

April 1, 1969

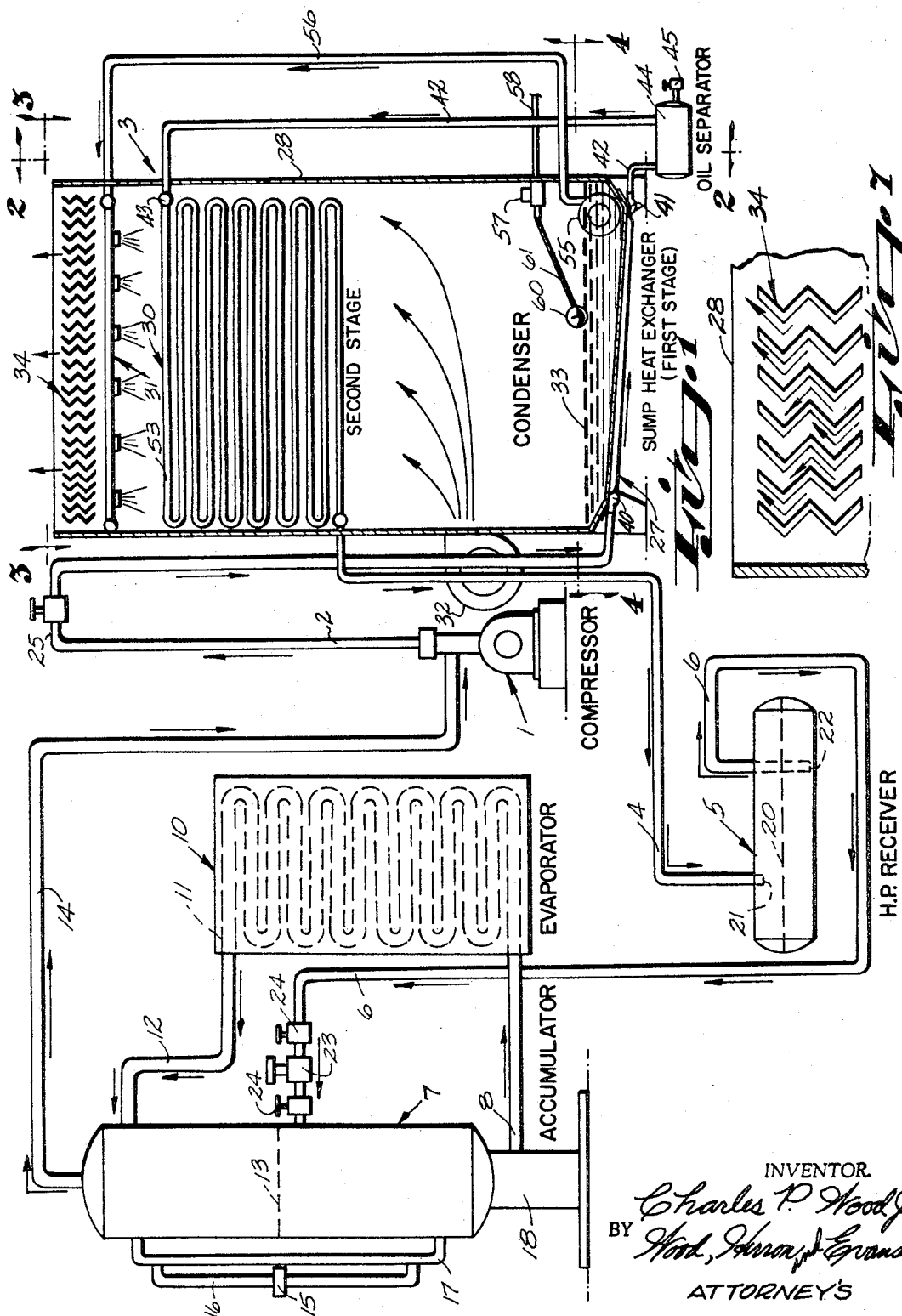
C. P. WOOD, JR

3,435,631

TWO-STAGE EVAPORATIVE CONDENSER

Filed Aug. 17, 1967

Sheet 1 of 4



April 1, 1969

C. P. WOOD, JR

3,435,631

TWO-STAGE EVAPORATIVE CONDENSER

Filed Aug. 17, 1967

