



(51) International Patent Classification:

F01L 13/00 (2006.01) *F01L 1/04* (2006.01)
F01L 1/18 (2006.01) *F02D 13/02* (2006.01)

(21) International Application Number:

PCT/US2010/024405

(22) International Filing Date:

17 February 2010 (17.02.2010)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

61/207,809 17 February 2009 (17.02.2009) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report (Rule 48.2(g))

(54) Title: VARIABLE VALVE ACTUATION APPARATUS, SYSTEM, AND METHOD

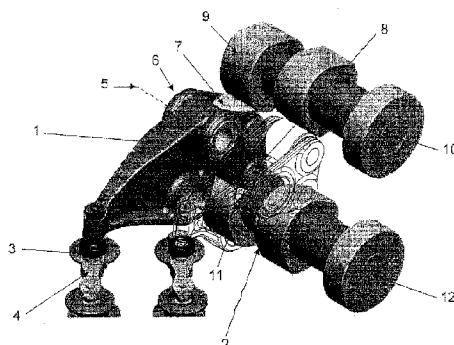


Fig. 1

(57) Abstract: A variable valve actuation system is disclosed, in one form a rocker is disclosed coupled with a valve stem at one end and a cam follower at the other end. The rocker is operable to pivot about a fixed axis. The cam follower is operable to be pivotally coupled with the rocker at one end of the cam follower. The cam follower includes a lower roller and an upper roller at its other end, each operable to engage cam lobes on separate cam shafts. In one form the cam follower includes a lower roller operable to follow a cam lobe on a lower cam shaft and an upper roller operable to follow a cam lobe on an upper cam shaft. The upper cam shaft and the lower cam shaft can have variable lobes. A spring can be used to bias the cam follower on the rocker.

VARIABLE VALVE ACTUATION APPARATUS, SYSTEM, AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application 61/207,809, filed February 17, 2009, and is incorporated herein by reference.

TECHNICAL FIELD

The present invention generally relates to internal combustion engines, and more particularly, but not exclusively, to variable valve actuation systems used in internal combustion engines such as diesel engines.

BACKGROUND

Variable valve actuation (VVA) can improve engine performance by enabling different combustion strategies at different operating conditions, including Miller cycling, internal exhaust gas recirculation (iEGR), thermal management for aftertreatment control, and decompression for engine starting. Both intake and exhaust valves can be variably actuated to enable this combustion strategies, changing the valve's lift and/or duration. Known VVA systems with both intake and exhaust lift and duration flexibility can be grouped into 3 categories: full electric, hydraulic lost motion (partially mechanical), and fully mechanical. One problem with full-functioning, fully mechanical VVA systems is their large physical size. Package space around the valves is classically limited due to height and width constraints and is increasingly limited in

advanced engines due to increasing fuel system space claims. Accordingly, there remains a need for further contributions in this area of technology.

SUMMARY

One embodiment of the present invention is a unique variable valve actuation device. Other embodiments include apparatuses, systems, devices, hardware, methods, and combinations for providing variable valve actuation. Further embodiments, forms, features, aspects, benefits, and advantages of the present application shall become apparent from the description and figures provided herewith.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 depicts one form of dual cam shafts and rocker assembly.

Fig. 2 depicts one form of dual cam shafts and rocker assembly.

Fig. 3 depicts one form of dual cam shafts and rocker assembly.

Fig. 4 depicts one form of dual cam shafts and rocker assembly.

Fig. 5 depicts one form of dual cam shafts, rocker assembly, and biasing component.

Fig. 6 depicts one form of dual cam shafts, rocker assembly, and biasing component.

Fig. 7 depicts one form of dual cam shafts, rocker assembly, and biasing component.

Fig. 8 depicts one form of dual cam shafts, rocker assembly, and biasing component.

Fig. 9 depicts one form of dual cam shafts, rocker assembly, and biasing component.

Fig. 10 depicts one form of dual cam shafts, rocker assembly, and biasing component.

Fig. 11 depicts one form dual cam shafts, rocker assembly, and biasing component.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the invention relates.

In one non-limiting embodiment the present invention utilizes two cams to provide both intake and exhaust variable actuation but packages both on one side of the cylinder head. In one form both intake and exhaust rockers read both camshafts instead of each rocker reading its own cam. This allows the two cam lobes driving each valve event to be packaged in the same plane perpendicular to the camshaft centerline.

With reference to Figs. 1-4 a rocker 1 rotates about a fixed axis 2, moving an adjustable e-foot 3 which actuates traditional overhead poppet valves via a crosshead 4. A follower 6 is pivotally coupled with the rocker 1 about an axis 5. The rocker 1 is rotated about the fixed axis 2 when it receives a force through its input axis 5 generated by movement of a follower 6. The movement of the follower 6 is generated by the geometric constraints of its three axes: its output axis which is coaxial with the input axis 5; an axis through an upper roller 7; and an axis through a lower roller 8. The upper roller 7 follows a cam lobe 9 on the upper cam assembly 10 while the lower roller 8 follows a cam lobe 11 on the lower cam assembly 12. The lower cam lobe 11 causes

the valve to open while the upper cam lobe 9 allows the valve to close. In an alternative embodiment the lower cam lobe 11 causes the valve to close while the upper cam lobe 9 causes the valve to open. Additional rocker motion is controlled via spring(s) (not illustrated). In one form, the spring(s) influence motion of the follower 6 such that the upper roller 7 disengages from the cam lobe 9 during at least a portion of a revolution of the cam assembly 10. Depending on the variable valve event desired, either the upper lobe 9 or the lower lobe 11 is fixed to a modulated shaft while the other is fixed to a non-modulating shaft. The shaft modulation is controlled via a cam phaser (not shown). With respect to movement of a valve, either the upper lobe 9 or the lower lobe 11 can control a variable event and the other can control a fixed event. To set forth just one non-limiting example, the upper lobe 9 can control a variable opening of an intake valve and the lower lobe 11 can support a fixed closing of the intake valve. In yet another example, for a system with both variable intake and variable exhaust, one cam assembly can support the fixed opening lobe of the intake and the variable closing lobe of the exhaust while the other cam assembly would support the variable closing lobe of the intake and the fixed opening lobe of the exhaust. The opening event of the intake valve can either be fixed or varying, as can the closing event. The same is true of the exhaust valve regarding its opening and closing event. Therefore, no limitation is hereby intended with the non-limiting examples above.

