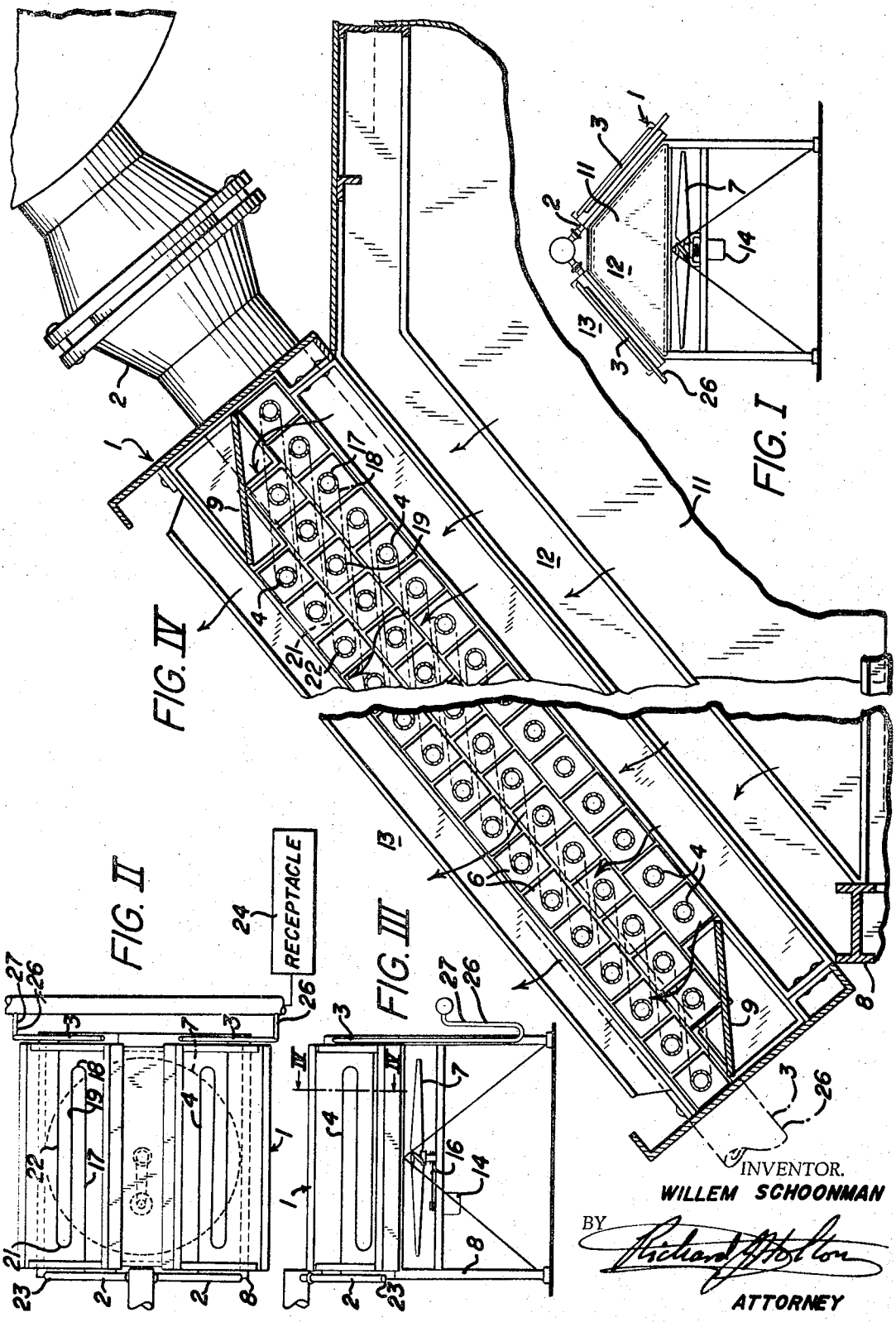
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AIR-COOLED CONDENSER WITH PROVISION FOR PREVENTION OF CONDENSATE FREEZING

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AIR-COOLED CONDENSER WITH PROVISION FOR PREVENTION OF CONDENSATE FREEZING

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ABSTRACT OF THE DISCLOSURE

Air-cooled condenser for steam or other condensable vapor is arranged to provide serpentine path for vapor and generally cocurrent flow of air to prevent freezing of condensate.

This invention contemplates an air-cooled condenser with vapor and air arranged for cocurrent flow so that condensate freezeup is avoided. A steam condenser embodiment suitable for outdoor service under winter conditions will be described here in detail, but it should be kept in mind that the invention can apply to a wide variety of air-cooled condenser applications.