Sheet 2 of 4

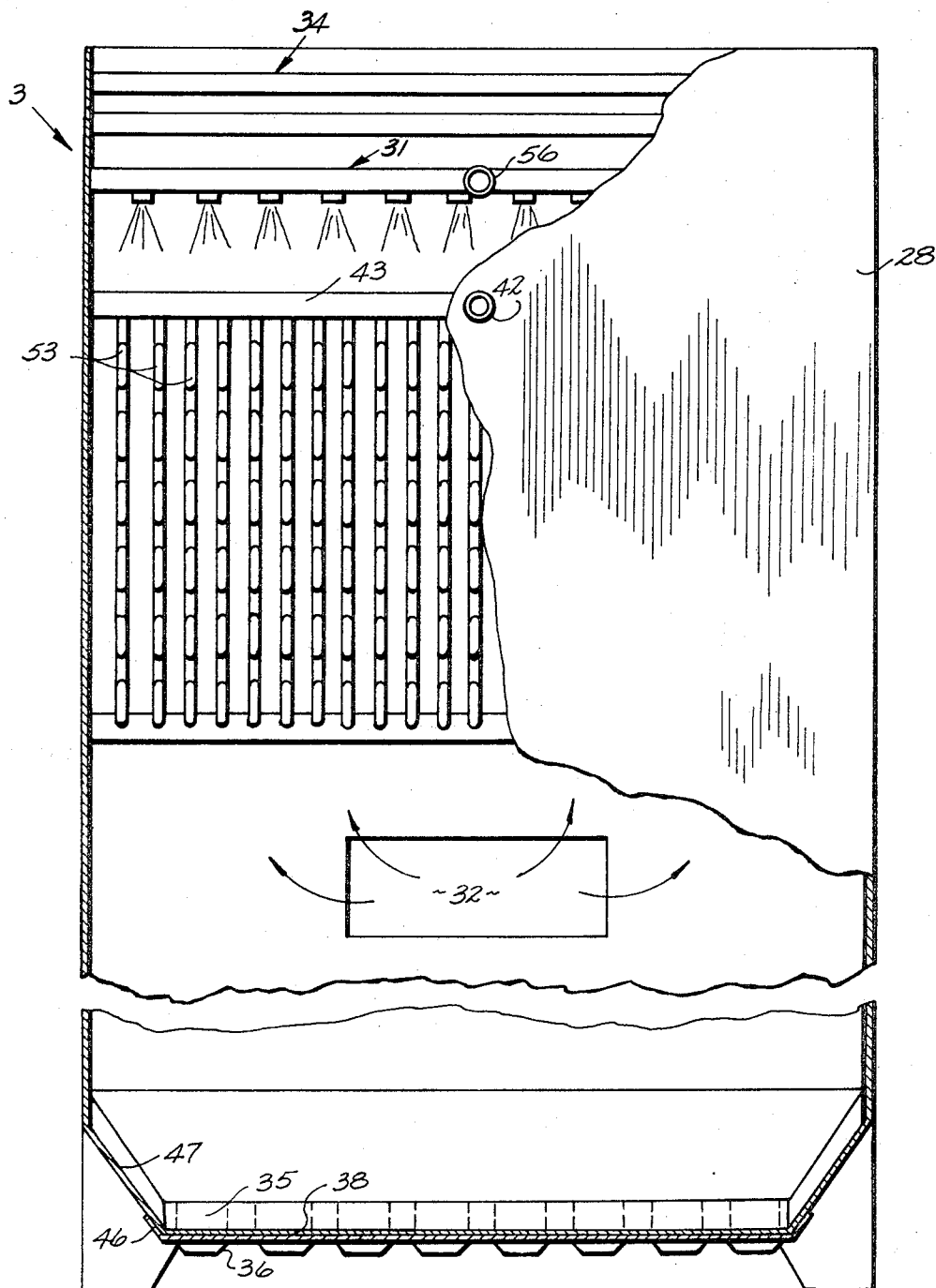


Fig. 2

INVENTOR.
Charles P. Hood Jr.
BY Hood, Hursey and Quano
ATTORNEY'S

April 1, 1969

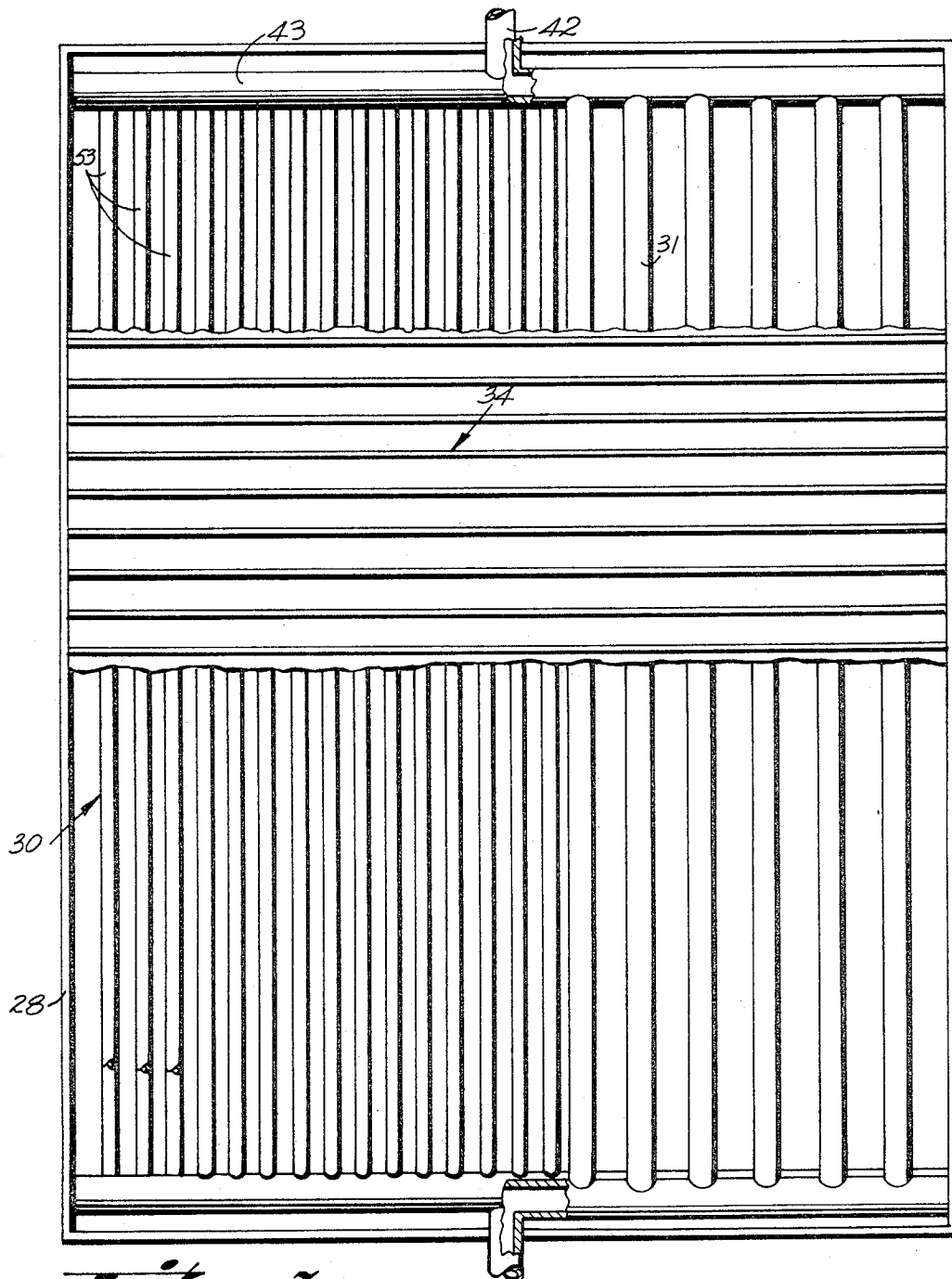
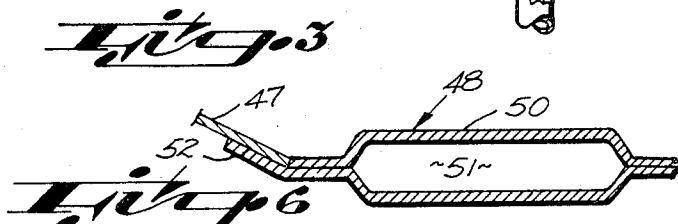
C. P. WOOD, JR

