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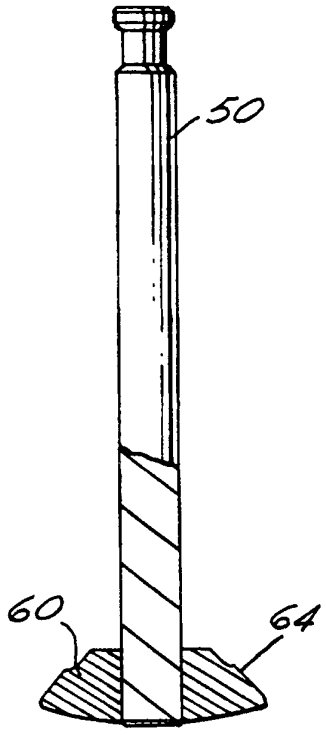
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(54) Title: METHOD OF MAKING A TWO PIECE VALVE

(57) Abstract

A valve and method of making a valve for an internal combustion engine includes centerless grinding or screw machining a valve (50) stem, providing a head (60) having a combustion exposure surface and a backing (64), and press fitting the stem through the backing (64) of the head (60) to form a joint between the valve stem (50) and the head (60). The valve stem (50) is preferably formed from a martensitic steel or an alloy steel, and the head (60) is formed from a martensitic steel. The head (60) and valve stem (50) preferably have different coefficients of thermal expansion so that upon exposure to the operating conditions of the engine, the valve components expand at different rates to tighten the joint. The joint can also be strengthened by laser welding, coining, or roll riveting the joint.



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METHOD OF MAKING A TWO PIECE VALVE

Technical Field

This invention relates to valves, and more particularly to a method of making a two piece valve for a small internal combustion engine.

Background Art

Small internal combustion four cycle engines typically include components such as a cam gear and a pair of cam lobes mounted on a camshaft. The cam gear meshes with a crankgear mounted on a crankshaft, thereby rotating the camshaft in timed relation to the engine cycle. Each rotating cam lobe reciprocates a push rod, which in turn respectively act on a rocker arm to alternate an intake valve and an exhaust valve between open and closed positions. In the case of an overhead cam type engine, the rocker arms normally act directly between the cam lobes and the valves.

Valves typically include a stem and a head, and may be formed in either one or two pieces. In a conventional two piece valve, the head is forged and then spun welded to the stem, after which the valve is ground to its finished dimensions. Other means of attaching the head to the stem include fasteners or mechanical locks. See, for example, U.S. Patent No. 1,117,924 to Stone and U.S. Patent No. 1,826,543 to Hervig et al.

It has also been proposed to form the valves with powdered metal or molded heads. For example, U.S. Patent No. 4,852,531 to Abkowitz et al. discloses a

poppet valve in which the stem is made of titanium alloy and the head is formed from a powdered titanium alloy. The head is joined to the stem by first cold compacting the stem and the head while they are in contact. The components are held at 40-60 Ksi for 5-15 seconds, and then the joined article is vacuum sintered at about 2200 degrees Farenheit for about two hours. The vacuum sintered article is subsequently compacted at elevated temperatures.

Similarly, U.S. Patent No. 4,834,306 to Nishiyama et al. discloses a composite valve having a hollow steel stem and a molded titanium head. To form the valve, the stem is inserted into a hole in the head, and the joint is exposed to uniform heating by a high-frequency device. Pressurized inert gas is then supplied from the opposite open end of the stem through its hollow portion so that the gas inside undergoes an instantaneous thermal expansion, causing the enlarged end of the stem to expand outwardly against the inside wall of the hole for a rigid pressure fitting.

Particularly in one cylinder engine applications such as hand held power tools, however, the overall size of the valve is very small. The diameter of the stem, for example, may approach several millimeter or less. Because of the difficulties of machining such small components, it is not cost effective to produce commercial quantities of these small valves by conventional techniques.

Summary of The Invention

The present invention is a method of making a valve for an internal combustion engine. The method

comprises centerless grinding or screw machining a stem, providing a head having a combustion exposure surface and a backing, and press fitting the stem through the backing of the head to form a joint between the stem and the head. The stem is preferably formed from a martensitic or an alloy steel, and the head is formed from a martensitic steel. The head and stem preferably have different coefficients of thermal expansion so that upon exposure to the operating conditions of the engine, the valve components expand at different rates to tighten the joint. The joint can also be strengthened by laser welding, coining, or roll riveting the joint. The present invention also includes the valve formed in accordance with this method.

