July 12, 1949. K. M. BARTLETT 2,475,586

METHOD OF ELECTROPOLISHING THE INTERNAL SURFACE OF HOLLOW VALVES

Filed April 9, 1943

Fig. 1

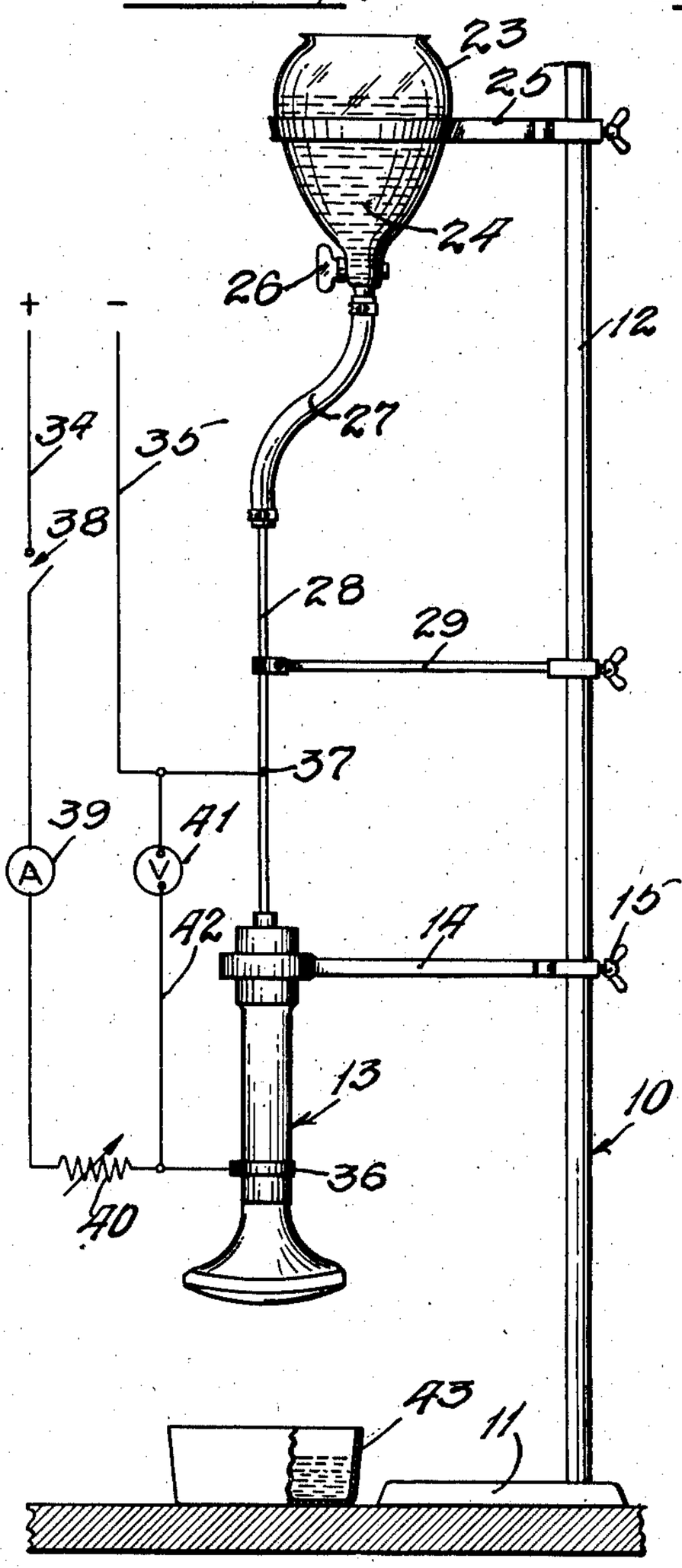
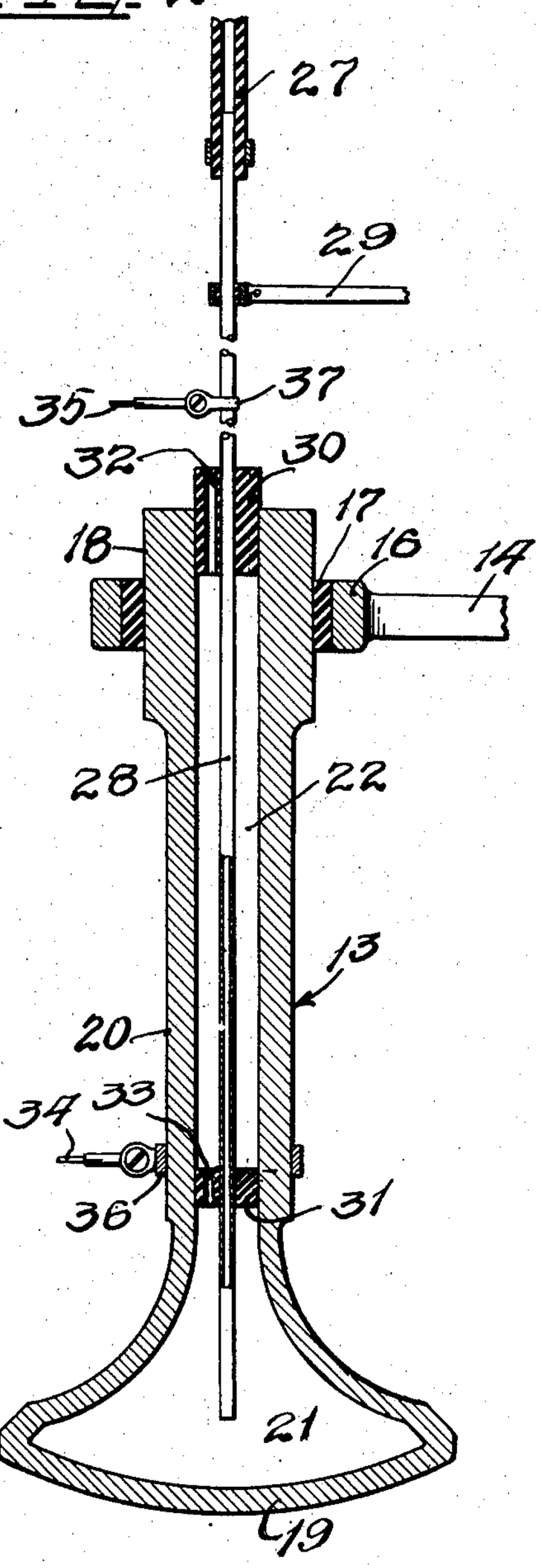


