

FLOW PROCESSING DEVICE

FIELD OF THE INVENTION

[0001] The present invention relates to a flow processing device, and more particularly to a flow processing device with programmable fluid control and extremely low cost.

BACKGROUND OF THE INVENTION

[0002] Microfluidics is nowadays an emerging technology and widely used in many biomedical and biochemical arenas, such as sample preparation, cell sorting, species separation, buffer mixing, DNA extraction etc. The operation of most microfluidic devices highly relies on a group of hardwares such as micro pump, valve, power supply, electronic motor etc. as well as their assembled modules. In addition, in order to precisely functionate the flow processing, one has to customize associated electronic unit and circuit board and control them through a processor with programming. Because of its small dimensions and compacted system design, the advancing of microfluidic technology enables a biomedical platform with plenty of advantages including portability, low weight, fast turn-around time, automation etc.

[0003] The above-mentioned niche has been widely adopted by the majority of device manufactures. However, when being used at outdoor environment, especially at some remote areas where the electricity is not easily accessible, these systems may hardly find their applications. Although the use of battery is an alternative, most of the batteries can only effectively work with a certain period. Once the battery life is exhausted, one has to recharge/ replace it or connect the device with a power socket. On the other hand, the customized electronic unit and

circuit board as well as associated hardwares introduce additional cost apart from the microfluidic chip/cartridge and therefore increase the overall price of the solution.

[0004] In light with the requirements and the issues addressed above, there is a need of providing a flow processing device with programmable control and extremely low cost.

SUMMARY OF THE INVENTION

[0005] An object of the embodiment of the present invention is to provide a flow processing device for such as pumping, disturbing, mixing and generating disturbed or mixed droplet and etc. The flow processing device may be free of electricity and firmware. The entire structure of the flow processing device is compact, and the cost is extremely low. In addition, the flow processing device may be portable.

[0006] An another object of the embodiment of the present invention is to provide a flow processing device as a handheld supplementary device for mobile nucleic acid detection, for example but not limited to, plasma extraction from whole blood, DNA extraction and sample preparation for NA detection. The flow processing device is designed with a self-locking mechanism and programmable control. When the first stage of fluid disturbing or multiple flow mixing is completed, the switch is adjusted to the second stage of pumping the disturbed or mixed droplet with the self-locking mechanism. The operation is easy. It facilitates saving processing time.

[0007] According to an aspect of the embodiment of the present invention, a flow processing device includes a cartridge and a flow processing unit. The cartridge includes a first chamber, a second chamber, a third chamber, a first channel, a second channel, and a valve. The first chamber is in communication with the second chamber through the first channel. The second chamber is in communication with

the third chamber through the second channel, and the valve is disposed on the first channel. The flow processing unit is configured to process a fluid of the cartridge. The flow processing unit includes a rack and a gear set. The rack includes a first piston aligned with the first chamber, a second piston aligned with the valve, and a third piston aligned with the second chamber. The gear set includes an adjustable gear shaft including a disturbing cam and a pumping cam. While the adjustable gear shaft is moved to a first position, the gear set pushes the first piston to abut against the first chamber to pump the fluid from the first chamber to the second chamber and drives the disturbing cam of the adjustable gear shaft to push the third piston to abut against the second chamber to disturb the fluid in the second chamber. While the fluid is pumped to the second chamber through the first channel, the gear set pushes the second piston to abut against the first channel to block the first channel. While the adjustable shaft is moved to a second position, the gear set drives the pumping cam of the adjustable gear shaft to push the third piston to abut against the second chamber to pump the fluid from the second chamber to the third chamber. In the embodiment, the cartridge may be a disposable cartridge.

[0008] In an embodiment, the flow processing unit includes a housing including a receiving seat and an accommodation space, wherein the receiving seat is communicated with the accommodation space and configured to receive the cartridge thereon, and the rack and the gear set are disposed in the housing and accommodated in the accommodation space.

[0009] In an embodiment, the gear set includes a main gear shaft, a first gear shaft, and a second gear shaft. The main gear shaft is disposed in the housing. The first gear shaft is disposed in the housing, engaged with the main gear shaft and includes a first cam aligned with the first piston. While the main gear shaft drives the first gear shaft to rotate the first cam, the first cam is rotated to push a first end

of the first piston, and a second end of the first piston abuts against the corresponding first chamber to pump the fluid from the first chamber to the second chamber through the first channel. The second gear shaft is disposed in the housing, engaged with the main gear shaft and includes at least one second cam aligned with the second piston. While the main gear shaft drives the second gear shaft to rotate the at least one second cam, the at least one second cam is rotated to push a first end of the second piston, and a second end of the second piston abuts against the valve to block the first channel after the fluid is pumped from the first chamber to the second chamber.

