Basic Sequences of Operation

The diagrams on the opposite page are extremely simplified to easily show the flows of steam, air, and water.

- A manual air cock represents the radiator vent(s) in the system.
- One radiator represents all the radiators in the system.
- The supply piping is directly connected to the radiation without a header.
- The return line is directly connected to the boiler without a Hartford Loop.
- They do not represent how a steam system should be piped.

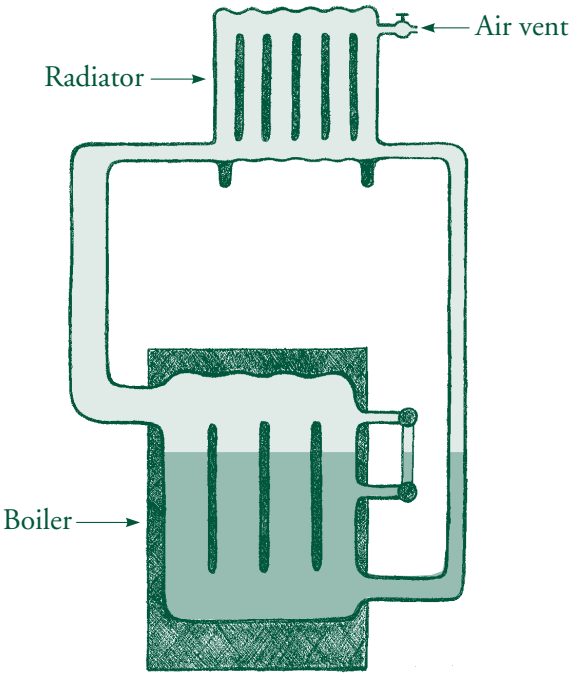
Fig. 1 System starts at rest with all water having returned to the boiler by gravity and the proper pitch of the pipes. Air fills the piping and radiation.

Fig. 2 Burner will fire to heat water to boiling point causing steam to release from water line.

Fig. 3 Steam builds up pressure inside boiler. Steam pressure will cause flow through piping to radiation with valve open. Higher steam pressure always moves to lower pressure outside piping/radiation. The steam pushes air through piping toward vent. Steam condenses on sides of supply pipes and flows back to boiler.

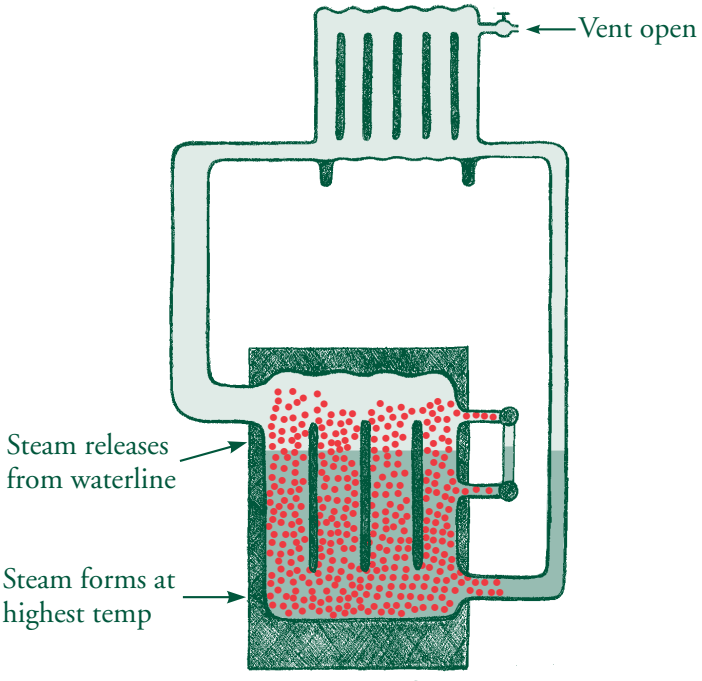
Fig. 4 Closed radiator vent valve causes steam to condense on cooler surfaces of radiation, turning back into water. Water flows back to the boiler through return line to be heated by burner to become steam again.

