

Dec. 8, 1953

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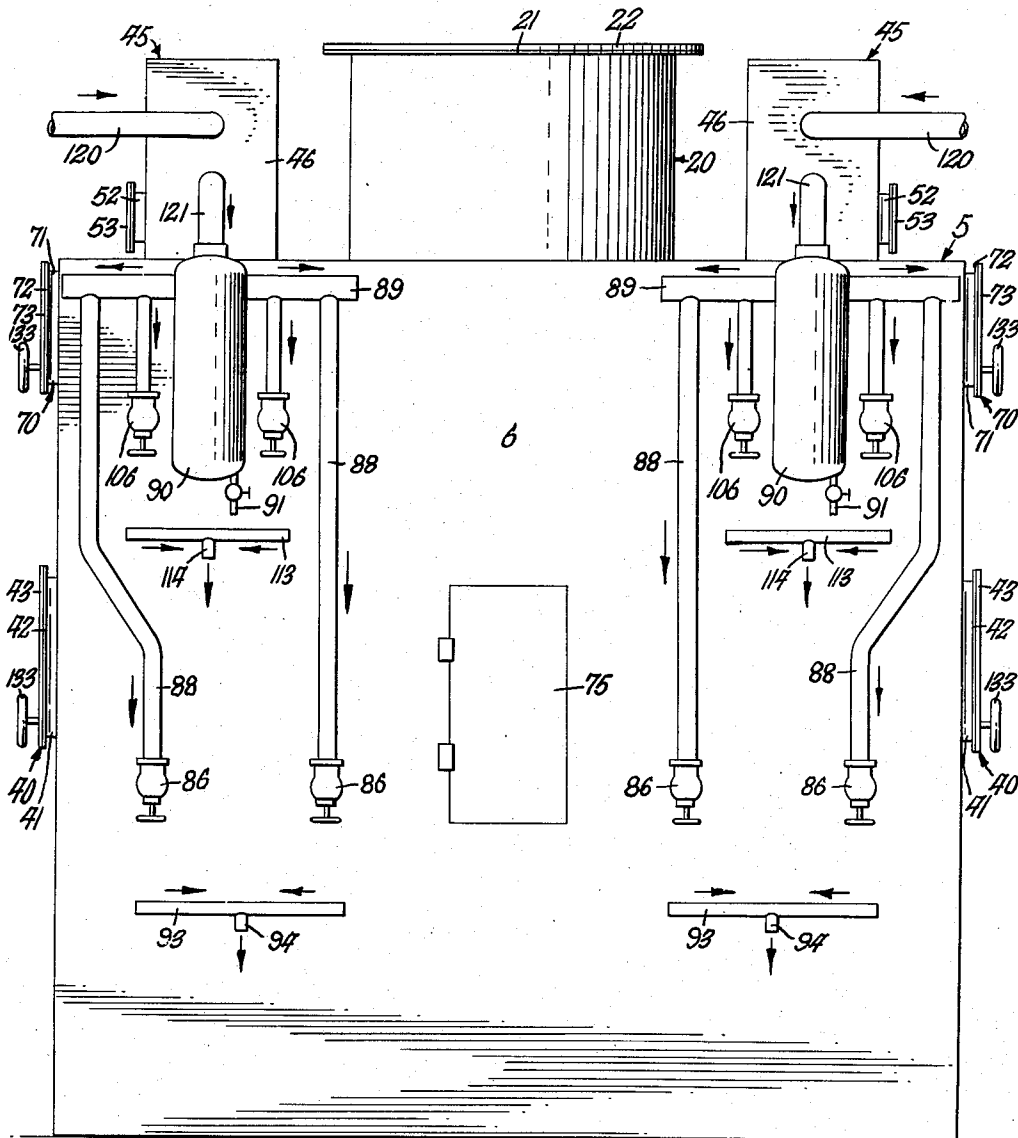
2,661,933

EVAPORATIVE COOLER FOR CONDENSING HOT COMPRESSED GAS

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4 Sheets-Sheet 1

Fig. 1.



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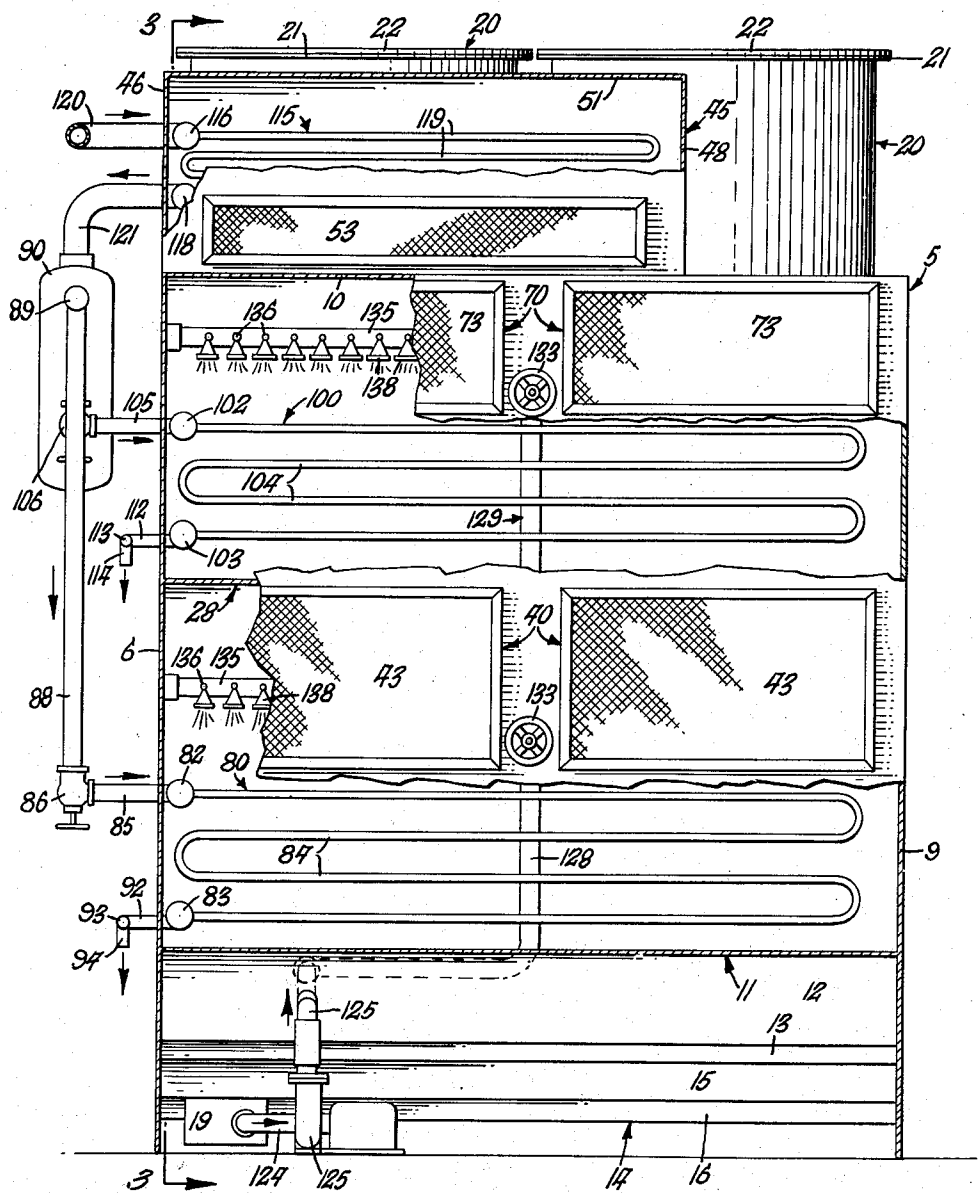
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Fig. 2.



