

CHAPTER 12

Fluid Machinery**12.1. Introduction**

There are two categories of fluid machines.

- (1) Those that do work on the fluid:
 - (a) pumps (used for liquids),
 - (b) fans (used for gases/vapor; $\Delta p < \text{a few inches of H}_2\text{O}$),
 - (c) blowers (used for gases/vapor; $\text{a few inches of H}_2\text{O} < \Delta p < 1 \text{ atm}$),
 - (d) compressors (used for gases/vapor; $\Delta p > 1 \text{ atm}$)
- (2) Those that extract work from the fluid:
 - (a) turbines

Fluid machines that do work on the fluid will be the focus of this chapter. These fluid machines may be further categorized into two types:

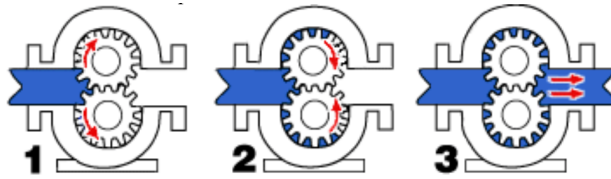
- (1) Positive Displacement Pumps (PDPs)
 - (a) Fluid movement is generated by using changes in volume.
 - (b) Examples include reciprocating piston engines, the heart, gear pumps, rotating screw pumps, and bellows.
 - (c) PDPs typically produce a periodic flow rate since the volume changes occur periodically.
 - (d) PDPs can produce large Δp (pressure rise), but usually have a small Q (flow rate).
- (2) Dynamic Pumps
 - (a) Dynamic pumps do not have closed volumes like PDPs. Dynamic pumps move the fluid by changing the fluid's momentum.
 - (b) Examples include axial flow and radial flow pumps (aka turbomachines), jet pumps, and electromagnetic pumps.
 - (c) The pressure change across dynamic pumps is usually smaller than the pressure change across a PDP, i.e., $\Delta p_{\text{dynamic pumps}} \text{ typically } < \Delta p_{\text{PDP}}$. However, the flow rate through a dynamic pump is usually larger than the flow rate through a PDP, i.e., $Q_{\text{dynamic pumps}} \text{ typically } > Q_{\text{PDP}}$.

These notes will only serve as an introduction to pumps and focus mainly on centrifugal pumps, which are one of the most common pump types found in engineering applications. There are many different pump types and numerous books and online resources are available describing their operation.

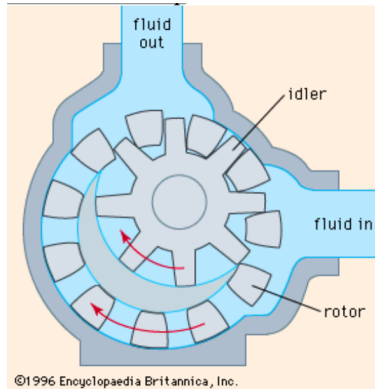
12.2. Some Examples of Positive Displacement Pumps

Positive displacement pumps (PDPs) operate by using changes in a cavity's volume to move fluid downstream. Large pressure changes can be achieved across a PDP, but the flow rates are typically small compared to dynamic pumps and the flow rates are often periodic since the volume changes occur periodically.

A large number of PDP designs have been proposed. The following figures (Figures 12.1 - 12.15) provide just a few examples.



(A) An external gear pump. Image from <http://www.pumpschool.com/principles/external.htm>.



(B) An internal gear pump. Image from <http://media-2.web.britannica.com/eb-media/56/3656-004-5CA4041D.gif>.

FIGURE 12.1. Examples of gear pumps. Gear pumps are often used in automatic transmissions.

