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(71) Applicant:
SEIKO EPSON CORPORATION
Shinjuku-ku, Tokyo 163-0811 (JP)

(72) Inventor: **Ikegami, Akihiko**
Suwa-shi, Nagano-ken 392-8502 (JP)

(74) Representative:
Hoffmann, Eckart, Dipl.-Ing.
Patentanwalt,
Bahnhofstrasse 103
82166 Gräfelfing (DE)

(54) Paper feeder and printer using it

(57) A paper feeder for a printer comprises a feed roller (3) for conveying paper and a stepping motor (2) for driving the feed roller (3). The feed roller and the stepping motor are coaxially disposed and the feed roller is directly driven by the stepping motor. The stepping motor (3) is adapted to perform Z base steps per one revolution and, in a microstep exciting system, each base step is subdivided into n microsteps in accordance with the expression $n \cdot Z = \pi Y \cdot X$ in which X represents the resolution of the printer, Y represents the diameter of the feed roller (3), and n represents an integer of 2 or greater.

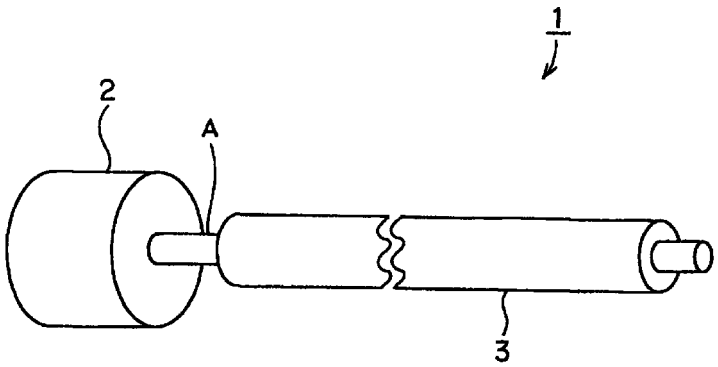

FIG. 1

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Description

[0001] The present invention relates to a paper feeder for a printer and to a printer using it.

[0002] Printers are generally configured to print characters and images on paper by means of a print head arranged to move relative to the paper in two orthogonal directions. Typically the print head moves in one of those two directions across the paper and the paper is moved in the other direction by means of a paper feeder. The paper feeder includes a feed roller for rolling and conveying the paper, and a motor for driving the feed roller.

[0003] A paper feeder of this type, for example, a highly accurate paper-sheet-feeding control apparatus is disclosed in JP-A-63-112175, in which the feed roller and the motor are directly connected. With this configuration, the accuracy of paper can be improved compared with an apparatus which includes a speed reducer or the like between the feed roller and the motor and which suffers from the effect of backlash and the like.

[0004] Further, when a stepping motor is used as the motor and it is controlled by a microstep exciting system, as disclosed in the above-described document, paper-feeding at a smaller pitch can be realized compared to the case where a step motor is controlled in accordance with a basic exciting system.

[0005] One such basic exciting system for stepping motors is a two-phase exciting system in which two phases of stator coils are simultaneously excited. On the other hand, in the microstep exciting system, a stepping angle, smaller than that (the base step) which is obtained in the basic stepping system using a small number of rotor teeth, can be obtained by switching the applied exciting current to a proper value for each phase.

[0006] The microstep exciting system, which is also called a ministep exciting system or a vernier exciting system, provides the advantage that the rotation of the rotor can be made smooth because the system improves, to a great extent, the rotational resolution of the stepping motor, i.e. each base step is divided into a certain number of microsteps.

[0007] In the above-described stepping motor which is used in the paper feeder, the rotational resolution capable of ensuring stop positions in accordance with the resolution of the printer is required. Therefore, the number of base steps and the number of divisions of the base step (the number of microsteps), according to the microstep exciting system, must be properly set.

[0008] Particularly, in the microstep exciting system, the maximum value of the torque applied to the rotor is reduced and the accuracy of stopping angles decreases as the base step is divided.

