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"AIR_PUMP"

DESCRIPTION

5 This invention relates to improvements in and concerning an air pump for supplying air into water, particularly into water in an aquarium.

The conventional air pump generally comprises, as
10 illustrated in Figure 1, a case 1, a reciprocating arm
3 disposed in the case 1, pivotally supported at one
end thereof by a support member 2 and provided at the
other end thereof with a permanent magnet 4. A
driving electromagnet 7 formed by winding a coil 6 on
15 a core 5 is disposed inside the case 1 with the core 5
opposed to the permanent magnet 4. A diaphragm 9 is
fitted on a valve housing 8 and held in place by a pin
10 on the arm 3 partway along the length thereof. An
air suction inlet 12 is formed in the valve housing 8
20 on the side incorporating a suction valve 11, and an
air discharge outlet 14 is formed on the valve housing
8 on the side incorporating a discharge valve 13. A
tube 15 is connected at one end thereof to the
aforementioned air discharge outlet 14 and at the
25 other end thereof to an air permeating stone inside an

aquarium. When the driving electromagnet 7 is actuated by supply of alternating current, the arm 3 is reciprocated about the support member 2 by the interaction between the rapidly alternating N and S poles generated in the core 5 and the magnetic poles of the permanent magnet 4, and thus the diaphragm 9 alternately inflates and deflates to a slight degree so as to suck in air through the air suction inlet 12 and discharge air through the air discharge outlet 14 by virtue of the valves 11, 13.

The first drawback resides in the fact that when the driving electromagnet 7 is actuated and the arm 3 drives the diaphragm 9, even if the reciprocation commences from a point adjacent the centre of travel of the permanent magnet 4 (which is the optimum position), the diaphragm 9 tends to inflate with continued operation until the axis of arm 3 reaches the position indicated by chain line in Figure 1, which is far removed from the optimum position as a result, the discharge of air is insufficient because the amplitude of reciprocation of the arm 3 is low and the change in the position of the diaphragm 9 between its inflated and deflated states is small.

5 The second drawback resides in the fact that while one end of the arm 3 should be supported without inducing an frictional resistance, the supporting of the arm 3 cannot actually be attained with the no frictional resistance. When the arm 3 is reciprocated therefore, the friction loss generated by the support member 2 reduces the amplitude of reciprocation of the arm 3. The discharge of air is thus insufficient.

10 Another drawback lies in the fact that with elapse of time, the support member 2 gradually wears and eventually reaches a point when the required support for the arm 3 is lacking and, as a result, the arm 3 slips off the support member 2 to interrupt the
15 operation of the pump.

20 The present invention seeks to overcome the drawbacks described above. Specifically, the present invention aims to provide an air pump which permits an efficient supply of air into water.

 According to the present invention, therefore, there is provided an air pump comprising a valve housing capped with a diaphragm and being provided with an air

suction inlet valve and an air discharge outlet valve,
said diaphragm being fastened to a driving arm, a
permanent magnet secured to an end of the driving arm
and juxtaposed the core of an electromagnet,
5 characterised by a further housing fastened to a
respective diaphragm and in that the driving arm is
operatively supported only by the diaphragms whereby
actuation of the electromagnet causes the driving arm
to oscillate about a point between the supporting
10 diaphragms.

Air pumps according to the present invention will now
be described, by way of example only, with reference
to the accompanying drawings, in which:-

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Figure 1 is a schematic view of a conventional air
pump.

Figure 2 is a schematic view illustrating the basic
20 construction of an air pump according to the present
invention.

Figure 3 through Figure 6 are schematic views each illustrating an air pump according to the present invention.

5 Figure 2 shows the basic construction of an air pump according to the present invention. A driving electromagnet 17 disposed inside a case 16 comprises a U-shaped core 18 and a coil 19 wound around one of the shanks of the core 18. Inside the case 16, two valve housings 20, 20' are disposed in a spaced array.

One of the housings indicated by 20 is provided internally with an air suction valve 21 and an air discharge valve 22. It is further provided on the air suction valve 21 side thereof with an air suction inlet 23 and on the air discharge valve 22 side thereof with an air discharge outlet 24. The other valve housing 20' is not internally provided with an air suction valve or an air discharge valve but is provided with an air suction inlet 23' and an air discharge outlet 24' which both communicate with the interior of the housing.

The two housings are capped with diaphragms 25, 25'. A slender driving arm 26 is fastened by pins 27, 27' to the two diaphragms 25, 25'. The opposite ends of this arm 26 are supported only upon the diaphragms 25, 25'. The arm 26 is provided at

one end thereof with a permanent magnet 28. This permanent magnet is disposed opposite the opening separating the two leading ends of the U-shaped core 18. Of the aforementioned valve housings, 20, 20', the valve housing 20, which is provided internally with the air suction valve and the air discharge valve, is disposed nearer to the electromagnet 17 and the valve housing 20' provided with neither an air suction valve nor an air discharge valve is disposed farther from the electromagnet 17. The air discharge outlet 24 of the valve housing 20 and the air suction inlet 23' of the valve housing 20' are interconnected by an air path 29. An air discharge path 30 is connected to the air discharge outlet 24' of the valve housing 20'. The remaining end of the aforementioned air discharge outlet 30 is connected to an air permeable stone inside an aquarium (not shown)