Accordingly, it is an object of the present invention to provide a method of making a two piece valve of the type described above for use in a small internal combustion engine.

Another object of the present invention is to provide a method of making a two piece valve of the type described above in which the stem is centerless ground or screw machined.

Another object of the present invention is to provide a method of making a two piece valve of the type described above in which the stem and the head have different coefficients of thermal expansion.

Another object of the present invention is to provide a method of making a two piece valve of the type described above in which the joint between the stem and the head is strengthened by welding, coining, or roll riveting.

Still another object of the present invention is to provide a valve formed in accordance with the method described above.

These and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in conjunction with the accompanying drawings.

Brief Description Of The Drawings

FIGURE 1 is a cross-sectional view of a small internal combustion engine;

FIGURE 2 is a side view of a valve stem for use in the present invention;

FIGURE 3 is a cross-sectional view of a valve head for use in the present invention;

FIGURE 4 is a partial cross-sectional view of one embodiment of a two piece valve formed according to the present invention;

FIGURE 5 is a cross-sectional view of another embodiment of a two piece valve formed according to the present invention;

FIGURE 6 is a cross-sectional view of still another embodiment of a two piece valve formed according to the present invention; and

FIGURE 7 is a cross-sectional view of still another embodiment of a two piece valve formed according to the present invention.

Best Mode For Carrying Out The Invention

With reference to the drawings, a method of making a valve for an internal combustion engine will be described. The method comprises turning a valve stem by centerless grinding or screw machining, providing a valve head, and press fitting the stem into the head.

Figure 1 shows a small one cylinder four cycle internal combustion engine 10 having a single lobe camshaft assembly including a camshaft 14, a cam lobe 16 and a cam gear 18. The engine 10 is advantageously dedicated, for example, to run a hand held power tool such as a line trimmer. The cam lobe 16 is mounted on the camshaft 14, which in turn is mounted to an engine block 22. The cam gear 18 meshes with and is rotated by a crankgear 24 mounted on a crankshaft 26. A pair of frog-leg-shaped followers 28 are pivotably mounted on a follower shaft 32, which extends generally parallel to the camshaft 14 and is fixedly mounted in the engine block 22. The followers 28 thus pivot on the follower shaft 32 in well known fashion as the cam lobe 16 rotates.

An intake valve 34 and an exhaust valve (not shown) are normally biased to a seated or closed position by springs 36. As the followers 28 pivot on the follower shaft 32, they reciprocate push rods 38 and 40. The push rods 38 and 40 extend up to and cooperate with rocker arms 42 and 44, which alternately actuate the intake valve 34 and the exhaust valve, respectively,

to conventionally supply a fuel-air mixture to a cylinder 46 and to evacuate the byproducts of combustion from the cylinder.

Figure 2 shows a valve stem 50 formed according to the present invention. The valve stem 50 is formed by turning a length of bar stock in either a screw machine or a centerless grinding machine. Centerless grinders are used to good advantage where large numbers of relatively small pieces must be ground and where the ground surface has no exact relation to any other surface except as a whole (Marks' Standard Handbook for Mechanical Engineers, Ninth edition 1987, p. 13-71).

The bar stock is preferably either a 410 or 440B martensitic stainless steel alloy, or a UNS 41400 alloy steel. These materials are strong enough to withstand contact with a rocker or a cam at the operating temperatures of the engine, which are typically about 1200-1400 degrees Farenheit. After the bar stock is turned into a substantially cylindrical shape to form the stem, it is hardened to 36-50 Rockwell C (R_c). For example, a 410 martensitic stainless steel stem is hardened at a temperature range of about 1700-1850 degrees Farenheit, quenched to a hardness of about 39-43 R_c, and then stress relieved at about 450-700 degrees Farenheit. The hardness of the stem 50 after stress relief is about 37-40 R_c. A groove 55 for a keeper is formed either before or after hardening of the stem. The valve stem 50 is preferably about 35 millimeters in length and about 2-3 millimeters in diameter.

Figure 3 shows a valve head 60 having a combustion exposure surface 62 and a backing 64. The head is of any conventional formation, including powdered metal, screw machined, or a sheet metal stamping. The Powder Metal Design Manual, published by the Metal Powders Institute Federation and hereby incorporated by reference, discloses a variety of compositions and techniques for obtaining the desired physical properties from a powdered metal part. Preferably, the head 60 is a martensitic 422 stainless steel which may be hardened. Alternately, the head is formed of a superalloy precipitation hardened to 20-40 R_c.

