

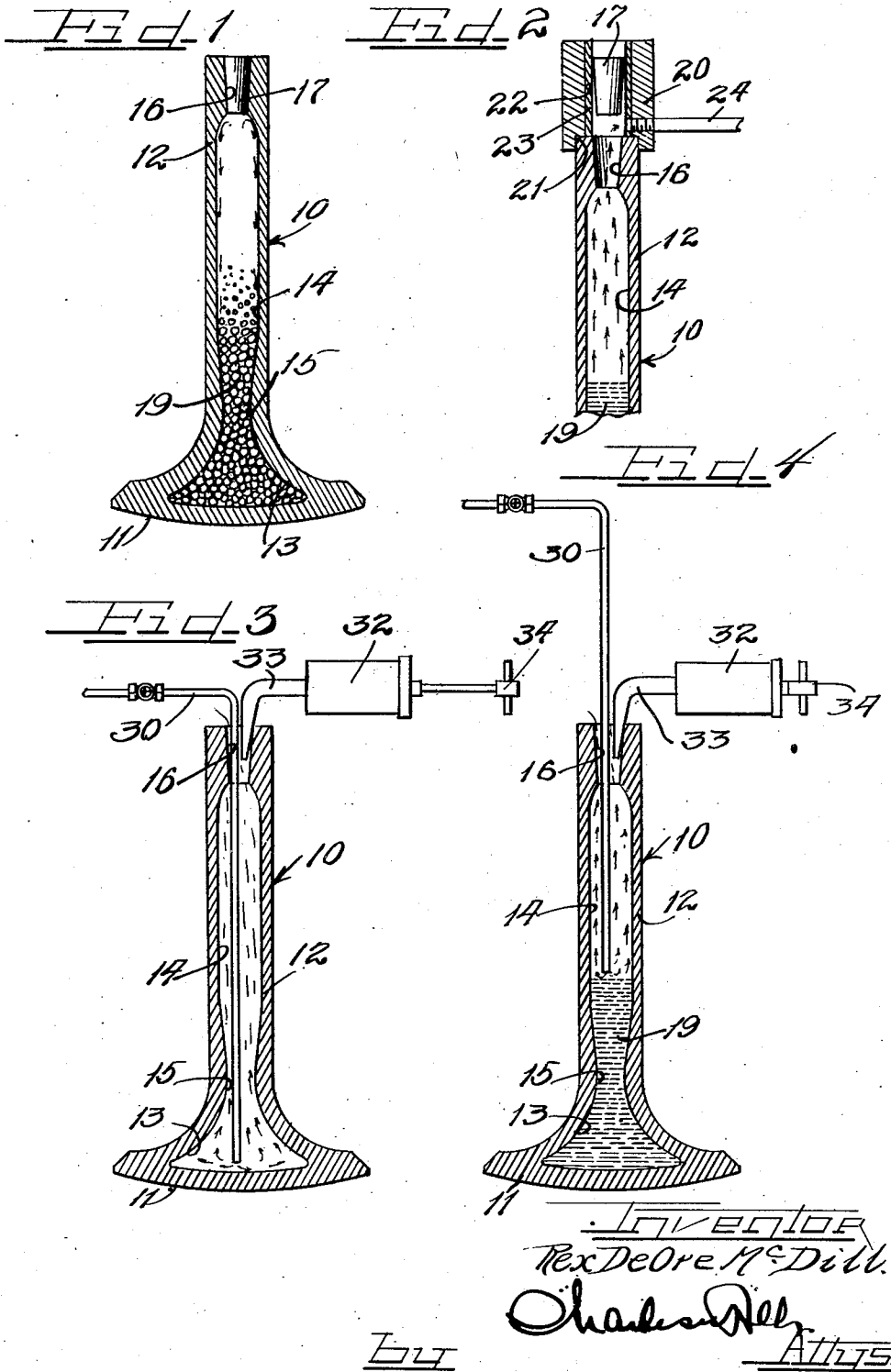
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EVACUATED COOLANT CONTAINING VALVE

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EVACUATED COOLANT CONTAINING VALVE

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This invention relates to a hollow evacuated poppet valve or the like for use in internal combustion engines. More particularly, the invention pertains to a valve of the type indicated containing a liquid or liquefiable coolant such as metallic sodium.

