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T. MIDGLEY, JR

COOLING DEVICE FOR VALVES AND THE LIKE

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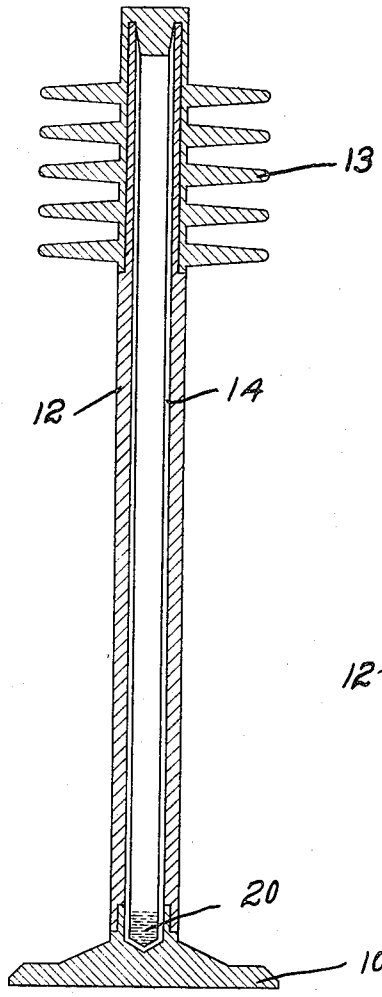


Fig. 1.

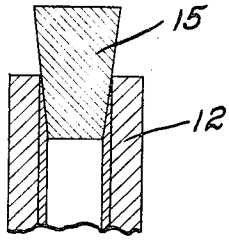


Fig. 2.

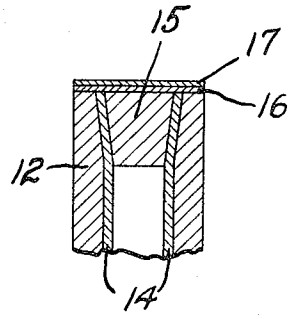


Fig. 3.

Witnesses
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UNITED STATES PATENT OFFICE.

THOMAS MIDGLEY, JR., OF DAYTON, OHIO, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE DELCO-LIGHT COMPANY, OF DAYTON, OHIO, A CORPORATION OF DELAWARE.

COOLING DEVICE FOR VALVES AND THE LIKE.

Original application filed January 10, 1918, Serial No. 211,224. Divided and this application filed October 2, 1918. Serial No. 256,530.

To all whom it may concern:

Be it known that I, THOMAS MIDGLEY, Jr., a citizen of the United States of America, residing at Dayton, county of Montgomery, State of Ohio, have invented certain new and useful Improvements in Cooling Devices for Valves and the like, of which the following is a full, clear, and exact description.

The present application is a division of my copending application, Serial No. 211,224, filed January 10, 1918. Said previously filed case relates to improvements in the construction of parts of cooling devices such as engine valves. And the present application relates to improved methods of constructing such valves or other devices.

Amongst the objects of the present invention are to provide improved methods of applying the veneer or coating by electro-plating process; also in cleaning the coating or veneer; also various methods for applying the coating after the cleaning operation has been effected; and improved methods of hermetically sealing the valve or other device.

Other objects will be apparent from the ensuing description. And in order that the entire valve construction may be well understood, the structure set forth and claimed in the above mentioned copending application will be herein set forth in detail, with reference to the accompanying drawing.

In said drawing:

Figs. 1 shows in cross section a valve to which the present invention is applied.

Figs. 2 and 3 illustrate the method of hermetically sealing the valve.

Referring to Fig. 1, the steel valve here illustrated comprises the head portion 10 and a stem 12, which may be provided with radiating fins or ribs 13, slipped over the stem in any suitable manner. The head portion 10 may be welded to the stem 12, so that the head and stem will constitute substantially one continuous piece of metal.

