Aug. 18, 1953 J. W. BROWN, JR 2,649,285

AIR COOLER

Filed Nov. 20, 1948 2 Sheets-Sheet 1

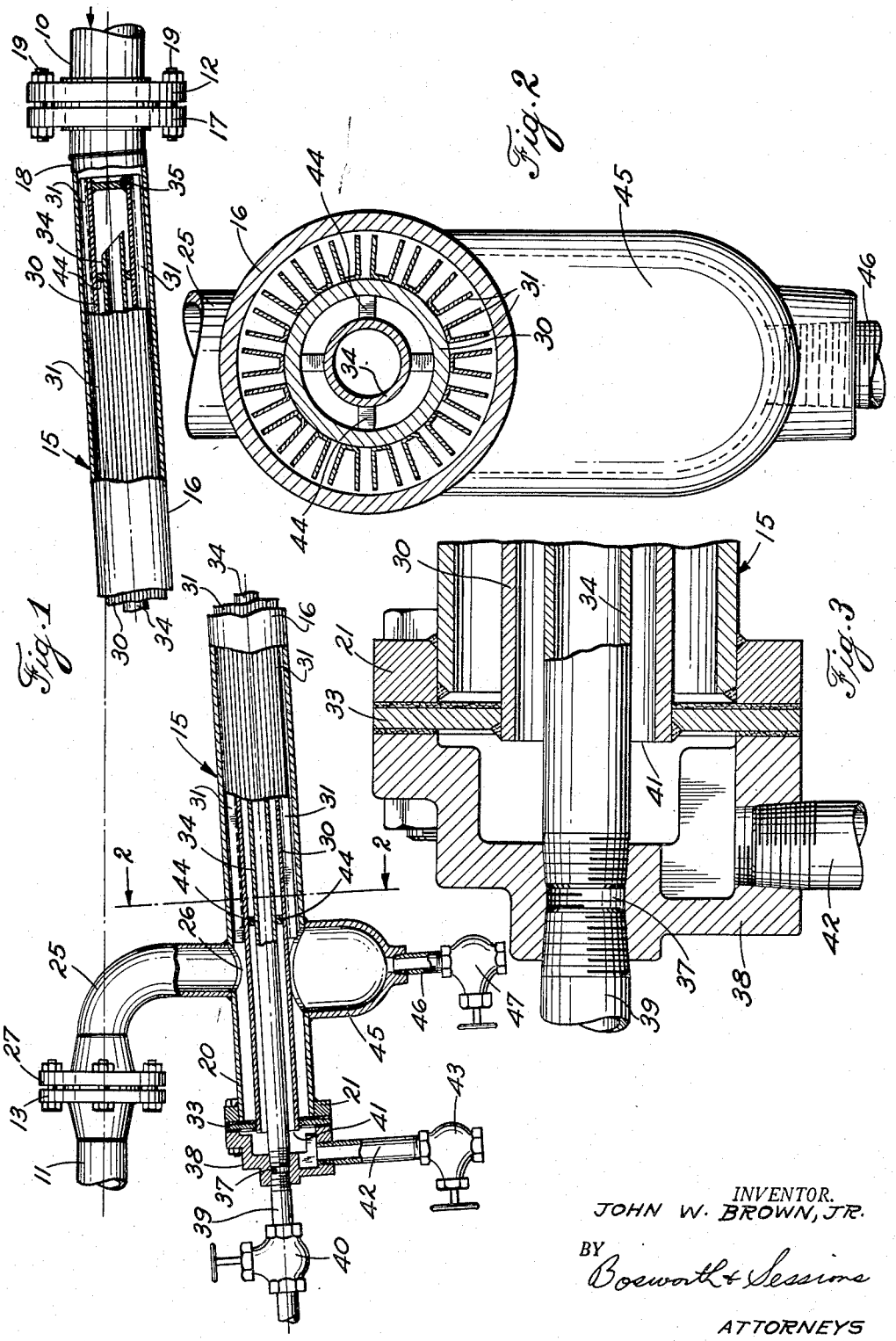


Fig. 1

Fig. 2

Fig. 3

INVENTOR.
JOHN W. BROWN, JR.
BY Bosworth & Sessions
ATTORNEYS

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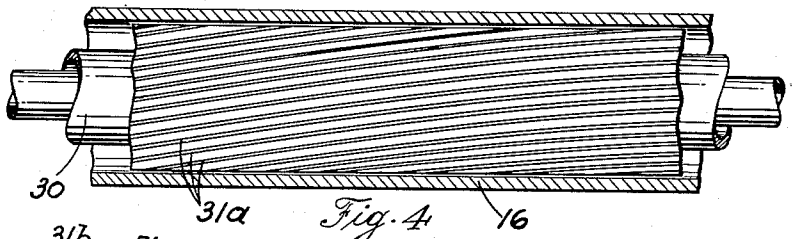