Fig. 2



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METHOD OF ELECTROPOLISHING THE INTERNAL SURFACE OF A HOLLOW VALVE

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1 Claim. (Cl. 204—140)

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This invention relates to a method of electropolishing the internal surface of a hollow metal valve and to the hollow metal valve so produced.

Hollow metal valves have heretofore been made by forging operations. After the valve has been forged, it is customary to ream out the stem portion of the valve to provide a relative smooth internal wall, and then to polish the wall with abrasive paper. The result of these reaming and polishing operations has always been to leave an amorphous layer over the surface of the internal wall of the valve. Such an amorphous layer, which is sometimes called a Beilby layer, is inherently formed as a result of any mechanical working of a metal surface. One disadvantage of such a layer is that it has a relatively low grade of heat transfer, so that it to some extent obstructs the passage of heat from the coolant, which may be metallic sodium, copper or the like, used in a hollow valve, to the wall of the valve and thence to the valve guide. It is, of course, very desirable to provide the highest efficiency of heat transfer in order that the head of the valve may be kept as cool as possible, to thereby prevent overheating of the valve.

I have now found that if the internal surface of a valve, or the like, is electropolished, a smooth, polished surface can be obtained that is entirely free from the objectionable amorphous layer produced by the mechanical working of the metal of the valve. The result is that a hollow valve having an electropolished interior surface permits a more efficient transfer of heat from the coolant used in the valve to the stem portion of the valve, and thence to the external guides.

It is therefore an important object of this invention to provide a method for electropolishing internal metal surfaces to insure a more efficient rate of heat transfer through such surfaces.

It is a further important object of this invention to provide a method for the electropolishing of the internal surfaces of hollow metal valves to eliminate or minimize the deleterious effect of scratches, remaining after a final mechanical polishing or smoothing by the use of abrasive cloths, on the endurance strength of the valve by partially or wholly removing such scratches.

It is a further important object of this invention to provide a hollow valve having an electropolished internal surface that is free from any amorphous layer and that is characterized by a high rate of heat transfer.

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Other and further important objects of this invention will be apparent from the disclosures in the specification and the accompanying drawings.

On the drawings:

Figure 1 is an elevational view, partly in section, of an apparatus embodying the principles of my invention and suitable for carrying out a method of electropolishing the internal surface of a hollow valve; and

Figure 2 is an enlarged fragmentary, sectional view of the valve and attachment illustrated in Figure 1, with parts in elevation.