In the interior of the hollow stem is provided the small portion of so-called "working" mercury 20, which vaporizes during the operation of the valve. The vapor passes up towards the top of the stem, where it is cooled and again transformed into its liquid state, dropping by gravity to the bottom of the stem, thus setting up a continuous or cyclic automatic cooling action.

The inner wall of the stem is provided, as shown with an intermediate heat transferring medium indicated by the reference number 14, which forms a coating, veneer or body superposed upon and in intimate contact with the inner face of said stem chamber for the purpose of facilitating the transfer of heat between the wall and the mercury, and vice versa. This coating is purposely shown on an exaggerated scale in the drawing to facilitate the understanding of the invention.

The operation and efficiency of the valve can be considerably increased by using such an intermediate heat transferring medium, which consists of an amalgam or alloy of mercury, applied in the form of a permanent coating before the valve is placed in use.

My improvements are directed first toward the securing of the best kind of amalgam for such a coating. My preferred forms of coating are devised both with reference to ability to facilitate transfer of heat, and ability to adhere strongly and permanently to the steel of the wall which supports it, so as to form a structure or coating which is mechanically strong and will not break off or become detached as a result of the vibration and temperature conditions under which the valve operates. These conditions are best met by the use of an amalgam, including a metal such as iron, which will strongly adhere to the metal of the valve; in an amalgam of this character, the mercury of the amalgam facilitates transfer of heat to and from the working mercury, while the iron of the amalgam facilitates transfer of heat to and from the steel of the valve, so that the metals of the amalgam, so to speak, form a link or chain system for the easy transfer of heat between the parts.

I have discovered another characteristic which gives added efficiency to such an intermediate heat transferring medium, viz, that it should be made of material which will not only tend to adhere strongly to the steel of the valve, but which, in the event of any part of the amalgam becoming disassociated from the steel, will also reassociate itself and adhere strongly to the steel that may have become exposed. That is, if the amalgam "breaks down", (that is, disassociates itself from the steel,) the coating or veneer becomes automatically re-

newed without having to replate it or recoat it by an external operation. This property of renewal or recoating under operating conditions is hereinafter referred to as the "building up" property of the amalgam. In the use of amalgams containing tin or such an equivalent as lead, or both, any of the amalgam of the veneer which breaks down under operating conditions becomes mixed with the working mercury of the valve, and is carried by the mercury vapor into contact with that portion of the steel from which the coating became detached, and thereby builds up or renews the coating at the desired point. In addition to amalgams containing tin and lead, I have found that other metals possess in varying degrees the ability to form an amalgam with the property of "building up"; for instance, brass, antimony and zinc, which may be regarded as equivalents of tin or lead. However, I prefer to use amalgams containing either or both tin and lead. The combined qualities of "building up" and of adhering strongly to the metal of the valve are best obtained by the use of an intermediate heat transfer medium consisting of an iron amalgam, such as described in the paragraph next preceding, and a quantity of "building up" amalgam. I prefer to use an iron amalgam containing thirty per cent (30%) of tin-lead amalgam.

I obtain improved results by placing a small quantity of an amalgam having "building up" properties in the working mercury, which amalgam is carried by the heated mercury into contact with any exposed part of the steel of the stem, with which it adheres. This amalgam which is mixed with the working mercury may be the same as that which forms the coating or veneer, or it may be one of the components of said coating or veneer. In practice, I prefer to use a tin or lead amalgam, or a tin-lead amalgam mixed with the working mercury, and I have obtained excellent results by the use of a tin or tin-lead amalgam mixed with the working mercury in the proportion of 30 to 50 per cent of the amalgam, in conjunction with a 30% to 50% tin-lead amalgam coating or veneer 14.

While I may use a veneer consisting of an iron amalgam, as above described, such coatings consisting simply of mercury and iron are not quite so satisfactory as some of the other amalgams mentioned which contain tin or lead, on account of the lack on the part of the simple iron amalgam, of the property of "building up" as described above. By using an amalgam of iron with tin or lead or both, the valuable properties of the iron in adhering to the steel and facilitating the transmission of heat from the veneer 14 to the steel stem are retained, while the valuable "building up" properties of the amalgam, due to the presence of the tin or lead insure the permanence of the coating in use.

