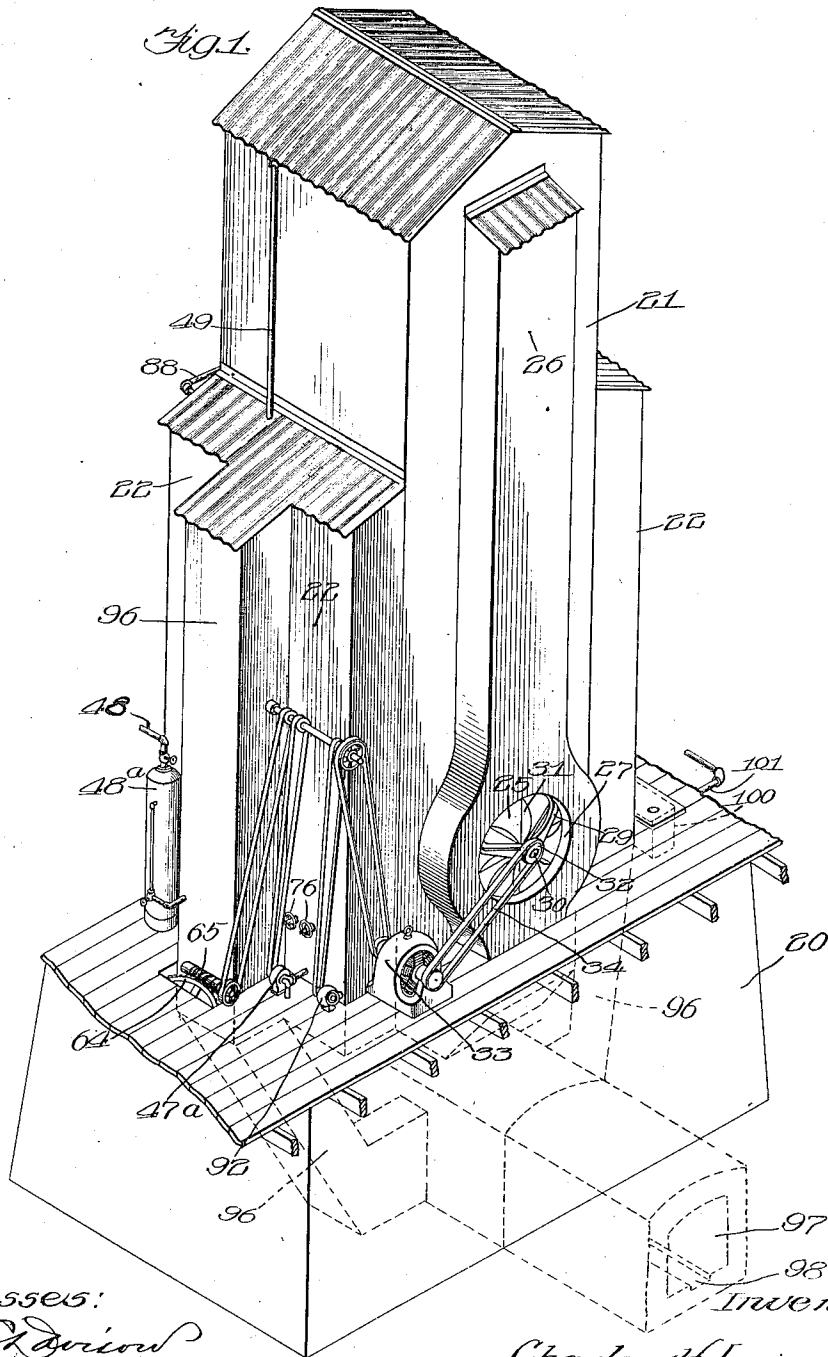


C. H. LEINERT.
 APPARATUS FOR REFRIGERATING AND DRYING GASES.
 APPLICATION FILED APR. 23, 1910.

1,039,148.

Patented Sept. 24, 1912.

8 SHEETS—SHEET 1.



Witnesses:

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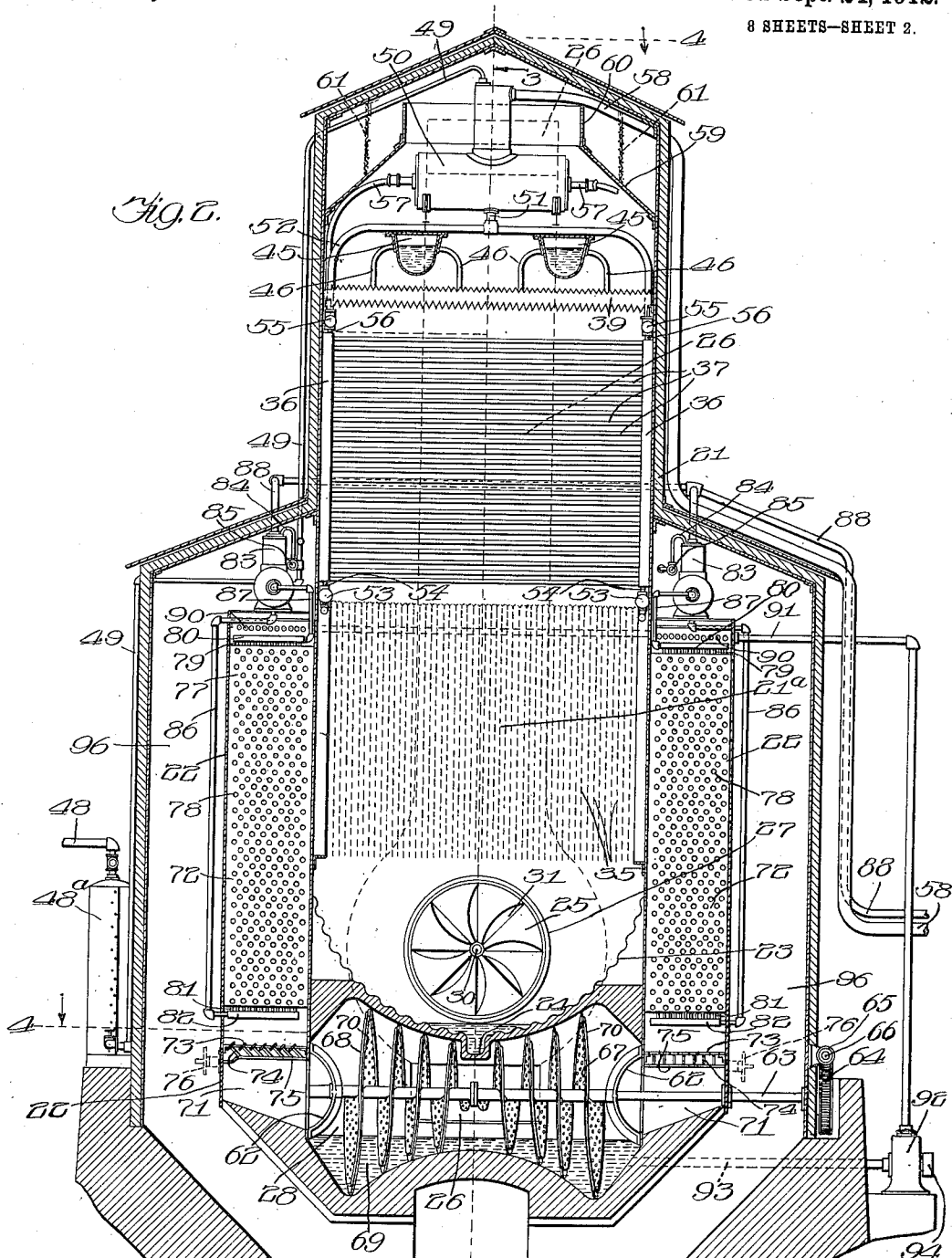
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Witnesses
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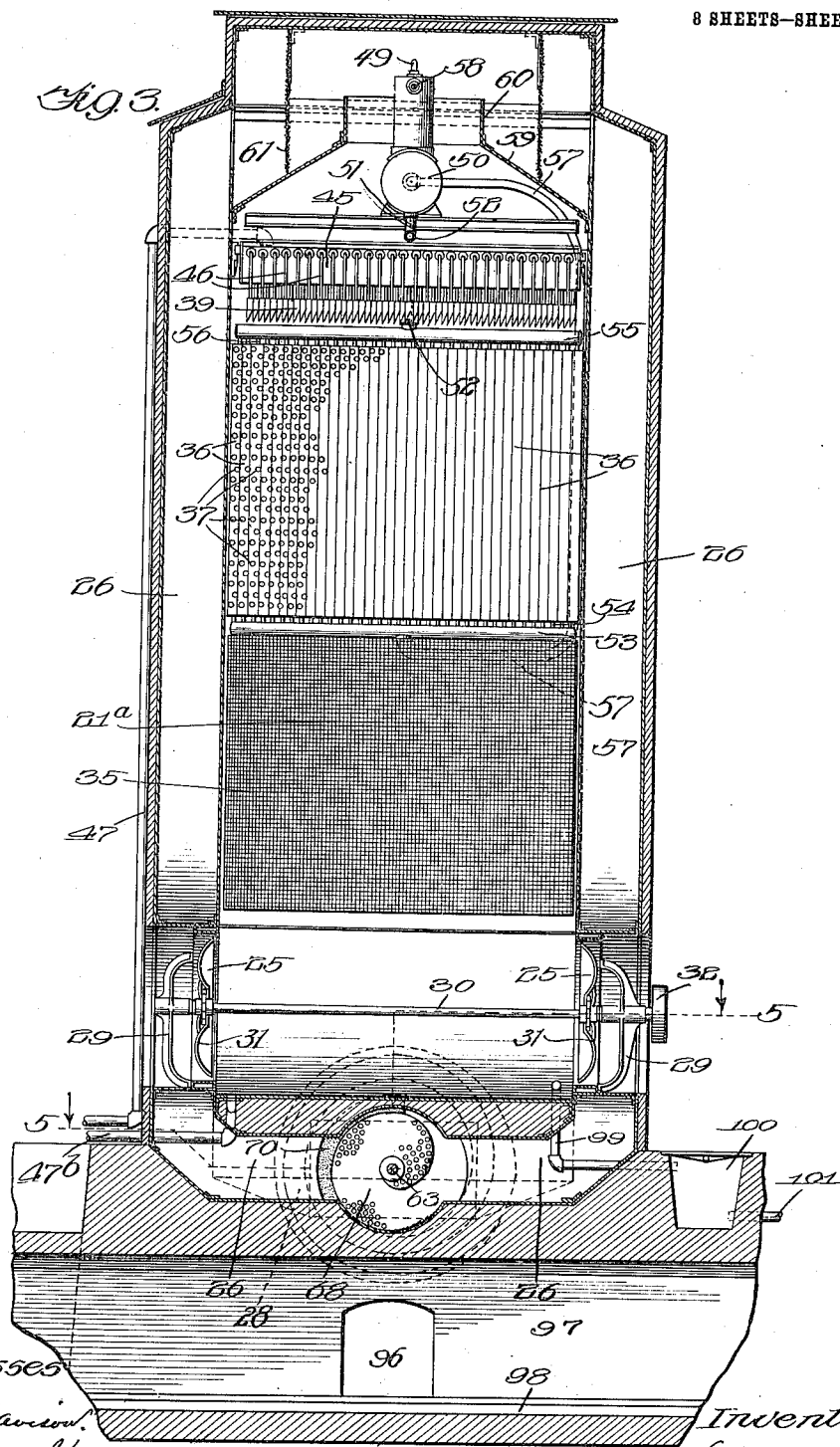
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8 SHEETS—SHEET 3.



