TOMSK POLYTECHNIC UNIVERSITY

REGENERATIVE HEATING AT NPP

MAIN FEATURES

- Definition
- Construction of high- and low-pressure heater
- Classification of regenerative heaters
  - Features
  - Construction
  - Advantages and disadvantages

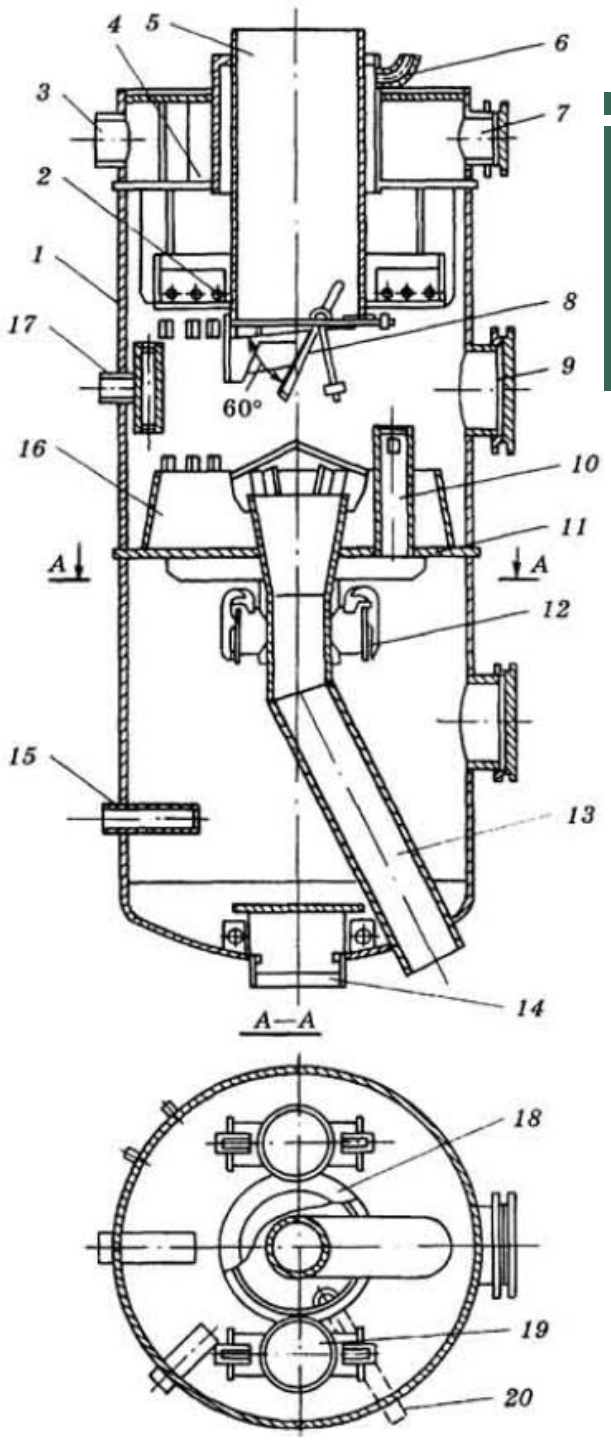
DEFINITION AND PURPOSE

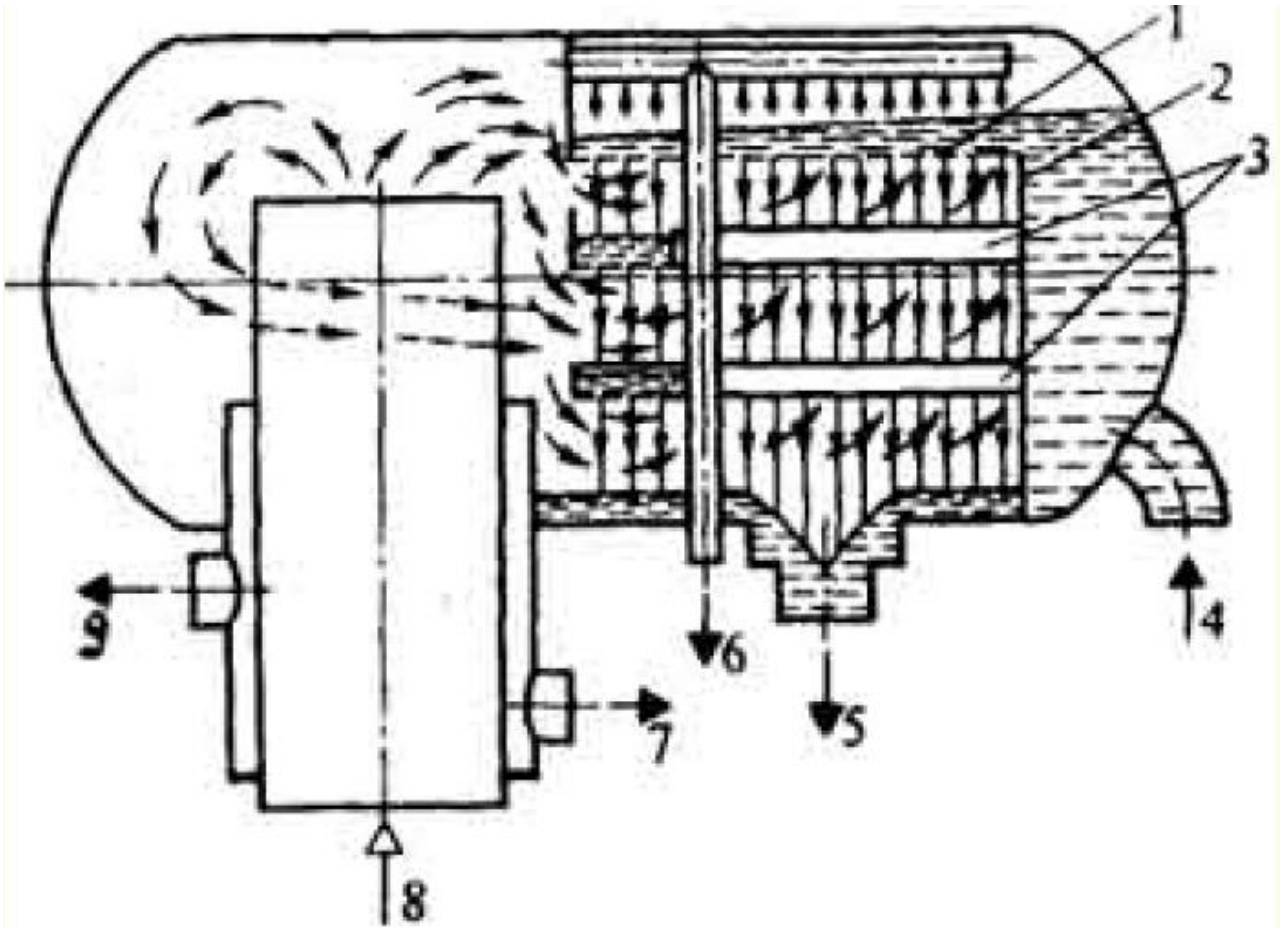
- Regenerative heaters are needed to increase feed water temperature thus decreasing heat losses in condenser and increasing thermal efficiency of NPP.
- The regenerative heaters apply heat of condensing steam from turbine bleed to increase temperature of feed water on the inlet of steam generator.
- Regenerative heaters are classified by:
  - **Pressure of steam:**
    - High pressure;
    - Low pressure.
  - **Type of heat transfer:**
    - Surface-type;
    - Mixing-type.

