

Nov. 9, 1937.

W. W. PAGET

2,098,671

HEAT EXCHANGE DEVICE

Filed Jan. 5, 1937

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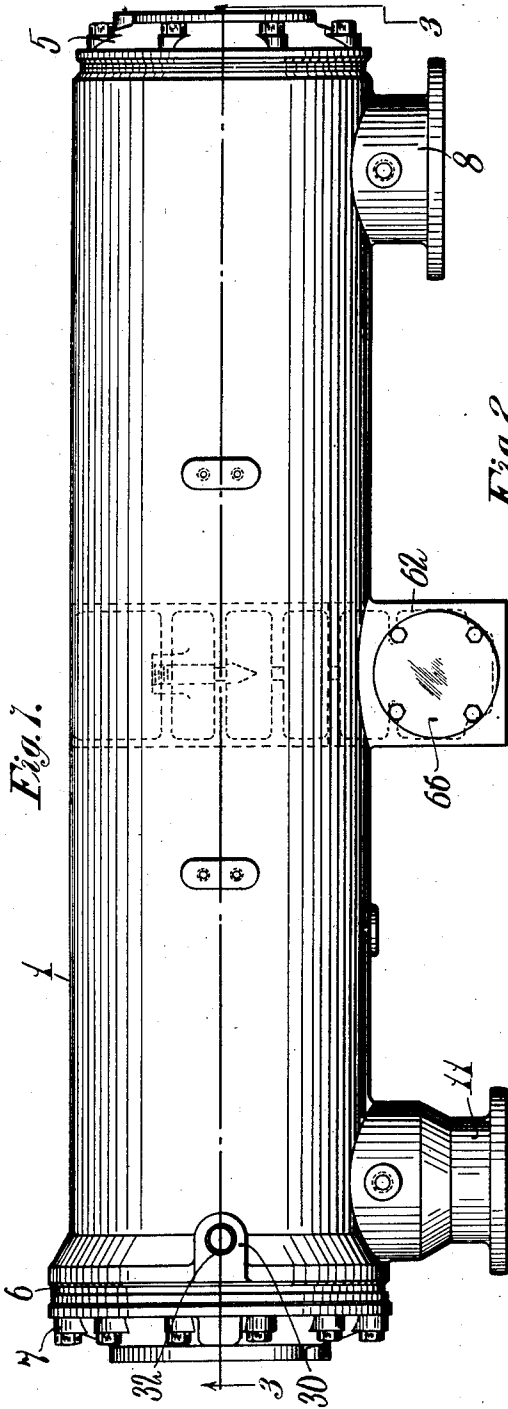
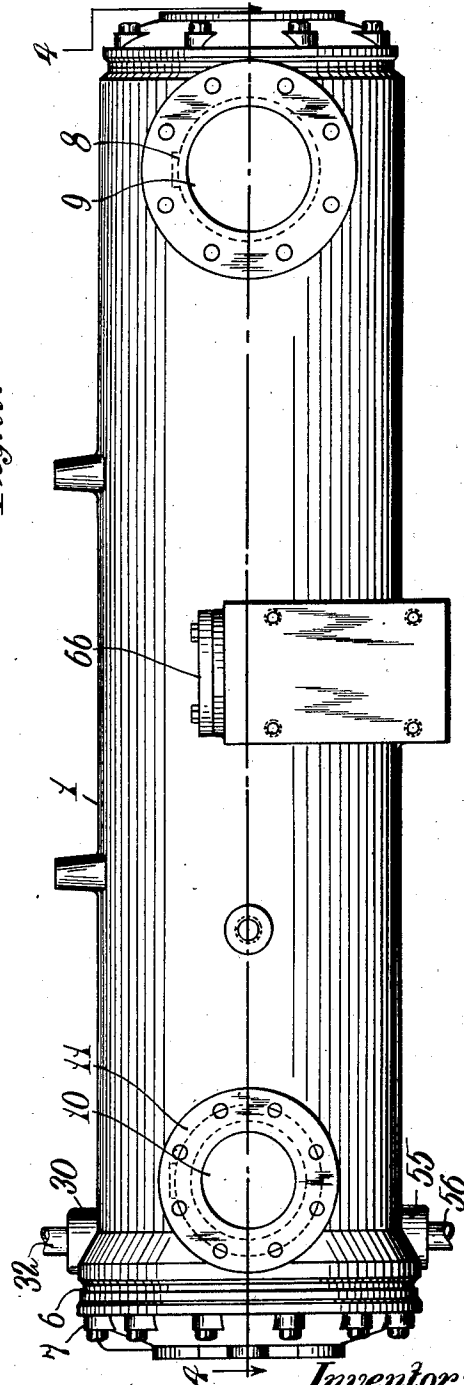


Fig. 2.



