April 9, 1957 KAZUHARU KATO ET AL 2,788,170

AQUARIUM AERATOR

Filed Nov. 2, 1953 2 Sheets-Sheet 1

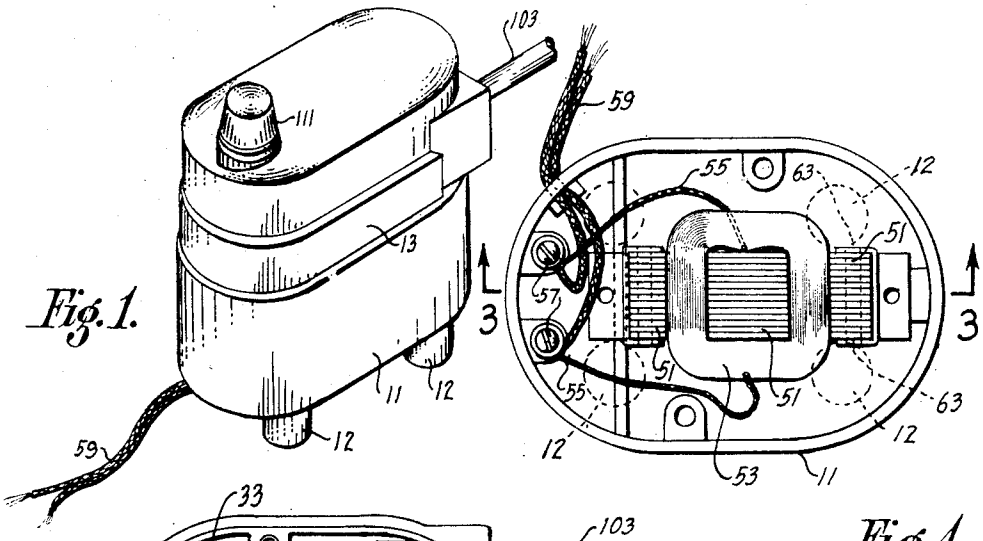


Fig. 1.

Fig. 4.

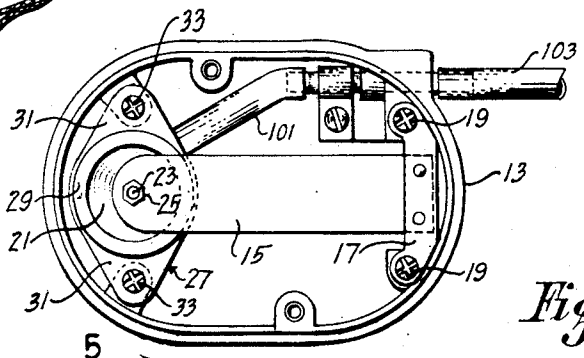


Fig. 2.

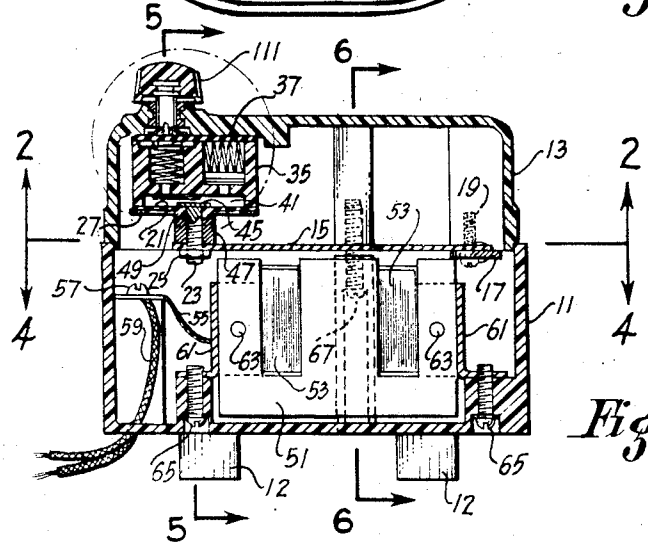


Fig. 3.

