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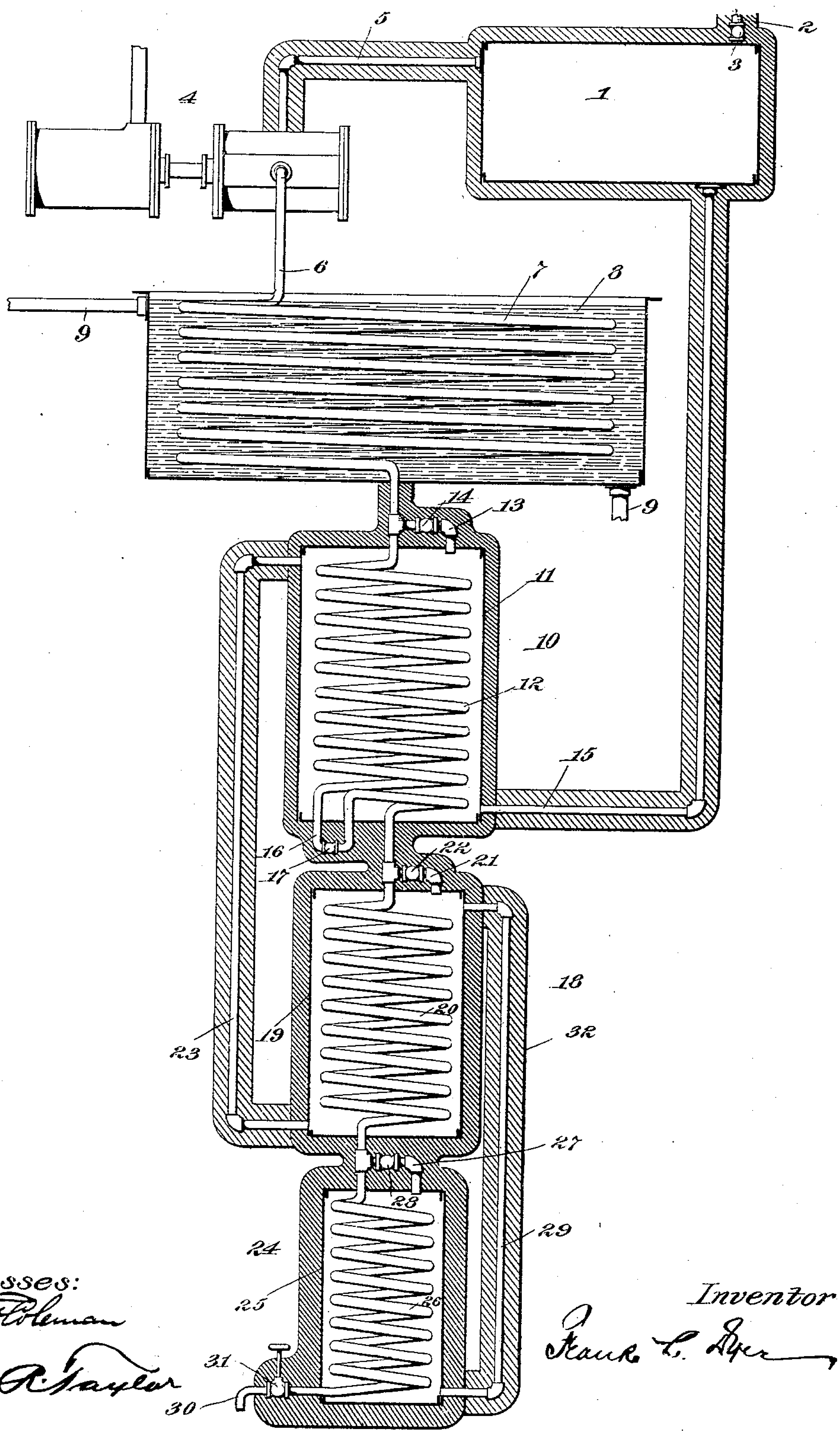
F. L. DYER.

METHOD OF REDUCING THE TEMPERATURE OF GASES OR VAPORS.

(Application filed Mar. 3, 1899.)

(No Model.)



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METHOD OF REDUCING THE TEMPERATURE OF GASES OR VAPORS.

SPECIFICATION forming part of Letters Patent No. 710,957, dated October 14, 1902.

