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Izuyama

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(54) **MAGNETIC CARD READER**

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(51) **Int. Cl.**^{7} **G06K 7/08**

(52) **U.S. Cl.** **235/449**

(58) **Field of Search** 235/449, 487, 235/493, 446; 360/123, 125, 129, 130.32, 2, 32; 380/201, 255, 28; 713/200, 189

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(57) **ABSTRACT**

This invention aims to provide a magnetic head for a magnetic reader improved so that the data can be read out from the magnetic storage medium with high security, that is, without an anxiety that the data might be illegally read out and, even if the data is illegally read out, such illegally read out data can not be used by the illegal person.

Here is disclosed a magnetic head of a magnetic card reader adapted to read out data stored on a magnetic card, comprising a core with a coil for sensing of the data stored on the card as analog signals, an A/D converter chip adapted to convert the analog signals to corresponding digital signals and a microprocessor adapted to encrypt the digital signals. The A/D converter chip and the microprocessor (IC) are fixed within a housing by means of a synthetic resin.

3 Claims, 7 Drawing Sheets

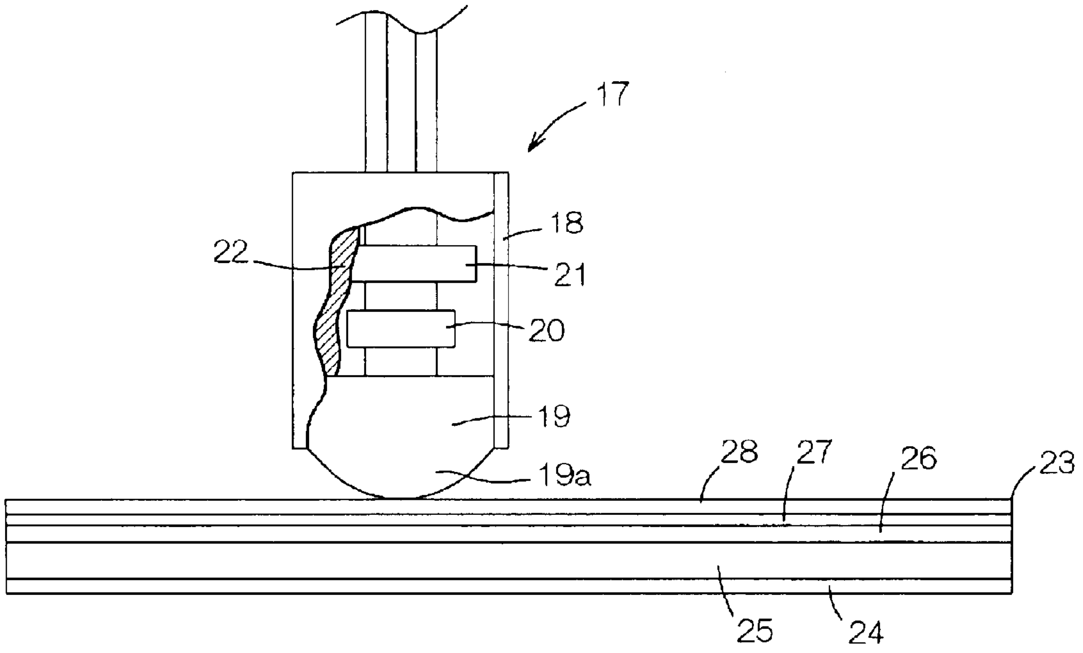


FIG. 1

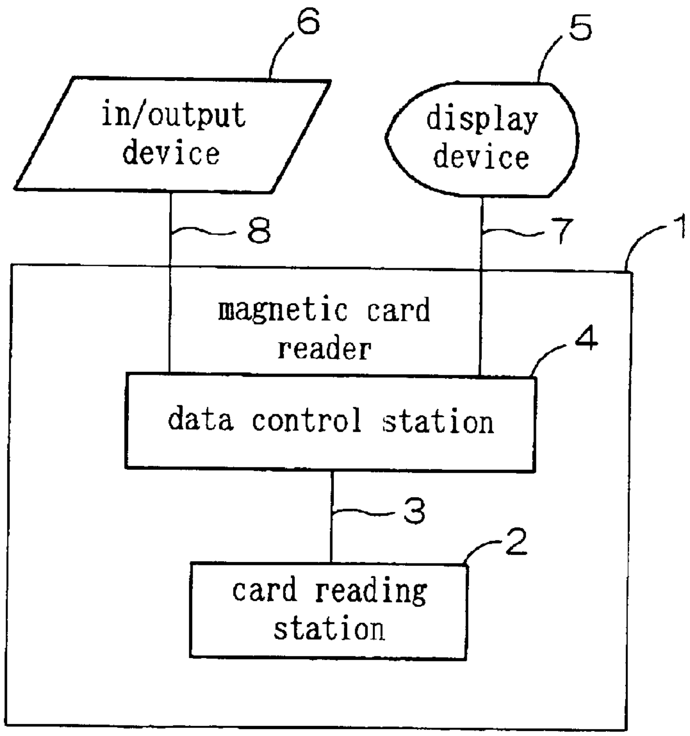

6
in/output device
5
display device
8
7
1
magnetic card reader
4
data control station
3
2
card reading station