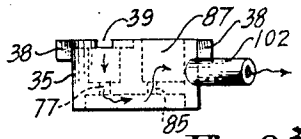


Fig. 3A.

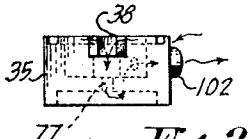


Fig. 3B.

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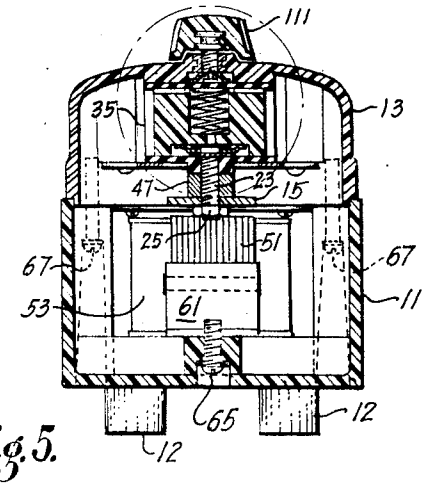


Fig. 5.

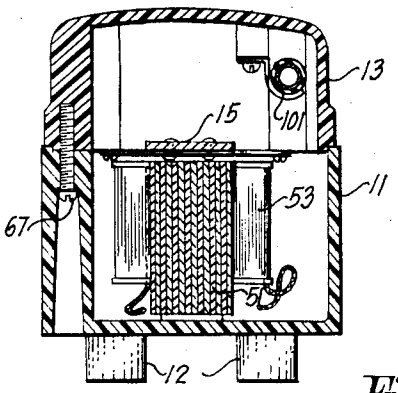


Fig. 6.

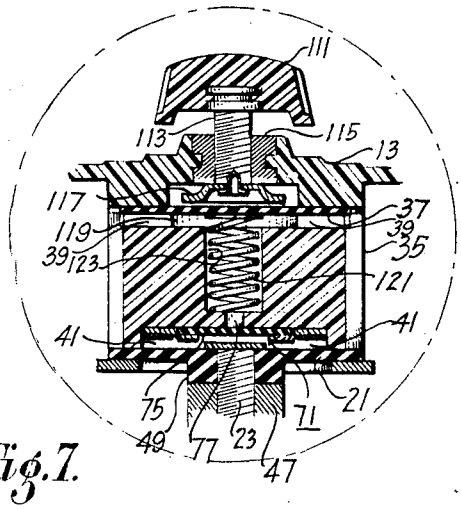


Fig. 7.

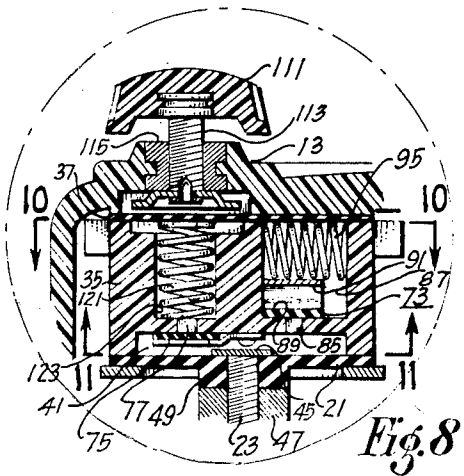


Fig. 8.

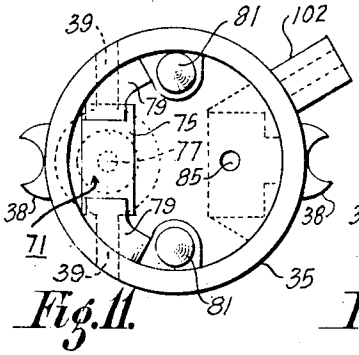


Fig. 11.

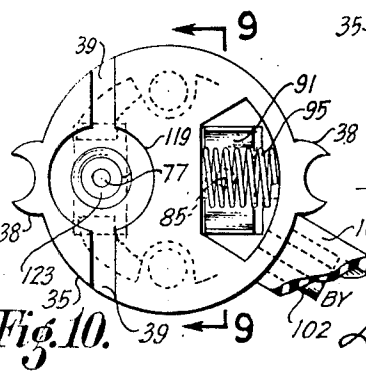


Fig. 10.

