June 18, 1940. A. HOWARD 2,205,292

HEAT EXCHANGER UNIT

Filed Jan. 5, 1939

Fig. 1.

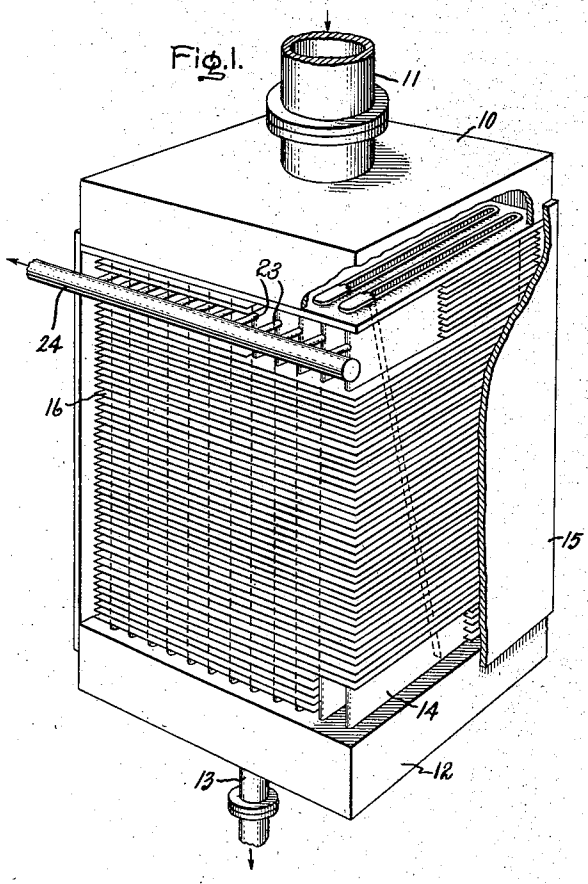


Fig. 3.

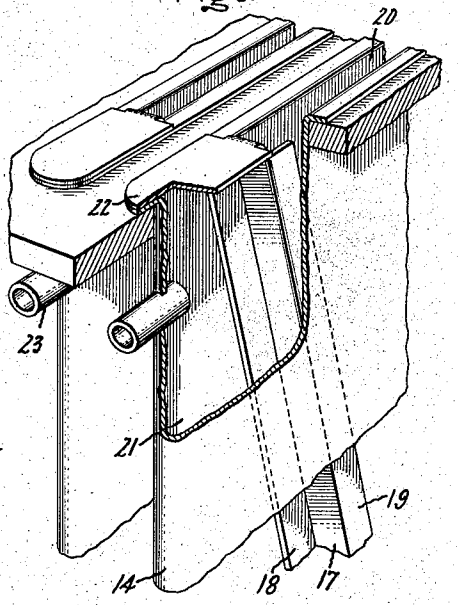


Fig. 4.

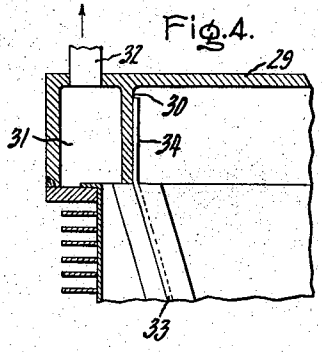
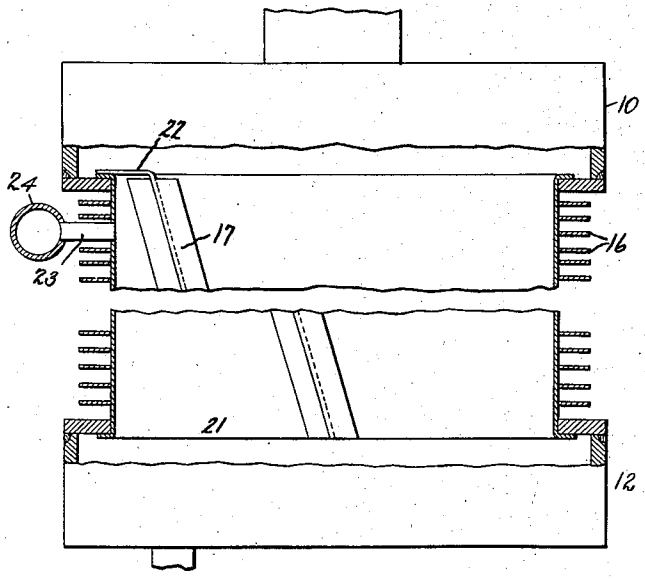


Fig. 2.