Fig. 1



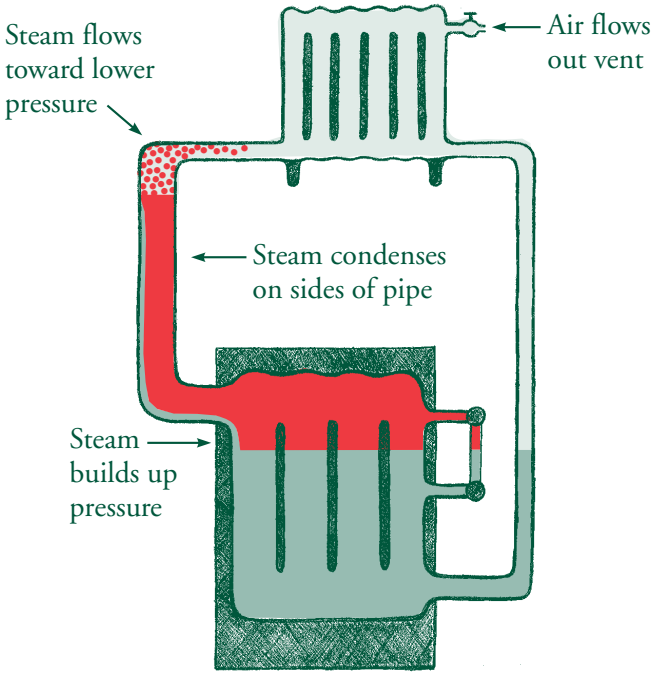
BURNER OFF

Fig. 2



BURNER ON

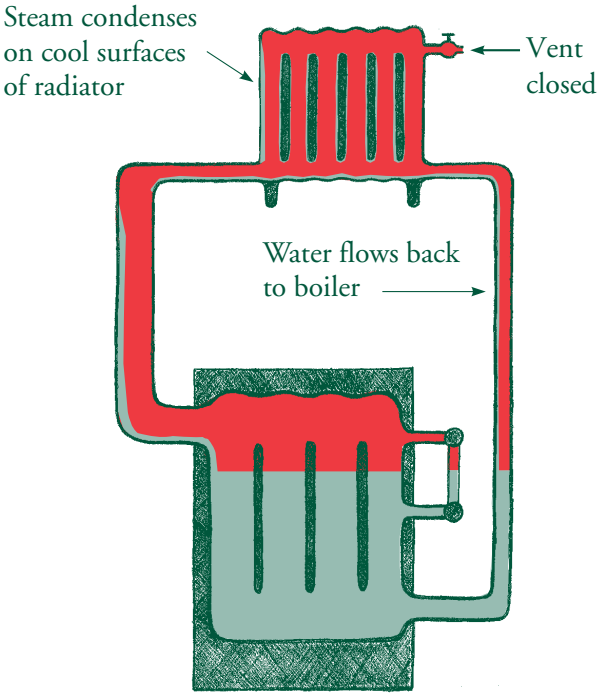
Fig. 3



BURNER ON

AIR WATER STEAM

Fig. 4



BURNER ON

Simplified Two Pipe Steam

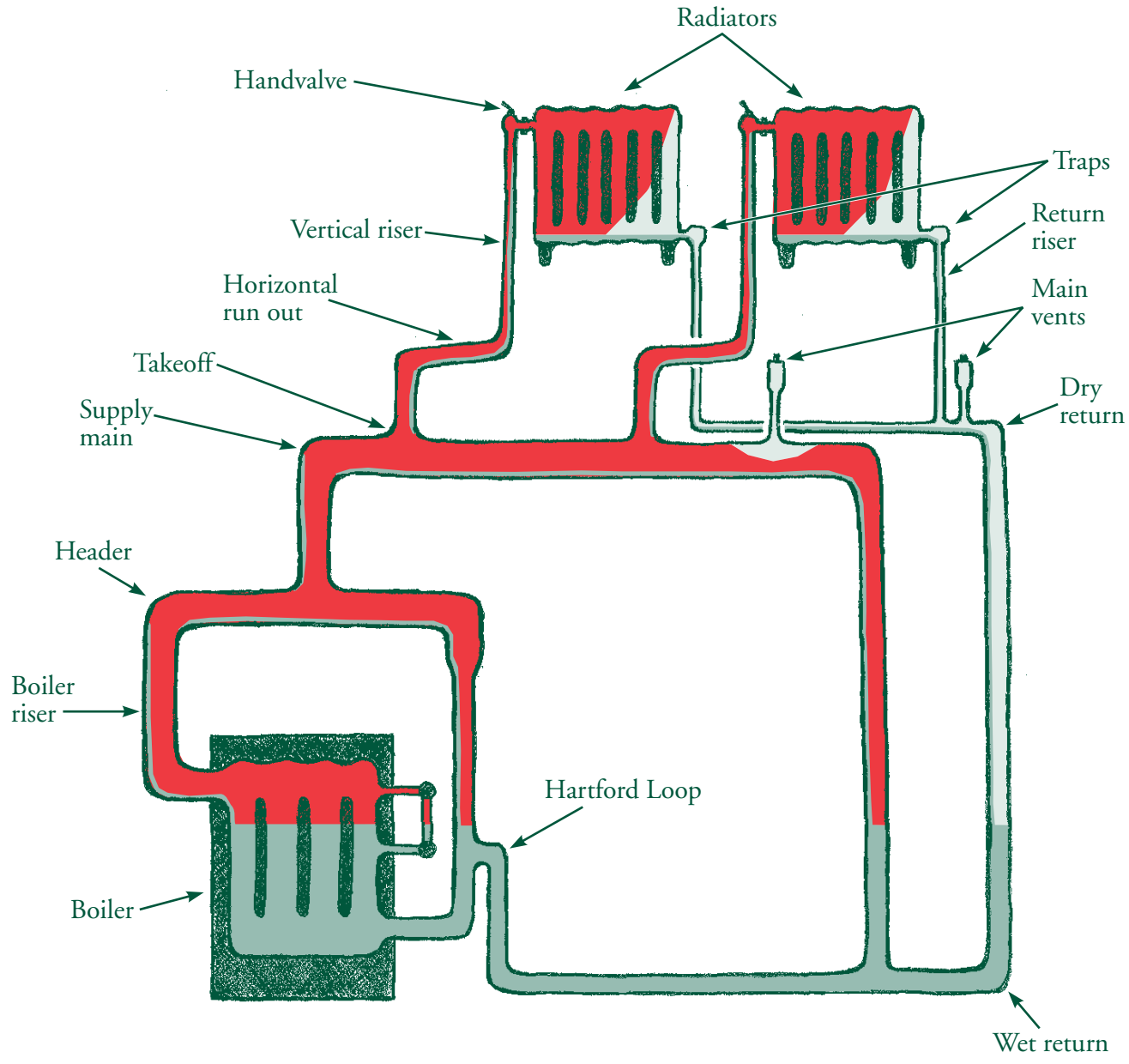
Sequence of the flows through the system.

