CHAPTER FIVE

# Water Back

## Why Returning Water to Maintain the Boiler Water Line Is Important

**Steam boilers cannot produce steam to heat the building without water.**

- Water should be free of grease and oil as explained on page 34.

**Water must be returned from the system to the boiler before the burner shuts off because of a low water condition.**

- Short cycles of the burner that waste fuel and cause uneven heating are created by slow condensate return.
- Boiler flooding problems that waste fuel and water are created by slow condensate return.

**The less make-up water used, the better it is for the boiler.**

- Fresh water contains minerals and oxygen that are released by the temperatures required to make steam.
- Minerals, such as lime, can build up in the boiler.
- Any build up can act as an insulation, affecting the transfer of heat from the burner to the water.
- Enough build up can cause boiler failure.

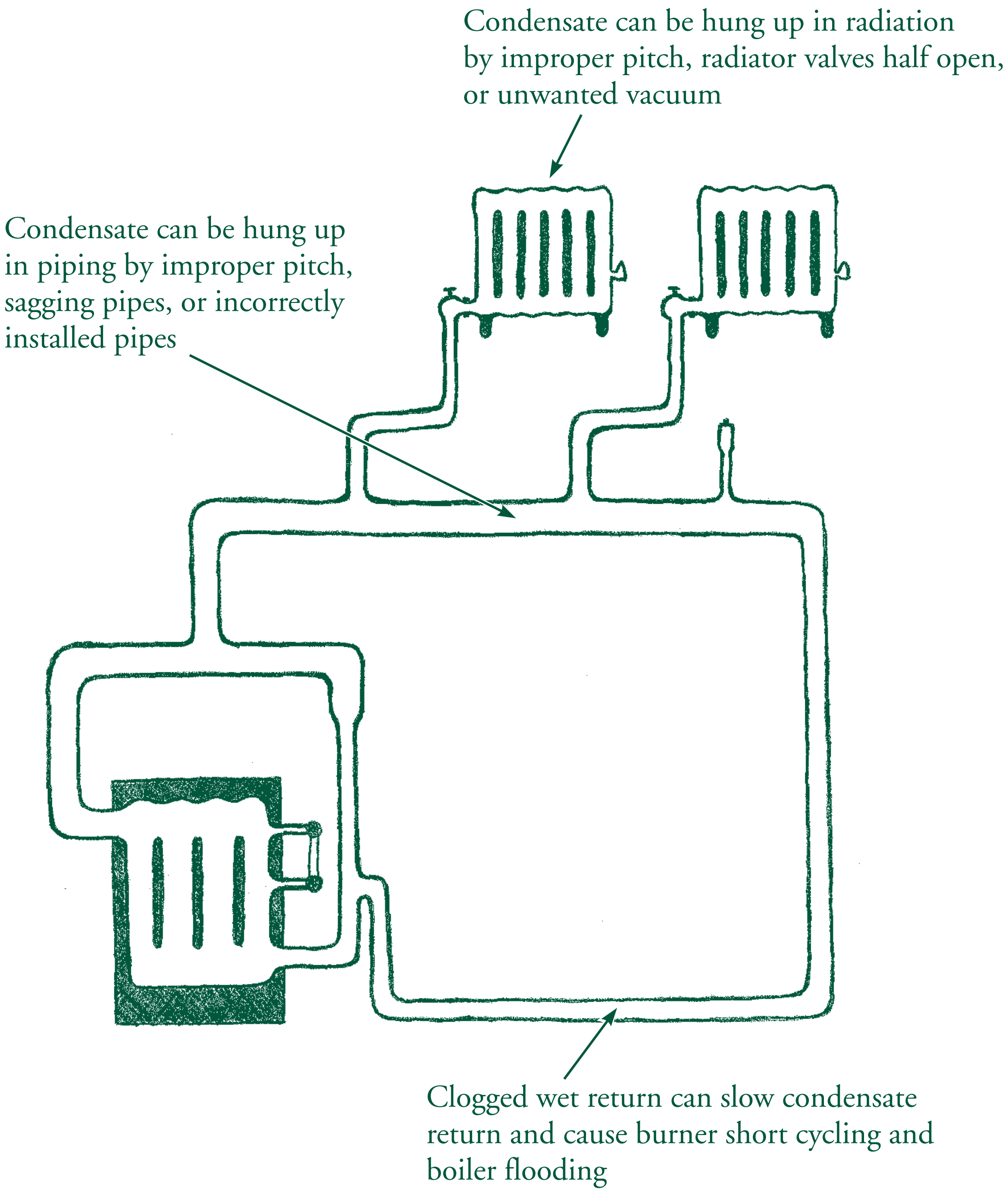
**Water that remains in the radiation or piping above the water line after the system cools down can cause water hammer on the next "call for heat."**

- Piping and radiation should be pitched so that all the condensate flows back to the boiler or pump units by gravity.
- Eccentric fittings need to be used in the horizontal piping whenever condensate will be present.
- Concentric fitting should be used in vertical piping.

**Fig. 1 The ideal burner run cycle during a "call for heat" is one that is not interrupted by the low water cut off.**

- Condensate can be slowed from returning because of a clogged wet return pipe.
- Condensate can be hung up in the system by improperly pitched, incorrectly installed, or sagging pipes.
- Condensate can be hung up in the system by unwanted vacuum in the radiation or piping caused by the closure of automatic valves.

Fig. 1


Condensate can be hung up in radiation by improper pitch, radiator valves half open, or unwanted vacuum
Condensate can be hung up in piping by improper pitch, sagging pipes, or incorrectly installed pipes
Clogged wet return can slow condensate return and cause burner short cycling and boiler flooding

## Follow the Path of Water Back to the Boiler

**Fig. 1 Water that condenses on the cold pipe at start-up flows back into the boiler against the flow of steam in the supply riser.**

- Pipe size affects steam velocity which affects how "wet" or "dry" the steam is. See page 58 through 62.

**Fig. 2 Water that separates from the steam in the header flows back to the boiler through the equalizer and return pipe.**

- Header should be pitched and piped to allow all water to flow back. See page 56 for near boiler piping.

**Water in the supply main flows to the end of the main in a parallel-flow system. The most common type installed.** **See page 52, Fig. 1.**

- Supply main pipe is pitched to direct water away from boiler header to the end of the main.

**Water in the supply main flows back to the boiler in a counter-flow system. This type is not commonly installed.** **See page 52, Fig. 2.**

- Supply main pipe is pitched to direct water back toward the boiler.

**Fig. 1 Water in a two pipe radiator flows back out to the dry or wet return through the trap or vapor device.**

- Water in the dry return flows back to the boiler through a wet return.
- Dry return connections must be connected to the boiler below the water line.

**Fig. 2 Depending on the pitch and the presence of drips or not, in a one pipe system, water in the run outs will flow back to the supply main or flow out to the riser and the drip.**

- Water in the vertical risers will flow back to the run out.
- Water in a one pipe radiator flows back out to the supply riser through the radiator valve.

**Wet returns collect all the condensate to return directly to the boiler or indirectly through condensate, boiler feed, or vacuum pumps.**

- Wet return must be clear of sediment build up to return condensate before automatic feeder adds water to the system, causing boiler flooding.

Fig. 1 Two Pipe Steam

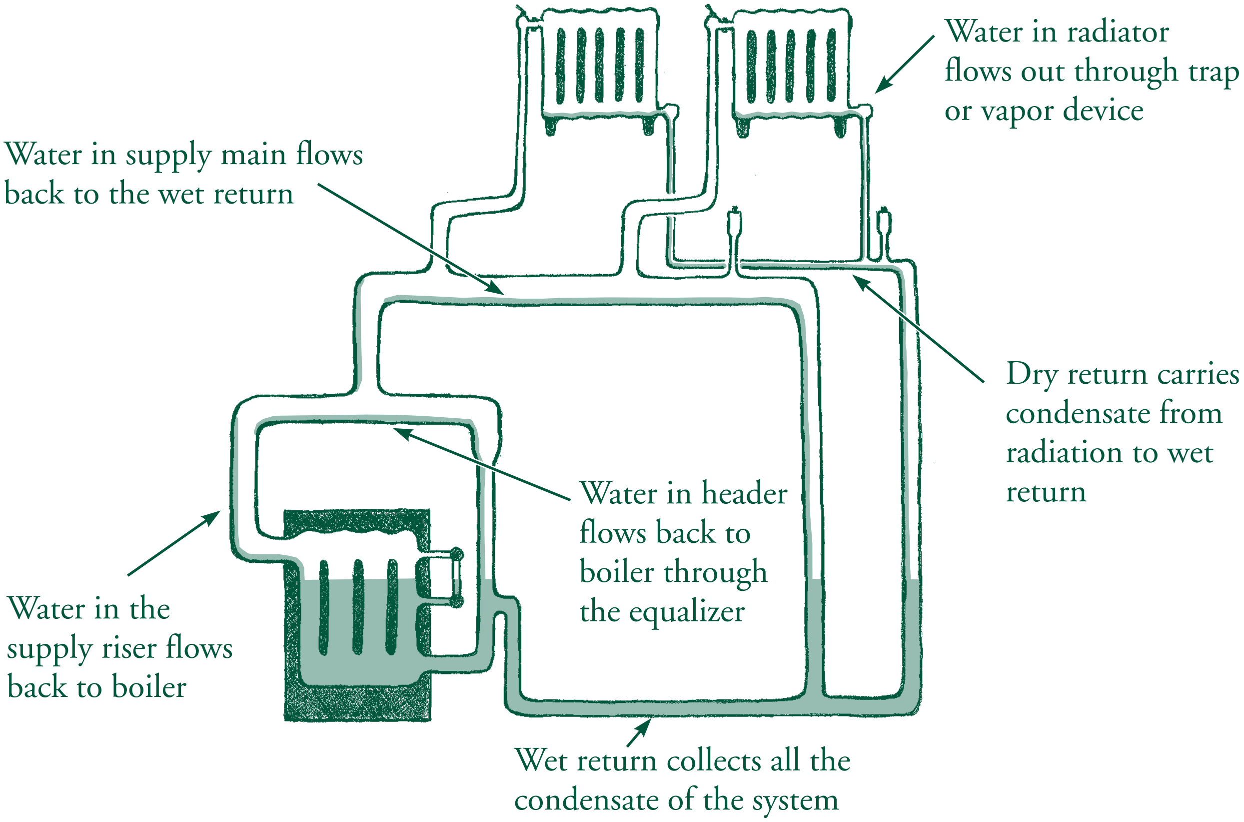
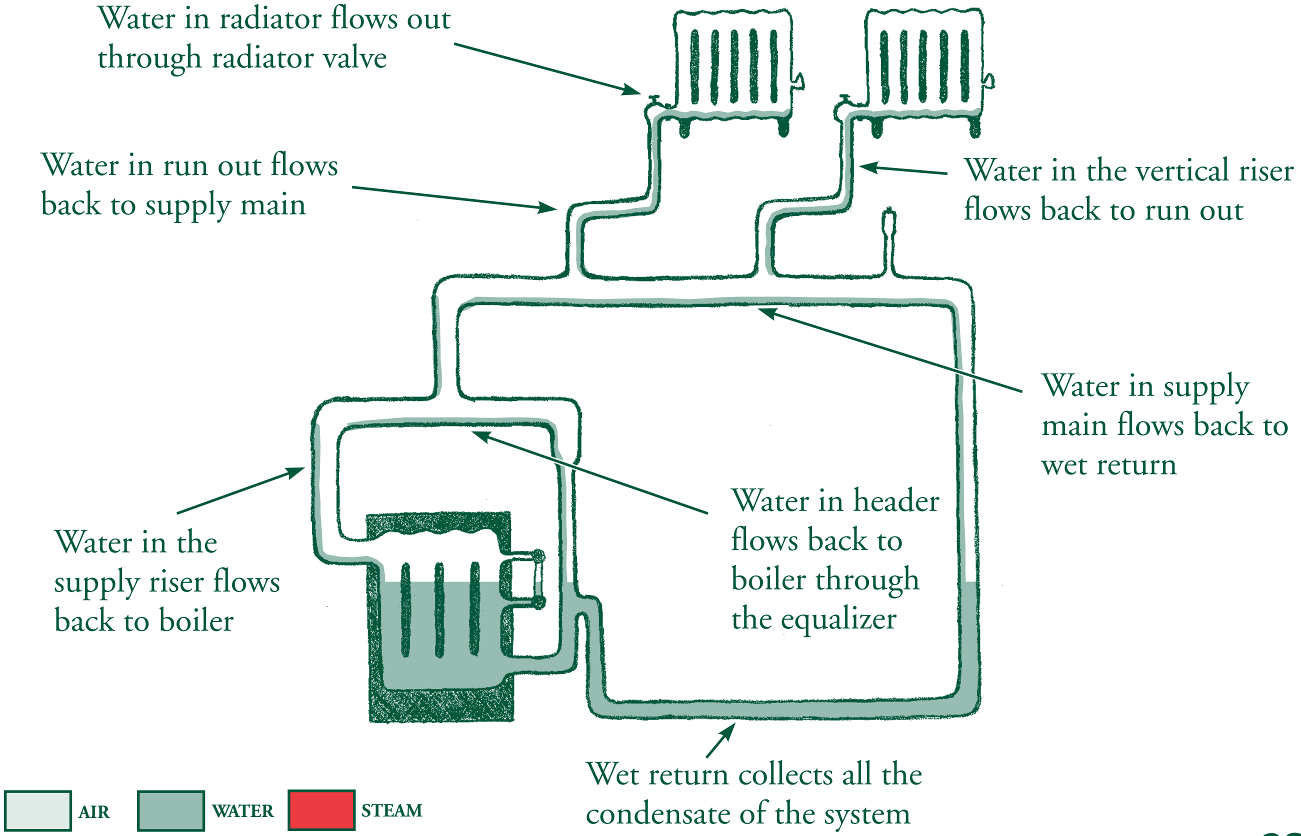



Fig. 2 One Pipe Steam



## Gravity Return Systems, One Pipe Steam

**Static pressure of water in vertical portion of the return makes the condensate flow back into the boiler.**

- The stacking effect of water in the return plus the left over steam pressure at the end of the main combine to force the water back into boiler.
- 28″ of water stacked above the waterline equals 1 pound of pressure.