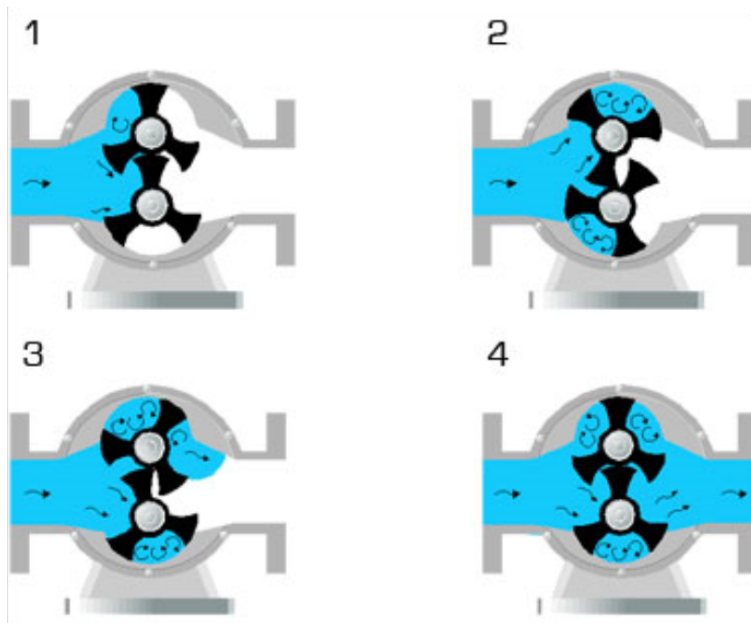


FIGURE 12.2. An example of a lobe pump. Lobe pumps often have two or three lobes and are often used in diesel superchargers. Image from http://www.megator.co.uk/lobe_pump.htm.

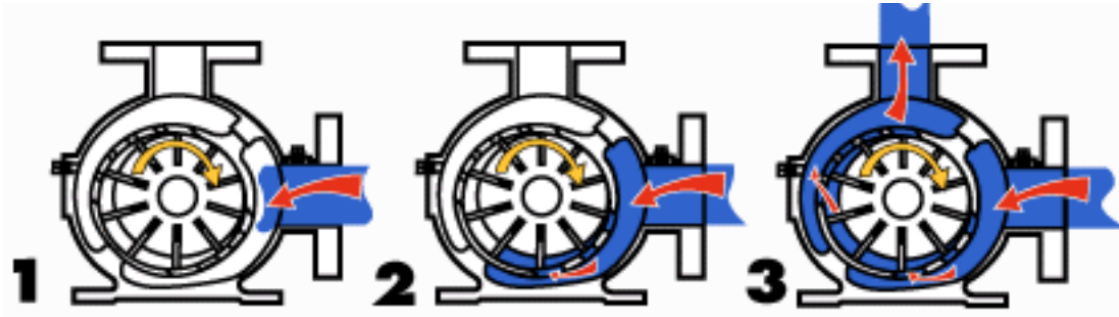


FIGURE 12.3. An example of a vane pump. Centrifugal force or springs are used to push out the vanes. These are often used as power steering pumps and in automatic transmissions. Image from <http://www.pumpschool.com/principles/vane.htm>.

