



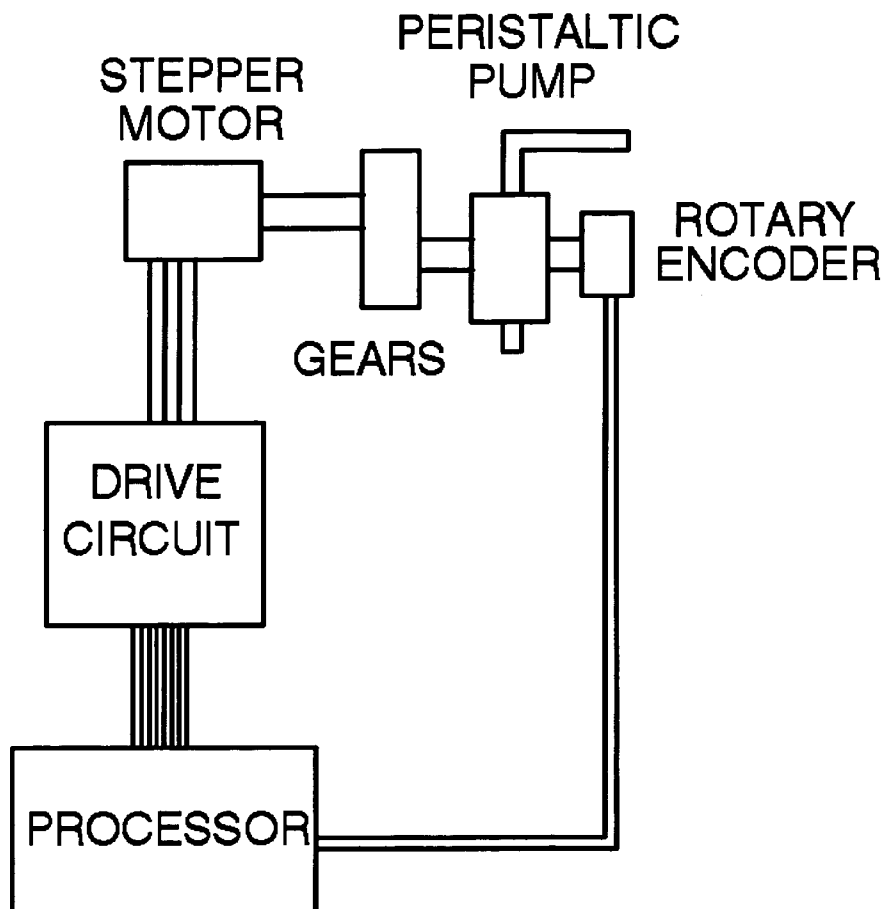
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(19) **United States**(12) **Patent Application Publication**
Bach(10) **Pub. No.: US 2005/0180856 A1**(43) **Pub. Date: Aug. 18, 2005**(54) **DRIVE TECHNOLOGY FOR PERISTALTIC
AND ROTARY PUMPS**(52) **U.S. Cl. 417/42; 417/410.3; 417/474**(76) **Inventor: David T. Bach, Ellicott City, MD (US)**(57) **ABSTRACT**

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Clifford Kraft**320 Robin Hill Dr.****Naperville, IL 60540 (US)**(21) **Appl. No.: 11/036,782**(22) **Filed: Jan. 14, 2005****Related U.S. Application Data**(60) **Provisional application No. 60/536,291, filed on Jan.
14, 2004. Provisional application No. 60/537,777,
filed on Jan. 20, 2004.****Publication Classification**(51) **Int. Cl.⁷ F04B 49/00; F04B 17/00**

A method and system for controlling a rotary pump where a rotary pump can be coupled to a stepper motor, and the stepper motor can be controlled with micro- or nano-stepping accuracy using a processor controlled drive system. The processor controlled drive system moves the stepper motor according to a predetermined move profile; this causes the rotary pump to dispense a precision amount of fluid. The rotary pump can be a peristaltic pump or any other type of pump. The rotary pump can be coupled to the stepper motor through a reduction gear with a reduction ratio of 2:1 or similar. The stepper motor can be mechanically coupled to a rotational position encoder so that a measure of the rotation position can be fed back to the processor. The processor can cause the stepper motor to interpolate between pulse positions of the encoder.