Witnesses
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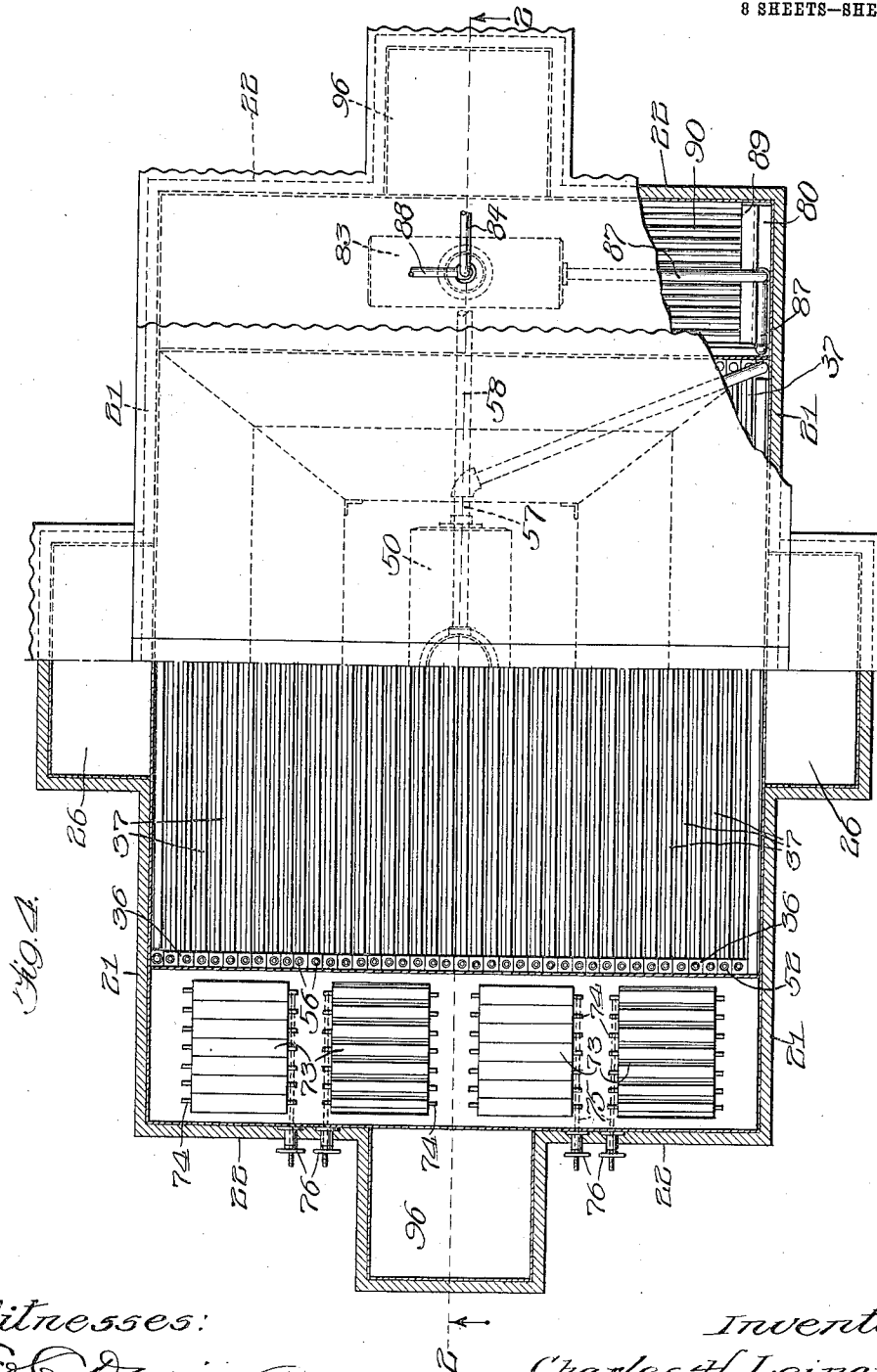
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Witnesses:
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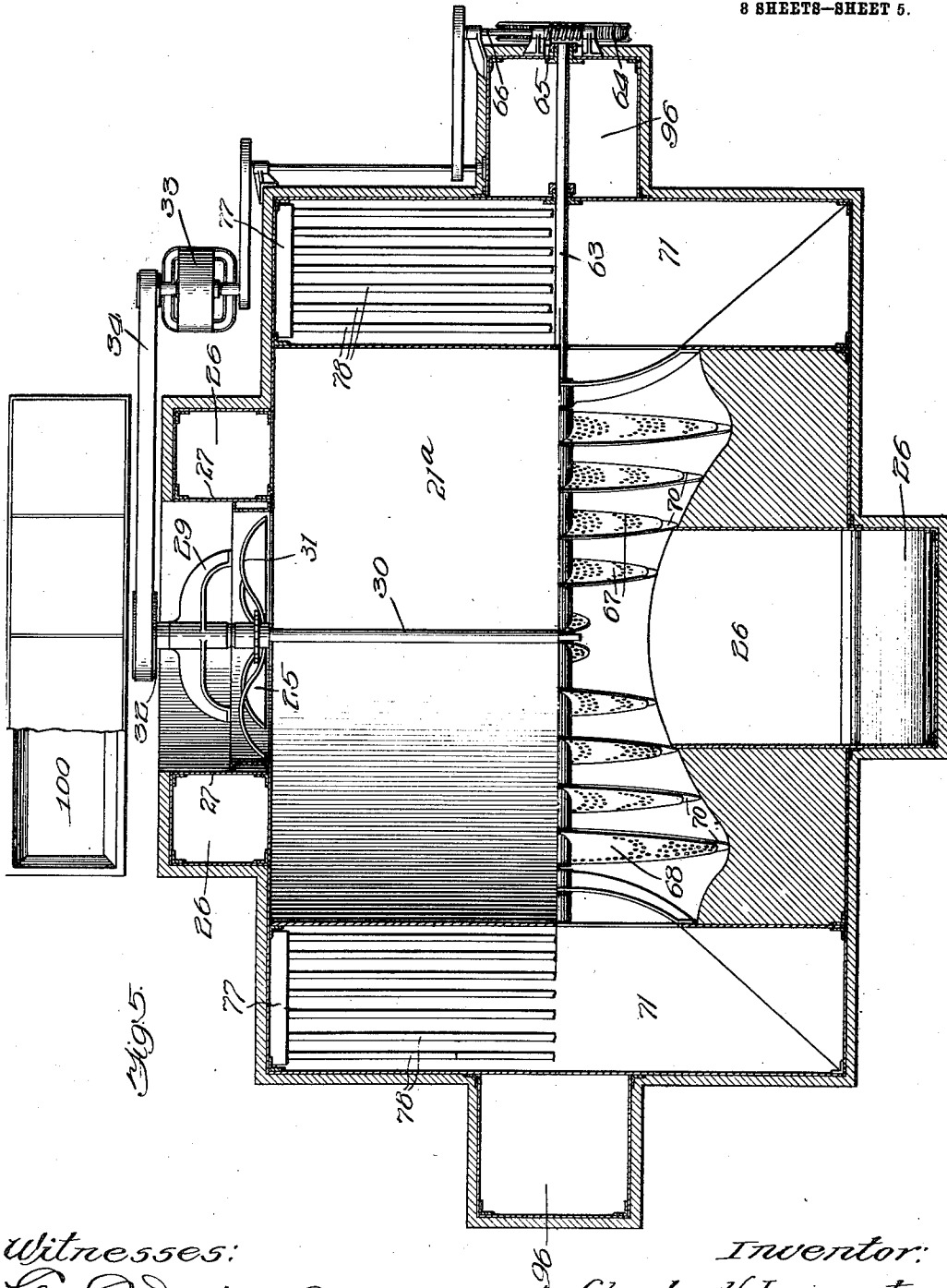
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Witnesses:
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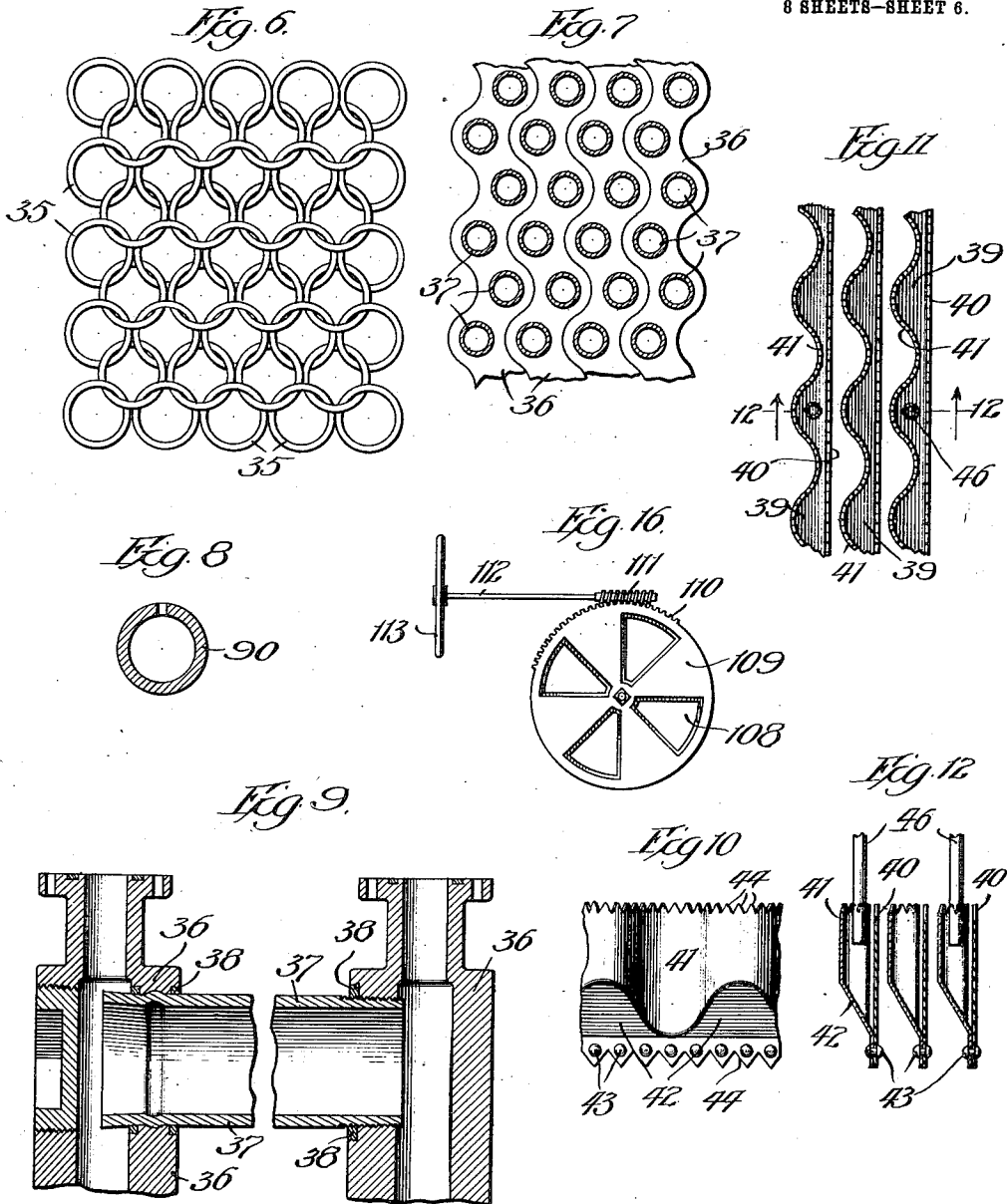
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Witnesses:
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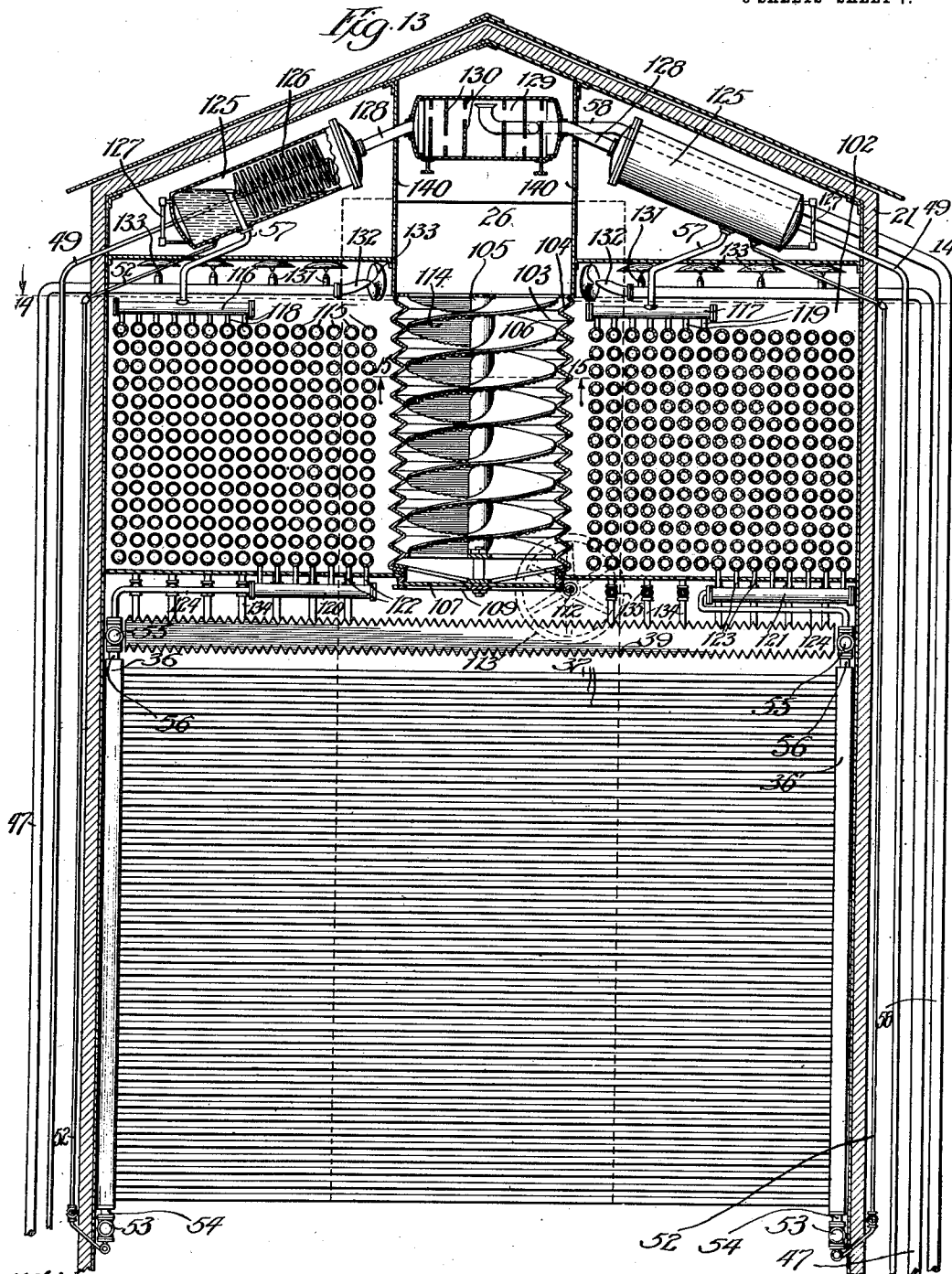
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8 SHEETS—SHEET 7.



