(No Model.) 2 Sheets—Sheet 1.

E. RIEGELMANN.

VALVE FOR EXPANSION CYLINDERS OF VAPOR COMPRESSION ENGINES.

No. 521,731. Patented June 19, 1894.

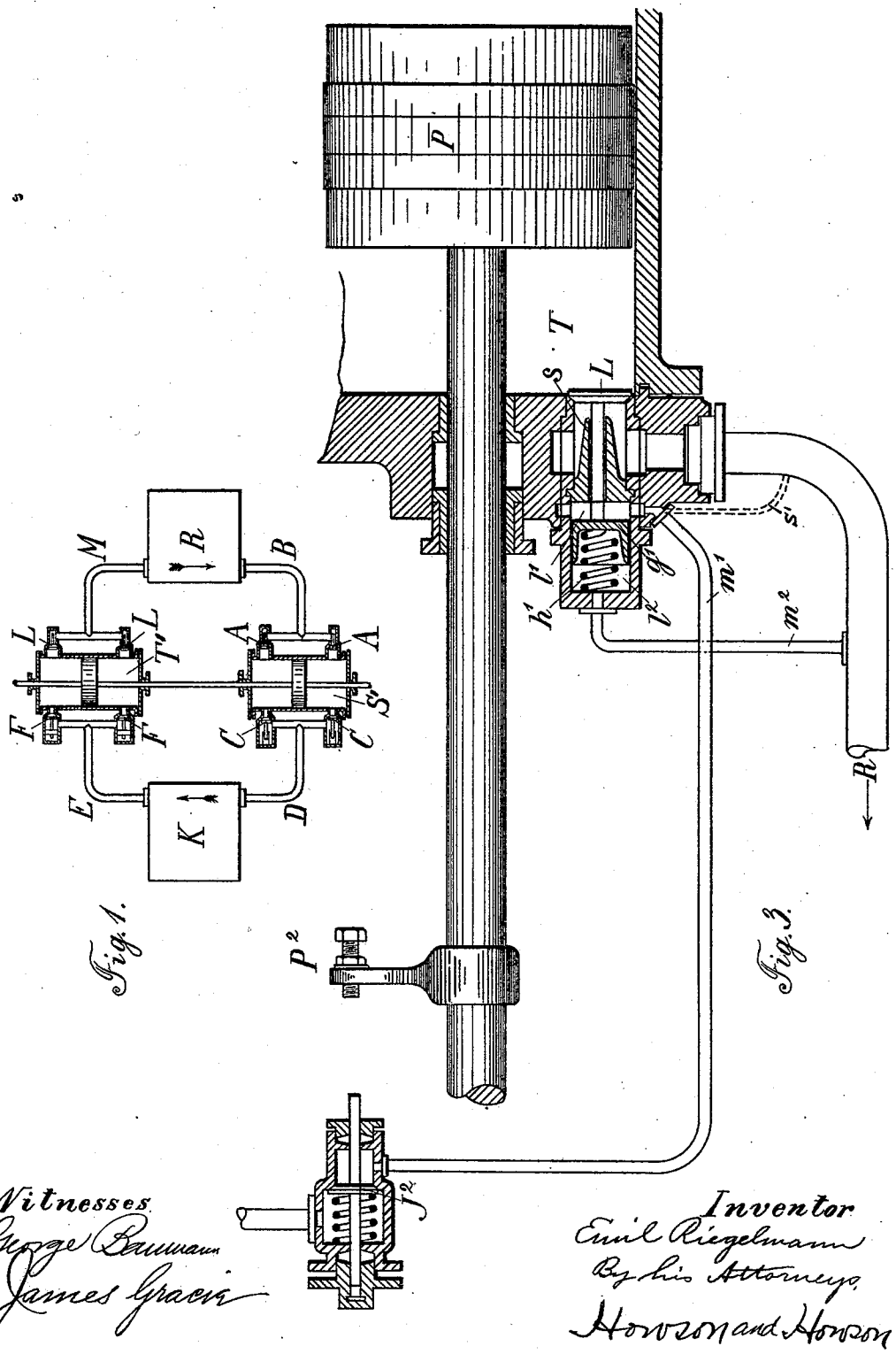

Fig. 1. Fig. 3.

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(No Model.) 2 Sheets—Sheet 2.