FEATURES OF HIGH PRESSURE HEATER CONSTRUCTION

- For surface-type heaters the substance with higher pressure flows through tubes while substance with lower pressure flows through space between tubes.
  - Construction: chamber-type with tube desk.
  - Orientation: vertical.
  - The steam and drainage coolers are situated outside heater.
  - Water-accumulative chambers are situated at the bottom.
  - The corrosion-resistant material of the tubes is usually used.
  - The two-walled design is widely applied.
- For mixing-type heaters the both vertical and horizontal orientations are applied.
  - Construction: mixing chamber and water-distribution plate.
  - No need for steam or condensate coolers.
  - Water-accumulative part is situated at the bottom.

CONSTRUCTION OF MIXING-TYPE REGENERATIVE HEATER





GENERAL FEATURES OF SURFACE-TYPE HEATER CONSTRUCTION

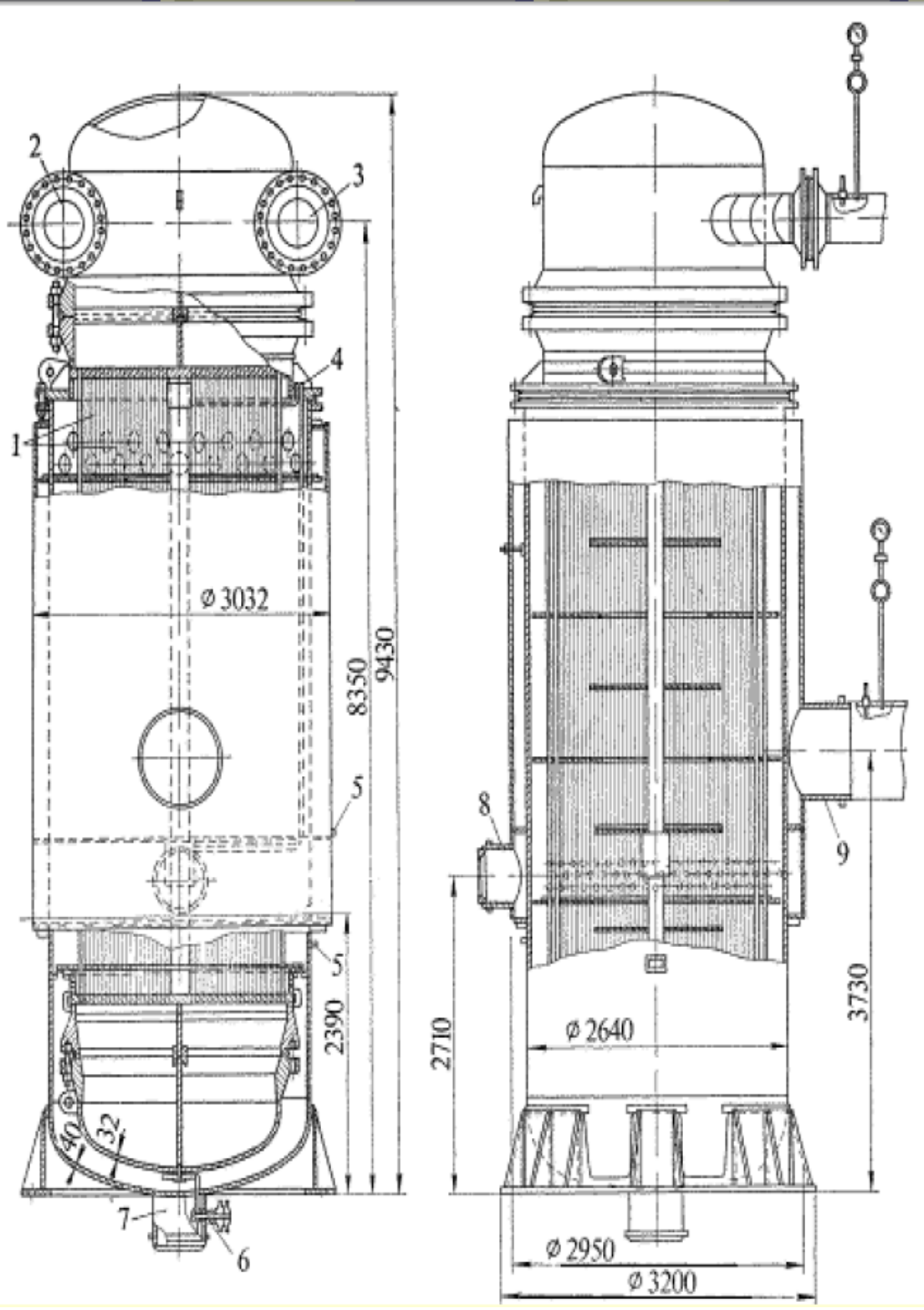
Surface-type heaters are the most widespread type of regenerative heaters on NPP.

1. Heat-transfer surface is situated inside the casing. The position of heater is planned in such way that casing could be removed without much trouble.
2. Substance with higher pressure – feed water – flows through tubes while substance with lower pressure – heating steam – flow in space between tubes.
3. The heating steam flows down from the top. Such solution simplifies removal of air and no-condensing gases from heater (at the top) and removal of condensate (at the bottom).
4. Tubes for non-condensing gases removal is made of corrosion-resistant alloys.
5. Absence of water boiling and hydraulic rams is ensured by higher pressure of feed water.
6. Usually surface-type heaters are made vertical.