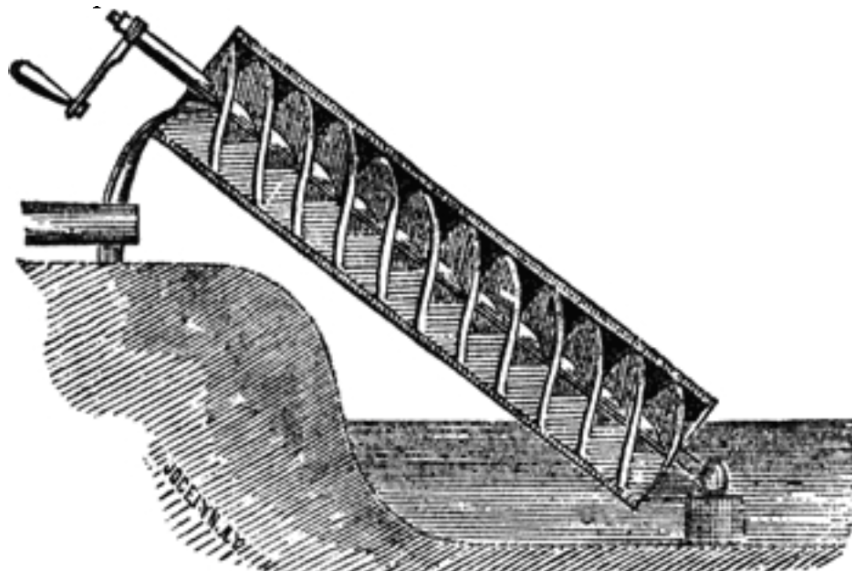
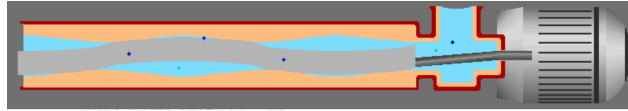
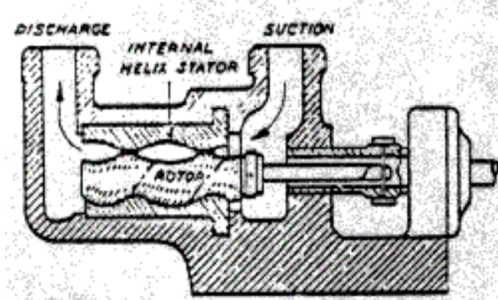


FIGURE 12.4. An example of a screw pump. Archimedes screw pumps were first used more than 2000 years ago. They're still in use for irrigation purposes. Image from http://en.wikipedia.org/wiki/File:Archimedes_screw.JPG.



(A) Image from <http://www.animatedsoftware.com/pumpglos/progrssv.htm>.



(B) Image from <http://www.roymech.co.uk/Related/Pumps/Rotary%20Positive%20Displacement.html>.

FIGURE 12.5. Examples of cavity pumps.

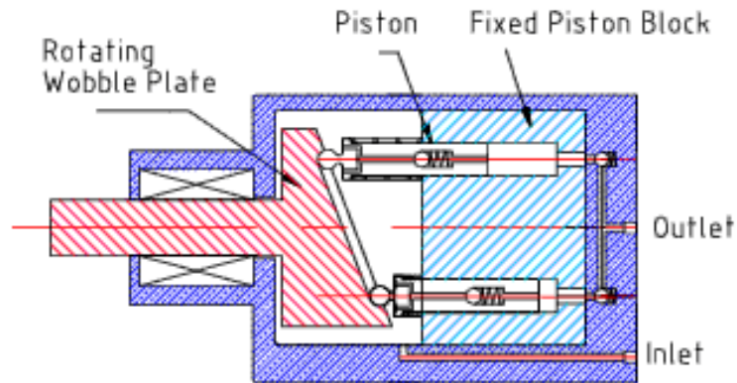


FIGURE 12.6. An example of a wobble plate piston pump. Image from <http://www.roymech.co.uk/Related/Pumps/Rotary%20Positive%20Displacement.html>.

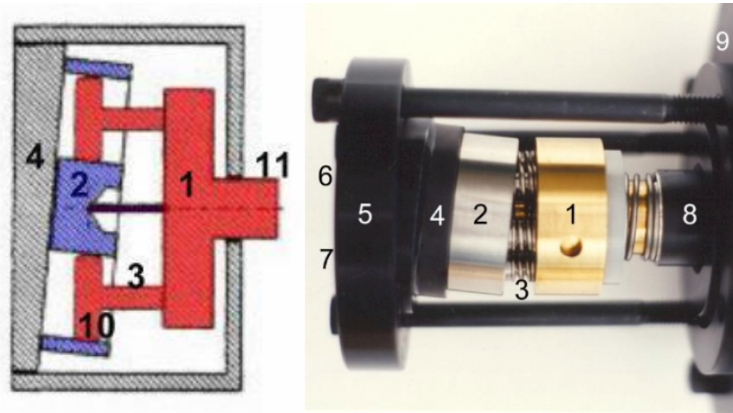


FIGURE 12.7. An example of a Wolfhart Principle pump. Image from http://www.allstar.fiu.edu/aero/wolfhart_pump_principle.htm.

