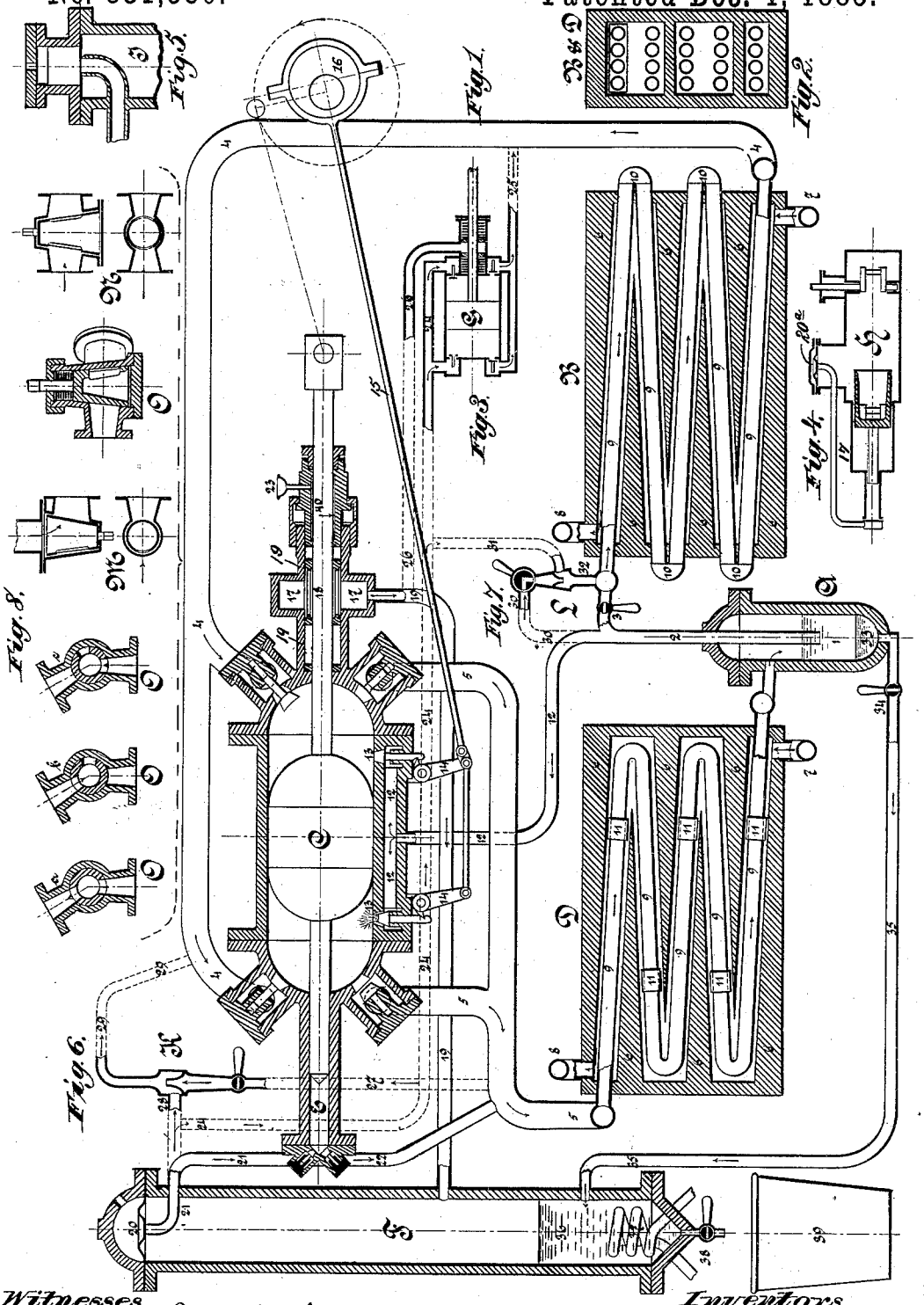
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H. NEHRLICH & A. NEUBECKER.

REFRIGERATOR.

No. 331,530. Patented Dec. 1, 1885.



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(No Model.) 3 Sheets—Sheet 2.

H. NEHRLICH & A. NEUBECKER.

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Fig. 9.

