Sept. 13, 1938. J. S. BAKER 2,129,638

QUICK STARTING VAPOR MOTOR

Filed Nov. 10, 1934

Fig. 1.

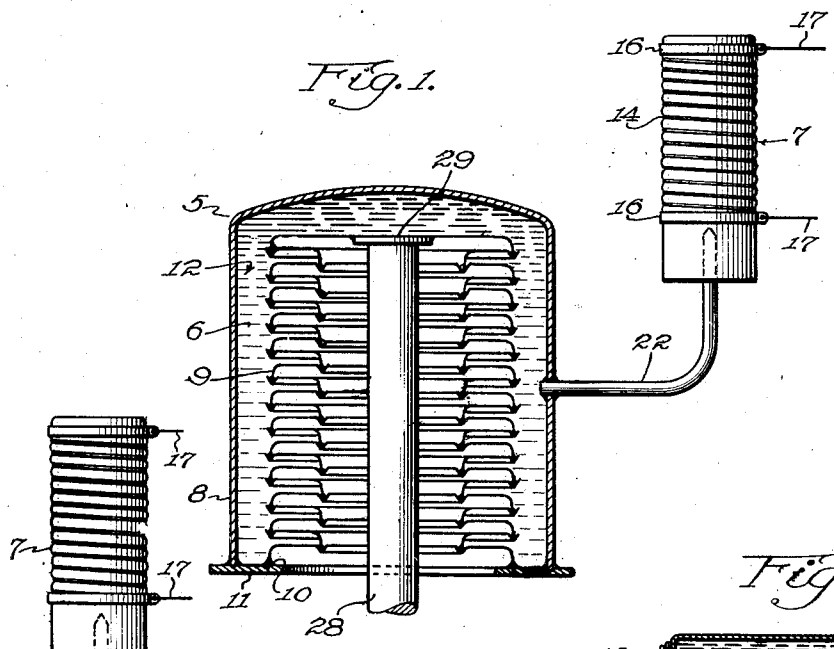


Fig. 2.

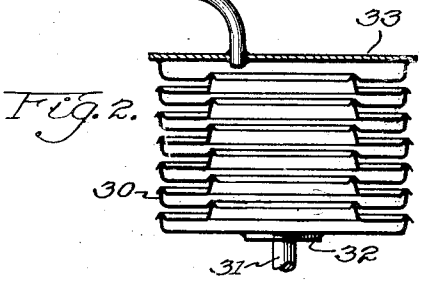


Fig. 3.

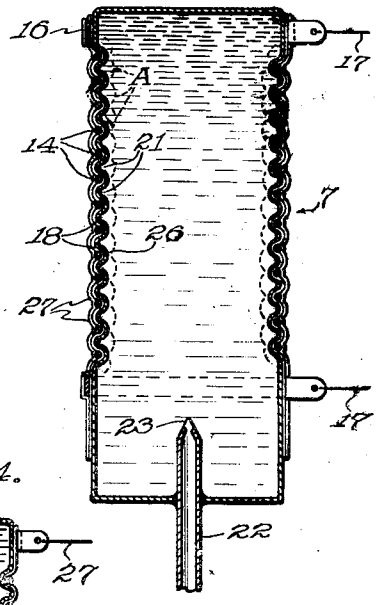


Fig. 5.

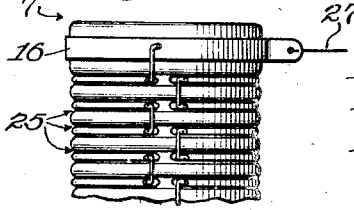
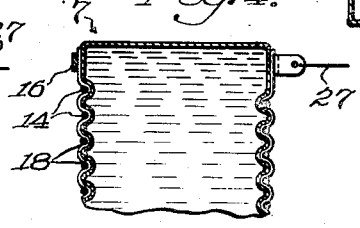


Fig. 4.



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2,129,638

QUICK STARTING VAPOR MOTOR

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Application November 10, 1934, Serial No. 752,416

2 Claims. (Cl. 60—25)

My invention relates to heat motors or thermally controlled vapor motors, and more particularly to motors of the type adapted to be influenced by a volatile liquid or like means.

