No. 707,633. Patented Aug. 26, 1902.

J. F. PLACE.

ART OR PROCESS OF LIQUEFYING AIR OR OTHER GASES AND COOLING BY MEANS THEREOF.

(Application filed Feb. 15, 1901.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1

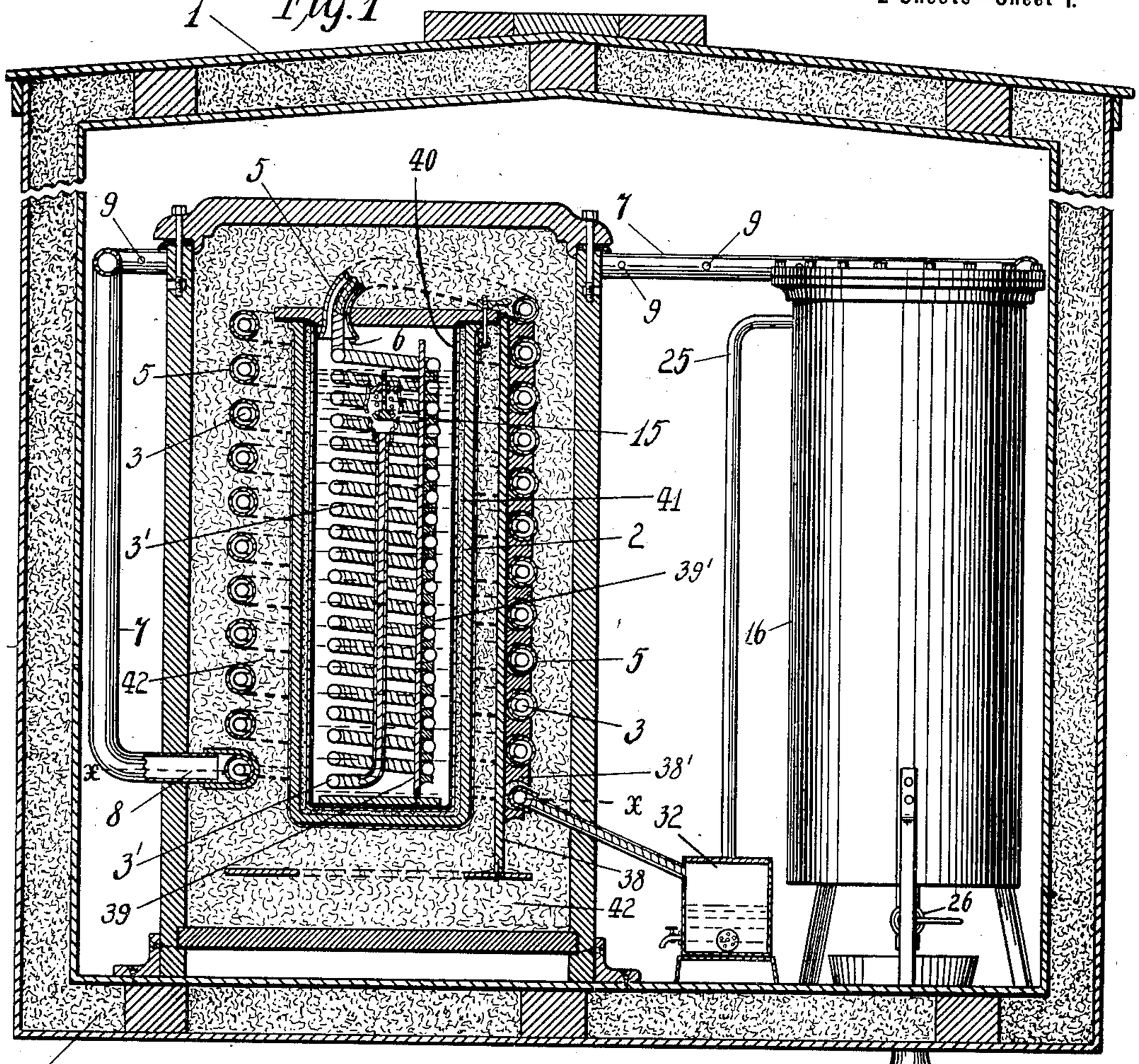


Fig. 4.