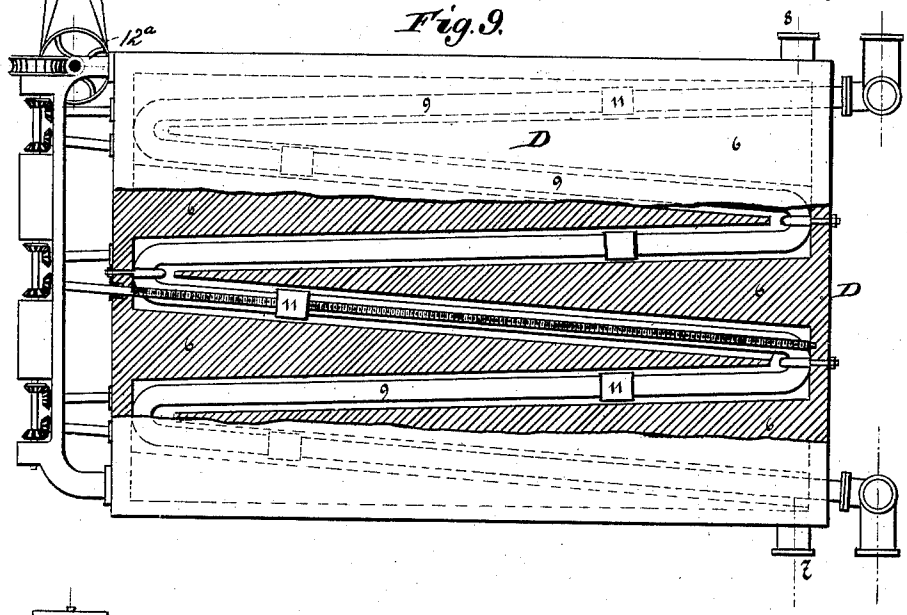


Fig. 10.

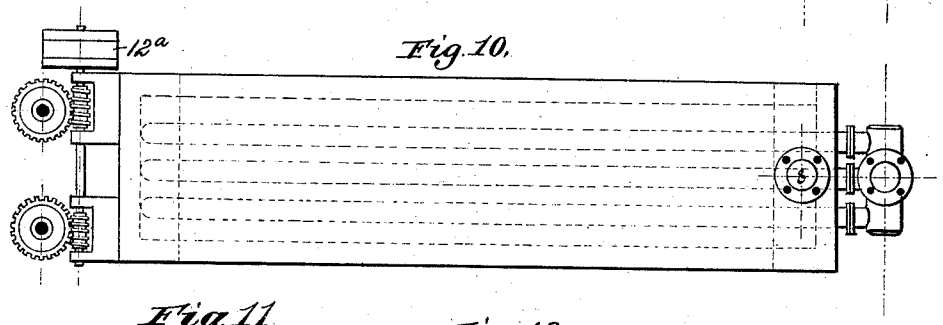


Fig. 11.

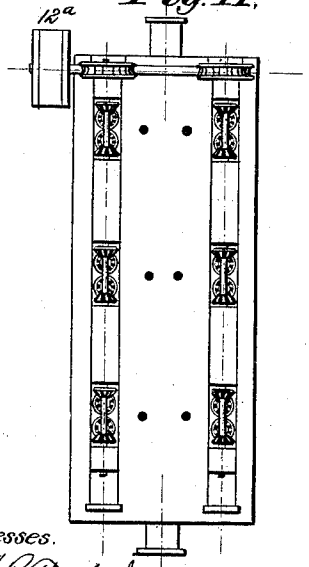


Fig. 12.

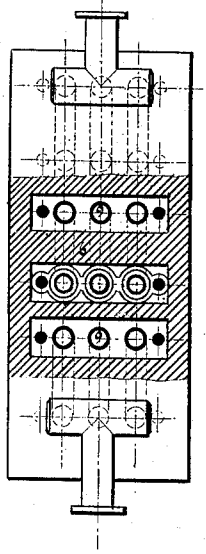


Fig. 13.

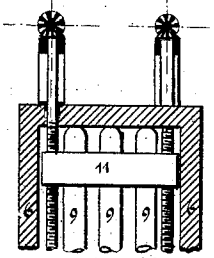
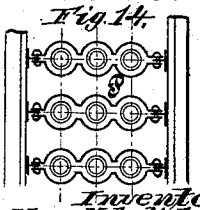


Fig. 14.



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Fig. 15.