Figure 4 shows the stem 50 tightly press fitted through the backing 64 of the head 60 to form a joint between the stem and the head. It is desirable that the stem 50 expand more than the hole in the backing 64 so that the joint tightens when exposed to elevated temperatures. For this reason, the coefficients of thermal expansion of the stem and head are preferably different, with the stem having the greater coefficient of thermal expansion. In a preferred embodiment, the UNS 41400 alloy steel stem has a coefficient of thermal expansion of about 7.3×10^{-6} inch/inch/degree Farenheit, and the martensitic stainless steel head has a coefficient of thermal expansion of about 6.5×10^{-6} inch/inch/degree Farenheit.

The joint can then be strengthened in one of several way if the intended operating conditions so require. As shown in Figure 5, one method of accomplishing this is to weld the joint. Any suitable weld, including those formed by conventional brazing or laser welding, may be made at either or both an upper

point 66 where the stem 50 enters the backing 64 and a lower point 68 where the stem emerges through the combustion exposure surface 62 of the head 60.

Another preferred manner of strengthening the bond between the stem 50 and the head 60 is coining. Figure 6 shows an embodiment of the valve formed by this operation in which the stem 50 does not extend fully through the head 60. The stem 50 is coined near the point where it enters the head 60 such that the lower end of the stem is indented and a portion of the head is pressed into the indentation 70 to lock the stem and head together.

Figure 7 shows still another method of strengthening the connection in which the joint is roll riveted or staked. Similar to the embodiment shown in Figure 5, the stem 50 is inserted entirely through the head 60. Thereafter, the lower end of the stem is deformed into a section 72 having a diameter greater than the hole through which the stem 50 extends. The deformed section 72 can be made either by holding the head in place on the stem and striking the lower end of the stem with a punch, or by compressing the lower end of the stem against an anvil.

The combustion exposure surface 62 of the valve can be finish ground, either before of after the head is joined to the stem. Likewise, the stem can be hardened as described above after assembly with the head, if it is not so hardened before assembly.

It should be understood that while the forms of the invention herein shown and described constitute preferred embodiments of the invention, they are not

intended to illustrate all possible forms thereof. It should also be understood that the words used are words of description rather than limitation, and various changes may be made without departing from the spirit and scope of the invention disclosed.

What Is Claimed Is:

1. A method of making a valve for an internal combustion engine, the method comprising:

centerless grinding a stem;

providing a head having a combustion exposure surface and a backing; and

press fitting the stem through the backing of the head to form a joint between the stem and the head.

2. The method of claim 1 further comprising welding the joint.

3. The method of claim 2 wherein the welding step comprises laser welding.

4. The method of claim 1 further comprising coining the joint.

5. The method of claim 1 further comprising roll riveting the joint.

6. The method of claim 1 further comprising finish grinding the combustion exposure surface of the valve.

7. The method of claim 1 further comprising hardening the stem.

8. The method of claim 1 wherein the stem extends entirely through the head.

9. The method of claim 1 wherein the stem includes martensitic stainless steel.

10. The method of claim 1 wherein the stem includes alloy steel.

11. The method of claim 1 wherein the joint tightens when exposed to elevated temperatures.

12. The method of claim 1 wherein the head includes powdered metal.

13. The method of claim 1 wherein the head is stamped.

14. A method of making a valve for an internal combustion engine, the method comprising:

screw machining a stem;

providing a head having a combustion exposure surface and a backing; and

press fitting the stem through the backing of the head to form a joint between the stem and the head.