3,435,631

TWO-STAGE EVAPORATIVE CONDENSER

Filed Aug. 17, 1967

Sheet 3 of 4



INVENTOR
Charles P. Wood Jr.
BY *Wood, Harrison and Evans*
ATTORNEY'S

April 1, 1969

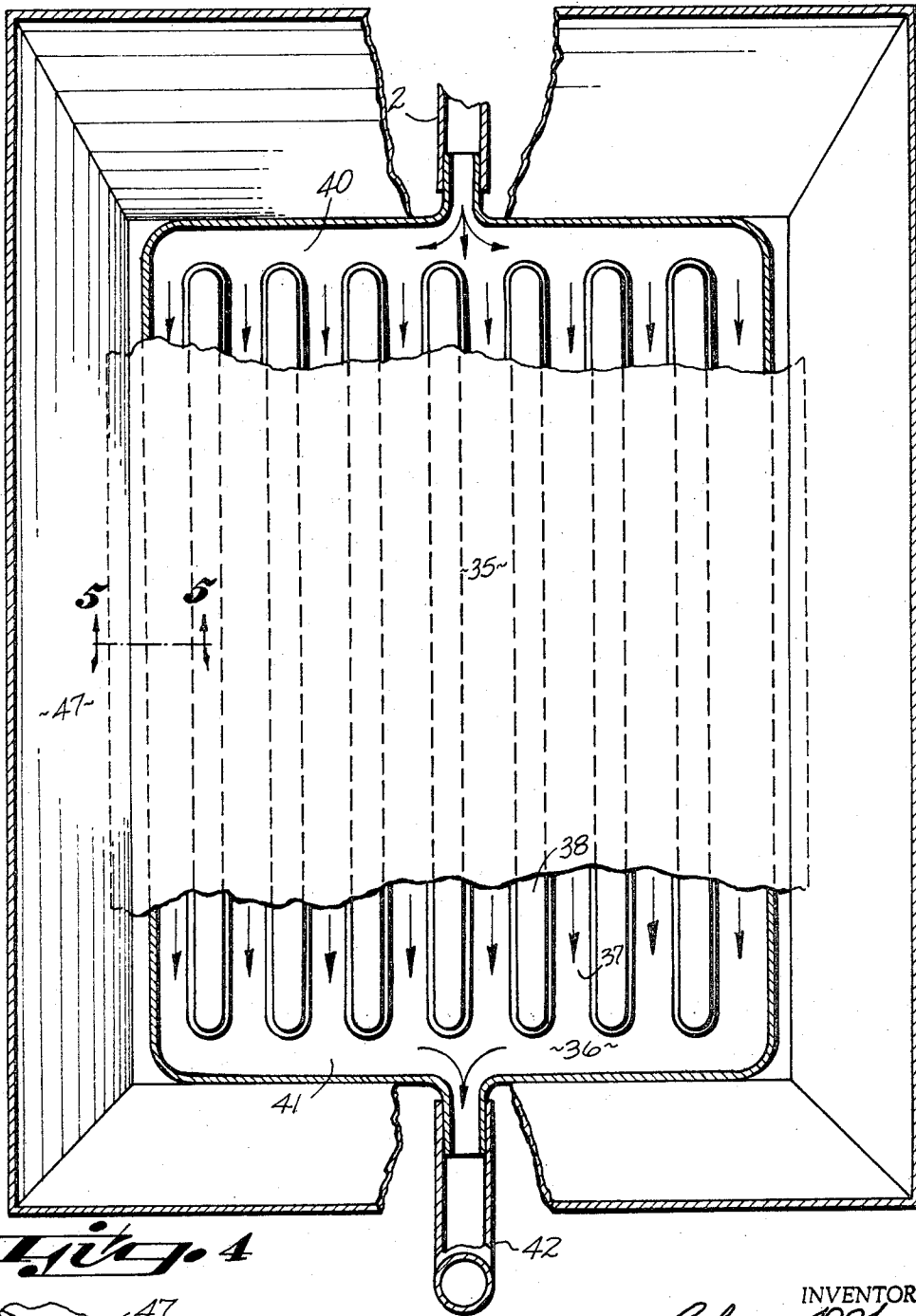
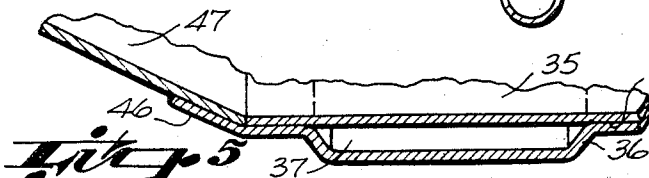
C. P. WOOD, JR

3,435,631

TWO-STAGE EVAPORATIVE CONDENSER

Filed Aug. 17, 1967

Sheet 4 of 4



INVENTOR

Charles P. Wood, Jr.

