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6 Water and Draft Systems

A traction engine's ability to make steam depends on two continuous processes: managing water as it enters the boiler, and managing draft as hot gases leave it. These two systems work together from the moment feedwater is pressurized until the exhaust finally exits the stack.

Water management and draft management are two halves of the same cycle:

- Water enters the boiler through injectors or pumps, often preheated by the heater.
- Steam is generated as the fire burns hotter under the influence of the exhaust-driven draft.
- Exhaust steam not only powers the engine but also drives the draft system that keeps the fire burning.
- Spent steam from the Marsh pump and injectors may preheat feedwater, improving efficiency.
- Sediment is removed through the blowdown valve to keep the boiler clean and safe.
- Combustion gases exit through the smokebox and stack, completing the cycle.

Together, these systems allow a traction engine to maintain steady steam production under varying loads and operating conditions — the heart of reliable field work.

- injectors use steam pressure and velocity to force water into a boiler without moving parts. They rely on steam expansion, entrainment, and condensation to raise feedwater pressure.
- Ejectors are like injectors but are use to transfer water from a tank or other source into a tender.
- pumps are mechanical devices that move water into the boiler using positive displacement. There are two types:
    - direct mechanical drive
    - steam driven
- feedwater heaters warm incoming water using exhaust steam or hot gases, improving efficiency and reducing thermal shock to the boiler.
- The smokebox is the chamber at the front of the boiler where hot gases from the flues mix with the engine's exhaust steam before being drawn up the stack.
- The stack is the tall exhaust chimney on a traction engine that creates draft for the fire by discharging exhaust steam and smoke upward.
- Blower is a small steam-driven exhaust that pulls draft up the stack when the engine is not moving, improving firebed combustion.
- The exhaust nozzle is the jet orifice in the smokebox that shoots each exhaust pulse up the stack, creating the draft that makes the fire burn.
- blowdown controls the release of water from the boiler to remove sediment, scale-forming minerals, and impurities that concentrate during operation.

6.1 Injectors

These have been covered elsewhere.

6.2 Direct-Drive Feedwater Pump

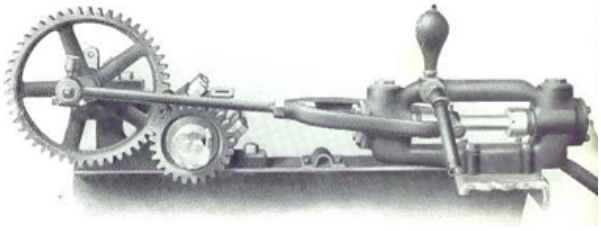

Fig. 1 Feedwater pump

6.2.1 Mechanical Fundamentals

A reciprocating plunger pump driven from the engine through a **gear reduction**, not directly from the crank throw. A small gear on the crankshaft drives a larger gear; the larger gear carries a yoke or crankpin that moves a push rod connected to the pump plunger. The **gear ratio determines the pump-stroke rate**, typically giving several engine revolutions per pump stroke. Inside the pump, inlet and outlet check valves control water flow.

6.2.2 Operating Principles

As the engine turns, the crankshaft gear drives the larger pump gear. The offset crankpin on the large gear converts rotation into reciprocating motion of the push rod and plunger. On the suction stroke, water enters through the inlet check; on the delivery stroke, the plunger forces water through the outlet check toward the boiler. A bypass valve allows excess water to return to the tank for feed-rate control. A relief valve prevents over pressurization.

6.2.3 Advantages

- Simple, durable, and mechanically efficient
- No steam consumption
- Very reliable at road speed
- Pump output naturally increases with engine workload
- Under steady load, the pump can be tuned with its inlet throttle valve to supply water at a stable rate matching boiler consumption

6.2.4 Disadvantages

- Cannot pump when the engine is stopped
- Weak delivery at very low engine speeds
- Requires tight packing and good check-valve condition
- Feed rate fixed by the gear ratio and engine RPM, limiting fine control
- The pump is always engaged with the engine

