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METHOD OF AND APPARATUS FOR PRODUCING VAPOR SATURATION

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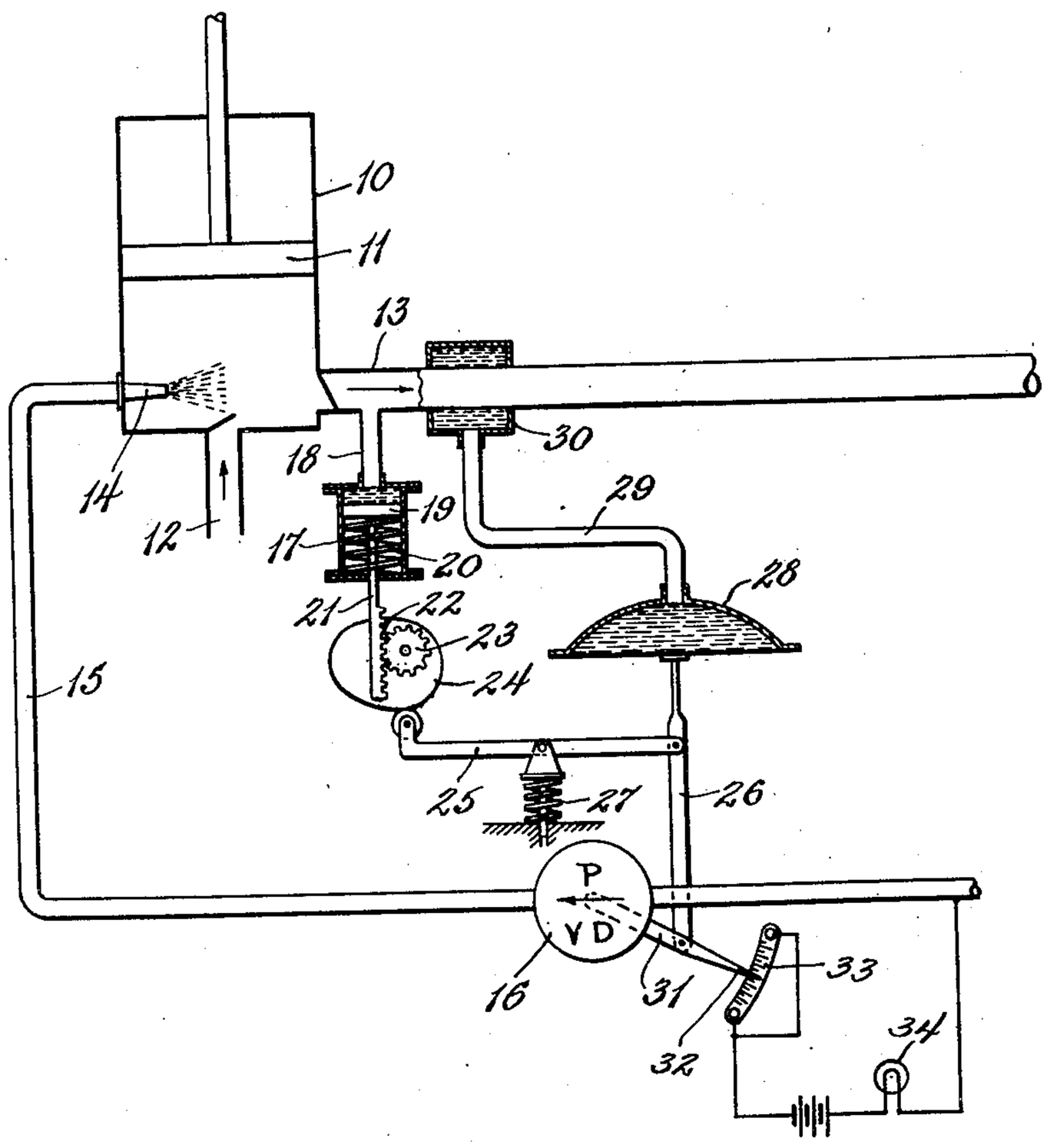