1. Steam pressure generated in boiler moves through boiler riser, header, supply main, takeoff, horizontal run out, vertical riser, and radiator valve, to lower pressure in radiator with trap and main vent on dry return open.
2. Condensate from boiler riser flows back to boiler against steam flowing out of boiler.
3. Condensate from header returns to the boiler through the equalizer line.
4. Air in supply main is vented to basement through main vent at end of supply main.
5. Steam turns to condensate as it gives up its heat to the cooler surfaces of the radiator.
6. Air in radiator passes through open trap to vent through main vent on dry return.
7. Condensate slides down the sides of the radiator and leaves the radiator through the trap.
8. Condensate flows from radiator to the boiler through the return riser, dry return, wet return, and Hartford Loop.

All the paths must be properly sized and pitched for proper operation.

- Refer to pages 56 and 57 for the details of the near boiler piping.
- Refer to pages 62 and 63 for checking the size of existing near boiler piping.
- Refer to pages 54 and 55 for information on supply mains, horizontal runouts, and vertical risers.

Simplified Two Pipe System at Mid-Cycle



AIR WATER STEAM

Follow the Path of Air Out of the System

Air fills the radiation and piping at start-up.

- **Air** must be pushed or pulled **out** of the system so that **steam** can fill it **up**.

Air in the near boiler piping and supply mains is forced to the end of the steam supply main by the flow of the steam.

- **Fig. 1** Air typically leaves the supply main through the main air vent.
- **Fig. 2** Air can also pass to the dry return on two pipe systems by a radiator trap installed above the main.
- **Fig. 3** End of supply main F+T traps can be used to pass air to a vented condensate, boiler feed, or vacuum unit.

Air in the run outs and upfeed risers is forced into the radiation.

- **Fig. 4** In a one pipe radiator the air is forced through an air vent to atmosphere or through an air valve to a vacuum pump or central venting point.
- **Fig. 5** In a two pipe radiator the air is forced through the trap to the dry return, where it is vented to atmosphere through a main vent or to a vacuum pump.

In systems with a vacuum pump, the air is drawn to the vacuum unit and vented to the atmosphere.

- Vacuum units do a great job of air removal, therefore creating better steam distribution.
- Vacuum units pull the air quickly through the mains and radiation to allow the steam to flow quickly and evenly.