6.3 Independent pump

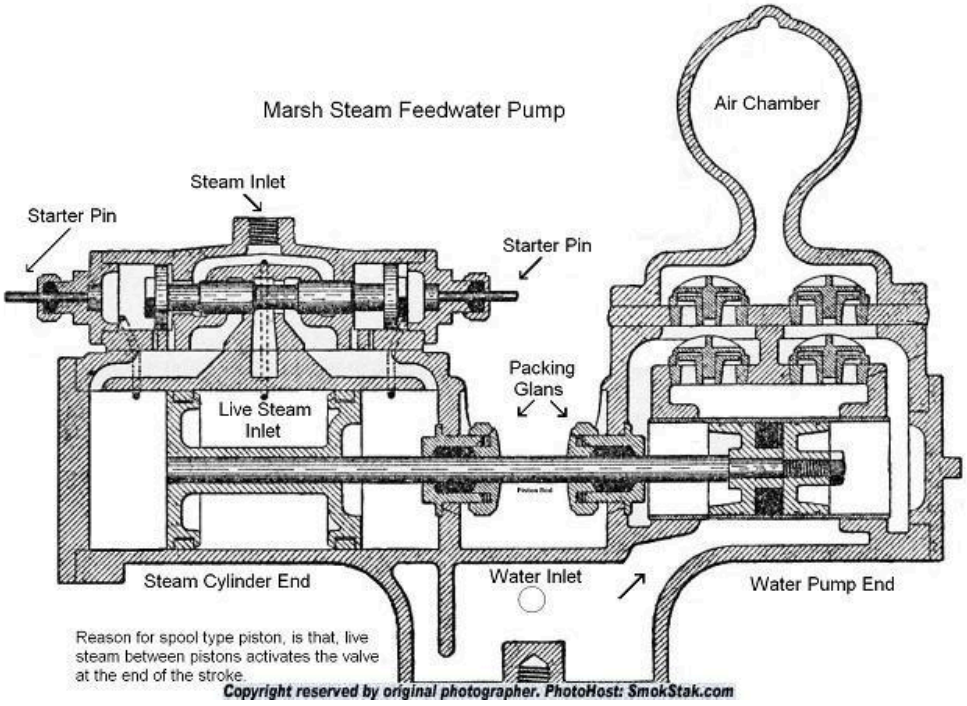

Fig. 2 Marsh pump

The Marsh Pump (specifically the Marsh Simplex) is an independent steam-driven feedwater pump commonly supplied on Case traction engines, either as standard equipment or as an option alongside the mechanical pump. Unlike the mechanical pump—which only works when the engine is turning—the Marsh pump is a self-contained steam engine dedicated to moving water.

6.3.1 Operation

The pump has two cylinders on a common piston rod:

- a steam cylinder that receives live steam from the boiler, and
- a water cylinder that forces feedwater toward the boiler.

6.3.2 Simplex Design

It is a simplex pump: one steam cylinder and one water cylinder. A distinctive internal piston-valve mechanism automatically shifts steam admission from one end of the cylinder to the other, allowing the pump to reciprocate continuously without a flywheel or external valve gear.

6.3.3 Feedwater Preheating

A key advantage of the Marsh pump is that it exhausts its spent steam directly into the incoming feedwater. This warms the water before it enters the boiler, reducing thermal shock to the flues and improving overall steaming efficiency.

6.4 Heater

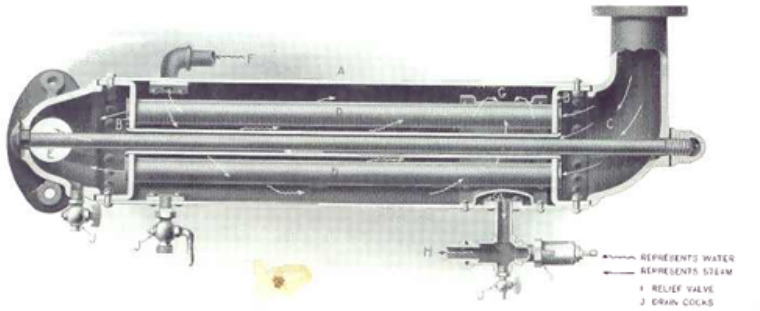

Fig. 3 Heater

The heater is essentially a small, non-pressurized feedwater heater. Exhaust steam from the engine is routed through a bank of small tubes, and the surrounding water space absorbs that heat. The water space is supplied and pressurized by the mechanical pump, and a check valve at the pump discharge prevents boiler pressure from pushing back into the heater.

On engines equipped with a pump, the heater warms the incoming feedwater before it enters the boiler, reducing thermal shock and improving steaming efficiency.

Case shipped all engines with a heater, but many engines left the factory without a pump. On those engines, the heater still receives exhaust steam, but with no pump to move water through it, the entire heater simply rises to the temperature of the exhaust steam and serves no feedwater-heating function.

6.5 Exhaust and Draft System

6.5.1 Smokebox

The smokebox is the front compartment of a locomotive-type boiler, located just behind the stack. Its job is to collect the hot gases that have passed through the boiler flues and combine them with the engine's exhaust steam. When each exhaust pulse shoots through the exhaust nozzle, it creates a vacuum in the smokebox. That vacuum pulls the fire's hot gases through the flues and sends them up the stack, completing the draft system.

Inside the smokebox you'll find the exhaust nozzle, the petticoat pipe (on engines that use one), the blower ring, and the ends of the flues. The smokebox must stay reasonably tight so the draft comes through the fire and flues—not through leaks around the door or seams. A leaky smokebox weakens draft and makes an engine sluggish to steam.

Because the smokebox handles soot, ash, and cinders, it requires regular cleaning. A buildup of soot can choke the flues, reduce heat transfer, and impair draft. Case engines often have a hinged or bolted smokebox door to make this maintenance straightforward.

The smokebox is the central meeting point of the entire draft system:

- Firebox → flues → smokebox → stack
  and it works in partnership with the exhaust nozzle (draft while running) and the blower (draft while stopped).