[0010] In an embodiment, the adjustable gear shaft is engaged with the second gear shaft. While the adjustable gear shaft is moved to the first position and the main gear shaft is rotated, the disturbing cam of the adjustable gear shaft is driven to push the third piston to abut against the second chamber to disturb the fluid in the second chamber. While the adjustable gear shaft is moved to the second position and the main gear shaft is rotated, the pumping cam of the adjustable gear shaft is driven to push the third piston to abut against the second chamber to pump the fluid from the second chamber to the third chamber.

[0011] In an embodiment, the cartridge includes a fourth chamber in communication with the third chamber and the second channel and configured to contain an assistant fluid, the rack includes a fourth piston aligned with the fourth chamber, and the gear set includes a third gear shaft including a third cam, wherein while the pumping cam of the adjustable gear shaft is driven to push the third piston to abut against the second chamber and the third gear shaft is engaged with the adjustable gear shaft, the third cam of the third gear shaft pushes the fourth piston to abut against the fourth chamber to pump the assistant fluid from the fourth chamber to the third chamber.

[0012] In an embodiment, the gear set includes a connection bar, a first arm, and a second arm, wherein the connection bar includes a first slot and a second slot, the connection bar is connected with the adjustable gear shaft through the first arm and connected with the third gear shaft through the second arm, one end of the first arm is coupled with the adjustable gear shaft, the other end of the first arm is slidably received in the first slot, one end of the second arm is coupled with the third gear shaft, and the other end of the second arm is slidably received in the second slot. While the adjustable gear shaft stays at the first position, the connection bar drives the third gear shaft to separate from the adjustable gear shaft, wherein while the adjustable gear shaft is adjusted to the second position, the third gear shaft is moved by the connection bar to engage with the adjustable gear shaft. While the adjustable gear shaft is engaged with the third gear shaft and the main gear shaft is rotated, the third cam of the third gear shaft pushes the fourth piston to abut against the fourth chamber to pump the assistant fluid from the fourth chamber to the third chamber.

[0013] In an embodiment, the gear set includes a supporting shaft, wherein one end of the supporting shaft is connected to the rack, and the other end of the supporting shaft is pivotally connected with the connection bar.

[0014] In an embodiment, the housing includes at least one first guiding slot, and an end of the third gear shaft is received in the first guiding slot.

[0015] In an embodiment, the flow processing unit includes a braking bar, wherein while the braking bar is moved from a start position to a braking position, the braking bar is engaged with the main gear shaft to lock the rotation of the main gear shaft.

[0016] In an embodiment, the flow processing unit includes a crank gear and a crank connecting rod, wherein the crank gear is engaged with the adjustable gear shaft, and the crank connecting rod includes an end connected to the crank gear and

the other end in contact with the braking bar, wherein while the crank gear starts to rotate, the crank connecting rod drives the braking bar from the start position to the braking position.

[0017] In an embodiment, the housing includes a second guiding slot, and the crank connecting rod includes at least one guiding pin received in the second guiding slot.

[0018] In an embodiment, the housing includes at least one third guiding slot, and an end of the braking bar is received the third guiding slot.

[0019] In an embodiment, the flow processing unit includes a spring connected to the braking bar and a control switch bar connected to the adjustable gear shaft and including a blocking end configured to block the braking bar at the braking position, wherein while the adjustable gear shaft is moved to the second position, the blocking end is separated from the braking bar, and the braking bar is driven by the spring to move from the braking position to an unlock position.

[0020] In an embodiment, the adjustable gear shaft includes a connecting gear engaged with the crank gear, wherein the gear ratio of the connecting gear and the crank gear is smaller than 0.1.

[0021] In an embodiment, the flow processing unit includes a knob or a handle connected to an end of the main gear shaft and configured to rotate the main gear shaft.

[0022] In an embodiment, the gear set includes a spring windup module disposed on the housing and connected to the main gear shaft to store a driven energy for rotating the main gear shaft.

[0023] In an embodiment, wherein the cartridge includes a thin film disposed at a bottom of the second chamber, and the disturbing cam is flower-shaped, wherein while the main gear shaft drives the disturbing cam of the adjustable gear shaft to

push one end of the third piston, the other end of the third piston contacts with the thin film and drives the thin film to vibrate to disturb the fluid in the second chamber.

[0024] In an embodiment, each of the first chamber, the second chamber, and the third chamber includes a rubber plunger disposed at an original position aligned with the first piston, the third piston, and the fourth piston, respectively, wherein while the rubber plunger is pushed, the rubber plunger is maintained at a pumped position.

