end corrosion is more of a problem in an air heater than an economizer because of the low entering combustion air temperatures. Figure 2-18 establishes minimum allowable metal temperature if corrosion is to be controlled. Cold air bypass ducts and dampers, hot air recirculation, steam coil air heaters, and low- level economizers are examples of methods for preheating the combustion air before it enters the air heater. These methods help control cold end corrosion but also reduce the efficiency of the system by raising exit gas temperatures.

# SECTION II. BOILER ACCESSORIES AND FITTINGS

## 2-9. ASME REQUIREMENTS.

To ensure safe operation, the ASME Boiler and Pressure Vessel Code requires that boilers be equipped with a water gage glass and gage cocks, water column, pressure gage, and safety valves. Forced circulation, high temperature water boilers which have no water line do not require a gage glass and gage cocks, but a temperature gage is required. Detailed requirements for the location and installation of these accessories on power boilers are found in Section I of the ASME Boiler and Pressure Vessel Code, and the requirements for heating boilers are in Section IV. Section IV requires each boiler to be equipped with two controls to cut off the fuel supply so as to prevent steam pressure or water temperature from exceeding boiler limits. These controls are pressure operated for steam boilers and temperature operated for hot-water boilerts. Low-water fuel cutoff instrumentation is also required. Oil and gas-fired boilers must be equipped with suitable flame safeguard controls, safety limit controls, and burners which are approved by a nationally recognized organization.

## 2-10. GAGE GLASS, GAGE COCKS.

Each boiler must have at least one water gage glass. If the operating pressure is 400 psig or greater, two gage glasses are required on the same horizontal line. Eaqch gage glass must have a valved drainj, and the gage glass and pipe connections must not be less than ½ inch pipe size. The lowest visible part of the gage glass must be at least 2 inches above the lowest permissible water level, which is defined as the lowest level at which there is no danger of overheating any part of the boiler during operation. For horizontal fire tube boilers the age glass is set to allow at least 3 inches of water over the highest point of the tubes, flues, or crown sheet at its lowest reading. Figure 2-21 illustrates a typical water gage. Each gage consists of a strong glass tube connected to the boiler or water column by two special fittings. Thee fittings sometimes have an automatic shutoff device that functions if the water glass falls. Requirements for the fabrication of these shutoff devices are also given in the ASME Code. When the boiler operating pressure exceeds 100 psig, the gage glass must be furnished with a connection to install a valved drain to some safe discharge point. Each boiler must have three or more gage or try cocks located within the visible length of the gage glass. Gage cocks are used to check the accuracy of the boiler water level as indicated by the gage glass. They are opened by handwheel, chain wheel, or lever, and are closed by hand, a weight, or a spring. The middle cock is usually at the normal water level of the boiler; the other two are spaced equally above and below it. Spacing depends on the size of the boiler.

## 2-11. WATER COLUMNS

A water column is a hollow cast-iron, malleable-iron, or steel vessel lhaving two connections to the boiler. The top connection enters the steam space of the boiler through the top of the shell or head, and the water connection enters the shell or head at least 6 inches below the lowest permissible water level. The pipe used to connect the water column to the boiler may be brass, iron, or steel, depending on the pressure; it must be at least 1 inch in diameter. Valves or cocks are used in these connecting lines if their construction prevents stoppage by sediment deposits and if the position of the operating mechanism indicates whether they are open or closed. Outside screw-and-yoke-type gate valves are generally used for this service. Lever-lifting-type gaate valve or stop cocks with permanently attached levers arranged to indicate open or closed position may also be used. **These valves or cocks must be locked open.** Crosses are generally used in place of elbows or tees on the piping between the water column and the boiler to facilitate cleaning the line. A valved drain or blowdown line is connected to the water column for removal of mud and sediment from the lines and column. Ends of all blowdowns should be open and located for ease of inspection. The water column shown in figure 2-22 is equipped with high- and low-water alarms which operate a whistle to warn the operator. The whistle is operated by either of the two floats.