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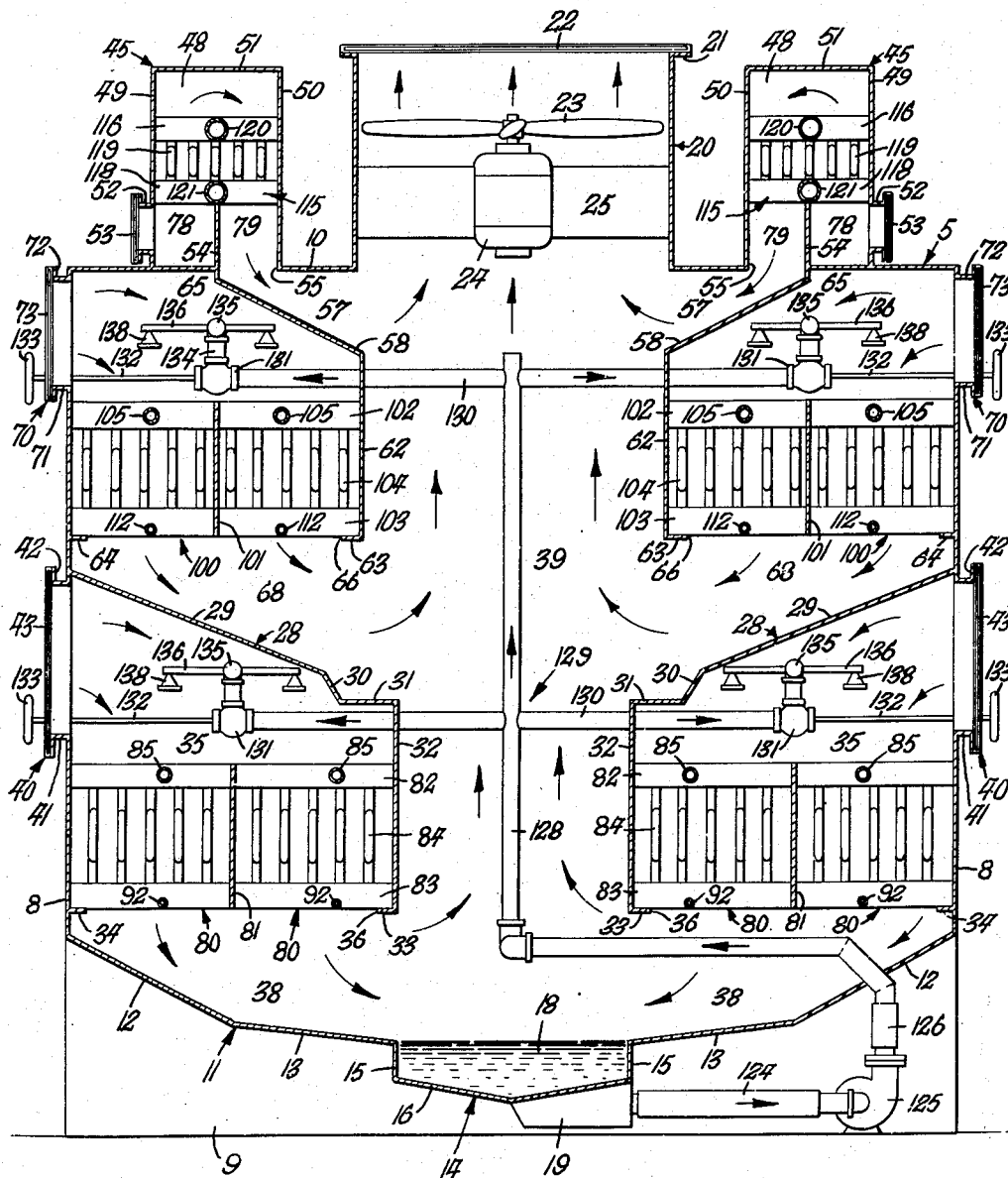
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4 Sheets-Sheet 3

Fig. 3.