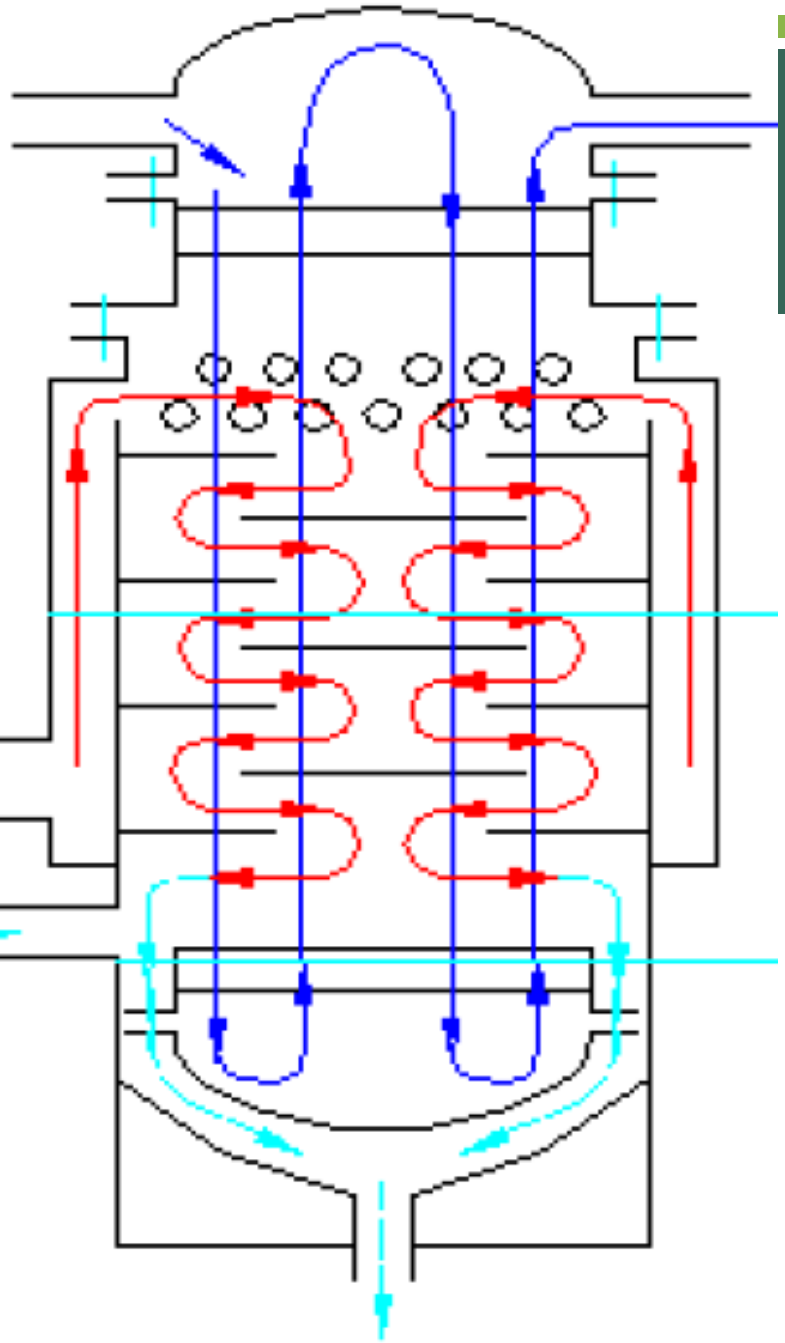
CONSTRUCTION OF VERTICAL HEATER PN-1800

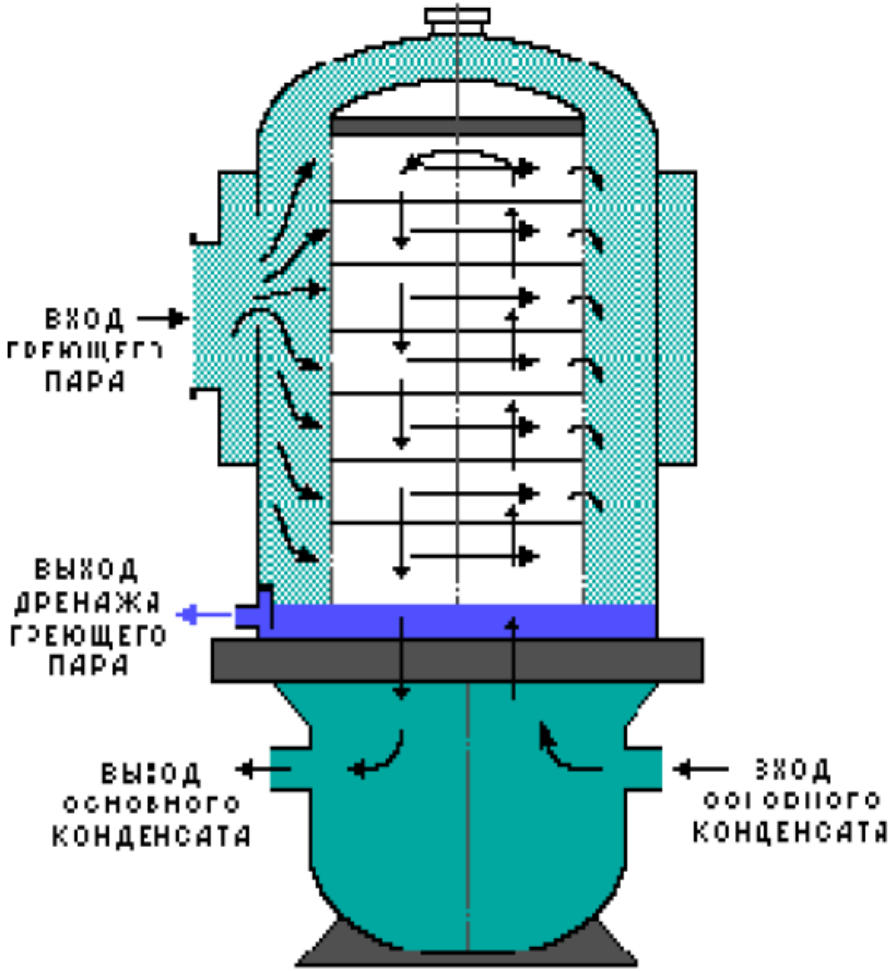
FEATURES:

- Straight tube with 16 mm diameter and 1 mm thickness.
- Moving lower water chamber.
- Amount of passes – 4.
- Collar connection is welded.
- Directive walls are made in form of a ring

