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DIAPHRAGM PUMP

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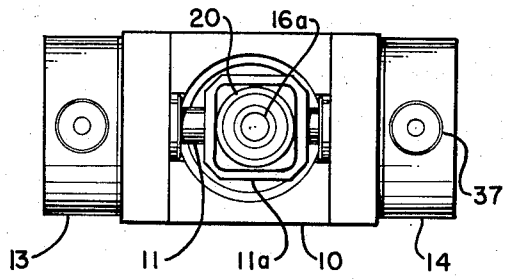


Fig. 2

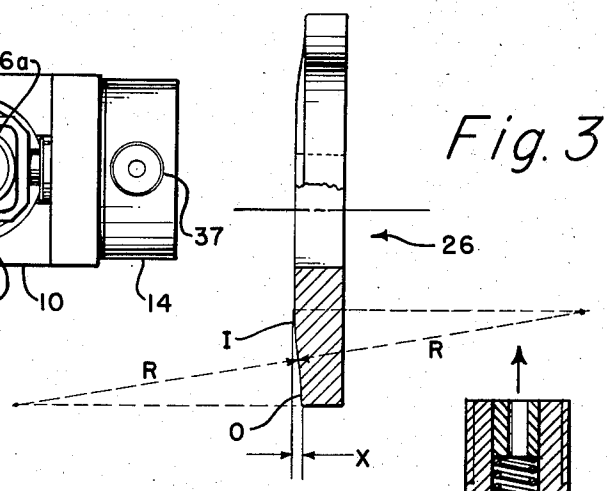


Fig. 3

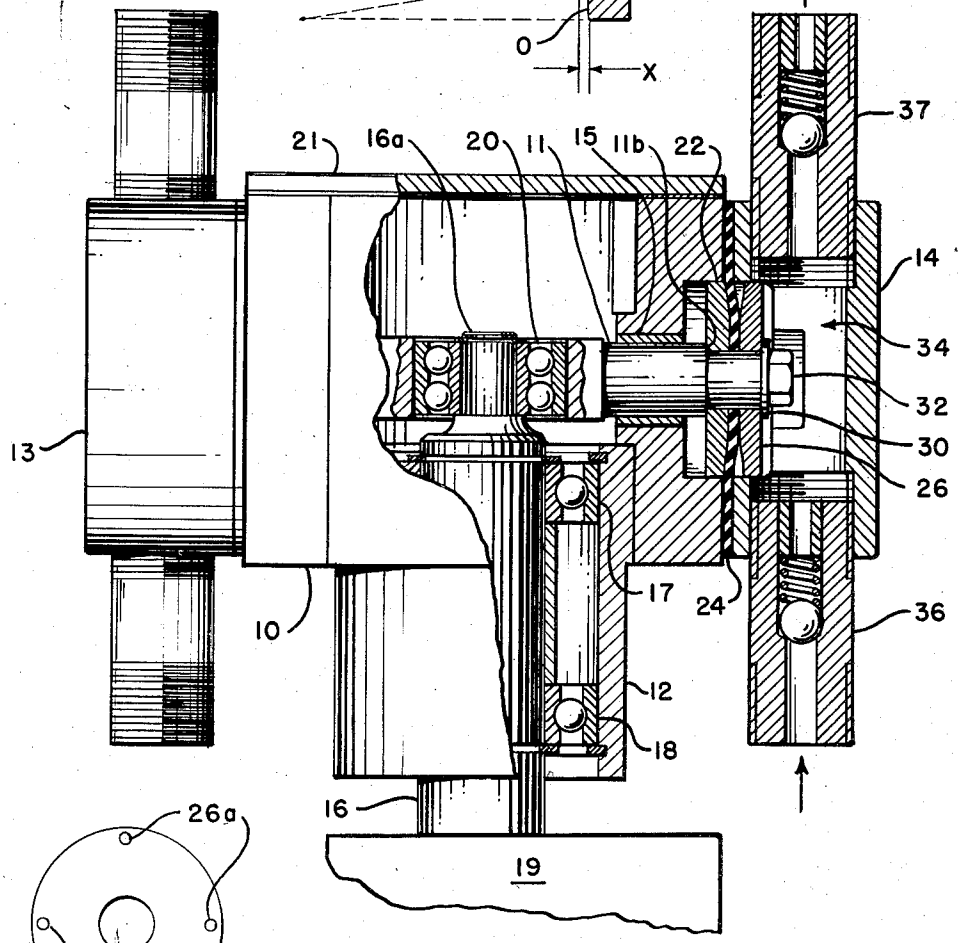


Fig. 1

Fig. 4

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DIAPHRAGM PUMP

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The invention here relates to a pump of the diaphragm type and in particular to a pump for use with porcelain enamel slips and other liquid suspensions of abrasive material.

In the electrostatic spray coating of articles of manufacture such as automatic home laundry equipment it is necessary to quite accurately meter the flow of porcelain enamel slip or other liquid coating material to the atomizing device. Difficulties arise when ceramic materials are to be fed to the atomizing device. Because of the extreme abrasive qualities of ceramic materials, it is desirable to use a diaphragm pump but no known diaphragm pump would accurately deliver over long periods of time the precise volumes of liquid coating material required for high quality electrostatic spray coating.

The invention provides a diaphragm pump highly resistant to abrasive materials which will deliver extremely constant flows of liquid substantially entirely free from the influence of variations in pump chamber pressures and liquid viscosities and which will deliver such flows for lengthy periods of time. The pump includes novel diaphragm control members which materially reduce the unit bending stresses in the diaphragm and thereby increase the life of the diaphragm as well as insure uniform deformation of the diaphragm for each cycle of the pump and thereby insure a consistent flow of liquid. Preferably the pump chamber is essentially a small vertical cylinder which minimizes undesirable settling within the chamber of solids from the liquid being pumped.

An object of this invention is to provide a simple pump which will resist wear, closely meter the flow of liquid, and operate over long periods of time with a minimum of attention. Means for accomplishing the foregoing and related objects of the invention will now be described in detail with reference to the accompanying drawings in which:

Fig. 1 is a partially broken away elevational view of an embodiment of the invention;

Fig. 2 is a plan view of the pump shown in Fig. 1 with its cover plate removed;

Fig. 3 is a partial cross-sectional view of one of the diaphragm control members in Fig. 1 showing its construction; and

Fig. 4 is a further view of the diaphragm control member.

The invention is particularly adapted for pumps for liquids containing abrasive material. However, the invention is not so limited, may be used for any liquid, and may assume many different forms. The following description is illustrative of the principles of the invention whose scope is not to be restricted by such description.

Figs. 1 and 2 show two similar pump units embodying the invention and operated from a single source of power. The apparatus includes a main pump casing **10**, which is bored to receive an eccentrically driven plunger **11**, and a lower casing **12** adapted to receive a drive shaft for the plunger. Mounted on opposite sides of main casing **10** are a pair of similar pump heads **13** and **14**, only the latter of which will be described in detail.

Plunger **11** is adapted to be moved on bearings **15** (only one being shown) back and forth along its axis by means of an eccentric motion transmitted by a drive shaft **16** which is rotatably mounted on a pair of anti-friction bearings **17** and **18** which in turn are mounted within lower casing **12**. Drive shaft **16** is rotated by a suitable source of power **19**, the details of which form no part of the invention.

The upper end **16***a* of drive shaft **16** is cylindrical with its axis set eccentrically in relation to the major axis of rotation of shaft **16**. An anti-friction bearing **20** surrounds upper end **16***a* of the drive shaft and bearing **20** is seated within the center portion of plunger **11**, which center portion is in the form of a yoke **11***a* with the outer surface of bearing **20** resting snugly against opposing interior surfaces of yoke **11***a* as shown. Accordingly, rotation of drive shaft **16** will be transmitted as a back and forth movement of plunger **11** along its major axis. A cover plate **21** mounted on top of main casing **10** is designed to protect the plunger **11**, shaft **16** and bearing **20** from dust and other foreign matter.