[0025] In an embodiment, the valve includes a rubber plunger disposed at an original position aligned with the second piston, wherein while the rubber plunger is pushed, the rubber plunger is maintained at a blocked position.

[0026] In an embodiment, the cartridge is made by thermoplastic material, polymer, paper, glass, silicon, metal, or a combination thereof.

[0027] The above objects and advantages of the embodiments of the present invention become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. 1 shows an exploded view of a flow processing device according to an embodiment of the present disclosure;

[0029] FIG. 2 shows the explode view of the flow processing device of FIG. 1 along with another viewpoint;

[0030] FIG. 3 shows a schematic view of the flow processing device of FIG. 1;

[0031] FIG. 4 shows a cross sectional view of the flow processing device according to the embodiment of the present disclosure;

[0032] FIG. 5 is a cross section view illustrating the cartridge in an initial status;

[0033] FIG. 6 is a cross section view illustrating the cartridge in an actuated status;

[0034] FIG. 7 shows an internal view of the flow processing device with the adjustable gear shaft at the first position;

[0035] FIG. 8 shows an internal view of the flow processing device with the adjustable gear shaft at the second position;

[0036] FIG. 9 shows a start position of the flow processing device according to the embodiment of the present disclosure;

[0037] FIG. 10 shows an internal view of the flow processing device of FIG. 9;

[0038] FIG. 11 shows a braking position of the flow processing device according to the embodiment of the present disclosure;

[0039] FIG. 12 shows an internal view of the flow processing device of FIG. 11;

[0040] FIG. 13 shows an unlocking status of the flow processing device according to the embodiment of the present disclosure; and

[0041] FIG. 14 shows the unlocking status of the flow processing device and taken along another viewpoint.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0042] The present invention will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of the embodiments of this invention are presented herein for purpose of illustration and description only; it is not intended to be exhaustive or to be limited to the precise form disclosed.

[0043] The embodiment of the present invention provides a flow processing device, which includes a flow processing unit and a cartridge. The cartridge is

mounted on the flow processing unit designed with a self-locking mechanism and programmable control to provide the major functions of fluid disturbing or multiple flow mixing, and on-chip droplet generation for mobile nucleic acid detection. The flow processing device of the embodiment may be a portable flow processing device, and the cartridge may be a disposable cartridge.

[0044] FIG. 1 shows an exploded view of a flow processing device according to an embodiment of the present disclosure. FIG. 2 shows the explode view of the flow processing device of FIG. 1 along with another viewpoint. FIG. 3 shows a schematic view of the flow processing device of FIG. 1. FIG. 4 shows a cross sectional view of the flow processing device according to the embodiment of the present disclosure. As shown in FIGS. 1 to 4, the flow processing device 1 includes a cartridge 10 and a flow processing unit 2. The cartridge 10 includes a first chamber 11, a second chamber 12, a third chamber 13, a first channel 14, a second channel 15, and a valve 16. The first chamber 11 is in communication with the second chamber 12 through the first channel 14. The second chamber 12 is in communication with the third chamber 13 through the second channel 15. The valve 16 is disposed on the fluidic circuit according to the design, and for example the first channel 14 and configured to selectively open or close the first channel 14. The first chamber 11 is configured to receive a fluid. Moreover, the flow processing unit 2 is configured to process the fluid of the cartridge 10.

[0045] In the embodiment, the flow processing unit 2 includes a rack 20, a housing 30, and a gear set 40. The housing 30 includes a receiving seat 31, an accommodation space 32, and a partition plate 33. The partition plate 33 is disposed between the receiving seat 31 and the accommodation space 32. The receiving seat 31 is in communication with the accommodation space 32, located at the upper portion of the housing 30 and configured to receive the cartridge 10 thereon. The

accommodation space 32 is located at the lower portion of the housing 30. The partition plate 33 has at least one opening 331. The rack 20 and the gear set 40 are assembled together, mounted in the housing 30 and accommodated in the accommodation space 32. The rack 20 includes a first piston 21, a second piston 22, and a third piston 23. The first piston 21, the second piston 22, and the third piston 23 pass through the at least opening 331 of the partition plate 33. The first piston 21 is aligned with the first chamber 11. The second piston 22 is aligned with the valve 16. The third piston 23 is aligned with the second chamber 12.