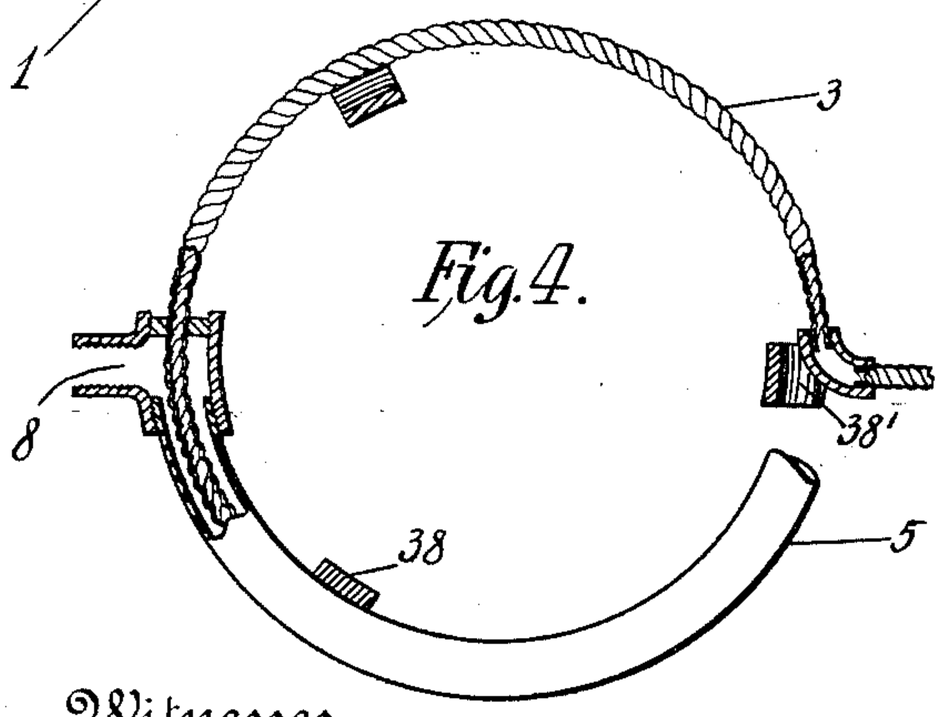


Fig. 6.

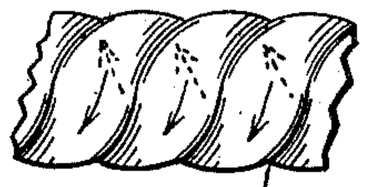


Fig. 6a.

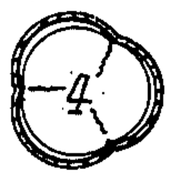
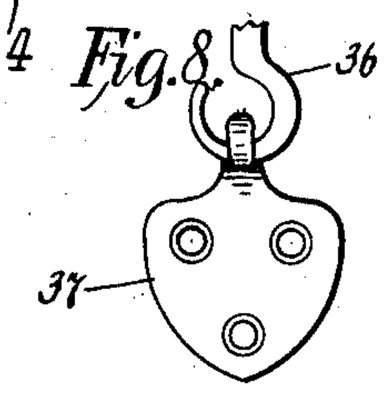


Fig. 7.

Fig. 8.



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No. 707,633. Patented Aug. 26, 1902.

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ART OR PROCESS OF LIQUEFYING AIR OR OTHER GASES AND COOLING BY MEANS THEREOF.

(Application filed Feb. 15, 1901.)

(No Model.) 2 Sheets—Sheet 2.