FIG.2

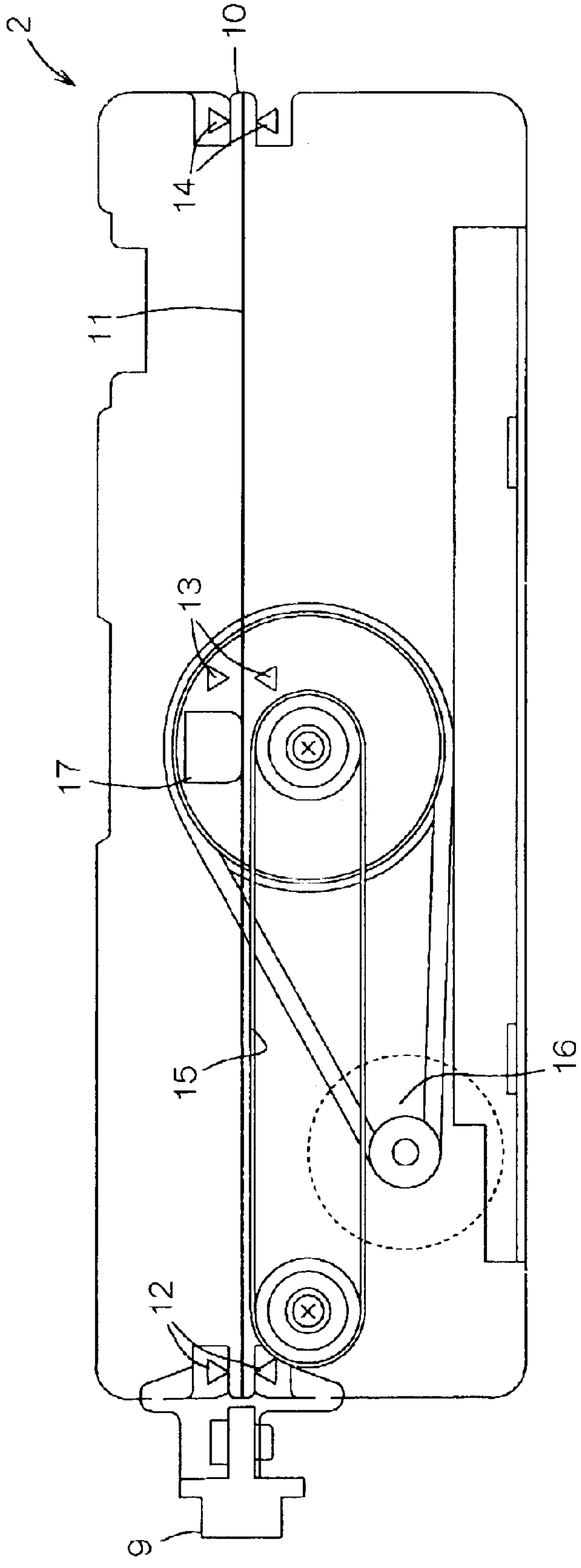


FIG.3

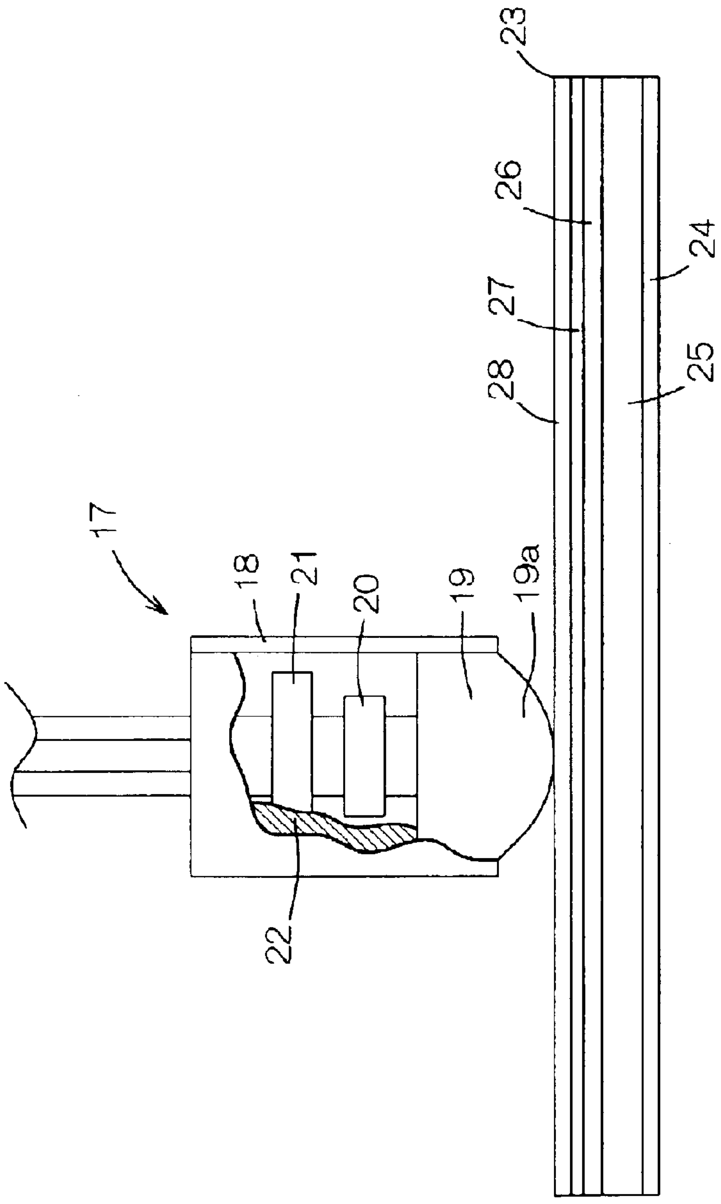


FIG.4

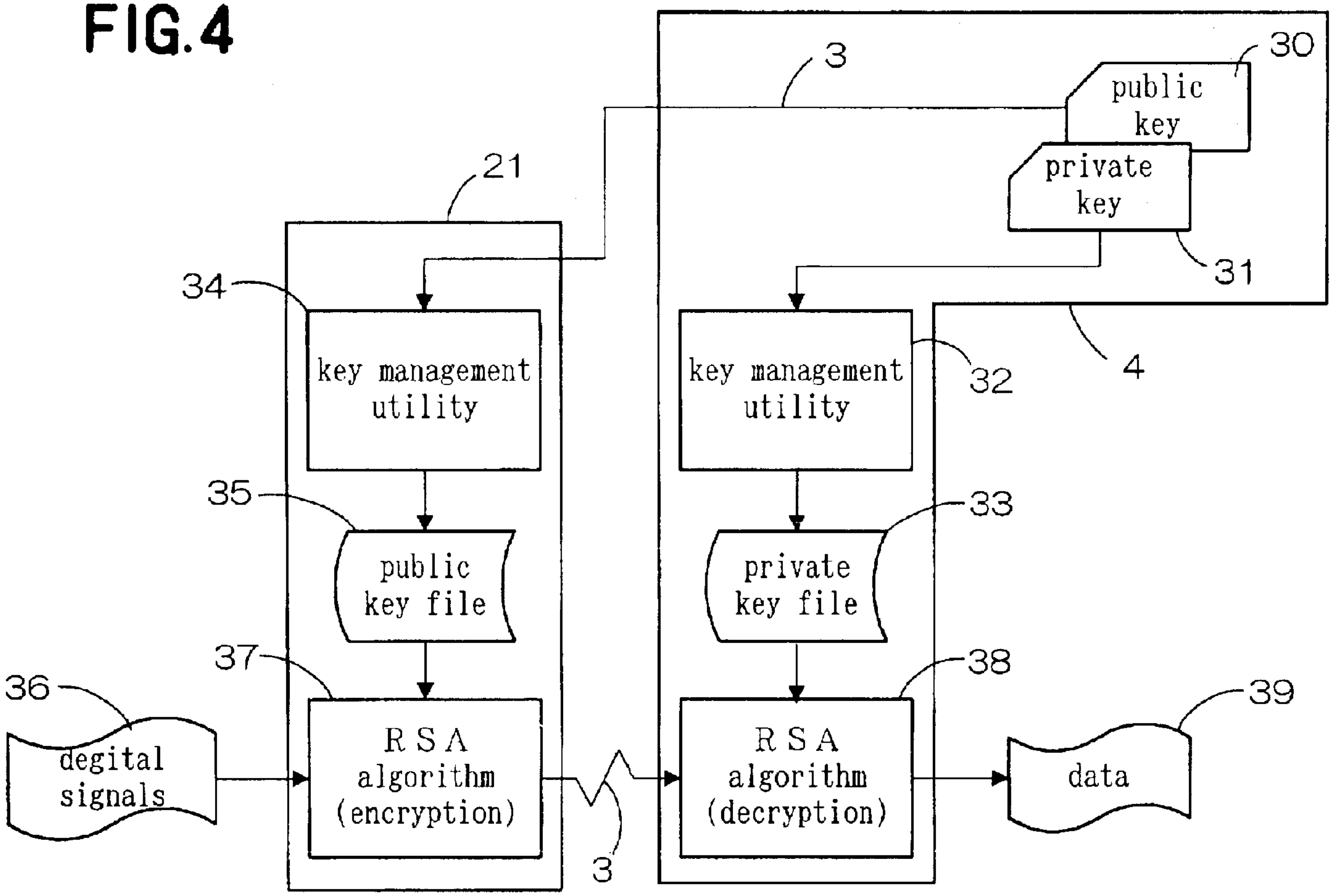

3
30
public key
private key
31
21
34
key management utility
32
key management utility
4
35
public key file
33