BY

Wood, Howard & Evans

ATTORNEYS

1

3,435,631

TWO-STAGE EVAPORATIVE CONDENSER

Charles P. Wood, Jr., Cincinnati, Ohio, assignor to Midwest Research & Development Corporation, Cincinnati, Ohio, a corporation of Ohio

Filed Aug. 17, 1967, Ser. No. 661,255

Int. Cl. F28d 5/00; F25b 43/02

U.S. Cl. 62—305

9 Claims

ABSTRACT OF THE DISCLOSURE

The application discloses a self-contained water-air condenser which operates in two stages in cooling and condensing superheated gas, such as ammonia, as the gas issues from a power-driven compressor. In general, the condenser comprises a housing, the lower portion of which includes a water sump heat exchanger (first stage) through which the superheated gas advances from the compressor to be desuperheated or partially cooled. From the sump, the partially cooled gas passes upwardly to a tube-type condenser section (second stage) mounted within the housing above the sump. The housing includes a spray head system above the condenser section which receives water from the reservoir contained in the sump or passage downwardly through the condenser section to aid in reducing the desuperheated gas to a liquid state for recirculation back to the refrigeration system. The cooling action of the second stage condenser section is promoted by passing an air blast stream upwardly to cause partial evaporation and cooling of the water droplets falling by gravity through the tubes of the second stage condenser section.

BACKGROUND OF THE INVENTION

The two-stage evaporative condenser of the invention is particularly intended for installation in a location out-of-doors, for example, on the roof of a building which includes refrigerated or air-conditioned areas. As applied to a refrigeration system, disclosed as a selected embodiment of the invention, the refrigeration system is generally conventional, including the compressor which advances the compressed gas to the two-stage evaporative condenser of the invention where the gas is liquified. From the condenser, the liquid refrigerant is conducted to a receiver, consisting of a tank in which the liquid refrigerant is stored. In addition, the system also includes an accumulator which maintains the liquid refrigerant at a controlled level for passage through an evaporator or evaporators. After passing through the evaporator, a small portion of the unevaporated liquid refrigerant is returned to the upper portion of the accumulator for storage while the evaporated refrigerant gas is recirculated back to the compressor.

Condensers or heat exchangers of the type disclosed have been known in the past. However, the prior structures, while utilizing the principle of locating the condenser out-of-doors and of utilizing tubular condenser sections cooled by a combination of water spray streams and air blast streams have been relatively expensive and complex in structure.

SUMMARY OF THE INVENTION

It is common practice, in climates where winter temperatures fall below freezing, to install an indoor sump for the water reservoir, thereby to prevent freezing which could occur in the use of an outdoor sump of conventional design. However, with the condenser section mounted, for example, on the roof of the building, with the sump mounted within the building, a rather expensive piping system is required in order to circulate water from the sump upwardly to the spray heads which are mounted

2

above the condenser coils. Moreover, the relatively high head of water requires a high pressure pump and relatively powerful motor in circulating the water because of flow resistance due to head pressure.

It has been a primary objective of the present invention to provide a two-stage, self-contained evaporative condenser which is compact in design, which is highly efficient in operation, and which eliminates the indoor sump and attendant piping and high power pumping equipment.

According to this aspect of the invention, the two-stage condensing operation is carried out by providing a housing having a water sump heat exchanger unit in its base which desuperheats the hot compressed gas issuing from the compressor. The sump heat exchanger unit, according to the invention, is fabricated from sheet metal and is of simple design, including corrugations or flutes through which the hot compressed gas passes, the upper surface of the sump being cooled by a reservoir of water which is maintained in the lower portion of the housing above the sump heat exchanger unit. The water from the sump is circulated by a low pressure pump directly to a spray head system in the upper portion of the housing as liquid coolant for the second-stage condenser section.

A further objective has been to provide a self-contained water-air cooled two-stage evaporative condenser which is not damaged in the event that the unit is exposed to cold weather which causes freezing of the coolant water confined in the sump heat exchanger when the system is shut down.

According to this feature of the invention, the sheet metal sump heat exchanger unit is designed to allow expansion without damage should ice form in the water reservoir of the sump in the base of the housing. Moreover, the ice, which may form, is thawed rapidly by the hot compressed gas flowing from the compressor through the flutes of the sump heat exchanger when the refrigeration system is again placed in operation.

A further advantage of the present system arises from the fact that the tubes of the second stage condenser section are protected, at least partially, from the formation of scale normally resulting from water evaporation by reason of the fact that the gas is desuperheated or partially cooled before passing across the tubes by operation of the sump heat exchanger unit.

In the preferred arrangement, as is disclosed herein, an oil separator is interposed in the conduit which leads from the discharge side of the sump heat exchanger unit to the second stage condenser tube section. By virtue of this arrangement, the system takes advantage of the primary cooling action of the sump to aid in separating oil which may be entrained in the compressed gas which issues from the compressor.

The various features and advantages of the invention will be more fully apparent from the following description taken in conjunction with the drawings.

DESCRIPTION OF THE DRAWINGS

In the drawings:

FIGURE 1 is a diagrammatic view showing a refrigeration or air-conditioning system with the two-stage evaporative condenser installed as part of the circuit to illustrate the principles of the invention.

FIGURE 2 is a front elevation taken along the line 2—2 of FIGURE 1 partially broken away, illustrating the two-stage evaporative condenser.