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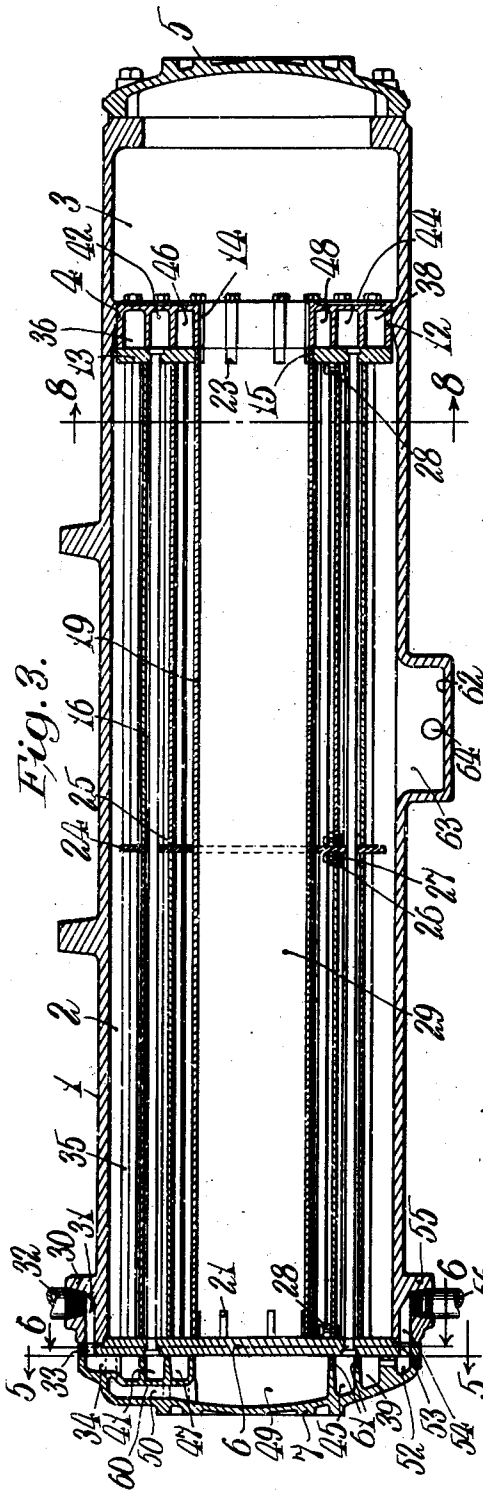
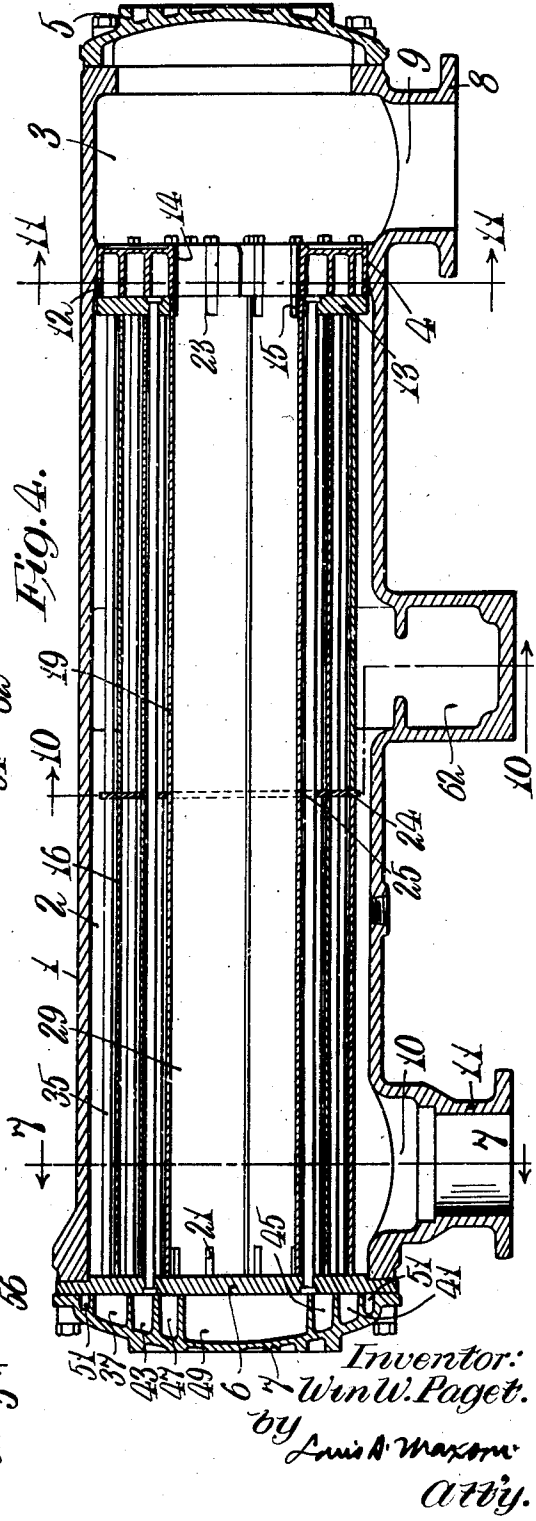
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5 Sheets-Sheet 2



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5 Sheets-Sheet 3

Fig. 5.