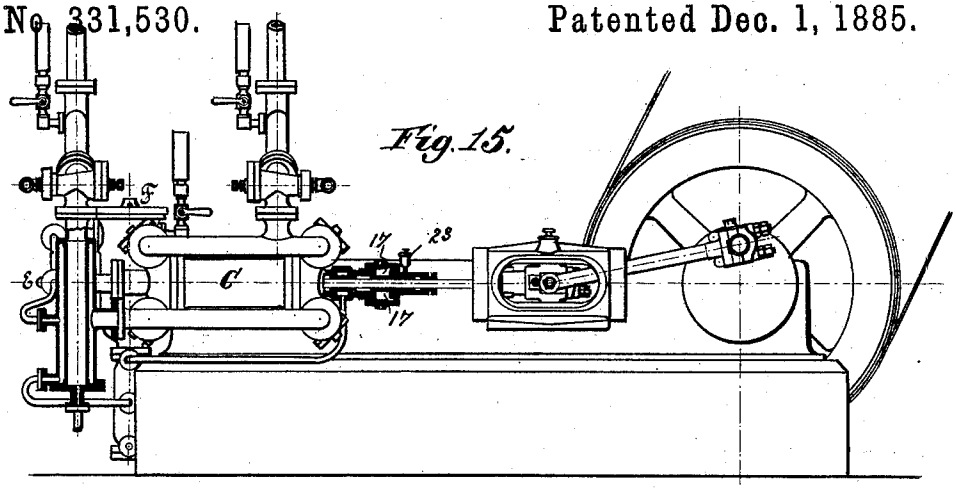


Fig. 16.

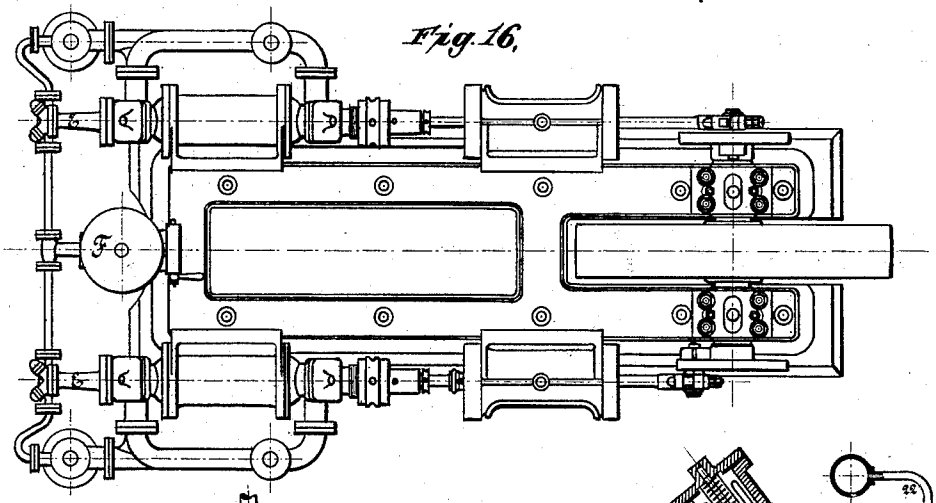


Fig. 17.

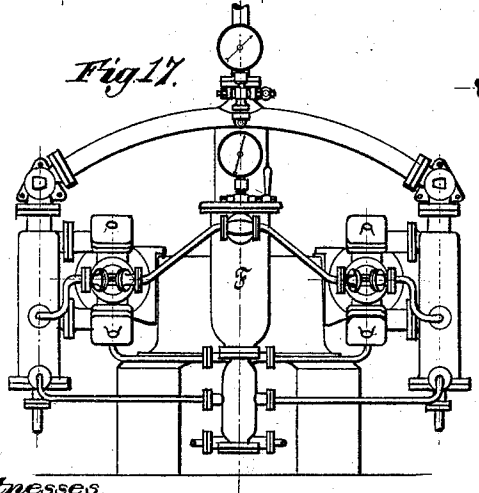
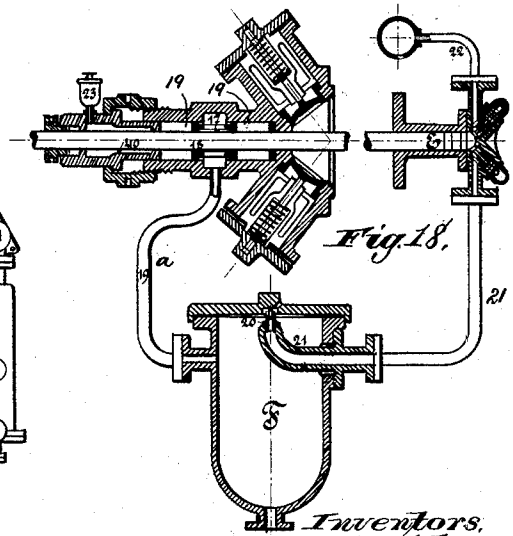