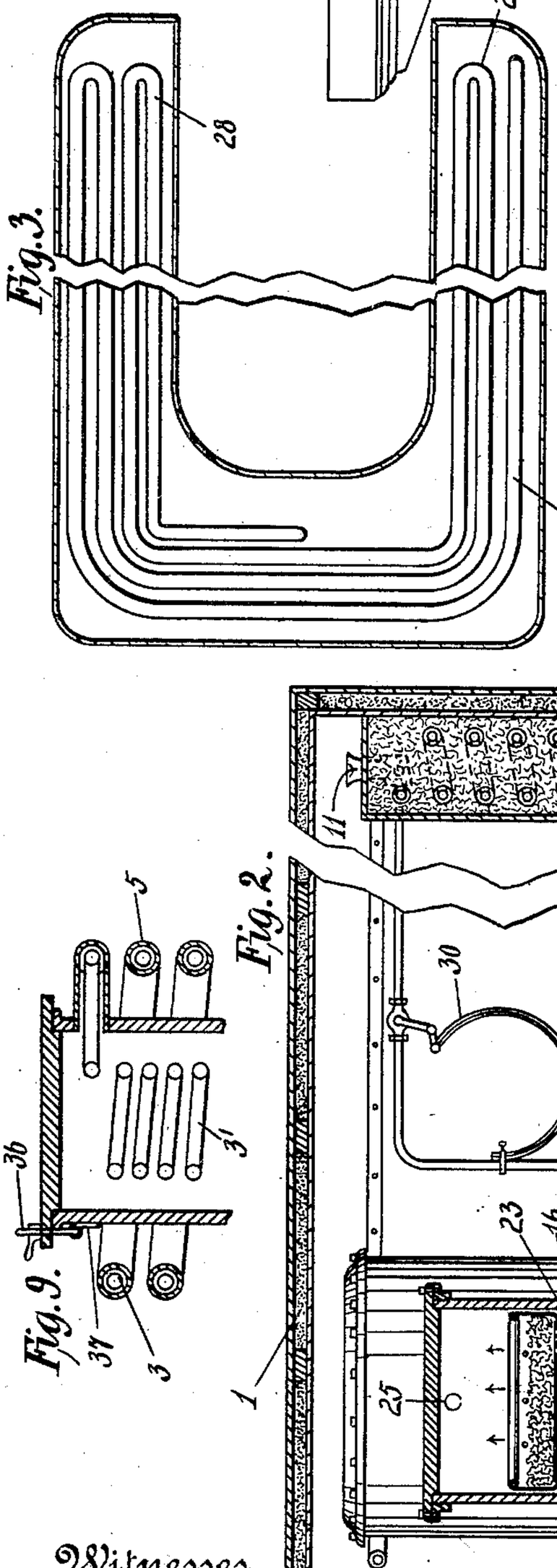

Fig. 3.

Fig. 2.

Fig. 9.

Fig. 5.

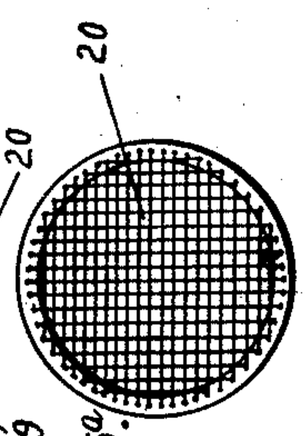

Fig. 5a.

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UNITED STATES PATENT OFFICE.

JAMES F. PLACE, OF GLENRIDGE, NEW JERSEY.

ART OR PROCESS OF LIQUEFYING AIR OR OTHER GASES AND COOLING BY MEANS THEREOF.

SPECIFICATION forming part of Letters Patent No. 707,633, dated August 26, 1902.

Application filed February 15, 1901. Serial No. 47,458. (No model.)

To all whom it may concern:

Be it known that I, JAMES F. PLACE, a citizen of the United States, and a resident of Glenridge, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in the Art or Process of Liquefying Air or other Gases and Cooling by Means Thereof, of which the following is a specification.

My invention relates to an improved art or process of liquefying air or other gases and cooling any given inclosed space by such liquefied air or gas or by means of the said process.

My process also comprises the maintaining of a relatively low temperature within the space to be cooled and automatically regulating and controlling the same.

The invention is adapted to cooling any inclosed spaces—such as cold-storage warehouses or market, hotel, and refrigerator rooms—but is especially adapted to cooling and maintaining a low temperature in so-called "railway refrigerator-cars." By my improved process liquid air is used for cooling the car, which is a much more condensed and compact refrigerant than ice, and while not only cheaper the injury and destruction to the rails and bridges caused by the salt brine dripping from ice-cooled cars are entirely avoided. The delay and expense of refilling the "ice-bunkers," which are very considerable in ice-cooled cars, are also entirely obviated by use of liquid air. The supply of liquid air by my process is obtained by charging compressed air into a condensing apparatus inside the car from any suitable outside source; but preferably it is taken from the air-brake system of the train. The heat of compression in the air can be removed by radiation or by passing the compressed air through pipes or coils in the water-tanks of the tender of the locomotive.

