 in a mouse mode. In the mouse mode, the mouse operation unit 338 receives  
5 the X-axis and Y-axis drive signals from the first and second encoding assemblies 2, 2'. Then, the mouse operation unit 338 controls the wireless communications unit 38 to establish a wireless communications link in a known manner with a computer  
10 4 so as to transmit the X-axis and Y-axis drive signals wirelessly for reception by the computer 4 via a corresponding standard communications unit (SCU) 40 thereon. Thus, the X-axis and Y-axis drive signals can be used to control movement of a cursor on a screen (not  
15 shown) of the computer 4. The switch set 36 functions in a manner similar to the switches found on a conventional computer mouse. When the switch set 36 is operated, the mouse operation unit 338 controls the wireless communications unit 38 to transmit the  
20 corresponding switch signals to the computer 4.

The switch set 36 can be further operated so as to enable operation of the processor 33 in a keyboard mode. In the keyboard mode, the keyboard operation unit 339 receives the computer codes generated by the character  
25 recognition unit 331. Then, the keyboard operation unit 339 controls the wireless communications unit 38 to establish a wireless communications link with the

computer 4 so as to transmit the computer codes wirelessly for reception by the computer 4 via the standard communications unit (SCU) 40, thereby enabling the pen computer 1 to serve as a character input device for the computer 4. The pen computer 1 of this invention can thus facilitate the input of characters of a complex language, such as Chinese.

Referring again to Figures 10 and 10B, in the preferred embodiment, the processor 33 is further configured to include a power managing unit 337 that is associated operably with the memory device 32 such that, when power to the pen computer 1 is turned off or when residual power of the power supply unit 31 is insufficient to ensure normal operation of the control unit 3, the power managing unit 337 will transfer data, such as a name and the associated contact number, in the static RAM into the FLASH RAM to avoid data loss.

The configuration of the first and second encoding assemblies should not be limited to that described beforehand. Other forms of encoding assemblies can be employed in the pen computer of this invention, as shown in Figures 13 and 14.

Figure 13 illustrates a rotary member 23a and a sensing unit 24a of an encoding assembly of the second preferred embodiment of a pen computer according to the present invention. The rotary member 23a is made of plastic, and has a central mounting portion 232a

mounted securely on the rotary shaft (not shown), and a plurality of equally spaced shielding arms 230a that extend radially and outwardly from the central mounting portion 232a. The sensing unit 24a includes first and second photo detectors (T1), (T2), such as photo transistors, mounted on the frame member (not shown) in a side-by-side relationship proximate to the rotary member 23a. When the rotary shaft rotates in the first direction, each of the shielding arms 230a shields the first photo detector (T1) first before shielding the second photo detector (T2). Thus, the drive signal from the first photo detector (T1) changes to a high logic state before that from the second photo detector (T2). When the rotary shaft rotates in the opposite second direction, each of the shielding arms 230a shields the second photo detector (T2) first before shielding the first photo detector (T1). Thus, the drive signal from the second photo detector (T2) changes to a high logic state before that from the first photo detector (T1). When the rotary shaft does not rotate, the first and second photo detectors (T1), (T2) are not shielded by the shielding arms 230a, and generate a corresponding drive signal that is maintained at the low logic state.

Figure 14 illustrates a rotary member 23b and a sensing unit 24b of an encoding assembly of the third preferred embodiment of a pen computer according to the present invention. The rotary member 23b has a central

mounting portion 232b mounted securely on the rotary shaft (not shown), and a plurality of equally spaced arms 230b that extend radially and outwardly from the central mounting portion 232b. Each of the arms 230b  
5 has a permanent magnet thereon. Preferably, each of the arms 230b is formed from a permanent magnet material. The sensing unit 24b includes first and second hall effect sensors (S1), (S2) mounted on the frame member (not shown) in a side-by-side relationship proximate  
10 to the rotary member 23b. When the rotary shaft rotates in the first direction, each of the arms 230b moves closely adjacent to the first hall effect sensor (S1) first before moving adjacent to the second hall effect sensor (S2). Thus, the drive signal from the first hall  
15 effect sensor (S1) changes to a high logic state before that from the second hall effect sensor (S2). When the rotary shaft rotates in the opposite second direction, each of the arms 230b moves closely adjacent to the second hall effect sensor (S2) first before moving  
20 adjacent to the first hall effect sensor (S1). Thus, the drive signal from the second hall effect sensor (S2) changes to a high logic state before that from the first hall effect sensor (S1). When the rotary shaft does not rotate, the first and second hall effect sensors (S1),  
25 (S2) are not affected by the magnetic properties of the arms 230b, and generate a corresponding drive signal that is maintained at the low logic state.