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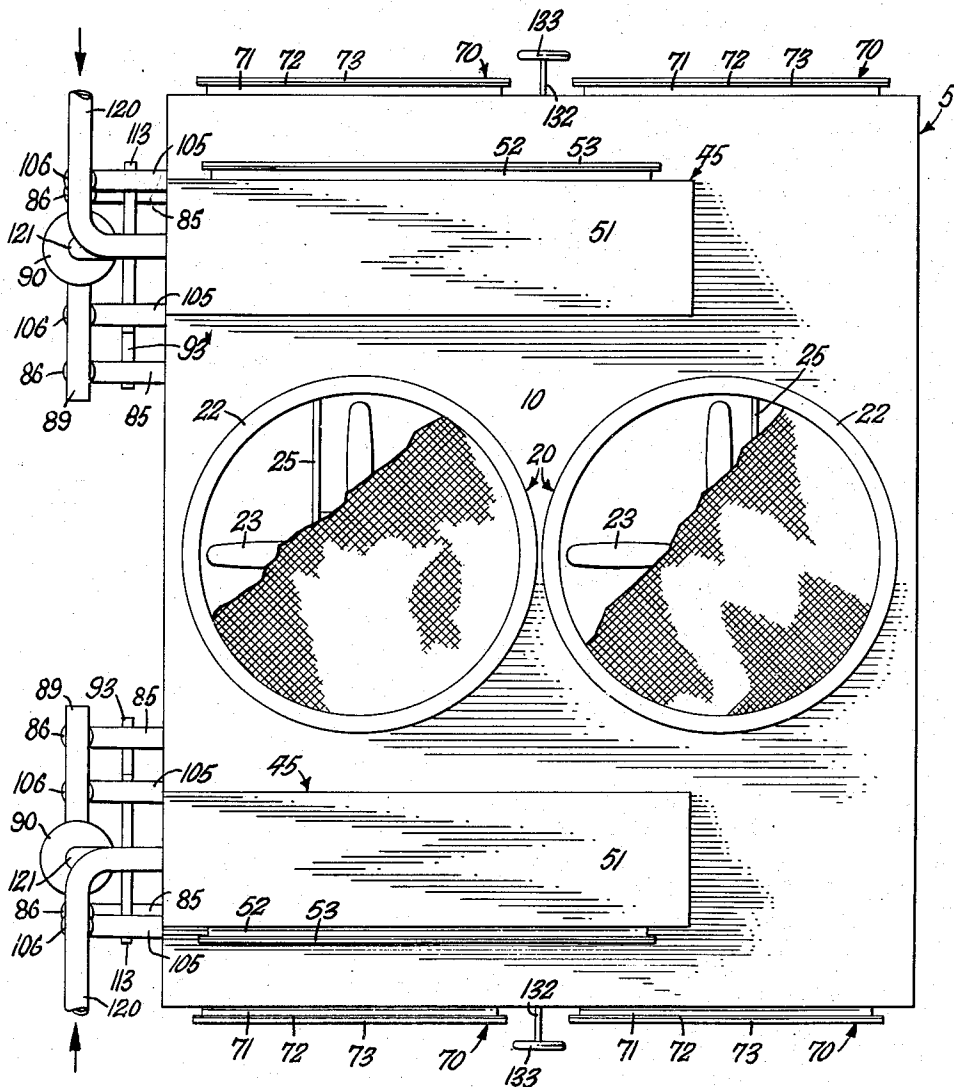
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4 Sheets-Sheet 4

Fig. 4.



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EVAPORATIVE COOLER FOR CONDENSING
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10 Claims. (Cl. 257—37)

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This invention relates to an evaporative cooling tower and is shown as embodied in a condenser for condensing the hot compressed gas of a refrigeration system, although it can be employed wherever it is desired to cool a gas or liquid to a point near the wet bulb temperature of the atmosphere. The cooler is more particularly intended for use where there is a very heavy load, such as to cool and condense the hot compressed gas of, say, a 350 ton refrigeration system.

One of the principal objects of the invention is to provide a cooler for cooling and/or condensing a gas or a liquid, such as compressed superheated refrigerant gas, in which the cooling water is recirculated and the cooling effect achieved principally by evaporation of cooling water on the tubes through which the gas is conducted. By this means an economy is effected in the cost of cooling water and by its use the municipal sewer systems are not overtaxed by the installation of large refrigeration systems for which the present cooler or condenser is particularly designed and which normally require large amounts of cooling water for condensing the hot compressed refrigerant.

Another object of the invention is to provide such an evaporative condenser or cooler which is specifically intended for very heavy loads, such as condensing the compressed refrigerant gas for refrigerating systems producing hundreds of tons of refrigeration.

Another object of the invention is to provide such a large capacity cooler or condenser which is composed principally of relatively small sized identical units, which can be readily produced in a shop and which also can be readily assembled at the location.

Another object of the invention is to provide such a large capacity cooler or condenser which is extremely flexible in capacity, it being possible to cut any desired number of the units into and out of operation thereby to adjust the cooler or condenser to the load being handled.

Another object of the invention is to provide such a cooler or condenser which can be readily repaired without stopping operation, it being possible to cut the defective unit out of operation and repair that unit without interfering with the operation of the other units.

Another object of the invention is to arrange the flows of the air and water so as to obtain maximum evaporative cooling efficiency, thereby to require a minimum amount of heat exchange tube surface and space.

Another object of the invention is to provide

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such a cooler or condenser which can be readily kept in a clean and efficiently operating condition, the sprays and sprayed surfaces being readily accessible from a large central chamber which a man with a ladder can enter.

Another object of the invention is to provide a structure which is compact, considering the very high capacity of the apparatus.

Another object is to provide such a cooler which is suitable for use in cooling fluids having a relatively high entering temperature. Temperatures above 115° F. spray water will evaporate rapidly and deposit a scale upon the tubes conducting such initial high temperature medium to be cooled. In accordance with the present invention the temperature of the medium to be cooled is first reduced to at or below 115° F. by air cooling before being subjected to evaporative cooling so that any deposit upon the sprayed tubes which does occur is so soft as to be immediately washed off the pipes by the sprays.

Another object of the present invention is to provide such a condenser in which the first or air cooling stage merely removes sensible heat from the gas to be condensed to bring it below the point at which a scale would form with evaporative cooling and to remove the balance of the sensible heat and the latent heat in a second stage by evaporative cooling. By this means the preponderance of the heat is efficiently removed by evaporative cooling and a relatively small heat exchange tube surface is required for the first or air cooling stage.