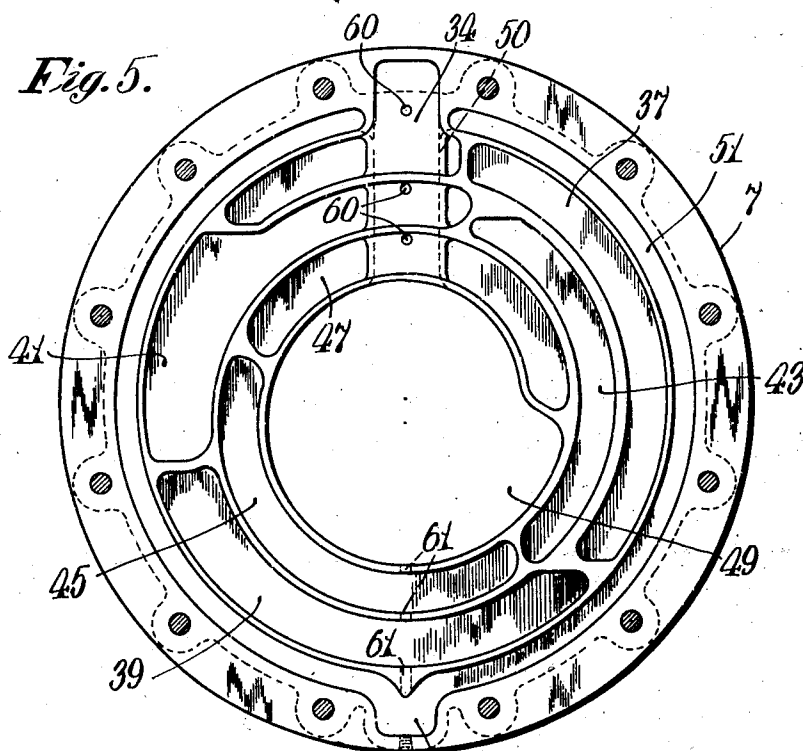
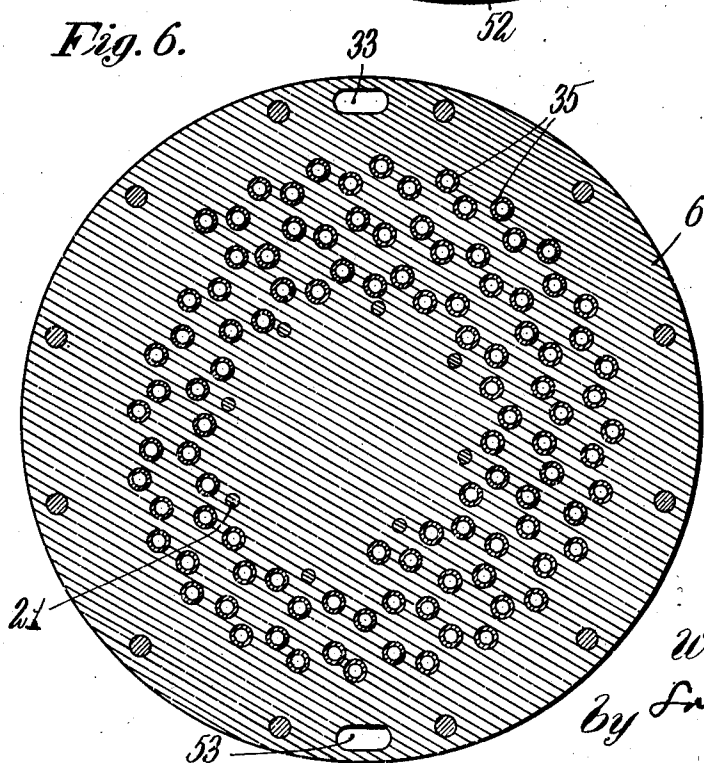


Fig. 6.



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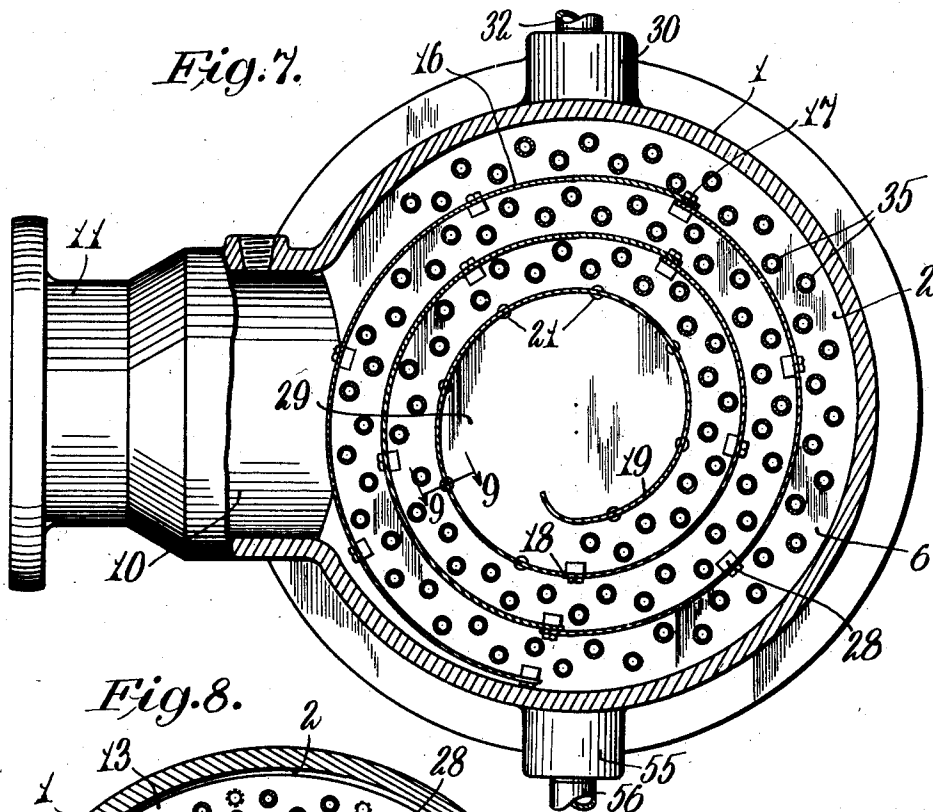
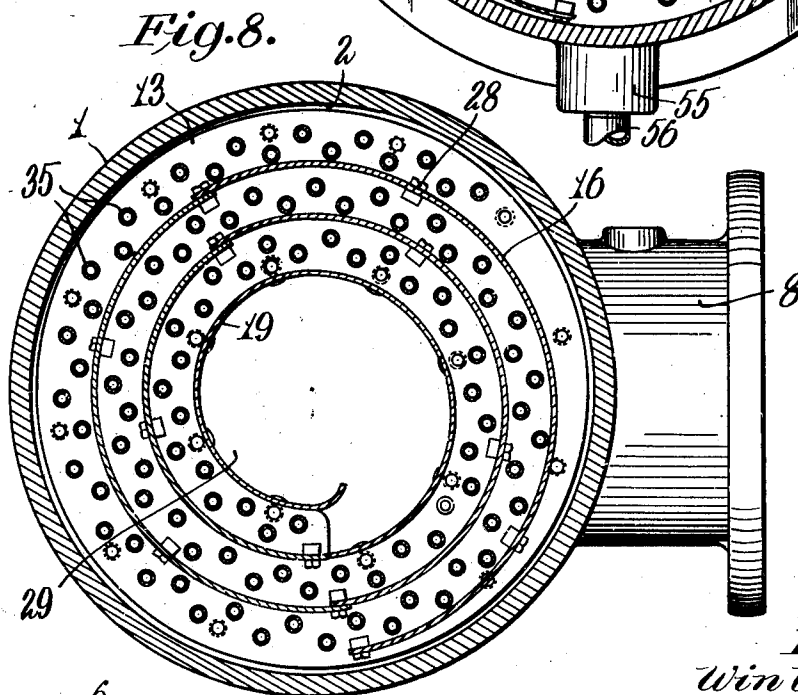
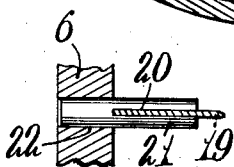
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HEAT EXCHANGE DEVICE