private key file
37
38
36
39
degital signals
R S A algorithm (encryption)
R S A algorithm (decryption)
data
3

FIG. 5

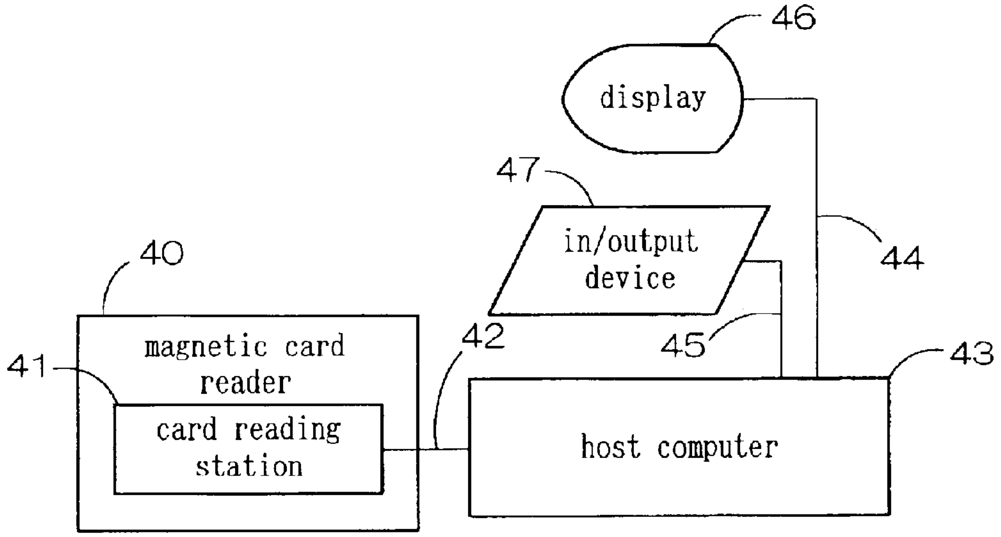

46
display
47
in/output device
44
40
magnetic card reader
41
card reading station
42
45
43
host computer