I have also found that I am able to obtain satisfactory results by the use of a veneer 14 of tin applied in any suitable manner to adhere to the steel; this tin becomes transformed into a tin amalgam when the valve has been in use, as a result of the action of the working mercury on the tin.

I may also use an amalgam veneer 14, for instance, iron amalgam, for the valve stem, and place in the working mercury a quantity of another amalgam, which may have "building up" properties, for instance, tin-lead amalgam, relying upon the action of the working mercury to carry the tin-lead amalgam to the iron amalgam veneer so as to build it up continuously. The tin-lead amalgam is preferably present in the working mercury in the proportion of between 30% to 50%.

The thickness of the coating or veneer may vary in practice; I find that a relatively thin layer is quite sufficient for the purposes of the invention.

I will now proceed to describe some methods of constructing valves or other devices in accordance with my invention, and will first refer to methods of applying the veneer or coating by electro-plating processes.

A rigid metal rod is suspended inside the tube or valve stem to be plated, spaced from and in a substantially symmetrical position with respect to the wall thereof. The rod is the anode and the wall of valve stem is the cathode. This rod (which may be in the form of a wire) may be coated with mercury which is to be deposited upon the walls of the tube. This wire should consist of a metal which, when itself deposited by electrolytic action on the walls of the tube along with the mercury, will assist in producing an amalgam having the qualities which are desired. For instance, I have found that it is preferable to use a steel or iron wire carrying the mercury, because when the iron from the wire passes to the cathode, it assists in building up a desirable iron amalgam.

Instead of using a steel wire coated with the amalgam, I may use a plain steel or iron wire or other suitable metallic rod or wire without a coating of amalgam, providing that the electrolyte contains a salt of mercury, so that under the electrolytic action, the iron or metal from the anode and the mercury from the salt are deposited electrolytically on the inside walls of the tube.

When it is desired to provide an amalgam coating or veneer of tin, or lead, or both, an anode consisting of a wire or rod of these metals may be used, in conjunction with an electrolyte consisting of a mercury salt. In applying my preferred form of heat

transfer medium I employ an anode consisting of tin-lead wire, and I form an electrolyte from a bath of hydrochloric acid with mercury together with some iron, this making an electrolyte consisting of a salt of mercury and iron. As a result of plating the inner wall of the tube serving as a cathode with the metals coming from an anode and bath of this character, I obtain a very satisfactory deposit of an amalgam of iron, tin and lead, this amalgam having the desirable qualities hereinbefore set forth.

In order to obtain a deposit of the desired thickness, I find it preferable to repeat the plating operation several times, say four or five times, cleaning it with mercury between this plating operation. Some of this mercury is added by adsorption to the plating.

In order to prevent a short-circuit during the electrolytic operation, I prefer to provide a porous insulation around the tin-lead wire serving as the anode; care should be taken to use an insulation which will be sufficiently porous to permit of the escape of gases.

After the coating with the amalgam has been effected, I find that it is important to clean the coating or veneer with dry mercury, that is, re-distilled mercury, otherwise dirt will remain and form a crust, which, when the valve is heated, will tend to interfere or destroy the heat-transferring action of the amalgam veneer.

The effective deposit of a coating or veneer of amalgam is very much facilitated by the preliminary cleansing or treating of the steel. I find that the best results are obtained by preliminarily cleaning the steel with hydrochloric acid. It is also desirable to clean the interior of the valve prior to treating it with the hydrochloric acid, both mechanically, for instance by reaming or drilling, and afterwards with sodium hydroxide solution which removes the oil left from the drilling or reaming operation.