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5 Sheets-Sheet 4



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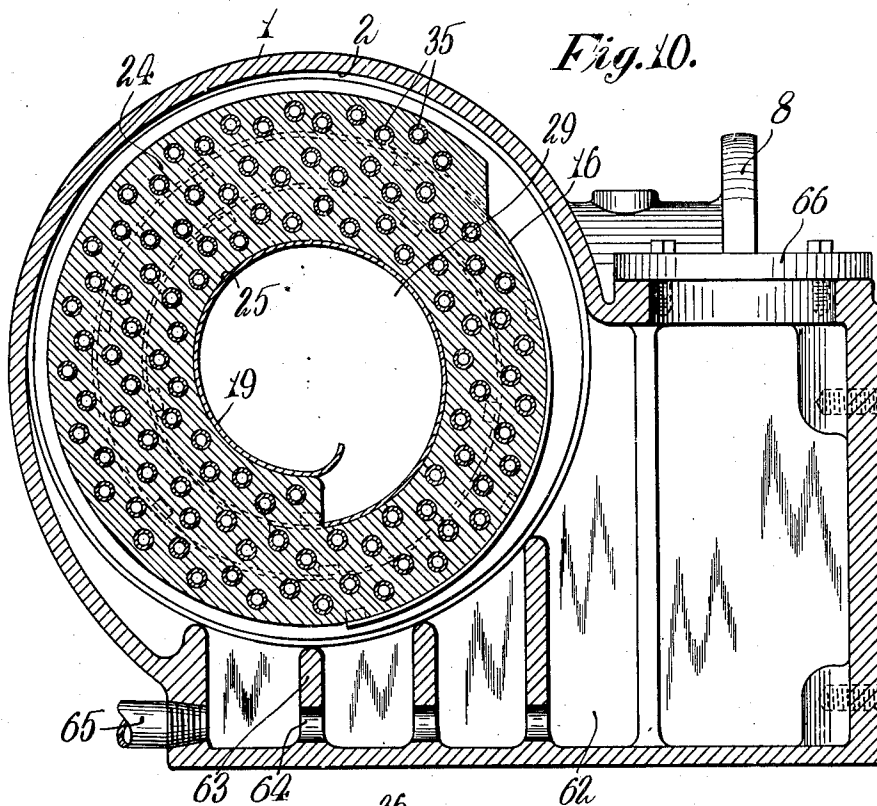
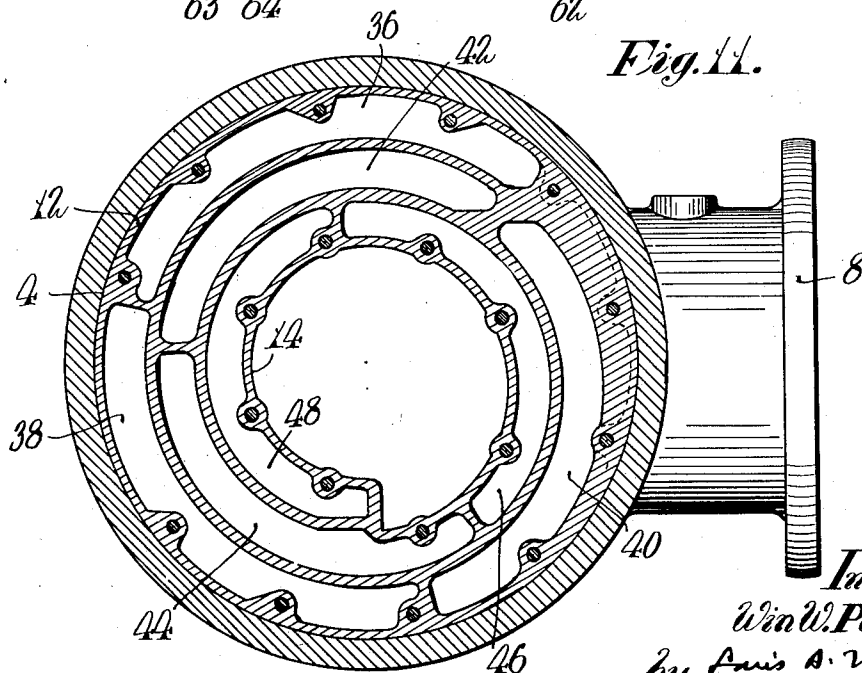
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HEAT EXCHANGE DEVICE