FIG.6

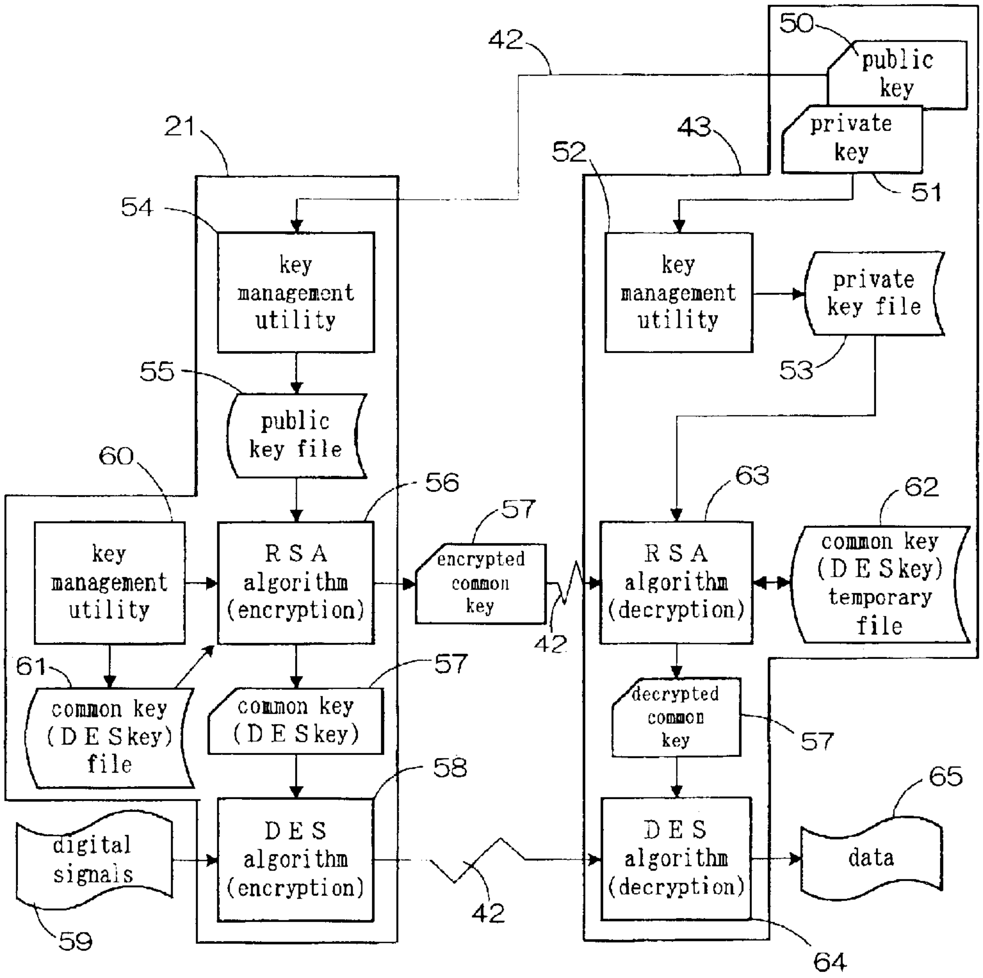
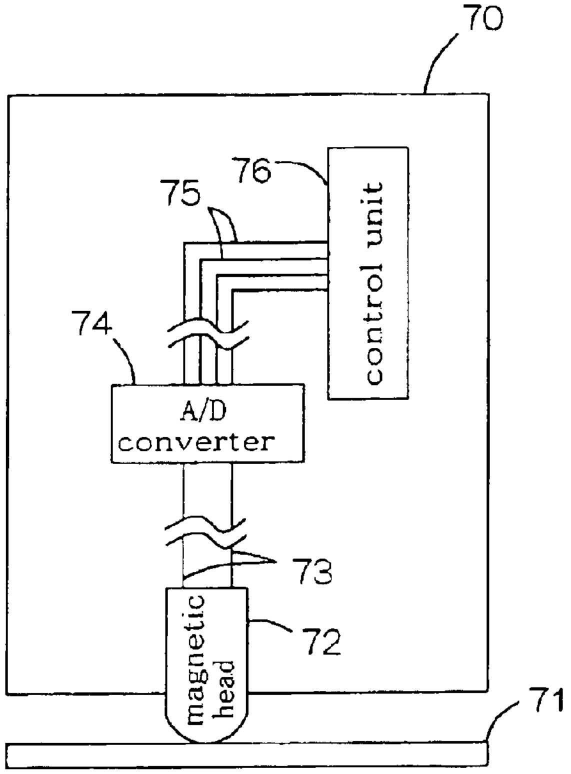

42
50
public key
private key
51
21
43
52
54
key management utility
key management utility
private key file
53
55
public key file
60
56
57
63
62
key management utility
RSA algorithm (encryption)
encrypted common key
42
RSA algorithm (decryption)
common key (DESkey) temporary file
61
57
common key (DESkey) file
common key (DESkey)
decrypted common key
57
58
65
digital signals
DES algorithm (encryption)
DES algorithm (decryption)
data
59
42
64

FIG.7



PRIOR ART

MAGNETIC CARD READER

BACKGROUND OF THE INVENTION

This invention relates to a magnetic head used in a magnetic reader.