In order that those skilled in the art may understand my improved art or process and be enabled to make use of the same, I have illustrated it in connection with an ordinary railway refrigerator-car and have shown such appliances on the inside and outside of the same as will serve to explain more clearly the art or process of liquefying air under my invention and of cooling by liquid air, maintaining a relatively low temperature in the space to be cooled and regulating said temperature as desired automatically within the space to be cooled. My invention, however, comprises the art or process of liquefying any other gas besides atmospheric air and the cooling of any inclosed spaces or rooms thereby as well as the cold-storage rooms on steamships or other vessels, and the illustrations and descriptions are equally applicable thereto to explain the process.

In the accompanying drawings, which will serve to illustrate my invention, Figure 1 represents a vertical transverse section of a refrigerator-car and shows my liquid-air tank and condenser in vertical section, with the calcium-chlorid holder in side elevation. Fig. 2 is a longitudinal vertical section of the same car, showing also, partly in section, a tender connected to locomotive and in vertical section my improved calcium-chlorid holder or cylinder and the outside or primary counter-current apparatus. Fig. 3 is plan, partly in section, of the locomotive-tender, showing cooling-pipes for compressed air. Fig. 4 is a horizontal view, partly in section, of pipe connections forming the secondary counter-current apparatus within the condenser on the line $x\ x$ of Fig. 1. Fig. 5 is a view in vertical section of one of my improved calcium-chlorid pans, (within the chlorid-holder,) and Fig. 5^a an under side view showing the wire-screen bottom of pan. Figs. 6 and 6^a show a side view and end section of my improved helical tube or conduit for carrying the compressed air, by which a helical or screw-like movement of the compressed air is maintained within the conduit and helically in respect thereto as it is conducted through the conduit, thus bringing all parts of the air or other compressed gas in contact with the interior surfaces of the conduit, so that the heat is the more rapidly taken up by the cold evaporated dry vapor or gas in the counter-current which passes through the larger conduit surrounding the small helical tube. Figs. 7 and 8 are side and front views, on a large scale, of the hinge-bolt which holds the cover onto the inner liquid-air tank within the condenser. Fig. 9 is a modification of the said cover of liquid-air tank, showing how the pipes forming the counter-current apparatus are made to enter

the side, thus allowing the cover to be readily removed for purpose of filling tank with initial charge of liquid air or other liquid gas.

Similar reference-marks refer to similar parts throughout the several drawings.

The compartment or car-body is shown at 1, which may also represent the partition of any inclosed space or refrigerating-room.

2 is the liquid-air vessel, containing an initial charge of liquid air or other liquefied gas, which contains, besides the liquid charge, the submerged conduit or coil 3′, which is a continuation of the conduit 3, which latter forms a part (or the compressed-air-inlet pipe) of what I call my "secondary counter-current coils." As the compressed air, which has been cooled and dried, as will be hereinafter explained, passes through the conduit 3 it is subjected to the cooling action of the dry cold evaporated air or gas derived from the liquid charge in the vessel 2 as said evaporated liquid air passes into the annular orifice 6 and through the outside annular conduit 5 as a counter-current to the incoming column or current of compressed air. This compressed air is subjected to the further cooling action of the charge of liquid air as it passes through the submerged conduit 3′ within said liquid charge, by and in which it is liquefied and is delivered through the valve 15 into the liquid charge, thus replenishing said liquid charge and maintaining continuously a supply of cold evaporated liquid gas to the counter-current in the conduit 5 and through the outlet 8 into pipe 7 and through the holes 9 into the space to be cooled. These conduits 3 and 5 I call my "secondary counter-current apparatus," by which the compressed air is subjected to the cooling action of the evaporated gas derived from the liquid charge, for the compressed air or other compressed gas is first subjected to the cooling action of the evaporated gas derived from the liquid charge after it (the evaporated gas) has been delivered to the space to be cooled from the pipe 7 and before or during the time it is allowed to escape from said compartment or space and is thus partially cooled, as shown at 10. (See Fig. 2.) In this my first or primary counter-current apparatus the cold dry gas or evaporated liquid air is allowed to escape from the cooled space through the opening 11, which connects with the large conduit or coil 12, which surrounds the helical conduit 13, through which the compressed air or other gas is admitted to the compartment to be cooled from the air-brake system 14 or other outside source of supply. The compressed air or other compressed gas as it passes into the conduit 13 is subjected to the cooling action of the escaping expanded and cold air or gases in the surrounding counter-current conduit 12 in a similar manner as in the secondary counter-current apparatus or helical coils surrounding the liquid charge in the vessel 2.