Another object of the invention is to provide, in combination with a condenser, means for removing the maximum amount of oil from the gas being condensed thereby to prevent such oil from building up and caking on the heat transfer surfaces in contact with which the condensed gas is subsequently passed.

A further object is to provide such an oil eliminator in which the oil is conveniently available for reuse.

Another object is to provide such an oil eliminator which does not have any moving parts other than the valves necessary to remove the oil collected therein.

Another aim is to provide such an oil eliminator which is particularly adapted to an evaporative type of condenser in which the cooling effect is obtained principally from the evaporation of water on the cooling surface which is arranged in an air stream passing over the surface. Such an evaporative condenser has many times the cooling capacity of a dry coil of the same size and

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under normal conditions cools the fluid being condensed to a much lower temperature than is possible with a dry coil.

Another object is to provide such an oil eliminator in combination with a condenser which is, without special control, self-balancing under varying load and wet bulb conditions such self-balancing operating to remove the maximum amount of oil from the fluid being condensed under all operating conditions.

Another aim is to provide such an oil eliminator, in combination with a condenser, in which the maximum removal of oil from the gas being condensed under all load and atmospheric conditions can be placed under accurate instrument control.

Another object is to provide such a large capacity condenser which is relatively low in cost, considering its extremely high capacity, both in fabricating the units and also in setting up these units on the job.

Other objects and advantages of the invention will be apparent from the following description and drawings in which:

Fig. 1 is a front elevational view of a large capacity, tower-type evaporative condenser embodying the present invention.

Fig. 2 is a side elevational view thereof, with parts broken away, and viewed from the right hand side of Fig. 1.

Fig. 3 is a vertical transverse section taken generally on line 3—3, Fig. 2.

Fig. 4 is a top plan view with a part of the air outlet screen broken away.

The tower-type of condenser embodying the present invention is substantially symmetrical along a vertical fore-and-aft medial plane and hence a description of the apparatus at one side of the condenser will be deemed to apply to the counterpart apparatus at the opposite side of the condenser, and the same reference numerals have been applied.

The invention is shown as embodied in a large tower-type condenser designed for cooling and condensing the hot compressed gas of compressor-condenser-expander refrigeration apparatus of large capacity, say, 350 tons, as well as removing oil from this gas.

The condenser includes a main sheet metal shell 5 of generally rectangular form having a front wall 6, side walls 8, 8 and a rear wall 9. The main shell is also provided with a top wall 10 connecting the front, rear and side walls. The bottom wall 11 of the shell comprises side drain boards or sheets each composed of an outer sheet 12 each connected with the adjacent side wall 8 and running the full length of the casing to connect the front and rear walls 6 and 9 and inclining downwardly toward the center of the shell, and a sheet 13 of lesser inclination connecting at its upper edge to the lower edge of the sheet 12 and extending the full length of the shell. These drain boards or sheets 12, 13 discharge into a sump indicated generally at 14 having vertical side walls 15 extending the full length of the shell and a trough shaped bottom 16. The end walls of this sump are provided by the front and rear walls 6 and 9 of the main shell and the sump contains a body 18 of water. This sump also has a depressed part 19.

A pair of circular exhaust stacks 20 rise from the top 10 of the main shell, these stacks being in fore-and-aft alinement at the center of the shell, as best shown in Fig. 4. Each of these circular stacks is provided with an annular flange 21 at

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its upper end and to which a circular screen 22 can be secured. Within each of the stacks 20 is mounted a disk or propeller type fan 23 mounted on the shaft of an electric motor 24 although reduction gearing could, of course, be employed. The axis of each propeller and its motor is concentric with the axis of the corresponding stack 20 and the motor casing can be supported in any suitable manner as by radial arms 25 connected at their inner ends to the main shell of the motor 24 and at their outer ends to the wall of the corresponding stack 20. The propeller type of fans 23 are shown as each having four blades, although any number could be used, and are rotated in a direction to draw air from the interior of the main shell up through the circular exhaust ducts 20 and out past the screens 22. These blades can be fixed or can be variable pitch blades.

Approximately midway of the height of the main shell 5 a baffle plate 28 is provided at each side thereof, this baffle plate extending the full length of the shell and connecting with the front and rear walls 6 and 9 thereof. Each of these baffle plates 28 comprises an upper inclined portion 29 the upper longitudinal edge of which connects with the side wall 8 about midway of the height of this side wall. The lower edge of this inclined portion 29 is continued downwardly at a steeper angle to provide a downward extension 30 and from the lower edge of this downward extension 30 the baffle plate is continued horizontally toward the center of the condenser, as indicated at 31. The inner edge of this horizontal part 31 of the baffle plate connects with the upper edge of a vertical wall 32 which extends downwardly from the horizontal part 31 and at its ends connects with the end walls 6, 9 of the main shell, this vertical wall 32 thereby forming a part of the baffle plate 28. The lower edge of each vertical wall 32 is bent to extend horizontally toward the companion side wall 8, thereby to provide a shelf or flange 33 extending the full length of the casing. In horizontal alinement with this shelf or flange 33 a similar shelf or flange 34 is mounted on the side wall 8 of the casing.

The baffle 28, including the vertical wall 32 and side and end walls of the main shell provide a spray chamber, indicated generally at 35, this spray chamber being open at its bottom, as indicated at 36 and this opening 36 at the bottom of the spray chamber being spaced from the bottom wall 11 of the shell so as to provide a horizontal passage 38 leading to a central plenum chamber 39 the lower part of which is defined by the vertical walls 32, 32 of the two spray chambers 35.

Each of these spray chambers 35 is provided with a pair of air inlets indicated generally at 40. These air inlets are arranged in the side walls 8 of the main shell and are arranged to admit air into the upper parts of these spray chambers. Each of these air inlets is in the form of a rectangular neck 41 projecting outwardly from a rectangular opening in the corresponding side wall 8 and provided with an outwardly extending vertical flange 42. This flange 42 of each of the air inlets 40 preferably supports a screen 43 in any suitable manner.