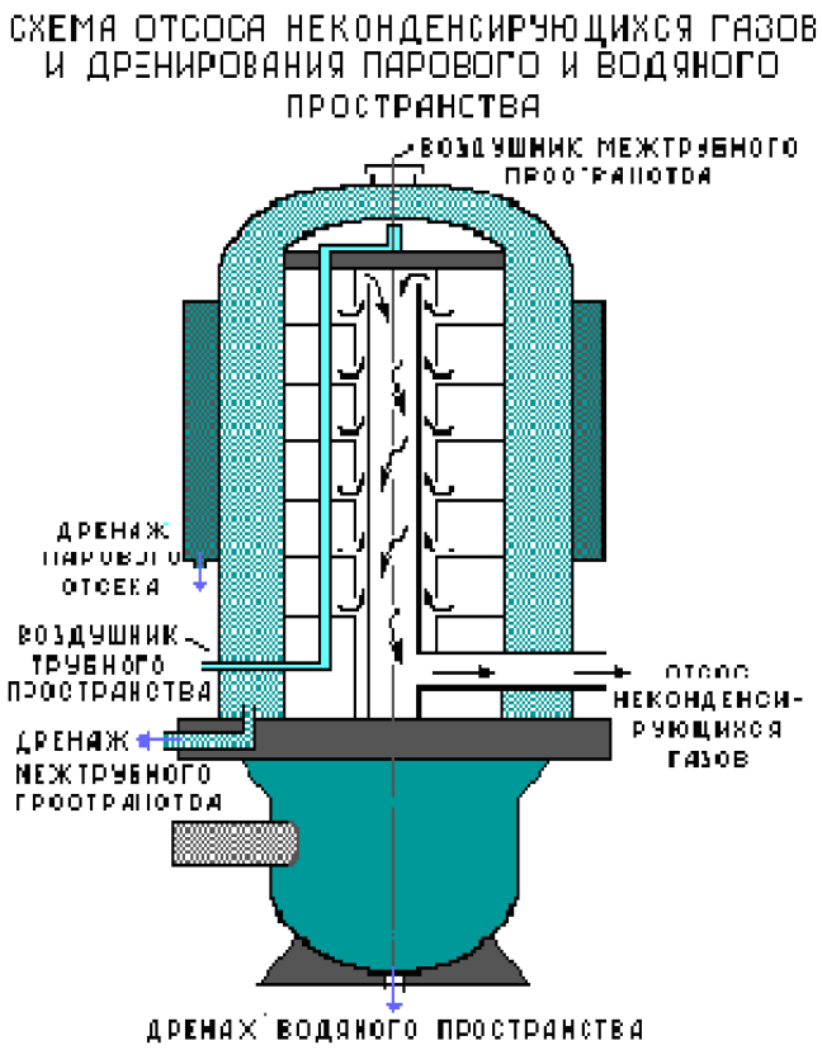


SCHEMES OF FEED WATER CIRCULATION IN TWO AND FOUR-PASS HEATERS

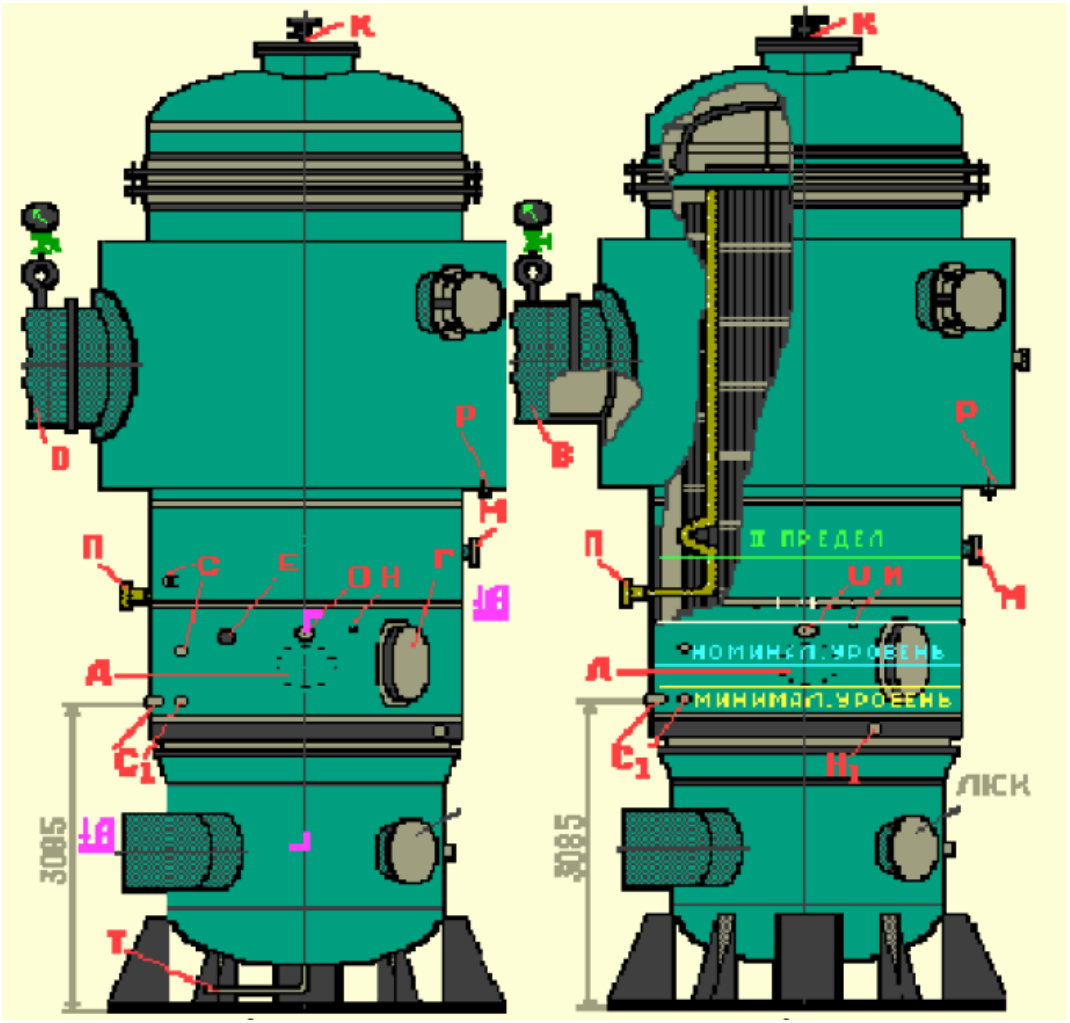




SCHEME OF DRAINAGE AND NON-CONDENSING GASES REMOVAL FROM HEATER



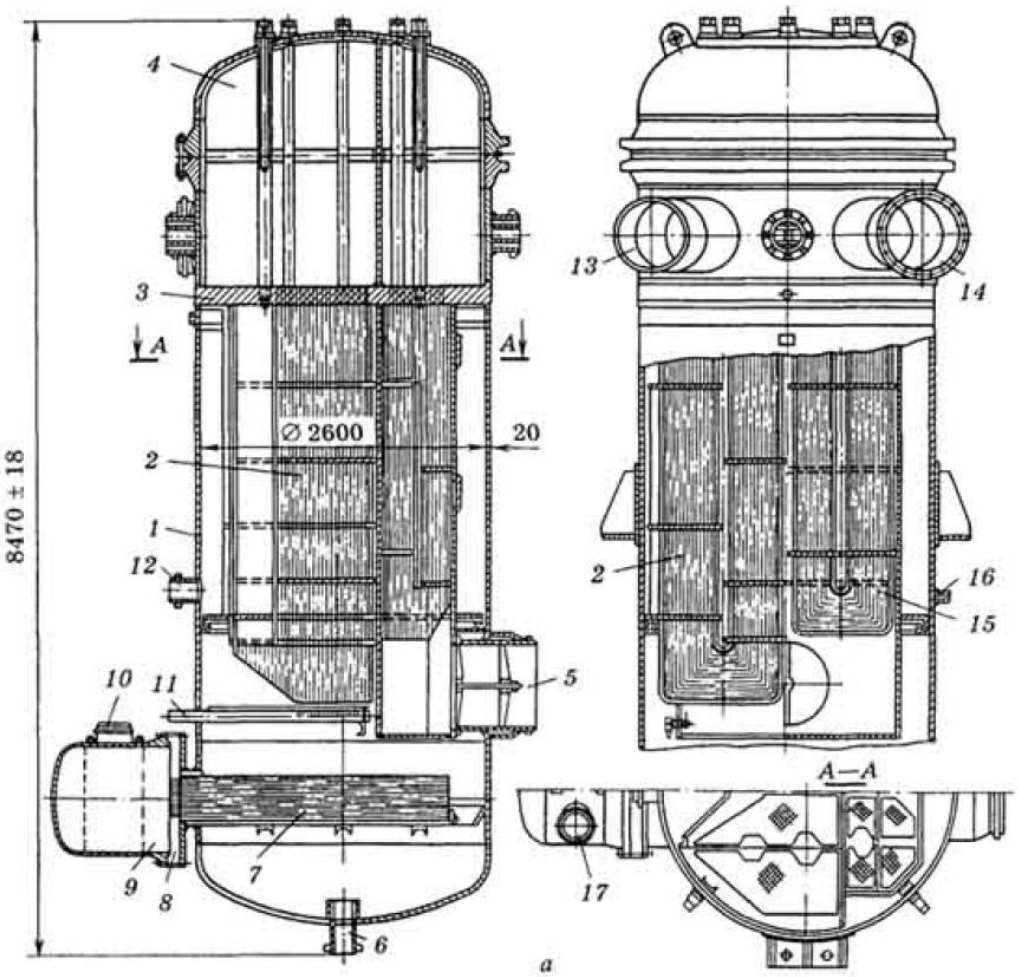
ASSEMBLY SCHEME OF REGENERATIVE HEATER



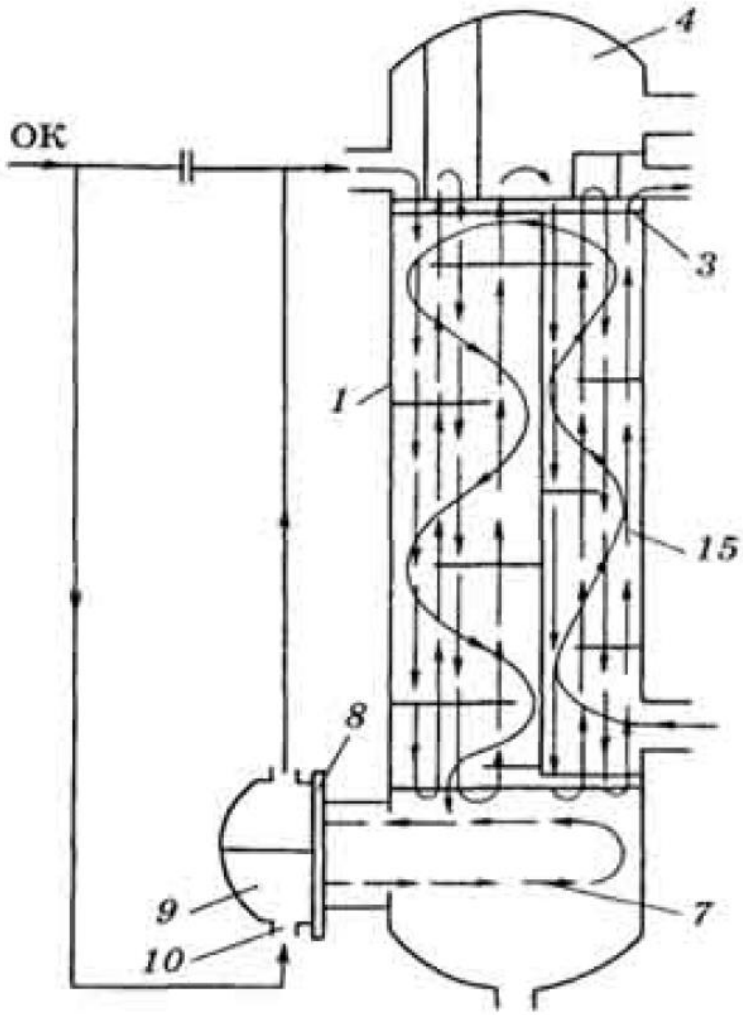
- А – main condensate inlet
- Б – main condensate outlet
- В – heating steam inlet
- Г – heating steam drainage outlet
- Д – drainage inlet from heater
- Е – non-condensing gases inlet
- Ж – steam space drainage outlet
- И – walls for space between tube
- К – air outlet for space between tubes
- Н – measurement pipe
- О – non-condensing gases outlet
- П – air outlet of water chamber