Application filed March 3, 1899. Serial No. 707,599. (No specimens.)

To all whom it may concern:

Be it known that I, FRANK L. DYER, a citizen of the United States, residing at Montclair, in the county of Essex and State of New Jersey, have invented a certain new and useful Method of Reducing the Temperature of Gases or Vapors, of which the following is a specification.

My invention relates to an improved method by which the temperatures of gases and vapors or mixtures of gases and vapors may be reduced sufficiently to result in the liquefaction thereof, or to any point above the temperature of liquefaction, and to improved apparatus for carrying out the method commercially.

The method resides in the fact that when a gas or vapor—simple, complex, or compound—is subjected to pressure the latent heat is converted into sensible heat, resulting in a rise in temperature, and when the compressed gas or vapor is then allowed to cool until in its compressed state it has regained, or approximately regained, its original temperature a subsequent expansion of the gas or vapor, to allow it to regain its original volume, will result in a diminution of temperature. The well-known refrigerating systems depend upon this fact. Obviously the degree of cold which can be secured in this way is limited to the extent to which the degree of expansion can be effected.

In the carrying out of my method it is possible to secure any degree of cold which may be desired and without the necessity of employing prohibitively or uneconomically high pressures.

My method consists in effecting a series—two or more—of refrigerating operations whereby a progressive reduction in temperature will be effected. To this end I first compress the gas or vapor, either simple, complex, or compound, to raise the temperature thereof. The compressed gas or vapor is then cooled in a suitable cooler or condenser, whereby heat will be absorbed therefrom. A portion of the compressed and cooled gas or vapor is now allowed to expand, whereby a drop in temperature will be effected dependent upon the degree of expansion. The expanded portion of the gas or vapor is directed into proximity with the unexpanded portion thereof, so as to reduce the temperature of the latter. By the first stage a compressed gas or vapor will be secured which will be of a lower temperature. A portion of the refrigerated compressed gas or vapor may be now allowed to expand, whereby a further reduction in temperature will be secured. When this is done, the second portion, which is thus expanded, is directed into proximity with the refrigerated compressed gas or vapor, so as to effect a further reduction in temperature thereof. These operations may be continued indefinitely until the desired degree of cold is secured.

The apparatus which I have invented and which forms the subject-matter of a divisional application, Serial No. 54,726, filed April 6, 1901, for the carrying out of this method comprises, essentially, first, a compressor for compressing the desired gas or vapor—simple, complex, or compound—whereby the temperature thereof will be increased; second, a cooler or condenser to permit the compressed gas or vapor to be cooled and which may be either influenced by the atmospheric air or circulating water or by a separate refrigerating system; third, a primary cooling device wherein the bulk of the compressed gas or vapor will be subjected to a cooling effect produced by the expansion of a portion thereof, either in the primary or secondary cooling device, and, fourth, a secondary cooling device wherein the bulk of the compressed gas or vapor cooled in the first cooling device will be subjected to a second cooling effect produced by the expansion of a portion of the gas or vapor cooled in the first cooling device. The apparatus may comprise any further additional cooling devices for securing further and additional cooling effects. Preferably the apparatus also comprises a receiver for supplying the gas or vapor to the compressor and which is connected with the cooling devices, whereby the expanded gas or vapor from the cooling devices will be returned to the receiver to be again compressed. Manifestly the gas or vapor thus returned from the cooling devices will be of a relatively low temperature, thereby representing energy which is conserved by thus returning it to the compressor. Since the expanded portion of the gas or vapor which is expanded in the secondary cooling device is of a lower temperature than the expanded portion of the gas or vapor which is expanded in the primary cooling device, the apparatus preferably consists in providing conduits for returning the expanded gas or vapor from the secondary cooling device through the primary cooling device, and thence to the receiver. In this way efficiency is increased, since the reduced temperature of the expanded gas or vapor from the secondary cooling device is utilized in reducing the temperature of the compressed gas or vapor in the primary cooling device. When the apparatus is provided with additional cooling devices, the return-conduits for the expanded gas or vapor therefrom extend preferably through the preceding cooling devices.

In order that the invention may be better understood, attention is directed to the accompanying drawing, forming a part of this specification, and in which is illustrated a diagrammatic view of the preferred form of apparatus adapted for the carrying out of my method and wherein three cooling devices are shown.