Fig. 18.



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UNITED STATES PATENT OFFICE.

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REFRIGERATOR.

SPECIFICATION forming part of Letters Patent No. 331,530, dated December 1, 1885.

Application filed March 16, 1885. Serial No. 159,058. (No model.)

To all whom it may concern:

Be it known that we, HUGO NEHRLICH, of the city of Berlin, in the Kingdom of Prussia and German Empire, and ADAM NEUBECKER, of the city of Offenbach-on-the-Main, in the Grand Duchy of Hesse, Germany, have invented a certain new and useful Improvement in Refrigerators, of which the following is a specification, reference being had to the accompanying drawings, and to the letters of reference marked thereon.

The machine, as shown in the drawings, is a refrigerating steam-engine, the vapors of which are reduced into their liquid state by mechanical compression. A proper refrigerating substance which has become liquid is to be placed in the receiver A at No. 1. It is conducted into the evaporator B by pipe 2 and the throttle-valve (or cock) 3, where it evaporates, by heating at a low temperature, an external liquid, (preferably a solution of salt.)

Figure 1 is a sectional diagrammatic view of a portion of our improved refrigerating apparatus, showing the receiver, evaporator, compressor, condenser, pump, leveling-vessel, and connections, also in dotted lines the relations of the apparatus to certain modifications of the pumping devices. Fig. 2 is a cross-section of either the evaporator or the condenser, showing their interior construction, which is substantially alike in both. Figs. 3 to 7 illustrate, respectively, the arrangement of certain modifications, to be hereinafter referred to. Fig. 8 illustrates the construction of certain gas-cocks or taps placed in the pipes between the compressor, condenser, evaporator, receiver, leveling-vessel, and donkey-pump. Fig. 9 is an enlarged sectional side elevation of the condenser with cleaning devices. Fig. 10 is a plan view of the same. Figs. 11 to 14 illustrate certain details in the construction of the condenser. Fig. 15 is a general view of our improved refrigerating steam-engine in side elevation. Fig. 16 is a top or plan view of the same. Fig. 17 is an end view. Fig. 18 is a sectional view illustrating a modification in the arrangement of the leveling-vessel, donkey-pump, and compressor-connections.

The vapors flow from the evaporator through pipe 4 into the compressor C, and thence through the pipe 5 into the condenser D, where, under the combined action of the higher tension and a lower temperature produced by another external liquid, they are again precipitated, and accumulate in the receiver A in a liquid state, and thence they recommence their circular motion.

Suppose that this process of producing cold, as well as its theoretical principles, are known, we in the following description of improvements first aim at approaching, as nearly as possible, the mechanical process to the conditions which theory asserts to be of the best and most useful result, and on the other hand to prevent any escape of the volatile refrigerating substance. These improvements are to be carried into effect as follows: In order to lower the differences of temperature which are required to convey the heat at the very lowest degree, a peculiar arrangement of the evaporators and condensers must be provided for. In order to prevent the vapors from being overheated during the process of compression, the liquid refrigerating substance must be conducted into the compressor. In order to prevent the escape of gas out of the compressor, the stuffing-box must be peculiarly and carefully arranged. In order to have the gas-pipe conduits tight and safe, the cut-off valves or stop-cocks must be peculiarly arranged. We also propose to show how the lubricating-oil can be recovered and be made use of, and how the rectification of it takes place inside the machine.