Follow the Path of Air Out of the System

Fig. 1

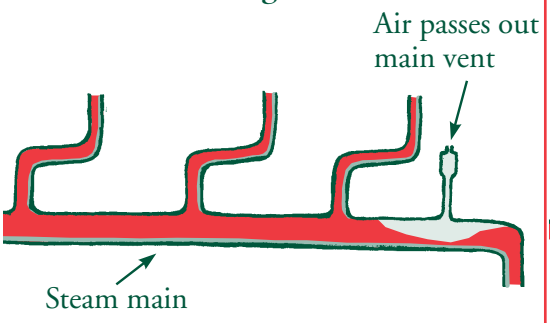


Fig. 2

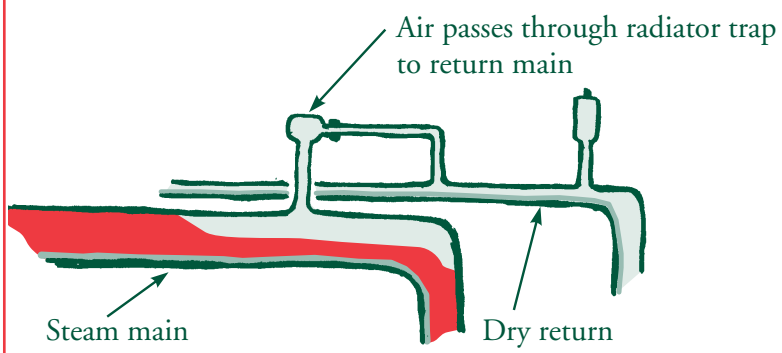


Fig. 3

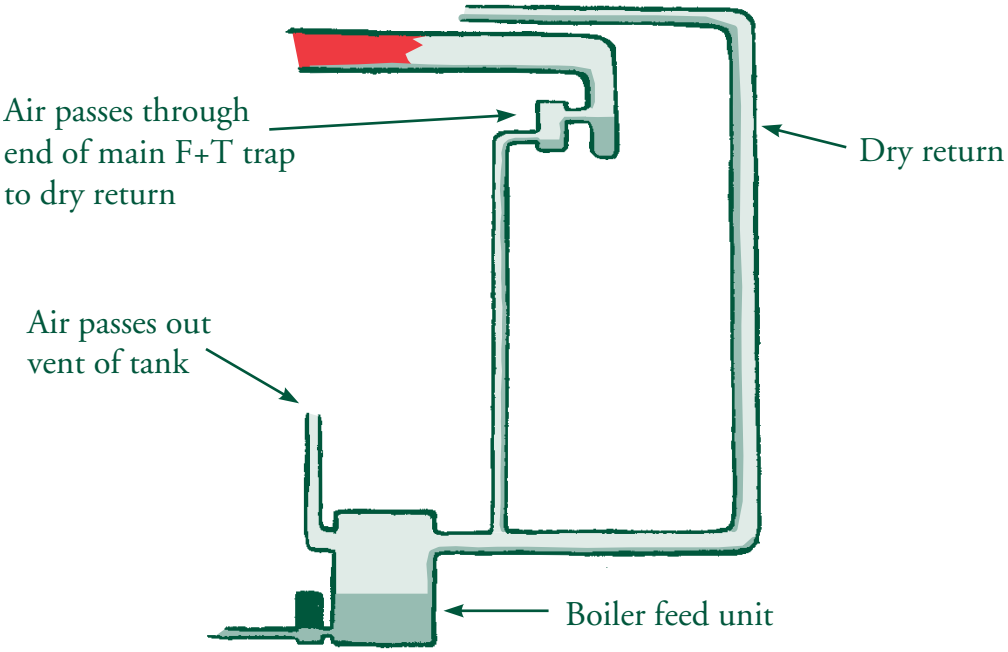


Fig. 4

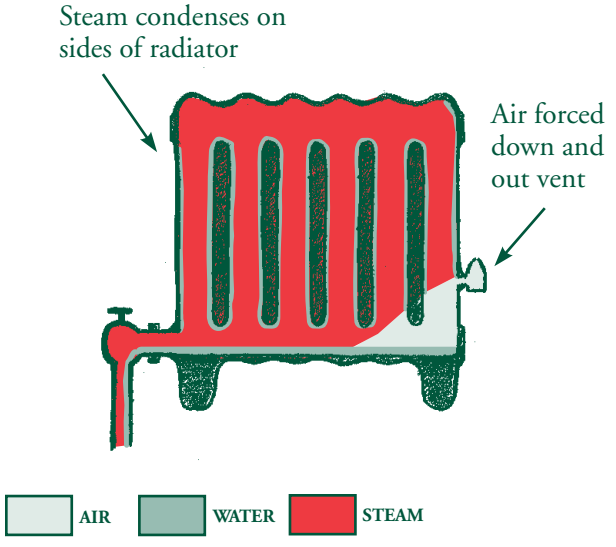
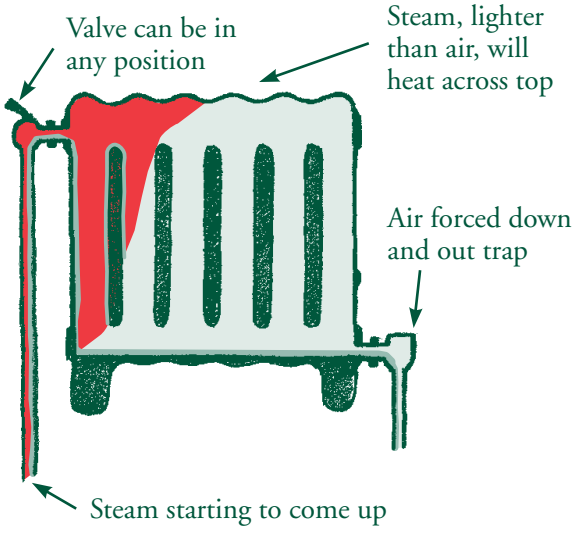


Fig. 5



Hartford Loop and Equalizer

Fig. 1 The Hartford Loop was developed by the Hartford Insurance Company to prevent boiler explosions.