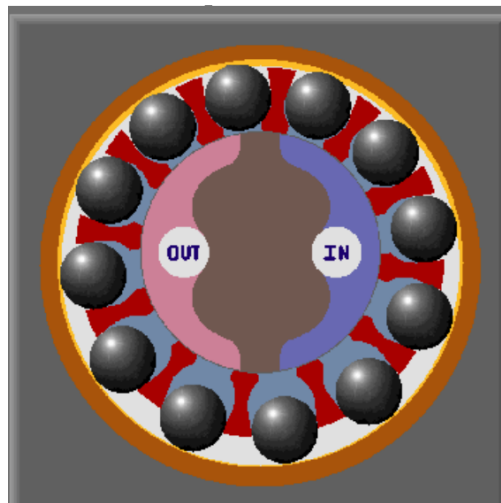


FIGURE 12.8. An example of a ball piston pump. Image from <http://www.animatedsoftware.com/pumpglos/ballpist.htm>.

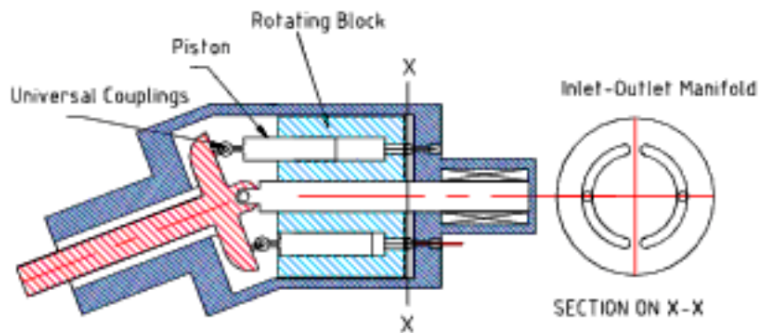


FIGURE 12.9. An example of a bent axis piston pump. Image from <http://www.roymech.co.uk/Related/Pumps/Rotary%20Positive%20Displacement.html>.

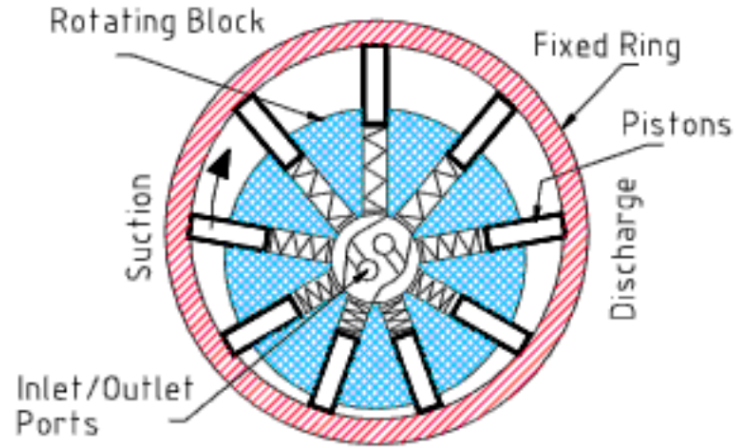


FIGURE 12.10. An example of a radial piston pump. Image from <http://www.roymech.co.uk/Related/Pumps/Rotary%20Positive%20Displacement.html>.

