CHAPTER 21

Boiler Safety Automatic Limit Controls

The controls described in this Chapter depend for the operation of the various devices upon:

1. Pressure of the steam.
2. Temperature of the water or steam.
3. Height of the water in the boiler.

Abnormal or faulty operation of a burner sometimes occurs, due to causes beyond the ability of the controls already described to correct. To protect the boiler and furnace in such cases limit controls are provided.

Ques. What are limit controls?

Ans. Special "stand by" or emergency controls whose function is to shut off the burner in case of any abnormal action not corrected by the regular control system.

Limit controls are fundamentally safety controls, although they are sometimes also used for other purposes.

Ques. Where is a limit control located electrically?

Ans. In the main supply line to the burner.

Ques. How is the limit control actuated?

Ans. By steam pressure or water temperature, depending upon the type of control used and the system on which it is installed.

Ques. What happens when the limit control opens?

Ans. It causes a complete shut down of the burner regardless of what the thermostat or primary control may demand.

Ques. When does the limit control open?

Ans. When the pressure (or temperature) at the boiler reaches the point for which the control has been set.

Ques. What happens when the boiler has cooled off to a point below this setting?

Ans. The limit control will close again completing the circuit to the master control.

Ques. What occurs when this happens?

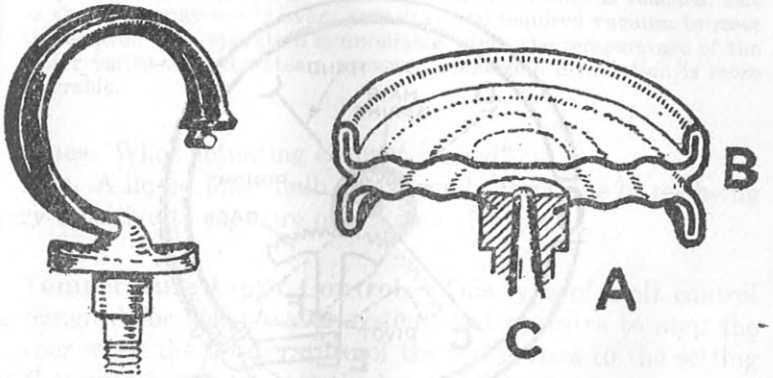
Ans. The closing of the circuit by the limit control will not start the burner unless the thermostat is still calling for heat.

Classes of Limit Control.—The various types of heating systems require limit controls adapted to the conditions characteristic of each and their different conditions give rise to various kinds of limit controls which may be classed according to functions as:

1. Pressure { steam / "vapor" / vacuum
2. Temperature { (hot water) / (combined hot water limit and circulator)

3. Warm air furnace.
4. So called "operating."
5. Low water.

Pressure Limit Control.—In the case of a steam boiler, the pressure limit control stops the oil burner in case the steam pressure exceed the limit at which the control is set. As the pressure goes down to normal, the low setting of the control



FIGS. 1 and 2—Bent tube and diaphragm as used in the two classes of steam gauges.

automatically starts the burner, if, at that time the thermostat be calling for heat.

Ques. What is the operating element in a pressure limit control?

Ans. It may be a Bourdon tube or a bellows.

Ques. What is a Bourdon tube?

Ans. A curved tube closed at one end and having a steam connection at the other end, as shown in fig. 1.

Ques. Upon what does its operation depend?

Ans. The tendency of a curved tube to assume a straight position when under pressure.

Fig. 3 shows tube and multiplying mechanism as made for a steam gauge.

Ques. Give an example when a pressure limit control is necessary to protect the boiler.