I will now proceed to describe some methods of forming an intermediate heat transferring medium as a coating or veneer on the interior wall of the valve stem or tube, after the cleaning operation has been effected as described above, or in some other suitable manner.

Example.

(*a*) The electrolyte is first prepared electrolytically; the positive pole is constituted by a body of mercury while the negative pole consists of sheet steel. The electrolyte is commercial hydrochloric acid. The poles are connected to a source of current at 6 volts, and take from 5 to 5½ amperes with one ohm resistance in series. The electrolytic action will continue for a period of about two hours, at which time the electrolyte will be ready for use. It should be filtered before using.

(*b*) A tin lead wire is prepared for use as the central electrode, which wire is surrounded with a porous insulation to prevent short-circuiting, as described above.

(*c*) The valve is then plated in the following manner. The interior of the tube or stem is filled with the electrolyte, and the tin lead wire is arranged in the interior of the tube and connected with the positive pole of a suitable source of current, while the valve stem itself is connected with the negative pole. The plating operation takes place by passing a current of about 3 amperes at 6 volts for sufficient time until the electrolyte is substantially exhausted. The wire and electrolyte are then removed, but the valve is not rinsed. Mercury is then added and the valve stem containing the mercury is shaken. This mercury cleans the plating and some of it is adsorbed by the plating. This plating operation is repeated about four or five times.

(*d*) The valve is then cleaned in water, and afterwards in mercury. Some of this mercury is added by adsorption to the plating.

(*e*) Sodium hydroxide solution is introduced into the interior of the valve stem to neutralize any acid which may be present; the hydroxide is removed and the stem rinsed in clean water.

(*f*) The valve is dried without oxidization in any suitable manner and rinsed in dry, re-distilled mercury.

This completes the operation of depositing the amalgam coating or veneer upon the interior of the surface. After this has been completed, the working mercury is introduced into the valve in the desired quantity, (for example, about five grams), and if it is desired to employ a quantity of amalgam for the purpose of building up the coating or veneer in the manner herein described, then some of the desired amalgam, for instance, tin lead amalgam (about 3 grams), is also introduced along with the mercury. This may be prepared by melting solder into the mercury, and heating, taking care to prevent the formation of oxides.

Where it is desired to coat the interior of the valve stem with a veneer of simple iron amalgam, the practice may be substantially the same, excepting that an iron or steel wire will be employed in place of the tin lead wire which is used for the central electrode.

I have found that an effective electrolyte for the plating operation can be obtained by dissolving lithium citrate in saturated mercuric chloride solution and acidifying to clearness with hydrochloric acid. In practice, I obtain satisfactory results by dissolving one gram of lithium citrate in 125 cc. of

saturated mercuric solution, and thereupon acidifying to clearness with hydrochloric acid, as described above. This electrolyte is used for the plating operation in conjunction with the steel or tin lead or other suitable central wire which acts as the anode in the plating operation.

I may also proceed without the use of an external electric circuit for the plating operation, using an electrolyte such as that prepared as a result of step (*a*) of the example given above, or the electrolyte prepared from lithium citrate and saturated mercuric chloride solution, and placing an aluminum wire in metallic contact with the inside of the valve after it has been nearly filled with the electrolyte, thereby setting up a plating action which results in the deposit of metal from the electrolyte onto the surface of the tube. The most effective results are obtained by rubbing the valve with the aluminum wire, which effects a deposit of metal upon the interior of the valve stem. After the wire and electrolyte are removed, the valve is treated in the same manner as that set forth in connection with the example given above. This method is, in effect, an electroplating process in which the aluminum wire comprises one pole of a primary battery and the walls of the valve stem constitute the other pole.

I find that I can plate metals with electrolyte other than those referred to above, by means of the aluminum plating method described above, the electrolyte being a salt of the metal that it is desired to deposit, and the electrode being of higher scale in the E. M. F. table than the metal which is to be deposited, so as to bring about the battery action described above. This process of plating is particularly valuable in connection with the plating of the interior of spark plugs, for instance, in plating the spark plugs described in my Patent No. 1,328,051, dated January 13, 1920, and also in the co-pending application of Charles Franklin Kettering, Serial No. 211,425, filed January 11, 1918, where owing to the very narrow bore, it is difficult to connect the bath with an external circuit.