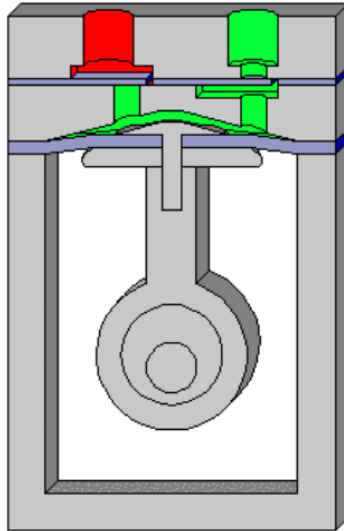


FIGURE 12.11. An example of a rotary cam pump. Image from <http://www.labpump.co.kr/data/aboutpump.htm>.

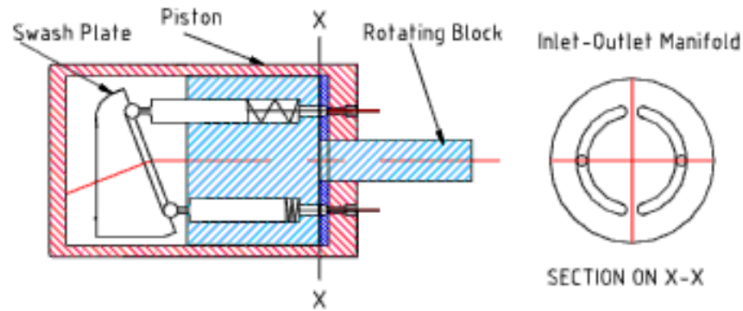


FIGURE 12.12. An example of a swash plate piston pump. Image from <http://www.roytech.co.uk/Related/Pumps/Rotary%20Positive%20Displacement.html>.

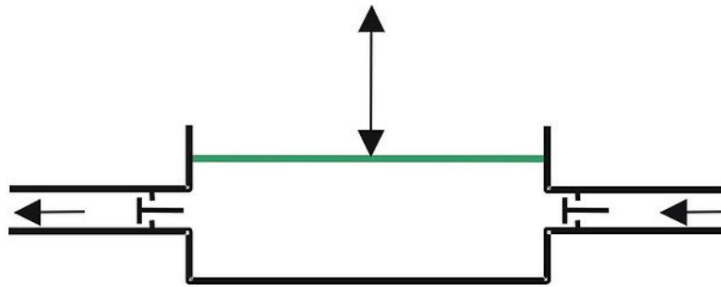


FIGURE 12.13. An example of a diaphragm pump. Image from http://en.wikipedia.org/wiki/File:Bomba_diafragma.jpg.

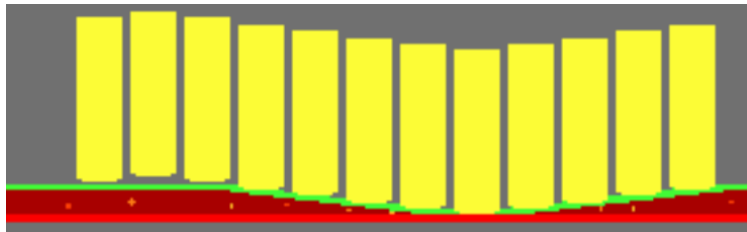
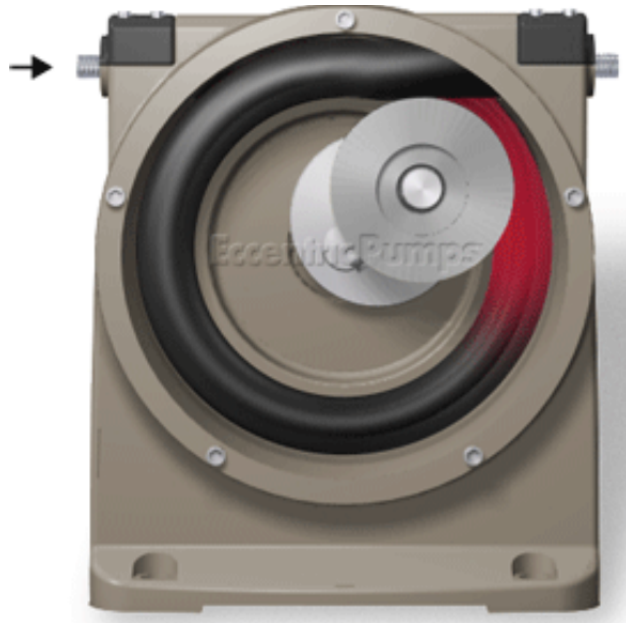
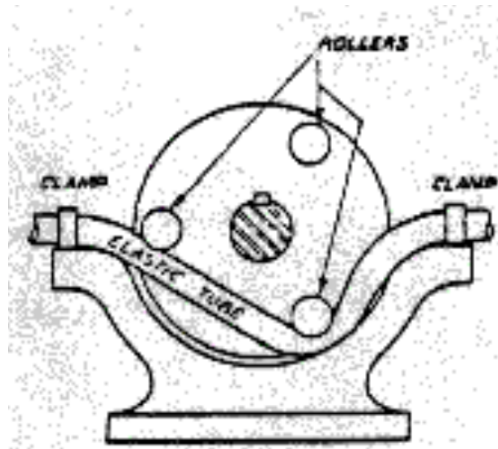