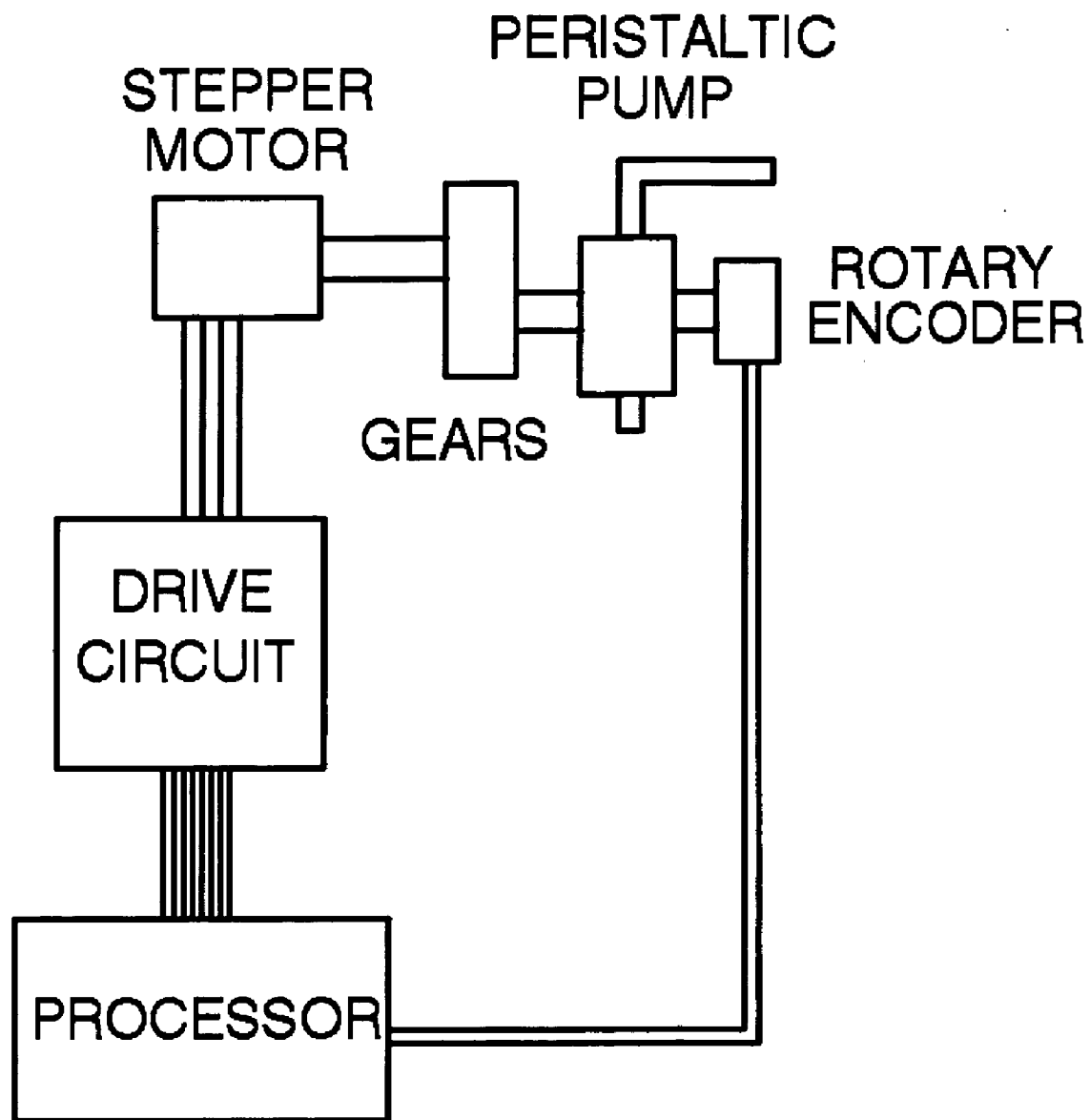


FIG. 1

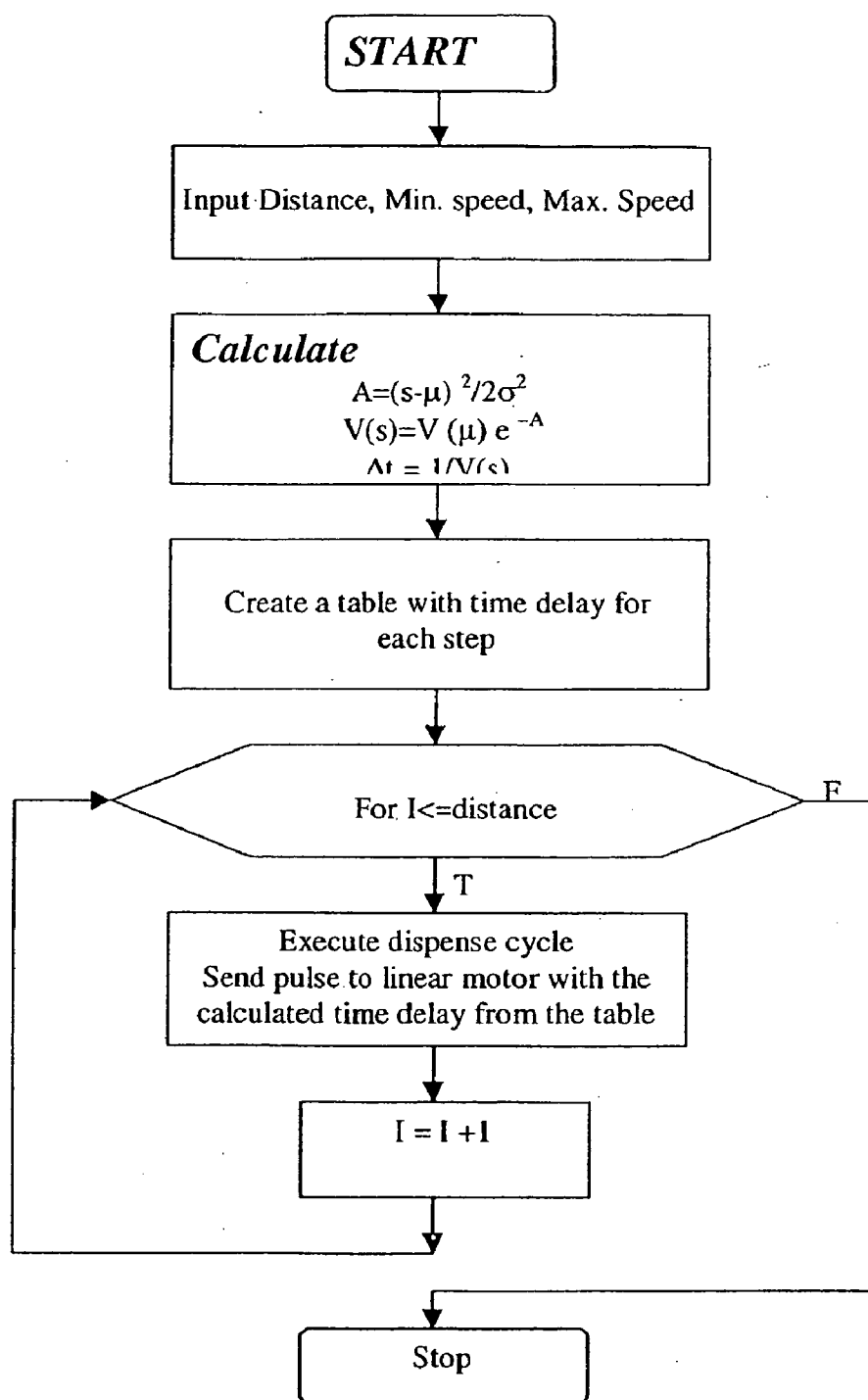


FIG. 2

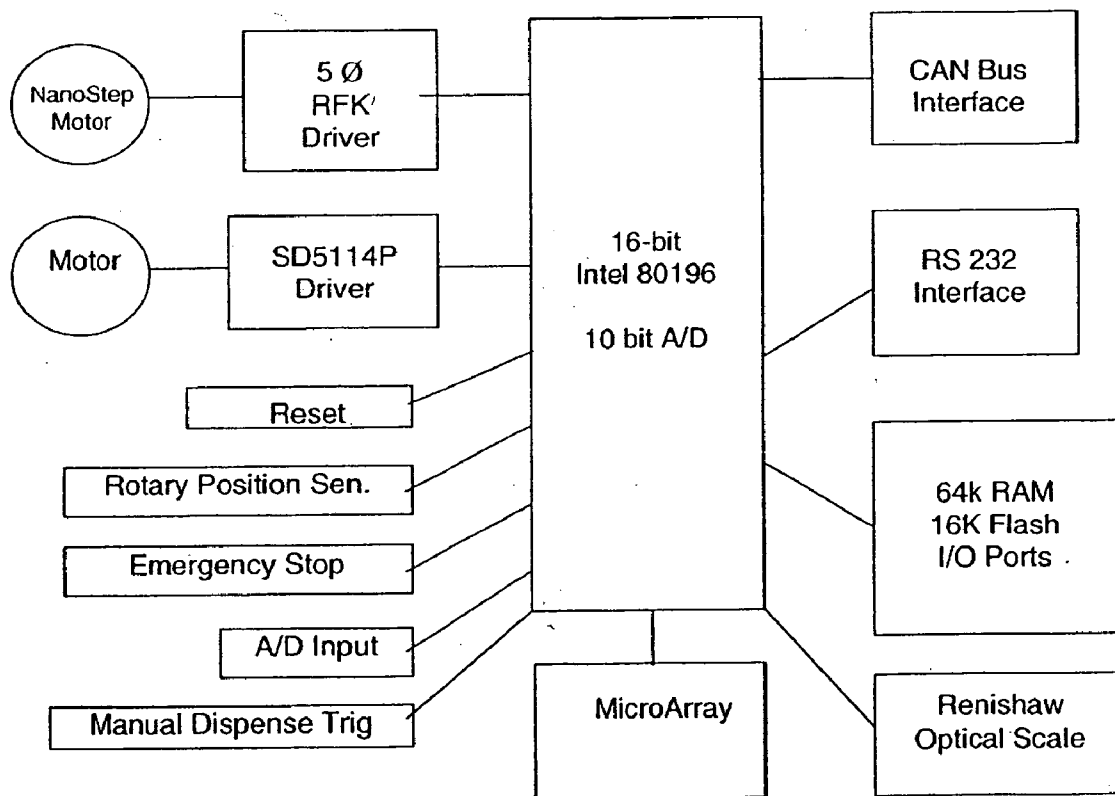


FIG. 3

Resolution					
Setting	Step Angle	Steps/Rev	mm Motion Per Step	No. Steps to Move 0.5 Micron	
1	0.72	500	0.01	0.050	
2	0.36	1000	0.005	0.100	
3	0.288	1250	0.004	0.125	
4	0.18	2000	0.0025	0.200	
5	0.144	2500	0.002	0.250	
6	0.09	4000	0.00125	0.400	
7	0.072	5000	0.001	0.500	
8	0.036	10000	0.0005	1.000	
9	0.0288	12500	0.0004	1.250	
10	0.018	20000	0.00025	2.000	
11	0.0144	25000	0.0002	2.500	
12	0.009	40000	0.000125	4.000	
13	0.0072	50000	0.0001	5.000	
14	0.00576	62500	0.00008	6.250	
15	0.0036	100000	0.00005	10.000	
16	0.00288	125000	0.00004	12.500	

FIG. 4

DRIVE TECHNOLOGY FOR PERISTALTIC AND ROTARY PUMPS

[0001] This application is related to and claims priority from U.S. provisional patent applications 60/536,291 file Jan. 14, 2004 and 60/537,777 file Jan. 20, 2004. Applications 60/536,291 and 60/537,777 are hereby incorporated by reference.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates generally to the field of fluid pumps and more specifically to the use of a multiple resolution stepping drive for a peristaltic or rotary pump.

[0004] 2. Description of the Prior Art

[0005] Peristaltic pumps have a unique advantage over other pumps in that they can be cleaned by merely removing the tubing and discarding it. New tubing is rapidly loaded making product changeover quite easy and contamination free. Also, the fluid shearing effect on tubing, known with other pumps, does not exist with peristaltic pumps. This protects products being pumped such as fluids containing fragile blood cells.