At 16 I show my improved calcium-chlorid holder or cylinder for the purpose of absorbing the moisture from the compressed air or other gas before it is allowed to enter the secondary counter-current coils and condenser or liquid-air vessel 2. This holder is preferably made in shape of a long upright cylinder and is so constructed that the compressed air as it passes through the same is subjected to the drying action of the hygroscopic or moisture-absorbing substance by being brought in contact therewith, and thus the moisture in the air or other gas is absorbed or taken up before it enters the conduit 3. The details of construction of this moisture-absorbing or air-drying apparatus are preferably as follows: In Fig. 5 I show a shallow pan 17, made of tin or sheet-iron, which has a wire edge at 18 to give it strength. At 19 is shown a flange turned in around the bottom edge, and upon the flange I place a coarse-wire screen-disk 20, which forms the bottom of the pan. These pans I place in the cylinder 16 on the flange 21 (with a packing-ring, of leather or rubber, 22, on the flange) to the number of three or more, resting one on top of another. Between each pan is a round packing-ring 23 and 23′, and each pan is filled with the hygroscopic substance, preferably calcium chlorid, broken in small or suitable pieces. The compressed air or other compressed gas is admitted through the pipe 24, and as it passes upwardly in the cylinder 16 through the screens in the pans and through and in contact with the successive charges of the hygroscopic substance (calcium chlorid) the moisture is thoroughly absorbed by said calcium charges through the chemical action thereof, and the dry air or gas emerges from the cylinder through the pipe 25, near the top, and passes on to the condenser. A drip-cock is provided at 26 to draw off the brine as it may gather in the bottom of the holder 16. By placing a few holes 27 through the walls of the pans near the top they are relieved from any air-pressure, while the packing-rings 22 and 23 23′ prevent any of the compressed air from getting to the top of the cylinder without passing through and coming thoroughly in contact with the hygroscopic substance.

At 28 is shown a pipe within the water-tank of a locomotive-tender, through which the compressed air as it comes from the pump 29 is conducted and the heat of compression is practically removed. At 30 I show an ordinary thermostatic governor, by which the amount of compressed air or other gas admitted to the condenser is automatically regulated by the temperature within the cooled compartment, and at 31 I show a purifying brine-tank and at 32 a drip-box to catch any moisture which may have escaped the moisture-absorbing cylinder 16. By the cocks 33, 33′, and 34 the compressed air from the air pump or compressor 29 may be forced through the cooling-pipes in the water-tank or may be passed on to the air-brake system without

going through said cooling-pipes, and by operating the cock 35 the compressed air may be admitted or shut off from any particular refrigerator-car, as desired.

At 38 I show one of three wood supports for the conduits forming the secondary counter-current apparatus, with small wood blocks 38′ between each coil fixed to the upright support, and at 39 I show one of three similar wood supports for the liquefying helical coil within the liquid-charge vessel, with similar wood blocks 39′ between each coil of the helical conduit.

The liquid-charge vessel 2 has a lead lining 40 and insulating-packing 41. This vessel is also thoroughly insulated by the hair-felt packings and coverings 42. The submerged conduit 3′, it will be noticed, is, in fact, a continuation of the compressed-air conduits 13, 25, and 3.