FIGURE 12.14. An example of a finger pump. Image from <http://www.animatedsoftware.com/pumpglos/fingerpu.htm>.



(A) Image from http://en.wikipedia.org/wiki/File:Eccentric_pump.gif.



(B) Image from <http://www.roymech.co.uk/Related/Pumps/Rotary%20Positive%20Displacement.html>.

FIGURE 12.15. Examples of peristaltic pumps. Peristaltic pumps are used in a wide variety of applications, including fuel pumps.

12.3. Some Examples of Dynamic Pumps

Dynamic pumps operate by using momentum changes to increase the fluid pressure. The pressure changes across dynamic pumps are generally smaller than what can be achieved by PDPs, but the flow rates are typically larger and not periodic.

Like PDPs, there are a large number of dynamic pump designs. The following figures (Figures 12.16 - 12.21) provide just a few examples.

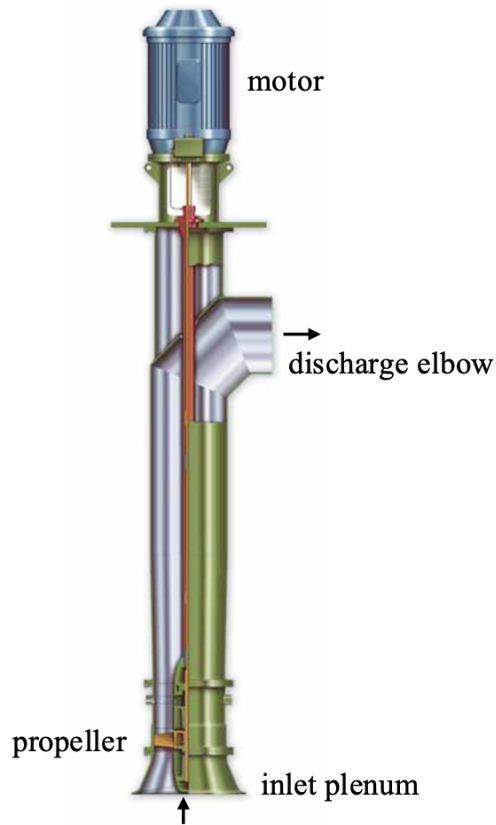
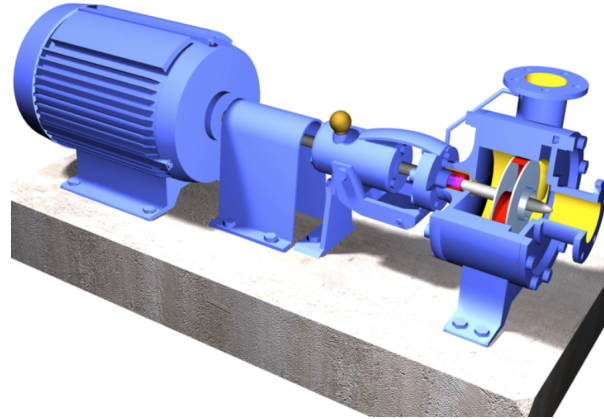
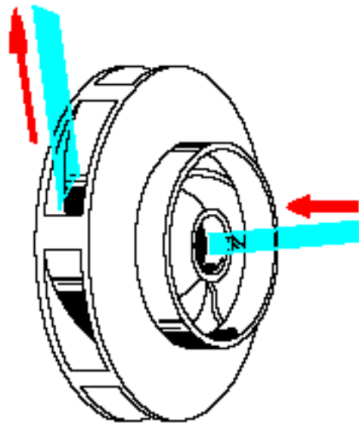