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,098,671

HEAT EXCHANGE DEVICE

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Application January 5, 1937, Serial No. 119,124

10 Claims. (Cl. 257—240)

This invention relates to heat exchange devices, and more particularly to an improved fluid compressor intercooler of the spiral flow type for cooling the compressed fluid.

An object of this invention is to provide an improved heat exchange device. Another object is to provide an improved heat exchanger especially designed to use with fluid compressors for cooling the compressed fluid in an improved manner. A further object is to provide an improved heat exchanger of the spiral flow type whereby the fluid to be cooled is directed in a spiral or volute path and having embodied therein improved cooling means of the so-called zig-zag type for conducting the cooling liquid back and forth across the path of fluid flow in a generally counter-current direction in relation to the fluid flowing through the fluid passage, so that the fluid is cooled in an extremely effective manner.

Yet another object is to provide an improved intercooler for a fluid compressor. A still further object is to provide an improved intercooler of a comparatively simple and compact character adapted, due to its improved design, to be manufactured in an inexpensive manner. Still another object is to provide an improved intercooler having improved means for supporting the flow guide sheet and water tubes and an improved passage arrangement for the cooling liquid and the fluid to be cooled. These and other objects and advantages of the invention will, however, hereinafter more fully appear in the course of the following description.

An intercooler constructed according to the illustrative embodiment of the invention, may comprise an outer horizontal cylindrical casing or shell having formed internally therein by means of a guide sheet a substantially spiral, volute or like passage for the fluid to be cooled, the end heads or so-called tube headers closing the ends of the fluid passage, having formed therein spaces for cooling liquid and corresponding generally to the spiral arrangement of the fluid passage and connected by substantially horizontal cooling tubes extending longitudinally of the shell through the fluid passage, each of said cooling liquid spaces being divided by partitions into compartments so disposed that cooling liquid admitted to an upper compartment of the liquid space in one header will flow successively across through some tubes and back through others in zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the spiral fluid passage. A fluid intake pipe having a lateral aperture may serve to lead the fluid to be cooled centrally to the inner end of the fluid passage through an opening formed in the adjacent tube header, the fluid outlet from the fluid passage being at the opposite end of the fluid passage at the inner

periphery of the shell and connected through a lateral aperture to a fluid discharge pipe. The cooling liquid may be admitted through a top inlet to one compartment of the outer convolution of the water space in the outer header at one end of the shell and, after passing back and forth through the tubes, be discharged through a bottom outlet from the last compartment of the inner convolution. If desired, the fluid flow may be reversed and then, of course, the cooling liquid flow is correspondingly reversed, and also the cooling liquid may be admitted to the bottom compartment of the liquid space in the outer header instead of the top compartment.

In the accompanying drawings there is shown for purposes of illustration one form which the invention may assume in practice.

In these drawings,—

Fig. 1 is a plan view of the illustrative embodiment of the improved intercooler.

Fig. 2 is a side elevational view of the intercooler shown in Fig. 1.

Fig. 3 is a vertical sectional view taken longitudinally through the intercooler on line 3—3 of Fig. 1.

Fig. 4 is a horizontal sectional view taken longitudinally through the intercooler on line 4—4 of Fig. 2.

Fig. 5 is an enlarged end elevational view taken on line 5—5 of Fig. 3, showing the compartments of the cooling liquid space in the outside header.

Fig. 6 is an enlarged cross sectional view taken on line 6—6 of Fig. 3.

Fig. 7 is an enlarged cross sectional view taken on line 7—7 of Fig. 4.

Fig. 8 is an enlarged cross sectional view taken on line 8—8 of Fig. 3.

Fig. 9 is a detail sectional view taken on line 9—9 of Fig. 7, showing one of the supports for the central guide sheet section.

Fig. 10 is an enlarged cross sectional view taken on line 10—10 of Fig. 4.

Fig. 11 is an enlarged cross sectional view taken on line 11—11 of Fig. 4.