15. The method of claim 14 further comprising welding the joint.

16. The method of claim 15 wherein the welding step comprises laser welding.

17. The method of claim 14 further comprising coining the joint.

18. The method of claim 14 further comprising roll riveting the joint.

19. The method of claim 14 further comprising finish grinding the combustion exposure surface of the valve.

20. The method of claim 14 further comprising hardening the stem.

21. A valve for an internal combustion engine produced in accordance with the method of claim 1.

22. A valve for an internal combustion engine produced in accordance with the method of claim 14.

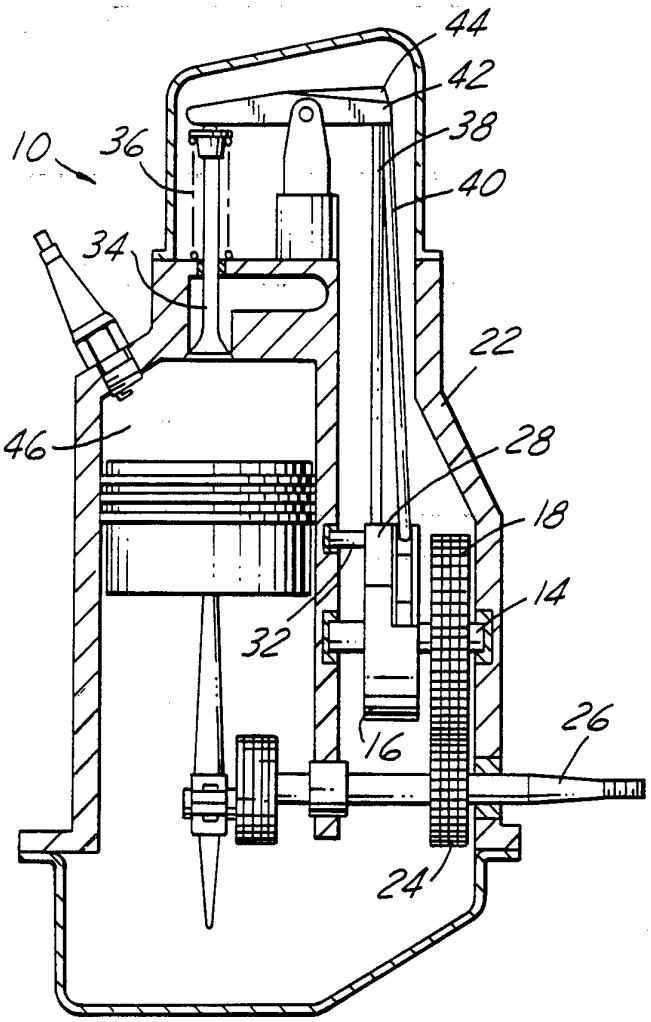


Fig-1

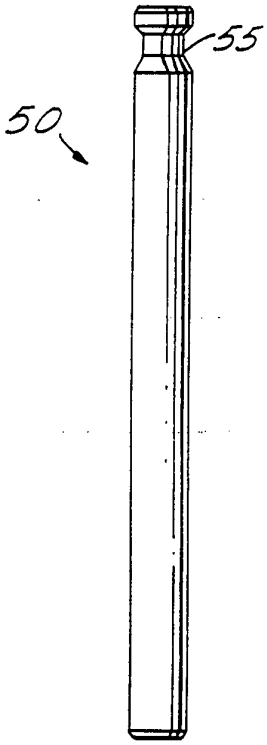


Fig-2

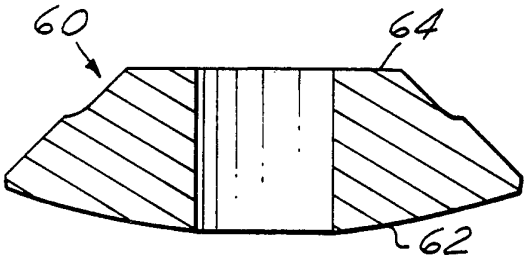


Fig-3

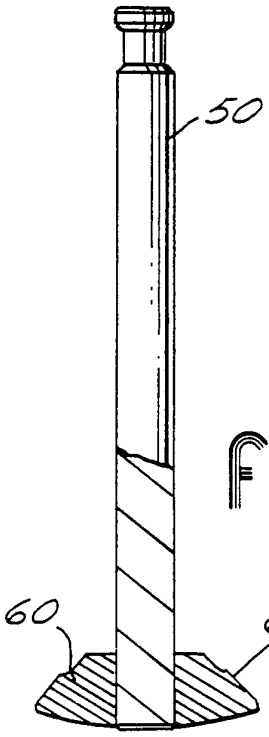


Fig-4

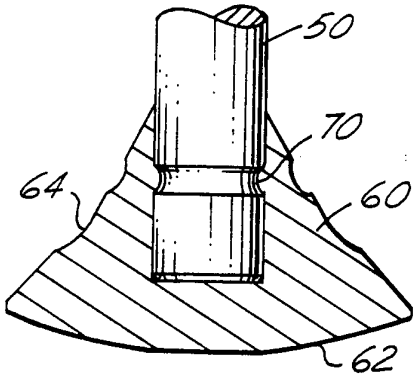


Fig-6

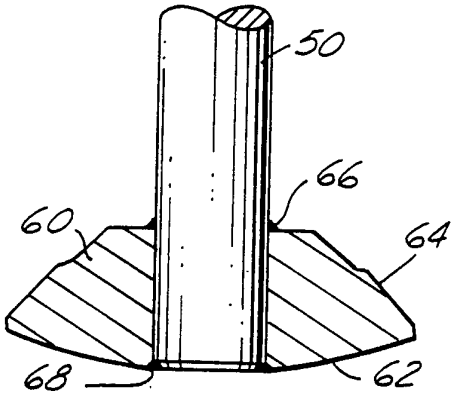


Fig-5

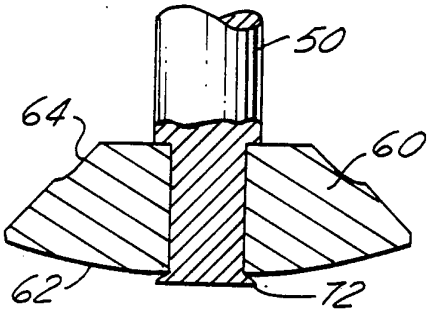


Fig-7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/02147

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :B23P 15/00
US CL :29/888.460,888.4,558; 51/103F; 123/188.2, 188.3,90.51
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 29/33k,37A,38B,558,557,888.460,888.4; 51/49,103TF,289R,241VS,29; 123/188.2,188.3,90.51

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 1,546,358 (ATWATER) 21 JULY 1925 SEE ENTIRE DOCUMENT	1-22
Y	US, A, 4,852,531 (ABKOWITZ ET AL.) 01 AUGUST 1989 SEE ABSTRACT, FIG. 2, COL. 2, LINES 42-68	12
Y	JP, A, 0,059,046 (HONDA MOTOR IND KK) 05 APRIL 1985 SEE ABSTRACT	12