[0009] Such reduction of the maximum value of the torque on the rotor can be compensated for by increasing the applied current. There is, however, a limit to this compensation from the viewpoint of the maximum supply voltage to be applied, heat generation, and the like.

[0010] The highly accurate sheet-feeding control apparatus, disclosed in the above mentioned JP-A-63-112175, is described as an apparatus in which the equilibrium point of the stepping motor can be set to any point regardless of the mechanical shift pitch (pitch of the base steps). However, sufficient consideration has not been given to the relationship between the resolution of the printer and the rotational resolution of the motor, and the decrease in the torque applied to the rotor and the decrease in the accuracy of stopping angles, which are described above. Therefore, it is understood that positioning of the rotor is performed in a remarkably unstable manner.

[0011] Accordingly, it is an object of the present invention to provide a paper feeder and a printer using it, in which paper can be conveyed accurately and efficiently.

[0012] This object is achieved with a paper feeder as claimed in claims 1 and 3. A preferred embodiment of the invention is subject-matter of the dependent claim.

[0013] With the paper feeder according to the invention, the rotational resolution of the stepping motor for driving the feed roller is set in accordance with the resolution of the printer and paper-feeding can be performed accurately and efficiently in accordance with the resolution of the printer, as is described below.

[0014] The length of the paper sheet to be conveyed in one step of the stepping motor is set according to a given resolution X of the printer. As the resolution X of the printer represents the number of dots per unit length, the length of the paper sheet to be conveyed in one step of the stepping motor is set to be the same as the dot pitch in the resolution X (the reciprocal of the resolution X).

[0015] As the length of the paper sheet to be conveyed in a step equals the value obtained by dividing the circumference of the feed roller by the rotational resolution of the stepping motor, the rotational resolution of the stepping motor can be obtained by multiplying the circumference of the feed roller and the resolution X of the printer. The circumference of the feed roller is πY, where Y represents the diameter of the feed roller.

[0016] The rotational resolution of the stepping motor equals the product of the number Z of base steps in one revolution of the rotor and the number of microsteps per base step, i.e., the number of divisions of the base step according to the microstep exciting system.

[0017] Accordingly, when the number Z of base steps is determined based on the configuration of the stator and rotor, the number of microsteps per base step according to the microstep exciting system remains to be set.

[0018] In the microstep exciting system, control can be performed in a relatively simple manner when a current pattern is repeatedly applied in a uniform manner in

each base step. The base step is preferably divided by an integer of 2 or greater.

[0019] In the paper feeder, excellent paper-feeding is enabled by setting the product of the circumference πY of the feed roller and the resolution X of the printer to be equal to a multiple of the number of base steps Z and the integer n.

[0020] When designing the paper feeder, the circumference πY is obtained from the above-described expression when the resolution X of a printer and the rotational resolution of a stepping motor to be used are determined.

[0021] According to the embodiment set forth in Claim 2, the paper feeder has a configuration which satisfies the above-described expression in which n represents an integer of 12 or smaller. When the base step of the stepping motor is divided by an integer of 12 or smaller, whereby paper-feeding can be performed more accurately and efficiently.

[0022] In a microstep exciting system, the problem is that the maximum value of torque on a rotor is reduced as the base step is divided, and the accuracy of stopping angles decreases. In contrast, in the paper feeder according to the invention, the maximum value of torque on the rotor and the accuracy of stopping angles can be maintained at a satisfactory level while keeping the drive voltage of the motor tow and heat generation in a practically allowable range, because the number of divisions of a base step is set relatively small.

[0023] When each base step is divided into a very large number of microsteps, it is difficult to ensure the maximum value of torque on the rotor and the accuracy of stopping angles, whereby there is a risk of deteriorating the performance of the printer. The risk can be avoided without fail, according to the present invention.

[0024] These and other objects, features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which

Fig. 1 is an external view of a paper feeder according to an embodiment of the present invention, and

Fig. 2 is an external view of a paper feeder according to the embodiment of the present invention.