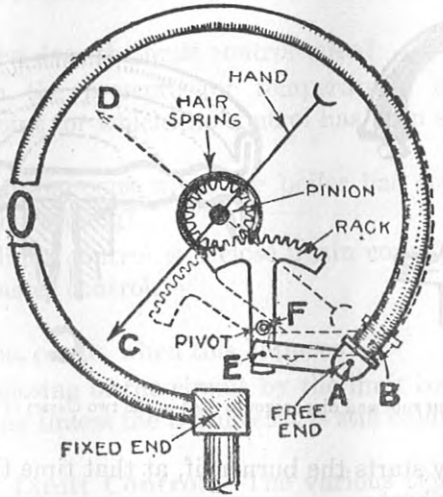


FIG. 3—Multiplying mechanism of a bent tube steam gauge, showing zero position in full lines and one position under pressure in dotted lines. The free end A, of the tube is connected by a link to the rack arm at E, the latter being pivoted at F, as shown. Evidently when the free end of the tube moves a short distance, as from A to B, the motion of the pointer or indicating hand will move a much greater distance as from C to D. The hair spring takes up any lost motion.

Ans. The combination of very cold weather and a fresh air crank.

He will open up windows in a room where the thermostat is located, go out, and forget to close them. Result, the thermostat keeps on calling for heat and can't be satisfied, meantime the burner responds to the thermostat and continues running. Evidently, the boiler pressure will rise dangerously high (if the safety valve be stuck) were it not for the pressure limit control which stops the burner at the high limit point.

Vapor and Vacuum Limit Controls.—The terms *vapor* and *vacuum* here mean steam at low and very low pressures; that is, a few ounces above atmospheric pressure and absolute pressures *below* atmospheric pressure.

When the actuating element of these controls are placed in the steam, they will cut out properly when the desired pressure is reached, but as the boiler may not in every case draw the required vacuum to reset the control, then operation is unreliable. Since the temperature of the water varies with the steam pressure, immersion installation is more desirable.

Ques. What actuating element is used?

Ans. A liquid filled bulb or a large bellows, the latter being very sensitive to pressure or vacuum changes.

Temperature Limit Control.—This type of limit control is designed for a hot water system, and operates to stop the burner when the temperature of the water rises to the setting of the control, and to start the burner when the water cools to the lower limit as set.

Ques. Name two types of temperature limit control?

Ans. The *immersion* type and the *clamp on* type.

Ques. What is the object of the *clamp-on* type?

Ans. To save the work of drilling and tapping when the boiler has no tapped opening for attaching the control.

Ques. Of what does the operating element in the immersion type consist?

Ans. It is usually a bimetal strip, but on some controls a liquid filled vessel is connected to a Bourdon tube or bellows, depending upon make.

So Called "Operating" Control.—The word *operating* here applied is a ridiculous name for the familiar summer-winter hot water supply limit control called by one manufacturer an *immersion aquastat.*

Ques. How does a summer-winter hot water supply system with tank work?

Ans. 1. When the thermostat calls for heat, the switching relay of the limit control is actuated to start the circulator. 2. At the same time, a parallel circuit to the primary control is closed which starts the burner. 3. The circulator and burner continue in operation until the room thermostat is satisfied.

4. Should the temperature of the boiler reach the setting of the high limit while the thermostat is calling for heat, the burner, but not the circulator, will be shut down. The burner cannot be started until the boiler water has cooled to the "on" point of the limit control. The circulator will continue in operation as long as the thermostat calls for heat. 5. The summer-winter limit control will start the burner whenever necessity between periods of thermostat operation to maintain a minimum boiling water temperature.

Low Water Limit Control.—If every boiler owner could be made to fully appreciate the hazard of low water, and realize the cost of repairing the damage it causes, there would be a safety low water limit control or cut off on every steam boiler.

The causes of low water are numerous, such as leaky air valves, sagging returns which trap condensation, improper piping of any kind foaming, syphoning, etc.

To cope with this danger, devices have been developed which shut down the oil burner until water has been added to the boiler to bring it up to a safe operating level.

There are two methods of operating these controls:

1. By temperature excess caused by sinking water level.
2. By float movement corresponding to sinking water level.

The first method is based on the expansion and contraction of a volatile liquid with changes in temperature. As shown in fig. 4, the liquid is contained in a metal tube and bellows, the tube or temperature element is tapped into the boiler a little above the *danger* low water level.