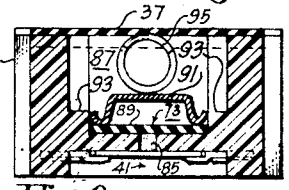


Fig. 9.

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AQUARIUM AERATOR

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Application November 2, 1953, Serial No. 389,827

6 Claims. (Cl. 230—23)

The present invention relates to an air pump of the diaphragm type, actuated by a magnetically driven vibrating reed. Particularly, the pump is adapted to supply air bubbles to water tanks for the purpose of supplementing the oxygen content. However, it should be realized that the pump of the instant invention finds general application in the field of gas supply.

Prior art aquarium aerators, in general, relay upon an adjustment of the frequency of vibration of the pump reed to regulate the rate of air flow to the tank. Such mechanisms, whether mechanical or electrical, are relatively complex in contrast with the solution offered by the present invention and add greatly to the cost of such products.

The present invention provides flow regulation without altering the spacing between the vibrating reed and its driving source thereby affording a compact pump. The invention requires no adjustment of current through an electro-magnetic driver and hence is unconcerned with temperature compensation or heating problems.

The pump of the instant invention includes a valve housing having an inlet valve and an outlet valve adapted to be opened alternately respectively to admit and exhaust air in respect to the housing. A reed actuated diaphragm draws air along an inlet passage-way, through the inlet valve and into an air chamber recess formed in the housing and covered by the diaphragm and exhausts the contained air on the succeeding or reverse reed and diaphragm stroke along an outlet passage-way, through the outlet valve and out of the housing by way of an exhaust conduit. Means are provided to restrict the inlet opening so as to regulate the volume of air to be pumped per stroke. These valves are of the uni-directional flap type wherein the inlet valve is opened on the suction stroke and the exhaust valve is opened on the pump stroke, the inlet valve being maintained closed by increased air chamber pressure during the latter stroke and the exhaust valve being maintained closed by suction or reduced air chamber pressure on the former stroke.

The means for regulating the flow of air to the chamber comprises a flexible plate adapted to be pressed into a recess forming a part of the air inlet passage-way to restrict the passage-way as desired. Control of the inlet air supply permits the pump to be adjusted over a wide range of output.

A further feature of the invention resides in the provision of an exhaust chamber formed in the valve housing between the exhaust valve and the exhaust conduit. The volume of air forced from the air chamber to the exhaust conduit on each pump stroke loses velocity upon entering the exhaust chamber and hence the supply of bubbles to the tank is somewhat averaged over both strokes rather than completely intermittent. It might be noted that the general source of power supply is 60 cycle-110 volt so that each stroke of the pump only consumes $\frac{1}{120}$ second and the smoothing action per pump stroke need only be effective over a $\frac{1}{60}$ second interval.

With the foregoing in mind, among the objects of the present invention are: the provision of a compact gas pump admitting of economy of manufacture; the provision of a gas pump including mechanical means for regulating the gas volume pumped; and the provision of a gas pump having a substantially uniform output flow.

The present invention will be more apparent to those skilled in the art from a reading of the following detailed explanation thereof when viewed in the light of the accompanying drawing wherein:

Fig. 1 is a view in perspective of an aquarium aerator in accordance with the present invention;

Fig. 2 is a bottom plan view of the cover of the pump of Fig. 1;

Fig. 3 is a longitudinal sectional view of the pump of Fig. 1;

Fig. 3A is an elevational view of the valve housing of the pump;

Fig. 3B shows the valve housing in side elevation and rotated approximately 90° from the position shown in Fig. 3A;

Fig. 4 is a view in plan of the pump of Fig. 1 with the cover removed;

Fig. 5 is a sectional view of the pump of Fig. 1, the plane of section being indicated by the line marked 5—5 of Fig. 3;

Fig. 6 is a further sectional view of the pump of Fig. 1, the plane of section being taken along the line 6—6 of Fig. 3;

Fig. 7 is an enlarged view of a portion of the structure shown in Fig. 5;

Fig. 8 is an enlarged view of a portion of the structure shown in Fig. 3;

Fig. 9 is a view in section of the valve housing, the plane of section being indicated by the line 9—9 of Fig. 10;

Fig. 10 is a view in plan of the valve housing per se;

Fig. 11 shows the valve housing of Fig. 10 in bottom plan.