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METHOD OF AND APPARATUS FOR PRODUCING VAPOR SATURATION

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3 Claims. (Cl. 230—208)

This invention relates to a method of and apparatus for producing substantially constant saturation of a vapor under varying compression pressures and, among other objects, aims to provide improved means for injecting a liquid into a compressor during the compression stroke and controlling the injection automatically in response to both the temperature and the pressure of the vapor discharged from the compressor. The idea is to reduce the energy required to pump a given volume of vapor or gas from one temperature and pressure to a higher temperature and pressure by injecting liquid into the cylinder during the compression stroke so that the final state of the delivered vapor or gas is at a lower temperature than it would have been without liquid injection and near the saturated condition. In short, the vapor is compressed at constant quality and more vapor or gas is delivered from the cylinder discharge at the same pressure, but at lower temperature, with less expenditure of energy, on the same weight of vapor passing through the cycle. A unit weight of vapor has a definite latent heat capacity at a given pressure; therefore, the greater weight delivered per unit of expanded energy, the greater the heat pumping capacity of the compressor.

Other aims and advantages of the invention will appear in the specification, when considered in connection with the accompanying drawing, wherein:

The figure is a diagrammatic illustration of one form of apparatus capable of practicing the method.

In many industrial processes, such as the manufacture of artificial ice using an ammonia compressor, for example, vapor is compressed to increase both its temperature and pressure. When the vapor is compressed to a very high pressure, it is superheated. This invention, therefore, aims to provide a novel method of and apparatus for producing substantially constant saturation of the vapor while it is undergoing compression in order to reduce the power required to drive the compressor for a given operation. To this end, the method involves the injection of a liquid of which the vapor undergoing compression is composed at a temperature preferably, though not necessarily, higher than the temperature of the vapor in the cylinder at its final compression pressure and controlling the injection of said liquid in response to relative variations in the pressure and temperature of the vapor as it is discharged from the compressor. The liquid is preferably injected into the cylinder in the form of a fog or very fine mist and is introduced continuously during the compression stroke so that it almost immediately evaporates and commingles with the vapor undergoing compression. For the purposes of this explanation, it will be assumed that the compression is adiabatic.

Referring particularly to the illustrative apparatus for practicing the method, there is shown a vapor compressor 10 having a reciprocating piston 11. The vapor is delivered from an evaporator to the cylinder through an intake conduit 12 and is discharged through an outlet conduit 13 leading to the heat exchanger. A spray nozzle 14, conveniently of the fuel injector type used in Diesel engines, is connected to discharge into the cylinder and is supplied with the saturating liquid through a conduit 15 by a variable discharge pump 16, also of the type generally employed in Diesel engines. The variable discharge pump is controlled in response to differentials between pressure and temperature of the discharged vapor. In this instance, a pressurestat, including a cylinder 17, is connected to the discharge outlet 13 by a conduit 18. A piston 19 in the cylinder is acted upon by the vapor and is normally held in the position shown by a coil spring 20 of the required compression strength. If desired, the strength of the spring may be varied in a well known manner to vary the amount of delivered superheat. A piston rod 21 having rack teeth 22 meshing with a pinion 23 rotates or oscillates a cam 24, the surface of which is shaped to correspond with the pressure-temperature curve setting of the particular vapor at saturation. The cam will be different shapes for different vapors.

In this example, the cam 24 acts on one end of a pivoted lever 25 which is pivotally connected at its other end to a link 26. The pivot is shown as being mounted on a compression spring 27. A temperature responsive device is also connected to the link 26. It is shown as being of the fluid pressure type having a diaphragm on a diaphragm casing 28 connected by a conduit 29 to a jacket 30 around the outlet pipe 13. The arrangement is such that movement is imparted to the link 26 in response to differentials in pressure and temperature. This link is connected to a control arm or member 31 of the variable discharge pump 16. As long as the pressure and temperature of the discharge vapor remain substantially constant, the control mechanism will operate to deliver a constant quantity of liquid to the cylinder through the discharge nozzle 14. If the vapor should become superheated the quantity of liquid introduced will be increased. The pressurestat and

thermostat are so connected that they respond almost immediately to changes in pressure and temperature of the discharging vapor. They are preferably arranged as near as is convenient to the discharge outlet of the compressor.