It will be seen from this description that by my process of liquefying air or other gases and cooling thereby compressed air or other compressed gas is taken from an outside source after the heat of compression has been removed and is then subjected to the cooling action of dry cold air or other gas evaporated from a charge of liquid air or other liquid gas in successive counter-currents, the first carrying the dry evaporated liquid air or other evaporated gas after it has been delivered to the space to be cooled and before or during the time it is allowed to escape therefrom as it enters the orifice 11, say, and passes through the conduit 12, and the second carrying said dry cold evaporated air or other evaporated gas (which has evaporated from the liquid charge in the vessel 2) before its delivery to the space to be cooled or after said cold evaporated liquid air has left the liquid charge, but before it has passed from the outlet 8 and pipe 7 into said space, and that during this process or before said compressed air or other compressed gas has been subjected to the cooling action of the aforesaid second counter-current it is also subjected to the drying action of the hygroscopic or moisture-absorbing substance or brought in contact therewith in passing through the cylinder 16, and its moisture is absorbed or taken up thereby. After this thoroughly cooled and dried compressed air or other compressed gas has left the conduit 3 and has passed therefrom into the submerged conduit 3′ it is subjected to the further cooling action of the liquid charge and is successively liquefied by and delivered to said liquid charge through the relief pressure-valve 15. This operation naturally causes portions of the liquid charge to vaporize, and thus said charge is being continuously replenished by the liquefied compressed air or liquid gas from valve 15 and continuously evaporated and the cold evaporated liquid gas therefrom is being continuously supplied through the pipes 5, 8 and 7 and 11 and 12, to the counter-currents and space to be cooled.

Having thus described my invention, what I claim as new and original, and desire to secure by Letters Patent, is—

1. The art or process herein described of cooling by liquid air or other liquid gas which consists in delivering to the space to be cooled a supply of dry cold gas evaporating from an initial charge of liquid air or other liquid gas, and allowing said evaporated gas to subsequently escape from the said space to be cooled, and subjecting compressed air or other compressed gas to the cooling action of said dry cold evaporated gas in successive counter-currents—the first carrying the dry evaporated liquid air or other gas after it has been delivered to the space to be cooled and before or during the time it is allowed to escape therefrom; and the second carrying said dry cold evaporated liquid air or other gas before its delivery to the space to be cooled; and then conducting during the process said cooled compressed air or other compressed gas to and subjecting the same to the cooling action of said initial charge or a replenished charge of liquid air or other liquid gas, and successively liquefying said cooled compressed air or other gas and delivering same to said liquid charge and evaporating the same; thus continuously replenishing said liquid charge and continuously supplying dry cold evaporated liquid air or other evaporated gas to the counter-currents and the space to be cooled, substantially as set forth.

2. The art or process herein described of liquefying air or other gases and cooling thereby, which consists in subjecting a column or current of compressed air or other gas to the cooling action of a counter-current of air or gas escaping from the space to be cooled, and absorbing the moisture therefrom by the chemical action of calcium chlorid then successively subjecting said dry compressed air or other gas to the cooling action of the cold dry gas derived from a charge of liquid air or other liquid gas, in a counter-current, and to the further cooling action of said liquid charge by passing same through a conduit submerged therein, and successively liquefying said cooled dry compressed air or other gas, and delivering same to said liquid charge, and thus continuously replenishing said liquid charge and continuously supplying dry cold evaporated liquid gas from said charge to the counter-currents and space to be cooled, substantially as set forth.

3. The art or process herein described of liquefying air or other gas and cooling thereby, which consists in subjecting a column or current of compressed air or other compressed gas to the cooling action of a counter-current of air or other gas escaping from the space to be cooled; and in also subjecting the same to the drying action of a hygroscopic or moisture-absorbing substance, or bringing same in contact therewith, and thereby absorbing moisture from said compressed air or other compressed gas; and then successively sub-

jecting said dry compressed air or other gas to the cooling action of the cold dry gas derived from a charge of liquid air or other liquid gas, in a counter-current; and to the further cooling action of said liquid charge by passing same through a conduit submerged therein, and successively liquefying said cooled dry compressed air or other gas, and delivering same to said liquid charge; and thus continuously replenishing said liquid charge and continuously supplying dry cold evaporated gas from said charge to the counter-currents and space to be cooled, substantially as set forth.

Signed at New York, in the county of New York and State of New York, this 11th day of February, A. D. 1901.

JAMES F. PLACE.

Witnesses:
CLARENCE PLACE,
C. SEDGWICK.