## 2-12. PRESSURE GAGE, TEMPERATURE GAGE.

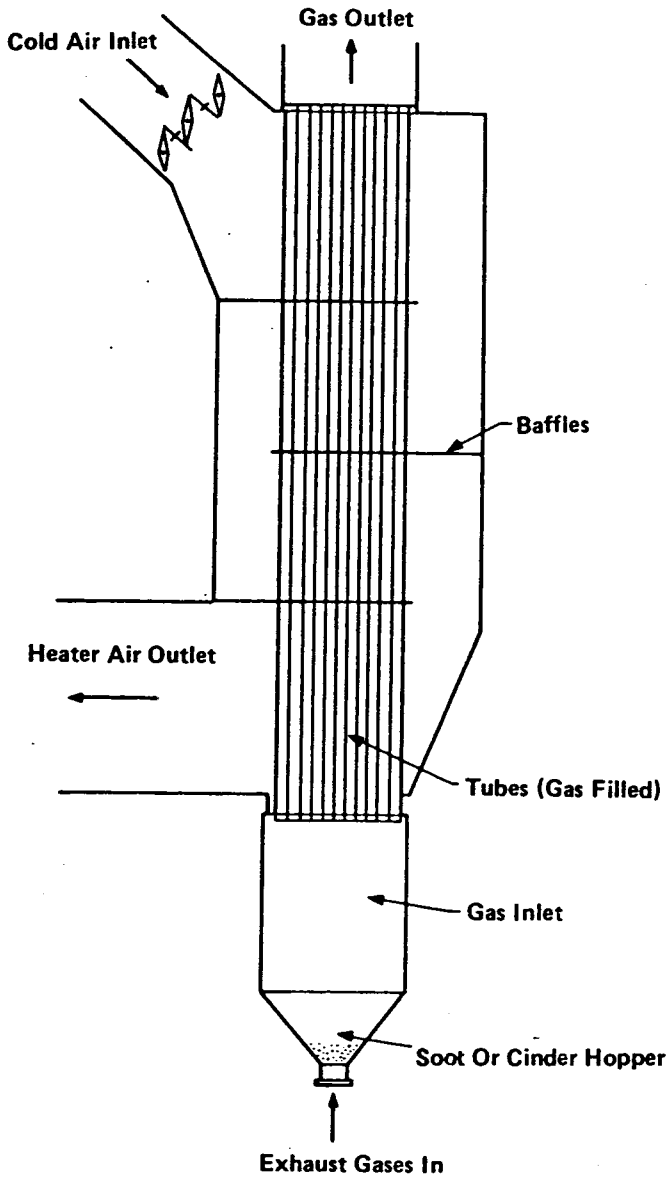



FIGURE 2-19. TUBULAR AIR HEATER

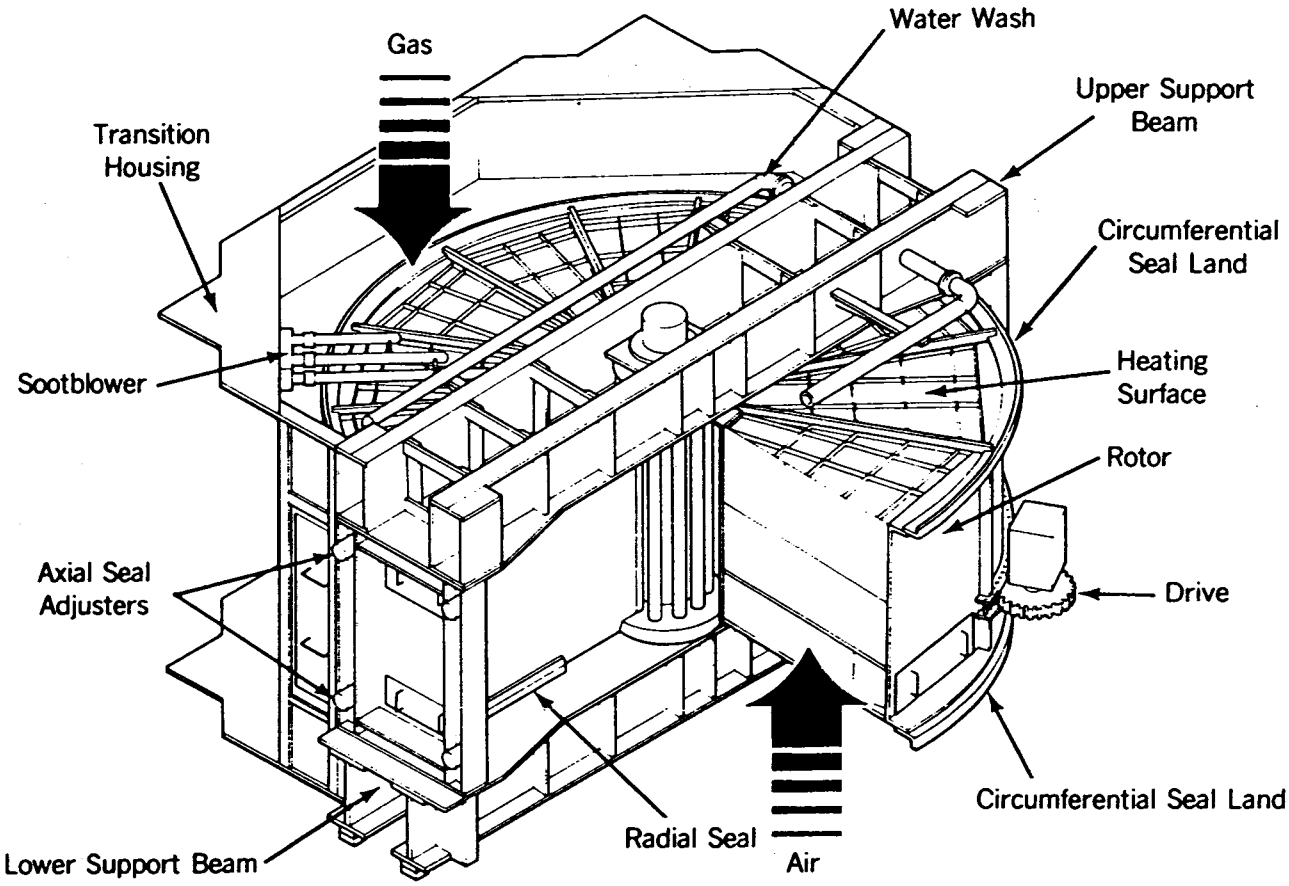



FIGURE 2-20. REGENERATIVE AIR HEATER

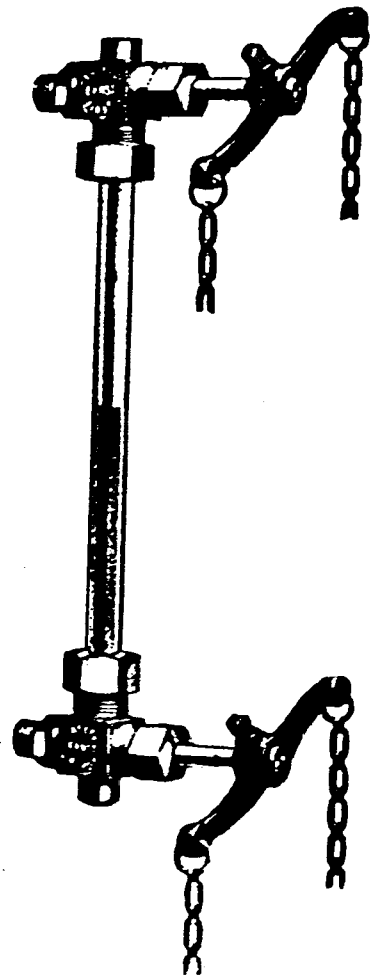


FIGURE 2-21. WATER GAGE GLASS

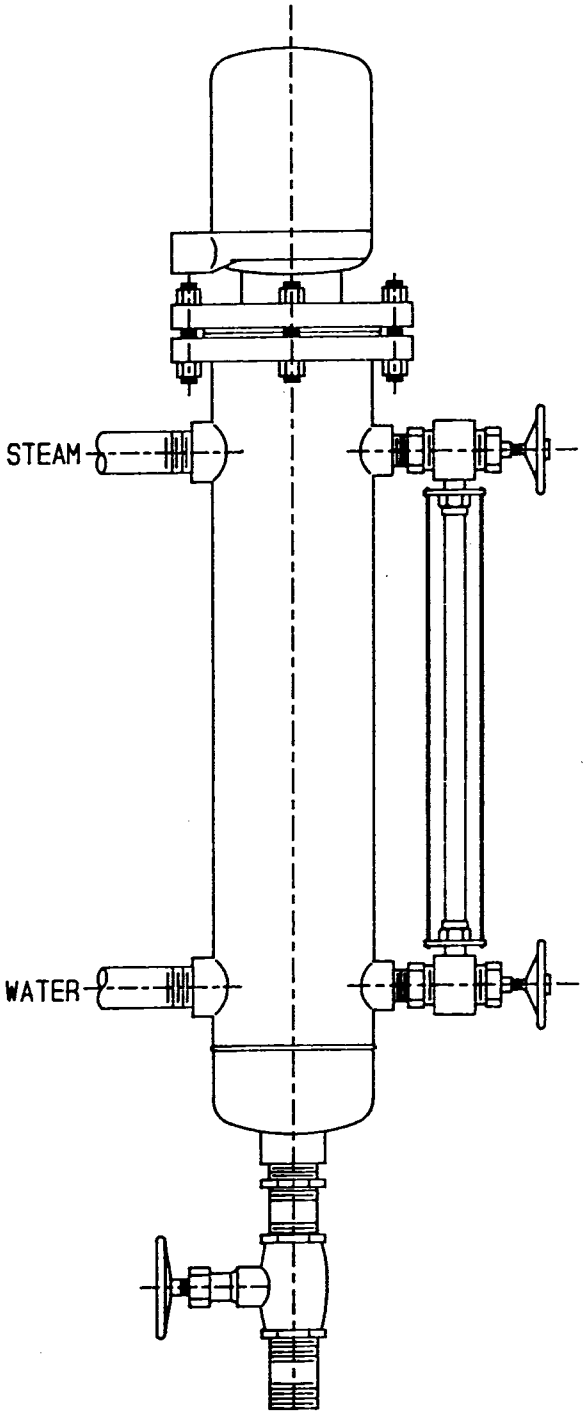



FIGURE 2-22. WATER COLUMN

Every boiler must be equipped with an easily readable prssure gage. The pressure gage must be installed so that it indicates the pressure in the boiler at all times. Each steam boiler must have the pressure gage connected to the steam space or to the steam connection of water column. A valve or cock must be placed in the gage connection adjacent to the gage. An additional valve or cock may be located near the boiler, provided that it is locked or sealed in the open position. No other shutoff valves may be located between the gage and the boiler. The pipe connection must be of ample size and arranged so that it may be cleared by blowing out. For a steam boiler the gage or connection must contain a syphon or equivalent device which will develop and maintain a water seal to prevent steam from entering the gage tube. Pressure gage connections must be suitable for the maximum allowable working pressure and temperature. The connections to the boiler must not be less than ¼ inch standard pipe size. Where steel or wrought iton pipe or tubing is used, it must be at least ½ inch inside diameter. The dial of the pressure gage must be graduated to approximately double the pressure at which the safety valve is set, and it should never be less than 1½ times this pressure. Every hot water boiler must also have a temperature gage located and connected for easy readability. The temperature gage must be installed so that it indicates the boiler water temperature at or near the outlet connection at all times.

## 2-13. SAFETY VALVES.

Safety valves are installed to prevent excessive pressure buildup in the boiler, superheater, or economizer. Safety valves are designed to quickly pop to the full open position when the steam pressure rises to the set point and to quickly close when the pressure drops a preset amount (blowdown or blowback). They must close tightly without chattering or leakage, and remain tightly closed after reseating. Their construction, installation, and performance are rigidly prescribed in the ASME Code. No valve or stop is permitted between the boiler and safety valve, and the discharge line must be supported separately to prevent any undue stress on the valve. A recommended method of installation is shown in figure 2-23. Any economizer which may be shut off