It has heretofore been proposed to provide in a vapor motor a liquid pressure container for a volatile liquid and a heating element in heat inter-changing relation therewith, the latter developing the heat for vaporizing or expanding the liquid in the container. Typical of this type of vapor motor is the structure disclosed and claimed in United States Letters Patent No. 1,885,285 granted to Lawrence M. Persons on November 1, 1932 and assigned to the present assignee.

In vapor motors of this type, an electrical resistance coil is located adjacent to and usually in contact with the wall to influence the volatile liquid by the conduction of the heat through the wall. I have found, however, that one of the chief difficulties in the design and operation of vapor motors generally is that a rapid transfer of this heat, and thereafter a rapid expansion or volatilization of the volatile fluid, cannot be obtained so that operation of the motor can be obtained practically co-instantaneously with the flow of current through the heating element. In the type of motor disclosed and claimed in the aforesaid patent, a closer approach to this rapid operation has been obtained than in other types, say where the heat is applied to influence the entire body of volatile liquid in the motor. By providing a heating zone or chamber communicating with a work chamber, a limited amount of volatile liquid is influenced by the applied heat, and consequently, a smaller amount of this liquid need be vaporized to obtain the required expansion to produce the working stroke desired.

But I have found that, notwithstanding this arrangement of the heating zone and work chamber, and the smaller amount of liquid that need be vaporized, circulation of the volatile liquid in the heating zone begins as soon as the heat is applied, the warm liquid next to the wall of the heating chamber rising to the top and flowing toward the center and then downwardly through the center. Such circulation continues until substantially all the volatile liquid is hot before any vaporization will occur, with the result that vaporization is considerably delayed.

Moreover, where the heating element is wound about the exterior of the heating chamber, the wall of this heating chamber is engaged by the heating element by only a line contact. This method of applying the heating element results in a loss of a high percentage of heat by exterior radiation and convection. Furthermore, a large portion of the heat actually transmitted through the wall is absorbed through the heating of substantially all the volatile liquid in the heating chamber to a relatively high temperature before vaporization. I have found, however, that it is not essential to heat substantially all the volatile liquid in the heating chamber to secure rapid vaporization capable of producing the required working stroke. Moreover, I have found that a greater heating efficiency may be obtained by arranging the resistance coil in more intimate contact with the wall of the heating chamber, which not only has for its advantage the conduction of a high percentage of the heat, but also a construction within the heating chamber which permits rapid vaporization of small quantities of volatile liquid capable of accumulatively producing sufficient expansion of the power motor to deliver the desired power stroke.

One form of vapor motor structure obtaining rapid starting has been disclosed and claimed in United States Letters Patent No. 1,902,260, granted to Lawrence M. Persons on March 21, 1933, and likewise assigned to the present assignee. In this structure the starting period is reduced to about one third of the time formerly required. It is the purpose of the present invention, however, to reduce the starting period to a matter of a few seconds after the current flow through the heat coil instead of a matter of minutes as heretofore possible. Accordingly, the vapor motor embodying the present invention has obtained a capacity for work that could not be heretofore obtained, and has a speed of operation that vapor motors inherently lacked.

An object of my invention is, therefore, to provide a vapor motor of a construction that will operate practically co-instantaneously with the flow of current or application of heat by the heating element.

A further object of the invention is to provide a vapor motor having a heating element capable of rapidly transferring the heat to the volatile liquid so that the volatile liquid may immediately vaporize to secure quick operation of the vapor motor.

A further object of the invention is to provide a vapor motor having a heating zone adjacent the heating element which, by virtue of its construction, pockets or recesses small quantities of volatile liquid in close proximity to this heating element.

The invention further provides for the rapid heating and volatilization of the aforesaid small quantity of volatile liquid to effect quick operation of the vapor motor without requiring the heating of substantially all the volatile liquid in the heating zone. In this respect the invention broadly contemplates eliminating the slow warming of the volatile liquid in the heating zone which necessarily causes a slow circulation of the volatile liquid throughout the same until the liquid reaches the temperature vaporizing a sufficient quantity to effect operation of the motor.

Accordingly, I contemplate broadly a structure which will hold the volatile liquid inert adjacent the heated surface of the heating zone, and in such quantity or quantities, until sufficient heat is conducted thereto to raise the temperature to that of volatilization that expansion or operation of the motor will be quickly obtained to produce the desired working stroke.