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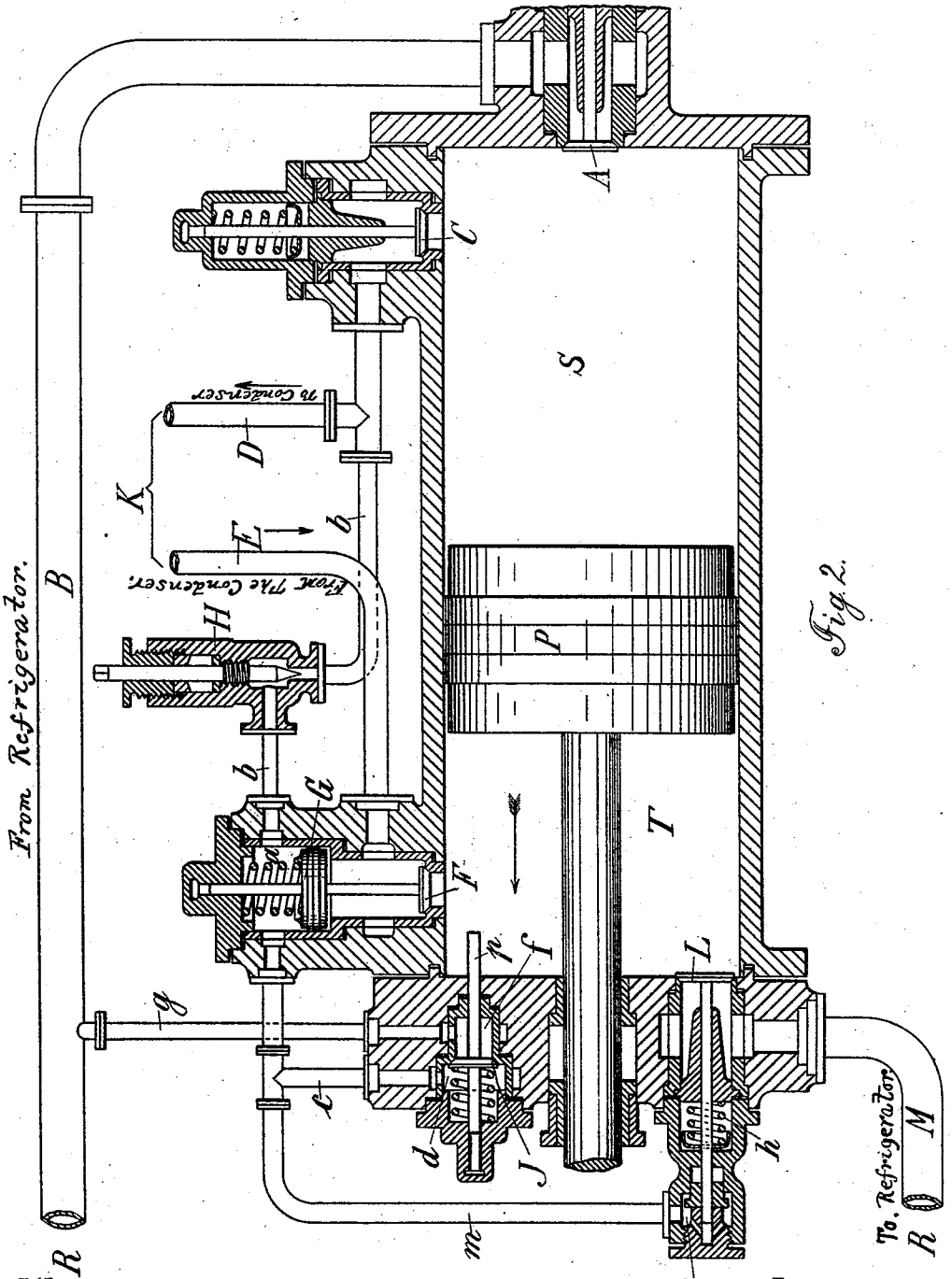

Fig. 2.

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UNITED STATES PATENT OFFICE.

EMIL RIEGELMANN, OF AUGSBURG, GERMANY.

VALVE FOR EXPANSION-CYLINDERS OF VAPOR-COMPRESSION ENGINES.

SPECIFICATION forming part of Letters Patent No. 521,731, dated June 19, 1894.

Application filed December 26, 1891. Serial No. 416,195. (No model.) Patented in Germany June 4, 1891, No. 60,282; in England September 15, 1891, No. 15,629, and in Austria-Hungary August 23, 1892, No. 45,458 and No. 31,740.

To all whom it may concern:

Be it known that I, EMIL RIEGELMANN, a subject of the Emperor of Germany, and a resident of Augsburg, Germany, have invented certain new and useful Improvements in Valves for Expansion-Cylinders of Vapor-Compression Engines, (for which I have obtained Letters Patent in Germany, No. 60,282, dated June 4, 1891; in Great Britain, No. 15,629, dated September 15, 1891, and in Austria-Hungary, No. 45,458 and No. 31,740, dated August 23, 1892,) of which the following is a specification.