[0006] A major problem with peristaltic pumps is precision and accuracy. This is true even when stated accuracy is said to be some fixed value, for example $\pm 0.5\%$. Over a period of a product run, the tubing and other accessories can change resulting in a loss of precision, because the precision is directly related to the tube diameter as well as the rotor speed.

SUMMARY OF THE INVENTION

[0007] The present invention relates to a method and system for controlling a rotary pump where a rotary pump can be coupled to a stepper motor, and the stepper motor can be controlled with micro- or nano-stepping accuracy using a processor controlled drive system. The processor controlled drive system moves the stepper motor according to a pre-determined move profile; this causes the rotary pump to dispense a precision amount of fluid. The rotary pump can be a peristaltic pump or any other type of pump. The rotary pump can be coupled to the stepper motor through a reduction gear with a reduction ratio of 2:1, 7:1 or similar. The stepper motor can have an internal rotational encoder, or it be mechanically coupled to a rotational position encoder so that a measure of the rotation position can be fed back to the processor. The processor can cause the stepper motor to interpolate between pulse positions of the encoder.

[0008] Using the present invention, it is possible to achieve a stepping resolution of at least 125,000 steps per revolution. With a 2:1 reduction gear, it is possible to achieve as high as 250,000 steps per revolution. The present invention allows the stepper motor to operate at different resolutions during a dispense cycle. An example might be 1000 steps per revolution which is then switched to 10,000 steps per revolution (or much greater) depending upon the needs of the application.

DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 shows a block diagram of a stepper motor pump drive system.

[0010] FIG. 2 shows a flowchart for a dispense algorithm.

[0011] FIG. 3 shows a block diagram of a stepper motor pump driver attached to a peristaltic pump.

[0012] FIG. 4 is a table of stepping resolutions.

[0013] Several figures and illustrations have been presented to aid in understanding the present invention. The scope of the present invention is not limited to the figures.

DESCRIPTION OF THE INVENTION

[0014] The present invention relates to the use of a multiple resolution stepping motor to drive a peristaltic or rotary pump to dispense fluids.

[0015] A conventional peristaltic fluid pump (or alternatively any rotary pump) benefits by using a multi-resolution stepping drive to increase precision and hence overall system dispensing accuracy. A stepper motor such as an "Oriental" motor or equivalent can achieve micro- or nano-stepping resolution if properly driven. This type of motor can then be directly attached to a peristaltic pump. The improved control and resolution of the stepper motor allows the peristaltic pump to dispense fluids with an accuracy approaching that of a linear pump and allows possible tubing wear compensation.

[0016] A pump drive system is shown in FIG. 1. This is the system described in U.S. Pat. No. 6,739,478 by Bach et al. This system uses a microprocessor coupled with a position feedback system to determine the position of the pump. The position feedback is optional since the accuracy of the micro- or nano-stepping motor can be such that direct rotational position feedback may not be necessary. U.S. Pat. No. 6,739,478 is hereby incorporated by reference.

[0017] A peristaltic pump system can select and use any of the 16 resolutions in this embodiment of on-the-fly to assist in enhancing precision. FIG. 4 shows a table of stepping resolutions that can be used. The motor stepping rate can start at 1000 steps per revolution, and then for example, switch to 10,000 steps per revolution to improve precision as a dispensing goal (final dispensed quantity) is approached. A gear head can be optionally used to further improve precision. For example, a VICI M6 multiple piston pump head could be run with a 2:1 gear head on a 16 step setting to achieve 250,000 steps per revolution. The same system could also run at 1000 steps per revolution. This type of stepper drive, with or without a gear head, allows greater drive range and capability that can be currently found on peristaltic pumps.

[0018] When an Oriental "Alpha" series pump is used (for example with a 110 V. driver), the pump can be rotated at 500, 1000, 5000 and 10,000 steps per revolution. With a reduction gear of 7:1, a maximum precision of around 70,000 steps per revolution can be achieved.

[0019] FIG. 1 shows a block diagram of possible electronics that could be used to drive a peristaltic pump. A micro- or nano-step motor can be driven with suitable drive electronics known in the art under the control of a microprocessor. The microprocessor can be any processor of any bit width and can also be a microcontroller. An example processor is a 16 bit processor made by Intel called the 80196. The processor can optionally couple into a CAN bus, an RS-232 interface, and can contain RAM, ROM and disk

storage. Optional rotational position feedback can be used through an A/D converter if desired.