In this illustrative embodiment of the invention 1 designates a cylindrical intercooler casing or shell having formed therein a cooling chamber 2 and a fluid receiving chamber 3, these chambers spaced longitudinally within the shell and being separated by an internal shoulder providing a reduced intermediate bore 4. The outer end of the fluid receiving chamber 3 is closed by an end cover 5 bolted to the intercooler shell, while the outer end of the cooling chamber 2 is closed by a rigid tube plate 6 and outside header 7. As shown in Fig. 3, the tube plate 6 is arranged between the adjacent end of the intercooler shell and the outside header, and the plate and header

are secured as by bolts to the intercooler shell. A horizontal intake connection 8 communicates through a lateral aperture 9 with the fluid receiving chamber 3, while the end of the inter-cooler chamber remote from the chamber 3 has a peripheral discharge communicating with a lateral aperture 10 of a horizontal discharge connection 11. Slidably guided within the intermediate reduced bore 4 between the chambers 2 and 3 within the intercooler shell is a floating header 12 secured at its inner side as by bolts to a floating tube plate 13, and said header and tube plate are formed with central openings 14 and 15 respectively, through which the fluid to be cooled flows from the fluid receiving chamber 3 centrally within the central portion of the cooling chamber 2. Arranged within the cooling chamber between the rigid tube plate 6 and the floating tube plate 13 of the floating header, is means for directing the fluid to be cooled, in a spiral or volute path, and this fluid directing means comprises a fabricated guide sheet 16 of spiral or volute form in cross section as viewed in Figs. 7 and 8 and composed of a series of semi-circular outer plates secured together end to end as at 17 in any appropriate manner and connected at 18 to an elongated central spiral guide sheet section 19 extending longitudinally between the inner surfaces of the rigid tube plate 6 and the floating tube plate 13 and secured to the plates. One end of the central spiral guide sheet section 19 is fixed within slots 20 (see Fig. 9) formed in pins 21 mounted within openings 22 formed in the rigid tube plate 6, while the opposite end of the central guide sheet section projects within the opening 15 of the floating tube plate 13 and is slotted at 23 to fit over the bolt bosses on the floating tube plate, so that the central section is firmly held in position. Arranged within the cooling chamber midway between the tube plates is a vertical guide sheet support 24 in the form of a plate to which the adjacent ends of the outer guide sheet sections are secured, this guide sheet support being formed with a central opening 25 shaped to conform with the outer surface of the spiral guide sheet section 19 and through which the latter extends in the manner disclosed. The guide sheet support 24 has projecting from its opposite sides lugs 26 to which the adjacent ends of the outer guide sheet sections are secured as by bolts 27, and the inner sides of the tube plates 6 and 13 have similar projecting lugs 28 to which the opposite ends of the outer guide sheet sections are secured. The guide sheet support is therefore arranged intermediate and supports the outer guide sheet sections, while the central guide sheet sections extend through the central opening in the support throughout the full length of the cooling chamber. It will thus be seen that the cooling chamber is divided into a spiral or volute passage, so that as the fluid to be cooled flows from the receiving chamber 3 centrally through the floating header and tube plate and into the longitudinal open center 29 of the spiral guide sheet, the fluid flowing in a spiral or volute path in a direction transversely relative to the length of the cooling chamber 2.

Now referring to the improved cooling means associated with the spiral flow passage for cooling the fluid, it will be noted that formed at one end of the intercooler shell at the top side of the intercooler is a boss 30 having a passage 31 communicating with a water inlet pipe 32, and this passage 31 is connected through an arcuate slot

33 formed in the rigid tube plate 6 with the top compartment 34 of the water space in the outer header 7. The compartments of the water spaces in the outer header 7 and the floating header 12 are separated by partitions and correspond to the convolution of the spiral flow passage for the fluid to be cooled, and the top compartment 34 is connected by a series of substantially horizontal cooling tubes 35 extending longitudinally through the spiral flow passage 29 and communicating with the upper compartment 36 in the floating header 12. The compartment 36 is in turn connected, through a series of substantially parallel cooling tubes extending longitudinally through the fluid passage, to a compartment 37 formed in the outside header 7. The compartment 37 is connected by a series of parallel cooling tubes extending longitudinally through the fluid passage to a compartment 38 in the floating header 12, and the compartment 38 is in turn connected by similar cooling tubes to a compartment 39 formed in the outside header 7. The compartment 39 is connected by similar parallel cooling tubes extending longitudinally through the fluid passage to a compartment 40 formed in the floating header 12. The compartment 40 is connected by similar parallel cooling tubes to a compartment 41 formed in the outside header 7; and the compartment 41 is connected by similar cooling tubes extending longitudinally through the fluid passage to a compartment 42 formed in the floating header 12. The compartment 42 is connected by similar parallel cooling tubes to a compartment 43 formed in the outside header 7, the compartment 43 in turn being connected to similar cooling tubes extending longitudinally through the fluid passage to a compartment 44 formed in the floating header. The compartment 44 is connected by similar cooling tubes to a compartment 45 formed in the outside header, and the compartment 45 is in turn connected by similar cooling tubes extending longitudinally through the fluid passage to a compartment 46 formed in the floating header. The compartment 46 is connected by similar cooling tubes to a compartment 47 formed in an outside header, the compartment 47 in turn being connected through similar cooling tubes extending longitudinally through the fluid passage to a compartment 48 formed in the floating header. The compartment 48 is connected by similar cooling tubes extending through the fluid passage to a central chamber 49 formed in the outside header 7, this chamber being connected by a vertical passage 50 with arcuate passages 51, 51 communicating at their juncture with a chamber 52 at the bottom of the outside header. The chamber 52 is connected by an arcuate slot 53 in the rigid tube plate 6 with a passage 54 formed in a boss 55 at the bottom of the intercooler shell directly below the inlet boss 30, as shown in Fig. 3. This passage 54 communicates with a water discharge pipe 56. It will thus be seen that the cooling liquid flows through the cooling tubes longitudinally back and forth through the spiral fluid passage in a zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the fluid passage, the coolest fluid in the fluid passage, in this instance, contacting with the coolest portions of the cooling tubes. As shown in Figs. 3 and 5, the cooling liquid compartments 34, 41 and 47 communicate with the vertical passage 50 through horizontal passages 60 to prevent trapping of fluid and resultant air pocketing, and 75

similarly the compartments 48, 39 and 52 are connected by vertical passages 51.