1 is a receiving-tank which is supplied with the gas or vapor to be cooled. When it is desired to employ the invention for the cooling of air, the entrance-pipe 2 communicates directly with the atmosphere. Preferably a check-valve 3 is provided in the entrance-pipe, which opens downwardly by suction to permit the gas or vapor to enter the receiver 1.

4 is a compressor of any suitable type, the suction-pipe 5 of which connects with the receiver 1. I illustrate a simple compressor; but obviously it may be provided with two or any greater number of compressing-cylinders. A discharge-pipe 6 from the compressor connects with a suitable cooler or condenser for reducing the temperature of the compressed gas or vapor. For this purpose the discharge-pipe may be formed into a coil 7, which may be exposed to the air or be immersed in a tank of water 8, having a constant circulation through the circulating-pipes 9 9. Obviously the cooling medium may be a separate refrigerating system or the tank 8 may be supplied with cooling-brine.

10 represents the primary cooling device, which, in its preferred form, comprises a receptacle 11, having a coil 12 therein, which constitutes a continuation of the pipes 6 and 7. An expansion-pipe 13 leads into the receptacle 11 and is provided with an expansion-valve 14 of any suitable type to permit the proper reduction in pressure of the gas or vapor. A pipe 15 connects the receptacle 11 with the receiver 1 to convey back to the receiver the expanded gas or vapor from the receptacle. The coil 12 may be provided with a suitable trap 16, having a valve 17 for receiving any water which may be condensed out of the gas or vapor, which water may be drawn off from time to time.

18 represents a secondary cooling device, which also preferably comprises a receptacle 19 and a coil 20 therein, which coil forms a continuation of the coil 12. The coil 20 may be of a smaller capacity than the coil 12. An expansion-pipe 21 leads into the receptacle 19 and is provided with an expansion-valve 22 therein. The pipe 23 from the secondary cooling device leads, preferably, to the primary cooling device, whereby the expanded gas or vapor from the secondary cooling device will be conveyed to the primary cooling device and thence to the receiver 1. Obviously, however, the pipe 23 may connect directly with the receiver 1, although I consider the former arrangement preferable.

24 represents a tertiary cooling device, which may or may not be used, as desired. This preferably comprises a receptacle 25, having a coil 26 therein, the latter constituting a continuation of the coil 20.

27 is an expansion-pipe leading into the receptacle 25 and having an expansion-valve 28 therein. The pipe 29 from the tertiary cooling device preferably leads to the secondary cooling device, whereby the expanded gas or vapor from the tertiary cooling device will pass successively through the secondary and primary cooling devices and thence to the receiver 1.

Any additional number of cooling devices may be employed, if desired.

The outlet 30 from the final cooling device—in this case the tertiary cooling device—is provided with a valve 31, by which the cooled gas or vapor may be drawn off. When the cooling is effected to the point of liquefaction, the liquefied gas or vapor will be drawn off through this pipe. All of the pipes, receptacles, &c., are preferably heavily insulated with an insulating-covering 32 of any suitable character.

The operation will be as follows: Upon starting the compressor the gas or vapor will be drawn into the receiver 1 through the pipe 2 and past the check-valve 3. This gas or vapor will be compressed by the compressor. If the gas or vapor which is being compressed is not atmospheric air, the valve 31 will be opened to permit air from the system to be expelled. The compression of the gas or vapor results in the conversion of the latent heat into sensible heat, whereby a rise in temperature is effected. The compressed gas or vapor will now be cooled in the cooling device until, in its compressed condition, its temperature has been reduced to the proper point. A small portion of the compressed and cooled gas or vapor is now allowed to expand past the expansion-valve 14 and through the expansion-pipe 13 into the receptacle 11. In thus expanding its temperature will be reduced to an extent proportional to the degree of expansion and the cooling to which it is subjected in the cooler. The compressed gas or vapor in the coil 12 will thus be reduced in temperature, whereby the gas or vapor in the coil 12 will be of the same pressure as the gas or vapor in the coil 7, but will be of a lower temperature than the latter. The expanded gas or vapor from the receptacle 11 being obviously cooler than the gas or vapor entering the receiver 1 through the pipe 2 is returned to the receiver by the pipe 15, whereby the energy will be conserved. A portion of the cooled compressed gas or vapor which has been cooled in the primary cooler 10 is now allowed to expand through the expansion-valve 22 and expansion-pipe 21 into the receptacle 19. A further reduction in temperature is thus secured, which results in the lowering of the temperature of the compressed gas or vapor in the coil 20. The expanded gas or vapor from the secondary cooler is conveyed through the pipe 23 to the primary cooler, where it assists in the cooling of the compressed gas or vapor in the coil 12. It is thence carried through the pipe 15 to the receiver. If a tertiary or other additional coolers are used, the operations described are repeated, each cooling device resulting in a lowering of the temperature of the gas or vapor in its cooling-coil, but without correspondingly affecting the pressure.