**"A" Dimension: What is it?**

- The estimated height that water rises above the water line in the vertical portion of the return that will cause water to return to the boiler.
- The end of steam main must be higher than "A" dimension or water will flood supply main causing water hammer and uneven heat caused by blocked runouts.

**Steam loses pressure as it moves through the supply main.**

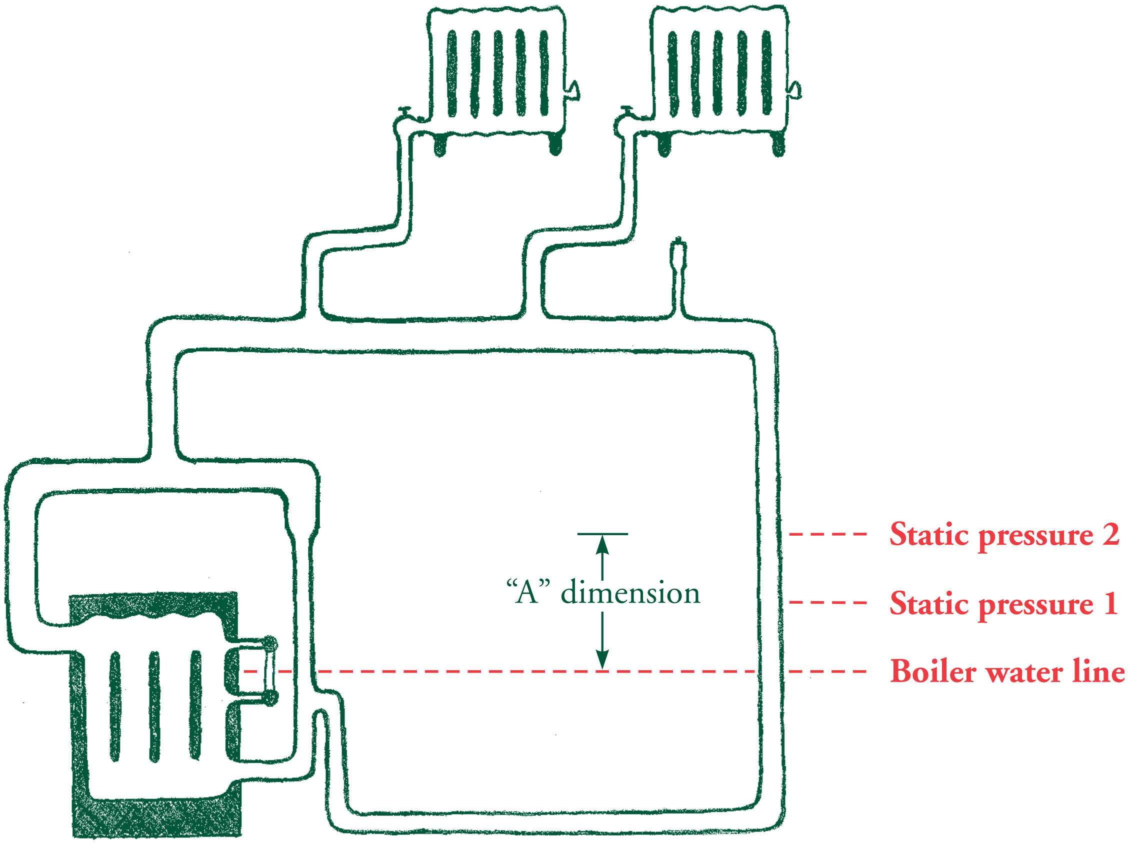
- Typical steam pressure loss from boiler to end of main is ½ pound.
- Static pressure 1 is the pressure required to make up for the system steam pressure loss.
- 14″ of water stacked above the water line creates ½ pound of pressure.

**Water flow through wet return creates pressure drop.**

- Typical water pressure drop through the wet return is ½ pound.
- Static pressure 2 is the pressure required to overcome the water pressure drop.
- 14″ of water stacked above static pressure 1 creates another ½ pound of pressure.
- Pitch wet return 1″ per 40′.

**"A" Dimension: What can go wrong.**

- New boiler may have a higher water line than old boiler.
- New boiler may have been raised out of pit to shorten existing "A" dimension.
- Pressure could be set too high for existing "A" dimension.
- Check valve in return adding friction to water flow in wet return.
- Clogged or restricted wet return adds water pressure drop to flow of condensate, making required "A" dimension higher.




**Static pressure 1 —** Pressure required to make up for system steam pressure loss, usually 1/2 pound pressure.

**Static pressure 2 —** Pressure required to overcome water pressure drop through wet return, usually 1/2 pound pressure.

**Static pressure 1 + Static pressure 2 = "A" dimension**

One pound of pressure = 28″ of vertical height.

If static pressure 1 equals 14″

and

If static pressure 2 equals 14″

then

"A" dimension equals 28″

# Gravity Return Systems, One Pipe Steam, continued

### Fig. 1 Water flow through wet return causes water pressure drop.

- Pressure drop is determined by the amount of flow and the pipe size.
- Wet return is the lowest point of system.
- The pipe in the wet return gets smaller through time by a build up of sediment, increasing pressure drop and "A" dimension.

### Get rid of check valves in the wet return

- Check valves are not necessary if an equalizer is installed (see page 102).
- Check valves are the most likely place for dirt to build up in the wet return to restrict flow and cause more water pressure drop.

### The pitch of the steam mains also determines how well water flows back to the wet return.

- Fig. 2 Parallel flow systems have supply mains that pitch from the boiler to the end of the supply main.
- The pitch for a parallel-flow system should be 1 inch per 20 feet of supply main.
- Fig. 3 Counter-flow systems have supply mains that pitch from the end of the supply main back to the boiler.
- The pitch for a counter-flow system should be 1 inch per 10 feet of supply main.

### The size of the steam mains also determines how well water flows back to the wet return.

- The steam main needs to carry both the volume of steam to heat the connected load and the condensate flow from the connected load.
- Pipe size for counter-flow mains is always larger than for parallel-flow.

Fig. 1

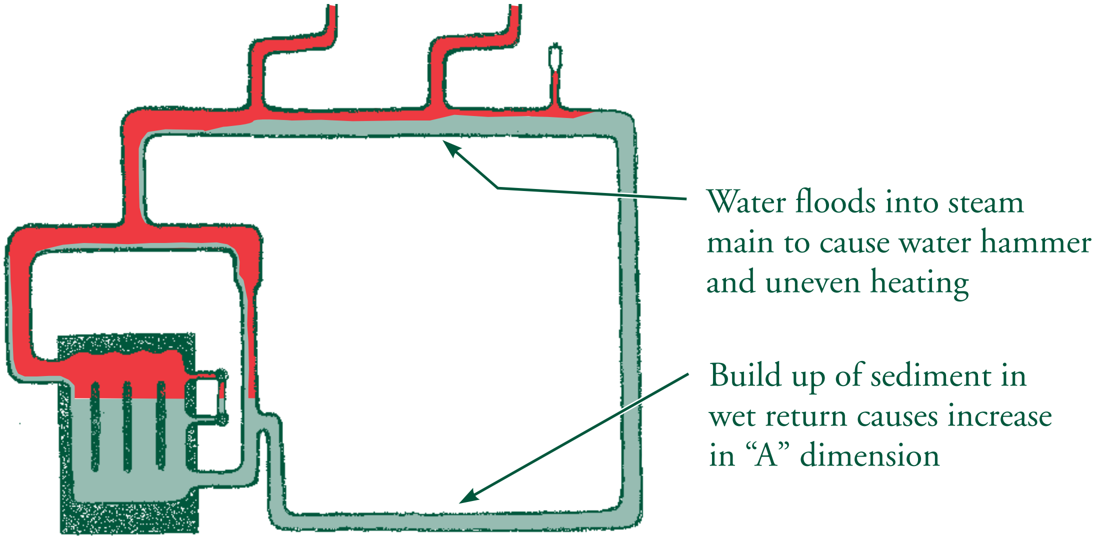



Fig. 2

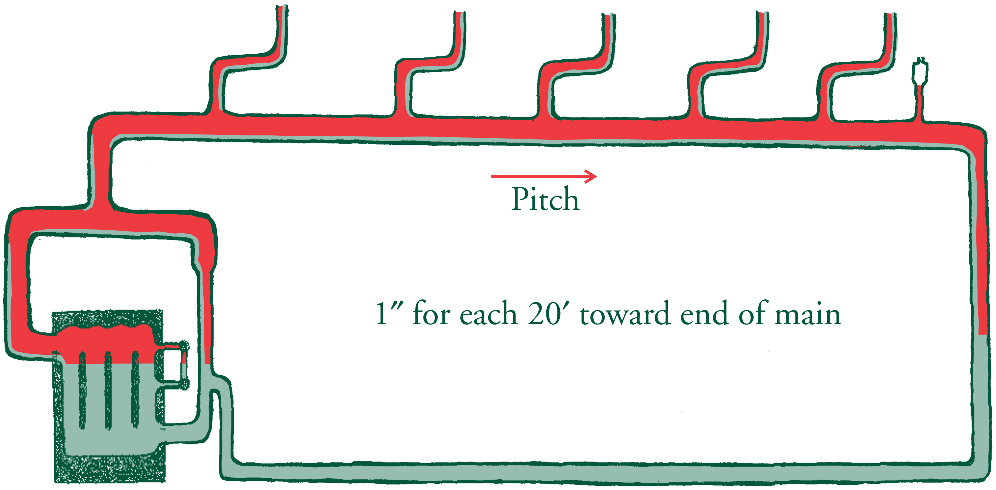
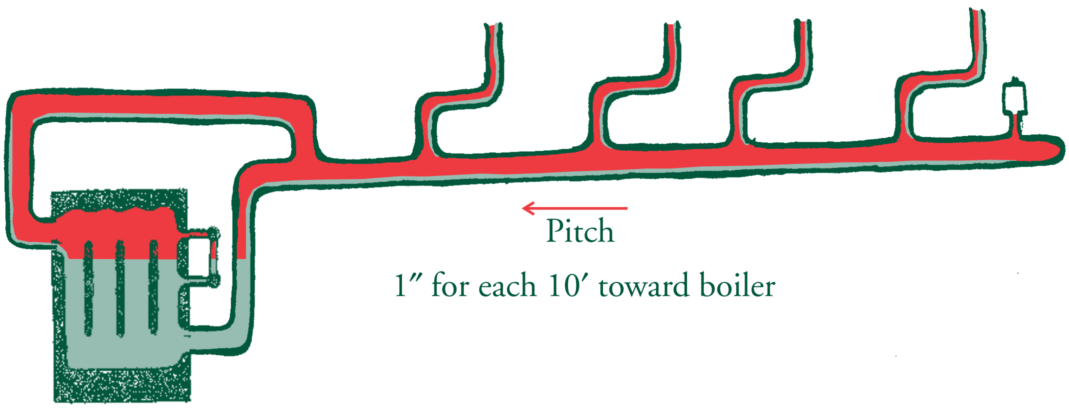



Fig. 3




AIR WATER STEAM

# Gravity Return Systems, One Pipe Steam, continued

**Fig. 1 The radiator valve must always be completely open to allow the water to flow back against the flow of steam into the radiator.**

- Partially closing the valve traps water in radiator.
- Never use less than 1˝. Valve must be sized properly. See chart page 55.
- Partially closed or undersized valves create more pressure drop (restriction) to the flow of water out of the radiator and increase the velocity of the steam entering the radiator.

**Fig. 2 The pitch of radiation must be back towards the radiator valve.**

- The building can settle or radiators can wear the floor enough to change the pitch of the radiator.
- Radiators pitched in the wrong direction will pool water at the vent end, causing water hammer in radiator and spitting air vents.

**Fig. 3 The pitch of run outs must be back towards the main.**

- Pitch 1 inch per 4 feet for horizontal portion of the run outs.
- Taking runout at 45° angle allows condensate to slide into bottom of main without interfering with the with the steam flowing at top of supply main.
- Taking run out at top of main causes condensate to flow into steam traveling along top of supply main.

**Fig. 4 The size of run outs is determined by the amount of radiator connected.**

- Use charts on pages 163, 164, and 165 to calculate load.
- Use the chart on page 161 to calculate pipe size of horizontal run outs.
- Use next size up for horizontal run outs over 5 feet long.
- If the riser is dripped, use chart on page 55.
- The horizontal run out will usually be larger than the size of the vertical riser.