[0046] The gear set 40 includes a main gear shaft 41, a first gear shaft 42, a second gear shaft 43, an adjustable gear shaft 45, and a third gear shaft 46. The main gear shaft 41 is disposed in the housing 30. In the embodiment, the main gear shaft 41 includes a knob or a handle 54 connected to an end of the main gear shaft 41 and configured to rotate the main gear shaft 41. In some embodiments, the gear set 40 further includes a spring windup module 55 disposed on the housing 30 and connected to the main gear shaft 41 to store a driven energy for rotating the main gear shaft 41. The first gear shaft 42 is disposed in the housing 30 and engaged with the main gear shaft 41. The first gear shaft 42 includes a first cam 42a aligned with and corresponding to the first piston 21. While the main gear shaft 41 is rotated to drive the first gear shaft 42, the first cam 42a of the first gear shaft 42 is rotated to push the first end of the corresponding first piston 21, and then the opposite second end of the corresponding first piston 21 abuts against the corresponding first chamber 11. Consequently, the fluid stored in the first chamber 11 is pumped to the second chamber 12 through the corresponding first channel 14.

[0047] In this embodiment, the second gear shaft 43 is disposed in the housing 30 and engaged with the main gear shaft 41. The second gear shaft 43 includes at least one second cam 43a aligned with and corresponding to the second piston 22.

While the main gear shaft 41 is rotated to drive the second gear shaft 43, the second cam 43a of the second gear shaft 43 is rotated to push the first end of the corresponding second piston 22, and then the opposite second end of the corresponding second piston 22 abuts against the corresponding valve 16. Consequently, the first channel 14 is blocked after the fluid is pumped from the first chamber 11 to the second chamber 12.

[0048] FIG. 5 is a cross section view illustrating the cartridge in an initial status. FIG. 6 is a cross section view illustrating the cartridge in an actuated status. As shown in FIGS. 5 and 6, the first chamber 11 includes a cylinder with a hollow portion and includes a rubber plunger 11a movably installed in the hollow portion of the cylinder. Before the cartridge 10 is mounted on the receiving set 31 of the housing 30, the rubber plunger 11a is at the lowest position within the hollow portion of the cylinder. While the cartridge 10 is mounted on the receiving set 31 of the housing 30, the first piston 21 is aligned with the rubber plungers 11a. While the first chamber 11 is abutted by the corresponding first piston 21 (see FIG. 1), the corresponding first piston 21 abuts against the rubber plunger 11a and pushes the rubber plunger 11a to move upwardly, so that the rubber plunger 11a is actuated and maintained at a pumped position. Meanwhile, the rubber plunger 11a can be tightly fitted with the inner wall of the first chamber 11, so that the rubber plunger 11a may not slide down and stay at the highest positions within the first chamber 11, and the volume of the first chamber 11 is shrunk. Consequently, the fluid stored in the first chamber 11 is pumped from the first chamber 11 to the second chamber 12. Similarly, the valve 16 includes a rubber plunger 16a. In an initial status, the rubber plunger 16a of the valve 16 is not actuated and stays at an initial position. Under this circumstance, the first channel 14 is opened. While the valve 16 is abutted by the corresponding second piston 22 after the fluid is pumped from the first chamber

11 to the second chamber 12, the rubber plunger 16a of the valve 16 is abutted by the corresponding second piston 22 so that the rubber plunger 16a is actuated and pushed upwardly to a blocked position. Consequently, the first channel 14 is blocked. Certainly, in other embodiment, each of the second chamber 12 and the third chamber 13 can also include a rubber plunger disposed at an original position relative to the third piston 23 and the fourth piston 24, respectively. While the rubber plunger is abutted by the corresponding piston, the rubber plunger is moved upwardly and maintained at a pumped position. In the embodiment, the cartridge 10 is made by thermoplastic material, polymer, paper, glass, silicon, metal, or a combination thereof.

[0049] In the embodiment, the adjustable gear shaft 45 disposed in the housing 30 can be driven by the main gear shaft 41 for example through the second gear shaft 43. The adjustable gear shaft 45 includes a disturbing cam 45a, a pumping cam 45b, and a knob 45c. In the embodiment, the adjustable gear shaft 45 can be switched between a first position and a second position by pushing or pulling the knob 45c, to select the disturbing cam 45a or the pumping cam 45b to push the third piston 23 to abut the second chamber 12. While the adjustable gear shaft 45 is moved to the first position, the main gear shaft 41 of the gear set 40 drives the disturbing cam 45a of the adjustable gear shaft 45 to push the third piston 23 to abut the second chamber 12. Consequently, the pumped fluid in the second chamber 12 can be disturbed. While the adjustable gear shaft 45 is moved to the second position, the main gear shaft 41 of the gear set 40 drives the pumping cam 45b of the adjustable gear shaft 45 to push the third piston 23 to abut the second chamber 12. Consequently, the disturbed fluid is pumped from the second chamber 12 to the third chamber 13. Preferably but not exclusively, the disturbing cam 45a is a flower-shaped cam, and the pumping cam 45b is an eccentric cam.