- Р – steam part drainage
- С – connection of condensate tanks
- Т – walls of tube space

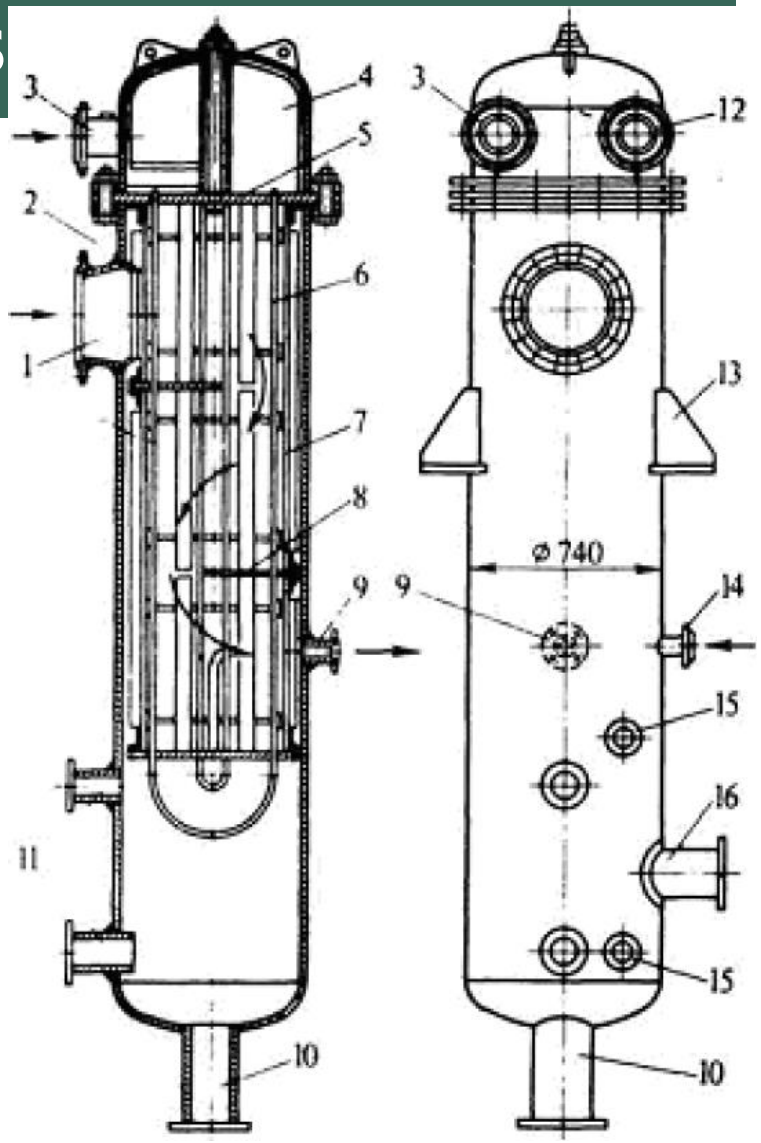
REGENERATIVE HEATER WITH STEAM AND DRAINAGE COOLER AND U-SHAPED TUBES

- Steam cooler tubes are situated into separate casing.
- Drainage cooler is situated at the bottom of the heater.
- Superheated steam from turbine flows into lower part of heater.
- Condensed steam moves into drainage cooler where it is cooled by part of feed water flow. Later it is removed through valve in the bottom of the casing.
- Main condensate (feed water) flows through four-pass heater and steam cooler.
- Small part of feed water is directed into drainage cooler.
- Drainage cooler are made of Ø16×1 mm tubes of C18N10T.



