SYNTHETIC MUSCLE BASED DIAPHRAGM PUMP APPARATUSES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation in part of application Ser. No. 09/586,962, filed on Jun. 5, 2000, which is a continuation in part of application Ser. No. 09/015,759, filed on Jan. 29, 1998.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to pump assemblies. More specifically, it relates to improved diaphragm pumps in a range of sizes, including micro-miniature pumps which may be used as bio-compatible medical implants for controlling diseases such as glaucoma and for controlled delivery of drugs.

[0004] 2. Description of the Prior Art

[0005] Mechanical and electromechanical medical implants are well known and, depending upon the type, have met with varying success rates. One problem with these devices is the lack of a reliable, long term power source. Ideally, the power source should last for the life of the implant, as many of these implants require invasive procedures both to install and maintain. Indeed, an external power source is virtually impossible in many situations.

[0006] One use for mechanical implants is the treatment of glaucoma. Glaucoma is a common eye disease which is caused by excessive ocular pressure in the anterior chamber of the eyeball. Many devices and techniques have been devised in order to control this pressure. The devices fall generally into two types; passive devices such as a simple tubular shunt or similar device which drains aqueous humor from the anterior chamber, and active devices which have means for controllably draining ocular pressure, the systems typically using check valves or similar mechanical devices. While these systems are somewhat effective, they all tend to suffer from the drawback in that they are unreliable or require frequent maintenance which always involves a fairly invasive procedure. Failure to properly maintain the devices can result in long term damage to the eye.

[0007] Recently, mechanical devices have been used in order to effect controlled delivery of drugs. These devices are almost all passive, with the exception of a few highly experimental devices such as nanobots. Mechanical devices, while possessing many advantages, are rarely used as the reliability of passive devices is already established, albeit with the aforementioned shortcomings.

[0008] U.S. Pat. No. 5,370,607 issued to Memmen discloses a glaucoma implant device which has a tubular shunt for draining fluid from the eye. By contrast, the present invention contemplates a controllable, self or inductively powered pumping mechanism for draining fluid from the eye to treat glaucoma.

[0009] U.S. Pat. No. 4,911,616 issued to Laumann, Jr. discloses a microminiature pump which may be used to administer medications in sensitive locations in the body such as the eye. The pump is programmable, but the patent does not disclose which aspects of the pump operation can be controlled. Also, the pump requires a separate power source. By contrast, the present invention contemplates a miniature pump and conduit assembly which may be used, among other things, to control glaucoma by controllably pumping fluid from the eye in accordance with sensed pressure conditions within the eye.

[0010] U.S. Pat. No. 5,062,841 issued to Siegel discloses an insulin pump which can be used to pump insulin directly into the bloodstream in response to blood glucose levels. By contrast, the present invention contemplates an inductively powered miniature pump which can be implanted into the tissue surrounding the eye and can controllably reduce ocular pressure.

[0011] U.S. Pat. No. 5,433,701 issued to Rubinstein discusses an active ocular pressure control device which includes a pump which is selectively operated in response to a control signal from a pressure sensor. However, no details as to the power source or structure of the pump, microprocessor, or pressure sensing means are disclosed.

[0012] The present invention contemplates a diaphragm pumping system, the size of the pump determined by the intended use. Prior art diaphragm pumps generally are relatively large and are characterized by a pumping chamber, in fluid communication with influent and effluent conduits, with a mechanical driver serving to force fluid into and through the inlet. Fluid is forced out of the effluent conduit by the driver, typically a piston, which is invariably positioned in a substantially central main body or housing. Contained within the housing is the pumping chamber, as well as a chamber containing hydraulic fluid called the transfer chamber. The transfer chamber and the pumping chamber are separated by a flexible diaphragm. Reciprocal movement of the piston causes flexing of the diaphragm which effects fluid movement through the pumping chamber. The influent and effluent conduits may both have check valves for limiting fluid flow through the pumping chamber.

SUMMARY OF THE INVENTION

[0013] The present invention concerns implantable, pressure adjustable diaphragm pump systems which are scalable and are characterized by a common type of actuating mechanism. The pumps may be inductively and transcutaneously powered via adjacent, mutually inductive electromagnetic coils. Alternatively the pumps may be effectively "self" powered using a synthetic muscle attached to a local bending or twisting force. The pumps may be used in a range of applications from mechanical applications to medical applications such as intraocular pressure control for glaucoma patients, bodily fluid drainage control, and drug delivery systems. These pump systems each include a pumping chamber having an anterior end attached to an implantable influent conduit. In the case of an ocular pressure control device, the influent conduit is inserted into the anterior chamber of the eye. A flexing ionic polymer conductor composite IPCC synthetic muscle, which is a type of ionic polymer metal composite (IPMC) synthetic muscle, functions as the primary actuator. The posterior end of the pumping chamber is connected to an effluent or drainage conduit, which may drain bodily fluids or dispense drugs to an area of the body. A key feature of the invention is the self or secondary power generation system in the form of a much larger piece of IPCC synthetic muscle which, in the case of