A liquid drain is provided for receiving the condensed liquid in the intercooler chamber, and this drain comprises a sump 62 formed in the lower portion of the intercooler shell and separated by vertical baffles 63 having bottom openings 64, and the liquid or other matter separated from the fluid and received in this drain sump, is discharged through a suitable drain pipe 65. A detachable hand hole cover 66 is provided for obtaining access to the interior of the drain sump. The bottom surfaces of the shell at the bottom of the cooling chamber may be inclined toward the drain sump so that the separated liquid may drain from the cooling chamber into the sump.

The operation of the improved intercooler will be clearly apparent from the description given. Assuming the fluid compressor with which the heat exchanger may be associated to be in operation, compressed fluid entering the horizontal intake connection 8 will flow through the lateral aperture 9 into the fluid receiving chamber within the shell, the fluid flowing from the chamber 3 centrally through the openings in the floating tube plate and header into the open center 29 of the spiral guide sheet and thence the fluid flows through the spiral passage provided by the guide sheet and discharges from the spiral passage at the inner periphery of the intercooler shell and passes out from the intercooler through the lateral opening 10 and the horizontal discharge connection 11. As the fluid flows through the spiral passage provided by the guide sheet, cooling liquid flows through the inlet pipe 32, passages 31, 33 to the upper compartment 34 of the liquid space in the outer header, the cooling liquid flowing from this upper compartment through the cooling tubes extending longitudinally through the spiral fluid passage to the upper compartment 36 of the water space in the floating header, the cooling liquid flowing back and forth longitudinally through the cooling tubes from one compartment to another in a zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the spiral fluid passage, the cooling liquid finally flowing to the bottom chamber 52 of the outer header and discharging through passages 53, 54 and the discharge pipe 56. It will thus be seen that the cooling liquid flows successively across through some tubes and back through others in zig-zag fashion, and the fluid to be cooled flows with a spiral motion through the spiral passage past the cooling tubes, the cooling liquid flowing back and forth across the path of fluid flow in a generally counter-current direction in relation to the fluid flowing through the passage, and the coolest fluid discharging from the cooling chamber at the coolest portions of the cooling tubes. As the fluid flows over the spiral guide sheet through the cooling chamber, any moisture or other matter entrained by the fluid will be separated from the fluid, and the separated fluid or matter will drain from the bottom of the shell into the drain sump 62, from which it is discharged through the drain pipe 65.

As a result of this invention, it will be noted that an improved heat exchanger is provided having improved means for circulating the fluid to be cooled through the cooling chamber, and a novel arrangement of the cooling tubes whereby the fluid is effectively cooled. It will further be noted that heat exchangers constructed as described are comparatively inexpensive and pro-

vide, in a relatively restricted space, a lengthy travel of fluid to be cooled in contact with the cooling tubes through which the cooling liquid makes a considerable number of passes back and forth longitudinally through the fluid passage in a generally counter-current direction in relation to the direction of fluid flow through the passage. It will still further be evident that the improved heat exchanger is comparatively simple and rugged in design, having relatively few component parts, and of substantial efficiency. These and other uses and advantages of the improved heat exchanger will be clearly apparent to those skilled in the art.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a heat exchange device, a casing, an outer header secured to one end of said casing, an end cover for the opposite end of said casing, an inner floating header slidably mounted in said casing, a spiral guide sheet arranged in said casing between said headers and secured at its ends to the latter, said guide sheet providing a spiral flow passage through which the fluid to be cooled flows in a spiral path, and cooling means for the fluid including cooling tubes extending longitudinally through said spiral flow passage and connected to said headers, said headers having liquid spaces with which said tubes communicate,

2. In a heat exchange device, a casing, an outer header secured to one end of said casing, an end cover for the opposite end of said casing, an inner floating header slidably mounted in said casing, a spiral guide sheet arranged in said casing between said headers and secured at its ends to the latter, said guide sheet providing a spiral flow passage through which the fluid to be cooled flows in a spiral path, and cooling means for the fluid including cooling tubes extending longitudinally through said spiral flow passage and connected to said headers, said headers having liquid spaces with which said tubes communicate, said liquid spaces divided into compartments by partitions and the tubes connecting said compartments so that the cooling liquid flows back and forth longitudinally of the flow passage through the tubes in a zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through said spiral flow passage.

3. In a heat exchange device, a casing, an outer header secured to one end of said casing, an end cover for the opposite end of said casing, an inner floating header slidably mounted in said casing, a spiral guide sheet arranged in said casing between said headers and secured at its ends to the latter, said guide sheet providing a spiral flow passage through which the fluid to be cooled flows in a spiral path, and cooling means for the fluid including cooling tubes extending longitudinally through said spiral flow passage and connected to said headers, said headers having liquid spaces with which said tubes communicate, and means for supplying cooling liquid to the top of the liquid space of said outer header and discharging liquid from the bottom of the liquid space of the same header.