FIGURE 3 is a top plan view of the two-stage evaporative condenser, as viewed along the line 3—3 of FIGURE 1.

FIGURE 4 is a sectional view taken along the line 4—4 of FIGURE 1, illustrating the first stage sump heat exchanger unit of the condenser.

3

FIGURE 5 is a sectional view taken along line 5—5 of FIGURE 4 illustrating a portion of the plate-type heat exchanger which forms the bottom of the sump heat exchanger.

FIGURE 6 is a fragmentary sectional view similar to FIGURE 5 showing a modified plate-type sump which may be utilized with the condenser of this invention.

FIGURE 7 is an enlarged fragmentary view taken from FIGURE 1, illustrating the moisture eliminators or fins which are utilized in the upper portion of the condenser.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Refrigeration system generally

A conventional refrigeration system, which is shown diagrammatically in FIGURE 1, has been selected to illustrate the principles of the two-stage evaporative condenser of this invention. It will be understood that the condenser may be installed in any one of the various commercial refrigeration or air-conditioning systems, whether the system is newly constructed or is an existing one.

Described generally, the refrigeration system shown in FIGURE 1 comprises a motor-driven compressor, indicated generally at 1, which communicates by way of a conduit 2, as indicated by the arrows, with the two-stage evaporative condenser of the invention, which is indicated generally at 3. The preferred structural details of the condenser 3 are described later.

As noted, the two-stage evaporative condenser 3 of the invention is designed preferably for installation outside the building in which the refrigeration system or air-conditioning system is installed, although it may also be installed indoors. When mounted out-of-doors, the condenser 3 provides a more efficient cooling and condensing action and also simplifies the system by eliminating the equipment which is normally required in disposing of the heated air which is generated by the conventional condensing equipment which is installed within the building. Generally speaking, the condenser 3 takes advantage of the evaporative chilling effect of a water spray system, combined with air currents induced by a blower to chill and liquify the hot refrigerant gas issuing from the refrigeration of air-conditioning system.

After passing through the two-stage evaporative condenser 3, as indicated by the arrows, the cooled liquified refrigerant flows by way of a conduit 4 (FIGURE 1) to a high pressure receiver 5, in the present example, in which the cooled liquid refrigerant is stored temporarily. From the receiver 5 the liquid refrigerant passes by way of a conduit 6 to the mid-portion of an accumulator 7 which comprises a cylindrical vessel or tank, in this instance. From the accumulator 7 the liquid refrigerant advances by way of a conduit 8, as indicated by the arrows, to an evaporator 10. In passing through the evaporator 10, the liquified refrigerant expands and absorbs heat to provide the refrigerating effect.

For purposes of illustration, a single evaporator 10 has been shown in FIGURE 1. However, it will be understood that a commercial or industrial refrigeration system can involve a number of chilling areas, each including one or more evaporators. As applied to commercial air-conditioning circuits, the same conditions prevail, that is, the system may involve a number of evaporators, each comprising a self-contained unit having individual temperature control devices. It will be understood that smaller two-stage condenser units, utilizing the principles of this invention, may also be furnished for use with smaller refrigeration or air-conditioning systems, for example, systems designed for household use.

The accumulator 7 acts as a reservoir for the expanded refrigerant gas from evaporator 10 and to collect unevaporated refrigerant which may pass through the coil 11 of the evaporator. It will be understood at this point that unexpanded refrigerant in the form of droplets is advanced through the conduit 12 from evaporator 10 along

4

with the expanded gaseous refrigerant. The space within the accumulator 7 above the level of the liquid refrigerant, indicated at 13, acts as a reservoir for the refrigerant gas passing from the evaporator 10 by way of the conduit 12. After passage to the accumulator 7, the refrigerant gas passes from the top of the accumulator by way of the suction line 14 back to the compressor 1 for recirculation.

In the present example, the liquid level 13 within accumulator 7 is maintained by a liquid level control device 15 which is mounted upon a vertical telltale tube 16. The liquid level control device 15 comprises a thermal sensor which is adjustably mounted upon the vertical telltale tube 16 and which is arranged to regulate the level 13 of the liquid refrigerant within the accumulator 7.

In the arrangement shown in FIGURE 1, the accumulator 7 is provided with a primary tubular column 17 having upper and lower ends which communicate with the interior of the accumulator tank 7 so as to act as a liquid level gauge. The secondary column or telltale tube 16 includes upper and lower ends communicating with the upper and lower portions of the primary column 17. The purpose of utilizing the primary column 17 and the secondary column 16 is to improve the accuracy in sensing the liquid level 13 by preventing surging which may occur within the accumulator 7 and within the primary column 17. The surging is brought about primarily by gas which may be generated within the accumulator 7 and within the primary column 17 due to heat infiltration to the chilled liquid refrigerant within the accumulator.

In the present example, the lower portion of the accumulator 7 includes a vertical standpipe 18 which communicates with the bottom of the accumulator 7 to provide a passageway for the liquid refrigerant through the conduit 8 to the coils 11 of the evaporator 10.

As the high pressure refrigerant gas passes through the two-stage evaporative condenser 3, the gas is cooled and converted to a liquid, which may be liquid ammonia or any other commercial refrigerant. As explained earlier, the refrigerant gas under high pressure, is advanced by way of the conduit 2 from the compressor 1 to the lower portion of the condenser 3, the arrangement being such that the high pressure gas flows upwardly through the condenser 3 to be discharged by way of the conduit 4 in the form of a liquid to the high pressure receiver 5.

Upon reaching the high pressure receiver 5 the liquid refrigerant is confined under condensing pressure and at lower temperature, the receiver 5 being partially filled with the refrigerant as indicated by the liquid level 20. The area within the receiver 5 above the liquid level 20 contains gas confined under pressure which acts as a cushion to provide and maintain the liquid refrigerant under high pressure to be advanced by way of the conduit 6 to the accumulator 7, as indicated by the arrows.