[0050] Notably, the first chamber 11, the corresponding first channel 14, the corresponding first piston 21, and the corresponding first cam 42a are configured together to provide the function of pumping the fluid. Moreover, the corresponding valve 15, the corresponding piston 22, and the second cam 43a are configured together to provide the function of blocking the corresponding first channel 14 after pumping the fluid. It is noted that the numbers of the first chamber 11, the corresponding first channel 14, the corresponding valve 16, the corresponding first piston 21, the second corresponding piston 22, the corresponding first cam 42a, and the second com 43a can be adjustable according to the practical requirements. In the forgoing embodiment, the flow processing device 1 includes three first chambers 11, three corresponding first channels 14, three corresponding first pistons 21, and three corresponding first cams 42a for processing three flows to the second chamber 12. While each of the three first chambers 11 receives a fluid, the flow process device 1 can further provide function of multiple flow mixing.

[0051] In the embodiment, the cartridge 10 further includes a fourth chamber 17 in communication with the third chamber 13 and the second channel 15 and configured to contain an assistant fluid, for example but not limited to an oil. The rack 20 includes a fourth piston 24 aligned with the fourth chamber 17. The gear set 40 further includes a third gear shaft 46 with a third cam 46a. While the pumping cam 45b of the adjustable gear shaft 45 is driven to push the third piston 23 to abut the second chamber 12 and the third gear shaft 46 is engaged with the adjustable gear shaft 45, the third cam 46a of the third gear shaft 46 pushes the fourth piston 24 to abut against the fourth chamber 17 to pump the assistant fluid from the fourth chamber 17 to the third chamber 13.

[0052] FIG. 7 shows an internal view of the flow processing device with the adjustable gear shaft at the first position. FIG. 8 shows an internal view of the flow

processing device with the adjustable gear shaft at the second position. Please refer to FIGS. 1, 2, 3, 7 and 8. In the embodiment, the gear set 40 further includes a connection bar 47, a first arm 47a, a second arm 47b, and a supporting shaft 48. The connection bar 47 includes a first slot 47c and a second slot 47d. The connection bar 47 is connected with the adjustable gear shaft 45 through the first arm 47a and connected with the third gear shaft 46 through the second arm 47b. One end of the first arm 47a is coupled with the adjustable gear shaft 45, and the other end of the first arm 47a is slidably received in the first slot 47c of the connection bar 47. One end of the second arm 47b is coupled with the third gear shaft 46, and the other end of the second arm 47b is slidably received in the second slot 47d of the connection bar 47. The supporting shaft 48 includes one end fixed on the rack 20 and the other end pivotally connected with a middle area of the connection bar 47, wherein the middle area is located between the first slot 47c and the second slot 47d. In the embodiment, the housing 30 further includes at least one first guiding slot 35, and an end of the third gear shaft 46 is received in the first guiding slot 35 to guide the movement of the third gear shaft 46. While the adjustable gear shaft 45 is moved to the first position, the connection bar 47 is driven by the movement of the adjustable gear shaft 45 and the third gear shaft 46 is driven to separate from the adjustable gear shaft 45. Alternatively, while the adjustable gear shaft 45 is moved to the second position, the adjustable gear shaft 45 drives the connection bar 47 to rotate and the second arm 47b slides along the second slot 47d so that the third gear shaft 46 is engaged with the adjustable gear shaft 45. Meanwhile, the third cam 46a is moved nearby the fourth piston 24. Since the adjustable gear shaft 45 is driven by the main gear shaft 41, while the adjustable gear shaft 45 is engaged with the third gear shaft 46 and the main gear shaft 41 is rotated, the third cam 46a of the third gear shaft 46 pushes the fourth piston 24 to abut the fourth chamber 17 to pump the assistant fluid

from the fourth chamber 17 to the third chamber 13. Meanwhile, the disturbed fluid, for example an aqueous mixture, can react with the assistant fluid to generate droplets for mobile nucleic acid detection. Namely, the major functions of fluid disturbing or multiple flow mixing and droplet generation are provided.