from the boiler must have one or more safety valves. Every superheater must also have one or more sfety valves located near the superheater outlet. A safety valve os defined as an "automatic pressure-relief device actuated by a static pressure upstream of the valve and characterized by full opening pop action." A safety valve is used for gas or vapor service, including steam. Hot water boilers use a safety relief valve which is defined as an "automatic pressure- actuated relief device suitable for use either as a safety valve or relief valve, depending on the application." All safety valves and safety relief valves are constructed so that the failure of any part cannot obstruct the free and full discharge of steam or water from the valve. Safety relief valves, like safety valves, must be manufactured and stamped in accordance with the ASME Code. Figure 2-23. Safety Valve Installation

**a. Types of Safety Valves.** One common type of safety vavle is the huddling chamber safety valve illustrated in figure 2-24. This safety valve opens rapidly because of the additional area on which steam pressure is exerted as soon as the valve startes to life from the seat, and the reaction of the steam on the seat. This second action resembles the action which causes a free air, water, or steam hose to whip around when the discharge velocity is high. The area between the valve seat and the adjusting ring is called the huddling chamber. As seen in figure 2-24, the clearance between the inside of the adjusting ring and the feather is comparatively small. The boiler pressure is exerted on the area of the feather which is equal to the inside area of the seat bushing. As soon as the seat is slightly displaced, steam starts to flow through the valve because of the excessive boiler pressure. The steam cannot esape between the feather and the adjusting ring as fast as it is flowing through the seat. As a result, pressure builds up under the feather. This in turn, increases the force available for pushing the valve off the seat. The flow of steam is turned by the feather, and this also exerts a force to open the valve. These two forces cause the valve to pop open. Becaus4e of the larger area subjected to the steam pressure and the reactive force of the flowing steam, the valve does not close until the pressure drops below that which caused it to open. The difference between the set or popping pressure and the closing pressure is called the blowdown. Jet flow and nozzle reaction safety valves are other common types. Power-actuated pressure relief valves are also allowed by ASME Code but are not used in Army installaltions.