In order to separate the gas which is confined within the receiver 5 above the liquid level 20, the return conduit 4, which enters the upper portion of the receiver 5, terminates as at 21 above the liquid level 20. On the other hand, the end of the conduit 6, which conducts the liquid refrigerant from the receiver 5 to the accumulator 7, is submerged as at 22 below the liquid level 20.

The conduit 8 leading from the standpipe 18 of accumulator 7 to the evaporator 10, preferably is thermally insulated to prevent heat exchange since the refrigerant flowing through the conduit 8 has been reduced in temperature. The accumulator 7 and other components of the system, which conduct chilled liquid refrigerant, also are preferably provided with thermal insulation for the same reason.

In the present example, the liquid level control device 15 is of the type disclosed in the copending application of Charles P. Wood, Jr., Ser. No. 573,327, entitled "Liquid Level Control Device for Refrigeration Systems." It will be understood that in place of the liquid level control device 15 the accumulator 7 may be provided with a conven-

tional float valve or switch which responds automatically to the liquid level 13 within the accumulator to admit liquid refrigerant. The control device 15 has the advantage of providing accurate regulation of the liquid level 13 within the accumulator and also of permitting the liquid level to be adjusted as required by the system.

The liquid level control device 15 comprises a conduction ring formed of metal and clampingly engaging the outside diameter of the telltale tube 16 and including a thermostat having electrical contacts which are interconnected with an electrically operated valve 23, which is interposed in conduit 6. The arrangement is such that the control device 15 senses the temperature externally by conduction through the wall of the telltale tube 16 which corresponds to the liquid level 13 within the accumulator 7.

A power circuit (not shown) interconnects the thermally controlled contacts of the control device 15 with the winding of the electrically operated valve 23, such that the valve is opened to permit the flow of liquid refrigerant from the receiver 5 by way of conduit 6 to the accumulator 7 when the liquid within the accumulator 7 drops below the predetermined level 13.

In addition to the electrically operated valve 23, the supply conduit 6 also includes two hand-operated valves 24—24. Valves 24 are conventional and permit the flow of liquid refrigerant from receiver 5 to be shut off manually when it is necessary to service the system.

In the present example, the conduit 2 from compressor 1 is in the form of an upright loop or inverted U, with one leg rising from the compressor 1 and communicating with a horizontal gas lock section 25. The gas lock section 25 leads to a second vertical leg, the lower end of which communicates with the condenser 3. The purpose of the gas lock 25 is to prevent liquid refrigerant, which may accumulate in the line 2 before reaching the condenser 3 and in the condenser 3, from draining back to the compressor. The horizontal gas lock section 25 includes a one-way valve 26 which permits the flow of gas from the compressor 1 to the condenser in the direction indicated, but which closes in response to backflow from the condenser 3 toward the compressor 1.

Evaporative condenser

As noted earlier, the two-stage evaporative condenser 3 operates on the principle of extracting heat from the compressed superheated refrigerant gas flowing from the compressor 1 by way of the conduit 2. The first stage of the cycle is carried out by passing the hot gas from conduit 2 through the water-cooled sump heat exchanger 27. As described later, the sump section 27 forms the bottom of a housing 28 which encloses the components of the condenser 3 and acts as a water reservoir. It will be understood at this point that the sump heat exchanger 27 comprises a sheet metal structure including flutes through which the compressed superheated refrigerant gas from conduit 2 passes, a water level being maintained in the sump section to desuperheat the gas in the first stage of the cycle.

The second stage of the cycle is carried out by passing the desuperheated gas from sump section 27 through a tubular condenser section, indicated generally at 30, which is mounted within the upper portion of the housing 28. The cooling action with reference to the condenser section 30 is accelerated by pumping water from the sump 27 to a spray head system 31 mounted within the housing 28 above the condenser section 30 while, at the same time, forcing an air blast stream upwardly from the lower portion of housing 28 through the condenser section 30. By this arrangement, the water from sump 27 falls by gravity from the spray head system 31 in the form of droplets which fall through, across and in contact with the tubes of the condenser section 30 to pass by gravity back to the sump. In place of the spray head system 31 a commercial open trough distribution system (not shown) may be utilized.

In order to force the air upwardly through the condenser section 30 in a direction counter to the droplets of water falling from the spray head system 31, there is provided a power-driven blower 32 which is mounted on the lower portion of housing 28 and arranged to direct a blast stream of fresh air upwardly, as indicated by the arrows in FIGURE 1. The upward air flow causes partial evaporation of the falling water droplets issuing from the spray head system 31 and the heat energy expended in evaporating the water droplets is derived, in part, from desuperheating the gas flowing from the sump heat exchanger 27 upwardly through the tubes of the condenser section 30.

The evaporating action naturally lowers the temperature of the spray water and promotes the cooling action with respect to the condenser section 30 through which the water droplets pass. In addition, the evaporative effect of the upward air blast streams act upon the water droplets after passing through the condenser section 30 and before the droplets reach the sump heat exchanger 27 and thus promote the cooling effect which is provided by the water confined within the sump, as indicated by the water level 33. The air-water evaporative effect thus acts upon the sump section 27 and condenser section 30 in the condensing cycle, taking advantage of the related positions of these components within housing 28.