STEAM AND FEED WATER MOVEMENT SCHEME AND CONSTRUCTION OF REGENERATIVE HEATER WITH BRASS TUBES

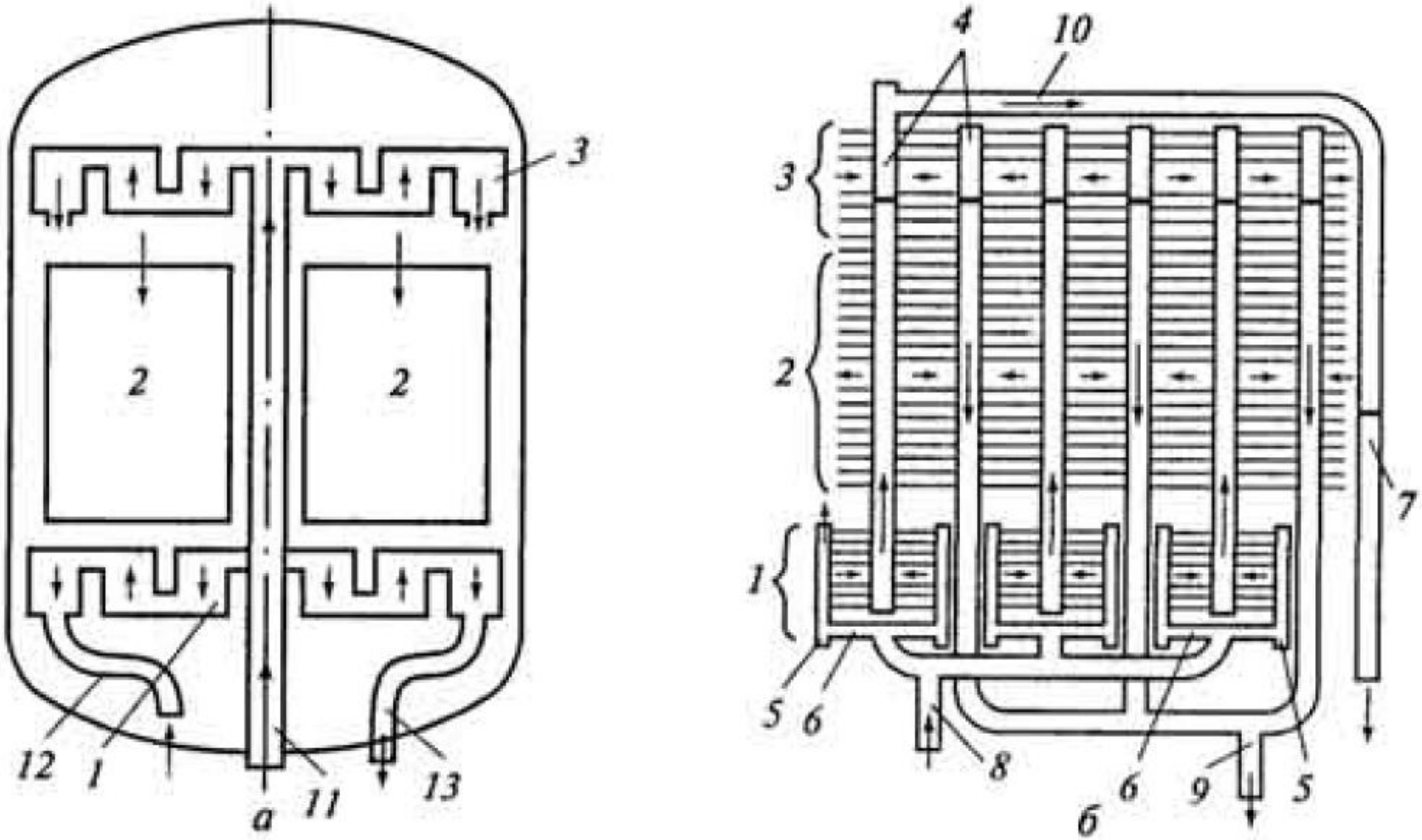




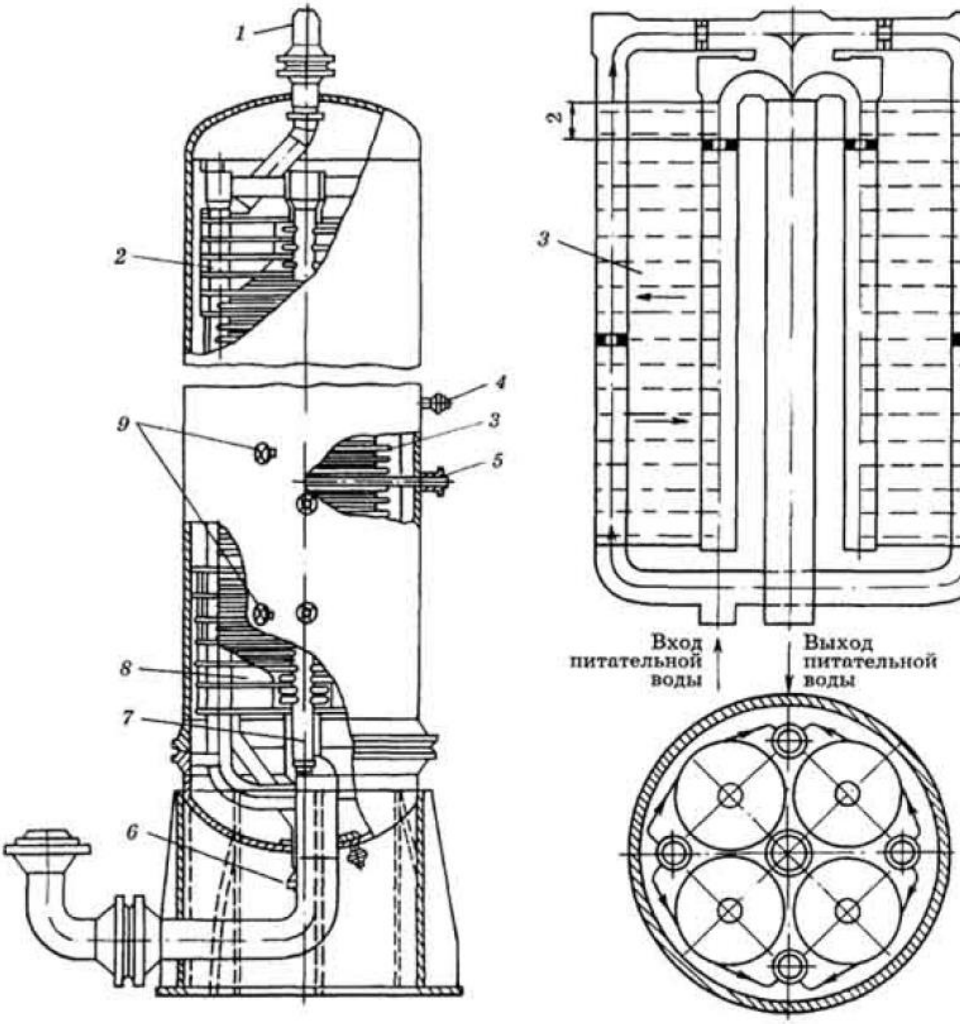
FEATURES OF HIGH-PRESSURE HEATER AT NPP

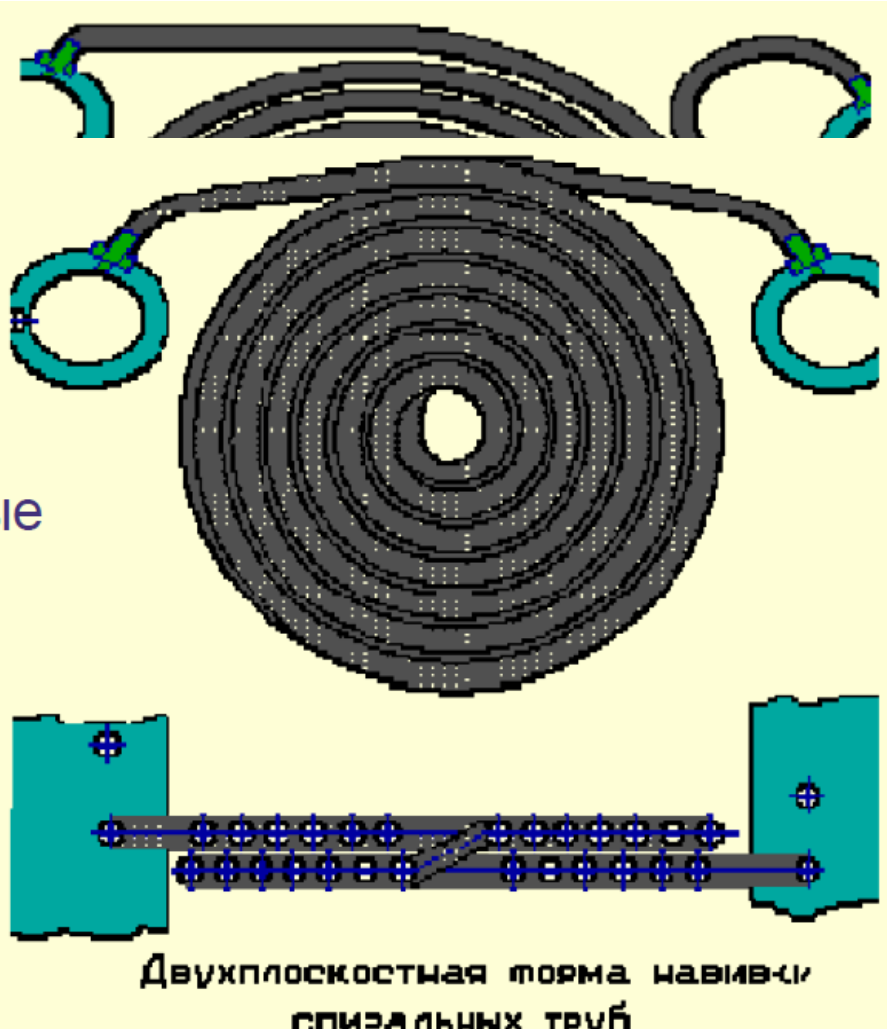
- Heater type: shell-tube.
- Substance with higher pressure is situated into tubes while with lower pressure – in space between tubes.
- Constructions of two types are applied:
  - Chamber type with tube desk;
  - Collector-spiral type;
- Be casing orientation:
  - Horizontal;
  - Vertical;
- Integrated drainage cooler
- Absence of steam coolers
- Tube system:
  - Vertical collector;
  - Horizontal coil.