Fig. 4

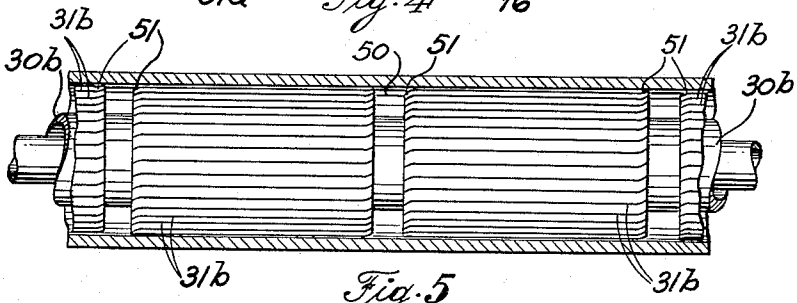


Fig. 5

Fig. 6

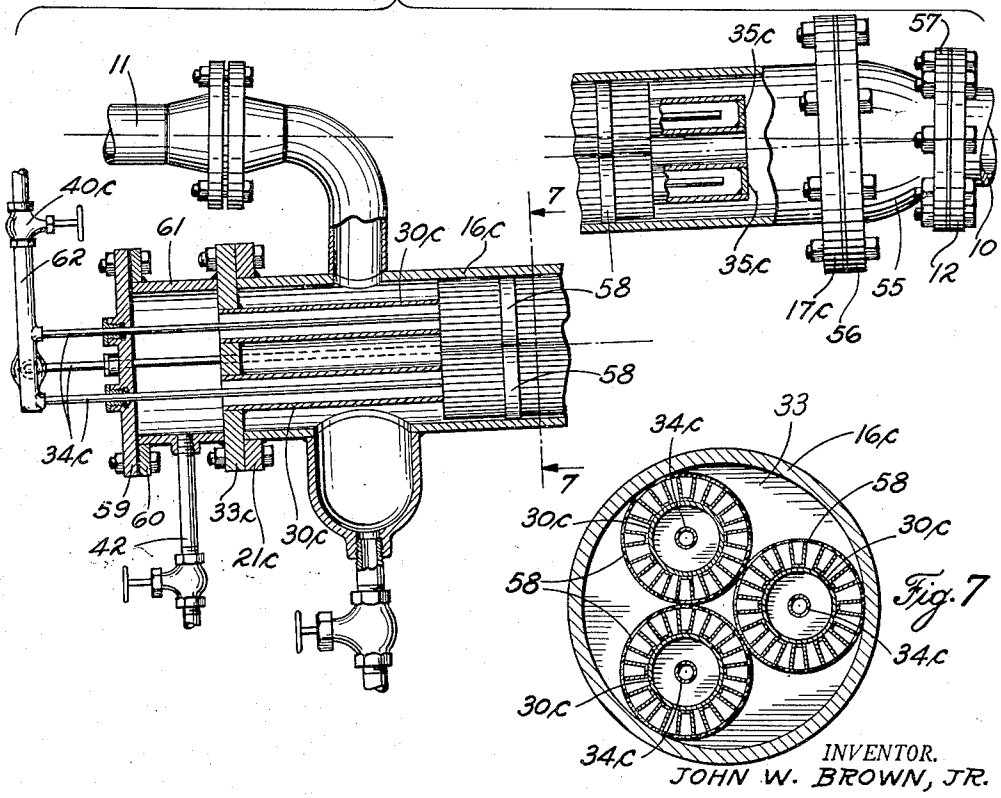


Fig. 7

INVENTOR.
JOHN W. BROWN, JR.
BY Bosworth & Sessions
ATTORNEYS

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UNITED STATES PATENT OFFICE

2,649,285

AIR COOLER

John W. Brown, Jr., Lakewood, Ohio, assignor to Brown Fintube Company, Elyria, Ohio, a corporation of Ohio

Application November 20, 1948, Serial No. 61,164

1 Claim. (Cl. 257—246)

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This invention relates to air coolers and the like and more particularly to air coolers and moisture separators adapted for use as aftercoolers in conjunction with air compressors.

