Dec. 19, 1944. R. DE O. McDILL 2,365,285

METHOD OF MAKING EVACUATED VALVES

Original Filed July 13, 1942

Fig. 1.

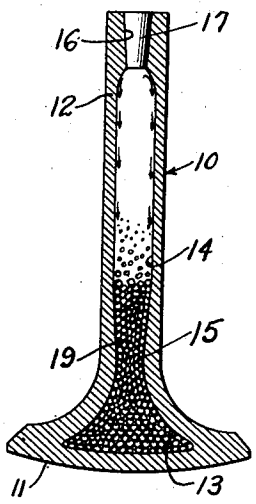


Fig. 2.

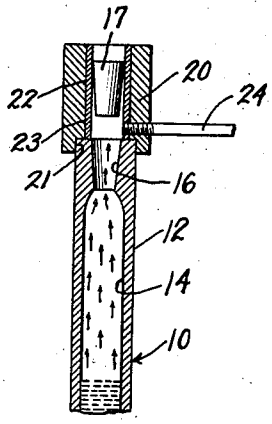


Fig. 3.

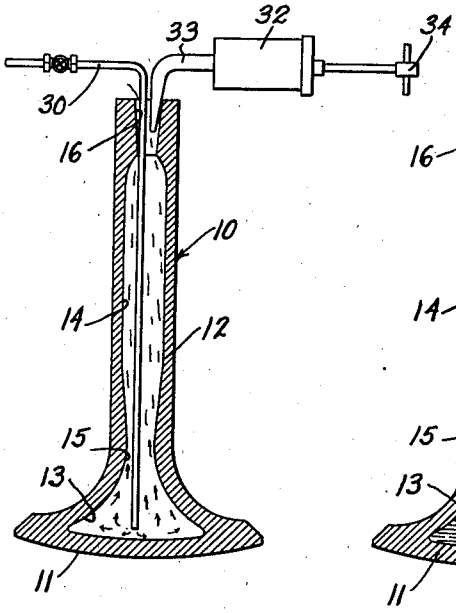
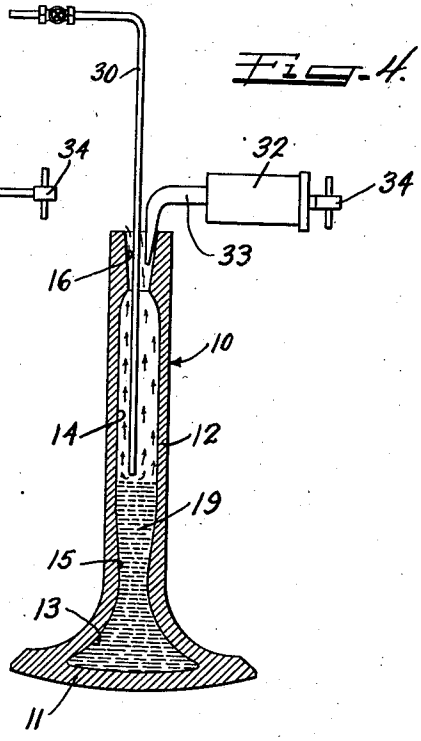


Fig. 4.



Inventor

REX DE ORE McDILL.

by Charles W. Hills Attys.

Patented Dec. 19, 1944

2,365,285

UNITED STATES PATENT OFFICE

2,365,285

METHOD OF MAKING EVACUATED VALVES

Rex De Ore McDill, Cleveland, Ohio, assignor to Thompson Products Incorporated, Cleveland, Ohio, a corporation of Ohio

Original application July 13, 1942, Serial No. 450,685. Divided and this application April 19, 1943, Serial No. 483,617

1 Claim. (Cl. 29—156.7)

This invention relates to a method of making hollow evacuated poppet valves or the like for use in internal combustion engines.

More particularly the invention relates to a method of evacuating coolant-containing hollow poppet valves by reacting coolants such as metallic sodium with oxygen.

This application is a division of my application Serial 450,685, filed July 13, 1942.

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	97.6
1,000	106.2
2,000	114.3
4,000	129.1
6,000	142.9
8,000	155.0
10,000	166.6
12,000	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 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, ° C.	Vapor pressure of sodium
222.8	4.575×10^{-4} mm.
241.2	1.137×10^{-3}
271.2	4.27×10^{-3}
271.3	4.144×10^{-3}
296.7	1.205×10^{-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
366.7	0.3025
401.95	0.371
428.05	0.716
451.0	1.255
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 evacuate hollow articles by introducing reacting materials into the article and causing a reaction between the ingredients.

A still further object of the invention is to provide a method of evacuating coolant-containing hollow poppet valves by reacting coolant in the valve with another material introduced into the valve for exhausting the space in the valve.

A still further object of the invention is to provide a method of evacuating hollow poppet valves partially filled with a coolant by reacting the coolant in the valve with oxygen for exhausting the interior of the valve.

A still further object of the invention is to provide a method of increasing the cooling capacity of coolant-containing poppet valves by reacting the coolant in the valves with another material.

A still further object of the invention is to provide a method of evacuating hollow poppet valves containing coolant material by displacing air in the valves with oxygen and by reacting the oxygen with the coolant.

A specific object of the invention is to provide a method of evacuating hollow sodium-filled poppet valves by displacing air in the valves with oxygen and by reacting the oxygen with the sodium.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheet of drawings which, by way of preferred example, illustrates one manner of carrying out the method of this invention and compares this method with another method of evacuating a poppet valve.

On the drawing:

Figure 1 is a diagrammatic vertical cross-sectional view of an evacuated sodium-containing valve prepared according to the method of 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 the process for filling a valve with sodium and oxygen in a manner according to this invention described in greater detail hereinbelow.

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

As shown on the drawing:

A valve produced according to the method of this invention is indicated generally in Figure 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 3/5 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.

According to this invention evacuation of the valve is effected chemically 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.

The method of this invention thus produces evacuated coolant-containing valves wherein the mobility of the liquid coolant has been greatly enhanced and the heat dissipating capacity of the valve greatly increased. At the same time, a coolant vaporization-condensation cycle has been set up to further increase the rate of heat transfer from the valve head to the valve stem.

It will, of course, be understood that various details of the method may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claim.

I claim as my invention:

The method of fabricating a sodium containing poppet valve which comprises forming a poppet valve with a hollow internal space open at one end only, positioning said valve with the open end uppermost, flowing oxygen into the space through said open uppermost end to displace air from the space and fill the space with oxygen at atmospheric pressure, partially filling said space with sodium through said open end, continuing the flowing of oxygen into the space during the sodium filling operation to maintain the space free from air, closing said open end to seal the hollow internal space of the valve, and heating the sealed valve to react all the residual oxygen with some of the sodium to produce an evacuated sodium cooled valve.

REX DE ORE McDILL.