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2,205,292

HEAT EXCHANGER UNIT

Alan Howard, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application January 5, 1939, Serial No. 249,458

9 Claims. (Cl. 257—36)

This invention relates to heat exchangers and particularly to the air cooled type adaptable for condensing elastic fluid.

Air cooled heat exchangers usually comprise a bank of thin walled tubes arranged in spaced apart relationship between upper and lower headers. Cooling air is circulated around the tubes usually by some blower means for conducting the heat therefrom. The tubes embodied in such heat exchangers are of many different shapes and sizes but for certain purposes it is more advantageous to use wide flat tubes instead of a relatively greater number of smaller cylindrical tubes. Because of the relatively lower resistance presented to the air flow, the efficiency of a flat tube heat exchanger is considerably greater than one with tubes of other shapes in that with a given total tubing surface area a greater heat transfer is derived for a given amount of energy expended in circulating the cooling air. Where the amount of heat to be dissipated is large, such as in condensers for reducing to condensate the exhaust from elastic fluid turbines, the total condenser capacity must of necessity be relatively large. Particularly in portable prime mover plants, such as in locomotive vehicles, space limitations require that the overall size of the condenser installation be kept as small as possible which in turn requires that a large volume of cooling air be circulated therethrough per square foot of face area. Considering the large amount of power required by the cooling air circulating blowers which is frequently of the order of 25% of the power output of the turbine, the matter of condenser efficiency becomes of increasing importance.

The use of flat tubes in condenser units, however, is complicated by the fact that some provision must be made for extracting air and other non-condensable gases therefrom. Further, in order that the maximum efficiency may be realized from the condenser units, it is necessary that the velocity of the elastic fluid flowing through the tubes be maintained substantially uniform lest the back pressure to the turbine be increased by a reduction in the rate of flow of the elastic fluid through the condenser.

It is an object of this invention to provide a new heat exchanger having relatively wide flat tubes with means arranged therein for improving the condensing characteristics thereof.

It is a further object of this invention to provide a new and improved condenser having relatively wide flat tubes with means arranged therein for facilitating the extraction of noncondensables therefrom.

In accordance with the illustrated embodiment of this invention, I provide a condenser unit having a plurality of flat rectangular tubes extending substantially the width of the unit each tube being provided with a partition forming two passages therein and so arranged as to constitute, in effect, a continuous passage of progressively decreasing cross-sectional area from the elastic fluid inlet to the outlet for the noncondensables.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto taken in connection with the accompanying drawing.

In the drawing, Fig. 1 is a perspective view partly in section of a heat exchanger or elastic fluid condenser unit embodying my invention; Fig. 2 is a cross-sectional view through one of the tubes of the condenser unit shown in Fig. 1; Fig. 3 is a fragmentary view in perspective illustrating certain details of the condenser; and Fig. 4 is a fragmentary cross-sectional view illustrating a modification of my invention.

Referring to Figs. 1, 2 and 3, a condenser unit is shown comprising an upper header 10 having an elastic fluid inlet 11 and a lower header 12 having a connection 13 for draining condensate therefrom. A plurality of flat tubes 14 are arranged between the upper and lower headers, parallel with each other and spaced suitably apart providing passages for cooling air therebetween, the tubes being of a width substantially equal to the width of the unit. The ends of the tubes may be secured in any suitable manner to the upper and lower headers and it is preferred to provide relatively rigid side plates 15 for stiffening the unit and to relieve the relatively thin tubes of stresses due to the weight of the upper header. For facilitating the heat transfer from the outer surfaces of the tubes, a plurality of suitable fins 16 may be provided as indicated.

In accordance with my invention, I provide in each tube a partition 17 extending from the upper end and adjacent one edge of the tube diagonally downwardly to approximately the center of the lower end as shown best in Fig. 2. The partition strip may be secured in any suitable manner within the tube. For example, as shown in Fig. 3, the strip may be preformed or folded so as to provide parallel side flanges 18 and 19. The side flange 18 of the partition strip may be soldered or welded to the sheet from which the tube will be made and as the sheet

is folded over to form the tube, the opposite side wall will engage with the flange 19 dividing the tube into two longitudinal, tapered passages 20 and 21. The upper end of the strip is provided with a flap portion 22 which is adapted to be folded over and secured upon the upper flanges of the tube substantially as indicated in Fig. 3 to close the upper end of the passage 21. The upper end of the passage 20 is substantially equal to the width of the tube and due to the diagonal arrangement of the partition, the passage decreases progressively in cross-sectional area in the downward direction, the lower end of the passage being substantially equal to one-half the size of the upper end. The passage 21 decreases progressively in cross-sectional area in the upward direction from substantially one-half the tube width at the lower end to substantially zero width at the upper end. It is understood that the angular arrangement of the partition strip may be varied for dividing the lower end of the tube into unequal portions, should it be desirable to compensate for the differences in temperature of the front and rear passages. The non-condensables are withdrawn from the upper end of the passage 21 through a connection 23 communicating with the conduit 24 to which is connected a suitable ejector or vacuum pump (not shown).