Fig. 1

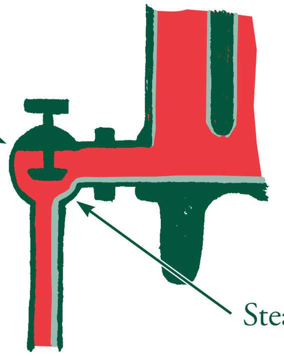



Fig. 2

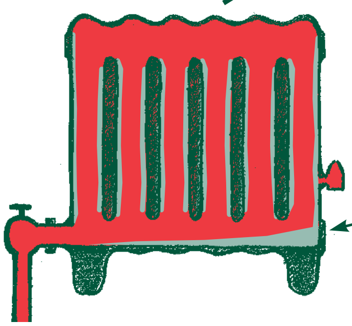



Fig. 3

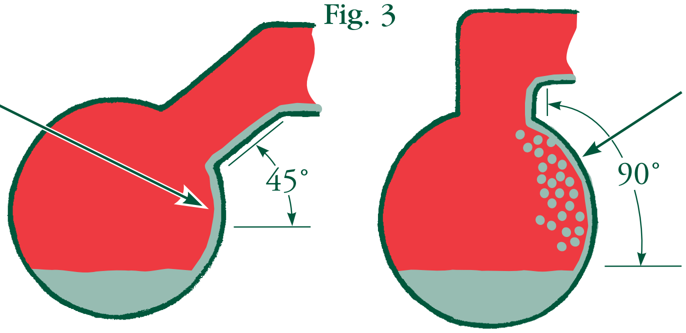
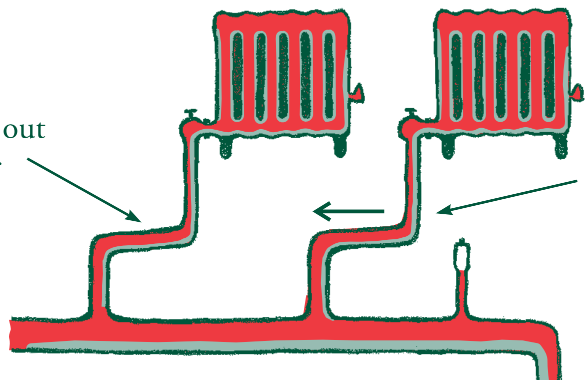
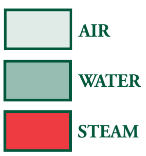



Fig. 4



## Gravity Return, Two Pipe

**Static pressure of water stacking up above the water line creates the pressure required to make the condensate flow back into the boiler.**

- **Fig. 1** When the end of the supply main ends with a water trap, the "A" dimension applies because there is leftover steam pressure.
- **Fig. 2** When the end of the supply main ends with an F+T trap, the "B" dimension applies because there is no steam pressure on the discharger side of the F+T trap.
- The "B" dimension always applies on the return main since there is no leftover pressure. There is no steam pressure on the discharge side of the radiator traps.

**The "B" dimension is the estimated height of water stacked in the vertical portion of the return above the water line that is required to return condensate by gravity.**

- Water height creates the pressure necessary to overcome the pressure in the boiler and the pressure drop in the wet return.
- 1 pound of pressure is created for every 28″ of water above the water line.
- Steam and return mains can flood if enough "B" dimension is not available.

**The returning water pressure has to exceed the operating pressure of the boiler.**

- Typical operating pressure of the boiler is 2 pounds.
- Static pressure 3 is the pressure required to overcome the operating pressure of the boiler.
- At 2 pounds pressure, 56″ would be required.

**Water flow through the wet return creates pressure drop.**

- Typical water pressure drop through the wet return is ½ pound.
- Static pressure 2 is the pressure required to overcome the water pressure drop.
- 14″ of water stacked above static pressure 3 creates another ½ pound of pressure.
- Pitch wet return 1″ per 40′.

**"B" dimension—what can go wrong.**

- Basement ceiling can be too low.
- Wet return can get clogged.
- Pressure setting can be too high.
- New boiler's water line can be lower than an existing mid-level wet return, creating water hammer.

Fig. 1 Water Seal on Supply Main

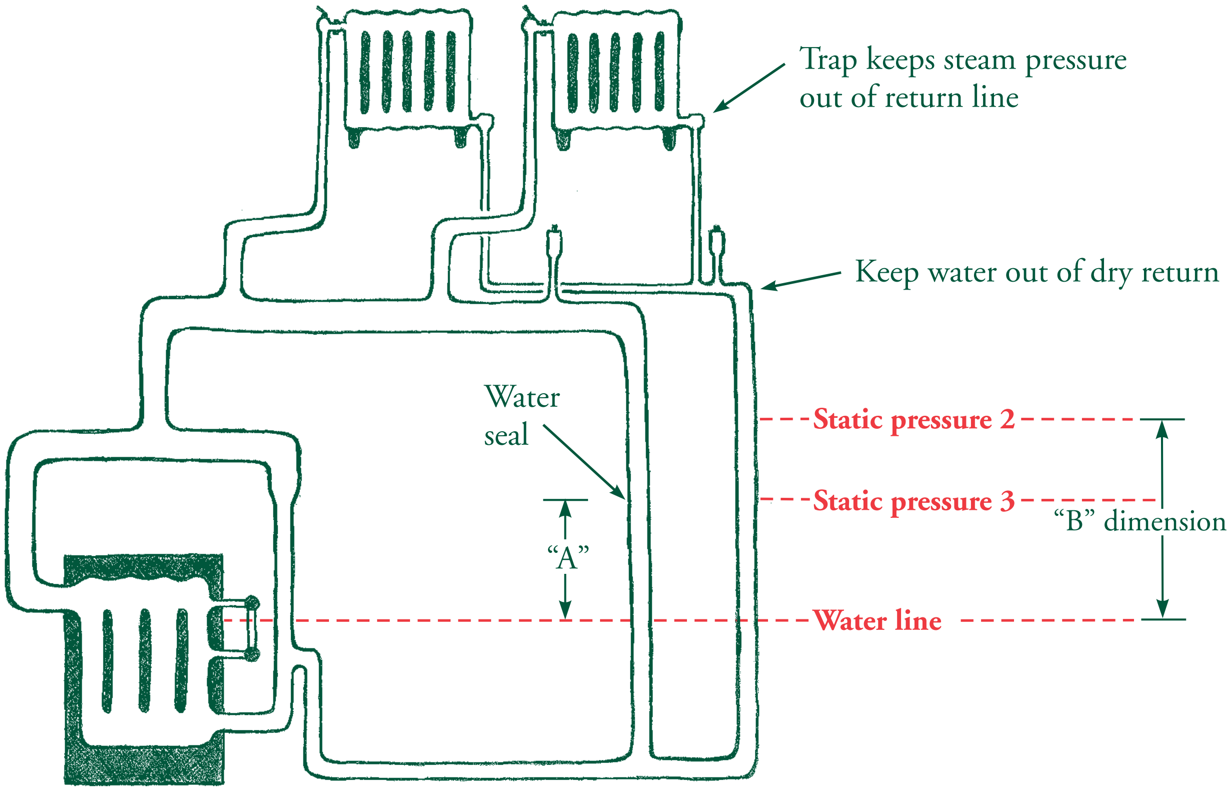
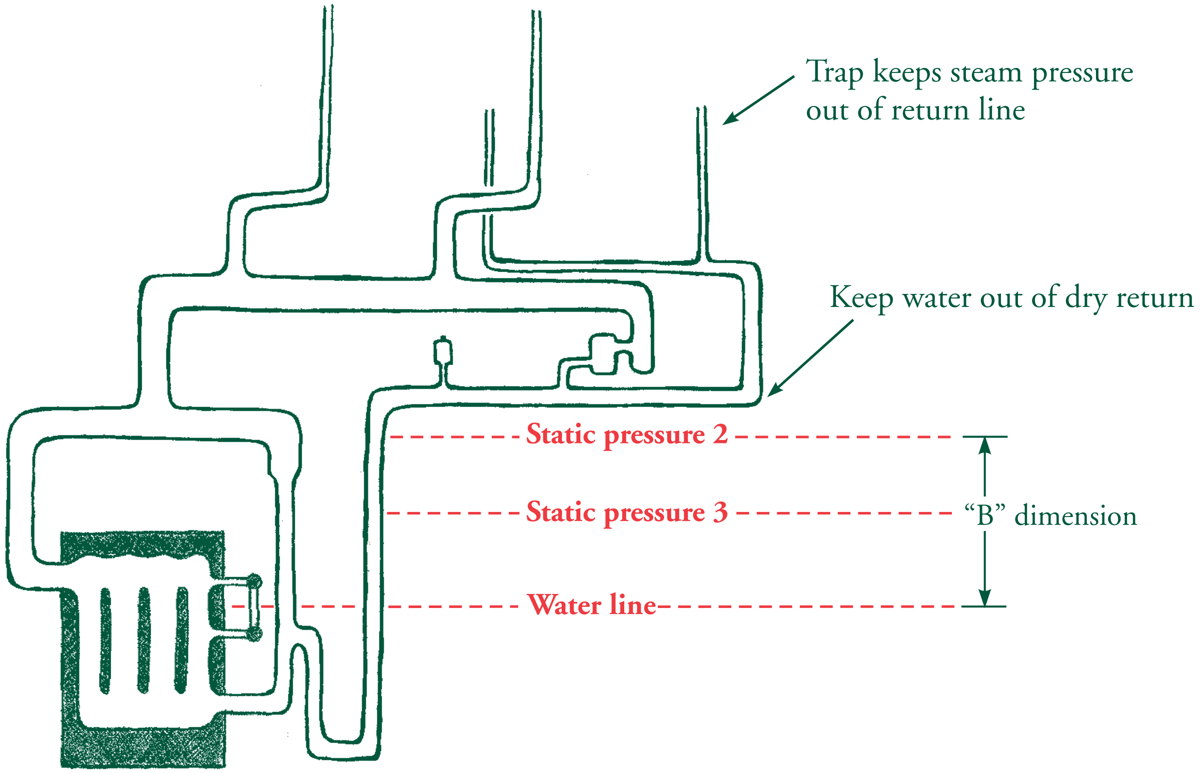



Fig. 2 F+T Trap on Supply Main




**Static pressure 2 + Static pressure 3 = "B" dimension**

## Gravity Return, Two Pipe, continued

**Fig. 1 The radiator trap or vapor device passes the water formed by the condensing steam out of the radiator.**

- Size radiator traps per trap manufacturer's capacity chart, usually ½˝.
- Dirt or scale can form on seat blocking the flow of water out of radiator.
- Pitch of radiator must be toward trap or vapor device to drain condensate.

**Fig. 2 End of main water traps pass the water from the main back to the boiler.**

- Operating pressure of boiler determines how high water will stack.
- End of one pipe mains carry condensate from radiation and main.
- End of two pipe mains carry condensate from main only.

**Fig. 3 End of main F+Ts trap pass the water at a fairly constant rate.**

- Water is discharged at the temperature of steam. Provide at least 12´ of pipe to act as cooling leg before connecting to open receiver tank on boiler feed or condensate unit.

**Fig. 4 Unit heaters in factories or warehouses commonly have return lines above the discharge of the trap.**

- Condensate can be lifted to overhead return lines by the steam pressure.
- A rule of thumb is 1 pound of steam can raise condensate 1´.
- Use a swing check valve on the discharge side of the trap to keep water from flowing back into the unit heater.

**Pitch dry return 1˝ in 100´.**

Fig. 1

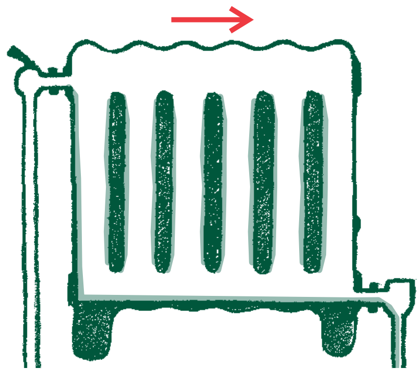



Fig. 2

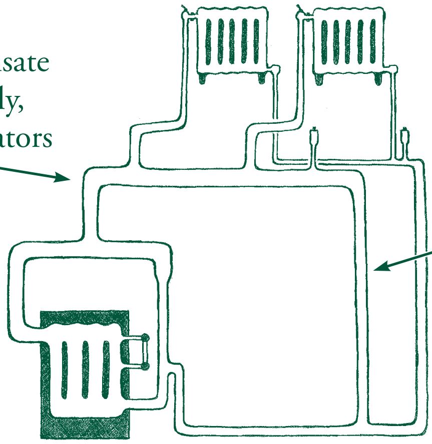



Fig. 3

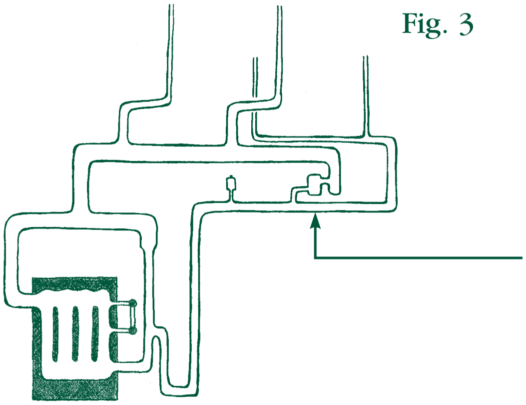
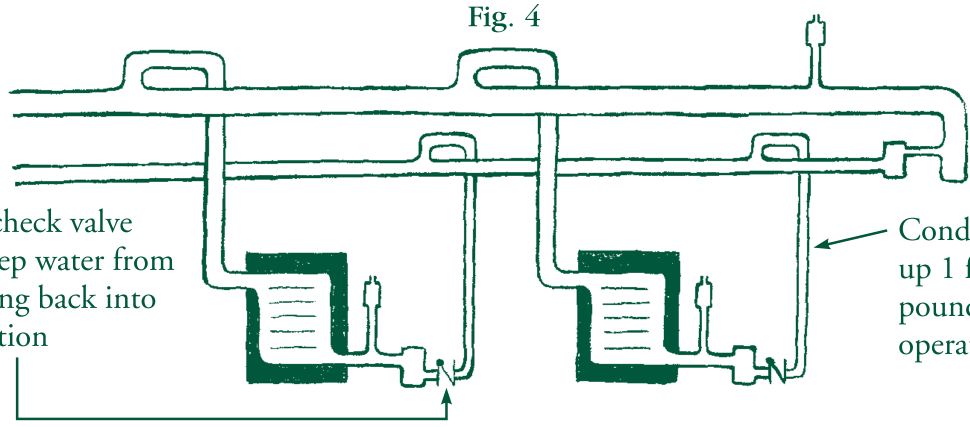



Fig. 4



# Two Pipe Gravity Return, Boiler Return Traps

**Boiler return traps, also called alternating receivers, were designed to return condensate to a coal-fired boiler if the steam pressure got too high.**

- Steam pressure was hard to control in a coal-fired boiler.
- They would act as a steam pressure high limit to prevent water from flooding the mains.