[0025] Fig. 1 shows a first embodiment of the paper feeder 1for a printer, which includes a feed roller 3 for conveying paper and a stepping motor 2 for driving the feed roller 3. The paper feeder 1 feeds paper in synchronization with the drive of a print head which is not shown.

[0026] The feed roller 3 and the rotor of the stepping motor 2 are integrally connected with each other through an axle A, and rotate together. Alternatively, an axle of the rotor and an axle of the feed roller 3 may be separate parts connected to each other by a joint such as a coupling 4, as shown in Fig. 2.

[0027] In one practical example, the resolution of the printer is 1440 dpi, and in the paper feeder 1, the diameter of the feed roller 3 is set to Y = 12.1276 mm, and the rotational resolution of the stepping motor 2 is set to 2160 microsteps per revolution. The circumference of the feed roller 3 is $Y \cdot \pi = 38.1000$ mm.

[0028] The above-described resolution of the printer is given in units of dpi (dots per inch), which is the unit generally used in the field. In order to make the unit of length in the following description uniform, the unit dots per millimeter will be used for the resolution of the printer, however, which means the resolution is 1440/25.4 dot/mm (1 inch = 25.4 mm).

[0029] The stepping motor 2 is provided with 135 small teeth around its rotor. The number of base steps per one revolution of the rotor in a two-phase exciting system is set to 540 in accordance with the relationship between the configuration of the stator and the number of teeth of the rotor.

[0030] The stepping motor 2 provides, in a microstep exciting system, a rotational amount smaller than the base step given in a two-phase exciting system. In the microstep exciting system according to the present embodiment, the base step is divided into four microsteps. Therefore, the rotational resolution of the stepping motor 2 of 2160 microsteps/revolution is obtained by multiplying the number of base steps by four.

[0031] According to the embodiment, the product of the circumference of the feed roller 3 and the resolution of the printer is

$$38.1000 \times 1440/25.4 = 2160$$

which is the rotational resolution of the stepping motor 2.

[0032] In the paper feeder 1 according to the embodiment, paper-feeding is performed accurately and efficiently in accordance with the resolution of the printer when the following expressions are satisfied:

$$n \cdot Z = \pi \cdot Y \cdot X, \text{ and}$$

$$n = 4$$

in which X represents the resolution of the printer, Y represents the diameter of the feed roller, Z represents the number of base steps of the stepping motor, and n is the number of microsteps per base step.

[0033] In the paper feeder, the value of n is set to 4, since this value ensures the maximum value of torque on the rotor and the accuracy of stopping angles are maintained at a satisfactory level while the drive voltage for the motor and the heat generation are kept in a practically low range.

[0034] In the stepping motor according to the embodiment, the accuracy of stopping angles can be

satisfactorily ensured without using a position detector such as an encoder. In order to obtain even more accurate stopping angles, however, a position detector may be employed, from which information on position is fed back to a rotation controller.

[0035] The stepping motor may be designed to have a predetermined stop position, i.e., have a configuration in which a predetermined stop position is registered in the stepping motor, and, when conveying paper, a sheet of paper is conveyed in one direction from the start to the end of printing thereon without a reverse movement in between. With this arrangement, the effect of hysteresis caused by changing the conveying direction can be avoided without fail.

[0036] A second embodiment according to the present invention is described below. According to this second embodiment, the resolution of a printer and setting of each component are different from those in the embodiment described above. Since the basic configuration is the same as in the above-described embodiment, the components common to the embodiments are referred to with the same reference numerals, and a description and drawings thereof are omitted.

[0037] In a paper feeder 1 according to the second embodiment, the resolution of the printer is 2000 dpi, that is, 2000/25.4 dot/mm, the diameter of the feed roller 3 is 10.9957 mm, and the rotational resolution of the stepping motor 2 is 2720 microsteps/revolution. The circumference of the feed roller 3 is 34.5440 mm.