Witnesses:
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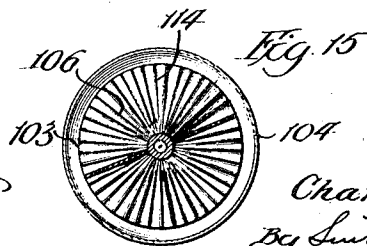
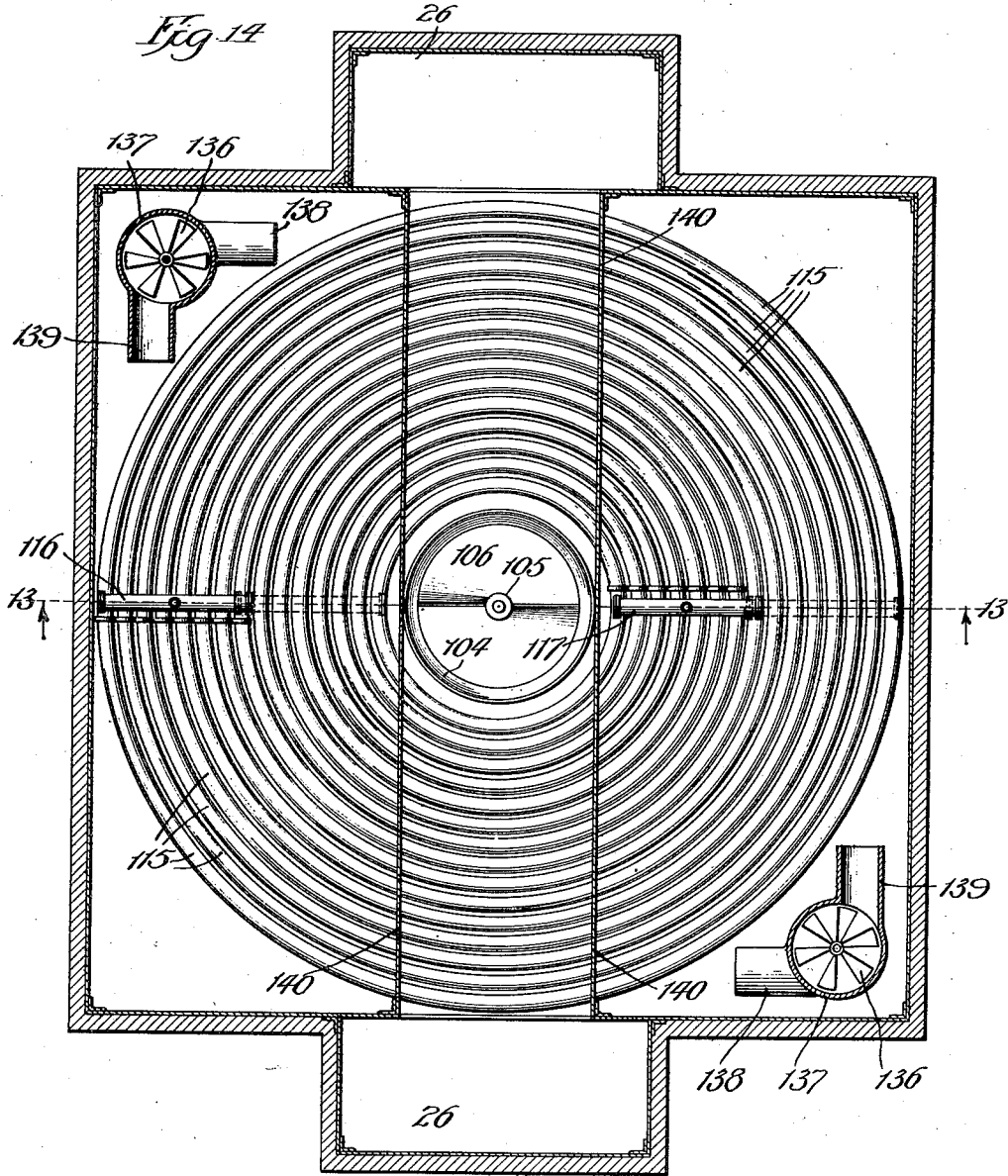
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8 SHEETS—SHEET 8.