It will be noted that the opening of the tubes in the header 10 is a maximum so that the intake resistance to the elastic fluid passing into the condenser unit is low. As the elastic fluid passes downwardly through the main condensing passages 20 and heat is extracted therefrom, the volume thereof is progressively diminished as condensation takes place. Since the cross-sectional area of the passages progressively decreases in the direction of flow, uniform velocity of the elastic fluid flow is maintained from the upper to the lower ends. The elastic fluid not condensed in the downward pass flows around the lower ends of the partition strips through the lower header 12 and continues upwardly through the after-cooler passages 21 which also are of progressively decreasing cross-sectional area in the upward direction and in which passages the condensation will be completed. It will be noted that the lower ends of the after-cooler passages are substantially of the same area as the lower ends of the main condensing passages so that all of the elastic fluid emerging from the latter passages may be accommodated in the after-cooler passages without experiencing any appreciable drop in velocity. It is understood that due to the action of the vacuum pump, ejector, or other device coupled to the conduit 24 for extracting the non-condensables from the condenser unit, a suction will be produced on the upper ends of the after-cooler passages so that the vapor not condensed in the downward pass will be drawn into the second section because of the relatively lower pressure maintained therein. The condensate forming in the after-cooler passages will, of course, drain downwardly into the lower header. Because of the relatively large opening of the lower end of the after-cooler passages, there will be little likelihood of condensate blocking the end thereof against the admission of non-condensed vapor. In effect, the two passages, 20 and 21, taken together perform as a single tube of uniformly and progressively decreasing cross-sectional area from the inlet header to the outlet for non-condensables, with means provided for draining the passage of condensate at the center.

It will be obvious that the partition may be formed in many ways. The arrangement shown is a simple one since only one flange, 18, of the diagonal strip need be secured to one tube side wall during the manufacture thereof, the flange 19 being adapted to merely press against the opposite tube side wall. Because of the low pressure existing in the passage 21 and the relatively higher pressure existing on the opposite side of the strip, the flange 19 will be pressed more or less firmly against the adjacent tube side wall. In the event that a slight leakage does occur past the edges of the partition adjacent side wall, no damage can result therefrom and the operation of the condenser unit will be very slightly affected thereby.

Because of the relatively light weight of the material from which the tubes are made, it might be undesirable to attempt to secure connections such as 23 thereto for the purpose of extracting noncondensables therefrom. In the modification shown in Fig. 4, the upper header 29 is provided with a transversely extending wall 30 providing therein an auxiliary header chamber 31 for the noncondensables from the after-cooler passages. The noncondensables may be extracted from the header chamber 31 through the connection 32 communicating therewith. The upper end of the partition 33 may be provided with a flap 34 which is adapted to rest against the wall 30 with spring pressure, which pressure, augmented by the inlet elastic fluid pressure, will maintain the flap substantially tight against the wall 30 throughout the operation of the condenser unit.

While I have shown the condenser unit as being made up of wide flat tubes having angularly arranged partitions therein forming two tapered passages in each tube, it is obvious that two separate tubes may be made up each having a shape corresponding to the shape of the passages 20 and 21. Such tubes could be suitably arranged between upper and lower headers and would operate in a manner not unlike the arrangement described in greater detail. The former arrangement is preferred primarily for manufacturing expediency.

With normal conditions prevailing, it is preferable that the air flow between the tubes be in such a direction as to first contact with the after-cooler sections so that complete condensation of the condensable vapors flowing therethrough takes place leaving but dry noncondensables to be extracted. It is obvious that during periods of abnormally low temperature of cooling air, the direction of air flow through the condenser unit may be reversed so that it contacts first with the section of the tubes carrying the more heated elastic fluid. By doing this, freezing of condensate within the after-cooler passages and the consequent blocking off of the noncondensable outlet would be precluded.