**b. Safety Valve Capacity.** The safety valve capacity for each boiler must be such that the valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6% above the highest pressure at which any valve is set, and in no case to more than 6% above the maximum allowable working pressure. The safety valve valve capacity must be in compliance with ASME Code and must not be less than the maximum designed steaming capacity as determined by the manufacturer. The required steam relief capacity, (in lb/hr) of the safety relief valves on a high-temperature water boiler is determined by dividing the maximum output in Btu/hr at the boiler nozzle by 1000. Economizer safety valve capacity is calculated from the maximum heat absorption in Btu/hr divided by 1000.

**c. Safety Valve Settings.** One or more safety valves on

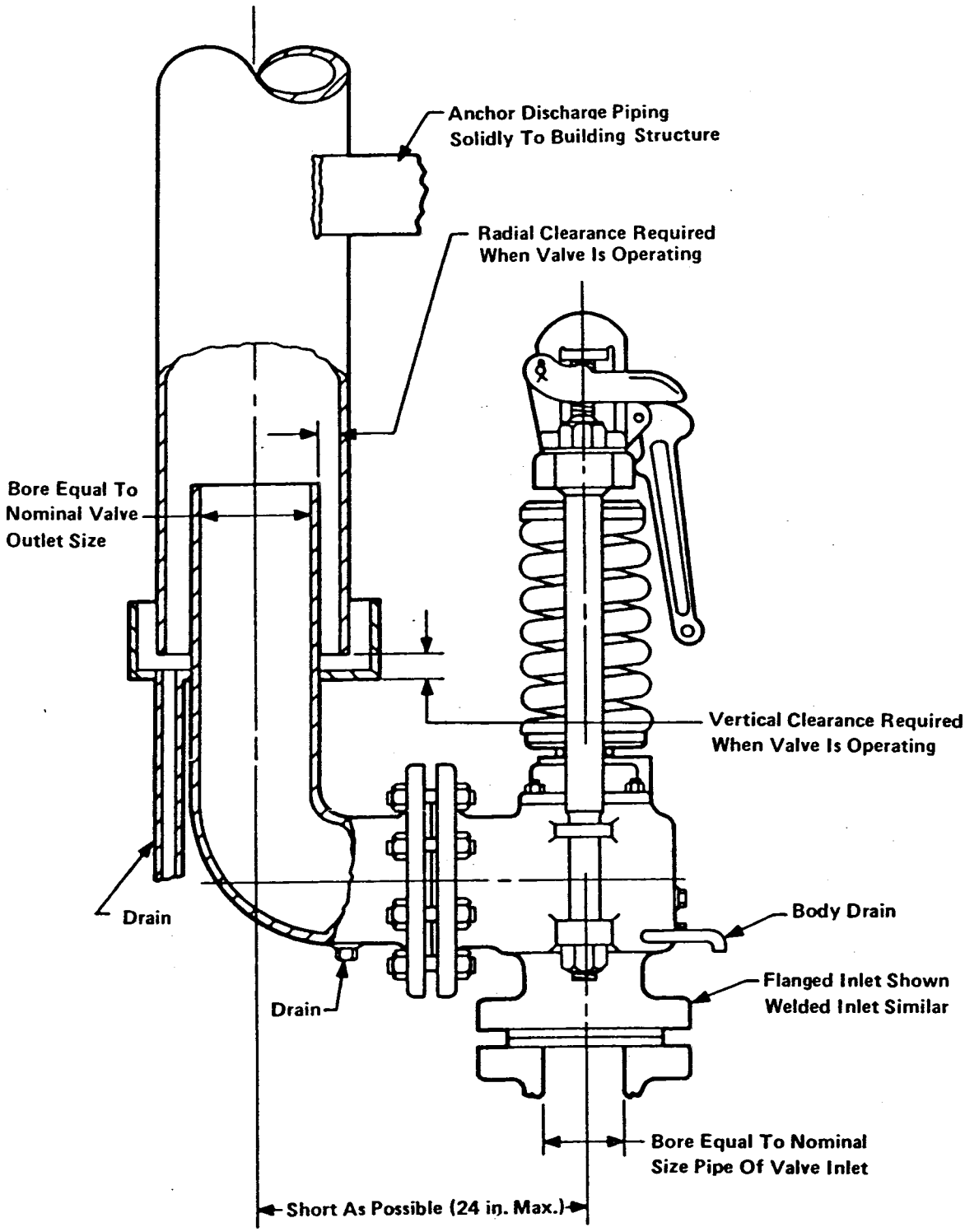



FIGURE 2-23. SAFETY VALVE INSTALLATION

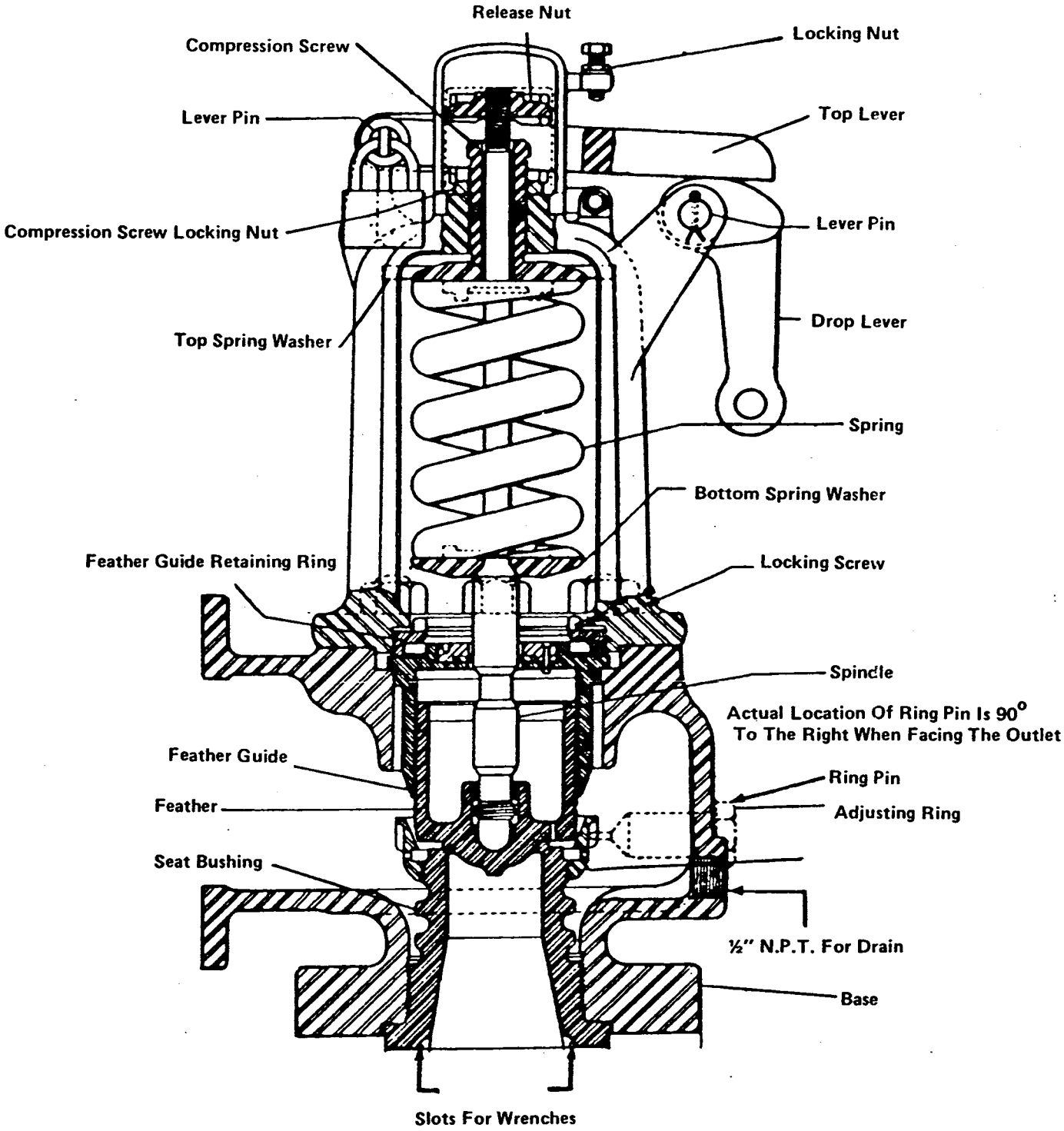



FIGURE 2-24. HUDDLING CHAMBER SAFETY VALVE

the boiler proper must be set at or below the maximum allowable working pressure. If additional valves are used, the highest pressure setting must not exceed the maximum allowable working pressure by more than 3%. The complete range of pressure settings of all the saturated-steam safety valves on a boiler must not exceed 10% of the highest pressure to which any valve is set. Pressure setting of safety relief valves on high-temperature water boilers may exceed this 10% range because safety relief valves in hot water service are more susceptible to damage and subsequent leakage than safety valves relieving steam. It is recommended that the maximum allowable working pressure of the boiler and the safety relief valve setting for high-temperature water boilers be selected substantially higher than the desired operating presure to minimize the frequency of safety relief valve lift.

## 2-14. BOILER OUTLET VALVES.

Each steam discharge outlet from a boiler, except the safety valve and superheater connections, must have a stop valve. If the valve is over 2 inch pipe size, it must be the outside screw-and-yoke rising-spindle type; the spindle position indicates whether the valve is open or closed. Refernce figure 2-25. A plug-type cock may be used if the plug is held in place by a gland or guard, if it allows remote indication of opening or closing, and if it is used with a show-opening mechanism. When two or more boilers are connected to a common header, the steam connection from each boiler having a manhole opening must be fitted with two stop valves with an ample, free blow drain between them. The stop valves should consist, prefereably, of one nonreturn valve set next to the boiler and a second valve of the outside screw-and-yoke type. However, two outside screw-and-yoke-type valves may be used. The nonreturn valve is a type of check valve which can be held closed (reference figure 2-26). It can be opened only by pressure in the boiler, and it closes when the boiler pressure is lower than the header pressure, a condition which may be caused by burst tube, loss of fire, or other reasons. The valves require a very small difference in pressure for proper operation. A dashpot is provided to prevent chattering or too rapid movement of the valve. Ladders and catwalks or other means for operating the valves from the operating floors in boiler rooms should be provided.