With reference to Figs. 5-11, and with continuing reference to Figs. 1-4, the follower 6 is shown coupled to an energy storage device 13 which is used to bias the follower 6 during operation. In the illustrative embodiment the energy storage device 13 includes a spring 14 that is retained by a guide 15. Other forms of the energy storage

device 13 are also contemplated herein. The guide 15 is coupled to the follower 6 on one end and can be coupled with a relatively fixed location of an internal combustion engine on the other end.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the inventions are desired to be protected. It should be understood that while the use of words such as preferable, preferably, preferred or more preferred utilized in the description above indicate that the feature so described may be more desirable, it nonetheless may not be necessary and embodiments lacking the same may be contemplated as within the scope of the invention, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as "a," "an," "at least one," or "at least one portion" are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language "at least a portion" and/or "a portion" is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus comprising:
a cam follower operable to be pivotally coupled with a valve rocker arm and having a first rotatable member operable to be engaged with a first cam lobe substantially throughout a revolution of a cam shaft and a second rotatable member operable to be disengaged from a second cam lobe through a portion of the revolution.
2. The apparatus of claim 1, wherein the cam follower includes one end that is pivotally coupled with the valve rocker arm and a second end having the first rotatable member and the second rotatable member.
3. The apparatus of claim 2, wherein the first rotatable member is operable to be coupled with a first cam shaft, and the second rotatable member is operable to be coupled with a second cam shaft.
4. The apparatus of claim 2, which further includes an energy member operable to bias the cam follower such that the second rotatable member is disengaged from the second cam lobe.
5. The apparatus of claim 4, wherein the energy member is a spring.

6. The apparatus of claim 2, which further includes the first cam shaft having a variable first lobe that is operable to engage the first rotatable member and the second cam shaft having a variable second lobe that is operable to engage the second rotatable member.

7. An apparatus comprising:

a cam follower having a pivot aperture operable to be pivotally coupled with a rocker arm, the cam follower having an end that includes a first cam lobe contact member operable to contact a first cam lobe and a second cam lobe contact member operable to contact a second cam lobe.

8. The apparatus of claim 7, wherein the first cam lobe contact member and the second cam lobe contact member include portions located in a plane perpendicular to a pivotal axis of the cam follower.

9. The apparatus of claim 7, wherein the first cam lobe contact member is a roller coupled to the cam follower through a bearing.

10. The apparatus of claim 7, wherein the cam follower includes a load bearing portion structured to receive a force from an energy member.

11. The apparatus of claim 10, wherein the energy member is a spring.
12. The apparatus of claim 11, wherein the spring is selected from the group consisting of a helical coil spring and a leaf spring.
13. The apparatus of claim 10, wherein the energy member operable to be coupled to a relatively fixed location of an internal combustion engine.
14. The apparatus of claim 7, wherein the first cam lobe contact member is operable to contact a first cam shaft and the second cam lobe contact member is operable to contact a second cam shaft.
15. The apparatus of claim 8, wherein the first cam shaft includes an independently variable cam lobe, the first cam lobe contact member operable to disengage from the independently variable cam lobe over a portion of a revolution of the first cam shaft.
16. An apparatus comprising:
 - a rocker arm operable to be used in a variable valve actuation engine;
 - a first cam shaft and a second cam shaft; and
 - means for engaging a lobe on the first cam shaft and a lobe on the second cam shaft.
17. A method comprising:

rotating a first cam shaft having a first lobe and a second cam shaft having a second lobe;

periodically engaging the first lobe with a first member of a cam follower;

substantially engaging the second lobe with a second member of the cam follower;

pivoting the cam follower about a rocker; and

moving the rocker to actuate a valve.

18. The method of claim 17, which further includes biasing the cam follower with an energy device.

19. The method of claim 17, wherein the periodically engaging and the substantially engaging occur on one side of the pivoting the cam follower.