SCHEME OF REGENERATIVE HEATER WITH COIL-TYPE TUBES



CONSTRUCTION OF REGENERATIVE HEATER WITH COIL-TYPE TUBES



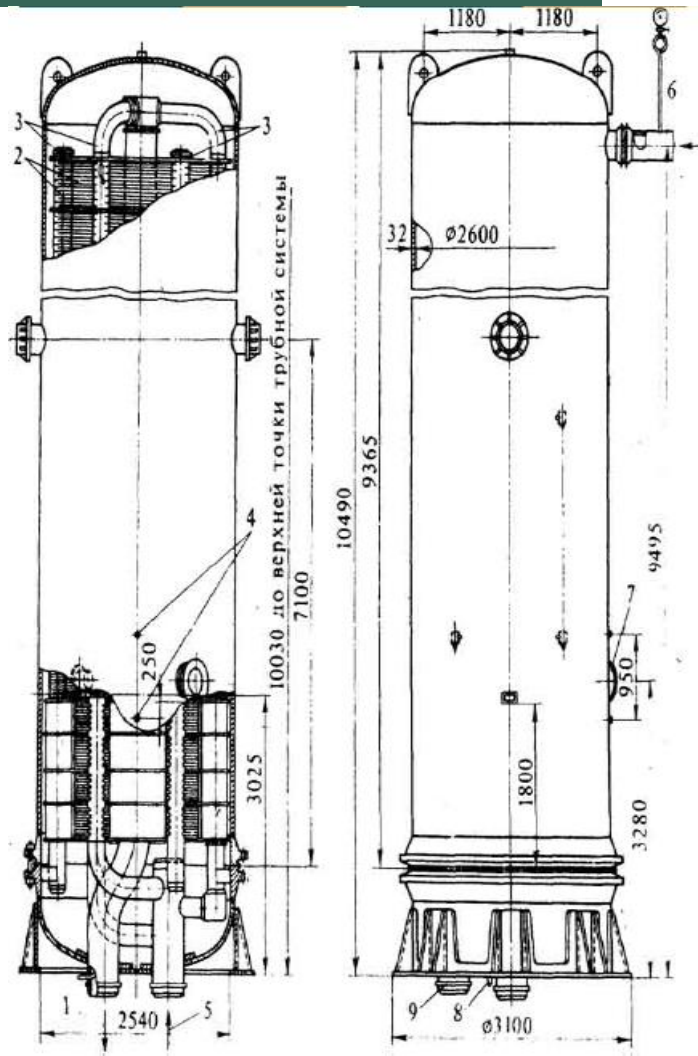


COLLECTOR SECTIONING

- The sectioning is applied:
  - To reach low velocities of water into tubes;
  - To increase heat transfer coefficient value;
  - To decrease heat transfer surface area.
- To increase the steam velocity the directional plates are applied.

Spiral heater:

- Heat transfer surface is made out of Ø32×1 mm.
- One-pass in drainage cooler part.
- Upper part could be removed.



ADVANTAGES AND DISADVANTAGES OF SPIRAL-TUBED HEATERS

Advantages of spiral construction:

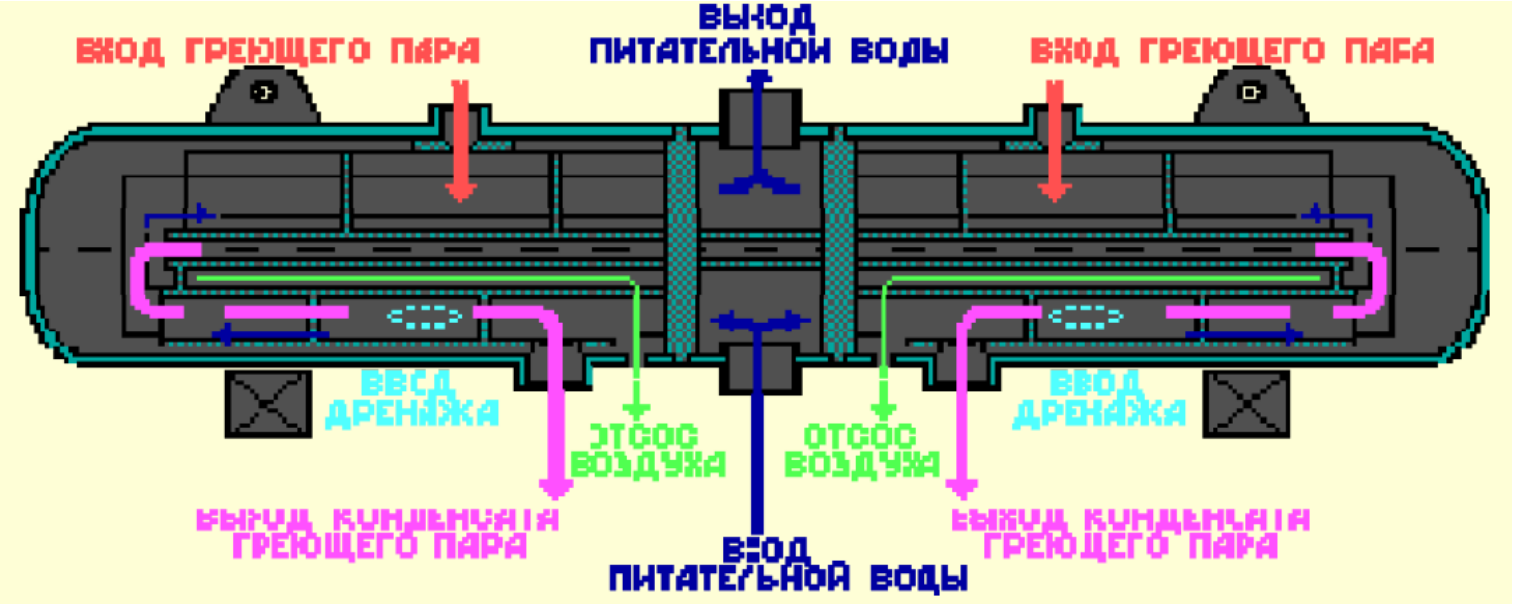
- Possibility to change every spiral tube;
- Counter-current scheme of steam and feed water movement.

Advantages	Disadvantages
1. Simplicity of construction.	1. High hydraulic losses.
2. Good liability to repair.	2. Bad dimensions.
3. High reliability (up to certain power).	3. High metal consumption.

CONSTRUCTION OF CHAMBER-TYPE HIGH PRESSURE HEATER

Horizontal style:

- Consist of two U-shaped tube packs;
- The water chamber situated in the center of the heater;
- Horizontal wall in the water chamber makes it two-pass.