## 2-15. BLOWOFF VALVES AND PIPING.

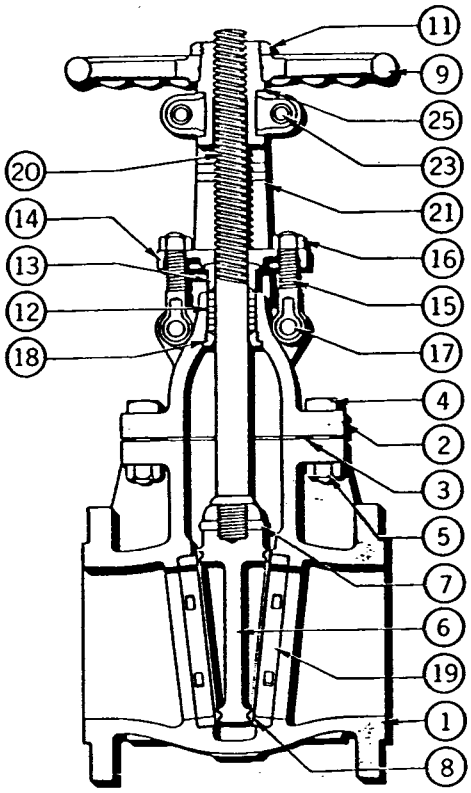
Each boiler must have at least one blowoff connection installed at the lowest water space available to allow removal of sludge. The pipe used must not be less than 1 inch or over 2½ inches. Extra-trong pipe must be used for pressures above 100 psig. The bolowoff line must be protected from direct furnace heat by brickwork or other heat-resisting material which is constructed to allow for inspection of the pipe. This is necessary because sediment collects in the blowoff line and, since there is no circulation of the water, the pipe may easily become overheated and burn out. Care must be taken to ensure ample room for expansion and contraction at the junction of the pipe and the setting. One slow-opening valve may be used in the blowoff line for pressures up to 100 psig. Two slow-opening valves, or a slow-opening valve and cock, are required for pressures above 100 psig. A typical slow-opening valve set is shown in figure 2-27. A slow-opening valve is one which requires at least five complete turns of the operating mechanism to change from the completely open to the completely closed positions and is used to avoid shock to the piping and possible ilnjury to personnel. Valves which have dams or pockets in which sediment can collect must not be used. Boiler blowdown is provided for the control of dissolved and suspended solids which concentrate in steam boilers. This is a separate subject and is discussed in paragraph 4-8.

## 2-16. FUSIBLE PLUGS.

Fusible plugs are sometimes used on fire tube boilers to provide added protection against low water. They are constructed of bronze or bradd with a tapered hole drilled lengthwise through the plug and filled with a low-melting alloy consisting mostly of tin. There are two types of fusible plugs, fire-actuated and steam- actuated.

**a. Fire-Actuated Plug.** Fire-actuated plugs are filled with an alloy of tin, copper, and lead with a melting point of 445 to 450° F. They are screwed into the shell or a special tube at the lowest possible water level. One side of the plug is in contact with the fire or hot gases, and the other side with water. As long as the plug is covered with water, the tin does not melt. If the water level ldrops below the plug, the tin melts and is blown out. The boiler then must be taken out of service to replace the plug. Fusible plugs of this type are renewed regularly once a year. The old castings should not be reused, but should be replaced with new plugs obtained from the boilder manufacturer.

**b. Steam-Actuated Plug.** The steam-actuated plug is installed on the end of a pipe outside the drum. The other end of the pipe, which is open, is at the lowest permissible water level. A valve is usually installed between the plug and the drum. The metal in the plug melts at a temperature below that of the steam in the boiler. The pipe is small enough to prevent water from circulating inside it and cooling the plug. The water around the plug is much cooler than the water in the boiler as long as the end of the pipe is below the water level. However, if the wter level drops below the open end of the pipe, the ool water runs out of the pipe and steam ondenses on the plug. The steam




| NO. | DESCRIPTION |
|---|---|
| 1 | BODY |
| 2 | BONNET |
| 3 | BONNET GASKET |
| 4 | BONNET BOLT |
| 5 | BONNET BOLT NUT |
| 6 | DISC |
| 7 | DISC PIN |
| 8 | DISC RING—TRIM 6 |
| 9 | HANDWHEEL |
| 11 | HANDWHEEL NUT |
| 12 | PACKING |
| 13 | PKG. GLAND |
| 14 | PKG. GLAND FLG. |
| 15 | EYEBOLT |
| 16 | EYEBOLT NUT |
| 17 | EYEBOLT RIVET |
| 18 | REPKG. SEAT BUSHING |
| 19 | SEAT RING |
| 20 | STEM |
| 21 | YOKE |
| 23 | YOKE BOLT |
| 25 | YOKE BUSHING |

FIGURE 2-25. OUTSIDE SCREW AND YOKE GATE VALVE

| | PART |
|---|---|
| 1 | HANDWHEEL NUT |
| 2 | HANDWHEEL |
| 3 | STEM |
| 4 | YOKE BUSHING NUT |
| 5 | YOKE BUSHING |
| 6 | YOKE BONNET |
| 7 | GLAND STUD NUT |
| 8 | GLAND |
| 9 | GLAND STUD |
| 10 | PACKING |
| 11 | BONNET BOLT NUT |
| 12 | BONNET GASKET |
| 13 | BONNET BOLT |
| 14 | DASH POT |
| 15 | PISTON RINGS |
| 16 | PISTON |
| 17 | LOCK NUT |
| 18 | DISC |
| 19 | DRAIN PLUG |
| 20 | SEAT RING |
| 21 | BODY |
| 22 | LUBRICATION PLUG |