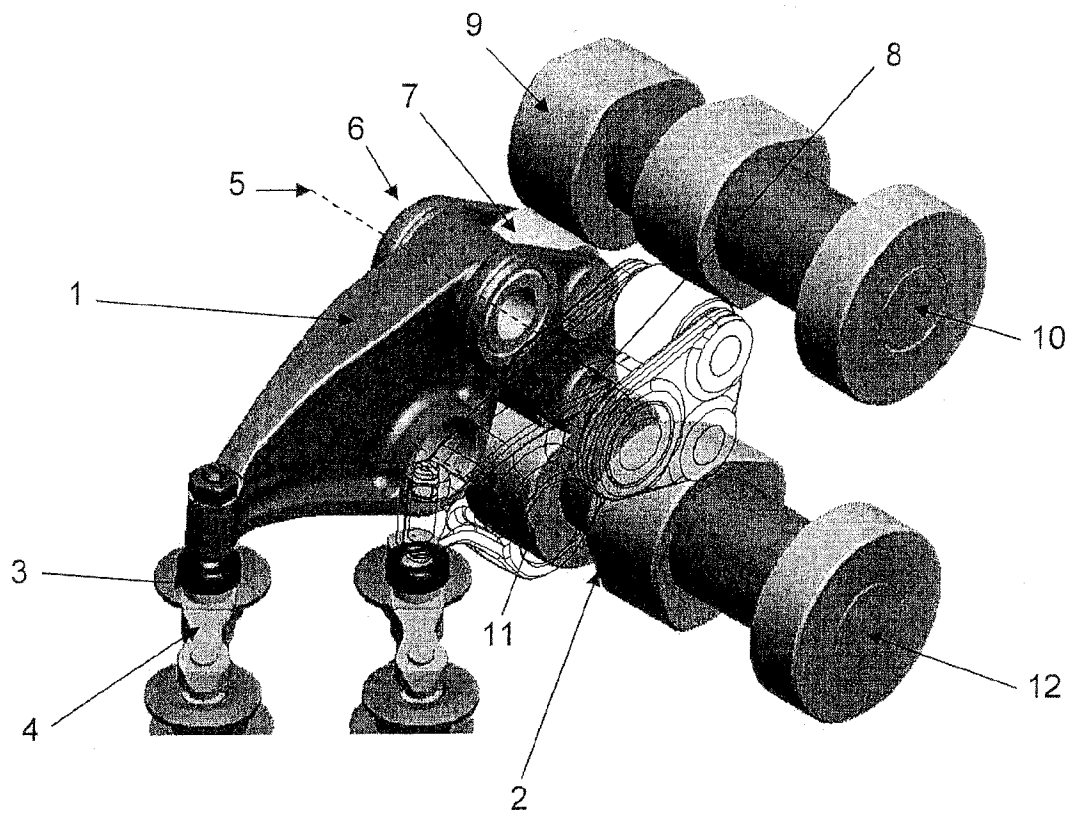


Fig. 1

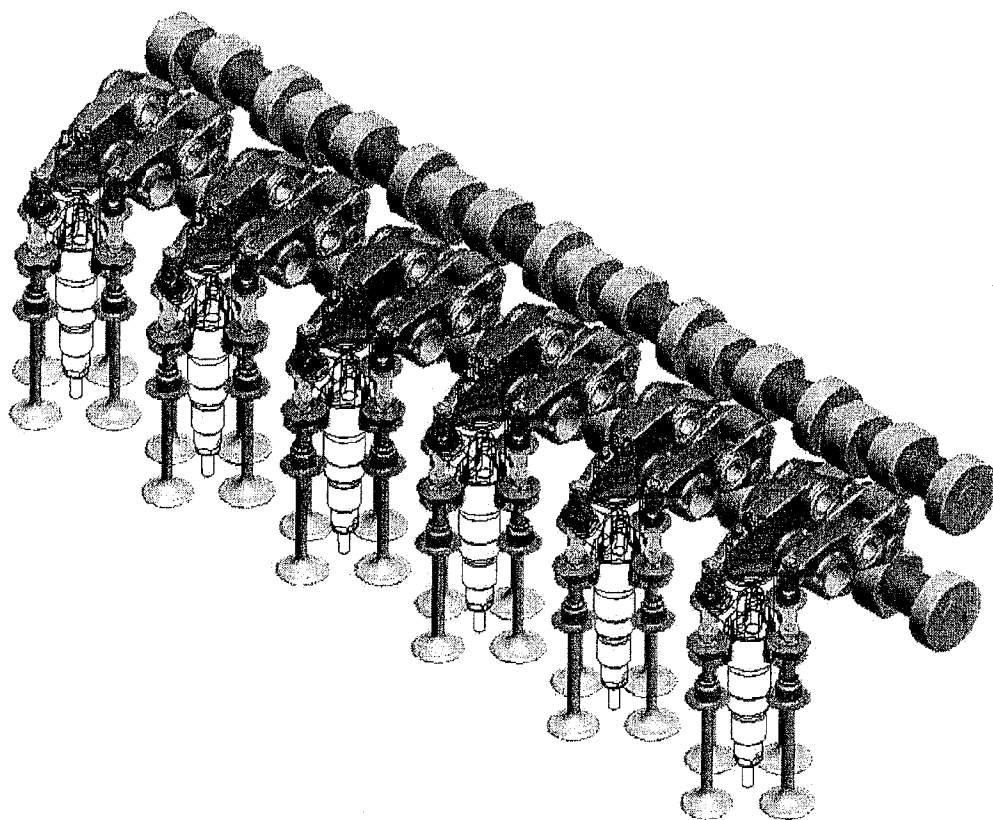


Fig. 2

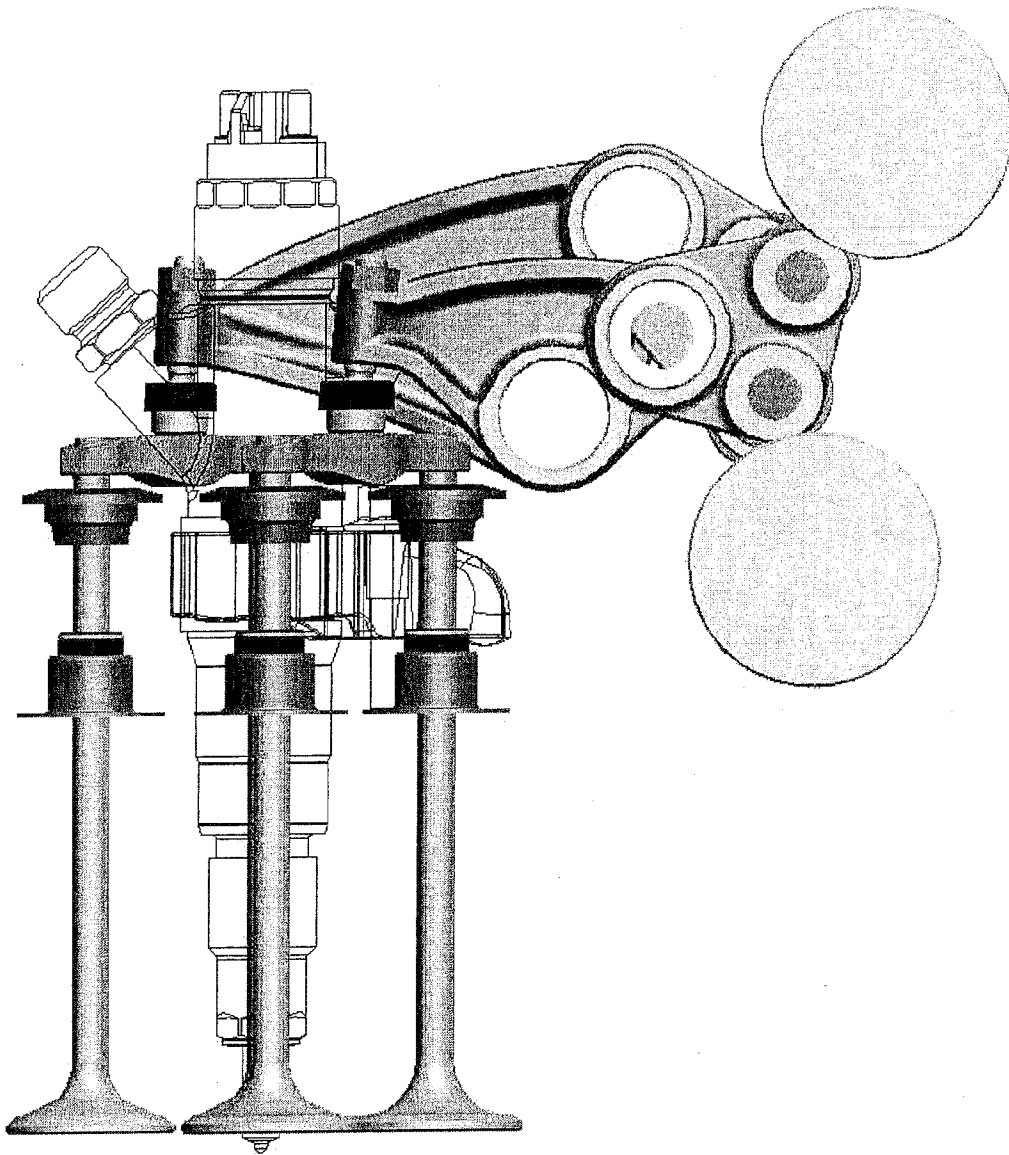