The compact unit of Fig. 1 comprises a base **11**, having supporting feet **12**, and a cover **13** each adapted to contain components of the pump. The base and cover may each be conveniently molded of plastic, such as bakelite, to provide an inexpensive unit requiring no machining. The interior of the cover **13** is exposed in Fig. 2, as generally seen along the plane 2—2 of Fig. 3. A vibrating reed **15** of iron or magnetizable metal is riveted or otherwise securely attached to a stay or cross bar **17** secured to the cover by the screws **19**. The free end of the reed **15** is secured to the center of a resilient diaphragm **21** by means of a screw **23** and locking nut **25**. An annular flange **27** is provided with a downwardly directed recess **29** adapted to accommodate the diaphragm **21** and ears **31** for attachment to the cover **13** by means of the screws **33**.

The outer edge or peripheral portion of the diaphragm **21** is compressed against a valve housing **35** (Figs. 3 and 8) so that the flange **27** supports the housing against the inner surface of the cover **13**. A flexible plate **37** is positioned between the cover **13** and the housing **35** and is also under slight compression about its outer edge or peripheral portion due to the manner of housing support. The housing **35** is positioned by a pair of ears **38** (Figs. 3A, 10 and 11) adapted to receive pins (not shown) depending from the inner surface of cover **13**. The diaphragm **21** and flexible plate **37** seal the upper and lower faces of the housing **35** with the exception of a pair of air inlet grooves or passage-ways **39** (Figs. 3A and 10) oriented as a chord of the housing **35**. The lower surface of the housing is recessed to provide an air chamber **41** when the diaphragm is secured in position.

The diaphragm **21** is attached to the reed **15** by the

screw 23 which has a flat head 45 disposed against one side of the diaphragm. The screw also accommodates a collar 47 in abutting relation with a raised central portion 49 of the diaphragm and the reed 15. The nut 25 secures the structure as outlined to the reed 15.

The reed 15 is adapted to open and close a pair of magnetic paths comprising the laminations 51 of an electro-magnet having three legs and a coil 53 disposed about the central leg, best shown in Fig. 4 as seen along the plane 4—4 of Fig. 3. The coil 53 is connected by way of leads 55 to a pair of terminals 57 adapted to accommodate an electrical cord 59 for attachment to a wall outlet. The laminations 51 of the electro-magnet are supported by a pair of U-shaped clamps 61 riveted thereto as at 63 and secured to the base 11 by the screws 65. Hence, it may be seen that the reed 15 is permanently secured to the cover 13 and the electro-magnet is positively attached to the base 11. When the cover 13 is secured to the base 11 by the screws 67 (Figs. 5 and 6) reed vibration occasioned by the electro-magnet is transmitted to the diaphragm 21.

The housing 35 is provided with an inlet valve generally designated at 71 (Figs. 7 and 11) and an outlet valve generally shown at 73 (Figs. 8 and 9). The inlet valve 71 is located in the air chamber 41 and comprises a resilient flap 75 adapted to cover the inlet air opening 77 (Figs. 8 and 11). The flap is supported near its edges by a pair of spring arms 79. The arms 79 are fixed to the housing 35 by a pair of pins 81 and clamp the edges of the resilient flap 75 against the upper wall of the housing recess or air chamber 41 so that air can only be admitted to the chamber 41 when the flap 75 is moved away from the air inlet hole 77. An air outlet hole 85 (Figs. 8 and 9) also communicates with the air chamber 41 and opens into an air exhaust compartment 87 by way of the exhaust valve 73. The valve 73 also includes a resilient flap 89 which covers the air outlet hole 85 and is clamped on either side of the opening 85 by an inverted channel 91 disposed between a pair of shoulders 93 of the exhaust compartment 87 and maintained in position by a spring 95 which extends laterally of the compartment 87 and is held in position by the flexible plate 37 in contact with the inner surface of the cover 13. Hence it may be seen that air can only be exhausted from the air chamber 41 when the resilient flap 89 is raised to uncover the passage-way or hole 85.