FIGURE 12.16. An example of a propeller pump. Image from http://www.sulzerpumps.com/Portaldata/9/Resources/brochures/power/vertical/JP_Vertical_E00635.pdf.



(A) Image from http://commons.wikimedia.org/wiki/File:CetriFugal_Pump.jpg.



(B) Image from http://www.motorera.com/dictionary/pics/r/Radial-flow_pump.gif.

FIGURE 12.17. Examples of radial dynamic pumps.

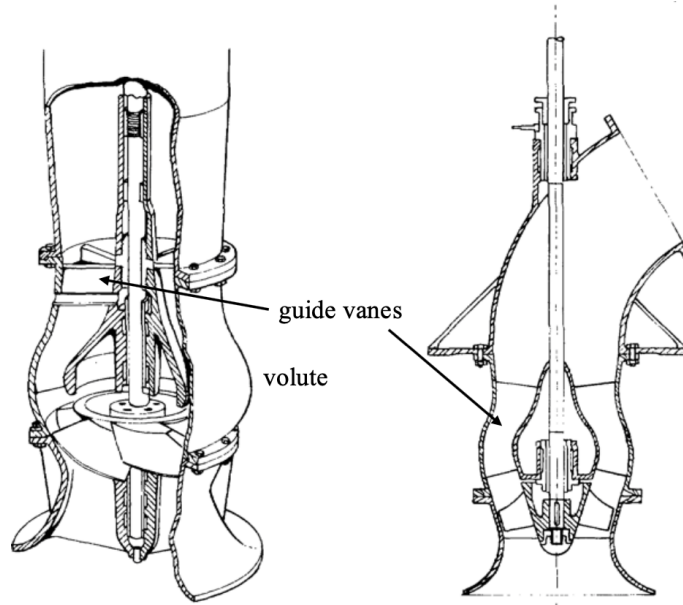


FIGURE 12.18. An example of a mixed pump. Image from <http://www.fao.org/docrep/010/ah810e/AH810E07.htm>.