It has heretofore been proposed to fabricate hollow valves partially filled with a liquid or liquefiable coolant having a vaporizing temperature greatly in excess of the usual operating temperature of the valves. Valves of this type are disclosed in the patents to Heron Nos. 1,670,965 and 1,823,452 as containing metallic sodium, the internal space above the sodium being filled with air. When such valves are operated, the temperature rises from the relatively cold starting temperature and the sodium is gradually melted but is not vaporized due to the high internal pressure within the valve. The liquefied sodium functions as a coolant by being heated in the valve head cavity and, on being bodily transferred to the valve stem when the valve reciprocates, delivering the heat picked up in the valve head to the valve stem whence the heat is dissipated.

It is highly desirable to conduct heat away from the valve head as rapidly as possible, because high temperatures cause corrosion of the valve metal in the presence of exhaust gases. Metallic sodium is an excellent coolant, being characterized by a high specific heat, high thermal conductivity and no tendency to expand greatly at elevated temperatures.

When conventional sodium filled valves are fabricated, the included air effects an initial internal pressure amounting to 15 pounds per square inch. Of this pressure, 3 pounds are due to the oxygen of the air and 12 pounds are due to the nitrogen of the air. When the valves are heated, the oxygen combines with the sodium to reduce the pressure by 3 pounds. But the expansion of the nitrogen at the elevated valve operating temperatures causes an internal valve pressure greatly in excess of the ambient pressure, as shown by the fact that when a conventional valve operating at an elevated temperature is pierced, the sodium is blasted out. As will be shown more clearly hereinbelow, the vapor pressure of metallic sodium is so low as to preclude any appreciable vaporization of the sodium in conventional valves.

Conventional sodium filled valves on the order of those disclosed by Heron are formed with a relatively large cavity in the valve head and with a relatively constricted hollow passage through the stem. The sodium must flow from

the valve head cavity through a restricted aperture into the stem in order to transfer heat to the valve stem for dissipation therefrom. The small aperture into the valve stem may become "gas pressure locked," for the liquefied sodium has a fairly high viscosity even at elevated temperatures. The situation presented by the conventional sodium filled valves is simply one of a viscous liquid and a gas under pressure attempting to reach a state of stability and equilibrium through a constricted orifice, and is similar to the pouring of cold molasses out of a jug.

It should also be noted that high internal pressures decelerate the melting of the sodium, as indicated by the following table.

Pressure, kg./cm. ²		Melting point of sodium
		°C.
1,000		97.6
2,000		106.2
4,000		114.3
6,000		129.1
8,000		142.9
10,000		155.0
12,000		166.6
		177.2

Further, the air present in the internal cavities of conventional valves is a poor conductor of heat. The agitation and the high temperatures tend to cause increased adsorption of air by the sodium, thus reducing the heat transfer to the valve stem surface due to the insulating characteristics of the sodium-air foam generated when the valves are operated.

In brief, the air present within conventional sodium filled valves impedes the transfer of heat from the valve head to the valve stem by delaying liquefaction of the sodium, by forming a gas lock within the valve and otherwise interfering with the free movement of the sodium, and by acting as an insulating medium, particularly in the form of an air-sodium foam.

I have now found that the disadvantages pointed out can be eliminated by evacuating sodium filled hollow valves. The evacuation should preferably be extended to a degree where the sodium can be volatilized. Thus evacuated valves dissipate heat much more rapidly than conventional sodium filled valves. Aside from the fact that the liquefaction of the sodium is not delayed, that no gas locks are formed, and that no insulation is effected by air, the efficiency of the valve is greatly enhanced by volatilization of sodium in the valve head and condensation of sodium

um in the valve stem, with consequent dissipation of the heat of vaporization. Since the valve stem can then be kept at a relatively low temperature, the resulting greater temperature gradient between the valve head and the valve stem makes for more efficient heat transfer to the valve stem for dissipation therefrom.

The importance of effecting as complete evacuation as possible is shown by the data tabulated hereinbelow:

Temperature	Vapor pressure of sodium
°C.	Mm.
222.8	4.575×10^{-4}
241.2	1.137×10^{-3}
271.2	4.27×10^{-3}
271.3	4.144×10^{-3}
296.7	1.206×10^{-2}
303.6	1.217×10^{-2}
331.2	0.0438
341.6	0.0628
360.2	0.1074
376.1	0.1769
376.2	0.1702
396.7	0.3025
401.95	0.371
428.05	0.716
451.0	1.265
498.2	3.653
663.7	67.37
705.7	110.1
738.9	165.5
767.7	228.1
797.4	317.4
840.1	482.5
858.0	760.0

Conventional sodium filled valves operate at from 1100° F. (593° C.) to 1600° F. (871° C.). Still lower operating temperatures are obtainable with the evacuated valves of the present invention. The importance of complete evacuation for effecting vaporization of sodium at low temperatures is evident.