- Water leaks in the return line would drain the water out of the hot boiler. Cold water would be released into the boiler by an unreliable water level control or inattentive operator. The sudden temperature change would send the boiler through the roof.
- The new piping arrangement kept water in the boiler in the event of a leak in a return line.
- It greatly reduced the number of boiler accidents and insurance claims.
- Today, it's a non-mechanical backup for the LWCO.

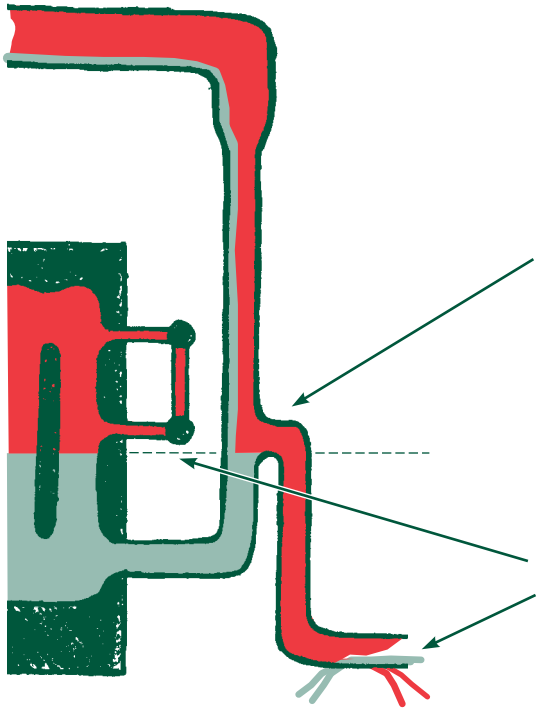
The height of the loop should be piped 2˝ to 4˝ below the water line to keep the horizontal portion underwater to prevent water hammer.

- Keep the horizontal pipe as short as possible by using a close nipple, street 90, or Y-tee pointed down.
- If steam would get into the horizontal pipe, the close nipple will prevent water hammer.

Fig. 2 The equalizer has two functions, to apply steam supply pressure to the return side to keep water in boiler and to drain the water from the header to assure dry steam.

- See chart on page 160 to size equalizer. It has to be large enough to handle the volume of water from the header and not cause steam pressure drop.
- The equalizer pipe is always sized smaller than the header.
- The best place to make the reduction is just below the elbow. A concentric reducer can be used on the vertical drop.
- Too much of a pipe size reduction or too long a pipe will result in steam pressure reduction in the equalizer.

Fig. 1 Hartford Loop

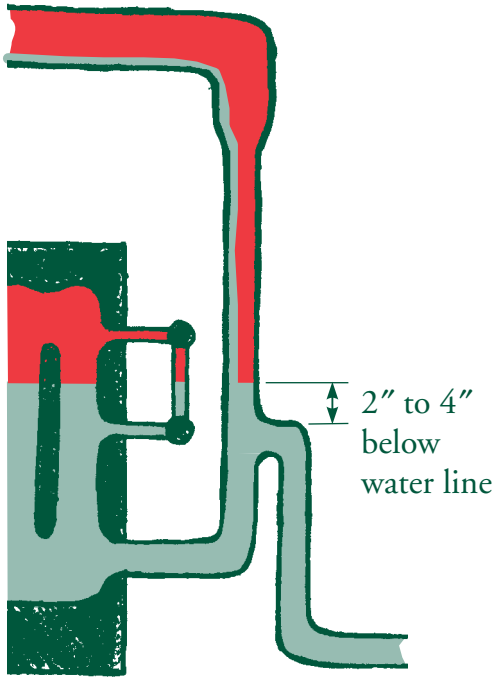


As short as possible to prevent water hammer
Can use:

1. Close nipple
2. Street elbow
3. Y-tee pointing down

Lowest level of boiler water line
if return line starts leaking

Fig. 2 Equalizer



Equalizer:

1. Drains header to assure dry steam in system
2. Equalizes pressure to return, keeping water in boiler
3. Replaces check valve in return line
   - **a.** Would stick open to allow water to back out of boiler
   - **b.** Would clog up to slow water returning to boiler
   - **c.** Both could cause water hammer at end of mains, spitting air vents, and/or flooded take offs

AIR WATER STEAM

Causes of Water Hammer at the Middle of the Steam Cycle

When the water hammer occurs at the middle of the steam cycle, look for places that will slow or block condensate during the steam cycle.