The reference numeral 10 indicates generally a support, having a base 11 and an upright rod 12 extending from said base. A valve, indicated generally by the reference numeral 13 is adapted to be supported from the stand 10 by means of a clamping member 14, adjustably mounted along said rod 12 by means of a thumbscrew 15. Said clamping member 14 is provided at its free end with a ring 16 having an inner, annular lining 17 of rubber, or other insulating material. The valve 13 is adapted to be inserted in said ring 16 at its stem end 18 to be frictionally supported therein.

As illustrated, the valve 13 comprises a mushroom shaped head portion 19 and an elongated stem portion 20. The head portion 19 is formed with a cavity of a shape in general conforming with the external contour of the head 19. The stem 20 is also formed with a cavity, indicated by the reference numeral 22, which extends for its full length and merges smoothly into the head cavity 21. Ordinarily, the valve 13 as it comes to the electropolishing step about to be described will have been reamed to produce the stem cavity 22. It may also have been mechanically polished, as by use of an abrasive cloth. It is advantageous that some mechanical means have been used that will leave the wall of the stem cavity 22 in a fairly smooth condition, relatively free from tool marks, since in that case the electropolishing step has less work to do and can be accomplished at a lower cost. Aside from this matter of cost, the electropolishing method about to be described could be used even where the internal surface of the stem of the valve is relatively rough, since in the electropolishing step the high points on the surface, or crests, are anodically dissolved away until, if the method is carried out for a sufficient length of time, the surface is left perfectly smooth and with a mirror polish.

Various metals and alloys may be employed in

making the valve 13, but for use in high compression internal combustion engines, the valves are usually made of a chromium-steel alloy, or of a chromium-nickel alloy. Suitable metals and their alloys for forming the type of valve here under consideration are the following: nickel-chromium and iron alloys such as Nichrome steel; nickel, molybdenum and iron alloys such as Hastelloy steel; non-ferrous nickel-chromium alloys such as Brightray; and cobalt, chromium and tungsten alloys such as Stellite. It should be understood, of course, that the invention herein described is not limited to the use of these particular alloys. It should further be understood that the hollow valve to which the method of my invention is applied may be either forged, cast or otherwise formed.

As illustrated in Figure 1, a reservoir 23 for holding a supply of an electrolyte 24 is mounted above the valve 13 from the ring stand 10, by means of a clamping member 25. Said reservoir 23, as illustrated, comprises a funnel having a stop cock 26 for controlling the rate of flow of the electrolyte.

The reservoir 23 is connected by means of a flexible hose 27 to a tubular electrode 28 that extends into the hollow valve 13 for the full length of the stem portion 20. The electrode 28 may suitably be supported by a clamping member 29, adjustable upon the ring stand 10. A spacer 30 of insulating material is mounted in the stem end 18 of the cavity 22 for spacing said electrode 28 equidistantly from the wall of the cavity 22. A second spacer 31 serves to center the lower end of said electrode 26. Both of the spacers 30 and 31 are provided with openings therethrough, such as the openings 32 and 33 respectively, which serve for the upward flow of the electrolyte that is introduced by the hollow electrode 28 into the head cavity 21.

An electrical circuit, comprising lead wires 34 and 35, connected to a suitable source of electrical energy (not shown), is arranged to include the valve 13 and the electrode 28. For this purpose, the lead wire 34, connected to the positive side of a source of direct current electricity, is connected to the valve 13 by means of a band connector 36, and the negative wire 35 is connected to the electrode 28 by means of a screw tightened clamping band 37. A switch 38 is provided in the lead wire 34, as are also an ammeter 39 and a rheostat 40. A voltmeter 41 is connected in parallel with the inner circuit through the electrolyte in the valve 13 by means of a wire 42 extending across the lead wires 34 and 35. As will be evident from this description, the valve 13 itself forms the anode of the circuit that includes the electrolyte within said valve, while the electrode 28 forms the cathode of the circuit.

Any suitable electropolishing electrolyte may be used in the method of my invention. Among the electropolishing electrolytes that are known to those familiar with the art may be mentioned sulphuric and phosphoric acids, and mixtures of the two. As a result of considerable research, concentrated orthophosphoric acid at a temperature between about 50 and 150° F. has been found to give the most satisfactory results in the electropolishing of the internal stem surface of a hollow valve made of a chromium-containing steel, or one of alloys referred to above. Preferably, a 75% aqueous solution of phosphoric acid, containing 75% of orthophosphoric acid by weight of the solution, and heated to about 100° F. is employed. When the conditions of operation hereinafter described are followed, a mirror-like, polished surface, free from any armorphous layer, is produced by the use of 75% orthophosphoric acid. Other electrolytes, however, may be used satisfactorily, provided that they are adapted to electropolish the particular metal or alloy of which the valve 13 is made.