In usual outdoor, air-cooled condenser installations steam is introduced into parallel tubes arranged to have air passed thereover. Tubes in contact with cold inlet air are subject to more cooling than the upstream tubes. By the effect of pressure drop equalization these cold tubes receive less steam than they can condense. These cold tubes become flooded with condensate over part of their lengths and the condensate becomes subcooled: i.e. sensible heat is donated by the condensate to the cooling air. Cold climate conditions aggravate subcooling to the extent that the condensate freezes with consequent plugging and tube damage.

Applicant teaches an air-cooled condenser which overcomes this freezeup problem in a novel and facile way. More particularly this condenser arranges a plurality of tubes each in cocurrent relationship with the cooling air so that, even under the most severe winter conditions, cold air contacts warm vapor from the vapor manifold. As the vapor passes through the tubes for condensation the cocurrent flowing air becomes warmer so that subcooling is lessened. Some flooding may take place due to maldistribution of air and/or steam flow. This flooding, however, is minor and only occurs at the outlet ends (condensate manifold ends) of the tubes. At these ends of the tubes the air has been warmed so subcooling influences are eased.

In the portions of the tubes which are in contact with cold air the steam is warm so condensation is only beginning. Under particularly severe circumstances an ice layer may here be formed, but such an ice layer would have an insulating effect so steam and cold air quickly reach a thin equilibrium thickness of ice with no damage to the tubes.

This disclosure also provides an economical, easily maintained condenser installation which is well suited to its intended function. Tube banks are inclined downward from a common ridge with tubes arranged in triangular patterns and formed in horizontal serpentine configurations with extended surface for compactness as well as for optimum heat transfer and air flow characteristics. Gravity drainage is accommodated and loop seals in condensate lines prevent backup of steam from banks operating at lower capacity to banks operating at full capacity.

These and other features will appear more fully from the accompanying drawings wherein:

FIGURE I is an end elevation view of an air-cooled condenser according to this invention.

FIGURE II is a plan view of the condenser.

FIGURE III is a side elevation of the condenser.

FIGURE IV is an enlarged section through a tube bundle.

In essence an apparatus of this type brings a condensable vapor into noncontact, heat-exchange relationship with flowing air. As seen in the drawings, banks **1** are each pitched away from a common ridge. Both banks have steam manifolds **2** at one end and condensate manifolds **3** at the other end. Each bank has a plurality of tubes **4** (with extended surface **6**) connecting its associated steam **2** and condensate **3** manifolds in flow series.

Flowing air extracts heat of vaporization from the steam so that condensation can take place. Toward this objective fan **7** is supported by frame **8**. Canalizing means including baffles **9** and shrouds **11** confine air flow over tubes **4** from inward side **12** toward outward side **13**. Fan **7** is driven by motor **14** through transmission **16**. Fan **7** can be switched on and off. Control can also be achieved by means of multi-speed motors or by use of louvres.

At the core of this invention is the cocurrent flow relationship of steam and air. Each of the tubes **4** defines a generally-horizontal, serpentine configuration with an upstream leg **17** connected to its associated steam manifold **2** on inward side **12**. Upstream leg **17** connects via U-bend **18**, intermediate leg **19** and U-bend **21** to downstream leg **22** which is connected in turn toward outward side **13** to condensate manifold **3**. Accordingly, steam courses for condensation from steam manifold **2** toward condensate manifold **3**.

Convenient drainage is essential for condensers. Each of the tubes **4** is provided with sufficient slope for gravity drainage to condenser manifold **3**. Drains **23** are provided for steam manifolds **2**. Condensate manifolds **3** exhaust to receptacles **24** via condensate lines **26** which are fitted with loop seals **27** so that back flow of steam from a bank operating at lower capacity to a bank operating at full capacity will be prevented.

It will be understood by those skilled in condenser design and related arts that wide deviations may be made in the shown embodiment without departing from the main theme of invention outlined in the claims. By way of example and without intending limitation, an induction draft fan could be employed. Any number of legs could have been provided for each tube. The manifolds could be vertical with horizontal tubes and inclined U-bends. Clearly the basic concepts here outlined would be applicable to air cooling any condensable.