Assuming that the temperature remains substantially constant while the pressure varies, cam **24** moves the lever **25** up or down which will, in turn, lower or raise the link **26**. When the link is lowered, more liquid is discharged by the pump. When the pressure is constant and the temperature varies, the diaphragm moves lever **26** accordingly. Of course, the effect of the temperature changes is modified by the pressure. As the arm **31** is moved down, the quantity of the saturating liquid injected is increased. It will be understood that the pump is operated intermittently in the same manner as the fuel pump for a Diesel engine. The driving mechanism forms no part of the present invention.

In some instances, it is desirable to employ means to indicate the condition of the discharged vapor. For example, the liquid injector or the pump may fail to function and the vapor will be superheated, causing the normal troubles due to excessive temperatures. In that case, an attendant should be notified of such condition. To that end, a suitable indicator, conveniently in the form of a pointer **32** on arm **31** cooperates with a scale **33** to indicate the quality of the vapor by the position of the pointer. Also, a suitable remote signal, in the form of a lamp or bell **34** may be connected to the indicator to notify the attendant of an abnormal condition.

It will be apparent to those skilled in the art that the illustrative control mechanism is subject to wide variations and may take many different forms. However, in all cases, the action of the temperature responsive means will be modified by the pressure responsive means to operate the control means. It is also contemplated that such control devices will have a very wide application to industrial processes wherein compressed vapors are employed and that, by maintaining the compressed vapors at substantially constant saturation an appreciable amount of power required for compression may be saved. For example, one pound of ammonia vapor compressed adiabatically from a pressure of 34.28 pounds absolute and 5° F. to a pressure of 170 pounds absolute will require approximately 5% more energy than when compressed from the same condition to the same pressure and at a final temperature of 86° F. by injecting approximately .105 pound of atomized liquid ammonia into the cylinder, lowering the superheat and taking up this energy by changing the liquid ammonia into vapor or by taking up the heat of superheat by the latent heat of the liquid ammonia.

While the particular apparatus shown necessarily practices the described method, it will be understood that the invention is not limited to such apparatus. Moreover, it is not indispensable that all the features of the illustrative embodiment thereof be used conjointly, since they may be employed advantageously in various combinations and sub-combinations.

What is claimed is:

1. That method of producing substantially constant saturation of a vapor in a compression chamber under varying compression pressures which comprises injecting saturating liquid at a temperature above the temperature due to final compression pressure into the vapor while it is undergoing compression and controlling the injection automatically in response to both the temperature and pressure of the vapor immediately after it leaves the compressor, throughout the range of temperatures and pressures for a saturated condition of the discharging vapor.

2. In combination with a vapor compressor of the character described, a spray nozzle connected to inject a saturating liquid in the form of a fine mist into the compressor; a variable delivery pump connected to the nozzle; a thermostat responsive to the temperature of the vapor as it is discharged from the compressor and connected to exercise a controlling effect on the variable delivery pump; means responsive to the pressure of the discharging vapor; and means connecting the pressure responsive means to modify the controlling action of the thermostat in accordance with the pressure temperature curve at saturation of the particular vapor acted upon.

3. In combination with a vapor compressor of the character described, means connected to inject saturating liquid in the form of a fine mist into the compressor; a variable delivery pump connected to supply said saturating liquid; temperature and pressure responsive devices connected to the discharge side of the compressor and both arranged to control the variable delivery pump in response to relative changes in pressure and temperature; and a signal device connected to signify an abnormal condition of the vapor.

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