**Differential loops are similar in function to boiler return traps, but have no moving parts.**

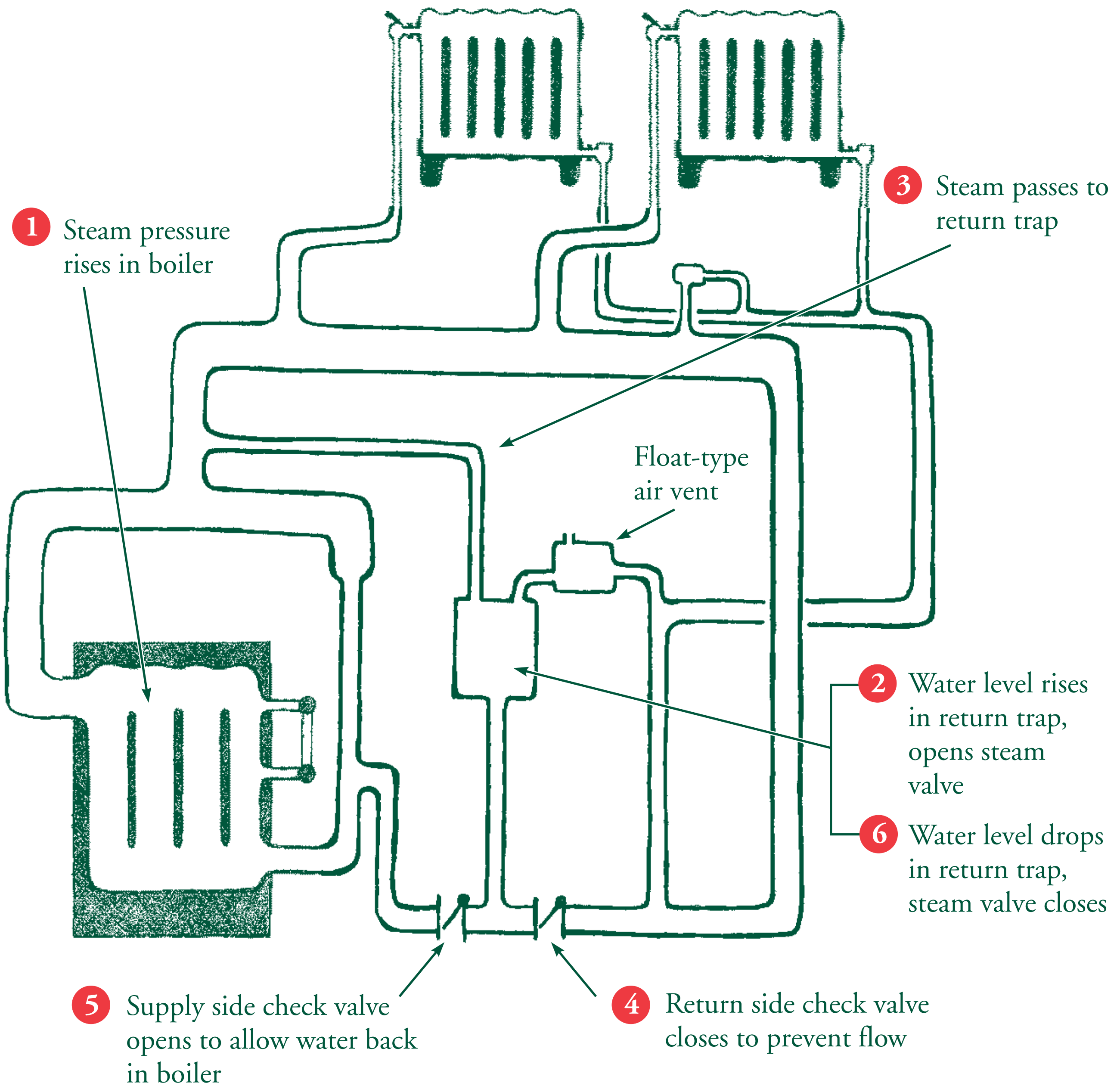
- Float chambers and dip tubes accomplish what floats, weights, and valves do in the return traps.

**On boiler replacements, these devices can be left alone.**

- If "B" dimension of installation is enough for operating pressure, device can be eliminated.
- Adjust pressure high limit to lowest setting possible or operate with vaporstat.
- If boiler feed unit is being installed, device can be eliminated.

**Fig. 1 Boiler Return Trap Sequence of Operation:**

1. Steam pressure rises in boiler.
2. Water level rises in float chamber of boiler return trap to open steam inlet valve.
3. Steam passes from steam main to boiler return trap.
4. Steam pressure forces water down and out of boiler return trap, closing check valve on return side.
5. Supply side check valve opens to allow water from boiler return trap to enter boiler.
6. When water level drops in float chamber of boiler return trap, steam inlet valve closes.


1 Steam pressure rises in boiler
3 Steam passes to return trap
Float-type air vent
2 Water level rises in return trap, opens steam valve
6 Water level drops in return trap, steam valve closes
5 Supply side check valve opens to allow water back in boiler
4 Return side check valve closes to prevent flow

## 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.

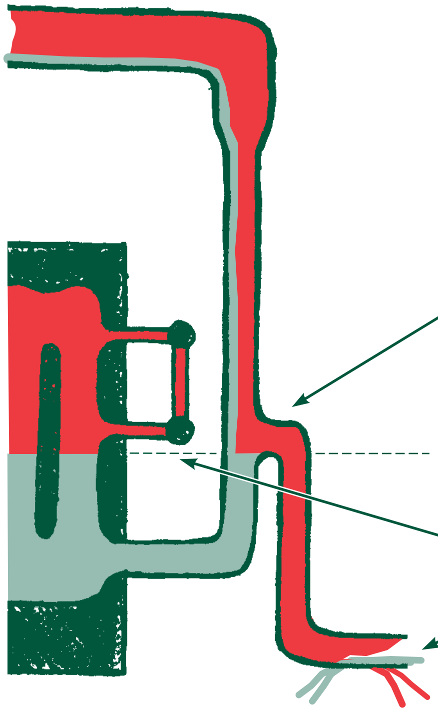
**The height of the loop should be piped 2″ to 4″ below the water line to keep the horizontal portion underwater to prevent water hammer.**

- 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

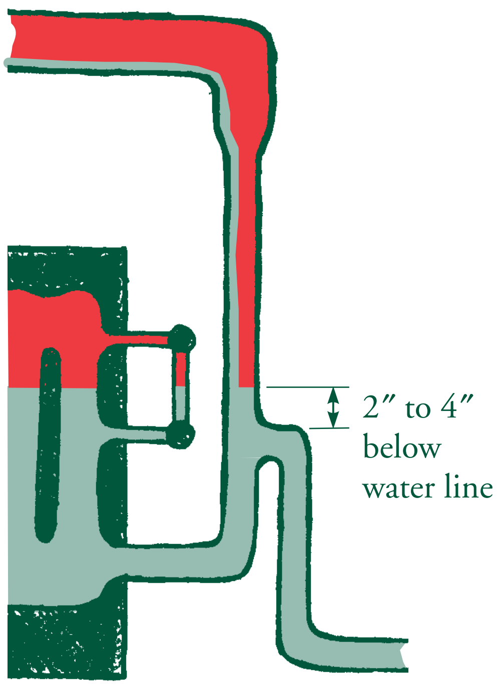


As short as possible to prevent water hammer
Can use:

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

# Maintaining the Boiler Water Line

**Proper steam generation is affected by the location and maintenance of the boiler water line.**

- If the water line is set too high or too low, the boiler will experience problems described on page 38.
- Returning the water to restore the water line is one of the most important components of "Water Back."

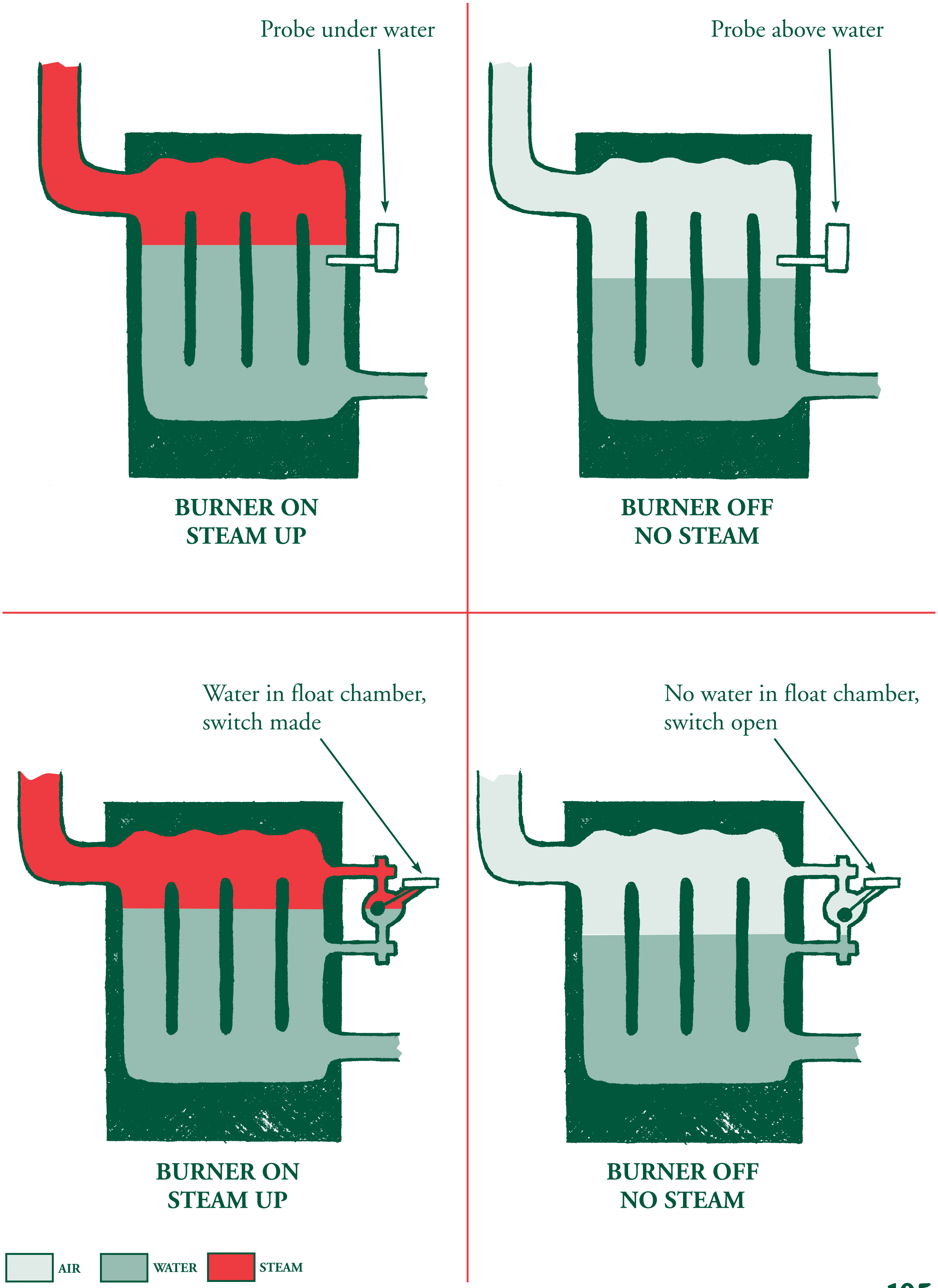
**If the water line gets too low during a run cycle, the low water cut off will shut off the burner.**

- When the burner is shut off during a "call for heat," the production of steam is interrupted.
- Poor steam distribution is the result.
- Higher fuel bills are caused by the short cycling of the burner. The similarity is to the gas mileage of a vehicle–highway mileage with a steady steam cycle; city mileage with a short cycling burner.
- Burner should not be interrupted by low water during "call for heat" burner.

**Some boilers still maintain the water line with a manual (hand) feed.**

- This requires someone (homeowner, maintenance person, or building super) to check boiler on a regular basis and adjust the water line.
- This is a good method of controlling the water line if done properly.

# Maintaining the Boiler Water Line



## Automatic Feeders

**Most boilers are now equipped with some method of automatic feed to refill the boiler.**

- As the water is lost through evaporation from the venting process, the automatic feeder senses the drop in water line and opens a valve to put water back into the boiler.

**One type of automatic feed is a direct feeder.**

- The direct feeder has a float chamber connected to the boiler with equalizing lines.
- **Fig. 1** The float is connected to a valve that opens as the float sinks.
- **Fig. 2** When enough water enters the boiler and the float rises, the valve shuts off.
- See page 132 for flooding problems, page 156 for servicing feeders.

**A second type of direct automatic feed uses a low water cut off and water solenoid valve in combination.**

- The low water cut off (LWCO) has a two position switch, or the boiler is using two separate LWCO's.
- The first switch on the LWCO that will make on the fall of the boiler water line, or the LWCO positioned higher, will activate the solenoid valve to open and feed water into the boiler.
- As the water level returns to its normal position, the switch opens to close the solenoid valve and stop feeding water into the boiler.