It will be understood that I do not desire to be limited to the specific construction mentioned for accomplishing the result set forth, because I believe that I am the first to devise a vapor motor capable of operating within several seconds after the heat is applied.

A still further object of the invention is to provide a vapor motor having a heating element which automatically reduces the heat input when reaching a predetermined high temperature. This is accomplished specifically by employing an electrical heating element that has a relatively high coefficient of resistivity so that the resistance materially increases upon a rise of temperature, thereby reducing the heat input and preventing excessively high temperatures during this "on" period.

Further objects and advantages will be apparent from the following detailed description when taken in connection with the accompanying drawing which forms a part hereof.

In the drawing:

Figure 1 is a vertical sectional view of a vapor motor embodying the invention, the heating device being in elevation.

Fig. 2 is a similar sectional view, but showing expansion of the vapor motor instead of contraction in Fig. 1 when the volatile liquid is expanded;

Fig. 3 is an enlarged vertical sectional view of the heating device;

Fig. 4 is a detail sectional view of the heating device, but illustrating a slightly modified construction; and

Fig. 5 is a detail elevational view of a portion of the heating device, and likewise illustrating a modified embodiment of the invention.

In the drawing, wherein, for the purposes of illustration, there are shown several preferred embodiments of my invention, the vapor heat motor may comprise an expansible and contractible vessel 5 having a volatile liquid 6 therein, such as benzol, toluene or other suitable liquid, and a source of heat for the volatile liquid, which, in this case, may be carried by a tube 7 in communication with vessel 5.

Although any suitable form of expansible and contractible vessel may be employed, it is preferably shown as comprising an inverted, rigid cup 8 and an expansible and contractible wall 9. In the particular form shown in the drawing, expansible and contractible wall 9 may be any well known form of bellows arranged in nested relation with respect to cup 8 and hermetically sealed at 10 to a rim plate in the form of a rim 11 to which cup 8 is also hermetically sealed, as by solder or otherwise. The arrangement provides a closed liquid chamber 12.

Tube 7 may be closed at either end and communicate at the opposite end with chamber 12. As to the specific form of heating device that may be used, it is obvious that the source may be an electric resistance coil conveniently located at or adjacent to tube 7. A heating zone will thereby be provided within tube 7 for heating volatile liquid 6. The vapor pressure will be rapidly increased and the liquid driven out of the heating zone and depressed into chamber 12. It is by this means that a predetermined expansion or power stroke of vessel 5 may be effectively obtained and held, without danger of the vapor pressure building up to a point where vessel 5 will burst.

A heating element 14, which, in this particular instance, is in the form of an electric resistance coil, suitably surrounds tube 7. This coil is, of course, electrically insulated from tube 7, as will be hereinafter explained, but is in close proximity thereto to conduct the heat developed by the current flow through the coil to volatilize liquid 6. Terminal bands 16 at each end of coil 14 receive conductors 17 comprising a control circuit in which any suitable or desired circuit regulator may be disposed.

By heating a portion only, a major portion of the liquid remains comparatively cool. The liquid in chamber 12 is not subjected to the heat. After the liquid in tube 7, which is not vaporized, is somewhat expanded and a portion thereof is depressed into chamber 12, there is no possibility of further vaporization or expansion. Accordingly, the vessel will be held at its limit of travel until the thermal balance or equilibrium is destroyed, which occurs when the current ceases to flow through coil 14. It is preferable that the interior of chamber 12 and tube 7 be substantially filled with the volatile liquid 6 so as to eliminate the presence of an air pocket at the upper end of this tube. The presence of an air pocket tends to cushion the expanding action of the vessel and destroy its positive movement; that is to say, the initial pressure developed by the vaporization of the liquid tends to compress the air instead of immediately depressing the liquid out of the tube to expand vessel 5. With the presence of air the device is not positive, requires a longer time for initial movement and is materially restricted in its power movement. On the other hand, air in the presence of a volatile liquid undergoing constant thermal expansion and contraction causes chemical reactions which tend to liberate a free gas, which, when combined with air, will increase the air pockets and thereby affect the return movements of vessel 5. It will be understood, however, that, in so far as the present invention is concerned, the presence or absence of air is immaterial, but its absence above the volatile liquid in tube 7 greatly aids in securing a more efficient and longer lived vapor motor.