A magnetic head of a magnetic reader adapted to read out data stored on a magnetic storage medium is well known. An example of a conventional magnetic head as is used for a magnetic card reader **70** will be described hereunder in reference to FIG. **7**. The magnetic card reader **70** reads data from a magnetic stripe of the magnetic card **71** through a magnetic head **72** coming in contact with a surface of the magnetic card **71** passing through a guide groove (not shown) of the magnetic card reader **70**. The magnetic card reader **70** comprises the magnetic head **72**, an A/D converter **74** connected to the magnetic head **72** via an interface cable **73** and a control unit **76** connected to the A/D converter **74** via an interface cable **75**.

The magnetic head **72** has a core and a coil wound around the core. The control unit **76** is a computer having a CPU, a memory, a hard disc, a CD-ROM drive and a floppy disc drive. Though not shown, a display (display device), a keyboard (input device) and a printer (output device) are connected to the control unit **76** via interface cables.

As the magnetic card **71** with the magnetic stripe passes through the guide groove of the magnetic card reader **70** by the distal end (core gap) of the magnetic head **72**, a magnetic flux changes around the core and thereby an induced electromotive force is generated so that an electric current flows in the coil to cancel a variation of the magnetic flux. The current flows from the coil to the A/D converter **74** via the interface cable **73** and is detected by the A/D converter as analog signals. The A/D converter **74** converts the analog signals input from the magnetic head **72** to corresponding digital signals. The digital signals are output from the A/D converter **74** to the control unit **76** via the interface cable **75**. The control unit **76** amplifies the digital signals and outputs the digital signals via the display and/or the printer in the form of character data and/or print data, respectively. Furthermore, the control unit **76** stores the data in the form of digital signals in its memory.

The magnetic card reader is generally classified into the reader of manual slide type in which the magnetic card is manually moved along a guide groove and the reader of electric motor-driven insertion type in which the magnetic card inserted into a card inlet is moved by a driving belt or a driving roller.

With the magnetic card reader **70** shown in FIG. **7**, if any devices are connected to the interface cables **73**, **75**, it is possible that the analog signals through the magnetic head **72** might be illegally read out via the cable **73** or the digital signals converted by the A/D converter **74** might be read out via the cable **75**. It is also possible that the data stored in the memory might be illegally read out via the cables **73**, **75**. Both writing and reading data in and from the magnetic card are relatively easy in view of the method of recording on the magnetic card. Accordingly, the magnetic card would be easily duplicated using the data in the form of analog or digital signals which is illegally read out.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a magnetic head for a magnetic reader improved so as to make it difficult for others to read out data illegally in the process of reading data from a magnetic storage medium and so as to encrypt the data in order to make the data unavailable to others even if the data is illegally read out.

According to this invention, there is provided a magnetic head of a magnetic reader adapted to read data from a magnetic storage medium.

The magnetic head comprises a core with a coil adapted to sense the data stored on the storage medium in the form of analog signals, an A/D converter chip electrically connected to the coil and adapted to convert the analog signals to corresponding digital signals and an IC electrically connected to the A/D converter chip and adapted to encrypt the digital signals.

This invention includes the following embodiments. The magnetic head further comprises a housing defining an outer peripheral surface of the magnetic head and containing therein the core, the A/D converter chip and the IC.

The A/D converter chip and the IC are fixed within the housing by means of a synthetic resin.

The magnetic reader includes a node terminal adapted to decrypt the digital signals having been encrypted by the IC and electrically connected to the IC of the magnetic head.

The IC is selected from a group including a microprocessor, a gate array, a field programmable gate array and a dedicated hard ware.

The magnetic storage medium is a magnetic card and the magnetic reader is a magnetic card reader.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram schematically illustrating a magnetic card reader;

FIG. **2** is a diagram schematically illustrating an internal construction of a card reading station;

FIG. **3** is a partially cutaway perspective view showing a magnetic head incorporated in the card reading station;

FIG. **4** is a flow chart illustrating a sequence of encryption and decryption effectuated between a microprocessor and a data control station;

FIG. **5** is a block diagram schematically illustrating an alternative embodiment of the magnetic card reader;

FIG. **6** is a flow chart illustrating a sequence of encryption and decryption effectuated between the microprocessor and a host computer; and

FIG. **7** is a diagram schematically illustrating a well-known magnetic head used in the magnetic card reader.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Details of a magnetic head used in a magnetic reader according to this invention will be more fully understood from the description of a magnetic head used in a magnetic card reader given hereunder in reference to the accompanying drawings.

FIG. **1** is a block diagram schematically illustrating a magnetic card reader **1**, FIG. **2** is a diagram schematically illustrating an internal structure of a card reading station **2** and FIG. **3** is a partially cutaway perspective view showing a magnetic head **17** incorporated in the card reading station **2**. In FIG. **3**, a core **19** of the magnetic head **17** has its distal end **19***a* in contact with an upper surface of a magnetic card **23**. FIG. **3** shows the interior of a housing **18** by partially cutting a synthetic resin **22** filled in the housing **18**.