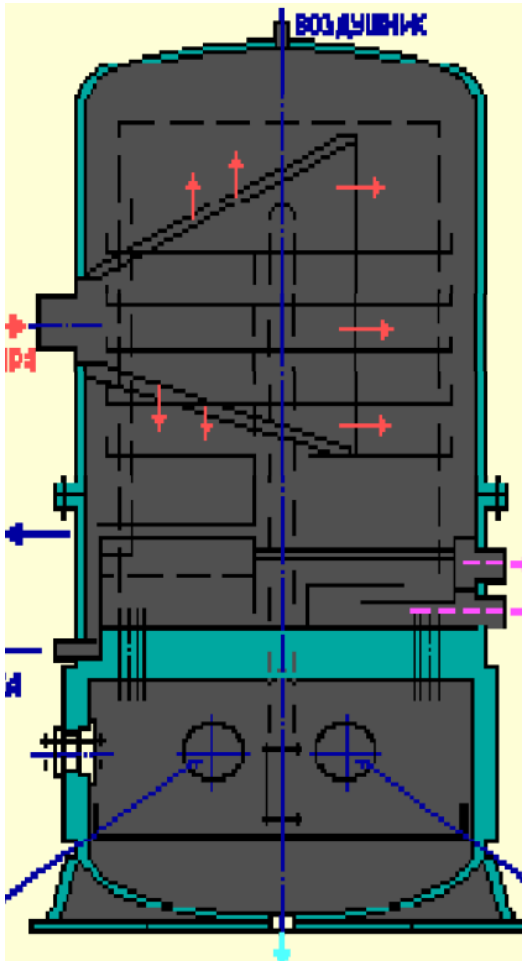
CONSTRUCTION OF CHAMBER-TYPE HIGH PRESSURE HEATER

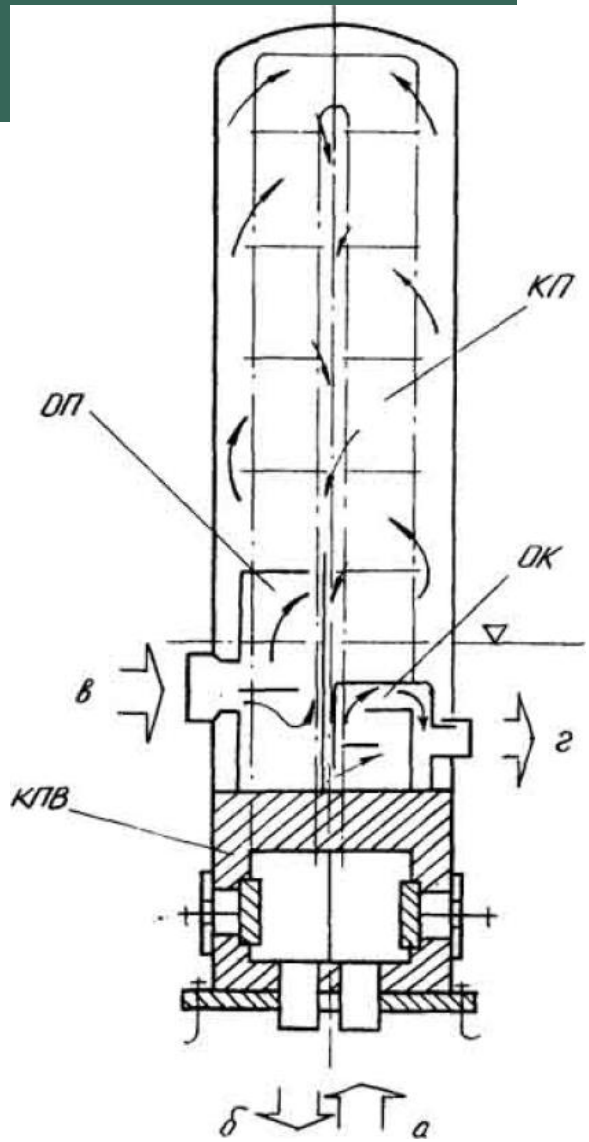
Vertical style:

- Prevents scale formation;
- Ensures tightness of casing.

Construction:

- P-shaped tubes Ø16×1,5 mm.
- Lower position of water chamber;
- Integrated steam cooler.





ADVANTAGES OF HIGH PRESSURE HEATERS WITHOUT COLLECTOR

- Lower hydraulic resistance of heater;
- Higher efficiency of turbine unit;
- Lesser steel consumption and dimensions;
- The cheaper alloys could be used;
- Elimination of welding of coil tubes to collector;
- Lesser weight (by approximately 30 %);
- Lesser dimensions;
- Lesser amount of impurities in feed water;
- Lesser amount of welding;
- Simplification of tube system.

MODERN REGENERATIVE HEATERS

- High underheating values in vacuum heaters (up to 15-20 °C);
- Presence of corrosion products into feed water;
- Relatively high costs and steel consumption.

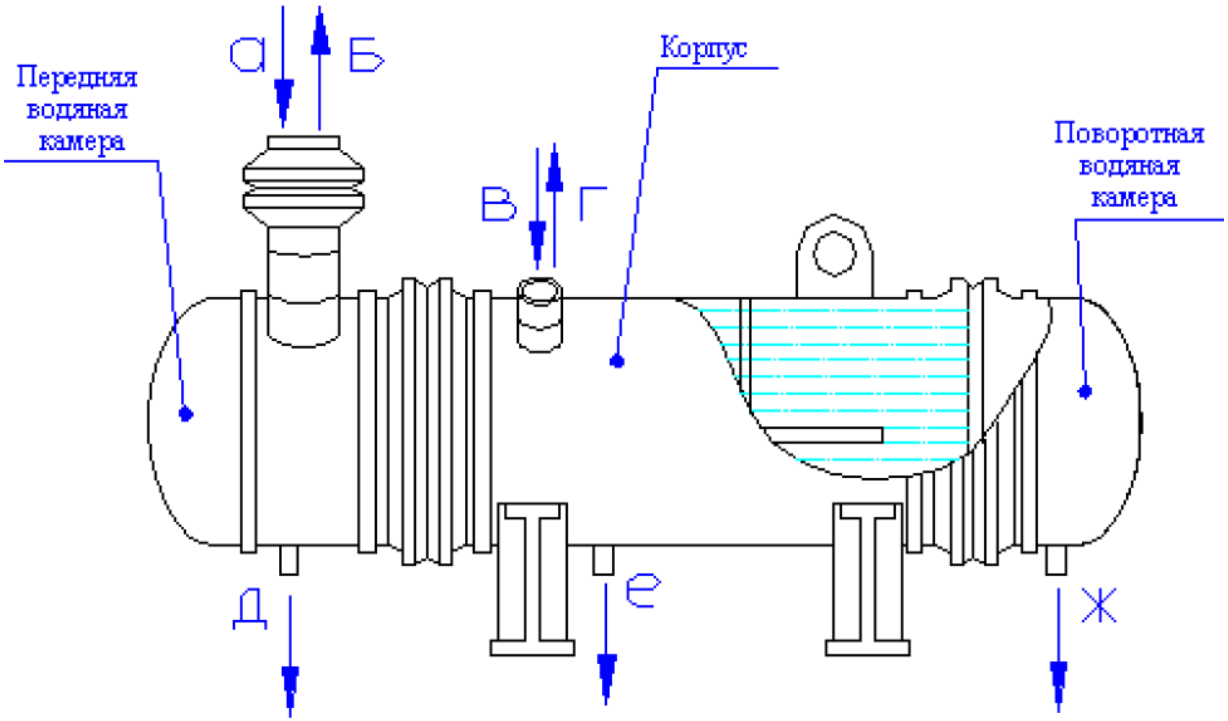
Ways of improving heaters:

- To decrease diameter of tubes (from 32 to 22 mm);
- Application of spiral with slope;
- Increasing collector values;
- Modernization of tube mounting system;
- Replacement of heaters with coil tubes on chamber-type;
- Intensifying of heat transfer by using ribbed tubed;
- Application of cheap alloys.

DRAINAGE COOLER

Drainage cooler – detached heat-exchanger.

- Only the part of feed water flow is directed to drainage cooler.
- Drainage cooler SDP-600-1 is horizontal shell-tube heat exchanger with smooth straight tubes which form the tube pack.



THANK YOU FOR YOUR ATTENTION