By referring particularly to Figure 3, it will be noted that the exterior surface of tube 7 is formed with a relatively deep helical groove 18. Groove 18 may be formed by corrugating the wall of tube 7 or by any other suitable means, it being preferable that the width of the groove thus formed be substantially close to the diameter of the wire forming the resistance coil 14. A substantial portion of the resistance coil will then lie within this groove 18 so that a large surface area of this resistance coil will engage the surface of the

groove as distinguished from a line contact, as heretofore obtained where this resistance coil has been wrapped about the heater.

Any suitable form of insulation may be employed for resistance coil 14. I find, however, that a high thermal conduction may be obtained by employing bare wire 14. The exterior surface of this tube 7 is first coated, however, with an insulating material, such as enamel 26, the resistance coil 14 being then laid in groove 18 and a second coating of insulating material, say enamel 27, being preferably applied thereover. This arrangement of the resistance coil 14 and helical groove 18 brings a substantial portion of the resistance wire into direct contact or engagement with the surface of the wall. Only a relatively small percentage of the heat will be then lost through radiation directly from the resistance wire.

Forming the wall of tube 7 with a helical groove 18 provides a series of recesses or annular pockets 21 about the inner wall surface of this tube. Small quantities of volatile liquid 6 will be trapped in these recesses or pockets 21. I have represented these small quantities of volatile liquid generally as "A". These small quantities of volatile liquid "A" in pockets 21 are, in effect, subjected to the hottest areas or portions along the wall of the tube. The large surface area of resistance coil 14 in engagement with the surface of the outer helical groove 18 results in a rapid conduction or transfer of a relatively large percentage of the heat generated in this resistance coil 14 to the liquid trapped in these recesses or pockets 21. The heating action is so rapid that the temperature of volatilization of the fluid is obtained almost co-instantaneously with the flow of current through the resistance coil 14.

I have found that the immediate vaporization of the small quantities of volatile fluid trapped in recesses or pockets 21 causes a vapor pressure in the tube 7 which will drive the unvolatilized fluid out of the tube through a connecting tube 22. Connecting tube 22 is open at its upper end 23 and passes downwardly through the bottom of tube 7 and communicates with chamber 12 by entering the cup 8 at any suitable point, there being a hermetically sealed connection provided both where this connection tube leaves tube 7 and where it enters the housing 8.

It is my belief that the action of this device includes rapidly vaporizing these small quantities of volatile liquid "A" trapped in the pockets or recesses 21 and the rising of the vapor to the top of the tube. The volatile liquid next to these vapor pockets is in turn rapidly brought into contact with the hot wall of these pockets for additional vaporization within the tube 7, if found necessary. The vapor which rises will accumulate in the upper portion of tube 7 and thereby drive the unvaporized liquid through opening 23 in tube 22. The action of vaporization and the accumulation of vapor in tube 7 is so rapid, due to an absence of rapid circulation of thermal currents that little, if any, of the unvaporized liquid is heated before it is depressed through opening 23 in tube 22. Consequently, a heat loss is avoided which was present in devices of the prior art. Any heat loss of this kind would necessarily cause a slower operating action of the vapor motor when the current is caused to flow through the resistance element 14.

It will be understood that the invention is not necessarily limited to the construction of a heating wall for tube 7 that is provided with exterior and interior grooves 18 and 21 for the resistance wire 14 and the volatile fluid 6 respectively. It is true that a very rapid and fast heating action of the volatile fluid 6 in tube 7 is obtained so that operation of the vapor motor will be practically co-instantaneous with the flow of current through the resistance coil 14. This single formation of either the exterior or interior grooves would be obtained where the wall of the tube 7 is substantially heavy and the formation obtained by machining or by molding the same in the making of the tube.

A further advantage of the present invention resides in making the resistance coil of wire having an especially high coefficient of resistivity. It is found in connection with the present construction that wire of a high coefficient of resistivity will cause a decrease of current flow after a predetermined temperature is obtained. Namely, when a sufficient vapor pressure is obtained in tube 7 to effect operation of the vapor motor, continued generation of heat at the initial rate is unnecessary in order to maintain this vapor pressure and hold the vapor motor operated.