As will be apparent from FIG. **1**, the magnetic card reader **1** comprises the card reading station **2** adapted to sense data stored on a magnetized layer **26** of the magnetic card **23** in the form of electric signals and a data control station **4** (terminal node) connected to the card reading station **2** via an interface cable **3**. The data control station **4** is a computer comprising a CPU (central processing unit), a memory (auxiliary memory), a hard disc, a CD-ROM drive and a floppy disc drive. A display **5** (display device) adapted to output data in the form of character information, a keyboard **6** (input device) adapted to add and/or change data and a printer **6** (output device) adapted to output the data in the form of printed information are connected to the data control station **4** via interface cables **7**, **8**.

As will be seen in FIG. **2**, the card reading station **2** is of motor-driven insertion type and has a card inlet **9** on its front end, a card outlet **10** on its rear end and a card guiding rail **11** extending from the card inlet **9** to the card outlet **10**. The card reading station **2** is provided at its longitudinally middle region with the magnetic head **17** which will be hereinafter described more in detail. In the vicinity of the inlet **9**, the outlet **10** and the magnetic head **17**, there are provided photo-sensors **12**, **13**, **14**, respectively, for position-detection of the magnetic card **23** moving along the guiding rail **11**. Upon insertion of the magnetic card **23** into the inlet **9** of the card reading station **2**, the magnetic card **23** is automatically moved along the guiding rail **11** and is ejected from the outlet **10**.

In the card reading station **2**, the distal end **19***a* of the core **19** (See FIG. **3**) constituting the magnetic head **17** is opposed to the guiding rail **11**. The card **23** is moved along the guiding rail **11** on a belt **15** provided within the card reading station **2**. The belt **15** is driven by motor **16** rotates.

As will be seen in FIG. **3**, the magnetic head **17** comprises the housing **18** covering an outer peripheral surface thereof, the core **19** provided with coil (not shown), an A/D converter chip **20** electrically connected to the coil and a microprocessor **21** (IC) electrically connected to the A/D converter chip **20**. In the magnetic head **17**, the core **19**, the A/D converter chip **20** and the microprocessor **21** are contained within the housing **18**. In the magnetic head **17**, the distal end **19***a* of the core **19** is exposed outward from the lower end of the housing **18**. Though not shown, the microprocessor **21** includes an arithmetic unit, a control unit and a cache memory.

The A/D converter chip **20** and the microprocessor **21** are entirely fixed to the inside of the housing **18** by means of synthetic resin **22** filled in the housing **18**. As the synthetic resin **22**, it is preferred to use a suitable thermosetting synthetic resin. It is also possible to use a thermoplastic synthetic resin in the place of the thermosetting synthetic resin.

The magnetic card **23** is composed of a color print layer **24**, a base layer **25**, a magnetized layer **26**, a shield layer **27** and a print layer **28** which are overlaid in this order from the lower surface of the magnetic card **23**. In the magnetic card **23**, the magnetized layer **26** is made from a ferromagnetic material and the base layer **25** is made from a polyethylene terephthalate.

When the magnetic card **23** is inserted through the card inlet **9** into the card reading station **2**, the photo-sensor **12** detects the magnetic card **23** and outputs a card insertion signal to the data control station **4**. Upon receipt of the card insertion signal, the data control station **4** outputs a command to the microprocessor **21** of the magnetic head **17** for reading of the data stored on this card **23**.

When the magnetized layer **26** of the magnetic card **23** passes by the distal end **19***a* of the core **19** (i.e., core gap) constituting the magnetic head **17**, a magnetic flux changes around the core **19** whereupon an induced electromotive force is generated and an electric current flows in the coil. A value of the electric current flowing in the coil is dependent on the variation of the magnetic flux and input to the A/D converter chip **20** in the form of analog signals. The A/D converter tip **20** converts the analog signals to the corresponding digital signals. The digital signals are then input to the microprocessor **21** connected to the A/D converter chip **20**. The microprocessor **21** encrypts the digital signals. The encrypted digital signals are then output from the microprocessor **21** to the data control station **4**.

If the photo-sensors **13**, **14** detect the magnetic card **23** passing by the magnetic head **17** and then being ejected from the card outlet **10**, the photo-sensors **13**, **14** respectively output card passage signals to the data control station **4**. In response to the card passage signals, the data control station **4** commands the microprocessor **21** to stop reading data.

The data control station **4** has an amplifier (not shown) for amplification of the digital signals and decrypts the digital signals having been amplified by the amplifier. The data control station **4** may output the decrypted digital signals to the display **5** or the printer **6**. The data control station **4** stores the encrypted or decrypted digital signals in the memory. The data control station **4** includes a cache memory so that the encrypted or decrypted digital signals may be stored also in the cache memory.

FIG. **4** is a flow chart illustrating a sequence of encryption and decryption effectuated between the data control station **4** and the microprocessor **21**. In the magnetic card reader **1** according to this invention, the public key cryptosystem (RSA pubic key cryptosystem) is adopted to encrypt and decrypt the data between the data control station **4** and the microprocessor **21**.

Upon receipt of the card insertion signal from the photo-sensor **12**, the data control station **4** generates a public key **30** for the encryption of the data stored on the magnetic card **23** and a private key **31** for the decryption of the data having been encrypted in this manner.

The private key **31** is input to a key management utility **32** of the CPU, in which the private key **31** is address-allocated in a predetermined manner. The private key **31** is then input from the key management utility **32** to a private key file **33** of the memory and stored therein. The public key **30**, on the other hand, is input from the data control station **4** to a key management utility **34** of the microprocessor **21** via the interface cable **3** and is address-allocated in a predetermined manner in the key management utility **34**. The public key **30** is input from the key management utility **34** to the cache memory of the microprocessor **21** and stored in a public key file **35** of the cache memory.