- During the steam cycle, condensate is constantly being produced.
- Condensate has to have a properly sized and pitched pipe to handle the volume of condensate produced.

Fig. 1 The most common place for condensate to be slowed or blocked is in the wet return.

- It is the lowest spot in the piping and will accumulate the most sediment.
- Sediment build up in the wet return can turn a 2″ pipe into a ¾″ pipe on the inside.
- The reduction in pipe size slows the flow of condensate, backing it up into the supply main where it will hammer.

A boiler making wet steam puts more condensate in the piping than it was designed for.

- Depending on how bad the problem is, the existing pipes cannot handle the extra load.
- The condensate then backs up in the system and starts to hammer.
- Overfiring or oversizing the boiler can cause wet steam or excess condensate loads for existing piping.

Fig. 2 Steam traps that are undersized or clogged with dirt or sediment can slow or block condensate.

- The condensate then backs up into the steam main during the steam cycle until it starts hammering.
- Sometimes the bellows assembly will break off and lodge in the seat to also slow or block condensate.

Uninsulated supply pipes produce more condensate than insulated pipes.

- Depending on how much pipe or how cold an area it runs through, the existing pipes cannot handle the extra load.
- The condensate then backs up in the system to start the hammering.

On one pipe radiators, if the venting rate is too fast, water hammer in the radiation can occur.

- The velocity of the steam increases to the point that the water cannot get back out of the radiator. See page 70 and 71.
- It's similar to not having the valve fully open.