Instead of applying the intermediate heat-transferring medium in the form of a veneer or coating by an electro-plating operation, I may employ any suitable plating operation, for instance, after cleaning the interior of the valve as described above, I may rinse it in an acidified solution of zinc chloride, and thereupon dip the valve in molten tin so as to coat the interior of the valve with tin. I then rinse the valve clean in slightly acidified water, and fill with clean tin amalgam which is allowed to remain within the valve for a period of about one hour; after this has been removed I add sodium hydroxide solution to neutralize any acid and then clean and prepare for use in the manner described above.

Before sealing the valve, I prefer to add with the working mercury, a quantity of tin-lead amalgam prepared in any suitable manner, for instance, as described above in connection with the first example given.

I also obtain good results by coating the interior of the valve with tin-lead amalgam, by proceeding in the following manner. After the interior of the valve has been cleaned as described above, I rinse with acidified solution of zinc chloride and then heat the valve to 212 degrees Fahrenheit with some tin-lead amalgam, which is prepared by melting soft solder in the mercury. I pour this tin-lead amalgam slowly into the interior of the valve until it is full and continue to heat until all the moisture has evaporated from the inside of the valve, after which I empty out the tin-lead amalgam contained in the stem. I then rinse clean in water and afterwards in mercury, after which I add sodium hydroxide solution to neutralize any acids and proceed in the manner described with reference to the first example given.

In all instances, I find it quite important to clean the valve after it has been provided with its coating of amalgam, by means of dry mercury in the manner described above, as it seems to have the effect of increasing the efficiency of the valve.

After the valve has been provided with its amalgam coating and the mercury along with the amalgam has been placed within the valve, it is necessary to seal it hermetically in order to prevent the escape of the vaporized mercury when the apparatus is in use.

I prefer to seal the valve by means of a welding operation, and I also take steps to avoid the permanent breaking down of the amalgam coating which would otherwise take place as a result of the welding operation.

When the valve is ready for sealing, I drive a tapered plug 15 into the open end thereof, as shown in Fig. 2, until the tube is practically hermetically sealed, and I then saw this off even to the top of the valve stem.

The valve is then placed within three-fourths of an inch of the top in water, as shown in Fig. 3, and an oxyacetylene flame is used to fuse over the entire end of the valve, after which two more layers of steel are added, as shown and indicated by the reference numerals 16 and 17, and thoroughly fused. While this end of the valve is red hot, it is turned upside down and the mercury and amalgam with the mercury is allowed to boil until the boiling ceases. This applies amalgam to any part of the coating of the upper portion of the stem which may have broken down due to welding, and also to the end of the plug 15, so

that when the valve has cooled, the amalgam coating will be intact.

Another advantage of carrying on this welding process in conjunction with a water bath, as described above, in order to cause the hermetic sealing of the valve tube, is the avoidance of any possibility of the air within the valve body becoming so heated as the result of the heat of the welding operation, as to cause the blowing out of the plug, as the result of its expansion. The welding may, of course, be effected electrically if desired.

I believe that I am correct in describing the metallic coatings herein as amalgams or alloys of mercury, but it will be understood that I also use the term "amalgam" herein not only specifically, but generally, to indicate the alloy or mixture of metals which are formed as a result of my improved methods of manufacture described herein. Tin and lead are known as tetrad metals, that is, they belong to a chemical series which forms the fourth group in the periodic classification table. Where the terms "tetrad metal" or "tin" are used in the claims it is to be understood that they include not only tin but such equivalents as lead, or tin-lead.

While I have described herein some preferred embodiments of my invention, it will of course be understood that many modifications and changes might be made by those skilled in the art without departing from the spirit or scope of my invention as defined by the appended claims.