Upon receipt of digital signals **36** from the A/D converter chip **20**, the microprocessor **21** takes the public key **30** out from the public key file **35** and makes up a RSA algorithm **37** using the public key **30**. The microprocessor **21** encrypts the digital signals **36** in accordance with the RSA algorithm **37** and outputs the encrypted digital signals **36** to the data control station **4** via the interface cable **3**. Upon receipt of the encrypted digital signals **36** from the microprocessor **21**, the data control station **4** takes the private key **31** out from the private key file **33** of the memory and makes up a RSA algorithm **38** using the private key **31**. The private key **31** taken out from the private key file **33** corresponds to the public key **30** which has been used by the microprocessor **21** to encrypt the digital signals **36**. The data control station **4** decrypts the encrypted digital signals **36** in accordance with the RSA algorithm **38** and thereby obtains data **39** stored on the magnetic card **23**.

In the magnetic card reader **1** according to this invention, both the A/D converter chip **20** and the microprocessor **21** are contained within the housing **18** and therefore it is impossible to attach a device adapted for illegal reading of the data in the form of the analog or digital signals to the magnetic card reader **1** without disassembly of the magnetic head **17**. Consequently, it is difficult to read out the data illegally. In the magnetic card reader **1**, the magnetic head **17** includes the microprocessor **21** adapted to encrypt the data stored on the magnetic card **23**. Consequently, even if the data stored on the magnetic card **23** is illegally read out, the data can not be used without decrypting the encrypted data. It is thus practically impossible to duplicate the magnetic card **23**.

FIG. **5** is a block diagram schematically illustrating an alternative embodiment **40** of the magnetic card reader and FIG. **6** is a flow chart illustrating a sequence of encryption and decryption effectuated between the microprocessor **21** and a host computer **43**.

The magnetic card reader **40** includes a card reading station **41**. The card reading station **41** contains therein the same magnetic head **17** as that shown in FIG. **3** adapted to convert the data stored on the magnetic card **23** to the corresponding digital signals and to encrypt the digital signals. The card reading station **41** of the magnetic card reader **40** has the same structure as that shown in FIG. **2** and detailed description thereof will be eliminated here. The magnetic card reader **40** is externally connected to the host computer **43** (node terminal) via an interface cable **42**.

The magnetic head **17** mounted on the card reading station **41** comprises the housing **18**, the core **19** with the coil, the A/D converter chip **20** and the microprocessor **21** (MPU). In the magnetic head **17**, the core **19** and the A/D converter chip **20** are contained within the housing **18** wherein the A/D converter chip **20** and the microprocessor **21** are entirely fixed within the housing **18** by means of the synthetic resin **22** (See FIG. **3**).

The host computer **43** is a computer having a CPU, a memory, a hard disc, a CD-ROM drive and a floppy disc drive. A display **46** (display device), a keyboard **47** (input device) and a printer **47** (output device) are connected to the host computer **43** via interface cables **44**, **45**.

In the card reading station **41**, if the photo-sensor **12** detects the magnetic card **23** being inserted into the card reading station **41** through the card inlet **9**, the photo-sensor **12** outputs card insertion signals to the host computer **43**. Upon receipt of the card insertion signals, the host computer **43** commands the microprocessor **21** of the magnetic head **17** to read the data stored on the card **23**.

If the photo-sensors **13**, **14** detect the magnetic card **23** passing by the magnetic head **17** and being ejected from the card outlet, the photo-sensors **13**, **14** respectively output card passage signals to the host computer **43**. In response to the card passage signals, the host computer **43** commands the microprocessor **21** to stop reading the data.

This magnetic card reader **40** adopts MIX cryptosystem which is a combination of the public key cryptosystem (RSA cryptosystem) and a common key cryptosystem (DES cryptosystem) to encrypt and decrypt the data between the microprocessor **21** and the host computer **43**.

The MIX cryptosystem is a encryption system making good use of advantages offered by the RSA cryptosystem and the DES cryptosystem, respectively. More specifically, a data processing rate based on the DES algorithm is as fast

as approximately 1/100 of the data processing rate based on the RSA algorithm, on the plus side, and it is difficult for the DES cryptosystem to distribute keys in security and the number of keys to be managed is large, on the minus hand. The RSA cryptosystem is not only advantageously free from delivery of the private keys but also the number of keys to be managed is far less than the number of keys to be managed by the DES cryptosystem. Thus the MIX cryptosystem uses the advantage of the DES cryptosystem makes good use of the high data processing rate provided by the DES cryptosystem and of the facile key management provided by the RSA cryptosystem. According to the MIX cryptosystem, the microprocessor **21** decrypts the data on the basis of a DES algorithm **58** and decrypts a common key **57** (DES key) used to make up another DES algorithm **64** on the basis of a RSA algorithm **56**.

Upon receipt of the card insertion signals from the photosensor **12** (See FIG. **2**), the host computer **43** generates a public key **50** used for the RSA algorithm and a private key **51** used to decrypt an encrypted common key **57**, as illustrated in FIG. **6**. The private key **51** is input to a key management utility **52** of the CPU and address-allocated by the key management utility **52** in a predetermined manner. The private key **51** is input from the key management utility **52** to a private key file **53** of the memory and stored therein. The public key **50** is input from the host computer **43** to a key management utility **54** of the microprocessor **21** via the interface cable **42** and address-allocated by the key management utility **54**. The public key **50** is input from the key management utility **54** to a public key file **55** of the cache memory and stored therein.