A rectangular roof casing indicated generally at 45 is mounted on the top wall 10 of the main shell 5 on each side of the circular air exhaust ducts 20, these casings 45 extending fore-and-aft but not extending the full length of the main shell 5, as best shown in Figs. 2 and 4. Each of these roof casings 45 is shown as having front and rear walls 46, 48, fore-and-aft side walls 49,

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50 and a top wall 51, the bottom being open and secured to the top wall 10 of the main shell 5. The outer side wall 40 of each roof casing 45 is provided in its bottom with a rectangular air inlet neck 52 and which permits atmospheric air to enter the roof casing 45. This rectangular air inlet preferably extends the greater part of the fore-and-aft length of the roof casing 45, as best illustrated in Fig. 2, and preferably carries a screen 53. In line with this air inlet 52 each roof casing 45 is provided with a central vertical partition 54 which extends the full length of the roof casing 45. The upper edge of this vertical central partition is shown as being approximately in line with the upper edge of the rectangular air inlet 52 and the lower end of this partition extends through a rectangular opening 55 in the top wall 8 of the main shell 5. Each rectangular opening is covered and enclosed by its roof casing 45 and is bounded by the front and rear walls 46 and 48, side wall 50 and vertical central partition 54 of its casing 45. The lower edge of each vertical partition 54 projects into the main shell 5 and connects with a baffle plate 58 which inclines downwardly toward the center of the main shell 5 to provide a passage 57 leading to the plenum chamber 39. This baffle plate connects at its ends with the front and rear walls 6, 9 of the main shell. The lower edge of this baffle plate 58 connects with a vertical wall 62, the ends of this vertical wall also connecting with the end walls 6, 9 of the main shell. It will be seen that each vertical wall 62 forms a continuation of the baffle plate 58. The lower edge of each vertical wall 62 is formed to extend toward the adjacent side wall 8 of the main shell 5 and provide a shelf or flange in horizontal alinement with this shelf or flange 63. A counterpart shelf or flange 64 is provided along each of the side walls 8 of the shell.

The baffle plate 58, vertical wall 62, side, front, rear and top walls of the main shell 5 provide a pair of spray chambers indicated generally at 65, each spray chamber being open at its bottom, as indicated at 66, this opening 66 in the bottom of the spray chamber being spaced from the baffle plate 28 so as to provide a horizontal passage 68 leading to the central plenum chamber 39, the upper part of which is defined by the vertical walls 62, 62 of the two spray chambers 65.

Each of these spray chambers 65 is provided with a pair of air inlets indicated generally at 70. These air inlets are arranged in the side walls 8 of the main shell and are arranged to admit air to the upper part of the spray chambers 65. Each of these air inlets is in the form of a rectangular neck 71 projecting outwardly from an opening in the corresponding side wall 8 and provided with an outwardly extending vertical flange 72. This flange 72 of each of the air inlets 70 preferably supports a screen 73 in any suitable manner.

For access to the plenum chamber 39, an access door 75 is provided in the front wall 6 of the main shell. Through this door a man can enter the plenum chamber 39 and by the use of a ladder has access to the fan motor 24. From this central plenum chamber access is also had to the internal spray piping hereinafter described. Access to the several spray chambers 35 and 65 is had through the several screened inlet openings 40, 70 by removal of the screens 43, 73, respectively.

From the above the course of atmospheric air

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through the apparatus will be readily understood, the air movement being illustrated by the free arrows in Fig. 3. Thus, at each side of the main shell, air is drawn through the lower screened air inlets 40 into the corresponding spray chamber 35 and flows downwardly through this spray chamber into the horizontal passage 38 and thence into the lower end of the plenum chamber 39. Similarly, at each side of the main shell air is drawn through the upper screened air inlets 70 into the upper parts of the corresponding spray chamber 65 and flows downwardly through this spray chamber into the horizontal passage 68 and thence into the central part of the plenum chamber 39. Similarly, at each side of the casing, air enters the screened inlets 52 of the roof casings 45 and thence flows upwardly through the upflow pass 78 provided by the central partition 54 into the top of the casing 45. From the top of the casing 45 this air flows downwardly through the downflow pass 79 provided by the central vertical partition 54 and out through the opening 55 in the top wall 10 of the main shell into the horizontal passage 57 and thence into the upper part of the plenum chamber 39. Air is exhausted from the upper part of the plenum chamber 39 by the fans 23 in the discharge ducts 20.

Arranged in each of the lower spray chambers 35 is a pair of cooling or condensing coils 80, 80 these cooling or condensing coils preferably being separated by a vertical partition 81 extending the full length of the shell and these coils being supported by the shelves or flanges 83 and 84. Each of these coils has an upper horizontal inlet header 82 disposed adjacent the front wall 6 of the main shell and a lower horizontal header 83 also disposed adjacent the front wall 6 of the main shell. Each inlet header 82 is connected to its companion outlet header by a plurality of serpentine tubes 84, these serpentine tubes extending the full length of the spray chamber, as best illustrated in Fig. 2. The inlet header 82 has an inlet neck 85 extending through the front wall 6 of the main shell and connected by a valve 86 and vertical pipe 88 with a horizontal header 89 arranged exteriorly of the main shell. One end of this header 89 is closed and its opposite end connects with the shell of an oil separator 90, the headers 89 forming the outlets for this oil separator. This oil separator is conventional and has the usual internal structure to reduce the velocity and change the directions of the gas passing therethrough, the liquid particles of oil settling to the bottom of the separator from which the oil can be removed through a valved outlet 91.

Each of the coil outlet headers 83 has an outlet neck 92 extending through the front wall 6 of the main shell and connecting with a manifold 93. This manifold 93 connects the outlet necks 92 of the two coils 80 at each side of the apparatus and is provided with a single outlet 94 from which the condensate can be returned to the usual receiver (not shown) of the refrigeration apparatus.