Fig. 3

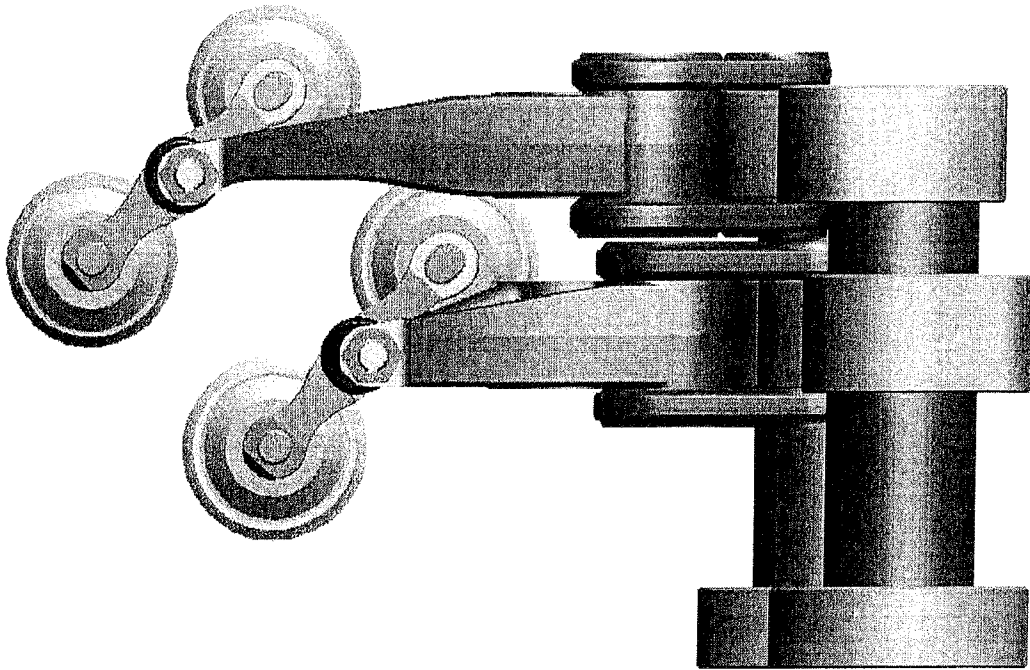


Fig. 4

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