**A newer method of automatic boiler feed uses a time delay on the feed valve.**

- The purpose of the time delay is to allow returning condensate to reestablish the water line before activating the feed valve, to prevent flooding.
- Besides the time delay, some feeders will only feed a certain amount of water, about 1/2 gallon, then wait another amount of time before feeding again, also to prevent flooding.

**Boiler feed pumps are controlled by a float type control at the boiler water line.**

- As soon as the water level drops, the feed pump is energized. See page 108 for operation.

**Multiple steam boilers piped to a common supply header can be fed individually if they don't share a common return header.**

- Feed methods for each boiler could be any of the above methods.
- An F+T trap at the boiler water line can keep the standby boiler(s) from flooding.

Fig. 1 Direct Feeder

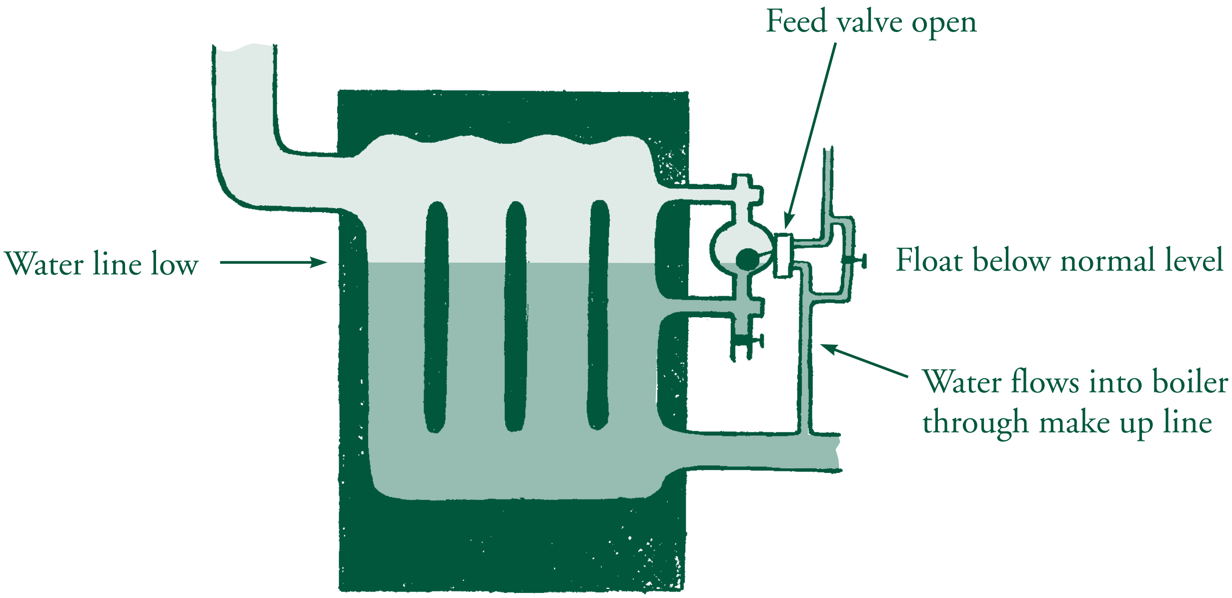
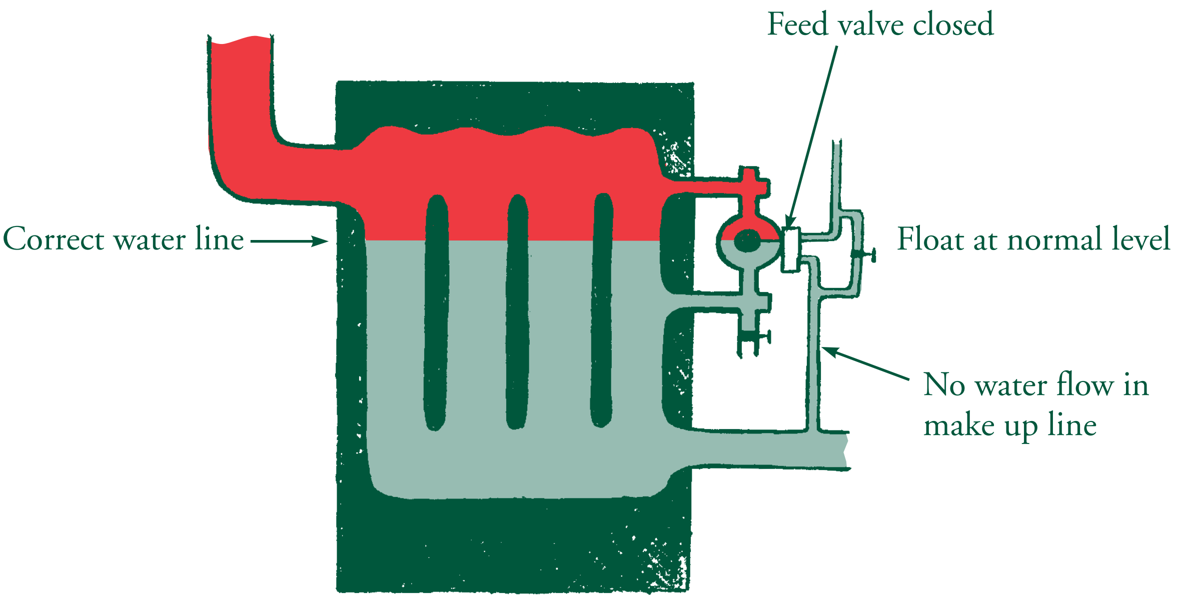



Fig. 2 Direct Feeder




AIR WATER STEAM

# Boiler Feed Units

**The purpose of a boiler feed unit is to provide a reservoir of water to be used to refill the boiler.**

- Modern boilers have much less water capacity than older boilers.
- As modern boilers produce steam, the water level drops faster than with an older boiler.

**Boiler feed units are designed to prevent both the short cycling and the flooding.**

- The water level may drop to shut off the burner in the middle of a "call for heat" before the condensate has a chance to make it back.
- This kind of short cycling causes high fuel bills and uneven heating.
- The water level may drop and cause a feeder to put more water into the system before the condensate has a chance to make it back.
- This kind of extra water feeding causes flooding problems.

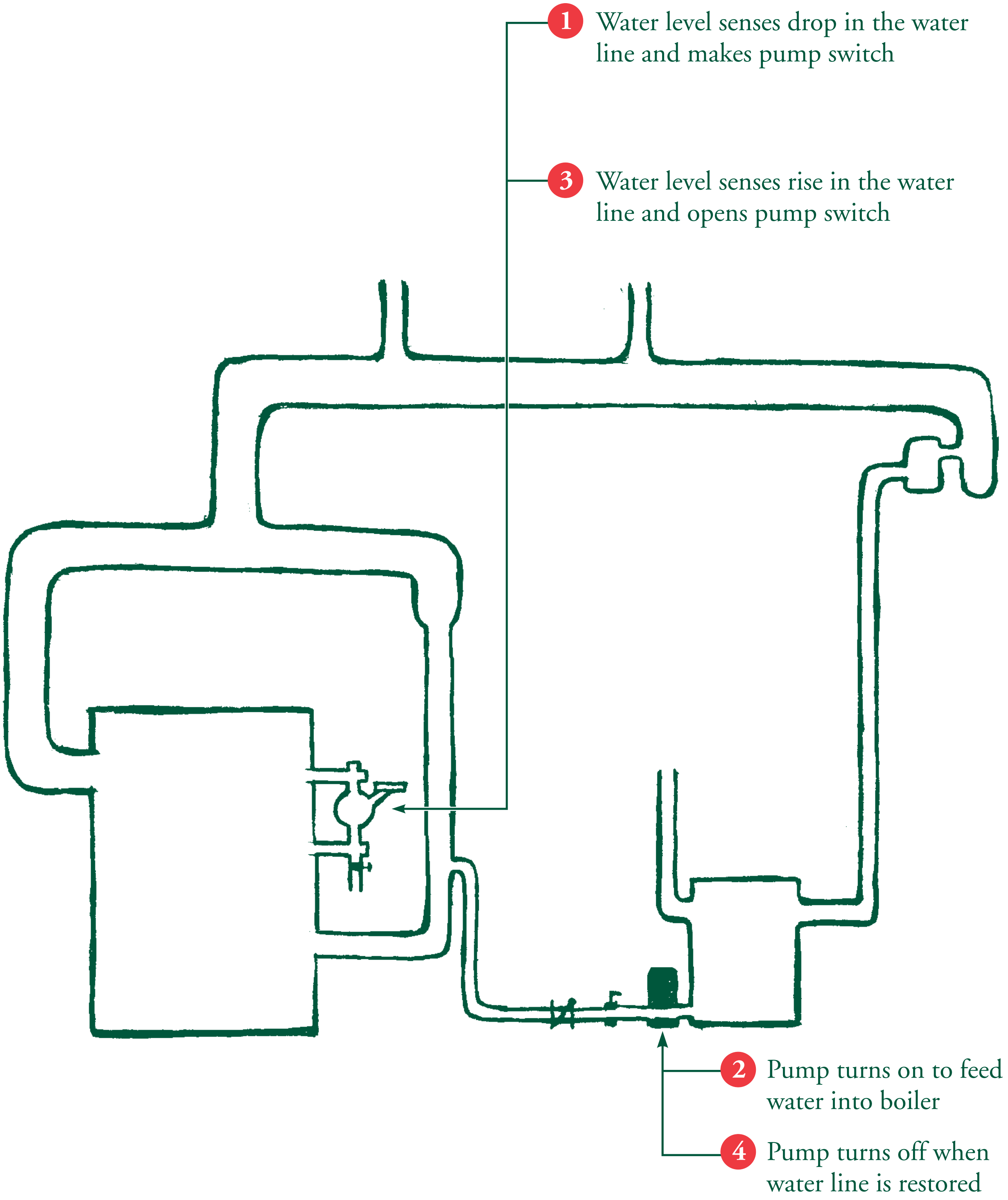
**Fig. 1 The boiler feed unit sequence of operation.**

1. A water level control on the boiler senses the drop in the water line and makes pump switch.
2. The level control then turns on the pump to feed water from the reservoir tank into the boiler.
3. The level control then senses the water level rising.
4. When the boiler water line is restored to the correct level, the water level control turns off the pump.

**A boiler feed system consists of a reservoir tank, a pump, a water level control on the boiler, and a water make-up valve on the tank.**

- The reservoir tank adds the water volume lost as boilers got smaller and more efficient.
- The pump provides the pressure to get the water back into the boiler. Now you don't have to worry about "A" or "B" dimensions.
- The water level control cycles the pump on and off to maintain an almost constant water line.
- The make-up valve on the tank feeds water back into the tank, not into the boiler.

Fig. 1


1 Water level senses drop in the water line and makes pump switch
3 Water level senses rise in the water line and opens pump switch
2 Pump turns on to feed water into boiler
4 Pump turns off when water line is restored

## Sizing and Piping Boiler Feed Units

**The reservoir tank should store at least 1 gallon of water for each boiler horsepower.**

- Multiply boiler input in BTUs by 0.00003 for number of gallons needed in tank. See page 160 for common boiler sizes.

**The pump has to have enough discharge pressure to overcome the operating pressure of the boiler and the friction loss of the piping.**

- Most stock units have at least 20 pounds of discharge pressure.

**The pump has to be able to move enough gallons of water per minute to keep up with the boiler's condensing rate.**

- Multiply boiler input in BTUs by 0.000006 for number of gallons per minute pump needs to move.

**When adding a boiler feed unit to an existing system, traps may have to be added to the system.**

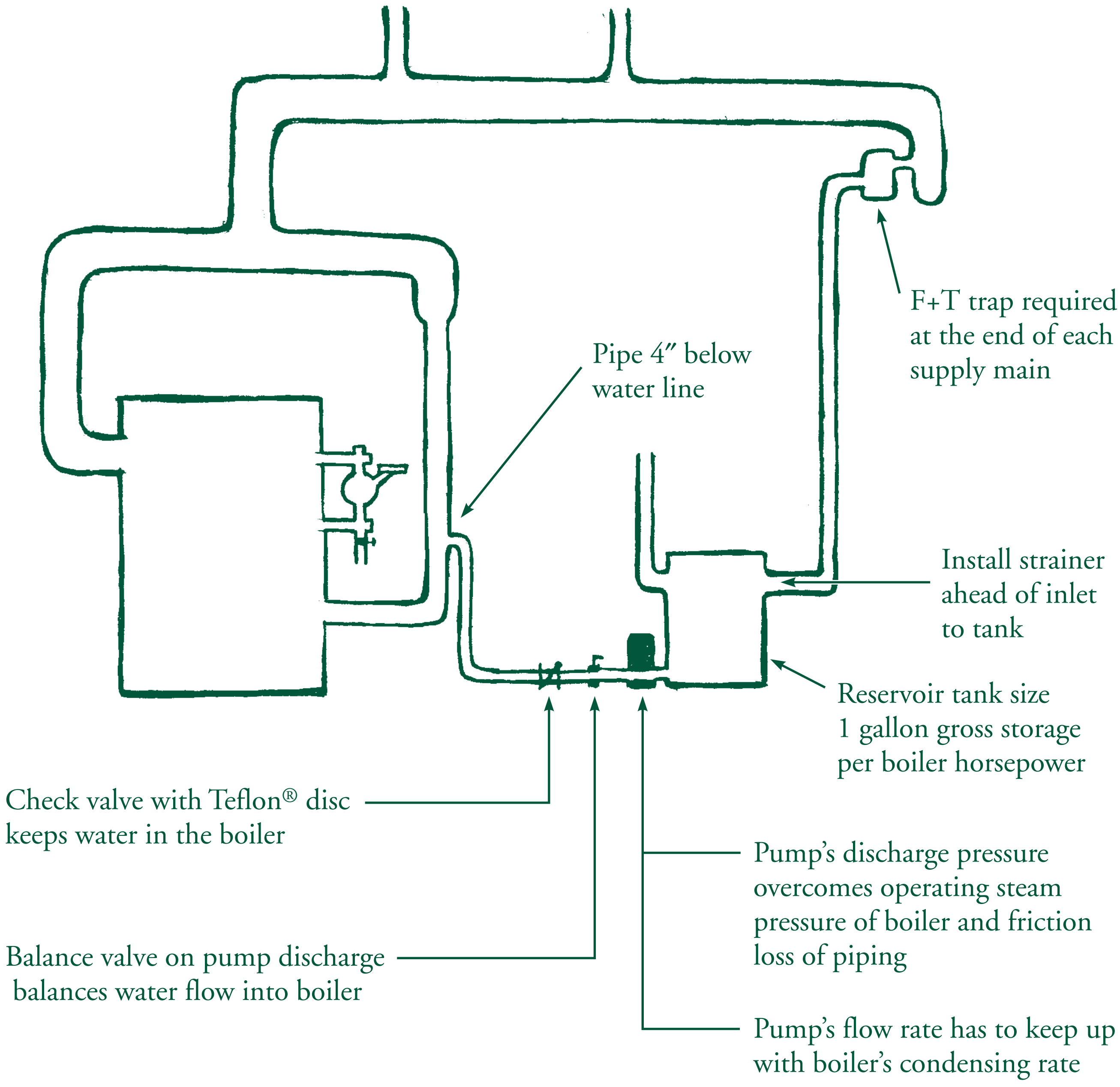
- Boiler feed tanks are open and vented to the atmosphere.
- On one and two pipe systems, the end of each steam supply main needs to be trapped individually.
- F+T traps work best because they vent air well and don't back up condensate.
- A vent may need to be added to the discharge side of the trap if the air cannot pass to the vent on the tank because of a water trap. See page 162.
- ⊘ Don't forget a cooling leg after any trap located near the tank.