[0053] FIG. 9 shows a start position of the flow processing device according to the embodiment of the present disclosure. FIG. 10 shows an internal view of the flow processing device of FIG. 9. FIG. 11 shows a braking position of the flow processing device according to the embodiment of the present disclosure. FIG. 12 shows an internal view of the flow processing device of FIG. 11. FIG. 13 shows an unlocking status of the flow processing device according to the embodiment of the present disclosure. FIG. 14 shows the unlocking status of the flow processing device along with another viewpoint. As shown in FIGS. 1 to 14, in the embodiment, the flow processing unit 2 includes a braking bar 49, a crank gear 51, and a crank connecting rod 52 disposed in the housing 30. The housing 30 further includes a second guiding slot 36, and the crank connecting rod 52 includes at least one guiding pin 52a received in the second guiding slot 36 to guide the movement of the crank connecting rod 52. Similarly, the housing 30 includes at least one third guiding slot 34 relative to the braking bar 49, and the end of the braking bar 49 is received in the third guiding slot 34. In the embodiment, the crank gear 51 is engaged with the adjustable gear shaft 45. The crank connecting rod 52 includes an end connected to the crank gear 51 and the other end in contact with the braking bar 49. While the flow processing device 1 is operated from an initial status as shown in FIGS. 9 and 10, the main gear shaft 41 is rotated by a user through the handle 54 or the spring windup module 55. The main gear shaft 41 drives the first cam 42a of the first gear shaft 42 to pump the fluid in the corresponding first chamber 11 through the corresponding first piston 21, and further drives the second cam 43a of the second

gear shaft 43 to actuate the valve 16 through the corresponding second piston 22 after the fluid is pumped from the first chamber 11 to the second chamber 12. Meanwhile, the adjustable gear shaft 45 keeps in the first position and the disturbing cam 45a is selected to push the third piston 23 to abut the second chamber 12. In an embodiment, the cartridge is disposable. The cartridge may be a disposable cartridge.

[0054] In the embodiment, the cartridge 10 includes a thin film 12a (see FIG. 5) disposed on a bottom of the second chamber 12 relative to a pushing end 23a of the third piston 23 (See FIGS. 1 and 2). Moreover, the disturbing cam 45a drives the third piston 23 with spring thereon in a reciprocating motion upwardly and downwardly (see FIG. 2). Consequently, the thin film 12a of the second chamber 12 vibrates because of the reciprocating motion of the third piston 23, and the fluid pumped in the second chamber 12 is disturbed. In the embodiment, the adjustable gear shaft 45 further includes a connecting gear 45d engaged with the crank gear 51 (see FIG. 2). The connecting gear 45d includes a gear ratio relative to the crank gear 51 smaller than a specific ratio, for example 0.1 to control the period of disturbing relative to the actuation timing of self-locking mechanism. In the embodiment, the adjustable gear shaft 45 is further connected to the crank gear 51 through the connection gear 45d. The gear ratio of connecting gear 45d relative to the crank gear 51 is for example 0.05. While the adjustable gear shaft 45 is rotated 10 cycles, the crank gear 51 rotates half cycle and the guiding pin 52a of the crank connecting rod 52 moves along the second guiding slot 36 and the long-rod end contacts with the braking bar 49 continuously. Thus, the braking bar 49 is driven to move from a start position (as shown in FIGS. 9 and 10) to a braking position (as shown in FIGS. 11 and 12) along the third guiding slots 34.

[0055] In the embodiment, the flow processing unit 2 further includes a spring 50 connected to the braking bar 49 (see FIG. 4) and a control switch bar 53 connected

to the adjustable gear shaft 45 (see FIG. 10). The control switch bar 53 includes a blocking end 53a configured to block the braking bar 49 at the braking position while the pumped fluid in the second chamber 12 has been disturbed. Namely, the crank connecting rod 52 moves to its ending position, the braking bar 49 is repelled downwardly along the third guiding slot 34 to engage with the main gear shaft 41 to stop the rotation of main gear shaft 41. At this stage, the fluid disturbing or multiple flow mixing is completed and the flow processing device 1 is locked automatically by using the above self-locking mechanism. Accordingly, the disturbing period of the flow processing device 1 can be ceased automatically after fluid disturbing or multiple flow mixing is completed.

[0056] In the embodiment, the above locked flow processing device 1 is unlocked by manually adjusting the control switch bar 53 connected with the adjustable gear shaft 45. While the adjustable gear shaft 45 is adjusted from the first position (as shown in FIG. 7) to the second position (as shown in FIG. 8), the blocking end 53a of the control switch bar 53 is separated from the braking bar 49, and the braking bar 49 is driven by the spring 50 to move along the third guiding slot 34 from the braking position to an unlock position (as shown in FIGS. 13 and 14). Simultaneously, the pumping cam 45b of the adjustable gear shaft 45 is selected to push the third piston 23 to abut the second chamber 12, and the third cam 46a of the third gear shaft 46 is moved to push the fourth piston 24 to abut the fourth chamber 17. Consequently, the operation of droplet generation is actuated. Accordingly, the disturbed or mixed fluid and the assistant fluid are pumped to the third chamber 13 through the second channel 15 and generate droplets for mobile nucleic acid detection. It is noted that the number and distributions of the chambers and channels of the cartridge 10 are adjustable and the design of the flow processing unit 2 is also adjustable according to the practical requirements.