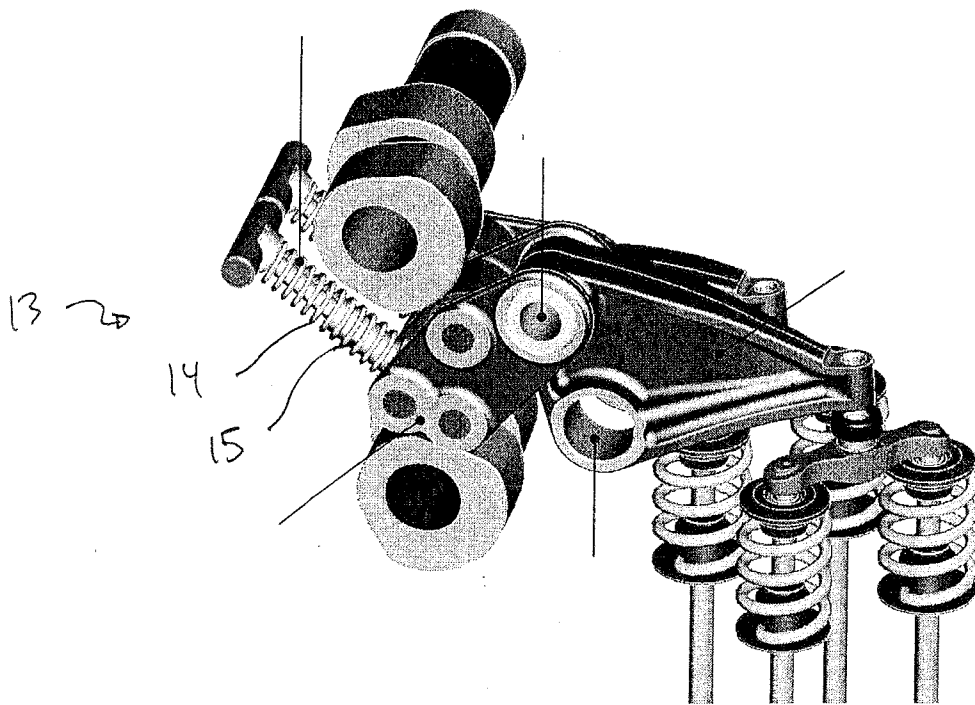


Fig 5

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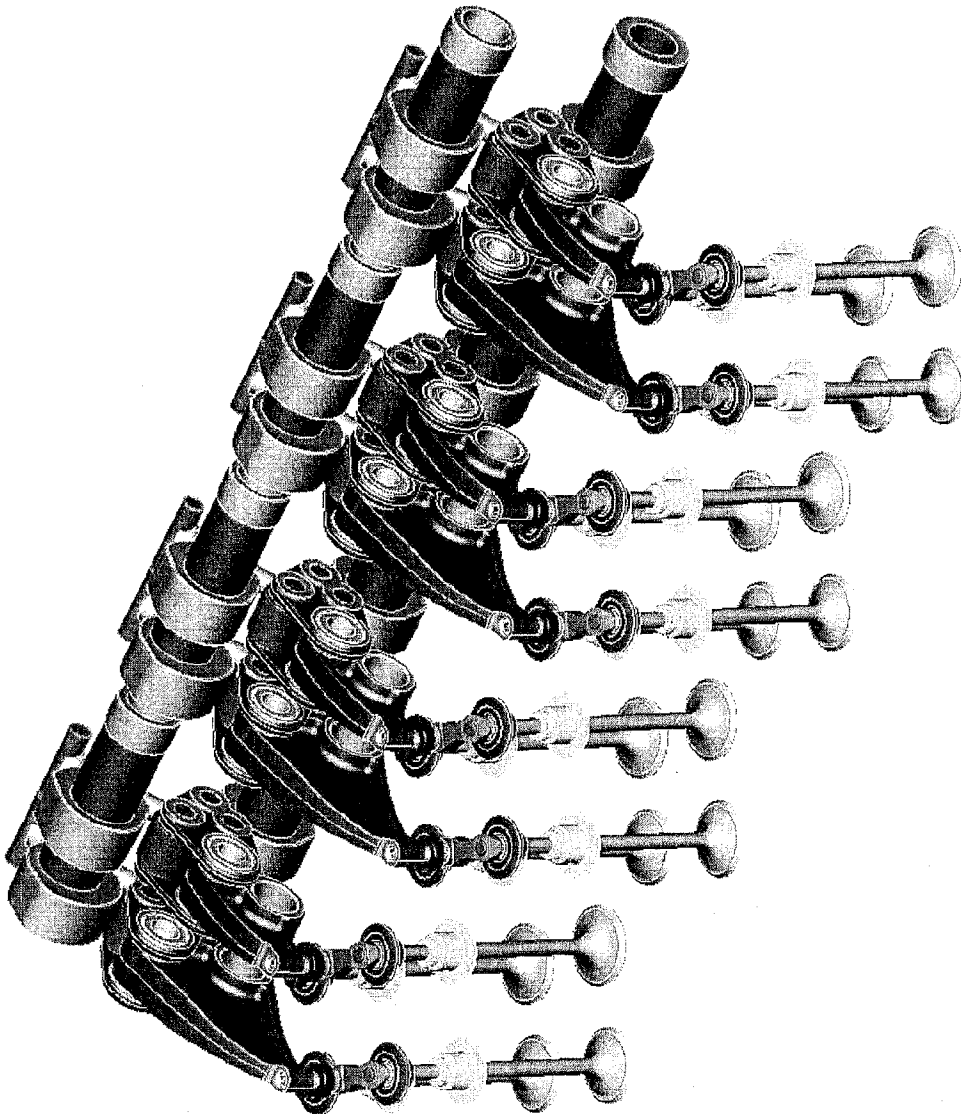