The operation of the pump will now be described. The inlet or suction stroke of the pump occurs when the reed 15 is drawn into contact with the laminations 51 and the pump or exhaust stroke takes place as the reed 15 moves into its upper position or out of contact with the laminations 51. On the downward strokes of the reed 15 the diaphragm 21 sucks air in along the grooves or passage-ways 39 (Fig. 10), down through the air inlet 77 and into the compartment 41, the flap 75 of the inlet valve 71 being moved downward against its resiliency to admit air to the chamber 41. Since suction is established during the inlet stroke the flap 89 of exhaust valve 73 tightly covers the exhaust opening 85 permitting the pressure in chamber 41 to be increased. During the exhaust or pumping stroke the reed 15 moves to its upper position causing the diaphragm 21 to force the air out through passage-way 85, opening the outlet valve 73 by moving the flap 89 upwardly against its own resiliency thereby permitting the air to escape into compartment 87 by moving along the tunnel formed by the U-shaped channel 91. The compartment 87 serves to smooth the flow of exhaust air which passes along outlet tube 101 in communication with outlet stub 102 (Fig. 3A) and exhaust pipe 103 (which leads to the aquarium not shown). This action is of course continuous to supply air bubbles to the tank to be aerated.

Regulation of the air supply admitted to chamber 41 is under the control of a thumb screw 111 best shown in detail in Fig. 7. The thumb screw 111 has a threaded shank 113 which engages the threads of a collar 115 set in the cover 13. The lower end of the shank 113 is connected to an inverted cup 117 adapted to depress the flexible plate 37, which forms the upper walls for air inlet grooves 39, into an opening or recess 119 ((Fig. 10) in the upper surface of the housing 35. This action restricts the passage-ways 39 to limit the air supply to chamber 41 on the suction stroke and hence the volume of air delivered by the pump to the tank. When the thumb screw 111 is completely depressed, the inverted cup 117 presses a circular portion of the flexible plate 37 into the recess 119 to close the air passage-ways 39 thus cutting off the inlet air supply. Hence, adjustment of the thumb screw position controls the air pumped. A coil spring 121 (Figs. 7 and 8) is located in cylindrical recess 123 of housing 35 and comprises the portion of the air inlet passage-way between the air chamber duct 77 and the air intake grooves 39. The spring 121 presses upwardly against the flexible plate 37 so that the latter always maintains the air inlet grooves 39 open as far as the screw 111 and inverted cup 117 permit.

Having now described the invention, what is claimed is:

1. An air pump comprising, in combination, a valve housing having a recess in a face thereof and a pair of air passage-ways from the recess to the housing exterior, said housing having a concavity, an exhaust conduit in communication with one of the passage-ways via the concavity, a diaphragm closing the recess to form an air chamber in the housing, means for maintaining at least a peripheral portion of the diaphragm in air-tight relation with walls of the recess, an exhaust valve disposed within the concavity to open said one passage-way upon pressure increase in the air chamber, an intake valve located within the air chamber to open the other of said passage-ways upon pressure decrease in the air chamber, a flexible plate comprising one wall of the passage-way through the inlet valve, means for moving the flexible plate in the direction of the housing to restrict the air passage-way through said inlet valve, and means for cyclically moving the diaphragm away from and in the direction of the housing to decrease and increase the air pressure in said pump.