Similarly arranged in each of the upper spray chambers 65 is a pair of cooling or condensing coils 100 preferably separated by a vertical partition 101 extending the full length of the shell and these coils being supported by the shelves or flanges 63 and 64. Each of these coils has an upper horizontal inlet header 102 disposed adjacent the front wall 6 of the main shell and a lower horizontal header 103 also disposed ad-

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jacent the front wall 6 of the main shell. Each inlet header 102 is connected to its companion outlet header by a plurality of serpentine tubes 104, these serpentine tubes extending the full length of the spray chamber 65, as illustrated in Fig. 2. The inlet header 102 has an inlet neck 105 extending through the front wall 6 of the main shell and connected by a valve 106 and vertical pipe 108 with a corresponding horizontal header 89, this header forming one of the outlets of the oil separator 90 as previously described.

Each of the coil outlet headers 103 has an outlet neck 112 extending through the front wall 6 of the main shell and connecting with a manifold 113. This manifold 113 connects the outlet necks 112 of the two coils 100 at each side of the apparatus and is provided with a single outlet 114 from which the condensate can be returned to the refrigeration apparatus.

In each of the roof casings 45 on the roof or top wall of the main shell 5 is arranged a precooling coil indicated generally at 115. Each of these precooling coils comprises an upper horizontal inlet header 116 and a lower horizontal outlet header 118, each of these headers being arranged adjacent the front wall 46 of the casing 45. These headers 116 and 118 are connected by a plurality of serpentine tubes 119 which extend substantially the full length of the casings 45, as best illustrated in Fig. 2. Each inlet header 116 is provided with an inlet pipe 120 and forms one of the inlets for the hot compressed refrigerant gas to be condensed. The outlet header has an outlet pipe 121 which extends through the front wall 46 of its casing 45 and connects with and forms the inlet of the oil separator 90 as best shown in Figs. 1 and 2.

The water for the spray system is withdrawn from the downward extension 19 of the sump 14 by the inlet line 124 of a recirculating pump 125. The outlet line 126 from this pump connects with the central vertical pipe 128 of a spray tree 129 arranged within the main shell 5. This central vertical pipe 128 has four branches 130 each extending transversely of the main shell and through the corresponding vertical wall 32 or 62 into the upper part of the corresponding spray chamber 35 or 65, these branches 130 being disposed above the coils 80 or 100 within these spray chambers. Each branch 130 terminates in a valve 131 having a stem 132 which extends the side wall 8 of the main shell and is provided, exteriorly of the main shell, with an operating wheel 133. The outlet 134 from each valve 131 extends upwardly and connects with a pipe 135 extending substantially the full length of the corresponding spray chamber 35 or 65. Each horizontal pipe 135 has a plurality of lateral branches 136 each carrying a downwardly directed spray nozzle 138.

It will be seen that water is withdrawn from the sump 14 by the pump 125 and passes through the lines 126, vertical pipe 128, branches 130 and valves 131 to the longitudinal pipes 135 from which it is distributed through the branches 136, to the several spray nozzles 138. This water sprays downwardly upon the coils 80 and 100 in the spray chambers 35 and 65, respectively, and wets these coils. It will be noted that both the air and water for these coils is supplied from the top of each spray chamber. The excess water from the spray chambers 65 runs down the baffles 29 and vertical walls 32 to the sump 14. Excess water from the coils 80 runs down the drain boards or plates 12 and 13 to the sump 14.

Operation

In the operation of the condenser and oil separator as above described, the hot compressed gases, having a temperature of, say 210° F., from the refrigeration system is supplied through the two inlet pipes 120, and, as best shown in Fig. 3, enter the inlet headers 116 of the dry precooling coils 115 and pass through the serpentine tubes 119 of these coils to the outlet headers 118 thereof. In these coils the gases have their sensible heat reduced to a temperature of, say, 100° F., and at this reduced temperature the gases pass through the outlet pipes 121 to the oil separators 90. In these oil separators, the gas is subjected to the usual reduction in velocity and change in direction to cause liquid particles of the oil to settle to the bottom of the oil separator.

From the outlet headers 89 of these oil separators a part of the gases passes downwardly through the pipes 88, under control of the valves 86 to the inlet necks 85 of the inlet headers 82 of the group of condenser coils 80. As best shown in Figs. 2 and 3 the gases pass through the serpentine tubes 84 of these groups of coils and in this passage are cooled below the condensation point so as to enter the outlet headers 83 of these coils as a condensate. This condensate passes through the outlet necks 92 of these outlet headers 82 into the manifolds 93 from which the condensate is returned to the refrigeration system through the outlets 94.

The other part of the gases passing through the oil separators 90 and the outlet headers 89 of these separators passes downwardly through the pipes 108, under control of the valves 106, to the inlet necks 105 of the inlet headers 102 of the group of condenser coils 100. As best shown in Figs. 2 and 3 the gases pass through the serpentine tubes 104 of these groups of coils and in this passage are cooled below the condensation point so as to enter the outlet headers 103 of these coils as a condensate. This condensate passes through the outlet necks 112 of these outlet headers into the manifolds 113 from which the condensate is returned to the refrigeration system through the outlets 114.

A supply of spray water is maintained in the sump 14 and this spray water is continuously being withdrawn by the pump 125 which discharges, as best shown in Fig. 3, through the outlet pipe 126 and vertical riser 128 of the spray tree 129. From this vertical riser the water is distributed through the branches 130 to the horizontal pipes 135, the flow of water through each of these branches 130 being under control of the valves 131 which are manipulated from the exterior of the apparatus by the hand wheels 133. From the longitudinal pipes 135 the spray water is distributed through the several branches 136 to the spray nozzles 138 which discharge the water downwardly against the coils 80 and 100.

A part of this water evaporates on these coils so as to reduce the temperature of the gas and condensate flowing through these coils to a temperature close to the wet bulb temperature of the outside air. The excess spray water from the coils 100 flows down the inclined baffle 29 and vertical wall 32 and returns to the sump 14. The excess water sprayed upon the coils 80 flows down the inclined drain boards or plates 12 and 13 and also returns to the sump 14. Accordingly it will be seen that the water is recirculated by the pump 125 and that the nozzles 138 discharge and distribute the stream of recirculated water over each of the cooling coils 80 and 100 to wet the

exterior of each of these cooling coils and to evaporate and absorb heat therefrom, with the excess returning to the sump 14. It will particularly be noted, however, that the coils 115 in the roof casings 45 are not wetted.