Fig. 1

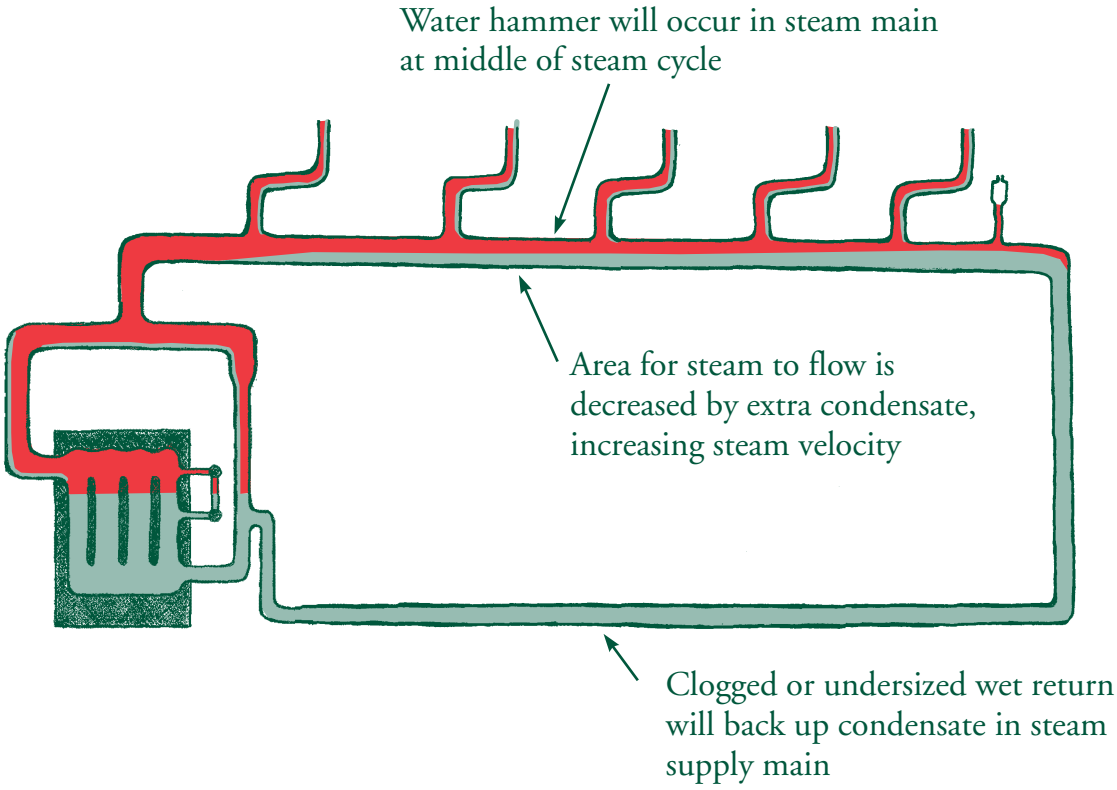
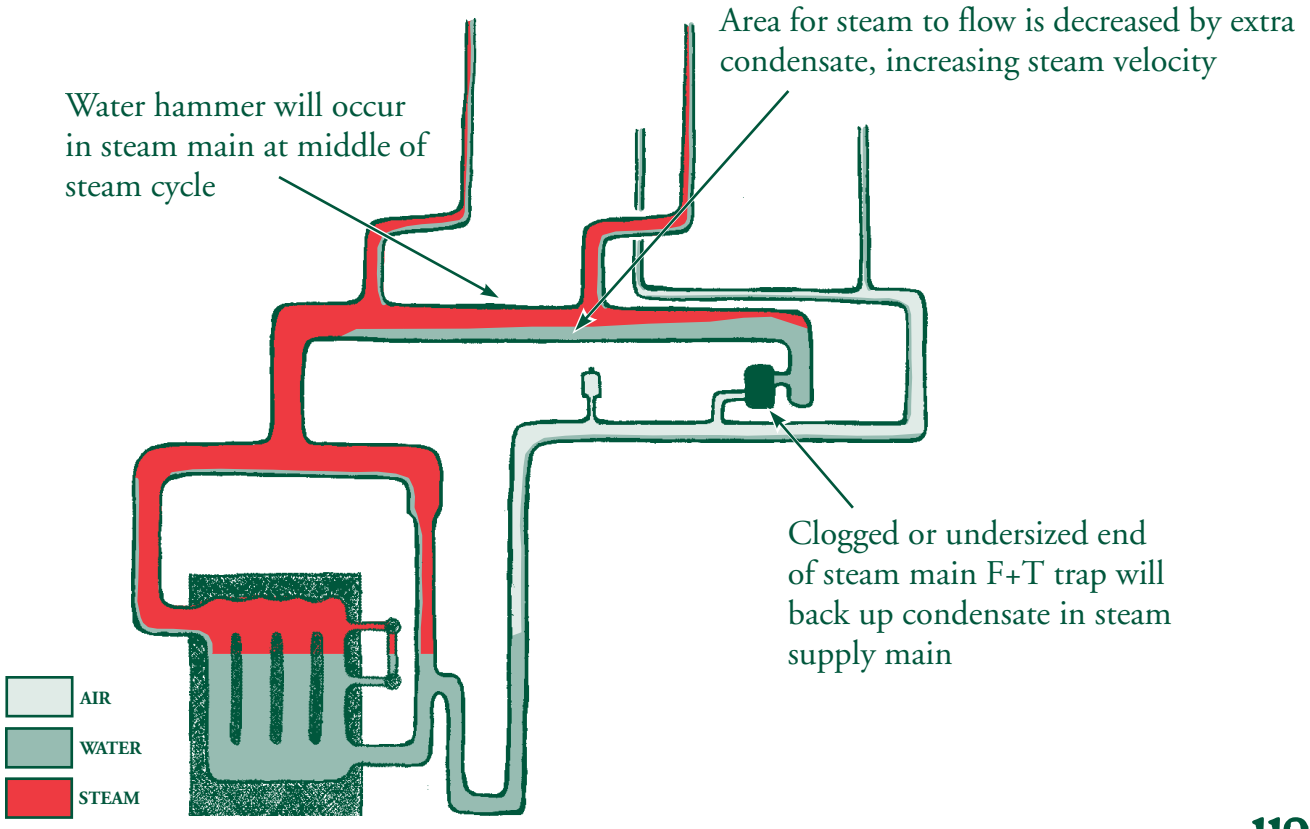
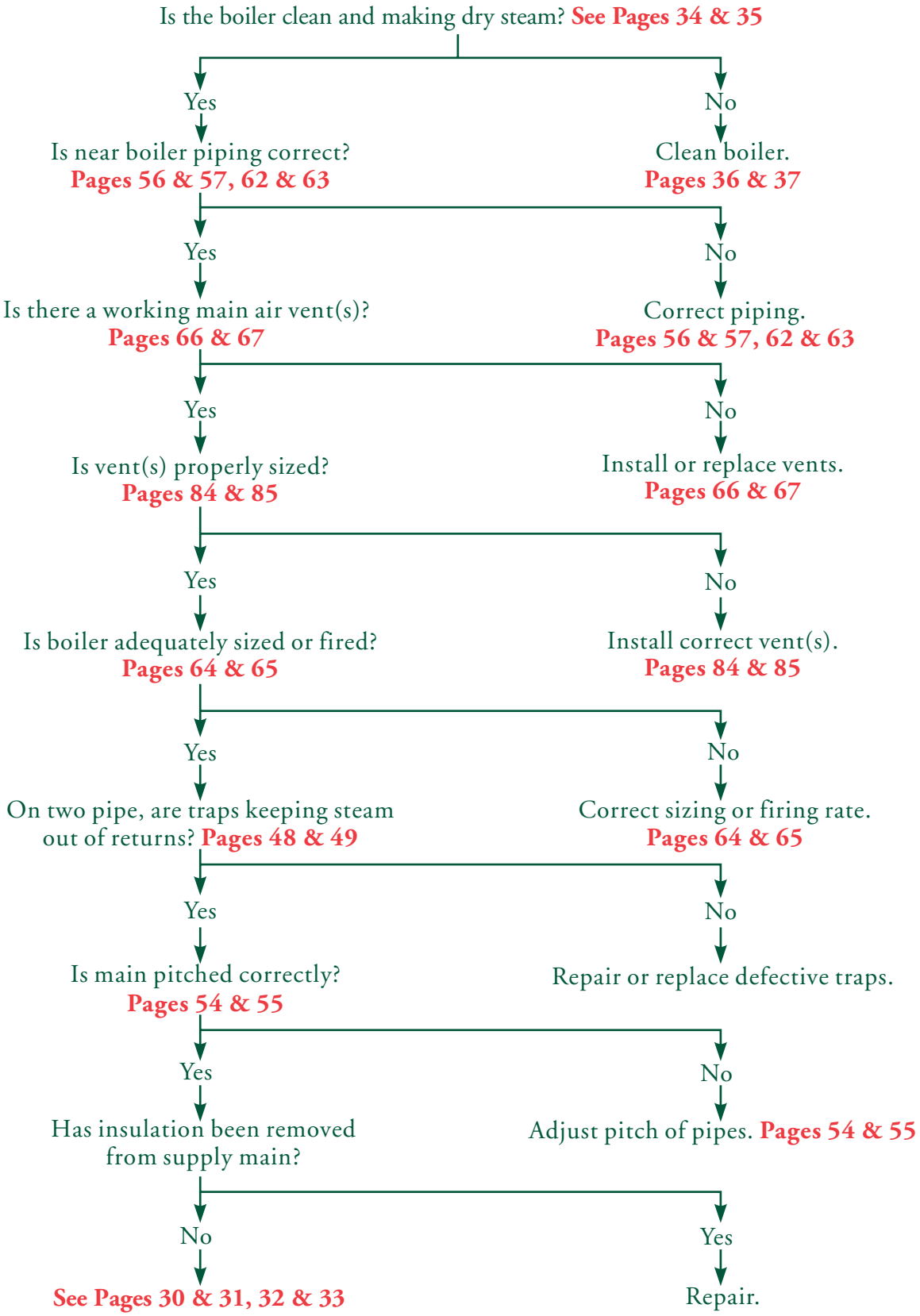