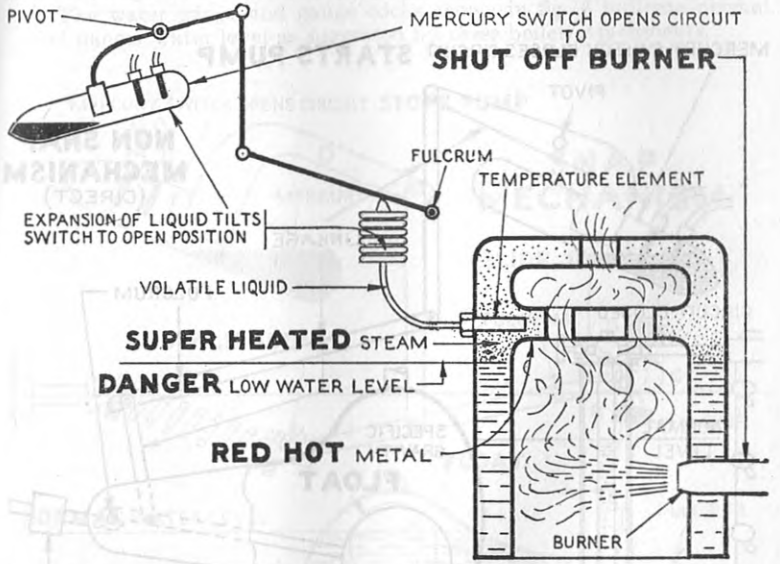


Fig. 4—Temperature element low water limit control based upon the expansion and contraction of a volatile liquid in an enclosed space corresponding to temperature changes.

Ques. How does it work?

Ans. As the water recedes to the low limit, the tube is exposed to the steam which becomes super-heated, due to overheating of the boiler metal above the water. This rise of temper-

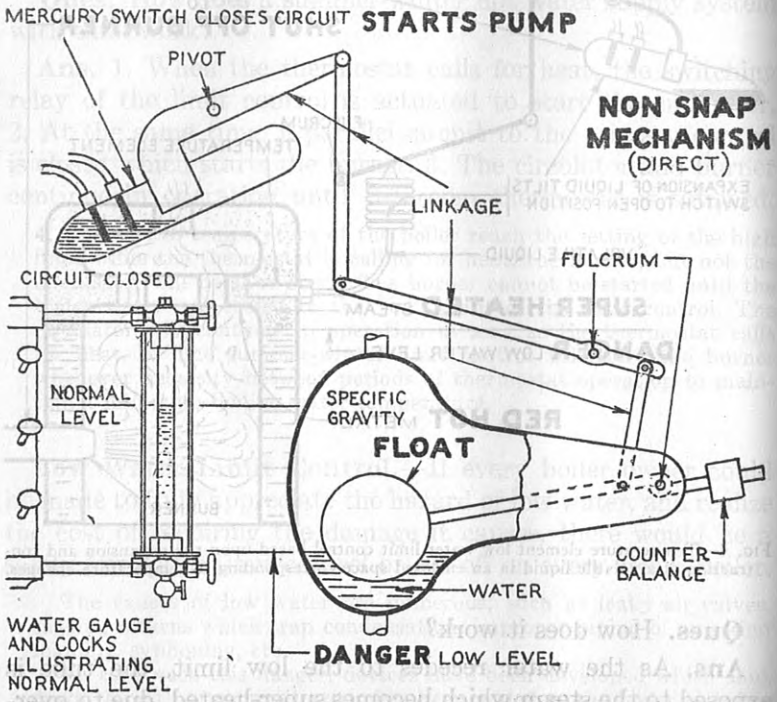
ature expands the liquid in the tube causing the bellows to expand and tilt the tube. This breaks the electric circuit and shuts off the burner.

Ques. Name two types of float control.

Ans. The *non-snap* and the *snap* mechanism.

Ques. Describe the non-snap float control.

Ans. This is a direct mechanism. As shown in fig. 5, a float



FIGS. 5 and 6—Float water level limit control with non-snap mechanism. Circuit closing pump feeder type. Fig. 6, suggests working range.

is located in a float chamber being connected externally by linkage to the mercury switch. In the position shown, the float has moved downward to low water level which has tilted the switch to close the circuit.