Two groups of streams of atmospheric air are drawn into the plenum chamber 39 by the disk fans 24 in the discharge ducts 20 and are discharged from these exhaust ducts.

One group of these air streams enters this plenum chamber 39 through the inlets 52 of the casings 45 on the roof or the top wall 10 of the main shell and thence passes up the upflow passes 78 and down the downflow passes 79 of these roof casings 45 and thence passes through the openings 55 in the roof 10 to the passage 57 formed by the baffle plates 58 and into the plenum chamber 39.

The other group of air streams enter the screened inlets 40 and 70 in the side walls 8 of the main shell and pass downwardly through the spray chambers 35 and 65 and past the coils 80 and 100 in these spray chambers. From these spray chambers 80 and 100, respectively, the air passes through the horizontal passages 38 and 68 into the plenum chamber 39.

The first group of air streams passes the tubes of the dry primary or superheat cooling coils 115 in the roof casings 45 and thereby pre-cools the gas to be condensed. These primary or superheat cooling coils 115 are proportioned to remove the superheat from the gas to be condensed and to cool it to a temperature slightly above its condensing temperature. The gas to be condensed therefore leaves the outlet headers 118 of these primary dry superheat coils 115 in the form of a gas and at a temperature slightly above its condensing temperature.

At this temperature it has been found that the maximum amount of oil can be separated from the gas to be condensed. In cooling the gas to be condensed to this temperature slightly above its condensing temperature the oil vapor in the gas is condensed so as to be in liquid form. At the same time the gas to be condensed is still in the form of a gas so that the separation is of a liquid from a gas and not of a liquid from a liquid as would be the case if the temperature of the gas to be condensed were permitted to fall below its condensing temperature.

Accordingly in passing through the oil separators 90 from the outlet headers 118 of the dry superheat coils 115 the oil in the form of a liquid is readily separated from the gas which is still in the form of a gas. These oil separators are of the usual type in which the velocity of the gas is greatly reduced and the direction of its flow changed whereby the entrained oil falls by gravity to the bottom of the separators from which it can be removed at intervals through the valved drains 91.

The gas leaving the oil separators 90, as above described, passes through the coils 80 and 100. These coils are sprayed with water withdrawn from the sump 14 at the bottom of the main shell 5 and discharged through the nozzles 138 against the tubes 84 and 104 of these coils 80 and 100, respectively, as above described. The cooling of the fluid passing through these wetted condensing coils 80 and 100 is thereby effected essentially by the evaporation of the water sprayed on these coils. At the same time the fluid being treated has been cooled to such an extent on passing through the dry primary superheat cooling coils 115 that there is no tendency for scale to form

on the condensing coils 80 and 100 from the water sprayed thereon. By employing evaporative cooling with the secondary coils 80, 100, these coils have many times the cooling capacity of a dry surface cooling coil of the same size. Further, since an evaporative cooling coil operates in response to the wet bulb temperature of the outside air and since under normal conditions the wet bulb temperature of the outside air is substantially lower than its dry bulb temperature, the condensate leaves at a very much lower temperature than if the coils were not wetted. This condensate leaves the outlet headers 83, 103 of the coils 80, 100 respectively, and flows through the outlets 92, 112 to the manifolds 93, 113 and is returned through the outlets 94, 114 to the usual receiver (not shown) of the refrigeration system.

An important feature of the invention resides in the fact that the apparatus as above described is self-balancing in response to variations in load and in response to variations in atmospheric conditions influencing the operation of the condenser. Under normal conditions the outside dry bulb temperature rises and falls with the outside wet bulb temperature. With a light load upon the condenser, or a low wet bulb temperature of the outside air drawn into the air inlets 40 and 70, greater cooling is effected by the sprayed condenser coils 80 and 100 and consequently the head pressure drops. The condensing temperature rises and falls with the head pressure and hence under light load or low wet bulb conditions the condensing temperature of the gas being condensed drops. At the same time with such a light load or low dry bulb temperature of the outside air the primary dry superheat cooling coils 115 cool the gas to be condensed to a lower temperature. Hence, with light load or low outside wet and dry bulb conditions, while the head pressure and condensing temperature of the gas is lowered, the primary dry superheat coils 115 effect a greater amount of cooling and hence bring the gas to its lowered condensing temperature. Conversely, with heavy load or high outside wet bulb conditions, a higher head pressure and higher condensing temperature is maintained by the sprayed condensing coils 80 and 100 and at the same time, because of the higher entering temperature of the gas or the higher dry bulb temperature of the outside air, the primary cooling coils 115 are less effective and the gas leaves these coils at a higher temperature. The apparatus is self-balancing, therefore, in that under varying load or outside temperature conditions the sprayed coils 80 and 100 adjust the head pressure and corresponding temperature to accord with the increased or decreased cooling effect of the dry primary coils 115. Hence these dry primary superheat cooling coils 115 can be designed to bring the gas close to but not below the condensing temperature under all normal conditions of operation.

An important feature of the invention resides in supplying both the air and sprayed water from the upper parts of the spray chambers 35 and 65 downwardly upon the coils 80 and 100 therein so as to provide a downflow of both air and water over these coils. Thus it is important that the spray nozzles 138 spray from above the coils so as to keep all parts of these coils wetted. By also having a downflow of air the air movement aids the movement of the films of water on the tubes of the coils by pushing the water along and in doing so reduces the thickness of each film to a

minimum. By so reducing the thickness of the films of water on the tubes to a minimum heat transfer from the outer surface of the film, which is subject to evaporation, to the tube surface, is improved and holding the water thickness to a minimum also prevents such build up of the water as would impede the air. Further by such downward flow of air, the air meets the evaporative coil surface at a minimum wet bulb temperature, thereby utilizing the highest possible moisture absorbing properties of the air. If the air moved upwardly, the air would first be contacted by the water falling from the coils which would increase the wet bulb temperature of the air before the air reached the evaporative coil surface.