It is obvious that when the apparatus is properly operating the only additional gas or vapor which is supplied to the system will be that entering through the pipe 2 and which will be only of sufficient quantity to compensate for the diminution in volume of the gas or vapor in the system due to the lowering of its temperature or to its actual liquefaction.

It will be obvious that after the apparatus has started and expanded gas or vapor from the secondary cooler begins to flow through the primary cooler and from the tertiary cooler through the secondary cooler the quantity of gas or vapor passing through the expansion-valves 14 and 22 may be reduced to secure the same cooling effect. Because of this fact I have determined that the method can be carried out by closing the valves 14 and 22 at all times or by dispensing with them, whereby only a single expanding operation will take place. Assuming the expansion pipes and valves 13 14 and 21 22 to be dispensed with the operation of the apparatus illustrated in the carrying out of the method will be as follows: The compressed gas or vapor after having had its temperature reduced in the cooler or condenser fills the coils 12, 20, and 26 under the pressure of the compressor and at the temperature obtained in the cooler or condenser. By now allowing for an expansion of the gas or vapor through the expansion-valve 28 and pipe 27 a reduction of temperature in the tertiary cooler is effected which will result in the lowering of the temperature of the compressed gas or vapor in the coil 26. The expanded gas or vapor from the tertiary cooler, and which obviously is of a lower temperature than the compressed gas or vapor in the coil 20, will be conducted by the pipe 29 into the secondary cooler, where it results in the lowering of the temperature of the gas or vapor in the coil 20. From the secondary cooler the expanded gas or vapor passes into the primary cooler, where a lowering of the temperature of the gas or vapor in the coil 12 is effected. It will be seen that under the effect of the expanded gas or vapor from the tertiary cooler the temperature of the gas or vapor in the coil 26 will be less than that in the coil 12. The reduction of the temperature of the gas or vapor in the coil 20 results in a gradual diminution in the temperature of the gas or vapor which passes through the expansion-valve 28 and pipe 27, which results in a gradual diminution in the temperature of the gas or vapor in the coil 26 and in the coil 20 of the secondary cooler and in the coil 12 of the primary cooler. In this way a gradual and continued reduction in temperature of the gas or vapor throughout the apparatus will be effected until the ultimate temperature is reached.

In describing the operation of my apparatus as it will take place when only a single expansion is effected I have referred to the tertiary cooler. It will be obvious that this operation may be effectively carried out when only a primary and secondary cooler are employed. The expansion of the gas or vapor in the secondary cooler results in the lowering of the temperature of the compressed gas or vapor therein, and the passage of the expanded gas or vapor from the secondary cooler results in the lowering of the temperature of the compressed gas or vapor in the primary cooler, which in turn results in a lowering of the temperature of the expanded gas or vapor in the secondary cooler, and so on.

The cooling devices of my apparatus consist, preferably, of a coil in which the gas or vapor is maintained under pressure located in a receptacle in which the circulation of the expanded gas or vapor is effected. It will be understood, however, that these elements may be reversed and that the gas or vapor under pressure may be maintained in the receptacle, while the expanded gas or vapor may be circulated through the coils.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is as follows:

The method of refrigerating and liquefying atmospheric air or other gas, which consists in compressing such gas, absorbing and removing by a cooling medium the heat generated in compression, and subjecting a portion of the cooled compressed gas to a series of successive refrigerations at substantially constant pressure, by allowing other portions of the compressed gas to expand from conditions of successively-increasing refrigeration, and applying the successive expanded portions of gas to the refrigeration of the unexpanded portions.

This specification signed and witnessed this 2d day of March, 1899.

FRANK L. DYER.

Witnesses:
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