It is, then, an object of this invention to provide a hollow evacuated coolant-containing valve.

A further object of the invention is to provide an evacuated hollow valve containing a liquefiable coolant such as metallic sodium.

A still further object of the invention is to provide a sealed hollow poppet valve filled to about 50 to 60% of its capacity with a coolant such as metallic sodium and having the remainder of the interior thereof exhausted.

A still further object of the invention is to provide a hollow poppet valve containing a coolant capable of being vaporized in the valve at the valve operating temperature.

Another object of the invention is to provide a coolant-filled valve wherein the coolant has been reacted with oxygen to form a solid oxide operating in an evacuated space.

A still further object of the invention is to provide a coolant-containing valve having the hollow interior thereof filled with a gas-liquid system formed by a single coolant.

Evacuation to produce valves of this invention may be effected either chemically or mechanically, as illustrated in the appended drawing, in which:

Figure 1 is a diagrammatic vertical cross sectional view of an evacuated sodium containing valve according to this invention.

Figure 2 is a fragmentary diagrammatic vertical cross sectional view of a valve being evacuated by mechanical means.

Figure 3 is a diagrammatic vertical cross sectional view showing the initial stage of a process for filling a valve with sodium and oxygen

in a manner described in greater detail hereinbelow.

Figure 4 is a diagrammatic vertical cross sectional view similar to Fig. 3 but showing a later stage of the process illustrated in Fig. 3.

As shown in the drawing:

A valve according to this invention is indicated generally in Fig. 1 by the reference numeral 10 and includes a head 11 and a stem 12. This valve is formed with a mushroom-shaped cavity including a head cavity portion 13 and a stem cavity portion 14 intercommunicating through a constricted aperture 15 formed in the neck of the valve. The head chamber 13 forms about 2/3 of the total internal capacity of the valve 10, with the stem cavity accounting for the remainder. The contents of the valve cavities include at ambient temperature from 50 to 60% sodium indicated by the reference numeral 19 with the valve at rest in non-operating condition.

The valve 10 is formed with a tapered aperture 16 at its top through which the valve is filled. This aperture is closed, after filling, with a tapered plug or pin 17.

As shown in Fig. 1, the sodium 19 is broken up into globules when the valve is operated, due to the shaking or oscillation of the sodium effected by the movement of the valve and due to boiling of the sodium. The sodium vapor generated will rise inside the valve stem and will tend to be condensed on the sides of the valve stem cavity, when the condensed sodium will tend to flow downwardly, as indicated by the arrows.

The evacuated valve of Fig. 1 may be obtained by mechanical means, as illustrated in Fig. 2. For instance, a suitable amount of sodium may first be introduced into the valve. Then a tubular member 20 may be fitted tightly over the top of the valve, the tubular member 20 being, for instance, countersunk as at 21 to adapt the member to be seated upon and to embrace the top of the valve 10. The member 20 is formed with an internal conduit 22 registering with and wider than the aperture 16 and lined with resilient material 23 of a thickness such that the plug 17 may be held thereby while the interior of the valve 10 as well as the conduit 22 are evacuated through a conduit 24 piercing the tubular member 20 near its bottom and connected to a source of vacuum. When evacuation is completed, the plug 17 may be rammed down into the aperture 16 to seal the valve. The tubular member 20 is then removed from the valve.

Evacuation may also be effected chemically, as by filling the valve with sodium and with oxygen and then sealing the valve. When the valve is heated, the sodium will then combine with the oxygen to form sodium oxide and to exhaust the valve to an extent determined by the purity of the oxygen. Even in a large cavity valve, the amount of sodium oxide formed would not exceed 35 milligrams. If nitrogen and other inert gases are completely excluded, the interior space in the valve can be very completely exhausted. Chemical exhaustion carried out in this manner may even be more efficient than mechanical exhaustion.

Figures 3 and 4 illustrate a specific method of filling a valve with sodium and pure oxygen. As shown in Fig. 3, a valved tube 30 connected to a source of oxygen may be inserted into the valve cavity so as to reach almost to the bottom thereof. The air in the valve cavity is then washed out with a stream of pure oxygen. Metallic sodium is then extruded into the valve cavity by

means of an internally threaded pressure gun 32 having a bent nozzle 33 and a threaded piston operated by means of a handle 34. As shown in Fig. 4, the tube 30 is raised as the level of the sodium in the valve cavity rises. A current of oxygen is kept flowing through the valve cavity as long as sodium is being introduced thereinto. When enough sodium has been introduced, the nozzle 33 is withdrawn from the aperture 16, the tube 30 is likewise withdrawn, and the plug 17 is rammed down into the aperture 16 to seal the same.

