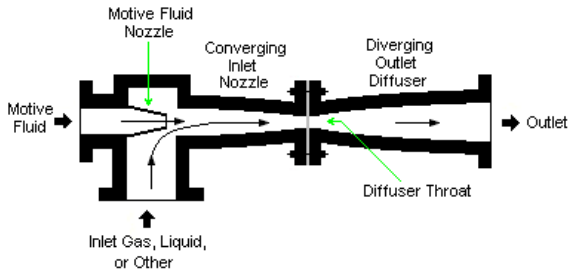
Injectors

An injector, ejector, steam ejector, steam injector or thermocompressor is a pump-like device that uses the Venturi effect of a converging-diverging nozzle to convert the pressure energy of a motive fluid to velocity energy which creates a low pressure zone that draws in and entrains a suction fluid. After passing through the throat of the injector, the mixed fluid expands and the velocity is reduced which results in recompressing the mixed fluids by converting velocity energy back into pressure energy. The motive fluid may be a liquid, steam or any other gas. The entrained suction fluid may be a gas, a liquid, a slurry, or a dust-laden gas stream.



The adjacent diagram depicts a typical modern ejector. It consists of a motive fluid inlet nozzle and a converging-diverging outlet nozzle. Water, air, steam, or any other fluid at high pressure provides the motive force at the inlet.

An injector is a more complex device containing at least three cones. That used for delivering water to a steam locomotive boiler takes advantage of the release of the energy contained within the latent heat of evaporation to increase the pressure to above that within the boiler.

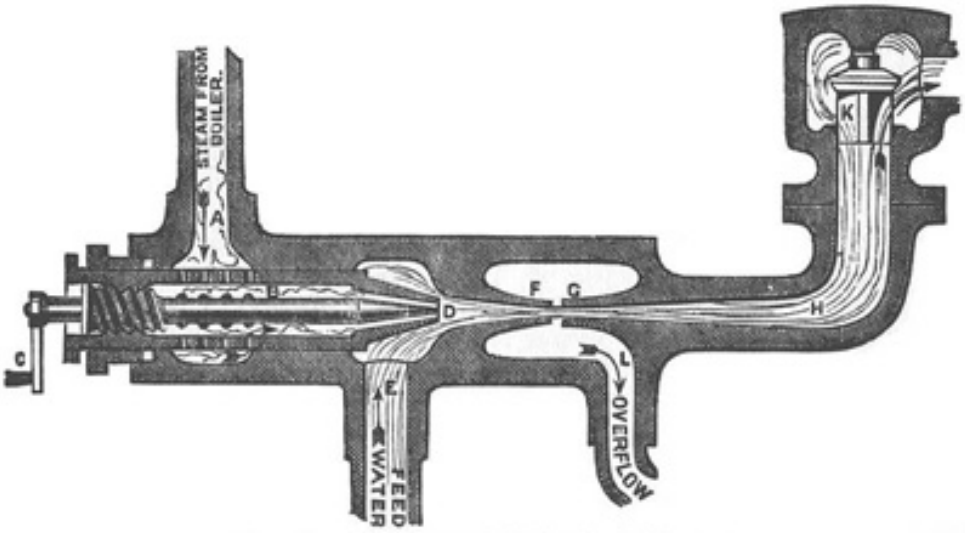
The Venturi effect, a particular case of Bernoulli's principle, applies to the operation of this device. Fluid under high pressure is converted into a high-velocity jet at the throat of the convergent-divergent nozzle which creates a low pressure at that point. The low pressure draws the suction fluid into the convergent-divergent nozzle where it mixes with the motive fluid.

In essence, the pressure energy of the inlet motive fluid is converted to kinetic energy in the form of velocity head at the throat of the convergent-divergent nozzle. As the mixed fluid then expands in the divergent diffuser, the kinetic energy is converted back to pressure energy at the diffuser outlet in accordance with Bernoulli's principle.

The injector was invented by a Frenchman, Henri Giffard in 1858 and patented in the United Kingdom by Messrs Sharp Stewart & Co. of Glasgow.

The injector was originally used in the boilers of steam locomotives for injecting or pumping the boiler feedwater into the boiler. The injector consisted of a body containing a series of three or more nozzles, "cones" or "tubes". The motive steam passed through a nozzle that reduced its pressure below atmospheric and increased the steam velocity. Fresh water was entrained by the steam jet, and both steam and water entered a convergent "combining cone" which mixed them thoroughly so that the water condensed the steam. The condensate mixture then entered a divergent "delivery cone" which slowed down the jet, and thus built up the pressure to above that of the boiler. An overflow was required for excess steam or water to discharge, especially during starting. There was at least one check valve between the exit of the injector and the boiler to prevent back flow, and usually a valve to prevent air being sucked in at the overflow.

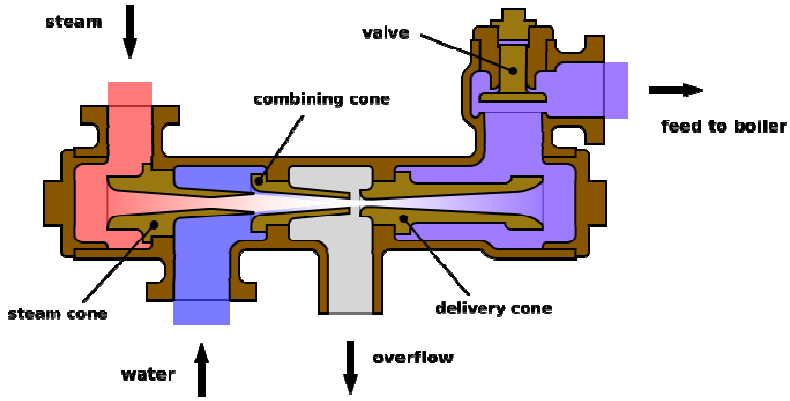
After some initial scepticism resulting from the unfamiliar and superficially paradoxical mode of operation, the injector was widely adopted as an alternative to mechanical pumps in steam-driven locomotives. The injectors were simple and reliable, and they were thermally efficient.



Section of Giffard's Injector.

A- Steam from boiler,
B- Needle valve,
C- Needle valve handle,
D- Steam and water combine,
E- Water feed,
F- Combining cone,
G- Delivery nozzle and cone,
H- delivery chamber and pipe,
K- Check valve

Efficiency was further improved by the development of a multi-stage injector which was powered not by live steam from the boiler but by exhaust steam from the cylinders, thereby making use of the residual energy in the exhaust steam which would otherwise have gone to waste.



A more modern drawing of the injector used in steam locomotives.