**Don't master trap right ahead of the boiler feed unit on a two pipe system.**

- The system already has traps.
- If steam is getting to the tank, fix the existing traps.
- Adding a second trap takes away the pressure differential that makes the existing trap work.
- Condensate won't return properly from the system.

**Pipe the discharge of the pump to the boiler 4˝ below the water line.**

- Include a strainer between reservoir tank and pump inlet if possible. Install strainer ahead of reservoir tank if not.
- Include a check valve with Teflon® disc and a balance valve between the pump and the boiler.
- Use an amp meter to check the motor current draw while setting the balance valve.
- ⊘ Don't operate motor of pump above its rated amperage.


F+T trap required at the end of each supply main
Pipe 4″ below water line
Install strainer ahead of inlet to tank
Reservoir tank size 1 gallon gross storage per boiler horsepower
Check valve with Teflon® disc keeps water in the boiler
Pump's discharge pressure overcomes operating steam pressure of boiler and friction loss of piping
Balance valve on pump discharge balances water flow into boiler
Pump's flow rate has to keep up with boiler's condensing rate

## Condensate Pump Units

**The purpose of a condensate pump unit is to move condensate.**
- Condensate can be moved from a low point in the system.
- Condensate can be moved back into the boiler.

**The condensate pump unit consists of a storage tank, a float switch, and a pump(s).**
- The storage tank collects the condensate from the return lines.
- The float switch activates the pump when enough water collects in the tank.
- The pump moves the water out of the tank to a boiler feed unit, overhead return, or directly to the boiler.

**Modern boilers with their small water content don't operate well with a condensate unit returning the water directly to the boiler.**
- Boiler flooding problems are common when condensate units are used for boiler feed, especially in mild weather.
- Condensate units pump water into the boiler if the boiler needs it or not.

**Condensate units can be used when underground wet return mains are removed because of leaks or remodeling.**
- End of supply main steam traps may need to be added to the system since the condensate unit will be vented to the atmosphere.
- Pipe all returns that previously connected to underground line to condensate unit now located above ground or in a pit.
- Pipe new overhead return with pitch back to boiler room.

**The radiation load connected to the condensate unit determines its size.**
- Check manufacturer's literature for rated capacity of unit.
- Select unit with capacity that exceeds the radiation load.
- ⃠ Don't undersize, because water will be lost out of the overflow.

**Fig. 1 and Fig. 2 Sequence of operation of condensate pump unit.**
1. Condensate from system flows into the tank.
2. Water level in tank rises.
3. Float in tank rises to make switch for pump.
4. Pump activates to move water out of tank through discharge piping.
5. Float in tank drops to open switch for pump.
6. Pump turns off.

Fig. 1

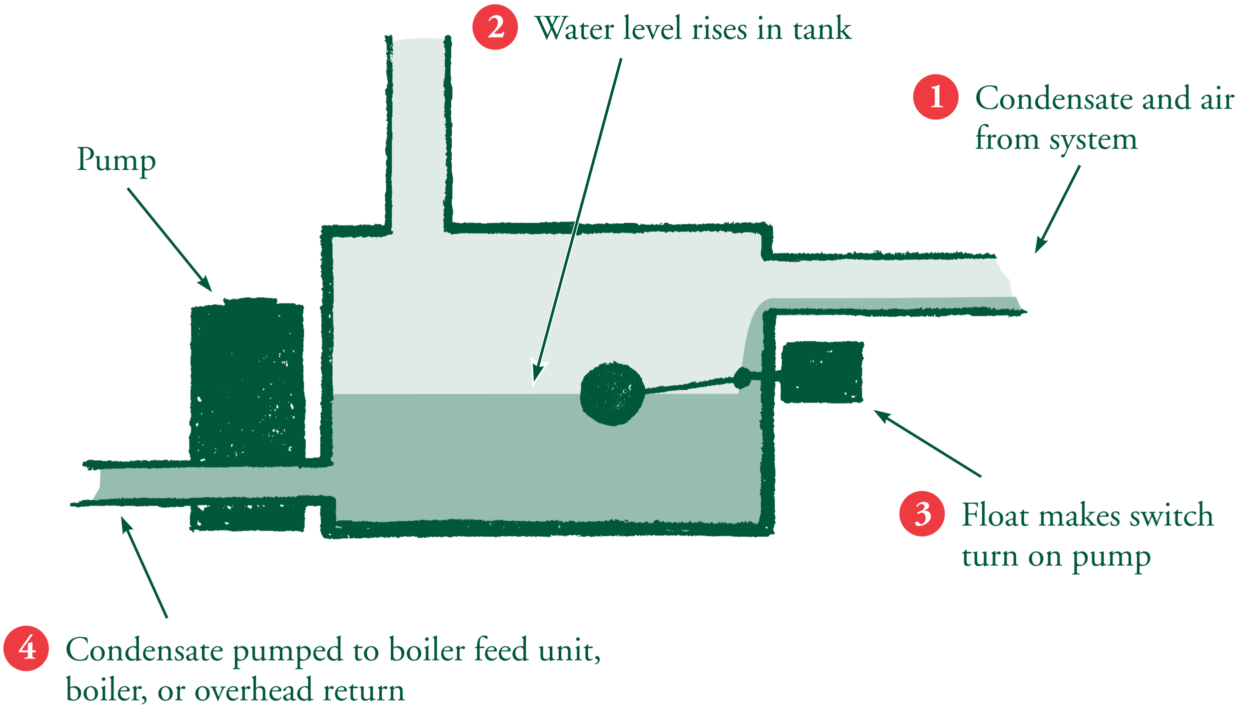
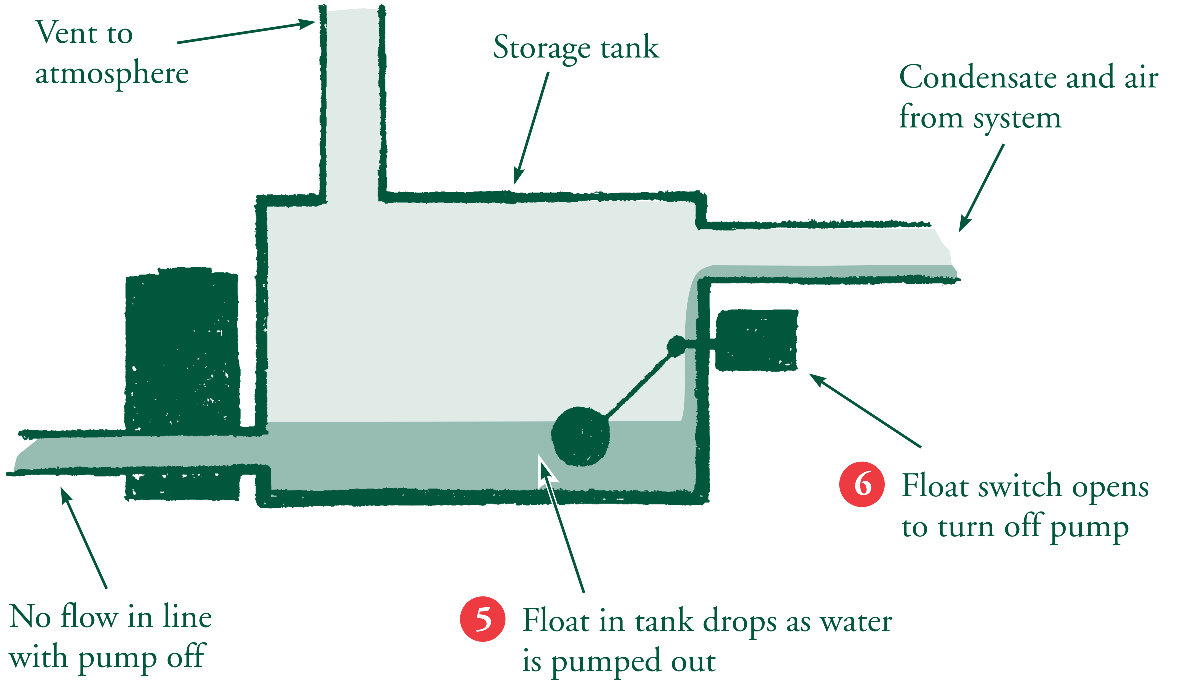

2 Water level rises in tank
1 Condensate and air from system
Pump
3 Float makes switch turn on pump
4 Condensate pumped to boiler feed unit, boiler, or overhead return

Fig. 2


Vent to atmosphere
Storage tank
Condensate and air from system
6 Float switch opens to turn off pump
No flow in line with pump off
5 Float in tank drops as water is pumped out
AIR
WATER
STEAM

# Water Hammer Theory

**Water hammer occurs when steam slams pockets of water around in the system.**

- It is not normal for a steam system to make noise.
- Water hammer is an indication that something is wrong and should be fixed.

**Most water hammer is caused by condensate return problems.**

- Condensate has to return to the boiler at the end of a steam cycle.
- Water left in the return or supply piping systems during the off cycle can be the cause of water hammer.

**There are many different problems that can cause water hammer.**

- Knowing at what point in the steam cycle the hammering occurs can help you find the problem.
- The next three sections explain the causes of water hammer at the beginning, middle, and end of the steam cycle.

**The most common cause of water hammer is the pitch of the pipe.**

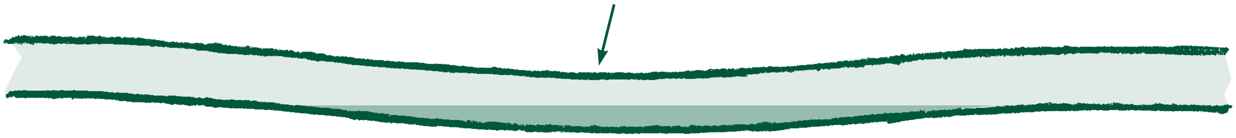
- Sags in the pipe due to the building settling or a hanger coming loose change the pitch of the pipe.
- **Fig. 1** Puddles of water stay in the piping during the off cycle instead of draining back to the boiler.
- **Fig. 2** The water is then whipped up by the velocity of the steam as it flows through the pipe during the on cycle.
- **Fig. 3** Slugs of water fill the pipe until the steam pressure blasts the slug down the main into the first bend, with a resulting bang.

**Using concentric fittings or pipe that has not been properly reamed are other common causes of water hammer.**

- They can both form puddles of water in the horizontal piping. See pages 116 and 117.

**Fig. 1**

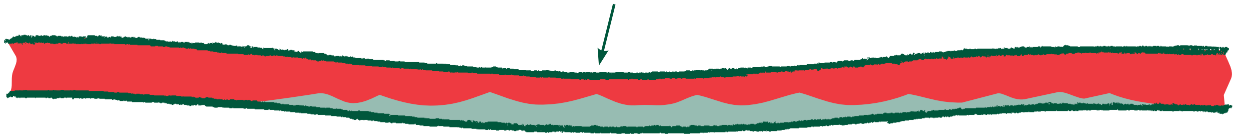
Pipe size is reduced by water
which increases steam velocity



Puddle of water forms in sag of pipe

**Fig. 2**

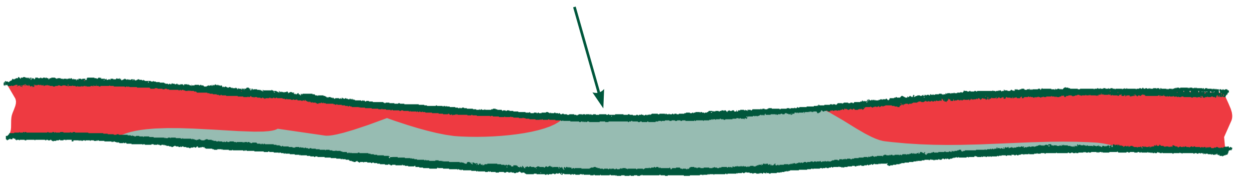
Waves decrease pipe size more, which
increases steam velocity more



Steam velocity whips up puddle of water into waves

**Fig. 3**

Slug blocks steam flow



Slug of water is created and then blasted down pipe to bang or hammer at first bend

AIR WATER STEAM

# Causes of Water Hammer at the Beginning of the Steam Cycle

**When the water hammer occurs at the beginning of the system cycle, look for places that the water can lay in the steam horizontal mains and run outs during the off cycle.**

- The supply mains and run outs should be free of any puddles of water at start-up.
- All the condensate from the previous run cycle should be able to drain back to the wet return, condensate unit, or boiler feed unit.