A more detailed description, together with the accompanying drawings, will make it clear why the purposes just enumerated have been pursued, and by what special contrivances they may be arrived at. The mechanical theory of heat teaches that in this process of refrigerating the higher the temperature is at which evaporation is produced the greater will be the quantity of cold (ice) produced, and on the other hand that the relative force required is less the lower the temperature by means of which condensation is effected. The lower temperature—*i. e.*, the temperature at which evaporation takes place—and its useful purpose still requires some further reduction

of temperature—a so-called "difference of temperature"—in order to convey the quantity of heat necessary for evaporation from the external heating liquid to the volatile refrigerating substance through the walls of the evaporator. The higher temperature depends equally upon the supply of cold water at hand, and it must also be raised in order to produce a slight difference of temperature, so that the volatile refrigerating substance may be able to convey its heat to the cold water through the walls of the condenser.

Although in mechanical processes the temperatures needed for useful refrigerating purposes and those of the cooling water cannot be changed, some care may nevertheless be taken that the differences in temperature which the evaporator and the condenser require should be brought down to a minimum, and which ought to be maintained. The motion caused by the working of anything or expansion of fluids generally involves an increasing of the surfaces, which are, however, limited for economical reasons, and great attention must be paid to the given surface being best made use of. It is well known that counter-stream apparatus at an equal extension of surface are of better effect—*i. e.*, require less difference of temperature—than the parallel-stream apparatus or the boiler apparatus, or the combination of the three systems.

All apparatus used hitherto with refrigerating-machines have been lacking more or less in the principle of counter-stream, whether the very imperfect boiler apparatus be used to convey the evaporation and condensation in a direct manner or whether serpentine pipes are used, which are put into a reservoir in form of a boiler. The evaporating and condensing apparatus B and D, as shown in the drawings, are however strictly based on the principle of counter-stream. The volatile refrigerating substance in both of the apparatus must pass through long pipes, as well as the counter-streaming (heating) liquid which is to be refrigerated in the first instance, and, secondly, the cold water which is to be heated. In consequence of this the difference of temperature between the volatile refrigerating substance and those liquids which convey or absorb the heat is reduced to the very lowest degree; therefore the temperature of evaporation relatively to the temperature of condensation has been brought as near as possible to those two extreme temperatures; and, secondly, the heating and refrigerating liquids are better made use of, which in particular have an essential effect upon the quantity of cooling water required for condensation. In consequence of the acquired advantage in the first instance the compressor has more power, because it absorbs thicker vapors and requires less motion, as the tension of compression remains lower.

The apparatus in question may either be composed of straight current-pipes, the same as shown in the evaporator B, said pipes being connected by the caps 10, or of zigzag-shaped pipes, the same as in the condenser D. It is most important that the cooling-surface, in particular, of the condenser is kept clean from slime, so that the transmitting power of the heating capacity of the cooling-surface is not diminished. Cold water, apparently quite clear and pure, after a short time leaves some slime in the pipes.

In order to keep the pipes clean and free from all dirt, a brush apparatus, 11, must be adjusted at the condenser D.

Each apparatus, whether for evaporating or condensing, consists of a rectangular box, which is divided by wedge-like partitions 6 into single rectangular canals, which are placed over each other, and which direct the external liquids to flow upward in wide zigzag lines. The evaporating and condensing liquids flow in through pipes 7, and they flow out through pipes 8. The canals take up a number of pipes, 9, placed beside each other, but only as many as are needed for the cross-section through which the volatile refrigerating substance must flow. The vapors of the volatile liquid substance in the pipes flow in zigzag lines downward, and thus maintain a steady fall, by which means on the one hand the liquid introduced into the evaporator flowing downward greatly influences the heating-surface, and on the other hand the precipitated liquid finds its way downward into the receiver.

In each canal of the condenser D a brush apparatus in shape of a socket, 11, is placed across each row of pipes. All these brushes are moved by some appropriate mechanical power—as, for instance, by an endless chain on the drum 12^a, Figs. 9, 10, and 11—or they are moved backward and forward in some other way. The evaporator B does not want such a cleaning as long as it works with a liquid circulating in a closed circle.

The condenser may be made of corrugated sheet metal, as shown in Fig. 14, such construction offering the advantage that besides profiting by the entire action of the counter-stream principle for the cooling with water, the air will likewise partake in the cooling process by coming in contact with a large area of surfaces.