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UNITED STATES PATENT OFFICE.

CHARLES H. LEINERT, OF CHICAGO, ILLINOIS.

APPARATUS FOR REFRIGERATING AND DRYING GASES.

1,039,148.

Specification of Letters Patent.

Patented Sept. 24, 1912.

Application filed April 23, 1910. Serial No. 557,225.

To all whom it may concern:

Be it known that I, CHARLES H. LEINERT, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Apparatus for Refrigerating and Drying Gases, of which the following is a specification.

My invention relates to apparatus for refrigerating and drying gases, and is particularly useful in connection with drying the air which is used for blast furnaces, although my invention may also be applied to refrigerating operations of various kinds.

Experiments have shown that saturated air at a temperature of approximately 96° Fahrenheit ordinarily contains in the vicinity of 14 grains of water per cubic foot of air, while if the air is cooled to a temperature of from 5° to 10° below zero, the moisture is reduced to approximately 0.5 grain per cubic foot. It will immediately be apparent that with this wide difference in the amount of moisture contained in air at different temperatures, the operation of a blast furnace will depend largely on the initial temperature of the air before it is introduced into the heating stoves.

In order to have a constant amount of moisture in the air which is used for the blast of blast furnaces, the so-called "Gayley dry blast" was introduced, the process consisting broadly in cooling the air which passes to the heating stoves to a certain fixed temperature, and thereby extracting moisture from the air by refrigeration. The temperature to which the air is cooled in this process is in the vicinity of 20° Fahrenheit, and the moisture is thereby reduced to from 1 to 1.5 grains per cubic foot of air.

In the Gayley system as ordinarily used, a series of pipes containing a solution of calcium chlorid is cooled by means of inclosing jackets through which liquid ammonia is passed. The pipes containing the cooled calcium chlorid or "brine" connect with coils in the refrigerating chambers. Air is passed through these chambers, a given portion of air passing through only one chamber, and the moisture congeals on the surface of the pipes through which the cooled brine passes. As the process progresses, more and more moisture congeals on the pipes within these cooling chambers.

When the moisture in any one chamber congeals on the pipes so that the ice is formed to a predetermined thickness, this chamber is shut down, the brine from the pipes being drained off into a storage tank, and warm water is then passed over the outside of these pipes, thus causing the congealed moisture to melt. This operation ordinarily requires seven or eight hours, and heats the chamber to a very considerable extent. After the ice has been melted off of the pipes, the brine is again allowed to run through the coils within the chamber, and the temperature is gradually reduced. In the operation of melting the ice from the pipes, the chambers which are contiguous to the one in which the melting is being conducted are heated to a considerable extent, so that it will be evident that, on account of the necessity of frequently shutting down one of the refrigerating chambers and the length of time involved in melting the ice and then again reducing the chamber to the proper temperature, a very considerable loss of energy results, with a consequent high cost of operation.