The basic construction of the air pump of the present invention is as described above. When an alternating current is passed through the coil 19 of the electromagnet 17, the arm 26 reciprocates by the magnetic action between the alternating N and S poles generated at the leading end portions of the core 18 and the permanent magnet 28. In this case, owing to the initial vibration of the arm 26, the inner pressure is heightened to a certain degree in each of the valve housings 20, 20' and the diaphragms 25, 25' are proportionately inflated. The condition so assumed by the diaphragms 25, 25' represents the standard position for the reciprocation of the arm 26 (dotted line in Figure 2). In its actuated condition, the arm 26 swings about a point or node "a" as its

center. When the diaphragm 25 is inflated, the other diaphragm 25' is contracted. When the diaphragm 25 is contracted, the other diaphragm 25' is inflated. When the diaphragms 25 is inflated, the air is sucked in via the air suction inlet 23 into the valve housing 20 by the action of the air suction valve 21. When the diaphragm 25 is contracted, the air held inside the valve housing 20 is discharged through the air discharge outlet 24 by the action of the air discharge valve 22. The air discharged via the air discharge outlet 24 advances through the air path 29 into the valve housing 20' and departs from the air discharge path 30.

When the electromagnet 17 is actuated therefore, the arm 26 is reciprocally driven despite the fact that it is not pivotally attached at either end. Thus, the air pump is allowed to fulfill its function fully.

Owing to the operation of the diaphragms 25, 25', the point "a" is enabled to occur between the portions

(pins 27, 27') at which the arm 26 is fixed to the diaphragms 25, 25'. To be precise, the point "a" is slightly toward the diaphragm 25' from the center between the two portions of fixation. This phenomenon is ascribable to the presence of the permanent magnet 28 at one end of the arm 26 and the absence of a permanent magnet at the other end, namely the lack of balance between the opposite ends of the arm 26. While the arm 26 is in the state of vibration, the conditions of inflation and contraction of the diaphragm 25 change more than those of inflation and contraction of the diaphragm 25'.

Figure 3 depicts another air pump embodying the present invention. The arm 26 is provided at one end thereof with a permanent magnet 28 and at the other end thereof with a permanent magnet 31 which is identical with the permanent magnet 28. The former permanent magnet 28 is opposed to the opening in the electromagnet 17. The two valve housings 20, 20' are provided with air suction valves 21, 21' and air discharge valves 22, 22' respectively. The air discharge path 30 is connected in common to the air discharge outlet 24, 24' respectively of the two valve housings 20, 20'. Further, in the arm 26, the portions at which the diaphragms 25, 25' are fixed to the arm 26 with pins 27, 27' are symmetrical, so that the length from the permanent magnet 28 to the fixed portion of one diaphragms 25 is equal to the length from the other permanent magnet 31 to the fixed portion of the other diaphragm 25'.

In the present embodiment, therefore, the arm 26 is well balanced. When the electromagnet 17 is actuated and the arm 26 is driven, the point "a" falls exactly at the center between the fixed portions of the two diaphragms. As a result, the

conditions of inflation and contraction caused by the shaking arm are equal between the two diaphragms 25, 25' and the air discharge outlets 24, 24' of the valve housings 25, 25' alternately discharge an equal volume of air. In this embodiment, the magnet 31 is disposed as described above for the purpose of counterbalancing the weight of the magnet 21. Thus, it may be replaced with some other object which is capable of fulfilling the purpose just mentioned.

Figure 4 depicts yet another air pump embodying the present invention. This embodiment differs in construction from that of Figure 3 in respect that the air path 30 is connected to the air discharge outlet 24 of the valve housing 20 disposed closer to the electromagnet 17, and an air discharge path 33 provided with a control valve 32 is connected to the air discharge outlet 24' of the valve housing 20' disposed farther from the electromagnet 17. Since Figure 4 is the same as Figure 3 except for the points described above, description of its construction is omitted. In the air pump constructed as described above, when the control valve 32 is closed and the electromagnet 17 is excited to set the arm 26 in motion, the diaphragm 25 of the valve housing 20 disposed nearer to the electromagnet 17 is alternately inflated and contracted and the air introduced via the air suction inlet 23 is forced out into the air path 30 via the air discharge outlet 24. Since the air discharge outlet 24' of the other valve housing 20' is kept in a closed state in this case, the inner pressure of the valve housing 20' gradually increases and causes the diaphragms 25' to be inflated to the point of ceasing the alternation of inflation and contraction. As a result, the point "a" of the arm 26 shifts from the center between the two diaphragms toward the

diaphragm 25' which is gradually inflating and finally reaches the fixed portion of the inflated diaphragm 25'. Thereafter, the shaking arm vibrates about this fixed portion as its fulcrum. Thus, the extents of inflation and contraction caused in the diaphragm 25 can be increased and the amount of air discharged can be proportionately increased.