Having described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A surface cooled condenser unit comprising an upper inlet header for elastic fluid to be condensed, a lower outlet header for condensate, a plurality of relatively wide flat tubes communicating between said headers, a partition angu-

larly arranged in each of said tubes forming two passages therein, the first passage having an opening into said upper header of a width substantially equal to the width of said tube, said first passage decreasing progressively in cross-sectional area downwardly, the opening of said first passage into said lower header being substantially one-half of the width of said tube, the second passage having an opening into said lower header of a width substantially equal to one-half of said tube width and decreasing progressively in cross-sectional area upwardly, the upper end of said second passage being closed, and a connection communicating with the closed upper end of said second passage for withdrawing noncondensables therefrom.

2. An air cooled condenser unit comprising an upper inlet header for elastic fluid to be condensed, a lower outlet header for condensate, a plurality of flat tubes arranged between said headers, said tubes having a width substantially equal to the width of said unit, a partition arranged in each of said tubes extending from the upper end thereof and adjacent one edge substantially to the center of the lower end thereof, said partition forming two tapered passages through said tubes, the first passage communicating between said upper and lower headers, the second passage being closed at the upper end by said partition, and means for withdrawing noncondensables from the closed upper ends of said second passage.

3. An air cooled condenser comprising an upper inlet header for elastic fluid to be condensed, a lower outlet header for condensate, a plurality of relatively wide flat tubes arranged between said headers, a partition arranged in each of said tubes providing two tapered passages therein, the first passage communicating between said headers and being relatively large and decreasing in cross-sectional area downwardly, the second passage communicating with said lower header and being relatively smaller than said first passage and decreasing in cross-sectional area upwardly, and means for withdrawing noncondensables from the upper end of said second passage.

4. A surface type condenser comprising an upper inlet header for elastic fluid to be condensed, a lower outlet header for condensate, a plurality of relatively wide flat tubes arranged between said headers, a partition arranged in each of said tubes cooperating therewith to form a main condensing passage communicating between said headers and an after-cooler passage communicating with said lower header, and means communicating with the upper end of said after-cooler passage for extracting noncondensables therefrom.

5. An air cooled condenser comprising an inlet header for elastic fluid to be condensed, an outlet header for condensate, a plurality of relatively wide flat tubes arranged between said headers, a header for noncondensables, a partition arranged in each of said tubes cooperating therewith to form two passages therein, one passage being relatively large and communicating between said headers, the other passage being relatively small and communicating with said lower header and with said header for non-condensables connected thereto at the opposite end thereof.

6. An air cooled condenser comprising an inlet header for elastic fluid to be condensed, an outlet header for condensate, a plurality of relatively wide flat tubes communicating between said headers, a partition substantially longitudinally arranged in each of said tubes cooperating therewith to form two passages therein, said partition substantially closing the upper end of one of said passages and a connection communicating with the closed ends of said passage for withdrawing noncondensables therefrom.

7. A surface type condenser comprising an upper inlet header for elastic fluid to be condensed, a lower outlet header for condensate, a plurality of heat exchanging tubes arranged between said headers, partitioning means arranged in each of said tubes cooperating therewith to form a main condensing passage communicating between said headers and an after-cooler passage communicating with said lower header, means communicating with the upper end of said after-cooler passage for extracting noncondensables therefrom, said partitioning means being angularly arranged with respect to a wall of said tube to maintain substantially uniform the velocity of fluid flow successively through said main condensing passage and said after-cooler passage.

8. A surface cooled condenser comprising an upper inlet header for elastic fluid to be condensed, a lower outlet header for condensate, a plurality of relatively wide flat tubes arranged between said headers, a header for noncondensables, means arranged in each of said tubes dividing each tube into two passages, a first passage communicating between said upper and lower headers, the second passage communicating between said lower header and said header for noncondensables, said dividing means being angularly arranged with respect to a wall of said tube to maintain substantially uniform the velocity of the fluid flow from said inlet to said header for noncondensables.

9. A surface type condenser comprising an upper inlet header for elastic fluid to be condensed, a lower header for accumulating condensate, means for conducting condensate from said lower header, a plurality of heat exchanging tubes arranged between said headers, means arranged in said tubes forming passages of progressively decreasing cross-sectional area from said upper header to said lower header, said means also forming passages of progressively decreasing cross-sectional area extending upwardly from said lower header, an auxiliary header adjacent said upper inlet header in communication with the upper ends of said last mentioned passages for accumulating noncondensables therefrom, and means for extracting noncondensables from said auxiliary header.

ALAN HOWARD.