Ques. What happens when the circuit closes?

Ans. It starts the boiler feed pump or sounds an alarm according to the hook up.

The water gauge and gauge cocks shown in fig. 6 indicate normal and danger water level as suggested by these boiler attachments.

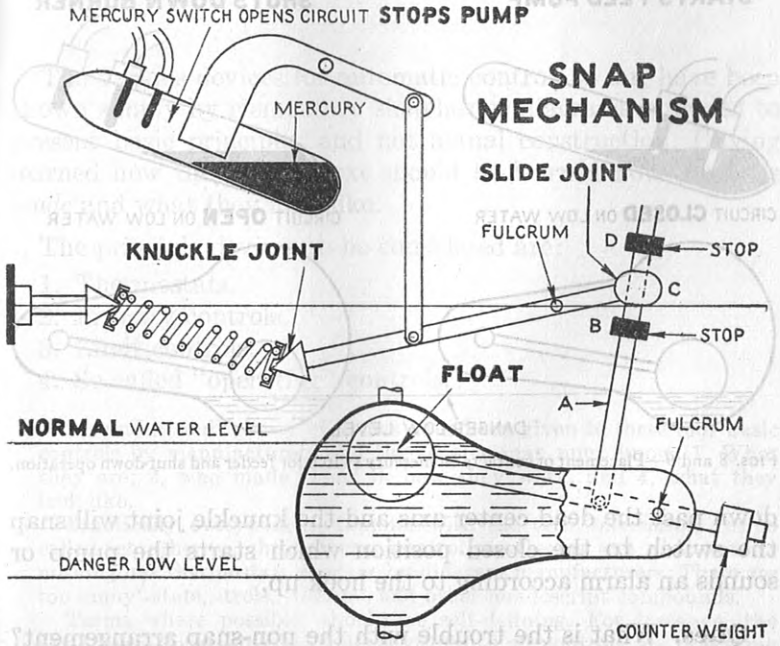


FIG. 7—Float water level limit control with snap mechanism. Pump feeder type showing circuit open on normal water level.

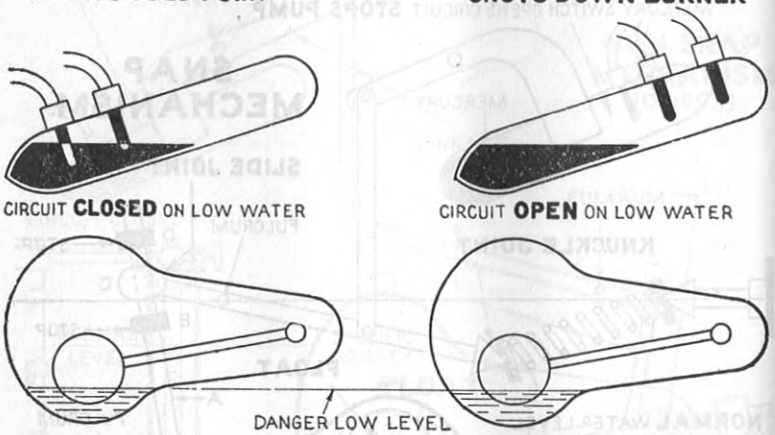
Ques. How does the snap mechanism float control work?

Ans. The essentials of this arrangement are shown in fig. 7.

The knuckle joint and linkage are the same as previously described, except that the operating link **A**, is connected to the float lever between fulcrum and float. There is a sliding joint with two *stops* to limit the travel, and there is no operating spring. *In operation*, (on rising water level) stop **B**, pushes arm **C**, upward until it passes dead center axis, when it snaps into the off position shown in the diagram. This tilts switch to break circuit and stops the feed pump.

Ques. What happens if the water fall to danger low level?

Ans. In fig. 7, stop **D**, moving downward will push arm **C**,



FIGS. 8 and 9—Placement of contacts on mercury switch for feeder and shut down operation.

down past the dead center axis and the knuckle joint will snap the switch to the closed position which starts the pump or sounds an alarm according to the hook up.

Ques. What is the trouble with the non-snap arrangement?

Ans. Lack of differential.