Fig. 6

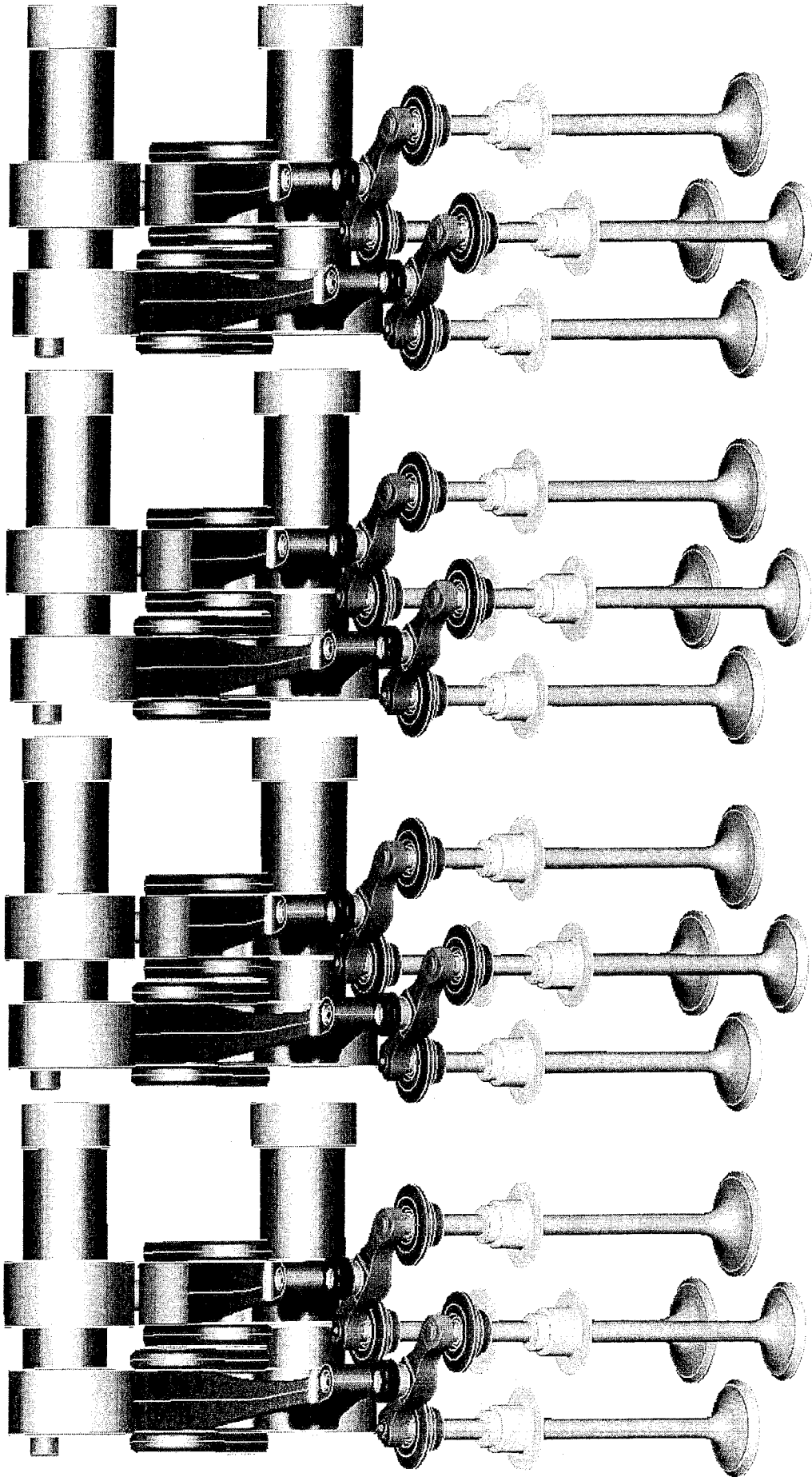


Fig. 7

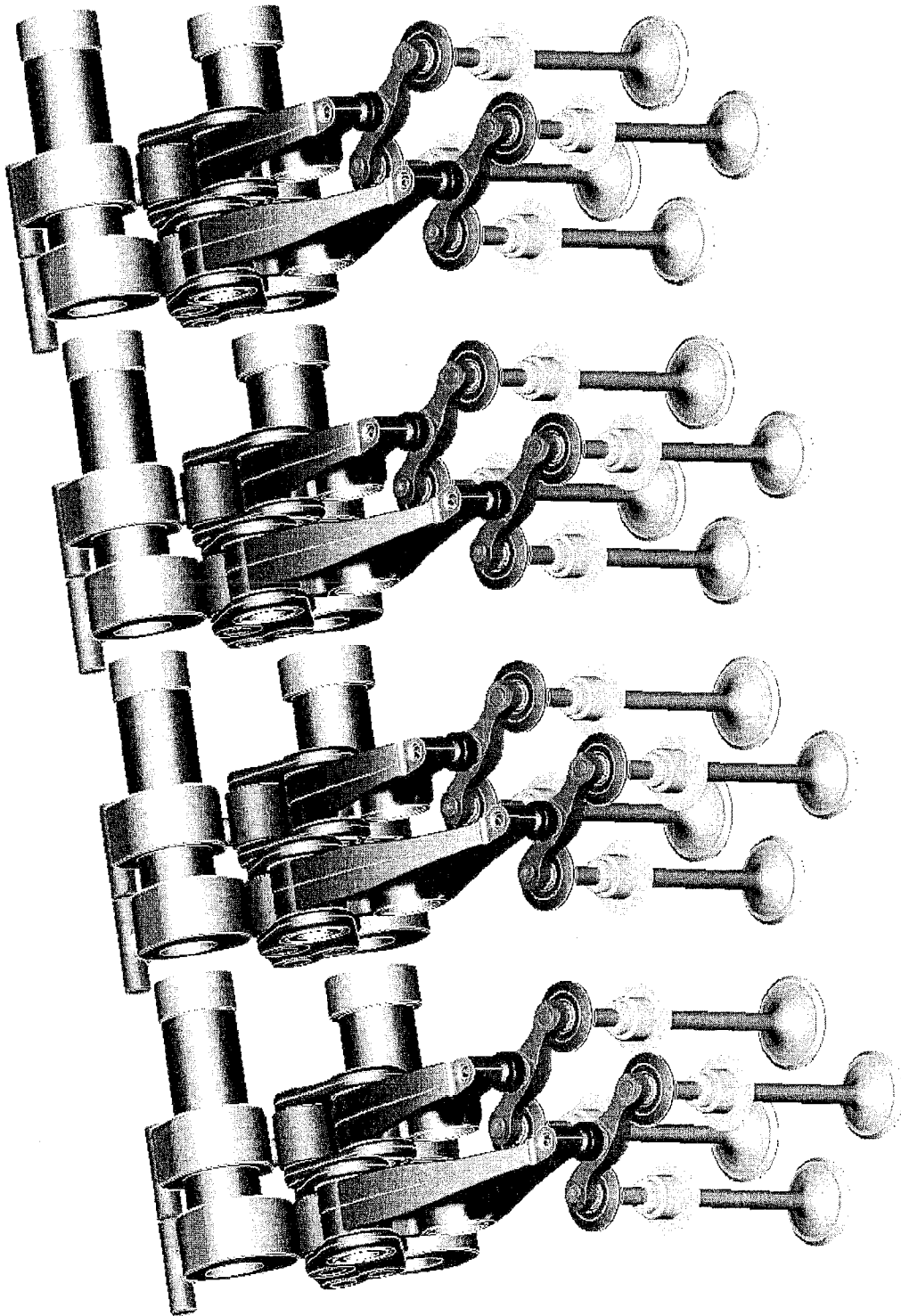