All the liquid introduced into the evaporator B is reduced into vapor, and therefore the vapor which comes out is thoroughly dry, and is possibly overheated already. Theory tells us that overheating results in the case of vapors compressed into this state, and that an augmentation takes place in the work of the compression which is required for vapors constantly saturated for purely isothermical compression; but the vapors remain saturated, if part of their maternal liquid is mixed up with them, if they come into contact with it. In this case a volatile refrigerating substance is conducted into the compressor C during the process of compression by means of the mechanism shown in the drawings. A conduit of

pipes, 2, 12, and 13, joins the receiver A to the injecting-valves 14, which are set into motion by the working of the lever 15 and eccentric 16 in such a way that they open when compression begins and close again before the compressor is quite lifted. The liquid in the receiver is under the highest compression, and of course thence continues to be injected into the compressor until it has reached the compression needed. Then the injection stops of itself, and therefore only takes place during the proper point of compression.

Instead of the valves 14, round or flat slide valves or cocks may be used, which are set into motion in the same way or by some other appropriate mechanism.

While Linde and others make use of a resisting-liquid in order to prevent the escape of the volatile refrigerating substance from the stuffing-box of the compressor, we place in stuffing-box or annular chamber 17 a box or chamber, 18, only filled with gas and not with a liquid. To keep this chamber 18 open, a movable gas-ring, 19, is inserted in the packing of the chamber 17. The escaping gas is caught in the gas-ring 19 and the chamber 18, and returned into the machine as follows—*i. e.*, the gas-chamber 18 is permanently connected with the adjusting-vessel F by means of the pipe 19ª. From this vessel F an auxiliary pump is sucking, not in a direct manner, but by means of the adjusting-valve 20 and the pipe-connection 21 and 22, and forces the gas which has been caught through pipe 23 back into the machine, in the present case into the condenser.

The adjusting-valve 20 aims at the uniformity of the tension of the gas in the leveling-vessel F, as well as in the fore chamber, 18, connected with it, with the external atmospherical pressure.

The donkey-pump is constructed in such a way that it can suck up with certainty all the gas which has escaped into the leveling-vessel; but as soon as the tension in the vessel F is lower than the atmospherical pressure the valve 20 closes up of itself, and then the pump is emptied. The valve in question is attached to a membrane, which is weighted by the external atmospherical pressure, and internally by the tension of gas. If the pressure in vessel F is going to rise beyond the atmosphere in consequence of the gas having penetrated into it from the chamber 17, then the membrane raises itself along with the valve and the donkey-pump begins to work again.

In the drawings the donkey or auxiliary pump is shown with the piston-rod of the compressor lengthened at the back, and in this way there is no cause for the gas to penetrate into the open air.

By means of the mechanism just described the tension of the gas in the fore chamber, 18, is kept equal to that of the external atmospherical pressure. The chamber 17, which externally separates this chamber, will not allow any gas to escape out of it, and at the same time no air can get into it.

It is well known that all gases diffuse into one another independently of their tensions, and in spite of their equal tensions a trifling exchange of either gas will take place before and behind the stuffing-box 18 if the latter is not perfectly tight, as is generally the case. In order to meet and make up for this deficiency of the interior gas escaping and the external air penetrating into it, the bush 40 of the stuffing-box is provided with a slot, which is oiled from the lubricator-vase 23. This oil has to fill up any deficiencies in the packing, and is to prevent the two gases coming into contact with each other, and thus to prevent their diffusion. The oil-space within the bush 40 of the stuffing-box serves also in a manner well known for smearing the piston-rod. The oil is not made use of in the same sense as the liquid separation by hydraulic packings, for it is not under any tension, nor under the pressure of compression, nor under that of suction, while the latter are.

These contrivances for preventing the escape of gas into the open air are more especially adapted for such machines which work with a refrigerating substance the tension of evaporation of which is higher than the external atmospherical pressure; but they may also be used with refrigerating substances which evaporate lower than at the atmospherical pressure, if only the tension of condensation is higher. If the tension of evaporation is nearly the same as that of the external atmospherical pressure, then it suffices simply to join the suction-pipe of the compressor to the fore chamber. This is the case with Pictet, who uses anhydrous sulphuric acid. Theory teaches us, however, that the liquids used for producing cold (ice) are the better and the more appropriate the more volatile they are—*i. e.*, if under the same proportions of temperature, they evaporate, however high the tension may be. While the simple contrivance made use of by Pictet is limited to a definite refrigerating substance and only works well if the temperature is kept exactly at 10° Celsius, the contrivance in question may be worked with any refrigerating substance, especially with such which are most volatile.