Water hammer will occur in steam main at middle of steam cycle
Area for steam to flow is decreased by extra condensate, increasing steam velocity
Clogged or undersized wet return will back up condensate in steam supply main

Fig. 2


Area for steam to flow is decreased by extra condensate, increasing steam velocity
Water hammer will occur in steam main at middle of steam cycle
Clogged or undersized end of steam main F+T trap will back up condensate in steam supply main
AIR
WATER
STEAM

Steam Does Not Reach End of Main



FOR ALL SYSTEMS

1. Make sure boiler is clean, page 34 A dirty boiler is the cause of so many problems and affects the quality of steam.
2. Make sure main vents are installed and working properly, page 66. Main vents have to be there to have even distribution of the steam along the main.
3. Check steam pressure control setting, page 42. It is the simplest adjustment to make, but has a major effect on the system.
4. Check water line position, page 38. Normal water line position has a huge impact on the production of steam.
5. Check the main vent(s) size, page 84. The bigger the opening is in the main vent, the faster the system will heat.
6. Check near boiler piping for proper size and orientation, page 56. This has to be right to get dry steam.
7. Check for the amount of combustion air that is available to burner. The burner has to have enough air to fire optimally.
8. Perform a combustion analysis to fine tune the burner. Record the results so they can be compared at next check
9. Insulate or re-insulate all the supply piping, including the near boiler piping. This may be the best investment to reduce the fuel bill.

FOR SYSTEMS OVER 500,000 BTU/HR

10. Install a boiler feed unit, pages 108, 110 and 158. A steady water line equals peak performance.
11. Install a cycle rate type control that senses both outdoor temperature and return water temperature. They are not cheap, but they have a great payback.

FOR ONE PIPE SYSTEMS

12. Make sure all radiator valves are fully open or closed, page 46. Partially closed valves slow condensate return.
13. Replace all radiator vents throughout system with one common size vent, page 72. The same size port on each vent proportions the steam flow for even heating.

FOR TWO PIPE SYSTEMS

14. Make sure all the radiator traps are working correctly, page 48. If traps are failed open, steam is being wasted and system will heat unevenly.
15. Install thermostatic radiator valves on each radiator, page 50. They will balance the flow of steam similar to the metering systems.