In the improvement of the Gayley system which forms the subject matter of my invention, the air is introduced into the cooling tower by means of rotary fans, and passes upwardly through water which trickles down over a number of screens or chains, thus bringing the air into intimate contact with the water. This water has been previously cooled by contact with pipes through which liquid ammonia passes. The function of this water is threefold: First, it removes the mechanical impurities, such as soot, etc., which may be present in the air; second, it cools the air to the temperature of the water, and thereby condenses a large proportion of moisture which may be present in the air; and third, on account of its constant motion, the water prevents the moisture in the air from congealing on the ammonia pipes over which the water passes and between which the air is forced. The water which I have just mentioned as trickling downwardly over screens or chains may be cooled by passing from a series of troughs over ammonia cooled pipes, or it may be cooled in a comparatively large tank in which are placed coils which are supplied with liquid ammonia, the water

passing through the bottom of this tank to a series of troughs which are either placed over a series of ammonia cooled pipes, or, if desired, may be placed directly over a series of screens or chains. The air, after passing upwardly past the trickling water, as has been described, is then led through suitable passages into the lower part of the cooling tower, and passes to the center of a chamber which contains a concentrated solution of calcium chlorid, sulfuric acid or other deliquescent reagent. A shaft passes through this chamber longitudinally, and on this shaft are mounted a pair of spirals which lead, respectively, from the central portion of the chamber to the ends thereof, so that as the shaft is rotated the air is carried by the action of the spirals from the central portion of the chamber toward its ends. These spirals are preferably constructed of expanded metal, or other similar material which will retain the calcium chlorid or other drying solution on its surface when the spirals are rotated, the lower portions of these spirals being always immersed in the drying solution. The air which is introduced into the chemical drying chamber just mentioned contains approximately 2.75 grains of water per cubic foot of air, and the action of the drying solution within this chamber is such that on reaching the ends of the chamber, the moisture has been reduced to approximately 2 grains per cubic foot. The air next passes upwardly through a pair of chambers containing a large number of ammonia cooled pipes, one of these chambers being located on each side of the preliminary cooling chamber which was first described. Inasmuch as the moisture in the air has been reduced to about 2 grains per cubic foot when the air reaches these final drying chambers, it will be apparent that but little additional moisture will be removed. This slight amount of additional moisture is prevented from congealing on the ammonia pipes by means of keeping said pipes covered with a thin film of calcium chlorid or other suitable solution, which trickles down over these pipes from a series of supply pipes placed in the upper part of each chamber. In these final drying chambers the moisture in the air is reduced to approximately between 1 and 1.5 grains per cubic foot. From the final drying chambers, the air next passes downwardly through suitable passages into the intake which leads to the blowing engines, and from thence to the blast-furnace stoves. It will be apparent that the air which finally reaches the top of the final drying chambers will be considerably heavier than the air which is drawn into the cooling tower, on account of its low temperature and freedom from moisture. This heavier air which passes downwardly

to the intake to the blowing engines, largely by the action of gravity, exerts a suction on the air which lies in the cooling tower between the fans and the top of the final drying chamber, and thus facilitates the work of the fans and at the same time keeps a constant supply of air flowing to the intakes of the blowing engines.

One of the most important advantages of my invention is that the drying chambers are so located that the effect of radiation is decreased.

In the ordinary form of the Gayley dry blast the various chambers which are used for refrigerating and drying occupy a large amount of space and are necessarily located in a building which is separate from that occupied by the blowing engines. My improved form of cooling tower, on the other hand, occupies much less space, and, if desired, can be located on the roof of the building containing the blowing engines or otherwise in immediate proximity to the same, thus dispensing with a long air pipe between the cooling tower and the blowing engines. I find it more economical to carry the ammonia or other cooling medium to the tower than to carry the very much greater bulk of air from the refrigerating plant to the blowing engine. This I believe to be a distinct improvement in the art.

The water which trickles down through the preliminary drying chamber collects in the bottom of the same, from which it is again pumped, either to the troughs which are in the upper part of the chamber or to the tank which contains the coils through which the liquid ammonia flows. As additional water is condensed from the air passing through this chamber, this surplus water is conducted by suitable pipes to the ammonia condenser, and, on account of its low temperature, effects a considerable saving in the operation of the same.

From the foregoing general description of my improved method of refrigerating and drying gases and the apparatus used therefor, it will be apparent that a great advance in the art has been effected. Instead of removing the moisture from the air by the direct condensation and congealing of this moisture on the surface of the brine-cooled pipes, I effect a preliminary drying by bringing the air into direct contact with cooled water, which cleanses the air and removes the greater part of the moisture therefrom, the water at the same time preventing the congealing of the moisture on the pipes or screens. I then subsequently bring this partially dried air, first, into contact with a chemical drier, and then finally into contact with a series of ammonia cooled pipes, which latter bring the content of moisture to from 1 to 1.5 grains per cubic foot. These and other advantages of my

invention will be more apparent by reference to the accompanying drawings, which show preferred embodiments of my improvements, and in which,—

5 Figure 1 is a perspective view showing my improved cooling tower and the various parts associated therewith; Fig. 2 is a vertical section through the cooling tower on the line 2—2 of Fig. 4; Fig. 3 is a vertical section on the line 3—3 of Fig. 2; Fig. 4 is a transverse section and partly plan view on the line 4—4 of Fig. 2; Fig. 5 is a transverse section on the line 5—5 of Fig. 3; Fig. 6 is an enlarged, fragmentary elevation of the chain screen used in the preliminary cooling chamber; Fig. 7 is an enlarged, fragmentary vertical section through the cooling pipes, showing a modified form of headers used in connection therewith; Fig. 8 is a transverse section through one of the brine pipes used in the final cooling chambers; Fig. 9 is an enlarged vertical section through one of the cooling pipes, showing the method of attachment to the headers; Fig. 10 is an enlarged, fragmentary, front elevation of one of the troughs used for distributing water over the cooling pipes in the preliminary cooling chamber; Fig. 11 is a fragmentary plan view of three of the troughs shown in Fig. 10; Fig. 12 is a vertical section on the line 12—12 of Fig. 11; Fig. 13 is an enlarged vertical section through the upper part of the cooling tower, showing a modified arrangement of the parts contained therein, this section being taken on the line 13—13 of Fig. 14; Fig. 14 is a horizontal section taken on the line 14—14 of Fig. 13; Fig. 15 is a transverse section on the line 15—15 of Fig. 13; and Fig. 16 is a plan view of the regulating valve or damper used in the modified construction of the cooling tower shown in Figs. 13 and 14.

Mounted on the base 20 is the casing 21 of the preliminary cooling chamber 21^a of the cooling tower of my invention. Located on either side of the casing 21 are the casings 22, 22, which inclose the final cooling chambers. As clearly shown in Fig. 2, the lower portion of the preliminary cooling chamber is provided with a semicircular bottom 23, which is preferably corrugated, and at its lowest point is provided with the trough 24. The openings 25, 25 in the lower parts of the front and rear walls of the casing 21 serve to establish communication between the inside of the preliminary cooling chamber 21^a and the outer atmosphere.

In the front and rear of the main casing 21 are provided casings which inclose the passages 26, 26 which communicate with the upper part of the preliminary cooling chamber and lead downwardly toward the openings 25, 25, which are inclosed by the housing 27 of each of the casings inclosing the

passages 26, 26. Below the openings 25, 25, the passages 26, 26 are in communication with the drying chamber 28, which is located below the preliminary cooling chamber.

Mounted within each of the housings 27, 27 is a spider 29, through which passes the shaft 30. Rigidly mounted toward each end of the shaft 30 and within the openings 25 are the fans 31, which are of suitable construction to draw air into the preliminary cooling chamber when the shaft 30 is rotated. On the front end of shaft 30 is mounted a pulley 32, which is connected with a suitable pulley on the motor 33 by means of the belt 34.

Suitably suspended in the lower portion of the preliminary cooling chamber, but in a position above the openings 25, 25, are the chain screens 35, the construction of which is best shown in Fig. 6. Toward the upper part of the preliminary cooling chamber are mounted the headers 36, 36, communicating with which are the horizontal cooling pipes 37, the method of connecting these cooling pipes with the headers being clearly shown in Fig. 9, it being possible to either screw the end of the pipe 37 into the header 36, as shown in the right-hand portion of Fig. 9, or to expand the metal of the pipe 37 into the metal of the header 36, as shown in the left-hand portion of the same figure. Suitable soldered joints, or autogenously welded joints 38 are provided in order to prevent leakage.