In operation, the electrolyte 24 from the reservoir 23 is allowed to flow through the stop cock 26 into the hollow valve 13 at a suitable rate which is controlled by proper adjustment of the stop cock 26. The electrolyte flows down through the hollow electrode 28 into the head cavity 21 of the valve and, after filling the valve, overflows through the opening 32 in the upper spacer 30, and runs down over the surface of the valve 13 into an overflow basin 43. After the valve 13 has filled up with electrolyte, the rate of flow may be adjusted to about 2 cc. per minute.

As soon as the valve 13 has been filled with the electrolyte, the circuit comprising the lead wires 34 and 35 is energized by closing the switch 38. A direct current capable of delivering an operating voltage of around 4 to 5 volts has been found suitable. The rheostat 40 is adjusted to give a reading on the ammeter 39 of around 2.5 to 3.5 amperes. On the basis of the internal surface of the valve undergoing electropolishing, this will ordinarily give about 0.5 ampere per square inch anode current density. If the anode current density is much greater or much less than this, the rheostat 40 should be adjusted to bring it within the limits mentioned.

The spacing of the anode from the cathode is relatively important. In the apparatus illustrated, the cathode electrode 28 may suitably be a copper tube having an outside diameter of one-eighth of an inch and an inside diameter of one-sixteenth of an inch. With the usual diameters of the stem cavity 22, this will result in an anode-cathode spacing of between one-eighth of an inch and three-eighths of an inch. These are, in general, the minimum and maximum anode-cathode spacings for optimum electropolishing results. The cathode electrode 28 need not be made of copper, but may be made of stainless steel, Monel metal or other suitable metal or alloy.

The ratio of anode to cathode area should not vary for best results very greatly from the ratio of 3.5 to 1.0. This ratio of anode to cathode area rather takes care of itself if the anode-cathode spacing is properly controlled as above indicated. It is important, of course, that the cathode 28 be properly centered with respect to the stem cavity 22, so that the radial distance between the outside of the cathode 28 and inner wall of the cavity 22 will be the same throughout the length of the stem.

The operation is continued until the surface of the stem cavity 22 has received a smooth, mirror-like polish, or whatever degree of polish is desired. With the conditions of electropolishing such as those above described, the entire electropolishing operation requires in the neighborhood of forty minutes. At the end of this period, the current is shut off and the valve 13 removed from its clamping bracket 14, emptied of the electrolyte and thoroughly washed. The internal surface of the stem cavity 22 will be found to have taken on a smooth, mirror-like polish and will be entirely free from any amorphous layer.

The electrolyte solution, may, of course, be re-used, as by returning the excess of electrolyte from the overflow receptacle 43 back to the res-

ervoir 23. Upon continued use, the dissolved solids contents of the electrolyte increases due to the anodic dissolution of metal from the surface of the stem cavity 22, until finally the electrolyte is no longer effective. This point is reached when about 0.17 gram of chromium are present for each 10 cc. of the electrolyte. The electrolyte may then be regenerated, or a new electrolyte used.

In my copending application, filed of even date herewith, I have described a method and an apparatus for descaling the wall of the valve head cavity, such as the cavity 21 of the valve 13. The descaling of the head cavity, as described in this copending application for patent, would ordinarily be carried out before electropolishing the inner surface of the stem portion of the valve. If desired, apparatus such as shown in my copending application might be used for the electropolishing of the walls of the head cavity 27, using the operating conditions hereinabove set forth for the electropolishing of the stem portion of the valve. In the method as above described, however, very little, if any, electropolishing of the walls of the head cavity takes place, because the cathode electrode 28 is relatively farther away from the walls of the head cavity 21 than it is from the wall of the stem cavity 22 and hence an insufficient amount of current passes through the walls of the head cavity to effect polishing. The lower end of the cathode electrode 28 may, of course, be inserted into the stem cavity 22 for only such distance as electropolishing of the stem portion may be desired to be carried, or, by using the electrode extension of my copending application, the walls of the head cavity 21 may be electropolished, as well as descaled.

It will, of course, be understood that various details of construction 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.

What I claim is:

The method of electropolishing the inner surface of the stem of a hollow valve which comprises positioning a hollow electrode in said stem, flowing an electropolishing electrolyte through said hollow electrode into said valve while permitting the excess of said electrolyte to overflow from said valve, making said inner stem surface the anode and said electrode the cathode, and while continuing said electrolyte flow passing an electric current from said anode through said electrolyte to said electrode of sufficient current density and for a sufficient period of time to effect a polishing of said inner stem surface and to render said inner stem surface free from any amorphous layer.

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