Y	US, A, 1,767,409 (SPIRE ET AL.) 24 JUNE 1930 SEE ENTIRE DOCUMENT	1-3,7-11, 14-16, 19-22
Y	US, A, 1,479,121 (WASHBURNE) 01 JANUARY 1924 SEE ENTIRE DOCUMENT	14-20,22
Y	US, A, 5,150,518 (FUCHS) 29 SEPTEMBER SEE ENTIRE DOCUMENT	ALL

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/02147

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,123,213 (VINSON) 23 JUNE 1992 SEE ENTIRE DOCUMENT	1-22
Y	US, A, 4,547,229 (LARSON ET AL.) 15 OCTOBER 1985 SEE ENTIRE DOCUMENT	1-22
Y	US, A, 1,587,991 (SPITZLEY ET AL.) 08 JUNE 1926 SEE ENTIRE DOCUMENT	1-22
Y	US, A, 1,470,034 (SCHUPP) 09 OCTOBER 1923 SEE ENTIRE DOCUMENT	1-22
Y	US, A, 1,470,041 (WILCOX) 09 OCTOBER 1923 SEE ENTIRE DOCUMENT	1-22
Y	US, A, 4,656,723 (UCHIDA) 14 APRIL 1987 SEE ENTIRE DOCUMENT	14-20
A	US, A, 1,949,515 (NORTON) 06 MARCH 1934 SEE ENTIRE DOCUMENT	14-20
A	US, A, 1,117,924 (STONE) 17 NOVEMBER 1914 SEE ENTIRE DOCUMENT	14-20
A	US, A, 1,772,482 (FORD) 12 AUGUST 1930 SEE ENTIRE DOCUMENT	1-22
A	US, A, 987,757 (SMITH ET AL.) 28 MARCH 1911 SEE ENTIRE DOCUMENT	1-22
A	US, A, 1,525,625 (TAYLOR) 10 FEBRUARY 1925 SEE ENTIRE DOCUMENT	1-22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/02147

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Group I, claims 1-13 & 21 are directed to a method of centerless grinding classified in class 51/03 and 123/188.2 and have the special technical feature of centerless grinding.
Group II, claims 14-20 and 22 are directed to a method of screw machining classified in class 29/888.460 and 123/188.2 and have the special technical feature of screw machining.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.