Fig. 8

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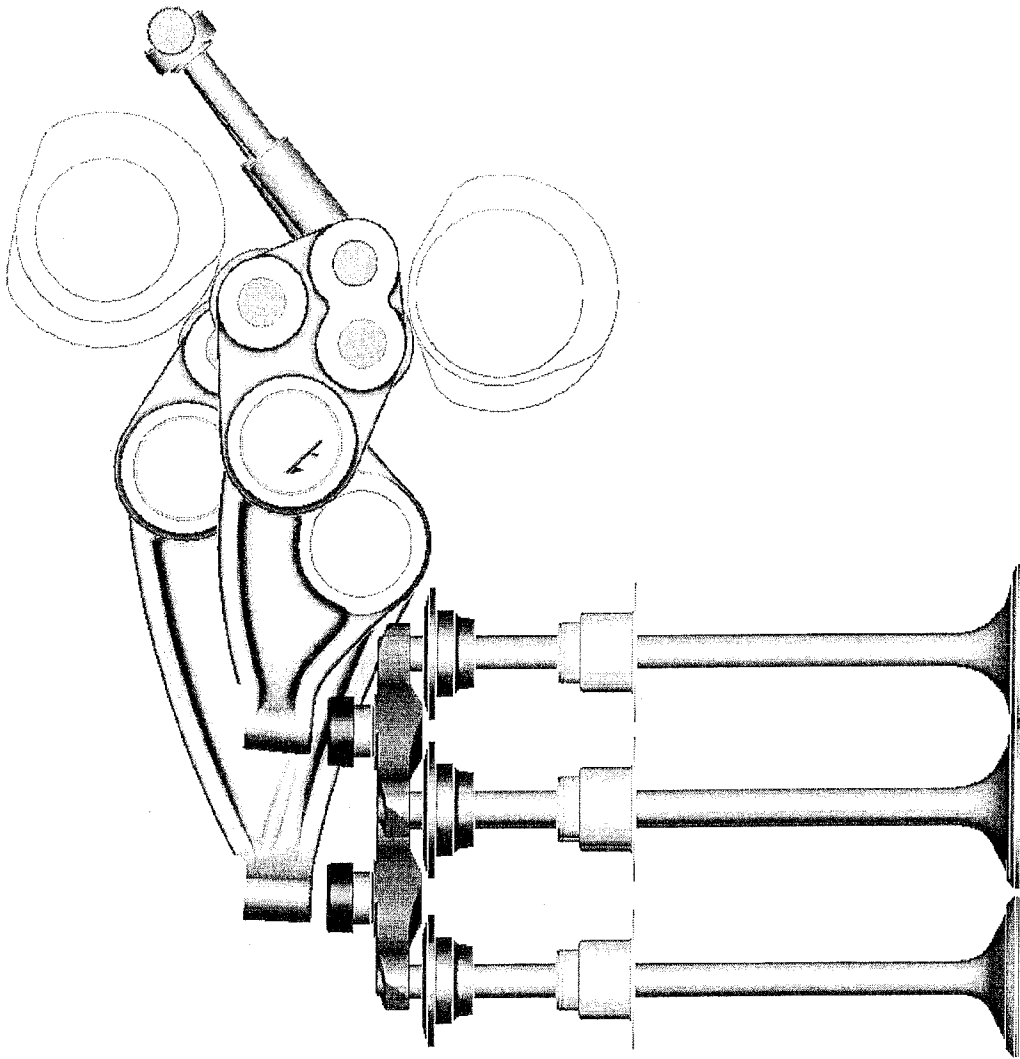