In Fig. 7, a modified form of the headers 36 is shown, by which it is possible to mount a greater number of cooling pipes 37 between these headers. Directly above the cooling pipes 37 are mounted the troughs 39, the construction of which is best shown in Figs. 10, 11 and 12. Each of these troughs has a straight vertical side 40. The opposite side of each trough consists of the vertical portion 41 and the oblique portion 42, which is connected with the side 40 by means of rivets 43. The upper portions 41 are corrugated, as most clearly shown in Figs. 10 and 11, this construction readily allowing air to pass between the contiguous troughs. Both the upper and lower edges of each trough are provided with notches 44, the object of which will be explained hereinafter, the notches in the sides 40 being cut slightly lower than on the opposite sides, for a purpose which will be explained hereinafter. Suitably suspended above the troughs 39 are the two tanks 45, 45, from which water passes to the troughs 39 by means of pipes 46. As clearly shown in Fig. 3, the pipes 46 on one side of each of the tanks 45 supply water to alternate troughs 39, whereas the pipes 46 on the opposite side of the tanks 45 supply water to alternate troughs 39 which lie between the first

series of alternate troughs above mentioned. The tanks 45, 45 are supplied with water from a pipe 47 which is connected with the pump 47^a, which in turn is connected with the pipe 47^b leading from the bottom of the preliminary cooling chamber 21^a. It will now be apparent that as water is supplied to the two tanks 45, 45, this water will pass downwardly through the pipes 46, 46 into the troughs 39, from which it will overflow through the upper notches 44, and will then pass downwardly through the upper notches 44 in the sides 40, over the outer surfaces of these sides, to the points lying between the lower notches 44, and will then drop downwardly to the pipes 37, over which the water will trickle.

I will next explain the method of supplying ammonia or other suitable cooling medium to the pipes 37 which pass between the headers 36, 36.

Ammonia, from a compressor of any well known type, is forced to a condenser, where it is liquefied, and thence passes through the pipe 48 to the ammonia receiver 48^a, from which it passes upwardly through the pipe 49 to the upper portion of the evaporator 50. The liquid ammonia next passes downwardly through pipe 51 connected with the bottom of the evaporator 50, into the two lateral branching pipes 52, from which it passes to the two horizontal headers 53, 53, which communicate with the vertical headers 36, 36, through pipes 54. The ammonia from the evaporator 50 will thus fill the headers 36, 36 and the cooling pipes 37 which pass between them. The liquid ammonia next passes to the horizontal headers 55, 55 through the pipes 56, and then overflows through the two pipes 57 back to the evaporator 50. Whatever ammonia has been gasified passes from the upper portion of the evaporator 50 into the pipe 58, which communicates with the ammonia compressor, where this ammonia gas is again compressed and forced to the ammonia condenser, and then passes back to the receiver 48^a.

In the upper part of the preliminary cooling chamber 21^a are the obliquely disposed plates 59, to the upper edges of which are suitably attached the vertically disposed plates 60, thus forming a funnel-shaped outlet from the preliminary cooling chamber. As clearly shown in Figs. 2 and 3, the passages 26 communicate with the space within the casing 21 which lies outside of the funnel-shaped outlet just described. Downwardly depending from the roof of the cooling tower are the curtains 61, 61, the lower edges of which come in contact with the obliquely disposed plates 59.

As explained above, the passages 26 communicate at their lower ends with the drying chamber 28, which, as clearly shown in

Fig. 3, is of circular cross section. Mounted at each end of the chamber 28 is a spider 62. Passing through these two spiders, and having its bearings therein, is the shaft 63, on the end of which is mounted the gear 64, which is in mesh with the worm 65 on the shaft 66. As best shown in Fig. 5, the shaft 66 is driven by means of suitable connection with the motor 33. Mounted on that portion of shaft 63 which lies within the drying chamber 28 are two spirals 67 and 68, which are preferably made of expanded metal or are provided with suitable perforations. These spirals pass around the shaft 63 in opposite directions, so that when air is introduced into the central part of chamber 28 from the passages 26, this air will be carried by the spirals to opposite ends of the chamber 28. In the bottom of chamber 28 is placed a drying medium 69, which is preferably a concentrated solution of calcium chlorid, although any other drying medium, such as sulfuric acid or the like, may readily be employed. Mounted on the edges of the spirals 67 and 68 are strips of leather or other flexible material 70, which serve to make a tight connection with the circular walls of the drying chamber 28. It will now be apparent that as the shaft 63 is rotated, the drying liquid 69 will be raised on these perforated spirals and the air brought into close contact with the drying liquid.

Communicating with each end of the chamber 28 are the outwardly flaring passages 71, each of which communicates with the bottom of a corresponding final drying chamber 72, which is inclosed by the casing 22. As best shown in Fig. 4, the communication between passages 71, 71 and the final drying chambers 72, 72 is through openings in which are placed a plurality of movable slats or louvers 73. Each of these louvers, as best shown in Fig. 2, is pivoted on its longitudinal axis, and rigidly connected with the bottom of the louver is a rod 74, the lower end of which is pivotally connected with a rod 75. The outer portion of rod 75 is threaded, and its movement is controlled by means of the screw 76. By regulation of this screw, which can be effected from the outside of the tower, as clearly shown in Fig. 4, the angle of inclination of the louvers can be governed at will, and the distribution of air passing from passage 71 into a final cooling chamber 72 can correspondingly be regulated. Such a construction is of great advantage, inasmuch as it will be evident that if passage 71 communicated directly with the final cooling chamber 72, the air would tend to remain in the central portion of this chamber.

Each of the chambers 72 is provided on its front and rear portions with the headers 77, 77, between which pass the cooling

pipes 78 in exactly the same manner as the pipes 37 communicate with the headers 36, 36, above mentioned. Each of the headers 77, 77 communicates through pipes 79 with an upper horizontal header 80, and through pipes 81 with a lower, horizontal header 82.

An evaporator 83 is provided in connection with each of the final cooling chambers 72, each of these evaporators being supplied with ammonia through the pipe 84, which communicates with supply pipe 49, a valve 85 being placed in pipe 84 to cut off the supply of ammonia, if desired. From evaporator 83, the ammonia passes through pipe 86 to the headers 82, a suitable branch being connected with the pipe 86 in order to supply both of the headers 82, and then passes upwardly through pipes 81 into the headers 77. The pipes 78 which are in communication with the headers 77 are, of course, filled with ammonia as the level of the same rises in the headers 77. The ammonia then passes upwardly through pipes 79 to the headers 80, and then overflows through pipes 87 back to the evaporator 83. A pipe 88 leads from the two evaporators to the ammonia compressor, which, as explained above, serves to compress the gaseous ammonia from the evaporator 83, and then forces the same to a suitable condenser. In the upper part of each of the final cooling chambers 72 is located a header 89, which, as best shown in Fig. 4, communicates with a row of horizontally disposed pipes 90, each of these pipes, as shown in Fig. 8, having a longitudinal slot on its upper surface. A pipe 91 communicates with each of the headers 89, and has its origin at the pump 92, which communicates through pipe 93 with the drying liquid 69 within the drying chamber 28. As the pump 92 is operated by means of a suitable connection with its pulley 94, the drying liquid 69 is pumped upwardly through pipe 91 into the headers 89, and then passes into pipes 90, from which it is expelled through the longitudinal slots above mentioned. This calcium chlorid or brine thus expelled from pipes 90, falls downwardly onto cooling pipes 78, and serves to prevent the congelation of moisture thereon. As the brine passes downwardly over pipes 78, it finally returns to the drying chamber 28 through the passage 71, and thus helps to keep the drying liquid 69 within the chamber 28 at a low temperature.

The upper end of each of the final cooling chambers 72 is left open and is in direct communication with the passages 96. The two passages 96 in turn communicate with the intake 97 which leads to the blowing engines. In the bottom of this intake is provided a trough or channel 98, in which any moisture in the intake 97 will collect.

Communicating with the lower portion of

the preliminary cooling chamber 21^a is the overflow pipe 99, which leads to the trough 100. A pipe 101 leads from the bottom of trough 100 to a pump which forces this cooled water to the ammonia condenser, or any other place where cold water may advantageously be used. It is thus apparent that the level of water which collects in the bottom of the preliminary drying chamber 21^a will always be kept constant.

Having thus described the construction of the apparatus which I employ, its operation may now be readily understood.