The refrigerating liquid, such for instance as carbonic acid, ammonia, sulphurous acid, Pictet liquid, or the like, coming from the condenser of a vapor compression engine possesses a certain capacity for doing work, before it enters the refrigerator where it produces cold by evaporation. This work can be utilized by allowing the refrigerating liquid, on its way from the condenser to the refrigerator, to expand and do work in a cylinder, the so-called expansion cylinder.

In the accompanying drawings, Figure 1 illustrates the general arrangement of a vapor compression engine of this kind. Fig. 2 is a sectional view of my improvement; and Fig. 3 is a modification thereof.

Referring to Fig. 1, the gas which is drawn out of the refrigerator R through the pipe B and valve A, is compressed in the cylinder S′. The compressed gas then passes, by means of the delivery valves C, through the pipe D, to the condenser K, in which it is liquefied by being cooled. The refrigerating liquid now passes through the pipe E and inlet valve F into the expansion cylinder T′ in which it does work that may be utilized in assisting to drive the piston of the compression cylinder S′. The mixture of expanded gas and liquid is conveyed by means of the valves L and the pipes M to the refrigerator R in which cold is produced in the well known manner. The refrigerating liquid thus travels in a continual cycle in the direction of the arrows.

Heretofore the inlet valves F and the outlet valves L of the expansion cylinder have been operated by a mechanical valve-motion, but according to the present invention, the difference in the pressures in the condenser and in the refrigerator is employed to operate those valves. This arrangement is illustrated in Fig. 2, as applied to a vapor compression engine, whose compression cylinder is combined with the expansion cylinder in such a manner that in the right hand half, S, of the cylinder, compression is effected, while expansion takes place in the left half T.

The various pipes and valves are marked with the same letters of reference as in Fig. 1.

The inlet valve F of the expansion half of the cylinder is connected with a piston or movable abutment G which works fluid-tight in a cylindrical casing. The space *a* above the piston G communicates by means of a pipe *b* with the pipe D leading to the condenser K, and by means of a pipe *c* with the chamber *d* of the distributing valve J. The pipe D having no valve the space *a* freely communicates with the condenser. The chamber *f* is connected by a pipe *g* with the suction pipe B coming from the refrigerator R. The valve J is normally held to its seat by a spring, and its rod *p* extends into the cylinder T. A throttle valve H is inserted in the pipe *b*. The outlet valve L of the expansion half T of the cylinder is pressed against its seat by a spring *h*, and the prolonged valve rod works in a closed chamber *l* which is connected by a pipe *m* with the pipe *c*. The pipe M connects the expansion half T, of the cylinder, with the refrigerator. As the piston P in the cylinder S T is about to complete its movement to the left in the direction of the arrow, it strikes against the rod *p* of the valve J, so that the latter opens and communication is made between the chambers *d* and *f*. In consequence of this, the gas contained in the chamber *a* of the inlet valve F, can pass through the pipe *c* to the chamber *d*, thence through the open valve J to the chamber *f*, and through pipe *g* to the pipe B, where a much less pressure exists than in the pipe D. The throttle valve H prevents too quick a rush of gas through pipe *b* to the space *a*, and in consequence of the decrease in pressure in this space *a*, and in response to the pressure on the opposite side of the piston or movable abutment G, this piston G rises, thus opening the valve F, and the condensed re-

frigerating liquid flows out of pipe E into the expansion half of the cylinder. The piston P moves to the right, and immediately after the beginning of this movement the distributing valve J is closed again by the action of its spring, so that the communication between the spaces d and f is interrupted, and gas can no longer flow from the space a to the pipe B. In consequence of this the pressure in the space a soon increases, so that the valve F is again closed. The duration of this equalizing of pressure is determined by means of the throttle valve H. The more the latter is opened, the quicker the valve F is closed, and the smaller is the charge. If it is desired to dispense with this variation of the extent of charge, the throttle valve H can be replaced by a mere fine opening. During the further movement to the right, the refrigerating liquid expands in the expansion half T of the cylinder, and performs work by acting upon the left face of the piston P.