Fig. 9

10/11

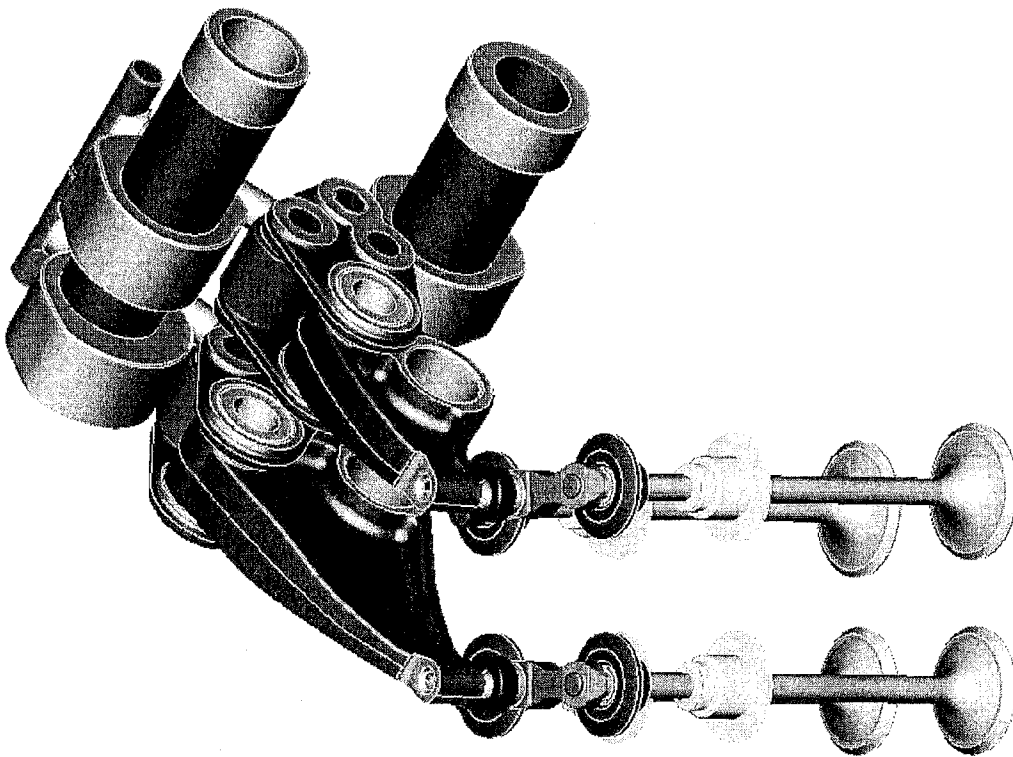


Fig. 10

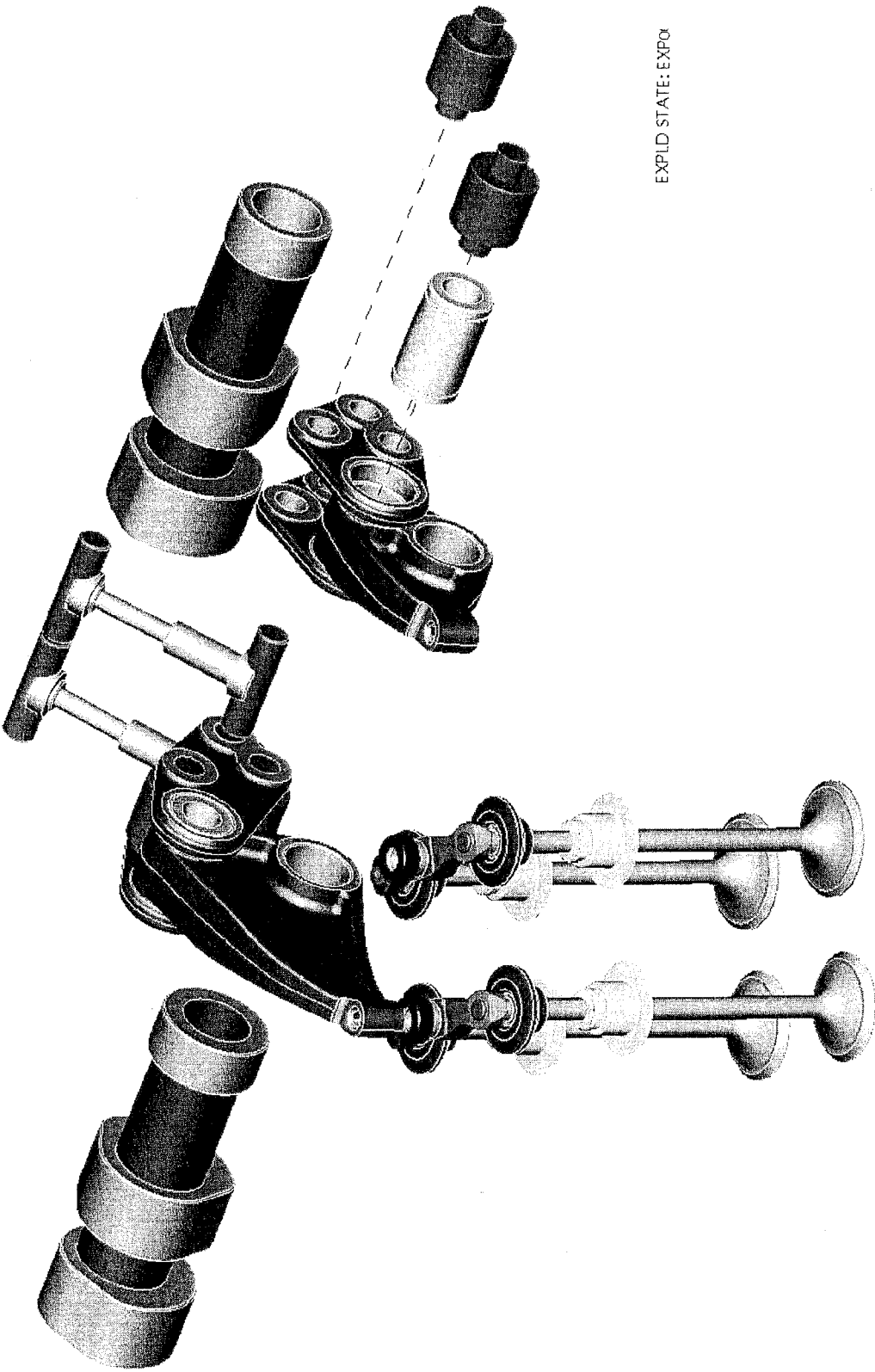


Fig. 11