2. An air pump comprising, in combination, a cylindrical valve housing having a substantially circular recess in a face thereof and a pair of air passage-ways from the recess to the housing exterior, said housing having a concavity, an exhaust conduit in communication with one of the passage-ways via the concavity, a diaphragm closing the recess to form an air chamber in the housing, means for maintaining at least a peripheral portion of the diaphragm in air-tight relation with walls of the recess, spring arms disposed within the concavity adjacent to said one of the passage-ways, a resilient member clamped across said one of the passage-ways by the spring arms to open it upon pressure increase in the air chamber, further spring arms located within the air chamber adjacent to the other of said passage-ways, a further resilient member clamped across said other of the passage-ways to open it upon pressure decrease in the air chamber, said housing having a grove in a face opposed to said first mentioned face in communication with the other of the passage-ways, a flexible plate disposed on the last mentioned face to cover the groove, means for moving the flexible plate in the direction of the housing to restrict the groove and thereby limit the air inlet supply, and means for cyclically moving the diaphragm away from and in the direction of the housing to decrease and increase the air pressure in said pump.

3. An air pump comprising, in combination, a hollow cover, a valve housing having a recess in a face thereof supported within the cover, a diaphragm adapted to abut the face and close the recess thereby defining an air chamber, a flange supported by the cover for maintaining outer portions of the diaphragm in contact with the face, a hol-

low base adapted to engage with the cover to form an enclosure, means located within the base for moving the diaphragm to increase and decrease the size of the air chamber, said housing having an open groove in a face opposed to said first mentioned face and an air inlet passage-way from the groove to the chamber, an air exhaust conduit, said housing having an air outlet passage-way from the chamber to the exhaust conduit, an intake valve to open and close the air inlet passage-way upon increase and decrease of the chamber size, an exhaust valve to open and close the air outlet passage-way upon decrease and increase of the chamber size, a flexible plate positioned between said last mentioned face and the cover interior, and manually adjustable means penetrating the cover to depress the plate in the direction of the housing for restricting the air inlet groove whereby control is established cover the volume of air pumped to the exhaust conduit.

4. An air pump comprising, in combination, a hollow base and a hollow cover adapted to fit together to form an enclosure, a cylindrical valve housing having a circular recess in an end thereof, said housing having an eccentrically located recess in an end thereof opposed to said first mentioned recess, said housing having an open groove in said last mentioned end deployed as a chord intersecting the eccentrically located recess, a flexible plate adapted to fit the last mentioned end of the housing to cover the groove and eccentrically located recess, a diaphragm adapted to abut the first mentioned end of the housing and close the circular recess to define an air chamber, a flange having a central opening secured across the mouth of the cover to support the diaphragm against the housing and the housing against the cover interior by way of the flexible plate, a reed secured to the diaphragm through the central opening of the flange, a cross bar secured across the mouth of the cover for anchoring an end of the reed remote from the diaphragm attached end, an electromagnet disposed within the base to vibrate the reed when the cover is fitted to the base thereby increasing and decreasing the size of the air chamber, said housing having an air inlet passage-way between the eccentrically located recess and the chamber, said housing an air exhaust compartment, an exhaust conduit leading from the compartment externally of the housing, said housing having an air outlet passage-way from the chamber to the compartment, an intake valve effective to open and close the air inlet passage-way upon increase and decrease of the chamber size, an exhaust valve effective to open and close the air outlet passage-way upon decrease and increase of the chamber size, a coil spring within the eccentrically located recess bearing upwardly against the flexible plate, and manually adjustable means penetrating the cover to depress the plate against the force of the coil spring into the eccentrically located recess for restricting the groove whereby control is established over the volume of air pumped to the exhaust conduit.

5. The air pump of claim 4 wherein the intake valve comprises a resilient strip positioned across the inlet passage-way within the chamber, and a pair of spring arms clamping the ends of the strip against the inner wall of the circular recess.

6. The air pump of claim 4 wherein the exhaust valve comprises a resilient strip positioned across the air outlet passage-way within the compartment and an inverted channel clamping the ends of the strip against the lower wall of the compartment.

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