Each end of plunger **11** is adapted to receive in the following order a disc-like first diaphragm control member, a flexible diaphragm, a second diaphragm control member, a retaining washer and a bolt. Near each end of the plunger there is a shoulder portion **11***b* against which the rear face of a first diaphragm control member **22** is secured. A diaphragm **24** is confined or secured between the adjacent interior faces of first diaphragm control member **22** and a second diaphragm control member **26**. A washer **30** and a bolt **32**, the latter being screwed tightly into the threaded end of plunger **11**, serve to hold the diaphragm and its two control members firmly together on the plunger.

Diaphragm **24** is made of a suitable flexible, liquid-proof material such as reinforced rubber. The diaphragm is generally disc-shaped and its outer edges are confined between the opposing faces of main casing **10** and pump head **14** by a series of bolts or other means not shown. Pump head **14** is bored vertically to provide a generally vertical cylindrical pump chamber **34** and is also bored horizontally to provide a cylindrical recess adjoining chamber **34** to receive the end of plunger **11** and diaphragm control member **26**. Chamber **34** is relatively small and has almost no corners into which solids contained in the liquid being pumped might settle to cause clogging or other undesirable effects. A one-way check valve **36**, designed to prevent the flow of liquid from chamber **34**, is mounted in the entrance passageway to the chamber and a similar one-way check valve **37** is mounted in the exit passageway to prevent the flow of liquid back into the chamber. Check valves **36** and **37** may be connected to suitable hoses or other liquid supply means.

Figs. 3 and 4 are more detailed views of diaphragm control member **26**, it being understood that member **22** is of similar construction and operates in a substantially similar manner. The use of members to control the movement of the diaphragms in pumps is known. Such members generally have been used to prevent buckling of the diaphragm about the plunger as in the case where excessive "back pressures" might be built up within the pump chamber. Diaphragm control members **22** and **26** achieve this result but have the further novel features of keeping the unit bending stresses within the diaphragm at a minimum and achieving substantially absolute uniform deformation of the diaphragm during each cycle of the pump.

In order to achieve the foregoing, member **26** is de-

signed so that its inner face, that is, the face or surface lying next to the diaphragm, will be in contact with substantially the entire free, unconfined portion of the diaphragm when the plunger is at one end of its stroke. For this reason the diameter of the disc-shaped member is preferably only slightly less than the diameter of the cylindrical recess in pump head **14** within which member **26** is reciprocated. In one pump constructed and successfully operated embodying the invention here, the clearance between the outer edges of the control members and the adjacent surfaces of the casing and pump head was only 1/64 of an inch.

To prevent entrapment of air between the diaphragm and the inner face of member **22**, which might prevent the diaphragm from bearing properly against control member **22** and result in a non-uniform liquid flow during operation of the pump, a series of holes may be provided in the control member. Similar holes such as **26***a* shown in Fig. 4 perform an even more important function in diaphragm control member **26** in that they prevent the entrapment of liquid between diaphragm **24** and the inner face of member **26** during the pumping cycle. The holes in the diaphragm control members are particularly important where the clearance between the moving member and its stationary chamber is small and also where the liquid contains a suspension of solids, because without the holes fluid tends to be restricted in its movement forth and back between the diaphragm and its control member.

Further to insure that the free portion of the diaphragm will rest against the inner face of the diaphragm control member without unnecessary strain on the diaphragm, this face of the control member is given a unique curvature corresponding substantially to the position of the diaphragm at the end of the plunger stroke in which the unconfined diaphragm will have minimum stresses throughout its extent. It is apparent that if diaphragm control members were not used the diaphragm would most likely be subject to maximum deformation, and hence maximum bending stresses and wear, at those points where the diaphragm emerges from confinement between the stationary casing and pump head and where the free portion of the diaphragm is attached to the moving plunger. In order to reduce wear at these points and to equalize the wear over the entire free, unconfined portion of the diaphragm, the inner face of each diaphragm control member is designed to include surface portions which lie preferably substantially tangent or parallel to the position of the confined portions of the diaphragm both where the diaphragm is attached to the casing and to the plunger, thereby avoiding sharp deformation and excessive wearing of the unconfined diaphragm normally caused by the back-and-forth movement of the plunger. The interior face of member **26** is preferably curved gradually and smoothly between its two tangent or parallel portions, that is, between its outer surface portion O and its inner surface portion I as shown in Fig. 3. Thereby the deformation of the diaphragm is made approximately equal throughout its extent and the bending stresses at any one point will be at a minimum.