From the foregoing it will be seen that the present invention provides a large capacity evaporative condenser or cooler which is composed of units which can be readily fabricated at a factory and also readily assembled in the field; which is fully accessible for repair, inspection or cleaning; which can be used in any number of sections to adjust it to less than capacity demands and to permit of repair of certain sections without shutting down the apparatus completely; which is free from scaling and also in which the oil is advantageously separated from the gas when the apparatus is used as a condenser; and which operates efficiently and without service difficulties.

I claim:

1. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other, a generally vertical wall enclosing the inner upper part of each of said spray chambers and having a space thereunder providing an air outlet from the lower inner part of each spray chamber to a central plenum chamber bounded by said generally vertical walls, a plurality of air inlets in each of said side walls and each leading to the upper part of a corresponding spray chamber, a pair of cooling coils in each of said spray chambers between its air inlet and its air outlet and through which the fluid to be cooled is adapted to pass and over which the air from the corresponding air inlet flows downwardly and out through the corresponding air outlet, the cooling coils of each pair being arranged side by side to extend generally parallel with the adjacent side wall of said shell, a vertical partition between each pair of said coils and extending parallel with the adjacent side wall of said shell, means arranged in the upper part of each spray chamber above the cooling coils therein to discharge and distribute a stream of water over the cooling coils therein to wet the exterior of said cooling coils and to evaporate and absorb heat therefrom, a sump in the bottom wall of said shell, a pump recirculating water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, and an exhaust fan in said exhaust duct.

2. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and

each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a precooling coil, means arranged to pass a stream of air over said precooling coil, and means conducting the fluid to be cooled in series first through said precooling coil and then through said wetted coils.

3. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a precooling coil, means arranged to pass a stream of air induced by said exhaust fan over said precooling coil, and means conducting the fluid to be cooled in series first through said precooling coil and then through said wetted coils.

4. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a precooling coil at each side of said casing, means arranged to pass a stream of air over each

of said precooling coils, and means conducting the fluid to be cooled in two streams each stream of said fluid passing in series first through one of said precooling coils and then through the wetted coils on the corresponding side of said shell.

5. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, internal baffles at each side of said shell and extending horizontally lengthwise of said shell and connected to said shell to provide with said side walls a pair of spray chambers arranged one above the other, each of said baffles being formed to extend downwardly toward the center of the shell and to provide an air outlet opening from the lower part of each spray chamber to a plenum chamber bounded by said baffles and said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to the upper part of a corresponding spray chamber, a cooling coil in each of said spray chambers between its air inlet and outlet and through which the fluid to be cooled is adapted to pass and over which the air from the corresponding air inlet flows downwardly and out through the corresponding air outlet, means arranged in the upper part of each spray chamber above the cooling coil therein to discharge and distribute a stream of water over the cooling coil therein to wet the exterior of said cooling coils and to evaporate and absorb heat therefrom, a sump in the bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a precooling coil, means arranged to pass a stream of air over said precooling coil, and means conducting the fluid to be cooled in series first through said precooling coils and then through said wetted coils.

6. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a casing mounted on the exterior of said shell, an opening in said shell and providing communication between the interior of said casing and said plenum chamber, an air inlet for said casing whereby said exhaust fan induces the flow of a stream of air through said casing, a precooling coil in said casing, and means conducting the fluid to be cooled in series first through said precooling coil and then through said wetted coils.

7. A cooler of the character described, comprising

prising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a casing mounted on the exterior of said shell, a central partition across said casing and extending generally perpendicular to the adjacent wall of said shell a distance short of the opposite end of said casing to provide two passes therein, an opening in said shell and providing communication between the adjacent end of one of said passes and said plenum chamber, an air inlet for said casing leading to the end adjacent said shell of the other pass, a precooling coil in said casing, and means conducting the fluid to be cooled in series first through said precooling coil and then through said wetted coils.

8. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said top wall leading from said plenum chamber, an exhaust fan in said exhaust duct, a casing mounted on the roof of said shell at each side of said exhaust duct, an opening in said shell and providing communication between the interior of each casing and said plenum chamber, an air inlet for each casing whereby said exhaust fan induces the flow of streams of air through said casings, a precooling coil in each of said casings, and means conducting the fluid to be cooled in two streams each stream of said fluid passing in series first through one of said precooling coils and then through the wetted coils on the corresponding side of said shell.

9. A cooler of the character described, comprising

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ing a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a precooling coil, means arranged to pass a stream of air over said precooling coil, means conducting the fluid to be cooled in series first through said precooling coil and then through said wetted coils, and an oil separator in said fluid conducting means between said precooling coil and said wetted coils.

10. A cooler of the character described, comprising a shell having top, bottom, front, rear and side walls, an internal baffle at each side of said shell and extending horizontally lengthwise of said shell and forming with the corresponding side wall a pair of spray chambers arranged one above the other and said baffles forming with one another a central plenum

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chamber bounded by said top, bottom, front and rear walls, a plurality of air inlets in each of said side walls and each leading to a corresponding spray chamber, the side of each of said spray chambers opposite its said air inlet being open to said plenum chamber, a cooling coil in each of said spray chambers and through which the fluid to be cooled is adapted to be passed, means arranged to discharge and distribute a stream of water over each of said cooling coils to wet the exterior of each of said cooling coils and to evaporate and absorb heat therefrom, a sump in said bottom wall of said shell, a pump recirculating said water from said sump to said discharging and distributing means, an exhaust duct in said shell leading from said plenum chamber, an exhaust fan in said exhaust duct, a precooling coil at each side of said casing, means arranged to pass a stream of air over each of said precooling coils, means conducting the fluid to be cooled in two streams each stream of said fluid passing in series first through one of said precooling coils and then through the wetted coils on the corresponding side of said shell, and a pair of oil separators in said fluid conducting means and each arranged between one of said precooling coils and the wetted coils on the corresponding side of said shell.

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