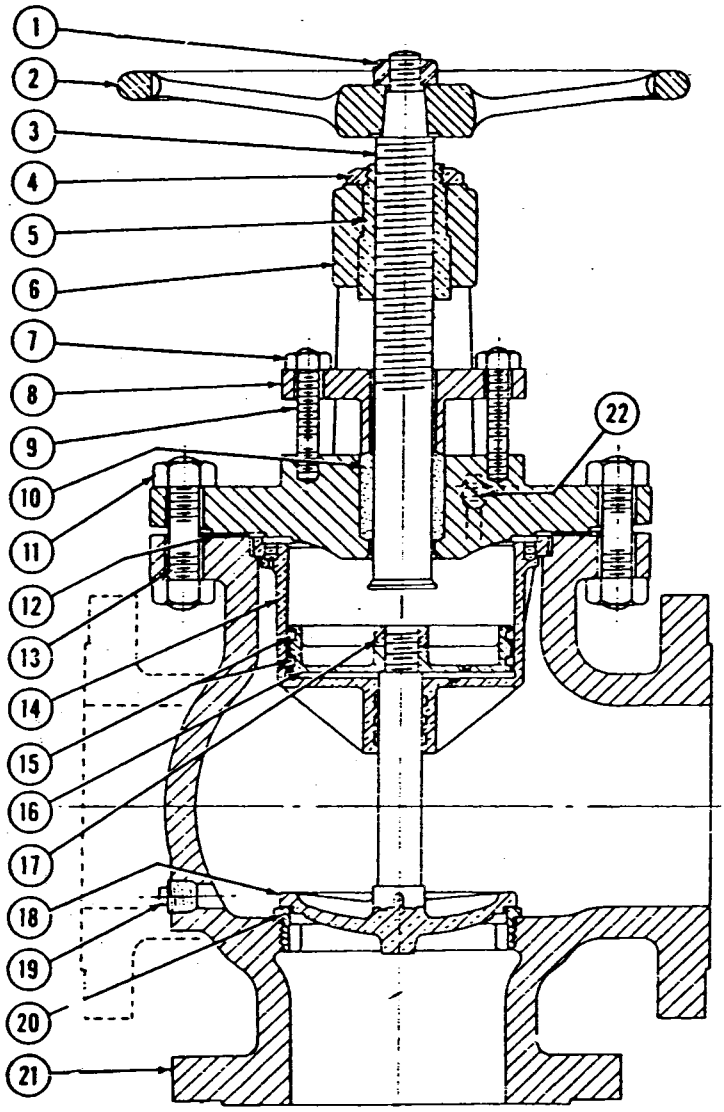



FIGURE 2-26. NON-RETURN VALVE

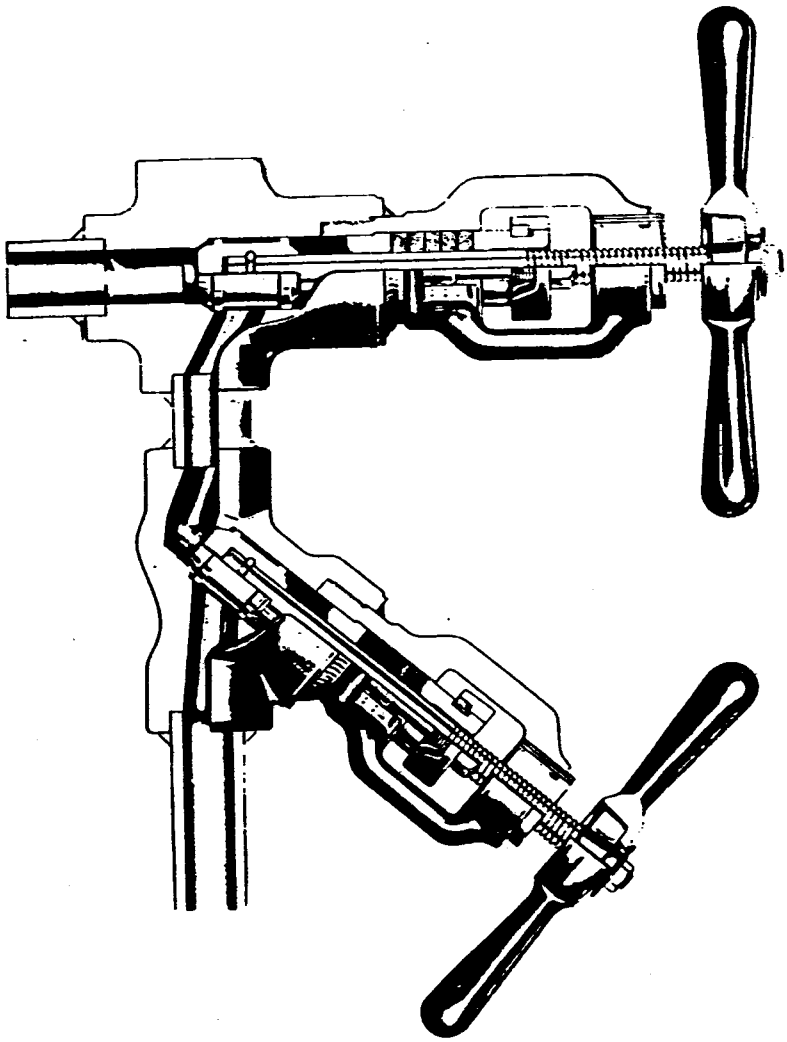


FIGURE 2-27. SLOW OPENING BLOWDOWN VALVE SET

melts the plug and steam blows out, watning the operator. This type of plug can be replaced without taking the boiler out of service, by closing the valve in the plug line.

## 2-17. SOOTBLOWERS.

Soot, fine ash, and cinders can collect on boiler tubes and cause a substantial decrease in the heat transfer rate. These substances are very poor conductors of heat; in addition, when excessinve amounts are deposited on the tubes, passages become plugged and gas flow is restricted. Brushes, scrapers, hand lances and occasionally sootblowers are used to remove these deposits in fire tube boilers. Hand lances and mechanical sootblowers are used to clean water tube boilers.

**a. Brushes, Scrapers, and Hand Lances.** Brushes and scrapers are made in various sizes to fit the boiler tubes. They are fastened to a long handle, usually a piece of pipe, and pushed through the tubes. Automatic brushing systems with vacuum dust-collecting attachments are effective and common. Figure 2-28 illustrates a fire tube cleaning system. The hand lance is a piece of pipe supplied with compressed air or steam. Occasionally, a special head is attached to the hand lance. The hand lance may be needed to remove deposits of ash or slag even on boilers equipped with mechanical sootblowers.