It is well known that the efficiency of compressed air systems can be increased by employing so-called aftercoolers between the compressors and the receivers or accumulators in which the air is stored. Heretofore, aftercoolers have comprised bundles of bare tubes through which cold water is circulated and over which the air to be cooled is caused to flow; these devices, however, are bulky and expensive. Cooling the air also results in the condensation of some of the moisture carried by it, and ordinarily it has been necessary to employ separators between the conventional coolers and the reservoirs in order to remove entrained moisture from the air.

A general object of the present invention is the provision of an air cooler, particularly adapted for use as an aftercooler, which is compact and efficient and relatively inexpensive to manufacture and install. Another object is to provide an air cooler which also is capable of acting as a separator to remove condensed moisture from the air passing through it. Another object is the provision of an air cooler which can be installed readily in an air line extending between a compressor and a receiver. A further object is the provision of such a device in which the connections for the cooling fluid are independent of the air connections so that the cooling fluid connections can be broken and the cooling elements removed for servicing without disconnecting or disturbing the connections between the cooler and the air line.

Further objects and advantages of the invention will become apparent from the following description of preferred forms thereof, reference being made to the accompanying drawings in which Figure 1 is a side elevational view with parts broken away, showing an aftercooler embodying the invention installed in an air compressor line; Figure 2 is a transverse section taken along the line 2—2 of Figure 1; Figure 3 is an enlarged sectional view of the portion of the aftercooler shown at the left end of Figure 1; Figures 4 and 5 are fragmentary longitudinal sectional views showing modified forms of cooling elements adapted to be used with aftercoolers of the type shown in Figure 1; Figure 6 is a longitudinal sectional view of a modified form of aftercooler embodying a plurality of finned tube cooling elements; and Figure 7 is a transverse section taken along line 7—7 of Figure 6.

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Referring particularly to Figures 1, 2 and 3 of the drawings, my aftercooler is adapted to be connected between a section 10 of an air line leading from the air compressor, for example, and another section 11 leading to a receiver or accumulator. Both the compressor and receiver may be of any conventional construction and are not illustrated herein. The two sections 10 and 11 of the air line are spaced apart and are customarily disposed in alignment with their axes substantially horizontal. These sections are provided with suitable connections such as the flanges 12 and 13, respectively, to which my aftercooler, indicated in general at 15, is connected. Thus, my aftercooler is adapted to be interposed between two spaced aligned substantially horizontal sections of an air line.

A preferred form of my aftercooler comprises a shell tube 16 having a flange 17 at the inlet end thereof which is connected to the air line section 10, a suitable gasket being interposed between the flanges 12 and 17. The end portion 18 of the shell tube 16 is angularly related to the axis of the main portion of the shell tube so that when the bolts 19 connecting the flanges 12 and 17 are drawn up, the axis of the shell tube 16 will slope downwardly at a slight angle to the horizontal as shown, thus disposing the discharge end 20 and flange 21 of the shell tube adjacent but beneath the flanged end 13 of the section 11. Thus, the intake end of the shell tube is connected directly to the section 10 of the air line while the discharge end of the shell tube is offset slightly beneath the end of the section 11 of the air line with the shell tube extending obliquely with respect to the sections of the air line.

In order to connect the shell tube with section 11 of the line, an elbow 25 is welded into the opening 26 in the upper portion of the wall of the shell tube adjacent the discharge end thereof; the other end of the elbow 25 is provided with a flange 27 which is bolted or otherwise suitably secured to the flange 13 of the air line section 11. It will be understood that gaskets or the like are employed with all flanged joints in order to make leak-proof connections. Thus, air entering the shell tube from section 10 can return to the air line through the elbow 25.