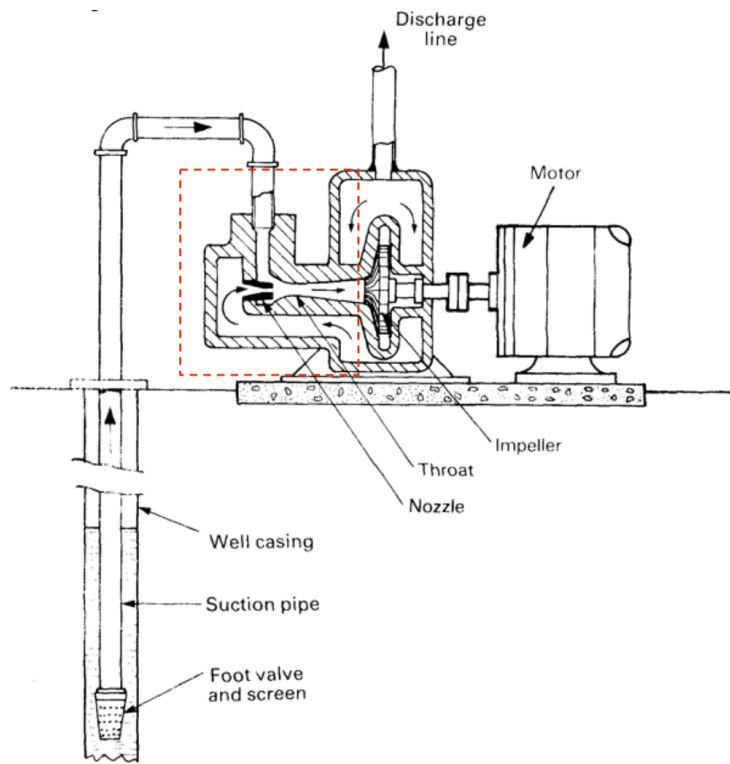


FIGURE 12.19. An example of a jet pump. Image from <http://www.fao.org/docrep/010/ah810e/AH810E07.htm>.

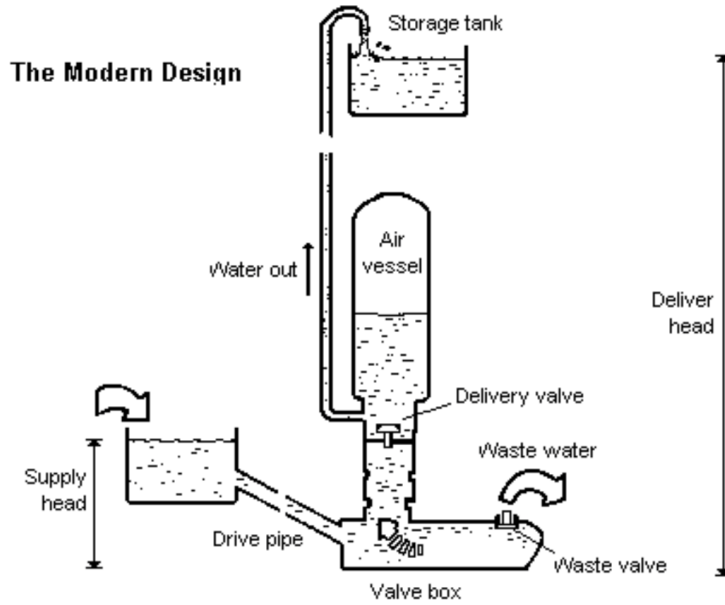


FIGURE 12.20. An example of a ram pump. Image from http://www.lifewater.ca/ram_pump.htm.

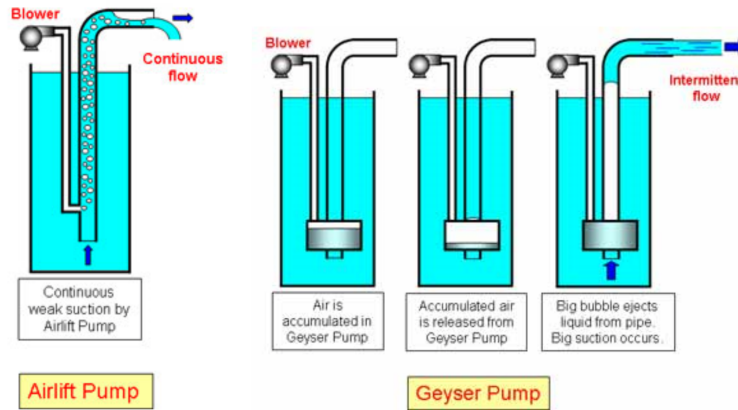


FIGURE 12.21. Examples of air lift pumps. Image from <http://www.airliftump.com/index.htm>.