In order to conserve water, that is, to prevent water droplets from being blown upwardly through the top of housing 28, the upper portion of the housing is provided with drift eliminators, indicated generally at 34 in FIGURES 1 and 7. The drift eliminators 34 are in the form of fins formed of sheet metal and of zigzag configuration in cross section extending in parallelism across the open top of the housing 28. The fins are spaced apart sufficiently to permit free passage of the air blast stream but are arranged to provide a tortuous passageway. Thus, water droplets or mist which may be carried upwardly by the air blast currents, contact the surfaces of the drift eliminators and adhere at least partially. The accumulated droplets eventually drop by gravity back to the reservoir of water which is maintained in the sump heat exchanger 27.

The sump heat exchanger 27 is formed of sheet metal such as aluminum, steel, or copper. As best shown in FIGURES 4 and 5, the sump 27 forms a floor of the water reservoir which maintains the water level 33. The structure comprises a flat upper sheet 35, which is slanted in the direction indicated in FIGURE 1. In the present example, a lower sheet 36 has stamped in it a series of parallel or tortuous flutes or corrugations 37 extending longitudinally, as indicated in FIGURE 4. The flutes may be arranged to provide other circuiting, such as serpentine, to provide the most efficient heat exchange.

In constructing the heat exchanger sheet for sump 27, the flutes 37 are stamped into the lower sheet, then the upper and lower sheets 35 and 36 are pressed in face-to-face engagement and welded or compressed along the areas 38 between the flutes 37, thus forming the fluted passageways for the flow of superheated refrigerant gas, as indicated by the arrows.

One edge portion of the assembled heat exchanger 27 includes an intake header or manifold 40 (FIGURE 4) extending at right angles to the flutes 37 and in communication with the flutes for the passage of gas. The conduit 2 conducting the superheated gas from compressor 1 communicates with the intake manifold 40 at a mid-point along its length, such that the refrigerant gas flows through the several flutes 37 from the manifold, as indicated by the arrows.

An exhaust header or manifold 41 extends along the opposite edge portion of the heat exchanger unit 27, also at right angles to the flutes 37 and communicating with the flutes. The gas, which is totally or partially desuperheated upon reaching the exhaust manifold 41, flows into

the conduit 42 (FIGURES 1 and 3) to the intake header 43 of the condenser section, previously indicated at 30.

It is to be noted at this point that an oil separator 44 is interposed in the conduit 42, the arrangement being such that lubricating oil which may have been entrained in the superheated gas is separated after having been de-superheated by operation of the sump heat exchanger 27. By virtue of this arrangement, the apparatus takes advantage of the cooling action of sump 27 to separate the oil which has been reduced from a vapor to a more nearly liquid state at this stage. The oil separator 44 is a commercially available type and, therefore, has not been disclosed in detail. The separator includes a drain valve 45 arranged to purge the accumulated oil from the separator at required intervals.

The sump heat exchange unit 27 includes marginal flanges 46 (FIGURE 5) projecting outwardly from the lower sheet 36. The lower portion of the housing 28 includes marginal intumed flanges 47 which are inclined downwardly with respect to the walls of the housing 28. The marginal flanges 46 of sump unit 27 are similarly inclined and are secured, preferably by welding, to the flanges 47 of housing 28.

The flanges 47 of housing 28 are inclined as indicated, in order to avoid damage to the housing in the event that the water in the sump 27 should freeze if the system should be shut down during extremely cold weather. In other words, the inclined base flanges protect the walls of the housing by permitting expansion of the water and upward slippage of the ice without pressure being applied directly against the walls of the housing.

The sump heat exchanger unit 27 shown in FIGURE 6 is a modified version of that shown in FIGURE 5. The modified sump heat exchanger 48 is generally similar in construction to sump 27 except that it is provided with an upper sheet 50 which is also provided with flutes or corrugations matching the flutes of the lower sheet, thereby providing a passageway 51 having a greater area for the passage of the gas. In the modified sump unit 48, the flutes extend parallel with one another in the direction of the slant to facilitate circulation of the water. The sump unit 48 includes flanges 52 which are welded to the lower flanges 47 of housing 28, as described earlier with reference to FIGURE 5.

The second stage condenser section, previously indicated at 30, comprises banks 53 of tubes, preferably of serpentine configuration, as viewed in FIGURE 1. Each bank of coils is arranged in a vertical plane and is spaced from the adjacent bank, as indicated in FIGURE 3, to provide passage of spray water and air, as noted earlier. The several banks 53 are supported by their headers, and, in addition, by rods or the like (not shown) attached to the housing 28.

The upper ends of each coil bank are connected in common to the intake header 43, previously noted, the upper end of conduit 42 being connected to the intake header 43 preferably at a point midway along the length of the manifold (FIGURE 3). The conduit 4 which leads to the high pressure receiver 5 communicates with exhaust header 54 preferably at a point midway along its length.

After passing through the condenser section 30, the previously desuperheated gas has been cooled sufficiently to condense and to be returned in the form of liquid refrigerant to the high pressure receiver 5, as indicated by the arrows and thereafter to be recirculated through the accumulator 7 and through the evaporator 10 back to the compressor 1.

The water supply to the spray head system 31 is provided by a motor-driven pump 55 (FIGURE 1). The pump 55 is a commercially available type which is submerged in the deep end portion of the reservoir 33 so as to withdraw the water for recirculation. A conduit 56 extends from pump 55 to the spray head system 31 for circulating the water from reservoir 33 to the spray head

system 31, the droplets being returned by gravity, as noted earlier.

To compensate for water which is lost from reservoir 33 through evaporation and drift in the form of mist from the housing 28, there is provided a make-up arrangement for supplying fresh water. As shown in FIGURE 1 there is provided a float valve 57 of conventional design mounted within the lower portion of housing 28. A water supply pipe 58 communicates with the float valve 57 to supply fresh water under pressure. Operation of the valve 57 is controlled by a float 60 connected by a rod 61 to the float valve 57, the arrangement being such that the valve supplies water to the reservoir from line 58 in response to the action of the float 60.