When a sealed valve filled with sodium and oxygen in the manner disclosed hereinabove is exposed to valve operating temperatures, the oxygen combines with the sodium to leave the space above the sodium almost completely exhausted.

In the finished valve there is no oxygen present which would tend to cause corrosion. The sodium present in the valve also reduces any metal oxide films coating the internal valve cavity, whereby any evolution of oxygen from such oxide films is prevented.

The sodium used as a coolant may be replaced by potassium, suitable eutectic alloys, salts, mercury or other compositions having suitable thermal characteristics.

It will thus be seen that in the novel evacuated valves of this invention, the mobility of the liquid coolant has been greatly enhanced and the heat dissipating capacity therefore greatly increased while at the same time a coolant vaporization-condensation cycle has been set up to still further increase the rate of heat transfer from valve head to valve stem.

Many details of construction and procedure may be varied within a wide range without departing from the principles of this invention and it is therefore not my purpose to limit the patent granted on this invention otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. A poppet valve having an interior hollow space extending through the head and the stem of the valve and having a tapered aperture through the end of the stem affording access to said space, sodium partially filling said space, the remainder of said space being evacuated, and a tapered pin seated in said aperture to seal the space.

2. A sealed hollow poppet valve having a stem, a neck and a head, said stem being formed with a tubular cavity and said head being formed with an enlarged cavity forming about $\frac{2}{3}$ of the hollow space within said valve, said head cavity and said stem cavity intercommunicating through a restricted aperture at the neck of said valve, said hollow space being filled to about 50 to 60 per cent of its capacity with metallic sodium and the remainder of said space being exhausted.

3. A poppet valve having a hollow head adapted to be exposed to high temperature conditions and a tubular stem adapted to be exposed to relatively lower temperatures than said head, said head and stem defining a closed continuous interior valve space adapted to contain a coolant for dissipating heat from said valve head through the walls of said valve stem, a coolant partially filling said space, the remainder of said space being evacuated for facilitating heat dissipation by said coolant.

4. A poppet valve having a hollow head adapted to be exposed to high temperature conditions

and a tubular stem adapted to be exposed to relatively lower temperatures than said head, said head and stem defining a closed continuous interior valve space adapted to contain a coolant for dissipating heat from said valve head through the walls of said valve stem, sodium partially filling said space, the remainder of said space being evacuated for facilitating heat dissipation by said sodium.

5. A poppet valve having a hollow head adapted to be exposed to high temperature conditions and a tubular stem adapted to be exposed to relatively lower temperature conditions than said head, said head and stem defining a closed continuous interior valve space adapted to contain a coolant for dissipating heat from said valve head through the walls of said valve stem, a liquefiable coolant partially filling said space, the remainder of said space being evacuated for facilitating liquefaction of said coolant.

6. A poppet valve having a hollow head adapted to be exposed to high temperature conditions and a tubular stem adapted to be exposed to relatively lower temperature conditions than said head, said head and stem defining a closed continuous interior valve space adapted to contain a coolant for dissipating heat from said valve head through the walls of said valve stem, a coolant capable of being vaporized in said valve space at the operating temperature of the valve, the remainder of the valve being evacuated at the operating temperature with the valve for facilitating vaporization of said coolant.

7. A poppet valve having a hollow head adapted to be exposed to high temperature conditions and a tubular stem adapted to be exposed to relatively lower temperature conditions than said head, said head and stem defining a closed continuous interior valve space adapted to contain a coolant for dissipating heat from said valve head through the walls of said valve stem, a liquid coolant partially filling said space, the remainder of said space being occupied exclusively by the vapor of said coolant for facilitating heat dissipation by said coolant.

8. A poppet valve having a hollow head adapted to be exposed to high temperature conditions and a tubular stem adapted to be exposed to relatively lower temperature conditions than said head, said head and stem defining a closed continuous interior valve space adapted to contain a coolant for dissipating heat from said valve head through the walls of said valve stem, a single liquid coolant partially filling said space, said space being filled at the operating temperature of said valve exclusively with a gas-liquid system formed by said single coolant for facilitating heat dissipation by said coolant.

9. An elongated hollow metal part adapted to operate back and forth with one end subjected to high operating temperature and with another end at a lower temperature, said part having a closed chamber extending therein from one end to the other end, a liquefiable vaporizable coolant partially filling said space for dissipating heat from the part end exposed to high temperature through the walls of the part end operating at a lower temperature, the remainder of said part being evacuated and filled exclusively with the vapor of said coolant for facilitating heat dissipation by said coolant.

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