As previously explained, water from the two tanks 45, 45 passes downwardly through the pipes 46, 46 into the troughs 39, from which it trickles downwardly over the cooling pipes 37, and then falls onto the chain screens 35, and finally collects in the bottom of the preliminary cooling chamber 21^a. This water then passes through the pipe 47^b to the pump 47^a from which it is returned through pipe 47 to the tanks 45, 45. It will thus be apparent that the same water is used over and over again in the cooling operation. The cooling pipes 37 are cooled by the action of ammonia, as was explained in detail in the preceding part of the specification. The fans 31, 31 being rotated, air is drawn from the outside through the openings 25, 25 into the preliminary cooling chamber 21^a. This air then passes upwardly between the chain screens 35, over which water is trickling, as just explained, and this water serves to remove the mechanical impurities, such as soot, from the air, and at the same time cools the air, thereby removing a large amount of moisture. The air next passes upwardly between the cooling pipes 37, and is further purified by the action of the water which is trickling over these pipes, and at the same time, inasmuch as the air comes into intimate contact with these pipes, it is further cooled and additional moisture is removed. When the air reaches the top of the preliminary cooling chamber 21^a above the cooling pipes 37, its temperature has been reduced to approximately 35° Fahrenheit, and its moisture content is in the vicinity of 2.75 grains per cubic foot. The moisture which is condensed with the air passes downwardly with the water into the bottom of the chamber 21^a, and this surplus water is then conducted through the pipe 99 into the trough 100, as explained above. The air next passes upwardly through the funnel-shaped outlet formed by the plates 59 and 60, and then passes downwardly, coming in contact with the canvas screens or curtains 61. Any fine mist which has been carried over by the water is caught by these curtains, and this water runs downwardly over the plates 59 into the angle formed between plates 59 and the casing 21, from which position it may be drained by an outlet pipe, as will readily

be understood. The air on striking the canvas curtains or screens 61 forces the same outwardly and passes below these screens into the passages 26, and from thence into the central portion of the drying chamber 28. The shaft 63 passing through the drying chamber 28 is rotated, as explained above, by the motor 33, which also serves to drive the fans 31. The spirals 67 and 68 now serve to conduct the air from the central portion of the drying chamber 28 to the ends thereof, the air being brought into intimate contact with the drying agent 69 of calcium chlorid, or other suitable reagent, this drying agent being carried upwardly by its adherence to the spirals, which action is brought about by the perforations within said spirals. In passing through the drying chamber 28, the moisture in the air is reduced from about 2.75 grains per cubic foot to about 2 grains per cubic foot. The air is next conducted through the passages 71 connected with the ends of the drying chamber 28, and then upwardly through the openings in which are located the shutters or louvers 73. The louvers are so regulated that the air will be directed in such manner that its distribution from the front to the rear of the final drying chamber 72, into which it next passes, will be uniform. The cooling pipes 78 located in the final cooling chambers 72 serve to still further reduce the moisture in the air, so that when the air reaches the tops of these chambers, its content of moisture is approximately 1 to 1.5 grains per cubic foot, and its temperature is about 20° Fahrenheit. As previously explained, calcium chlorid is pumped from the drying chamber 28 through the pipe 91 into the pipes 90. This calcium chlorid then passes through the longitudinal slits in the upper surfaces of these pipes downwardly over the cooling pipes 78, and serves to prevent the congelation of moisture on these pipes. After reaching the upper part of the final cooling chambers 72, the air next passes through the open ends of these chambers into the passages 96, 96, from which it next flows into the intake 97 leading to the blowing engines. It will be apparent that the air when reaching the upper ends of the final cooling chambers 72, 72 will be considerably heavier than the air which is drawn into the preliminary cooling chamber by the action of the fans 31, and for this reason will pass, by the action of gravity, as well as by the forcing action exerted by the fans 31, 31, downwardly to the intake 97. A suction action is thus exerted through the apparatus on account of the fact that the intake 97 is at a lower level than the inlet openings 25—25, and the action of the fans 31, 31 will be facilitated. At the same time, a constant supply of air will flow to the intake 97, thus preventing any danger of forming a partial vacuum in the blowing engines.

I have found it of advantage to use a steel construction for all of the parts which come in contact with the air which passes through the apparatus in the course which I have just described. The advantage of such a steel or other metallic construction is that there is no opportunity for the water which may be condensed from the air, or which is used in the cleaning and drying operations, to be absorbed in the body of the metal and thus crack the same when the water is frozen. On the other hand, if brick are employed, the action of the moisture is very deleterious, inasmuch as this moisture freezes in the body of the brick and cracks and disintegrates them.

I will next describe the modification of the upper part of my cooling tower which is shown in Figs. 13, 14, 15 and 16. The construction of the cooling tower used in this modification is exactly the same as previously described up to the top of the cooling pipes 37, which pass between the headers 36, 36. Directly above the cooling pipes 37 are placed the troughs 39, which are preferably located somewhat closer to the cooling pipes 37 than in the construction previously described. Above the troughs 39 and suitably attached to the casing 21 is the tank 102, the outer sides of which abut against the walls of the casing 21. An opening 103 passes in a vertical plane through the central portion of the tank 102, this opening being of circular shape and formed by the corrugated tube 104. Passing through the center of the opening 103 is the shaft 105, attached to which is the double spiral 106, the diameter of this double spiral being approximately equal to the diameter of the corrugated tube 104 between the inner portions of the corrugations. To the lower end of the tube 104 is attached the frame 107, which has in it openings adapted to register with corresponding openings 108 in the damper plate 109. As most clearly shown in Fig. 16, a portion of the periphery of the damper plate 109 is provided with the ratchet 110, which is in mesh with the worm 111 on the shaft 112, which is controlled by the hand wheel 113. It will thus be apparent that the air passing upwardly through the opening 103 may be regulated as desired. Each of the double spirals 106 is provided on its under surface with a series of radial corrugations 114, whereas the upper surface of each spiral is left smooth. When air passes upwardly through the openings 108, this air is given a spiral, rotary motion by means of the double spiral 106, and any excess moisture in the form of fine spray which may have been carried upwardly from the lower part of the preliminary cooling chamber 21^a is caught on the corrugations 114 and is then led inwardly to the shaft 105, from which it passes to the

upper smooth surfaces of the double spiral 106, or falls directly from the corrugations 114 onto these smooth surfaces. The spirals then serve to guide this water downwardly, and it falls into the troughs 39, or through the openings between these troughs onto the cooling pipes 37. The tank 102 is provided with a plurality of concentric spiral coils 115. As clearly shown in Fig. 14, each of these spiral coils 115 is independent of the others. Above the coils 115 are provided the headers 116 and 117, the header 116 being connected through pipes 118 with a series of coils lying toward the outer portion of the tank 102, whereas the header 117 is connected through pipes 119 with a series of coils lying toward the inner portion of the tank 102. The headers 120 and 121 are located below the tank 102, the header 120 being connected through pipes 122 with the same coils with which the header 117 is connected, whereas the header 121 is connected through pipes 123 with the same coils with which the header 116 is connected. The headers 120 and 121 are connected through pipes 124, 124 with the headers 55, 55, previously described. The pipe 49 leading from the ammonia receiver 48^a branches, and the two resulting pipes pass to the evaporators 125, 125, each of the pipes 49 being directly connected with the coil 126 within the evaporator 125. The liquid ammonia passing through pipe 49, after being conducted through the coil 126, passes into the main body of the evaporator 125. The coil 126, as is well known to those skilled in the art, is used for the purpose of preventing a spraying action when the ammonia is released on its passage into the main body of the evaporator 125. A gage glass 127 is provided on the side of the evaporator 125 in order to determine the height of liquid ammonia within the evaporator. The pipes 52, 52 lead from the bottoms of the evaporators 125, 125 to the horizontal headers 53, 53. The pipes 57, 57 lead from the headers 116 and 117 into the evaporators 125, 125. It will now be apparent that the ammonia from the evaporators 125, 125 will pass downwardly through the pipes 52, 52 into the horizontal headers 53, 53, and then upwardly through the headers 36, 36 and the pipes 37 into the horizontal headers 55, 55. From thence the ammonia passes through the pipes 124, 124 into the headers 120 and 121, and thence through the pipes 122 and 123 into the spiral coils 115. The ammonia then passes through the pipes 118 and 119 into the headers 116 and 117, and thence overflows through pipes 57, 57, back into the evaporators 125, 125, carrying with it the ammonia which has been gasified during the process of cooling. Pipes 128 pass from the upper portions of the evaporators 125 to the separator 129, in which are the offset baffle