In order to cool the air passing through the shell tube, I preferably employ a longitudinally extending tube 30 extending from the discharge end of the shell tube to a point adjacent the inlet end of the shell tube. The tube 30 is provided with a plurality of longitudinally extending external fins 31 thereon, the fins preferably

extending from a zone near the inlet end of the shell tube and stopping just short of the opening 26; a finned tube of the type described and claimed in my Patent No. 2,261,137, embodying channel section members having their bases welded to the exterior of the tube, is preferred. This arrangement provides an extended heat exchange surface over which the air flows; extended internal surface area is not required inasmuch as water, which is ordinarily employed as a coolant, has a much greater heat transfer coefficient than air.

Adjacent the discharge end of the shell tube, the finned tube 30 is supported by a plate 33; the finned tube is welded into an aperture in the plate, the plate being bolted to the flange 21 of the shell tube as shown and making a leak-proof connection therewith. Thus, the plate closes off the space surrounding the tube 30 within the shell tube 16, and air entering the inlet end of the shell tube can only flow out of the shell tube through the opening 26 into the elbow 25. Additional support for the finned tube may be furnished either by engagement of the fins 31 with the interior of the shell tube, or by appropriate supports (not shown) which may be of any suitable design.

In order to cool the tube 30, and by conduction to cool the fins 31, cold water or other cooling fluid is supplied to the interior of the fin tube 30 by means of the open ended tube 34 which extends from the discharge end of the shell tube to a point adjacent the closed end 35 of the tube 30 as shown in the right-hand portion of Figure 1. Tube 34 is supported adjacent the discharge end of the cooler in an opening 37 in housing 38 which is welded or otherwise suitably joined to plate 33. Coolant is supplied to the interior of tube 34 by supply tube 39. In order to make a leak-proof connection between the housing and the exteriors of the tubes 34 and 39, pipe threads, as shown, or other convenient means may be employed. Tube 39 is provided with a suitable control such as valve 40 for governing the flow of coolant into the interior of the finned tube 30; the coolant discharged from the end of tube 34 flows back within tube 30 out the open end 41 thereof into the housing 38 and is finally discharged through the discharge conduit 42, valve 43 being provided to control the rate of discharge. One or more spacers 44 may be employed to support and center the tube 34 within the tube 30.

In operation, the tube 30 and the fins 31 are cooled by water or other coolant flowing within the tube 30. The air flowing through the cooler in the direction of the arrow in Figure 1 is cooled by contact with the surfaces of the tube and fins, the fins providing an extended heat exchange surface. Cooling is thus accomplished efficiently with a compact apparatus, and by reason of the cooling, moisture is condensed in the air and on the tube and fin walls. This moisture drips downwardly onto the lower inner surface of the shell tube 16 and flows by gravity, with the assistance of the air flow, toward the lower or discharge end of the shell tube. In order to collect the moisture, I preferably provide a sump 45 connected to the lower portion of the shell tube adjacent the discharge end thereof, the sump being provided with a discharge conduit 46 and a valve 47 so that condensation may be periodically discharged therefrom.

It is to be noted that the fins 31 terminate in advance of the discharge opening 26 leading to the elbow 25; thus air flowing trough the shell tube can readily enter the elbow 25. Also, the elbow 25 is connected to the discharge opening 26 at right angles to the flow of air through the shell tube; the air flowing from the shell tube into the elbow 25 must make an abrupt turn, resulting in separation of moisture entrained in the air. Thus, the device acts not only as a compact and efficient air cooler, but also functions to separate the condensed moisture from the air passing through it.

In Figures 4 and 5, modified forms of fin tubes are illustrated which are arranged to increase the rate of heat transfer between the air and the fins and to improve the separation of moisture from the air. In Figure 4 the fins 31*a* extend in a steep spiral along the tube 30, thus increasing the turbulence of flow of air along the tube, and by the rotary motion of the air, throwing the entrained moisture to the inner walls of the shell tube 16.

In Figure 5 a similar result is obtained by employing a finned tube 30*b* wherein the fins 31*b* are cut into sections as indicated at 50, and the ends of the sections are bent or twisted as shown at 51 to increase the turbulence of the flow of air over the tube and to give it a rotary motion as described in conjunction with Figure 4 to cause entrained air to be thrown out to the inner walls of the shell tube 16.