[0057] It is noted that the embodiment of the present flow processing device 1 may be free from of electricity and hardware. The energy for performing flow processing may be provided by users. Therefore, the embodiment of the present flow processing device 1 is able to work at everywhere including these resource-poor arears. Moreover, the external hardware for fluid actuation and control in typical microfluidic system, such as electronic devices may not be necessary. Power consumption, heat dissipation and additional cost associated with typical controller based electronic devices may be avoided. By replacing the electronic devices necessary for most common systems with the flow processing unit 2, the flow processing device 1 is significantly shrunk to a hard disc sized cubic. In addition, as expensive power sources, fluidic pumps and valves are not necessary in the flow processing device 1, the cost may be extremely low.

[0058] In conclusion, the embodiment of the present invention provides a flow processing device for pumping, disturbing, mixing and generating the disturbed or mixed droplet. The flow processing device may be free of electricity and hardware. The entire structure of the flow processing device is compact, and the cost may be extremely low. In addition, the flow processing device may be portable. The flow process device is provided as a handheld supplementary device for mobile nucleic acid detection, for example, plasma extraction from whole blood, DNA extraction and sample preparation for NA detection. The flow processing device is designed with a self-locking mechanism and programmable control. When the first stage of fluidic disturbing or multiple flow mixing is completed, the switch is adjusted to the second stage of pumping the mixed droplet with the self-locking mechanism. The operation is easy. It facilitates to save processing time.

[0059] While the invention has been described in terms of what is presently considered to be the practical embodiments, it is to be understood that the invention

needs not be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims, which are to be accorded with the broadest interpretation to encompass all such modifications and similar structures.

WHAT IS CLAIMED IS:

1. A flow processing device comprising:

a cartridge comprising a first chamber, a second chamber, a third chamber, a first channel, a second channel, and a valve, wherein the first chamber is in communication with the second chamber through the first channel, the second chamber is in communication with the third chamber through the second channel, and the valve is disposed on the first channel; and

a flow processing unit configured to process a fluid of the cartridge and comprising:

a rack comprising a first piston aligned with the first chamber, a second piston aligned with the valve, and a third piston aligned with the second chamber; and

a gear set comprising an adjustable gear shaft comprising a disturbing cam and a pumping cam, wherein while the adjustable gear shaft is moved to a first position, the gear set pushes the first piston to abut against the first chamber to pump the fluid from the first chamber to the second chamber and drives the disturbing cam of the adjustable gear shaft to push the third piston to abut against the second chamber to disturb the fluid in the second chamber, wherein while the fluid is pumped to the second chamber through the first channel, the gear set pushes the second piston to abut against the first channel to block the first channel, wherein while the adjustable shaft is moved to a second position, the gear set drives the pumping cam of the adjustable gear shaft to push the third piston to abut against the second chamber to pump the fluid from the second chamber to the third chamber.

2. The flow processing device according to claim 1, wherein the flow processing unit comprises a housing comprising a receiving seat and an accommodation space, wherein the receiving seat is in communication with the accommodation space and

configured to receive the cartridge thereon, and the rack and the gear set are disposed in the housing and accommodated in the accommodation space.

3. The flow processing device according to claim 2, wherein the gear set comprising:

- a main gear shaft disposed in the housing;

- a first gear shaft disposed in the housing, engaged with the main gear shaft and comprising a first cam aligned with the first piston, wherein while the main gear shaft drives the first gear shaft to rotate the first cam, the first cam is rotated to push a first end of the first piston, and a second end of the first piston abuts against the corresponding first chamber to pump the fluid from the first chamber to the second chamber through the first channel; and

- a second gear shaft, disposed in the housing, engaged with the main gear and comprising at least one second cam aligned with the second piston, wherein while the main gear shaft drives the second gear shaft to rotate the at least one second cam, the at least one second cam is rotated to push a first end of the second piston, and a second end of the second piston abuts against the valve to block the second channel after the fluid is pumped from the first chamber to the second chamber.

4. The flow processing device according to claim 3, wherein the adjustable gear shaft is engaged with the second gear shaft, wherein while the adjustable gear shaft is moved to the first position and the main gear shaft is rotated, the disturbing cam of the adjustable gear shaft is driven to push the third piston to abut against the second chamber to disturb the fluid in the second chamber, wherein while the adjustable gear shaft is moved to the second position and the main gear shaft is rotated, the pumping cam of the adjustable gear shaft is driven to push the third piston to abut against the second chamber to pump the fluid from the second chamber to the third chamber.