plates 130. The function of this separator is to remove any liquid ammonia from the gaseous ammonia which comes from the evaporator 125, and thus prevent this liquid ammonia from subsequently being carried to the ammonia compressor. The liquid which collects in the bottom of separator 129 may readily be returned through suitable drain pipes to the evaporators 125, 125. A pipe 58 leads from the upper part of the ammonia separator 129 to the ammonia compressor in exactly the same manner as was described in connection with the construction which was previously described. The pipes 47 leading upwardly from the pump 47^a pass over the coils 115 within the tank 102. The portions of these pipes which lie over the coils 115 are provided with a plurality of nozzles 131, and a nozzle 132 is also provided at the end of each pipe. Opposite each of the nozzles 131 and 132 is provided a spraying reflector 133, which serves to atomize the water which is expelled through these nozzles and spray it over the surface of the ammonia-cooled coils 115. The water passing downwardly over the coils 115 collects within the tank 102, and may be maintained at any desired level by a suitable float valve, which, for the sake of simplicity, is not shown in the drawings. This float valve is suitably connected with the pipes 47, so that the inlet of water to the tank 102 is suitably regulated. A plurality of pipes 134 lead from the bottom of the tank 102 to the troughs 39. The outflow of water from the tank 102 may be regulated by means of the valves 135 in the pipes 134. In order to insure the maintenance of a uniform temperature in the water contained within the tank 102, I provide, preferably in two opposite corners of this tank, the circulating propellers 136, 136, which are driven by a motor or other similar means, which for the sake of simplicity, is not shown in the drawings. Each of the propellers 136 is inclosed by a casing 137. A tube 138 is connected with the lower portion of each of the casings 137, whereas a tube 139 is similarly connected with the upper part of each casing. The direction of inclination of the blades of the propellers 136 and the direction of rotation of these propellers are such that the water drawn inwardly through the tubes 138 passes upwardly within the casings 137, and is then forced outwardly through the tubes 139. In this way a thorough circulation of water within the tank 102 is obtained, with the result that the temperature is maintained uniform through all of the water within this tank.

Having described the construction of the modified apparatus contained within the upper portion of the preliminary cooling chamber, its operation will readily be apparent.

The air passes upwardly past the cooling pipes 37 in exactly the same manner as previously described. This air, however, next passes through the opening 103, through the central portion of the tank 102, and is directed in a spiral manner by the action of the double spiral 106. As previously explained, the flow of air through this opening 103 is regulated by the damper plate 109. From the opening 103, the plates 140 extend upwardly to the roof of the cooling tower, and form between them a passage which is in direct communication with the passages 26. It will be apparent that instead of employing the curtains 61, any moisture or spray which is contained in the air will be removed by the action of the double spiral 106. From the passages 26, the air passes through exactly the same course as was described in connection with the construction which was first described.

One of the principal advantages of the modification which I have just described is that the water which passes to the troughs 39 is much cooler than the water which passes to these troughs in the embodiment of my invention first described, owing to the fact that this water is cooled by the coils 115 within the tank 102, whereas in the first described embodiment, the temperature of the water in the tanks 45, 45 is approximately the same as that of the water which collects in the bottom of the preliminary cooling chamber 21^a. It will thus be apparent that in the first embodiment the action of the upper pipes of the series of cooling pipes 37 will be merely to cool the water to the same temperature as that which the water has which comes from the tank 102. This being the case, in my modified form of cooling apparatus, if desired, the cooling pipes 37 may be entirely eliminated, and replaced by grates or baffles of any desired description; or the flow of ammonia may be so regulated that it does not pass through these pipes 37, but is confined merely to the coils 115 within the tank 102, using the pipes merely as water distributing means.

It will be apparent that many changes may be made in the apparatus and method which I have described without departing from the spirit of my invention. For example, it will readily occur to those skilled in the art that, instead of using a pair of final cooling chambers, a single one might be employed; again, that the air could be passed horizontally, instead of vertically, through a chamber containing a cooling medium to a final cooling chamber containing ammonia cooled pipes, and then through this final chamber to an outlet located at a lower point than the inlet to the first chamber. From this brief mention of possible modifications, the broad scope of my invention will be apparent.

I claim:

1. In a cooling device, the combination of a preliminary cooling chamber, a pair of final cooling chambers adjacent to and on opposite sides of and of substantially the same height as said preliminary chamber, said final chambers thereby decreasing the radiation from said preliminary chamber, and means for passing through said preliminary chamber into said final chambers a gas to be cooled, substantially as described.

2. In a refrigerating device, the combination of a cooling chamber, means for introducing a liquid cooling medium into said chamber, means for spraying said cooling medium, means for cooling said medium in its sprayed condition, means for retaining said liquid medium in a finely divided state, and means for passing a gas through said chamber, said liquid medium thereby serving to reduce the moisture in said gas and to remove mechanical impurities therefrom, substantially as described.

3. In a refrigerating device, the combination of a preliminary cooling chamber having an inlet thereto, means for cooling said chamber, an intermediate chamber adapted to contain a chemical drier, a final drying chamber outside of and adjacent to said preliminary cooling chamber, means for cooling said final chamber, and means for successively passing through said chambers a gas to be cooled, substantially as described.

4. In a refrigerating and drying device, the combination of a cooling chamber, means for introducing a liquid cooling medium into said chamber, means for finely dividing said cooling medium, a drying chamber below said cooling chamber and adapted to contain a chemical drying agent, means for passing a gas through said first chamber into said second chamber, and mechanically actuated means within said second chamber for bringing said gas into intimate contact with said drying agent, substantially as described.

5. In a refrigerating and drying device, the combination of a cooling chamber, means for introducing a liquid cooling medium into said chamber, means for finely dividing said cooling medium, a drying chamber adapted to contain a chemical drying agent, a passage connecting said first chamber with said second chamber, means for passing a gas through said cooling chamber into said drying chamber, and rotatable spiral means adapted to bring said gas into intimate contact with the drying agent within said drying chamber, substantially as described.

6. In a refrigerating and drying device, the combination of a cooling chamber adapted to contain a liquid cooling medium, means for cooling said liquid medium, means for finely dividing said cooling medium, a drying chamber adapted to contain

a chemical drying agent, a passage connecting said cooling chamber with said drying chamber, a final cooling chamber, cooling means within said chamber, and means for successively passing through said chambers a gas to be cooled, substantially as described.

7. In a refrigerating and drying device, the combination of a first cooling chamber, a second cooling chamber connected with said first cooling chamber, means for passing through said chambers a gas to be cooled, and means for distributing said gas evenly through the cross-sectional area of said second chamber in its flow there-through, substantially as described.

8. In a refrigerating device, the combination of a first cooling chamber, a second cooling chamber connected with said first chamber, means for successively passing through said chambers a gas to be cooled, and a plurality of adjustable louvers adapted to regulate the distribution of the gas in its flow through said second chamber, substantially as described.

9. In a refrigerating and drying device the combination of a preliminary cooling chamber, cooling means within said chamber, a drying chamber connected with said preliminary cooling chamber, said drying chamber adapted to contain a chemical drying agent, means for passing a gas through said preliminary chamber into said drying chamber, spiral means rotatable within said drying chamber for conducting said gas into contact with said drying agent and to the ends of the drying chamber, a pair of final cooling chambers connected with the ends of said drying chamber, and cooling means within said final chambers, substantially as described.

10. In a refrigerating and drying device, the combination of a cooling chamber, a plurality of troughs within said chamber,

said troughs being located side by side and having vertical side walls, one side wall of each trough being corrugated, means for supplying liquid to said troughs, means for cooling said liquid, and means for forcing a gas through said chamber, substantially as described.

11. In a refrigerating and drying device, the combination of a cooling chamber, a pair of tanks in the upper part of said chamber, a plurality of troughs below said tanks and adapted to receive liquid therefrom, a plurality of pipes located below said troughs, means for cooling said pipes, said pipes thereby serving to cool the liquid overflowing from said troughs, and means for forcing through said chamber a gas to be cooled, substantially as described.

12. In a refrigerating and drying device, the combination of a cooling chamber, a pair of tanks in the upper part of said chamber, a plurality of troughs below said tanks and adapted to receive liquid therefrom, a plurality of pipes located below said troughs, means for cooling said pipes, said pipes thereby serving to cool the liquid overflowing from said troughs, a plurality of chain screens below said pipes, and means for forcing through said chamber a gas to be cooled, substantially as described.

13. In a cooling device, the combination of a cooling chamber, a pair of auxiliary cooling chambers adjacent to, on opposite sides of and communicating with said first chamber, said auxiliary chambers being of substantially the same height as said first chamber and thereby decreasing the radiation from the latter, and means for passing a gas through said chambers, substantially as described.

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Witnesses:

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HENRY M. HUXLEY.