What is claimed is as follows:

1. The process of electro-plating an amalgam coating upon the interior of a metallic hollow body consisting in applying electric current to an electrolytic cell of which the hollow body forms the cathode, the anode comprises one of the metals to be deposited, and the electrolyte comprises a salt of mercury and a salt of iron.

2. The process of electro-plating an amalgam coating upon the interior of a metallic hollow body consisting in applying electric current to an electrolytic cell of which the hollow body forms the cathode, the anode comprises a body of tin, and the electrolyte includes a salt of mercury.

3. The process of electro-plating an amalgam coating upon the interior of a metallic hollow body consisting in applying electric current to an electrolytic cell of which the hollow body forms the cathode, the anode comprises a tetrad metal, and the electrolyte includes a salt of mercury.

4. The process of electro-plating an amalgam coating upon the interior of a metallic hollow body consisting in applying electric current to an electrolytic cell of which the hollow body forms the cathode, the anode comprises a plurality of metals to be deposited, and the electrolyte includes a salt of mercury.

5. The process of electro-plating a hollow metallic body with an interior coating of mercury, lead, tin and iron, consisting in applying electric current to an electrolytic cell of which the hollow body forms the cathode, the anode comprises a body of lead-tin alloy, and the electrolyte includes a salt of mercury and a salt of iron.

6. The process of plating a metallic surface with a coating of amalgam consisting in electro-plating a deposit of the amalgam upon the surface and then washing the plated surface with mercury in order that additional mercury will be added to the plating by adsorption.

7. The process of plating a metallic surface with a coating of amalgam consisting in electro-plating a deposit of the amalgam upon the surface, then in washing the surface with water and then with mercury in order that additional mercury will be added by adsorption.

8. The process of plating a metallic surface with a coating of amalgam consisting in the successive electro-plating of the metallic surface with the amalgam, each plating operation being followed by washing the plated surface with mercury in order that additional mercury will be added to the plating by adsorption.

9. The process of preparing electrolytically an electrolyte for amalgam plating consisting in applying an electric current to an electrolytic cell of which a quantity of mercury is the positive pole, a piece of steel or iron is the negative pole, and the electrolyte included hydrochloric acid.

10. The process of plating a surface which consists in plating the surface with amalgam, subjecting the plated surface to the action of an alkaline solution, in rinsing in water, in drying the surface, and then in subjecting the surface to the action of dry, redistilled mercury.

11. The process of sealing a hollow body provided with an internal plating of amalgam including mercury and another metal, and containing a quantity of mercury in which is dissolved a quantity of said other metal, which consists in welding a plug in the open end of said hollow body, then, while the body is still hot, in placing the body in a position such that the mercury will come into contact with the welded portion in order that the mercury and the metal dissolved therein may replate any portions of the body from which the plating may have been destroyed due to welding.

12. The process of plating a surface which consists in plating the surface with amalgam, and in subjecting the surface to the action of dry, redistilled mercury.

13. The process of sealing a hollow body

provided with an internal plating of amalgam including mercury and another metal, and containing a quantity of mercury in which is dissolved a quantity of said other metal, which consists in immersing the body in a cooling medium with the open end of the body projecting above said medium, in welding a plug in the open end of said hollow body, then, while the body is still hot, in placing the body in a position such that the mercury will come into contact with the welded portion in order that the mercury and the metal dissolved therein may replate any portions of the body from which the plating may have been destroyed due to welding.

14. The process of sealing a metallic hollow body containing a quantity of heat transferring medium which consists in driving a metal plug into the open end of the body, in cutting off the outwardly projecting end of the plug flush with the end of the body, in welding the plug in position, and in successively welding one or more metallic discs in position over the end of the plug and the end of the body.

In testimony whereof I affix my signature.

THOMAS MIDGLEY, JR.

Witnesses:
M. E. GREENE,
W. H. THEIBENBERGER.