[0038] The stepping motor 2 is provided with 85 small teeth around its rotor. The number of base steps per one revolution in a two-phase exciting system is 340 in accordance with the configuration of the stator and the number of the teeth of the rotor.

[0039] In a microstep exciting system according to the embodiment, the base step is divided into eight microsteps. The rotational resolution of the stepping motor 2 of 2720 is obtained by multiplying the number of base steps by eight.

[0040] In the paper feeder 1 according to the second embodiment, paper-feeding can be performed accurately and efficiently according to the resolution of the printer when satisfying the following expressions:

$$n \cdot Z = \pi \cdot Y \cdot X, \text{ and}$$

$$n = 8$$

in which X represents the resolution of the printer, Y represents the diameter of the feed roller, Z represents the number of base steps of the stepping motor, and n represents the number of microsteps per base step.

[0041] In the paper feeder, the number n is set to 8, since this ensures that the maximum value of torque on the rotor and the accuracy of stopping angles are maintained at a satisfactory level while the drive voltage for the motor and heat generation are kept in a practically low range.

Claims

1. A paper feeder for a printer, comprising a feed roller (3) for conveying paper and a stepping motor (2) for driving the feed roller (3), in which the feed roller and the stepping motor are coaxially disposed and the feed roller is directly driven by the stepping motor,

   characterized in that the stepping motor (3) is adapted to perform Z base steps per one revolution and, in a microstep exciting system, each base step is subdivided into n microsteps in accordance with the following expression:

   $$n \cdot Z = \pi Y \cdot X$$

   in which X represents the resolution of the printer, Y represents the diameter of the feed roller (3), and n represents an integer of 2 or greater.