In the air pump of Figure 4 operated as described above, the control valve 32 can be adjusted so as to control the inner pressure of one of the valve housings and consequently change the position of the fulcrum point of the shaking arm as desired. Thus, the volume of air discharged can be continuously and appreciably varied by adjusting the alternate inflation and contraction of the other diaphragm.

In Japan, depending on the district, commercial line current is supplied at 50 cycles or 60 cycles and whether an air pump will operate efficiently at one of these cyclages normally depends on the length of the

arm²⁶ and the resilient force of the diaphragms²⁵. In accordance with the embodiment of Figure 4, however, since the change of the position of the fulcrum point constitutes itself a substantial change in the length of the arm, the air pump is enabled to operate most efficiently without reference to the cycle of the alternating current by suitably adjusting the volume of air flowing through the air discharge path 33 with the control valve 32 and setting the fulcrum point appropriately.

Figure 5 depicts still another air pump embodying the present invention. This embodiment differs in construction from that of Figure 3 in respect that two electromagnets 17, 17' are disposed as opposed to the permanent magnets 28, 31 at the opposite ends of the arm 26.

When the electromagnets 17, 17' are opposed to the opposite ends of the arm 26 as in the present embodiment, the arm 26 is caused by the actuation of the two electromagnets 17, 17' to reciprocate powerfully about the point "a", with the result that the diaphragms 25, 25' are alternately inflated and contracted to induce discharge of air through the air discharge path 30 connected in common to the air discharge outlets 24, 24' respectively of the valve housings 20, 20'.

Figure 6 depicts another air pump embodying the present invention. Inside the case 16, two sets each of laterally paired valve housings 20, 20' are disposed as vertically opposed to each other. Two arms 26a, 26b are fastened one each to two sets each of laterally paired diaphragms 25, 25' adapted to cap the valve houses 20, 20'. The arms 26a, 26b are each provided at the opposite ends thereof respectively with permanent magnets 28, 31. The two electromagnets 17, 17' disposed in the opposite end portions of the interior of the case 16 are opposed to the permanent magnets 28, 31. Thus, the two arms 26a, 26b are laid parallelly to each other.

In the present embodiment, therefore, when the two electromagnets 17, 17' are actuated the magnetic action generated between the two electromagnets 17, 17' and the permanent magnets 28, 31 drives the arms

26a, 26b and the operation of the diaphragms induces discharge of air through the air discharge paths 30a, 30b. In this embodiment, the cores 18, 18' of the electromagnets 17, 17' are in the shape of the letter E so that the permanent magnets may be opposed to the openings separating the adjacent leading ends of the core.

In the embodiments of Figure 5 and Figure 6

described above, when the alternating current is passed in ~~the~~ same direction through the coils 19, 19' of the two electromagnets 17, 17', the surfaces of the permanent magnets 28, 31, disposed at the opposite ends of the arm(s) 26 (26a, 26b) which are directed toward the corresponding electromagnets, are polarized oppositely. When the alternating current is passed in opposite directions through the cores 19, 19' of the two electromagnets, however, the aforementioned surfaces of the permanent magnets 28, 31 disposed at the opposite ends of the arms are similarly polarized. As a result, the arms 26 are each enabled to reciprocate about the point "a" at the center of the fixed portions of the diaphragms.

As is clear from the foregoing description, the present invention can reduce the deviation of the permanent magnet due to the change of the position of the arm during the inflation of the diaphragm while the air pump is in operation because the arm is supported in place by two diaphragms without requiring either of the opposite ends thereof to be pivotally attached. The magnetic action generated between the electromagnet and the permanent magnet is highly effective and the drive produced by the arm is powerful enough for the inflation and contraction of the diaphragm to be effected efficiently and for the amount of air discharged to be increased. Since the arm is not pivotally attached, the diaphragm is operated efficiently without entailing significant mechanical frictional loss. This invention, accordingly, provides an air pump of high economic value.

CLAIMS:

1. An air pump comprising a valve housing capped with
a diaphragm and being provided with an air suction
5 inlet valve and an air discharge outlet valve, said
diaphragm being fastened to a driving arm,

a permanent magnet secured to an end of the driving
arm and juxtaposed the core of an electromagnet,

10 characterised by a further housing fastened to a
respective diaphragm and in that the driving arm is
operatively supported only by the diaphragms whereby
actuation of the electromagnet causes the driving arm
15 to oscillate about a point between the supporting
diaphragms.

2. An air pump according to claim 1 wherein said
driving arm is provided with a permanent magnet at
20 each end.

3. An air pump according to either preceding claim
wherein the air discharge outlet of one of said two



housings is connected to the air suction inlet of the other housing.

4. An air pump according to any of claims 1 to 3
5 wherein the air discharge outlets of the two housings are connected to one common air discharge path.

5. An air pump according to claim 1 wherein one of
said housings has no air inlet or air discharge valve
10 and wherein the air outlet is provided with an adjustable control valve whereby the oscillation stroke of the driving arm acting upon the other diaphragm can be controlled.

15 6. An air pump substantially as hereinbefore set forth with reference to and/or as illustrated in Figures 2 to 6 of the accompanying drawings.