[0020] FIG. 2 shows a flowchart that can be used for a sample dispense. In this algorithm, a peristaltic (or any other) pump can be moved by creating a move profile. Here a Gaussian move profile is used. A step table is created that relates to accelerations, and the motor is moved according to the table.

[0021] FIG. 3 shows a block diagram of a stepper motor with processor controlled driver coupled through an optional reduction gear to a peristaltic pump. Typical drive electronics are sold under the trade name of ONE PUMP by Scientific Products and Systems of Baltimore Md. This electronics, as shown in FIG. 3, can be used to drive both linear and rotary pumps. This electronics also includes features such as the ability to separately control a nozzle, linking of multiple pumps on a CAN bus, and control of pumps by programmable logic controllers (PLCs).

[0022] A Renishaw rotary 4096 pulse per revolution encoder can be optionally interfaced to the controller to provide around 0.08 degree resolution (also some motors have internal revolution encoders). Stepping motor steps can be used to interpolate between encoder signals allowing for finer resolution (settings above 6 in FIG. 4). A home signal can be optionally incorporated so that counters can be calibrated and peristaltic pump rollers synchronized.

[0023] Several illustrations and descriptions have been used to aid in the understanding of the present invention. One of skill in the art will recognize that many variations and changes are possible. All such variations and changes are within the scope of the present invention.

I claim:

1. A method of controlling a rotary pump comprising the steps of:

coupling a rotary pump to a stepper motor, wherein said stepper motor is controlled with micro- or nano-stepping accuracy using a processor controlled drive system;

causing said processor controlled drive system to move said stepper motor according to a predetermined move profile, wherein said rotary pump dispenses a precision amount of fluid.

2. The method of claim 1 wherein said rotary pump is a peristaltic pump.

3. The method of claim 1 further comprising the step of causing said rotary pump to be coupled to said stepper motor through a reduction gear.

4. The method of claim 3 wherein said reduction gear is 2:1 or greater.

5. The method of claim 1 further comprising sensing a rotational position of said stepper motor using a rotary encoder.

6. The method of claim 5 wherein said processor interpolates between positions of said rotary encoder.

7. The method of claim 1 wherein said stepper motor has a resolution of at greater than 70,000 steps per revolution.

8. The method of claim 1 further comprising causing said stepper motor to operate at a plurality of different resolutions during a dispense cycle.

9. The method of claim 8 wherein said stepper motor operates at both 1000 steps per revolution and at least 10,000 steps per revolution during a dispense cycle.

10. An apparatus for dispensing fluid comprising:

a rotary pump;

a stepper motor coupled to said rotary pump;

a nano-stepping drive system under control of a processor driving said stepper motor;

a move profile stored in said processor for causing said stepper motor to move said rotary pump a predetermined amount to dispense a predetermined amount of fluid.

11. The apparatus of claim 10 wherein said rotary pump is a peristaltic pump.

12. The apparatus of claim 10 further comprising a rotary encoder coupled to said stepper motor.

13. The apparatus of claim 12 wherein said processor causes said stepper motor to interpolate between positions of said rotary encoder.

14. The apparatus of claim 10 further comprising a reduction gear between said rotary pump and said stepper motor.

15. The apparatus of claim 14 wherein said reduction gear is 2:1 or greater.

16. A method for precision fluid dispensing comprising the steps of:

causing a processor to control a stepping position of at least one stepper motor;

coupling a stepper motor driver for driving a stepper motor to said processor and to said stepper motor;

coupling a peristaltic pump mechanically to said stepper motor, said processor causing said peristaltic pump to rotate with a stepping precision of at least 10,000 steps per revolution.

17. The method of claim 16 wherein said stepping precision is greater than 125,000 steps per revolution.

18. The method of claim 16 further comprising placing a reduction gear between said stepper motor and said peristaltic pump.

19. The method of claim 16 further comprising coupling an optical encoder mechanically to said stepper motor, said optical encoder electrically also coupled to said processor.

20. The method of claim 19 wherein said processor causes said stepper motor to interpolate between positions of said optical encoder.

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