What is claimed is:

1. A condenser suitable for relatively cold ambient conditions and comprising

a vapor manifold and a condensate manifold disposed in an inclined common plane,

a plurality of substantially horizontal tubes, each connecting the manifolds in flow series and with each tube arranged in parallel flow relationship to each other,

means for flowing air over the outsides of the tubes to condense vapor therein,

means for exhausting condensate from each of the tubes via the condensate manifold,

each of the tubes forming a serpentine configuration with an upstream leg connected to the vapor manifold and a downstream leg connected to the condensate manifold,

each tube provided with sufficient slope for gravity drainage to the condensate manifold,

means for gravity draining each of the manifolds, and

means for organizing the air to flow simultaneously over each of the tubes passing over its upstream

leg before its downstream leg for cocurrent flow of vapor and air and for preventing condensate from being placed in substantial heat-exchange relationship with unpreheated air, whereby local freezing of condensate is avoided.

2. A condenser suitable for relatively cold ambient conditions and comprising

two elongated substantially planar banks each pitched downward away from a common ridge,

each bank having a vapor manifold at one end and a condensate manifold at the other end,

each bank having a plurality of tubes connecting its associated vapor and condensate manifolds in flow series,

each of the tubes arranged in parallel flow relationship with the rest of the tubes in its bank,

a fan arranged for flowing air upward over the outsides of the tubes to condense the vapor therein,

canalizing means for confining air flow over the tubes,

means for exhausting condensate from each of the tubes via its associated condensate manifold,

each of the tubes provided with sufficient slope for gravity drainage to its associated condensate manifold,

means for gravity draining each of the manifolds,

each of the tubes forming a generally horizontal serpentine configuration with an upstream leg connected to its associated vapor manifold and a downstream leg connected to its associated condensate manifold,

means for organizing the air to flow simultaneously over each of the tubes passing over its upstream leg before its downstream leg for cocurrent flow of vapor and air and for preventing condensate from being placed in substantial heat-exchange relationship with unpreheated air, whereby local freezing of condensate is avoided.

3. The condenser of claim 2 with the fan mounted below the banks.

4. The condenser of claim 3 with extended surface depending from at least one of the tubes.

5. A steam condenser suitable for relatively cold ambient conditions and comprising

a steam manifold and a condensate manifold disposed in an inclined common plane,

a plurality of substantially horizontal tubes each connecting the manifolds in flow series and with each tube arranged in parallel flow relationship to each other,

means for flowing air over the outsides of the tubes to condense steam therein,

means for exhausting condensate from the tubes via the condensate manifold,

each of the tubes forming a serpentine configuration with an upstream leg connected at its upper end to the steam manifold and a downstream leg connected at its lower end to the condensate manifold,

each tube provided throughout its length with sufficient slope for gravity drainage to the condensate manifold,

means for gravity draining each of the manifolds, and

means for organizing the air to flow simultaneously over each of the tubes over its upstream leg before its downstream leg for cocurrent flow of steam and air and for preventing condensate from being placed in substantial heat-exchange relationship with unpreheated air whereby local freezing of condensate is avoided.

6. A steam condenser suitable for relatively cold ambient conditions and comprising

two elongated substantially planar banks each pitched downward away from a common ridge,

each bank having a steam manifold at one end and a condensate manifold at the other end,

each bank having a plurality of tubes connecting its associated steam and condensate manifolds in flow series,

each of the tubes arranged in parrallel flow relationship with the rest of the tubes in its bank,

a fan arranged for flowing air upward over the outsides of the tubes to condense steam therein,

canalizing means for confining air flow over the tubes,

means for exhausting condensate from each of the tubes via its associated condensate manifold,

each of the tubes provided with sufficient slope for gravity drainage to its associated manifold,

means for gravity draining each of the manifolds,

each of the tubes forming a generally horizontal serpentine configuration with an upstream leg connected to its associated steam manifold and a downstream leg connected to its associated condensate manifold,

means for organizing the air to flow simultaneously over each of the tubes passing over its upstream leg before its downstream leg for cocurrent flow of stream and air and for preventing condensate from being placed in substantial heat-exchange relationship with unpreheated air, whereby local freezing of condensate is avoided.

7. The steam condenser of claim 6 with the fan mounted below the banks.

8. The steam condenser of claim 7 with extended surface depending from at least one of the tubes.

9. The steam condenser of claim 8

a receptacle,

each of the condensate manifolds having a condensate line connecting it to the receptacle for delivery of condensate thereto,

each of the condensate lines including a loop seal so that pressures in each condensate manifold are maintained substantially independent.

10. The steam condenser of claim 5 with the condensate manifold defining a port suitable for connection to an ejector system.

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