As a specific example of a pump embodying the invention, a pump substantially as shown in Figs. 1 and 2 was constructed with a plunger stroke of 1/16 of an inch. All of the pump's diaphragm control members were made similar to member **26** whose inner face had a curved outer surface portion O which was tangent to the adjacent diaphragm-confining surface of pump head **14**, and also substantially normal to the axis of plunger **11**. At the same time, surface portion I was tangent to the center diaphragm-confining surface of the control member itself. The normal distance between the two tangent surface portions O and I (distance X as shown in Fig. 3) was one half of the stroke of plunger **11** or 1/32 of an inch.

Thus with the plunger at one end of its pumping stroke, the outer surface portion O of the inner face of member **26** rests against and holds the adjacent free, unconfined diaphragm surface substantially parallel to the diaphragm portion confined by pump head **14** and thereby prevents sharp deformation and wear of this free portion of the diaphragm. The similar construction of diaphragm control member **22** prevents sharp deformation and wear of the free diaphragm at the opposite end of the pumping stroke. And while plunger **11** moves through its stroke, that portion of the free diaphragm nearest to interior surface portion I of the control member will be guided by surface portion I so as to prevent excessive deformation and wear of that free diaphragm portion.

In order to achieve a simple curved surface for the inner face of member **26** which is free of discontinuities and at the same time containing portions O and I each tangent to its nearest confined diaphragm portion, that surface of the inner face including and between portions O and I may be developed by two arcs of equal radii R, each tangent to its nearest diaphragm portion as shown in Fig. 3 and which arcs meet tangent to each other at a mid-point between surface portions O and I.

I claim:

1. A diaphragm pump comprising a casing, a plunger movably mounted within said casing, a pump head affixed to said casing, a flexible diaphragm having its outer edge confined between said casing and said pump head, and a pair of disc-like diaphragm control members mounted on said plunger with the center portion of said diaphragm confined between opposing inner faces of said members, the diameters of said members being only slightly less than the diameters of the respective cylindrical recesses in said casing and said pump head within which said members are contained whereby substantially the entire free, unconfined portion of the diaphragm may be supported by an inner face of one of said members, the outer portion of the inner face of each diaphragm control member being smoothly curved, and that portion of said inner face which lies most closely adjacent to the confined center portion of the diaphragm being tangent to said center portion, and the portion of said inner face which lies most closely adjacent to the confined outer edge of the diaphragm being tangent to said outer edge when the plunger is at one end of its pumping stroke.

2. A diaphragm pump as set forth in claim 1 in which the diaphragm control members contain a plurality of holes therethrough to prevent the entrapment of fluid between said diaphragm and said control members during the operation of said pump.

3. A diaphragm pump comprising a casing, a plunger movably mounted within said casing, a pump head affixed to said casing and containing a generally vertical cylindrical pump chamber with vertically extending fluid inlet and exit passages therefrom, a diaphragm of flexible, liquid-resistant material whose outer edge is confined between opposing surfaces of said casing and said pump head, said casing and said pump head each providing a generally cylindrical recess on either side of the free, unconfined portion of said diaphragm, and a pair of generally disc-shaped diaphragm control members mounted on said plunger with the center portion of said diaphragm confined between the center portions of the opposing inner faces of said members, the diameters of said members being only slightly less than the diameters of the respective cylindrical recesses in said casing and said pump head within which said members are contained whereby substantially the entire free, unconfined portion of the diaphragm may be supported by an inner face of one of said members, the outer portion of the inner face of each diaphragm control member being smoothly curved, and that portion of said inner face which lies most closely adjacent to the confined center portion of the diaphragm being tangent to said center portion, and the portion of said inner face which lies most closely adjacent to the confined outer edge of the diaphragm being

tangent to said outer edge when the plunger is at one end of its pumping stroke.

4. A diaphragm pump as set forth in claim 3 in which the diaphragm control members contain a plurality of holes therethrough to prevent the entrapment of fluid between said diaphragm and said control members during the operation of said pump.

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