4. In a heat exchange device, a casing, an outer

header secured to one end of said casing, an end cover for the opposite end of said casing, an inner floating header slidably mounted in said casing, a spiral guide sheet arranged in said casing
 5 between said headers and secured at its ends to the latter, said guide sheet providing a spiral flow passage through which the fluid to be cooled flows in a spiral path, and cooling means for the fluid including cooling tubes extending longitudi-
 10 nally through said spiral flow passage and connected to said headers, said headers having liquid spaces with which said tubes communicate, said liquid spaces divided into compartments by parti-
 15 tions and the tubes connecting said compartments so that the cooling liquid flows back and forth longitudinally of the fluid passage through the tubes in a zig-zag fashion and in a generally counter-current direction in relation to the fluid
 20 flowing through said fluid passage, and means for supplying cooling liquid to the top compartment of the liquid space of the outer header and discharging the liquid from the bottom compart-
 25 ment of the liquid space of the same header.

5. In an intercooler, a casing, an internal shoulder between the ends of said casing and dividing the casing into a cooling chamber and a fluid receiving chamber, said shoulder having a bore, an outer header closing the outer end of said cooling chamber, an end cover closing the
 30 outer end of said fluid receiving chamber, a rigid tube plate interposed between said outer header and the adjacent end of said casing, a floating header guided in said shoulder bore, a floating tube plate secured to said floating header,
 35 means arranged in said cooling chamber between said headers and secured to the latter for providing a spiral passage through which the fluid to be cooled flows in a spiral path, said headers formed with cooling liquid spaces, and
 40 tubes secured to said tube plates for conducting the cooling liquid back and forth between said headers, said tubes extending longitudinally through said spiral fluid passage, the direction of liquid flow through said tubes being generally
 45 counter-current in relation to the direction of fluid flow through the spiral passage.

6. In a heat exchange device, a horizontal shell, means arranged within said shell providing a substantially spiral passage for the fluid to be cooled,
 50 tube headers constituting the ends of said fluid passage, said headers having formed therein cooling liquid spaces corresponding generally to the convolution of the fluid passage, and substantially horizontal cooling tubes connected with said liq-
 55 uid spaces and extending longitudinally through said fluid passage, said liquid spaces each divided by partitions so disposed that liquid admitted to one of the liquid spaces will flow successively across through some tubes and back through
 60 others in zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the fluid passage.

7. In a heat exchange device, a horizontal shell, means arranged within said shell providing a substantially spiral passage for the fluid to be cooled, tube headers constituting the ends of said fluid passage, said headers having formed therein cooling liquid spaces corresponding generally to the convolution of the fluid passage, substan-
 70 tially horizontal cooling tubes connected with said liquid spaces and extending longitudinally through said fluid passage, said liquid spaces each divided by partitions so disposed that liquid admitted to one of the liquid spaces will flow suc-
 75 cessively across through some tubes and back

through others in zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the fluid passage, and means for supplying cooling liquid to the top of the liquid space in one header and discharging the cooling liquid from the bottom of the liquid space in the same header.

8. In a heat exchange device, a horizontal shell, means arranged within said shell providing a substantially spiral passage for the fluid to be cooled, tube headers constituting the ends of said fluid passage, said headers having formed therein cooling liquid spaces corresponding generally to the convolution of the fluid passage, substantially horizontal cooling tubes connected with said liq-
 15 uid spaces and extending longitudinally through said fluid passage, said liquid spaces each divided by partitions so disposed that liquid admitted to one of the liquid spaces will flow successively across through some tubes and back through oth-
 20 ers in zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the fluid passage, passage means for conducting the fluid to be cooled into the shell at one end of said fluid passage and for discharg-
 25 ing the cooled fluid from the shell at the opposite end of the fluid passage, and means at the same end of the shell as said fluid discharge for conducting cooling liquid to one header and for discharging the liquid from the same header.

9. In a heat exchange device, a horizontal shell, means arranged within said shell providing a substantially spiral passage for the fluid to be cooled, tube headers constituting the ends of said fluid passage, said headers having formed therein cooling liquid spaces corresponding generally to the convolution of the fluid passage, substantially horizontal cooling tubes connected with said liq-
 35 uid spaces and extending longitudinally through the fluid passage, said liquid spaces each divided by partitions so disposed that liquid admitted to one of the liquid spaces will flow successively across through some tubes and back through
 40 others in zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the fluid passage, and means for admitting cooling liquid to and discharging the liquid from the liquid space at one end of the shell.

10. In a heat exchange device, a horizontal shell, means arranged in said shell providing a substantially spiral passage for the fluid to be cooled, tube headers constituting the ends of said fluid passage, said headers having formed therein cooling liquid spaces corresponding generally to the convolution of the fluid passage, and substan-
 55 tially horizontal cooling tubes connected with said liquid spaces and extending longitudinally through the fluid passage, said liquid spaces each divided by partitions so disposed that liquid ad-
 60 mitted to one of the liquid spaces will flow successively across through some tubes and back through others in zig-zag fashion and in a generally counter-current direction in relation to the fluid flowing through the fluid passage, the inner
 65 end of the fluid passage communicating with a central opening in one of the tube headers, said tube header opening having a peripheral wall lying to the inside of the liquid space in the header, the outer end of said fluid passage formed
 70 with a peripheral opening, and the central opening serving as a fluid intake passage and the peripheral opening as a fluid outlet.