**b. Mechanical Sootblowers.** Permanently mounted mechanical sootblowers are used on water tube boilers. These blowers are mounted on the setting walls or boiler-supporting structure at several points, to clean as much of the surface as is practical. Blowers consist of a head which admits steam or air and turns the element, the element itself which distributes the steam or air, and the necessary bearings, piping, and other supports.

(1) **Head.** The head consists of an operating mechanism, usually a chain or handwheel loperating two gears, for turning the element within a limited arc; a poppet valve for admitting and controlling the flow of steam or air to the element; and a cam for opening and closing this valve (reference figure 2-29).The poppet valve is adjusted at startup to obtain proper steam or air regulation. The cam is cut or adjusted to establish the proper blowing arc and prevent steam or air from striking and cutting the baffles, drums, tubes, or headers.

(2) **Elements.** Elements are tubes containing a number of nozzles. These nozzels are spaced along the element to blow between the boiler tubes for lane blowing, or at a number of tubes for mass blowing. When elements are installed for lane blowing, it is important that the nozzle spacing fit the boiler-tube spacing and that the elements are located properly. Failure to observe these precautions may result in cut tubes because of the high velocity of discharge from the nozzles. The elements are made of plain, carborized, or alloy steel, depending on the temperature to which they are to be subjected; they are supported at regular intervals by bearings clamped on the boiler tubes. The distance between these bearings is determined by the flue-gas temperature in that specific area.

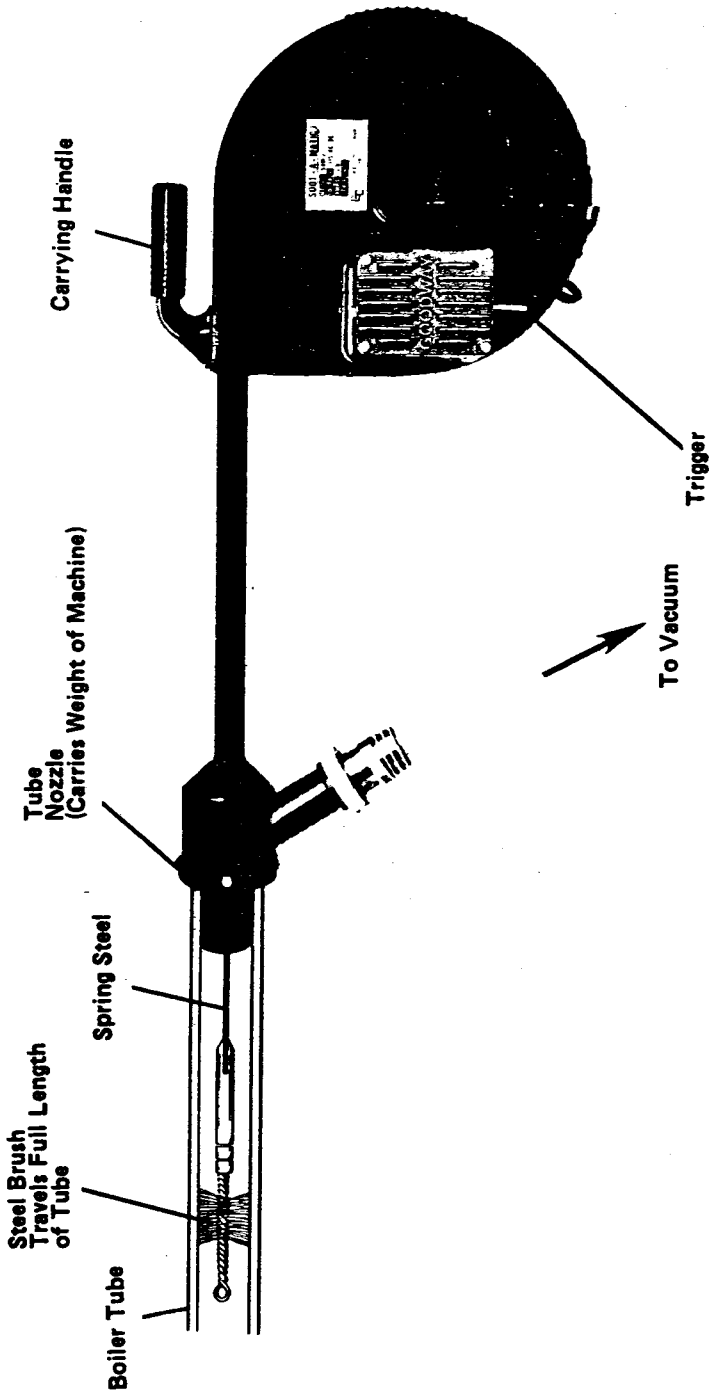



FIGURE 2-28. FIRE TUBE CLEANING SYSTEM

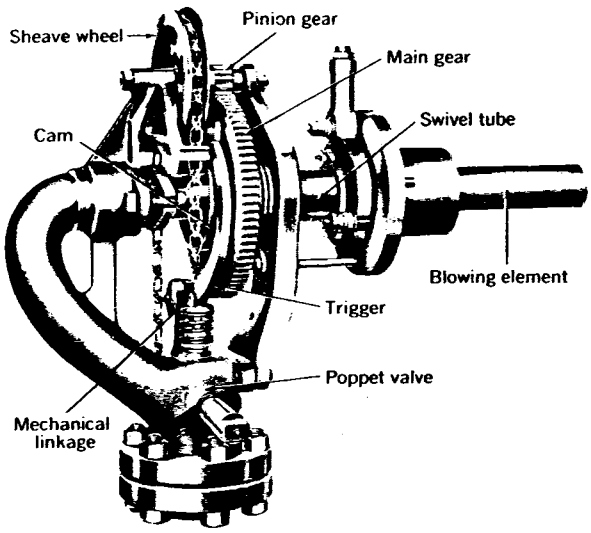



FIGURE 2-29. FIXED POSITION MECHANICAL SOOTBLOWER