5.28 A NEW PUMP FOR EXTERNAL AND IMPLANTED DRUG INFUSION SYSTEMS

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The main problem in the development of portable and implantable drug delivery systems consists in the realization of the pump. Besides the necessity to use only such materials that are not interacting with the respective drug, the demand of high precision dosage rate at minimum stroke volume and long life time are serious problems in the development of a convenient pumping element. Additional prerequisites for the application of the pump are a very small size, light weight, low power consumption and low costs.
Although a number of miniaturized pumps (roller or syringe type) are already available for use in portable drug delivery systems, most of them suffer from serious drawbacks. Based on the experiences in the development and clinical application of a high precision syringe pump delivery system, showing the disadvantage of large size, new designs have been developed. The best results have been obtained using a dynamic plunger pump, combining all the above mentioned features. In addition its design shows a remarkable simplicity.

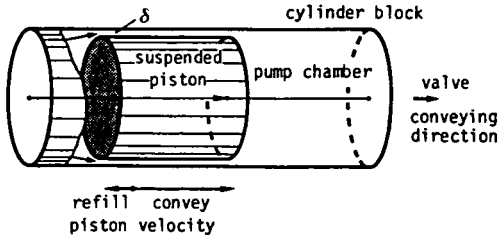

Fig. 1 Principle of the dynamic piston pump

The basic principle makes use of the leakage of plunger pumps, which are inevitable as an absolute piston packing results in too large moving forces. The normal operation of a suspended piston with no packing is used to convey the fluid by the pistons displacement. A defined leakage is taken into account. During the backward motion of the piston the drug flows from the reservoir through the gap between the piston and the cylinder block to refill the pumping chamber. A check valve guarantees unidirectional flow. The effectiveness of the pump is proportional to the velocity of the piston. A theoretical description of the relations between the sizes of piston and cylinder, especially the gap δ , the velocity or the driving force of the piston and the changing pressures on both sides of the pump together with the characteristics of the check valve remains difficult as a result of their interdependency. Using approximations the optimal values for both the size and the forces have been calculated to optimize the performance of the pumping system.

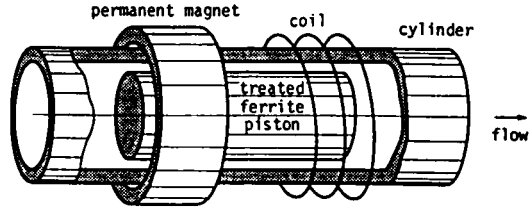

Fig. 2 A very simple realization of the piston pump

From the mechanical standpoint the pump is very easy to realize. The main problem consists in the transmission of motional energy to drive the piston. Moving parts that must be sealed should be avoided. The described design uses a magnetic motive of a ferrite piston. The fast forward motion is effected by the field of a coaxial coil which pulls the piston into its center position. The slow backward motion results from the attractive force of a permanent magnet. Thus the need for any moving parts can be completely avoided. As the pressure developed by the pump is proportional to the force F and inversely proportional to the sectional area A of the piston ($p=F/A$), it is evident that even small forces will guarantee high pressures in combination with small piston diameters. The main advantages of the system are low power consumption and high precision dosage at low delivery volumes. In addition only one valve is needed to provide unidirectional flow.