Upon receipt of digital signals **59** from the A/D converter chip **20**, the microprocessor **21** takes the public key **50** out from the public key file **55** and makes up the RSA algorithm **56** using the public key **50**. The microprocessor **21** generates the common key **57** (DES key) used for the DES algorithm **58** and then encrypts the common key **57** in accordance with the RSA algorithm **56**. The microprocessor **21** makes up the DES algorithm **58** using the common key **57** and encrypts digital signals **59** in accordance with the DES algorithm **58**. The common key **57** is input to a key management utility **60** and address-allocated by the key management utility **60** in a predetermined manner. The common key **57** is input from the key management utility **60** to a common key file **61** of the cache memory of the microprocessor **21** and stored therein. The microprocessor **21** outputs the encrypted common key **57** together with the encrypted digital signals **59** to the host computer **43** via the interface cable **42**.

Upon receipt of the encrypted common key **57** and the encrypted digital signals **59** from the microprocessor **21**, the host computer **43** address-allocates the encrypted common key **57**, then stores the common key **57** in a temporary file **62** of the memory, takes the private key **51** out from the private key file **53** of the memory and makes up a RSA algorithm **38** using this private key **51**. The host computer **43** decrypts the encrypted common key **57** in accordance with the RSA algorithm **63**. The host computer **43** makes up a DES algorithm **64** using the decrypted common key **57**. The host computer **43** decrypts the encrypted digital signals **59** in accordance with the DES algorithm **64** and thereby obtains data **65** stored on the magnetic card **23**.

The private key **51** taken out from the private key file **53** corresponds to the public key **50** having been used by the microprocessor **21** to encrypt the common key **57**, on one hand, and corresponds to the common key **57** having been used by the microprocessor **21** to encrypt the digital signals **59**.

The host computer **43** outputs the decrypted digital signals **59** in the form of character data to the display **46** and outputs the decrypted digital signals **59** in the form of print data to the printer **47**. The host computer **43** stores the encrypted digital signals **59** as well as the decrypted digital signals **59** in the memory.

With this magnetic card reader **40**, any device adapted for illegal reading out of the data in the form of analog or digital signals can not be attached thereto unless the magnetic head **17** is disassembled. In the case of this magnetic card reader **40**, even if the data stored on the magnetic card **23** is illegally read out, the data can not be immediately used since the data has been encrypted by the microprocessor **21** of the magnetic head **17**.

The public key cryptosystem is not limited to the RSA cryptosystem and it is possible to adopt any one of EPOC cryptosystem, Rabin cryptosystem, Diffie-Hellman ElGamal cryptosystem, and Elliptic Curve Diffie-Hellman Elliptic Curve ElGamal cryptosystem. It is also possible to adopt the common key cryptosystem alone. In this case, the common key cryptosystem is not limited to the DES cryptosystem and it is possible to any one of FEAL cryptosystem, IDEA cryptosystem, MISTY cryptosystem, MULTI cryptosystem and RC2/4/5 cryptosystem.

The magnetic head may include, in addition to a microprocessor, a gate array, a field programmable gate array or a dedicated hard ware.

The card reading station is not limited to that of the electric motor-driven insertion type but may be of the manual slide type. The interface cable may be selected from a group including a RS-232C cable, a RS-422A cable and a RS-423A cable.

The magnetic head according to this invention is applicable also to a magnetic ink character reader used to read a portfolio coated with a magnetic ink.

The magnetic head according to this invention is able to encrypt the data read out from the magnetic storage medium so that, even if the encrypted data is illegally read out, the encrypted data can not be used unless the encrypted data are decrypted. In this way, it is reliably prevented to duplicate the magnetic storage medium.

With the embodiment of the magnetic head containing the core, the A/D converter chip and the microprocessor within the housing, it is impossible to attach any device adapted for illegal reading out of the data either before or after A/D conversion unless the magnetic head itself is disassembled. In view of this feature also, illegal reading out of the data is substantially impossible.

With the embodiment of the magnetic head having the A/D converter chip and the microprocessor fixed within the housing by means of synthetic resin, the magnetic head can be disassembled first after the synthetic resin has been removed. However, removal of the synthetic resin inevitably results in destruction of the A/D converter chip and the microprocessor. This feature further reliably prevent the intention to attach any device adapted for illegal reading out of the data to the A/D converter chip and the microprocessor.

What is claimed is:

1. A magnetic card reader having a magnetic head adapted to read predetermined data from a magnetic card using a magnetic material to store said predetermined data, wherein:

said magnetic head comprises a core with a coil adapted to sense said data stored on said magnetic card reader as analog signals, and an A/D converter chip electrically connected to said coil and adapted to convert said analog signals to corresponding digital signals and an IC electrically connected to said A/D converter chip,

said core, said A/D converter chip and said IC are contained in a housing defining an outer peripheral surface of said magnetic head said A/D converter chip and said IC being fixed within said housing by means of a synthetic resin filled in said housing,

said magnetic reader including a node terminal electrically connected to said IC said IC and said node terminal encrypting said digital signals in accordance with a cryptosystem between said IC and said node terminal, and

said node terminals decrypts said digital signals having been encrypted in accordance with said cryptosystem.

2. The magnetic head according to claim **1**, wherein said IC is selected from a group including a microprocessor, a gate array, a field programmable gate array and a dedicated hard ware.

3. The magnetic card reader according to claim **1**, wherein said node terminal is capable of storing said digital signals having been encrypted and encrypted, respectively.

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