The action of the valve L is as follows:—While the valve J is closed, the pressure of the gas in the pipe m acting upon the valve rod in the chamber l is greater than the pressure of the spring h. When this valve J is opened, the gas in the pipe m finds an outlet through the pipe c, chambers d and f, and pipe g; consequently the pressure in the chamber l on the rod of the valve L is diminished and the spring h closes the valve. During the admission of the refrigerating liquid into the space T and its expansion therein, the pressure of the same tends to keep the valve L closed until the liquid in the space T has, by partial evaporation, reached a pressure equal to that in the refrigerator. Then (the valve J having meanwhile closed) the increased pressure in chamber l causes the valve L to open so that communication is made between the expansion half T of the cylinder and the refrigerator through pipe M. The valve L then remains open until the piston P, nearing the end of its return stroke to the left, acts upon the rod p and opens the valve J, as before explained. Finally the outlet valve L may be caused to close automatically by means of a second distributing valve. Fig. 3 illustrates this modification. The said distributing valve J^2 is arranged, instead of in the cylinder cover, externally to the same, in a separate casing, in such a manner that the valve rod projecting from the casing is struck by an adjustable pin carried by an arm P^2 fixed on the piston rod, thereby opening the valve. The valve L is in this case, modified as regards the construction shown in Fig. 2, by securing on its rod a piston g' which moves in a suitable casing and divides the latter into two spaces l' l^2. The space l' communicates by a pipe m' with one chamber of the casing of the distributing valve J^2, whose other chamber is connected with the condenser, or with the pressure pipe of the latter. In the space l^2 is the spring h' which opens the valve L as soon as the pressure in the space T of the cylinder is equal to or smaller than the pressure in the chamber l'. The chamber l^2 communicates by a pipe m^2 with the refrigerator or with the pipe of the latter.

The operation of this modification is as follows: At the end of the exhaust period, the rod of the valve J^2 is struck by the arm P^2 fixed on the piston rod, thus opening the said valve J^2, whereby the pressure in the chamber l' of the outlet valve rises to condenser pressure, and closes the valve L by excess of pressure upon the piston g' over that of the spring h'. During the next following period of admission, the pressure escapes from the chamber l' to the refrigerator through the small space s or through any other small or throttled way, as for instance through a pipe s' in substitution for the said space s, leading from the chamber l' to the refrigerator pipe, so that at the end of the expansion period refrigerator pressure exists in the chamber l'. Now, as the chamber l^2 is constantly under refrigerator pressure, the piston g' is without influence on the valve L; the latter is solely under the influence of the spring h' which opens it as soon as the pressure in the expansion space T has fallen to refrigerator pressure. The distributing valve J^2 might be arranged in the cylinder cover similarly to the distributing valve J shown in Fig. 2, and be opened by direct impact of the piston. Also the valve J of the first described arrangement can, similarly to the valve J^2, be arranged externally to the cylinder cover in a separate casing, and the rod p be actuated by an arm fixed on the piston similar to the arm P^3, or by any other suitable part of the engine.

In a double acting expansion cylinder, it will be evident that each end of the cylinder will receive the same arrangement.

Instead of transmitting the work of the expansion cylinder to the compression cylinder, the said work may be utilized in any other manner, as for example in an independent motor.

I claim as my invention—

1. In a vapor compressing engine having a refrigerator and a condenser, the combination of the expansion cylinder and its piston with an inlet valve and a movable abutment therefor moved in one direction by condenser pressure and in the other by refrigerator pressure, and outlet valves for the expansion cylinder controlled by condenser pressure, substantially as described.

2. In a vapor compressing engine having a refrigerator and a condenser, the combination of the expansion cylinder and its piston with inlet and outlet valves for the expansion cylinder, supplementary controlling valve J, a pipe connection from one side of the valve J to the condenser and from the other side of the valve to the refrigerator, the said valve J being operated by the piston to control the action of the pressure from the

condenser on the said inlet and outlet valves, all substantially as described.

3. The combination of an inlet valve for the expansion cylinder controlled by a piston working fluid-tight in a casing with a pipe connection between the condenser and the space between the valve and its piston, two pipe connections with the space on the other side of the piston, one communicating with the condenser and being throttled, the other leading to the refrigerator and provided with a valve, and means for automatically opening and closing the last named valve, all substantially as and for the purpose set forth.

4. The combination of an outlet valve for the expansion cylinder to the refrigerator and a valve casing, with a spring to close the valve, a pipe connection leading from the condenser to the casing back of the valve rod, whereby the pressure from the condenser overcomes the pressure of the spring as soon as the pressure in the expansion cylinder is about the same as that in the refrigerator, and means for controlling the pressure from the condenser on the back of the said valve rod, substantially as and for the purposes set forth.

5. In a vapor compressing engine having a condenser, the combination of the expansion cylinder with an inlet valve for the cylinder, a piston to control the said valve a pipe communicating with the condenser and leading to the space beyond the piston, and an adjustable throttle in the said pipe, substantially as and for the purpose set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

EMIL RIEGELMANN.

Witnesses:

JOSEF NIEMTOCTIS RUN,

HANS HÄMERLE.