The arrangement of the contrivance above described allows of many variations without altering the essential part of it. The donkey-pump E, for instance, instead of being joined to the compressor may also work as a separate pump, either single or double acting, in a vertical or in a horizontal position. It may be worked by an eccentric, a strap, &c.—as, for instance, the pump G, Fig. 3, which is sucking out the leveling-vessel F through the pipe-conduits 24 and 26, and eventually advances the work through the pipe 25 into the suction-pipe 4 of the compressor, instead of the condenser. The chamber belonging to this separate pump needs the same protection as

the principal stuffing-box, which simply may be brought about by connecting it with the leveling-vessel F by means of the small pipe 26. If the compressor is arranged so as to have its driving mechanisms put into a closed box—as, for instance, is the case with H, as shown in Fig. 4—and having instead of a piston moving backward and forward a shaft turning round, which is seen, then the packed piston is put in the place of the permeable interior chamber, 17, and the box might serve in the same time as the fore chamber, 18, and the leveling-vessel F. For this purpose an adjusting-valve, 20^a, is added to it. The shaft stuffing-box directly becomes an external stuffing-box well protected. The leveling-valve may also be placed under the influence of a piston instead of a membrane—as, for instance, with J, Fig. 5, which is also weighted externally by the atmosphere and internally by gas. The donkey-pump may further be replaced by an ejector, such as K or L.

In the ejector K the compressed vapors of the refrigerating substance flow through the pipe 27 into the nose-pipe or nozzle, Fig. 6, and work on the leveling-vessel in a sucking manner, the ejector being put into communication with the leveling-valve through the pipes 21, 22, and 28. The united vapors flow back into the compressor through pipe 29.

With the ejector L the liquid under pressure in the gathering-pot A, instead of going straight into the evaporator, flows through pipes 2 and 30 into the blast-pipe of the ejector, and sucks from the leveling-vessel through the pipe-conduit 21, 24, and 31, and when united with the absorbed gas the liquid is propelled into the evaporator through pipe 32.

Separations must be placed in the pipe-strings between the compressor, condenser, evaporator, gathering-pot, leveling-vessel, donkey-pump, &c., which make it possible that either of these apparatus, or even the pipe-strings, may at once be separated, as may be necessary, so that any leakage or any other damage may be easily remedied; but the part in question must, if possible, first be emptied by means of the compressor, and the volatile gas must be propelled into the other apparatus. In order to prevent any escape of gas during such manipulations, it is absolutely necessary that the separations in question should be perfectly firm against a high pressure of gas. The well-known self-tightening cocks are very well suited for this. Their handles are pressed into their shell. These taps answer their purpose in one direction only. For instance, if the corner tap, M, and the delivery-tap N, Fig. 8, are closed, they are only self-tightening when the separation ensues, in consequence of some pressure which acts in an arrow-like direction. If the pressure acts in the opposite direction, then the tap is raised and the self-tightening refuses to act. The separations with the machine in question, however, must keep tight in either direction alternately, depending on the separation being inserted either before or behind the tap.

The arrangement O has been assigned to the self-tightening cocks, serving for the purpose just-mentioned. They have been constructed as transit-cocks *a*, the ends of which are not placed in one axis, but they form an angle of one hundred and twenty degrees with each other. If there must be a separation in the direction of *b*, then the higher pressure is also on the tap, as it is in the reverse way *c*. It is a mistake to think that the same advantage will be derived from a rectangular position of the tap end. An experiment will prove the truth of this.

The steam-engine as shown in the drawings is a closed one. While with the hot-steam engine the lubricating-oil consumed is thrown out with the vapors, here by degrees it accumulates and would cause some disturbances during the process if it were not released from time to time; but this cannot be done without being very careful, for the oil, being under the high pressure prevailing in the engine, absorbs a considerable quantity of the volatile refrigerating substance, which, in consequence of the diminution of the external pressure, is released again, and would consequently be lost. The most judicious way of proceeding is to accumulate the oil in pot A, because it is carried away in small particles from the compressor into the condenser; but here it is precipitated with the condensed vapors, and in the end separates itself from the liquid refrigerating substances in consequence of the difference in the specific gravity. In the gathering-pot A it separates itself either above or below, according as these substances may be of lower or higher specific gravity than the oil. If the latter case be adopted, the oil 33 will then be lower than the refrigerating substance.