Having once obtained the power stroke and a relatively high temperature at tube 7, the resistance of the wire materially increases, thus reducing the heat input and preventing any excessively high temperature being obtained at the tube during the "on" period. This type of wire is generally known as ballast wire, and generally has the following characteristics with respect to temperature and resistance in the order of:

Temperature degrees Fahrenheit

68	212	392	572	752	932	1112	1292

Resistance in ohms

1.00	1.40	2.00	2.70	3.40	4.00	4.50	4.90

It will be noted, therefore, that the resistance increases considerably with an increase of temperature which results in the employment of a reduced current, and consequently, a reduced heat input after the desired temperature necessary to maintain the thermal balance to keep the vapor motor in its expanded position is obtained.

The device disclosed herein may be constructed of different materials. As a specific example of a preferred embodiment of the invention, it is mentioned that the wall of tube 7 may be of a relatively high heat conducting material such as copper of a thickness of .005 inches. When the circuit is closed across the line 17, current will flow through resistance coil 14 to generate heat preferably of a temperature of 350° F., which, with the body of volatile fluid in tube 7 and chamber 12, may develop a pressure of approximately 45 to 50 pounds per square inch. It will be understood that these are merely specific examples of characteristics of my vapor motor which may be varied to meet the different conditions without departing from the scope of the invention.

Exterior groove 18 may be helical in formation so that the resistance coil 14 may be continuously wrapped from end to end about tube 7. The helical formation of groove 18 may be eliminated and groove 18 otherwise provided in any desirable way, say by annular grooves 25 shown in Figure 5, the resistance coil 14 then being wrapped about these annular grooves 25 in individual turns, the ends of each turn electrically connecting with the ends of adjoining turns,

whereby they will be connected in series to provide a continuous flow of current between the end terminal bands 16. As previously mentioned, the groove 18 or each groove 25 may be made slightly deeper or wider than the diameter of the wire 14. And, as previously explained, to insulate each turn of the wire 14 in these grooves, any form of insulation may be provided. I have found that a coating of enamel 26 may be applied to the exterior of the tube 7. After enamel 26 dries the wire may be placed in these grooves and another coating 27 of enamel placed thereover so as to thoroughly insulate the wire exteriorly and prevent any accidental contact therewith. It is found that enamel will not hinder the rapid conductivity of heat generated in the resistance coil 14 and will not fuse at the maximum temperatures at which the vapor motor may be used to obtain the desired results. It is not necessary that the outer coating 27 be applied as I have shown in Figure 4.

Any type of well known expansible and contractible vessel may be used. In Figure 1 the expansible and contractible vessel is adapted to contract to produce a working stroke. This working stroke may be imparted through a work connection 28 suitably secured at 29 to the expansible and contractible vessel 9. To illustrate the variation in which the expansible and contractible vessel may be arranged without departing from the spirit and scope of the invention, an alternative embodiment is illustrated in Figure 2. In this alternative embodiment, the vessel 30 is adapted to expand to produce a working stroke through the working connection 31 secured at 32 to the base of the vessel 30. The connecting tube 22 between tube 7 and a top plate 33 of the vessel 30 is preferably arranged to enter the top plate 33 for communication with the interior of vessel 30. It will be apparent that operating connection 22 may be connected in a variety of ways to the chamber of the expansible and contractible vessel of the type shown, both in Figures 1 and 2 of the drawing.

Without further elaboration, the foregoing will so fully explain the gist of my invention that others may, by applying current knowledge, readily adopt the same for use under varying conditions of service, without eliminating certain features, which may properly be said to constitute the essential items of novelty involved, which items are intended to be defined and secured to me by the following claims.

I claim:

1. In a heat motor, a work chamber and a communicating heating chamber forming a closed system, a volatile liquid in said system, the wall of said heating chamber being corrugated, the inner recesses forming pockets in which said volatile liquid may rapidly volatilize in small quantities, and a resistance coil in the outer recesses having a relatively large surface contact with said heating chamber wall.

2. A heat motor comprising a substantially closed body filled with a volatile liquid, a portion of which is adapted to vaporize and create a predetermined vapor pressure producing a power stroke, and means for heating a portion of said closed body, said heating means including a chamber and a heating element for said chamber, the volatile liquid extending into said chamber, said chamber having means therein for pocketing a small quantity of volatile fluid and subjecting the same to the heating means for rapid vaporization, said last means continuing to supply small quantities of volatile liquid for rapid vaporization whereby to establish and maintain said predetermined vapor pressure in said closed body.

JOHN S. BAKER.