Having described my invention, I claim:

1. In a refrigeration system including an evaporator for receiving and expanding liquid refrigerant and having a power-driven compressor communicating with the evaporator, a self-contained two-stage evaporative condenser communicating with the compressor for condensing compressed superheated gas issuing from the compressor comprising:

a housing having an open upper portion for the circulation of air upwardly through the housing;

a sump section comprising a bottom element disposed in the lower portion of the housing providing a reservoir for confining a supply of liquid coolant;

said bottom element comprising a plurality of spaced, hollow flute elements spaced apart from one another and having connecting means therebetween;

said hollow flute elements constituting gas passageways and having intake and exhaust portions for circulating compressed, superheated refrigerant gas through said hollow flute elements for heat exchange with the liquid coolant in the reservoir of the sump section above the bottom element, said bottom element of the sump section constituting a first stage heat exchanger for desuperheating the superheated refrigerant gas;

means for conducting the superheated refrigerant gas from the compressor to the intake portion of the sump section;

a condenser section mounted within the housing above the sump section;

said condenser section having an intake and an exhaust portion and constituting a second stage heat exchanger for reducing the desuperheated refrigerant gas substantially to a liquid state;

means for conducting the desuperheated refrigerant from the exhaust portion of the sump section to the intake portion of the condenser section;

distribution means within the housing above the condenser section for projecting liquid coolant from the sump section downwardly through the condenser section; and

means for conducting the condensed liquid refrigerant from the exhaust portion of the condenser section back to the refrigeration system for recirculation.

2. A self-contained two-stage evaporative condenser as set forth in claim 1 in which the first stage sump section comprises a heat exchanger formed of sheet metal including an upper sheet and a lower sheet, at least one of said sheets having a plurality of flutes formed therein, said sheets being secured together in face-to-face relationship, whereby said flutes form passageways for the flow of the superheated refrigerant gas from the intake portion of sump section to the exhaust portion thereof.

3. A self-contained two-stage evaporative condenser as set forth in claim 1 in which the first stage sump section comprises a heat exchanger formed of sheet metal including an upper sheet and a lower sheet, at least one of said sheets having an intake header formed along one edge portion thereof and an exhaust header formed along a second edge portion thereof, at least one of said sheets having a plurality of flutes formed therein

and communicating with the intake and exhaust headers, said sheets being secured together in face-to-face relationship, whereby said headers and flutes form passageways for the flow of the superheated refrigerant gas from the intake header, through the flutes to the exhaust header of the sump exchanger.

4. A self-contained two-stage evaporative condenser as set forth in claim 1 in which the first stage sump section comprises a heat exchanger formed of sheet metal including an upper sheet and a lower sheet, at least one of said sheets having a corrugation formed in one edge portion thereof and providing an intake header, a second corrugation formed along a second edge portion of the sheet and providing an exhaust header, a plurality of flutes formed in said sheet, said flutes extending parallel with one another and having opposite ends communicating with the corrugations which form the intake and exhaust headers, said sheets being secured together in face-to-face relationship, whereby said flutes provide individual passageways for the flow of superheated refrigerant gas from the intake header across said flutes to the exhaust header.

5. A self-contained two-stage evaporative condenser as set forth in claim 1 in which there is provided a power-driven pump communicating with the sump section in the lower portion of the housing for withdrawing liquid coolant from the sump section, and means connecting said power-driven pump to the distribution means within the housing above the condenser section, whereby liquid coolant is withdrawn from the sump section and passed from the distribution means downwardly through the condenser section, adapting the liquid coolant to absorb heat from the second stage condenser section and to drop by gravity back to the first stage sump section for recirculation.

6. A two-stage self-contained evaporative condenser for a refrigeration system as set forth in claim 1 in which the sump section is delineated by a bottom wall located in the lower portion of the housing, said bottom wall having heat exchanger passageways extending from the intake portion to the exhaust portion thereof for conducting superheated gas from the intake to the exhaust portion of said bottom wall, said passageways being in contact with the liquid coolant which is confined in the sump section, said second stage condenser section comprising intake and exhaust headers mounted on opposite

sides of the housing, and a plurality of tubes communicating with said intake and exhaust headers for the circulation of desuperheated refrigerant therethrough.

7. A self-contained two-stage evaporative condenser as set forth in claim 1 in which there is provided a power-driven pump communicating with the first stage sump section in the lower portion of the housing for withdrawing liquid coolant from the sump section and in which the distribution means above the second stage condenser section comprises a header disposed in the housing above the condenser section, a plurality of spray pipes having ends communicating with the header, said spray pipes each including a plurality of apertures for projecting jet streams of liquid coolant downwardly through the second stage condenser section, and a conduit interconnecting the power-driven pump and header for conducting liquid coolant from the sump section under pressure to the said header.

8. A self-contained two-stage evaporative condenser as set forth in claim 1 in which there is provided a power-driven air blower communicating with the lower portion of the housing above the first stage sump section, said blower adapted to project blast streams of air upwardly through the second stage condenser section and outwardly through the open upper portion of the housing in a direction counter to the liquid coolant passing downwardly from above the second stage condenser section to fall by gravity back to the first stage sump section.

9. A self-contained two-stage evaporative condenser as set forth in claim 1 in which there is provided a conduit extending from the exhaust portion of the first stage sump section to the intake portion of the second stage condenser section, and an oil separator interposed in said conduit for separating oil from the desuperheated gas issuing from the sump section.

References Cited

UNITED STATES PATENTS

2,221,530	11/1940	Strang	62—305 X
2,493,141	1/1950	Henney	62—305
3,021,689	2/1962	Miller	62—84 X

WILLIAM J. WYE, *Primary Examiner*.

U.S. Cl. X.R.

45 62—84