Pipe 2, which conveys the oil into the gathering-pot A, does not touch the bottom of it, while pipe 35 leads from the bottom of the gathering-pot into the adjusting-vessel F. When tap 34 is opened, the oil 33 flows under the higher pressure from the gathering-pot into the adjusting-vessel F at 36. There it will find atmospherical tension, in consequence of which it releases the greater part of the absorbed gas, which is brought back into the engine by means of the donkey-pump, &c., as has been described already.

In order to release the oil from the least particle of absorbed gas, a small heating-worm, 37, is inserted at the bottom of the adjusting-vessel for the purpose of heating the oil, and it can be released through tap 38—for instance, into bucket 39—and when it has got cool and has deposited any dregs it contained it is again fit for use.

It will be seen that a highly-volatile refrigerating substance of any well-known kind—such as ammonia—is conducted in a liquid form from the receiver A into and through a counter-streaming evaporator, B, the external chambers of which are continuously supplied

with a suitable vaporizing-liquid—such as a solution of salt—the volatile substance being thereby converted into vapor, with consequent lowering of temperature in the vicinity of the evaporator. The vapors thus produced are conducted to the compressor C, and, in order to prevent overheating, this compressor is supplied through the passages 2 12 13, and valves 14 with a portion of refrigerating material from the receiver. Any loss of gas is prevented by the arrangement of the fore chamber, 18, and stuffing-box 17, in connection with the leveling or adjusting vessel F, the latter being employed in connection with a donkey pump or ejector or valve in either of the various ways described, or any modification thereof in such a manner as to conduct back to the machine any portion of gas that may escape from the compressor. It will also be seen that the stuffing-box of the compressor is provided with appropriate lubricating devices so arranged as to also prevent diffusion between the external air and the gas in the fore chamber. This lubricating-oil, after serving the above purposes, is gradually accumulated in the receiving vessel or chamber A, whence it is transmitted to the lower part of the adjusting or leveling vessel F and separated from any absorbed gases without loss of either. The compressed gases are conveyed through the pipes 5 into a counter-streaming condenser, D, the external chambers of which are continuously supplied with a suitable condensing-liquid, and the refrigerating substance thus converted again to a liquid form is returned to the receiver A to again make the circuit above described. By arranging the various connecting-pipes so that they can be readily separated, and providing them with suitable taps or cocks, as set forth, any necessary repairs can be easily made without loss of refrigerating material and with but little delay in the operation of the machine.

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent, is—

1. In a refrigerating-machine, an evaporator or condenser separated internally into compartments by wedge-shaped partitions, whereby the several compartments are alternately inclined in opposite directions, in combination with pipes placed in said compartments for the passage of a refrigerating substance, substantially as described.

2. In a refrigerating-machine, the combination, with the pipes 9, of annular cleaning-brushes 11, placed on and surrounding said pipes, substantially as described.

3. In a refrigerating-machine, the combination, with the receiver A and the compressor C, directly connected by pipes and valved passages, of the counter-streaming evaporator B, the counter-streaming condenser D, and pipes for connecting the receiver, evaporator, compressor, and condenser in a continuous circuit, substantially as described.

4. In a refrigerating-machine, the combination, with the receiver A, the compressor C, and the evaporator D, of the leveling-vessel F, having valve 20 and valved heating-coil 37, and pipes for connecting said receiver, compressor, condenser, and leveling-vessel, substantially as described.

5. In a refrigerating-machine, the combination, with the pump E and compressor C, of the fore chamber, 18, annular chamber 17, and lubricating-vase 23, substantially as described.

6. In a refrigerating-machine, the combination, with the receiver A, evaporator B, condenser D, and compressor C, connected in a circuit by pipes, of the valved leveling-vessel F, the pump or ejector E, the chamber 17, having lubricating-vase 23, fore chamber, 18, and gas-ring 19, pipes for connecting the leveling-vessel F to the receiver, pump, and chamber 17, and pipes and valved passages for connecting the receiver and compressor, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HUGO NEHRLICH.
ADAM NEUBECKER.

Witnesses:
ROBERT R. SCHMIDT,
CARL NOETHE.