6.5.2 Stack

On a traction engine, the stack is far more than a chimney. It is the upper end of the engine's draft system, the mechanism that pulls air through the firebed, across the grates, through the flues, and out the top of the boiler. The stack works in partnership with the exhaust nozzle in the smokebox: every time the engine exhausts steam, that jet of steam shoots upward into the stack

and creates a partial vacuum in the smokebox. That vacuum draws hot gases through the flues, which in turn pulls fresh air through the fire. This is why the engine "breathes" harder when it is working under load — more exhaust pulses mean stronger draft.

The stack also provides the vertical path for smoke, ash, and cinders to leave the boiler. Its height helps keep sparks away from the operator and reduces the chance of setting fire to dry stubble or straw around the machine.

6.5.3 Spark arresters

Because traction engines burned wood, straw, or soft coal, they could throw live cinders out the stack. A spark arrester is any device fitted inside or atop the stack to prevent those cinders from escaping. Designs varied widely:

- Screen arresters used fine wire mesh to catch sparks before they left the stack.
- Deflector-cone arresters forced the exhaust stream to change direction abruptly, causing heavier cinders to fall out of the flow.
- Cyclone or centrifugal arresters spun the exhaust gases so that embers were flung outward and trapped in a chamber.
- Stack caps sometimes incorporated baffles or screens to reduce spark throw while still allowing free exhaust.

A good spark arrester has to strike a balance: it needs to stop sparks without choking the draft. Too fine a screen or too restrictive a baffle can smother the fire and ruin steaming. Too open a design can start a field fire. This is why many engines had removable or seasonal arresters — operators would install them during dry harvest conditions and remove them when working on damp ground or in the spring.

6.5.4 Blower

The blower is a simple but essential draft-making device used whenever the engine is not running fast enough to produce its own exhaust draft. It consists of a ring or series of small nozzles located inside the base of the stack. When the operator opens the blower valve, live steam is admitted to these nozzles and shoots upward into the stack. That jet of steam creates a vacuum in the smokebox, pulling hot gases through the flues and drawing fresh air through the firebed.

The blower is used for several purposes:

- Starting the fire — to get draft before the engine can run.
- Maintaining draft while stopped — such as when belted to a machine and idling.
- Controlling the fire — a quick burst of blower can brighten the fire or clear smoke.
- Safety — when the engine is drifting downhill or coasting with the throttle closed, the blower prevents the fire from "backing up" into the flues.

Because the blower uses live steam, it must be used sparingly; too much blower wastes steam and can overfire the boiler.

6.5.5 Exhaust nozzle

The exhaust nozzle is the small, precisely sized opening at the base of the stack where the engine's spent steam is discharged into the smokebox. Every time the engine exhausts, that pulse of steam is forced through the nozzle at high velocity. As it shoots upward into the stack, it creates a partial vacuum in the smokebox. That vacuum pulls hot gases through the flues and draws fresh air up through the grates and firebed.

This is the core of the locomotive-type draft system:

- Exhaust pulse → jet through nozzle
- Jet → vacuum in smokebox
- Vacuum → strong draft through fire and flues

The harder the engine works, the more frequent and forceful the exhaust pulses become, and the stronger the draft. This is why a traction engine "fires up" under load and why the fire brightens when the engine is pulling hard.

The nozzle's diameter and position are critical. Too small a nozzle chokes the exhaust and wastes power; too large a nozzle weakens the draft and makes the engine sluggish to steam. Case and other builders spent real engineering effort getting the nozzle size right for each boiler and cylinder combination.

The exhaust nozzle works hand-in-hand with the stack, the smokebox, and the blower. When the engine is running, the nozzle provides nearly all the draft. When the engine is stopped or drifting with the throttle closed, the blower takes over to keep the fire from backing up into the flues.

6.6 Blowdown

The blowdown valve is mounted at the very bottom of the boiler—usually on the mud ring—so it can remove the heaviest sediment that settles out of the water. As the boiler operates, minerals, rust flakes, and impurities drop out of suspension and collect in the lowest part of the shell. If this material is not removed, it can insulate the metal from the water, cause uneven heating, and contribute to scale formation or even localized overheating.

When the operator opens the blowdown valve, boiler pressure forces water and sediment out in a fast, powerful jet. This rapid discharge scours the mud ring and carries the accumulated solids out of the boiler. Blowdown is normally done briefly and regularly—often once or twice a day—rather than in long intervals, to keep sediment from building up.

Because the blowdown valve opens directly to atmosphere, it must be strong, reliable, and absolutely tight when closed. It is typically a self-cleaning Y-valve designed to withstand full boiler pressure, although straight-through, quick-opening valves are also used . Operators must stand clear of the discharge and ensure no one is in the path of the hot water and steam plume.

The blowdown valve is part of the boiler's routine maintenance system, working alongside proper water treatment and regular washouts to keep the boiler clean, efficient, and safe.