**The most common place for water to form puddles is in sagging pipe.**

- As buildings settle, the pitch of the pipe can change.
- **Fig. 1** Pipe hangers that have come loose or been removed can cause dips and sags.
- Run outs that have been used for hanging items or used by teenage boys for chin-ups can have changes in the pitch of the pipe.

**The bottom of the horizontal supply piping must not go uphill.**

- **Fig. 2** A regular bell reducer (concentric) when used in a horizontal line creates a puddle of water.
- **Fig. 3** A tee that makes a pipe reduction on both the branch and the run creates a puddle of water.
- **Fig. 4** Pipe that is not reamed can create a puddle of water.

**Steam mains that change elevation by rising up need to have a working drip.**

- The drip can be with a water trap to a wet return or with a steam trap connected to a dry return, wet return, or condensate unit.
- ⊘ The drip trap can become clogged or plugged with sediment.

**Zone valves must be piped with a drip to return condensate when they are closed.**

- If condensate can collect on outlet side, use drip and vacuum breaker on outlet of zone valve.
- If condensate can collect on inlet side, use drip on inlet of zone valve.

# Causes of Water Hammer at the Beginning of the Steam Cycle

Fig. 1

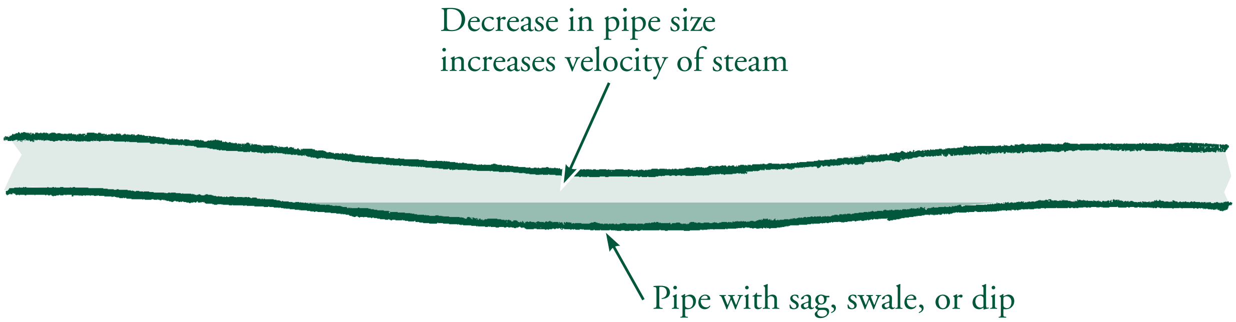



Fig. 2

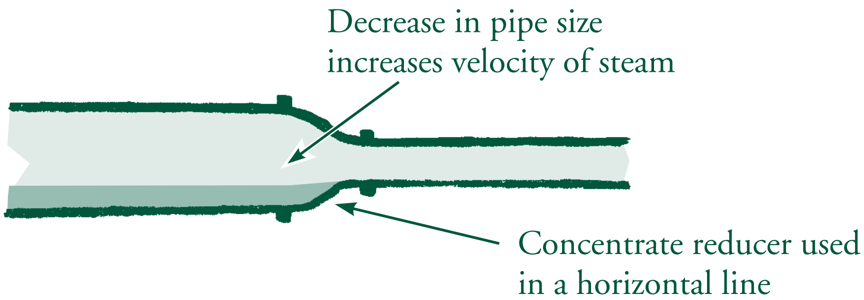



Fig. 3

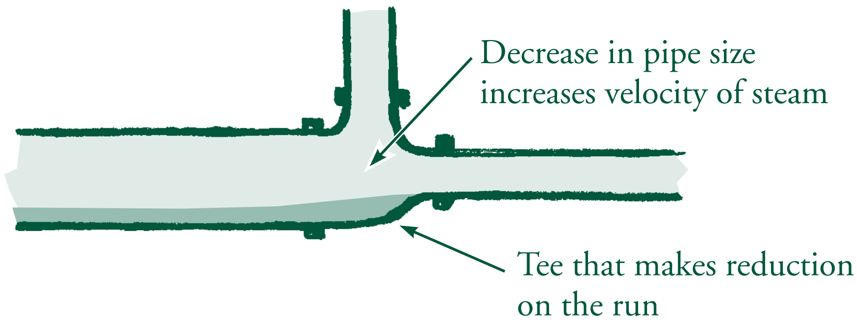
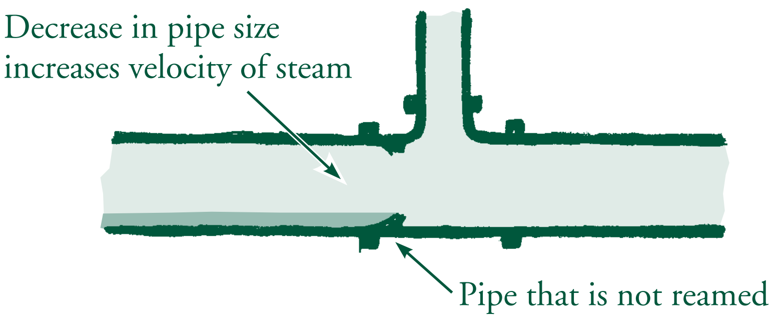



Fig. 4




# 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

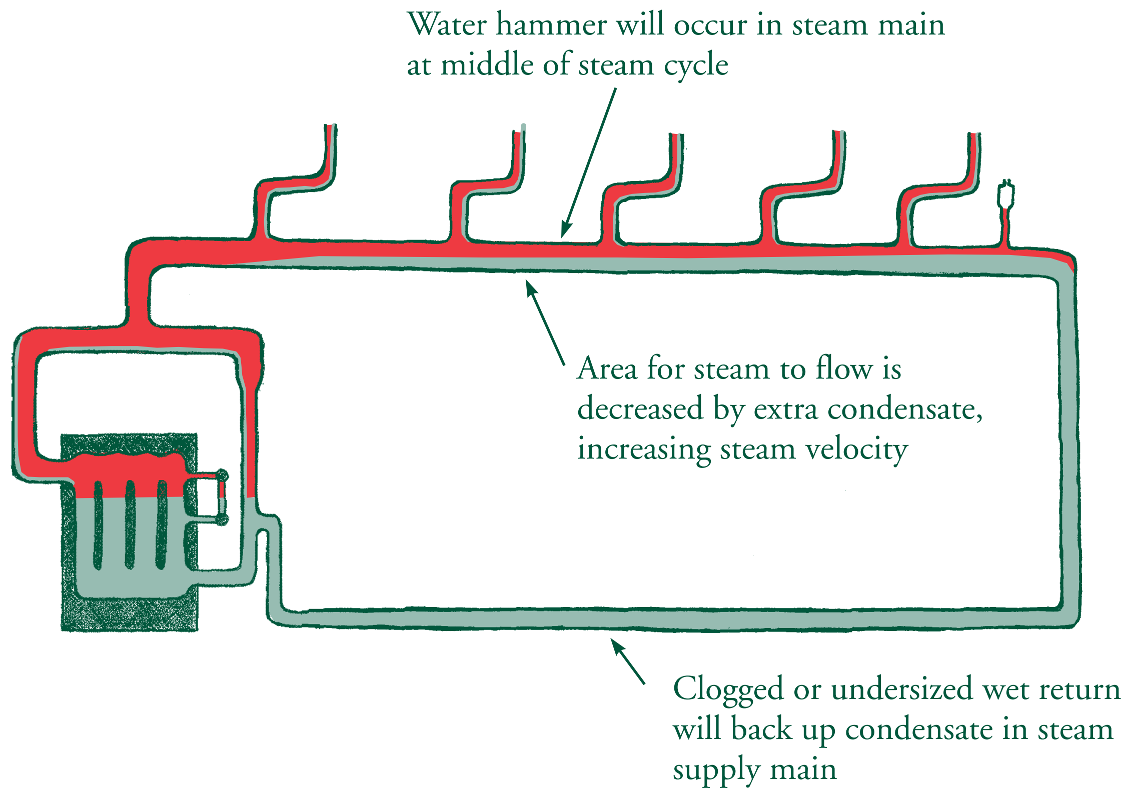
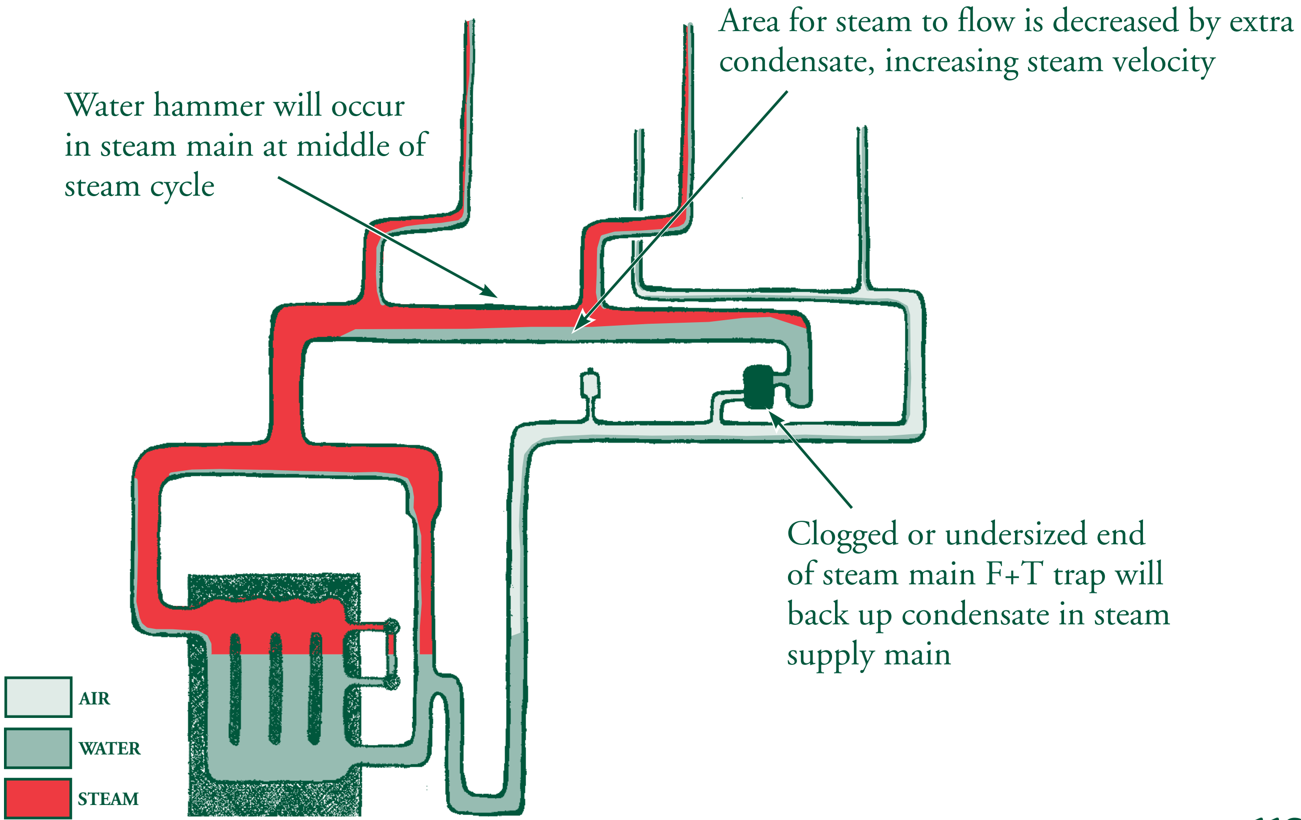

Water hammer will occur in steam main at middle of steam cycle
Area for steam to flow is decreased by extra condensate, increasing steam velocity
Clogged or undersized wet return will back up condensate in steam supply main

Fig. 2


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 end of steam main F+T trap will back up condensate in steam supply main
AIR
WATER
STEAM

## Middle Cycle Hammering, continued

**Incorrect piping around the Hartford Loop or boiler feed unit can cause water hammer at the middle of the steam cycle.**

- The details of near boiler piping need to be followed, refer to pages 56 and 57.
- The details of piping boiler feed units need to be followed. Refer to pages 110 through 111.

**Avoid water traps before the inlet to a boiler feed unit.**

- If the water trap cannot be avoided, like going under doorways, make sure to use an air vent after the trap. See page 162.

**Don't master trap right ahead of the boiler feed unit on a one pipe system.**

- Steam vapor will come out the reservoir tank vent because the trap does not have a cooling leg.
- The system will water hammer because steam is getting into the horizontal piping before the trap that has water in it.
- The steam wants to go to the trap and its lower pressure, so it hammers through the condensate laying in the horizontal piping.

**Always use the close nipple in the horizontal portion of the Hartford Loop.**

- If the water line drops low enough, steam can bounce around in the horizontal pipe.
- If the pipe is long enough, water hammer will occur.

**Fig. 1 Pumped condensate from the boiler feed pump can be forced up into the steam portion of the equalizer where it will hammer.**

- When piping from a boiler feed pump into the Hartford Loop, make certain the horizontal connection is 4″ below the water line.
- The returning pumped condensate will be less likely to be forced up into the equalizer.