In the modifications shown in Figures 1 to 5 only a single finned tube is employed. If desired, a plurality of finned tubes may be used; such an arrangement is illustrated in Figures 6 and 7 and is useful in installations where a short aftercooler is required. The general arrangement of the aftercooler of Figures 6 and 7 is identical with that previously described and the same reference characters have been applied to corresponding parts. However, in this form of the invention, the shell tube 16*c* is of greater diameter than the pipe sections 10 and 11, and the connection between the flange 12 of section 10 and the flange 17*c* of the shell tube is made by means of a connecting member 55 having flanges 56 and 57 bolted to the flanges 12 and 17*c*, respectively, which member provides for the necessary oblique connection and the change in diameter.

In this modification, the cooling is effected by a plurality of finned tubes 30*c* which are supported adjacent the discharge end of the shell tube by plate 33*c* bolted to the flange 21*c*, the tubes 30*c* preferably being welded to the plate. The finned tubes extend to a point near the inlet end of the shell tube and have their ends closed as indicated at 35*c*. These tubes may be supported within the shell tube in any convenient fashion, for example, by the use of spacer bands 58 wrapped around the fins of the tube; these bands function to prevent intermeshing of the fins of the several tubes, but offer substantially no resistance to the longitudinal flow of air.

Coolant is supplied to the interior of the tubes 30*c* by open ended tubes 34*c* identical in all material respects with the tubes 34 heretofore described. In this form of the invention, however, the tubes 34*c* are welded to a plate 59, which is in turn bolted to a flange 60 welded to a short tubular section 61. The section 61 is welded to the plate 33*c*, and thus the tubular section 61 and plate 59 correspond in function to the housing 38 of the previously described modification. Coolant is supplied to the open ended tubes 34*c* through a supply pipe 62 controlled by a valve

40c, and the coolant running out of the open ends of the finned tubes 30c flows into the short tubular section 61 and is discharged therefrom through the discharge pipe 42.

While the drawing illustrates three finned tubes within the shell tube 16c, it will be obvious that a greater or lesser number may be employed if desired. Also, finned tubes of the character shown in Figures 4 and 5 may be utilized in this modification of the invention.

From the foregoing description of preferred forms of my invention, it will be seen that I have provided a compact and efficient air cooler particularly adapted for use as an after-cooler in compressed air systems. My air cooler can be manufactured and installed at low cost and acts not only to cool the air but also to separate condensed moisture therefrom, thus in many cases eliminating the need for a moisture separator. Because of the offset arrangement of the air cooler, the bayonet tube or tubes can be removed without disturbing any of the compressed air connections and without interrupting the service of the line. Also, the finned tube or tubes can be removed without disturbing the main compressed air connections between the cooler and the sections 10 and 11. Thus, the parts can be cleaned and serviced with a minimum of difficulty. Furthermore, the number of joints for both the air and the cooling liquid are kept at a minimum, and there is substantially no possibility of the cooling liquid leaking into the compressed air stream.

Those skilled in the art will apreciate that various changes and modifications can be made in the invention without departing from the spirit and scope thereof. Accordingly, it is to be understood that my patent is not limited to the preferred forms of the invention described herein or in any manner other than by the scope of the appended claim.

I claim:

In combination with two spaced aligned sections of a substantially horizontal air line, an air cooler and moisture separator comprising a shell tube having the inlet end thereof open and adapted to be connected directly to the end of one section of said line, fitting means for connecting said end to said section with the axis

of said shell tube sloping downwardly from the point of connection with said section whereby the discharge end of said shell tube is disposed adjacent but at a lower level than the end of the other section of said line, a condensate sump connected with the lower portion of the wall of said shell tube adjacent the discharge end thereof, a discharge conduit extending laterally from the upper portion of the wall of said shell tube adjacent the discharge end thereof and adapted to be connected to said other section, a tube having longitudinally extending external fins disposed within and extending longitudinally of said shell tube, said finned tube extending from the discharge end of said shell tube to a point near the inlet end of said shell tube, the end of said finned tube adjacent the inlet end of said shell tube being closed, means detachably connected to said shell tube for closing the space between said finned tube and said shell tube at the discharge end of said shell tube, an open ended tube extending into said finned tube from the discharge end of said shell tube to a point near the closed end of said finned tube, connections for supplying a coolant to said open ended tube, and a housing for receiving coolant discharged from the open end of said finned tube, said open ended tube being removable from said finned tube and said finned tube being removable from said shell tube without disturbing the connections between said shell tube and said sections of said air line.

JOHN W. BROWN, JR.

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