5. The flow processing device according to claim 3, wherein the cartridge comprises a fourth chamber in communication with the third chamber and the second channel and configured to contain an assistant fluid, the rack comprises a fourth piston aligned with the fourth chamber, and the gear set comprises a third gear shaft comprising a third cam, wherein while the pumping cam of the adjustable gear shaft is driven to push the third piston to abut against the second chamber and the third gear shaft is engaged with the adjustable gear shaft, the third cam of the third gear shaft pushes the fourth piston to abut against the fourth chamber to pump the assistant fluid from the fourth chamber to the third chamber.

6. The flow processing device according to claim 5, wherein the gear set comprises a connection bar, a first arm, and a second arm, wherein the connection bar comprises a first slot and a second slot, the connection bar is connected with the adjustable gear shaft through the first arm and connected with the third gear shaft through the second arm, one end of the first arm is coupled with the adjustable gear shaft and the other end of the first arm is slidably received in the first slot, one end of the second arm is coupled with the third gear shaft, and the other end of the second arm is slidably received in the second slot, wherein while the adjustable gear shaft stays at the first position, the connection bar drives the third gear shaft to separate from the adjustable gear shaft, wherein while the adjustable gear shaft is adjusted to the second position, the third gear shaft is moved by the connection bar to engage with the adjustable gear shaft, wherein while the adjustable gear shaft is engaged with the third gear shaft and the main gear shaft is rotated, the third cam of the third gear shaft pushes the fourth piston to abut against the fourth chamber to pump the assistant fluid from the fourth chamber to the third chamber.

7. The flow processing device according to claim 6, wherein the gear set comprises a supporting shaft, wherein one end of the supporting shaft is connected to the rack,

and the other end of the supporting shaft is pivotally connected with the connection bar.

8. The flow processing device according to claim 5, wherein the housing comprises at least one first guiding slot, and an end of the third gear shaft is received in the first guiding slot.

9. The flow processing device according to claim 3, wherein the flow processing unit comprises a braking bar, wherein while the braking bar is moved from a start position to a braking position, the braking bar is engaged with the main gear shaft to lock the rotation of the main gear shaft.

10. The flow processing device according to claim 9, wherein the flow processing unit comprises a crank gear and a crank connecting rod, wherein the crank gear is engaged with the adjustable gear shaft, and the crank connecting rod comprises an end connected to the crank gear and the other end in contact with the braking bar, wherein while the crank gear starts to rotate, the crank connecting rod drives the braking bar from the start position to the braking position.

11. The flow processing device according to claim 10, wherein the housing comprises a second guiding slot, and the crank connecting rod comprises at least one guiding pin received in the second guiding slot.

12. The flow processing device according to claim 10, wherein the housing comprising at least one third guiding slot, and an end of the braking bar is received in the third guiding slot.

13. The flow processing device according to claim 10, wherein the flow processing unit comprises a spring connected to the braking bar and a control switch bar connected to the adjustable gear shaft and comprising a blocking end configured to block the braking bar at the braking position, wherein while the adjustable gear shaft is moved to the second position, the blocking end is separated from the braking bar,

and the braking bar is driven by the spring to move from the braking position to an unlock position.

14. The flow processing device according to claim 10, wherein the adjustable gear shaft comprises a connecting gear engaged with the crank gear, wherein the gear ratio of the connecting gear and the crank gear is smaller than 0.1.

15. The flow processing device according to claim 3, wherein the flow processing unit comprises a knob or a handle connected to an end of the main gear shaft and configured to rotate the main gear shaft.

16. The flow process device according to claim 15, wherein the gear set comprises a spring windup module disposed on the housing and connected to the main gear shaft to store a driven energy for rotating the main gear shaft.

17. The flow processing device according to claim 3, wherein the cartridge comprises a thin film disposed on a bottom of the second chamber, and the disturbing cam is flower-shaped, wherein while the main gear shaft drives the disturbing cam of the adjustable gear shaft to push one end of the third piston, the other end of the third piston contacts with the thin film and drives the thin film to vibrate to disturb the fluid in the second chamber.

18. The flow processing device according to claim 1, wherein each of the first chamber, the second chamber, and the third chamber comprises a rubber plunger disposed at an original position aligned with the first piston, the third piston, and the fourth piston, respectively, wherein while the rubber plunger is pushed, the rubber plunger is maintained at a pumped position.

19. The flow processing device according to claim 1, wherein the valve comprises a rubber plunger disposed at an original position aligned with the second piston, wherein while the rubber plunger is pushed, the rubber plunger is maintained at a blocked position.

20. The flow process device according to claim 1, wherein the cartridge is made by thermoplastic material, polymer, paper, glass, silicon, metal, or a combination thereof.