**CLAIMS:**

## 1. A pen computer comprising:

an elongated pen barrel having a writing end provided with a rotatable ball bearing that serves as a ballpoint writing tip, said pen barrel being adapted  
5 to be held on one hand for forming characters on a writing surface via said ball bearing;

a first encoding assembly, mounted on said writing end of said pen barrel, for encoding movement of said  
10 ball bearing along an X-direction and for generating X-axis drive signals corresponding to encoded movement of said ball bearing along the X-direction;

a second encoding assembly, mounted on said writing end of said pen barrel, for encoding movement of said  
15 ball bearing along a Y-direction and for generating Y-axis drive signals corresponding to encoded movement of said ball bearing along the Y-direction; and

character recognition means disposed in said pen barrel and connected electrically to said first and  
20 second encoding assemblies to receive the X-axis and Y-axis drive signals therefrom, said character recognition means identifying the characters formed on the writing surface via said ball bearing from the X-axis and Y-axis drive signals and generating computer  
25 codes that are assigned to the characters identified thereby.



2. The pen computer as claimed in Claim 1, further comprising an output device mounted on said pen barrel, and an output driver unit disposed in said pen barrel and connected to said output device, said character  
5 recognition means being associated operably with said output driver unit so as to enable said output device to indicate the characters identified by said character recognition means.
3. The pen computer as claimed in Claim 2, wherein said  
10 output device is a display unit for visual indication of the characters identified by said character recognition means.
4. The pen computer as claimed in Claim 3, further comprising electronic clock means, disposed in said pen  
15 barrel, for generating a time output, said electronic clock means being associated operably with said output driver unit so as to enable said output device to indicate the time output of said electronic clock means.
- 20 5. The pen computer as claimed in Claim 4, further comprising an alarm sound generator mounted in said pen barrel and connected to and controlled by said electronic clock means so as to generate an alarm sound output upon determination by said electronic clock  
25 means that the time output of said electronic clock means has reached a preset alarm time.



6. The pen computer as claimed in Claim 1, wherein the characters formed on the writing surface correspond to an arithmetic expression, said pen computer further comprising calculating means disposed in said pen barrel and associated with said character recognition means, said calculating means being operable so as to process the computer codes that are assigned to the characters identified by said character recognition means in order to compute a result of the arithmetic expression.

7. The pen computer as claimed in Claim 6, further comprising an output device mounted on said pen barrel, and an output driver unit disposed in said pen barrel and connected to said output device, said calculating means being further associated operably with said output driver unit so as to enable said output device to indicate the result of the arithmetic expression.

8. The pen computer as claimed in Claim 7, wherein said output device is a display unit for visual indication of the result of the arithmetic expression.

9. The pen computer as claimed in Claim 1, further comprising:

a dictionary database, disposed in said pen barrel, for storing information about the words of a language; and

dictionary searching means disposed in said pen barrel and associated with said character recognition



means and said dictionary database, said dictionary searching means being operable so as to process the computer codes that are assigned to the characters identified by said character recognition means in order to determine a word corresponding to the computer codes, and so as to retrieve the information corresponding to the word determined thereby from said dictionary database.

5 10. The pen computer as claimed in Claim 9, further comprising an output device mounted on said pen barrel, and an output driver unit disposed in said pen barrel and connected to said output device, said dictionary searching means being further associated operably with said output driver unit so as to enable said output device to indicate the information retrieved by said dictionary searching means from said dictionary database.

11. The pen computer as claimed in Claim 10, wherein said output device is a display unit.

20 12. The pen computer as claimed in Claim 1, wherein the characters formed on the writing surface correspond to a name and a contact number associated with the name, said pen computer further comprising:

a directory storage unit, disposed in said pen barrel, for storing a telephone directory database therein; and



telephone directory managing means disposed in said pen barrel and associated with said character recognition means and said directory storage unit, said telephone directory managing means being operable in a directory building mode so as to process the computer codes that are assigned to the characters identified by said character recognition means in order to determine the name and the contact number corresponding to the computer codes, and so as to store the name and the contact number determined thereby in said directory storage unit.

13. The pen computer as claimed in Claim 12, wherein said telephone directory managing means is further operable in a directory searching mode, where said telephone directory managing means processes the computer codes that are assigned to the characters identified by said character recognition means in order to determine the name corresponding to the computer codes, and searches said directory storage unit for the contact number associated with the name.