**Fig. 2 On two pipe systems, steam traps that have failed in the open position can cause water hammer at mid-cycle.**

- At the beginning of the cycle, steam is condensing on the cold surfaces of the radiator and does not pass through the open trap.
- At mid-cycle when the radiator surfaces are warm, steam passes through the open trap.
- Steam then reaches the dry return, where it will cause water hammer, as well as uneven heating and high fuel bills.
- ⃠ Don't neglect trap maintenance.

Fig. 1

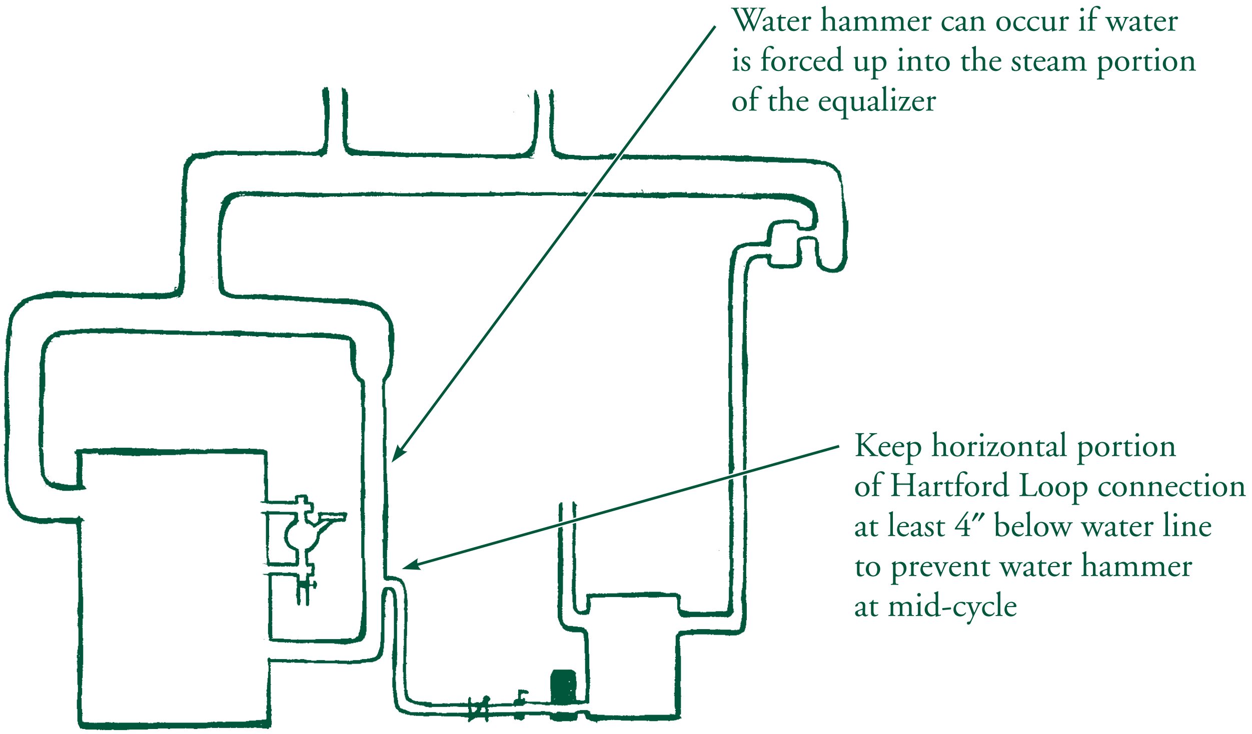
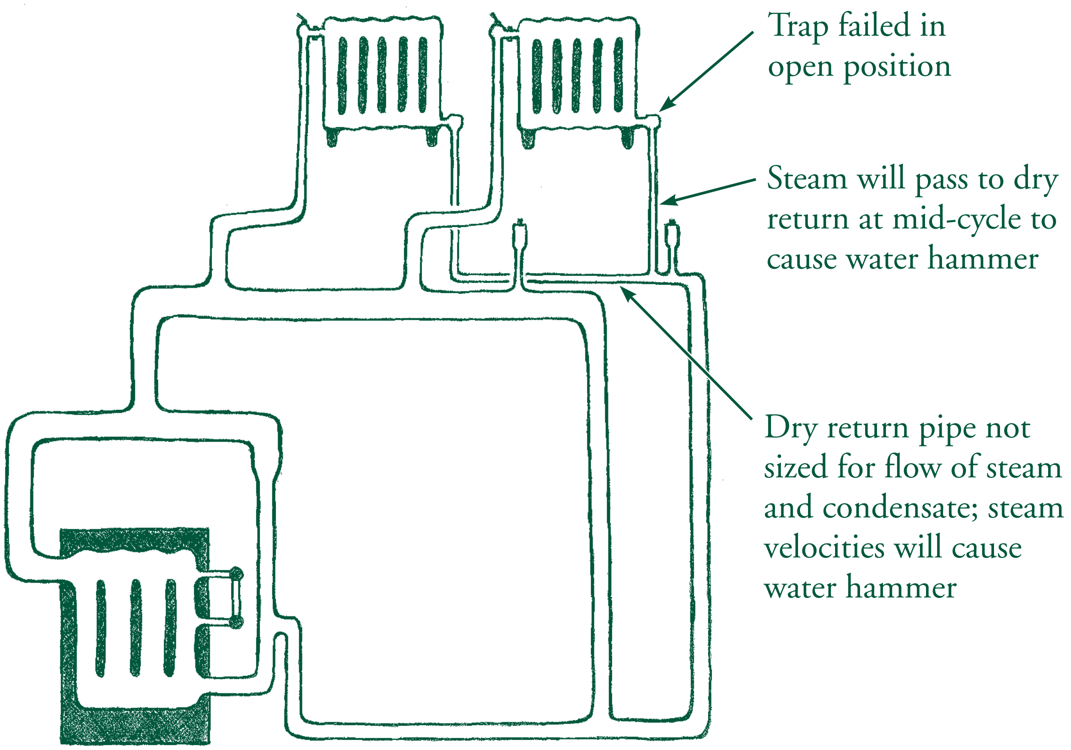

Water hammer can occur if water
is forced up into the steam portion
of the equalizer
Keep horizontal portion
of Hartford Loop connection
at least 4″ below water line
to prevent water hammer
at mid-cycle

Fig. 2


Trap failed in
open position
Steam will pass to dry
return at mid-cycle to
cause water hammer
Dry return pipe not
sized for flow of steam
and condensate; steam
velocities will cause
water hammer

# Causes of Water Hammer at the End of the Cycle and in the Boiler

**Fig. 1 When the water hammer occurs at the end of the boiler cycle, look at the near boiler piping.**
- On gravity return systems, the Hartford Loop connection must be at least 2″ below the water line.
- At the end of the boiler cycle, the steam pressure is generally at its highest while the water level is at its lowest.
- The steam pressure pushes the water down in the equalizer to expose the horizontal portion of the Hartford Loop to steam.
- Steam then mixes with the returning condensate to create hammering.

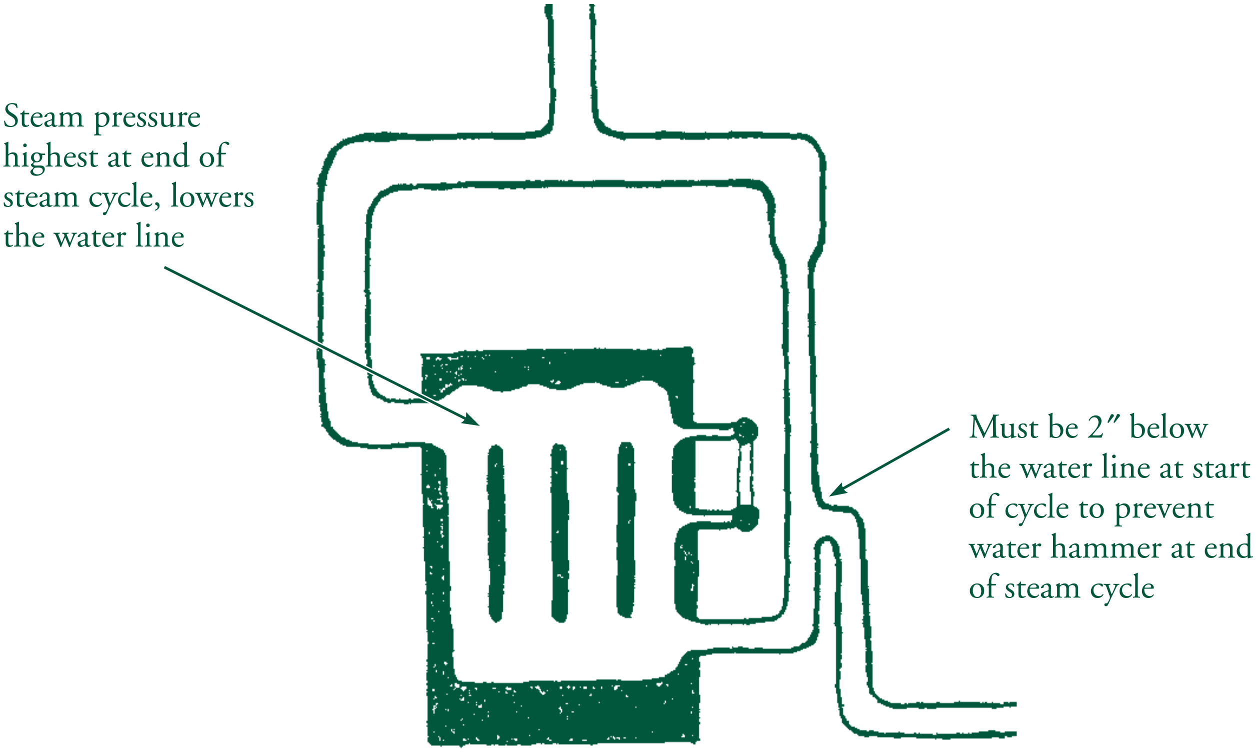
**Check for insulation on the near boiler piping of gravity return systems.**
- Without insulation on the boiler piping, when the boiler shuts down it can create a vacuum.
- This vacuum can cause the water level in the boiler to surge, allowing steam into the return lines where it will momentarily hammer.
- Insulate all steam piping, even around the boiler.
- To correct, install a vacuum breaker above the water line of the boiler or on supply piping.

**Fig. 2 When the water hammer occurs in the boiler, look for causes of uneven temperatures in the boiler.**
- Sediment build up, mineral deposits from excessive fresh water make up and core sand from manufacturing can all cause uneven temperatures of the boiler water.
- Steam systems rust from the inside.
- The returning condensate can carry that rust or sediment back to the bottom of the boiler.
- Heat from the burner can dislodge this sediment causing hammering in the boiler.

**Poor circulation can cause areas of the boiler water to have different temperatures.**
- When very hot water in the boiler suddenly moves to areas of cooler water, hammering can occur.
- To correct, flush bottom of boiler of any build up to improve circulation. See page 155.

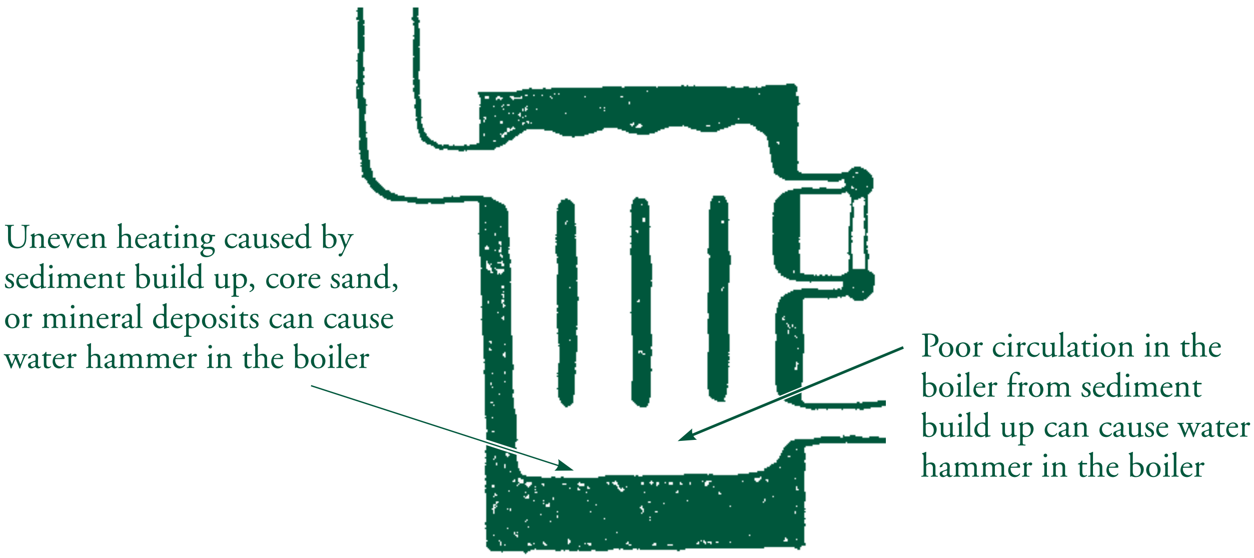
**Another cause of uneven temperature of the boiler water is the flame pattern of gas or oil power burners.**
- If the heat from the burner is concentrated into one area of the combustion chamber, it causes uneven temperature of the boiler water.
- The surging of the hotter water to cooler areas of the boiler can cause the boiler itself to hammer.
- Make sure that all insulation blankets and wet packs are properly installed in an oil fired boiler's combustion chamber to avoid temperature imbalance.

Fig. 1




**WATER HAMMER AT END OF STEAM CYCLE**

Fig. 2




**WATER HAMMER IN THE BOILER**