2. A paper feeder according to Claim 1, **characterized in that** n represents an integer of 12 or smaller.

3. A printer having a paper feeder as defined in claim 1 or 2.

FIG. 1

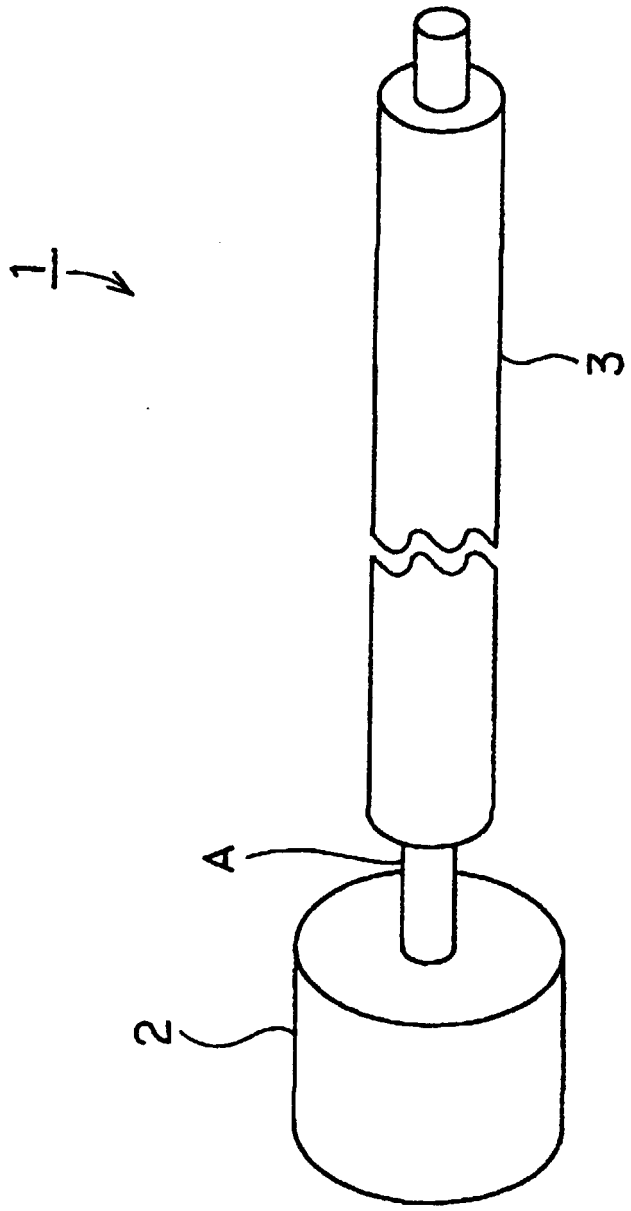
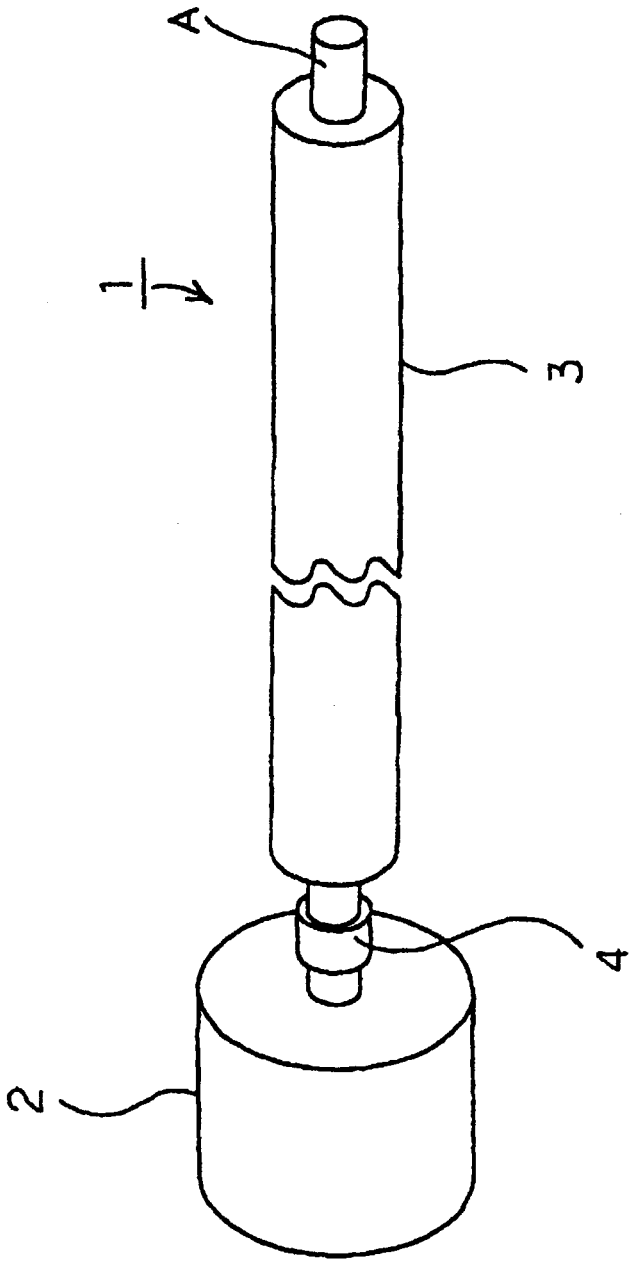


FIG. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 00 11 1848

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 356 (M-745), 26 September 1988 (1988-09-26) & JP 63 112175 A (NEC CORP), 17 May 1988 (1988-05-17) * abstract *	1-3	B41J11/42
A	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 01, 29 January 1999 (1999-01-29) & JP 10 264426 A (FUJI PHOTO FILM CO LTD), 6 October 1998 (1998-10-06) * abstract *	1-3	
A	US 5 588 761 A (SEIB KEN L) 31 December 1996 (1996-12-31) * the whole document *	1-3	
A	US 3 951 061 A (BREMMER JR DAVID F ET AL) 20 April 1976 (1976-04-20) * column 4, line 28-42; figure 9 *	1-3	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7) B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	22 September 2000	Ziegler, H-J

CATEGORY OF CITED DOCUMENTS

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22-09-2000

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