14. The pen computer as claimed in Claim 13, further comprising an output device mounted on said pen barrel, and an output driver unit disposed in said pen barrel and connected to said output device, said telephone directory managing means being further associated operably with said output driver unit so as to enable said output device to indicate the contact number



retrieved by said telephone directory managing means from said directory storage unit.

15. The pen computer as claimed in Claim 14, wherein said output device is a display unit.

5 16. The pen computer as claimed in Claim 1, further comprising ink supplying means, disposed in said pen barrel, for supplying ink to said ball bearing.

17. The pen computer as claimed in Claim 1, wherein each of said first and second encoding assemblies comprises:

10 a frame member mounted securely on said writing end of said pen barrel;

a rotary shaft mounted rotatably on said frame member;

15 a contact member mounted securely on said rotary shaft and in contact with said ball bearing such that rotation of said ball bearing can drive corresponding rotation of said rotary shaft;

a rotary member mounted securely on said rotary shaft for co-rotation therewith; and

20 a sensing unit mounted securely on said frame member for generating the drive signals in response to detected movement of said rotary member.

18. The pen computer as claimed in Claim 17, wherein:

25 said rotary member is formed as a conductive member having a central mounting portion mounted securely on said rotary shaft, and a plurality of equally spaced contact arms that extend radially and outwardly from



said central mounting portion, said rotary member being adapted to be connected electrically to a voltage source; and

5       said sensing unit includes an insulator substrate and front and rear conductor plates mounted respectively on front and rear sides of said insulator substrate, said insulator substrate being mounted on said frame member proximate to said rotary member such that rotation of said rotary shaft in a first direction  
10 enables said contact arms to contact successively said front conductor plate and such that rotation of said rotary shaft in an opposite second direction enables said contact arms to contact successively said rear conductor plate.

15       19. The pen computer as claimed in Claim 17, wherein:

      said rotary member has a central mounting portion mounted securely on said rotary shaft, and a plurality of equally spaced shielding arms that extend radially and outwardly from said central mounting portion; and

20       said sensing unit includes first and second photo detectors mounted on said frame member in a side-by-side relationship proximate to said rotary member such that rotation of said rotary shaft in a first direction enables each of said shielding arms to shield  
25 said first photo detector first before shielding said second photo detector, and such that rotation of said rotary shaft in an opposite second direction enables



each of said shielding arms to shield said second photo detector first before shielding said first photo detector.

20. The pen computer as claimed in Claim 19, wherein  
5 said first and second photo detectors are photo transistors.

21. The pen computer as claimed in Claim 17, wherein:  
said rotary member has a central mounting portion  
mounted securely on said rotary shaft, and a plurality  
10 of equally spaced arms that extend radially and outwardly from said central mounting portion, each of said arms having a permanent magnet thereon; and

said sensing unit includes first and second hall effect sensors mounted on said frame member in a  
15 side-by-side relationship proximate to said rotary member such that rotation of said rotary shaft in a first direction enables each of said arms to move closely adjacent to said first hall effect sensor first before moving adjacent to said second hall effect sensor, and  
20 such that rotation of said rotary shaft in an opposite second direction enables each of said arms to move closely adjacent to said second hall effect sensor first before moving adjacent to said first hall effect sensor.

25 22. The pen computer as claimed in Claim 1, further comprising:



a mouse operation unit disposed in said pen barrel and connected electrically to said first and second encoding assemblies to receive the X-axis and Y-axis drive signals therefrom; and

5 a communications unit provided on said pen barrel and connected electrically to said mouse operation unit;

said mouse operation unit being operable so as to enable said communications unit to establish a  
10 communications link with a computer.

23. The pen computer as claimed in Claim 22, wherein said mouse operation unit is operable so as to enable said communications unit to transmit the X-axis and Y-axis drive signals for reception by the computer.

15 24. The pen computer as claimed in Claim 23, wherein the X-axis and Y-axis drive signals are adapted to control movement of a cursor on a screen of the computer.

25 25. The pen computer as claimed in Claim 22, wherein said communications unit is an infrared communications unit.

26. The pen computer as claimed in Claim 1, further comprising:

a keyboard operation unit disposed in said pen barrel and associated with said character recognition  
25 means to receive the computer codes therefrom; and

a communications unit provided on said pen barrel and connected electrically to said keyboard operation



unit;

said keyboard operation unit being operable so as to enable said communications unit to establish a communications link with a computer.

5 27. The pen computer as claimed in Claim 26, wherein said keyboard operation unit is operable so as to enable said communications unit to transmit the computer codes for reception by the computer.

10 28. The pen computer as claimed in Claim 26, wherein said communications unit is an infrared communications unit.

