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(54) **Valve-control mechanism and machines including such a mechanism.**

(57) A valve-control mechanism comprises a cam (4) for controlling the motion of a valve (11). The cam (4) is provided with a bulge or post-cam (I) at the descending part of its profile, causing compensation of the play of the valve controlling system until the valve (11) is resting on its seat (12), preceded by the main valve-actuating portion (1, 2, 3). The ascending side of the cam is provided with a pre-bulge or pre-cam (II) causing compensation of the play of the valve-control mechanism while the valve (11) is still resting on its seat (12) prior to opening and accurate timing of the opening of the valve (11).

The main body (1, 2 and 3) of the cam (4) between the bulges (I, II) is modified such that the ensuing valve kinematics match the kinematics of the medium flow control by the valve so as to optimize medium flow.

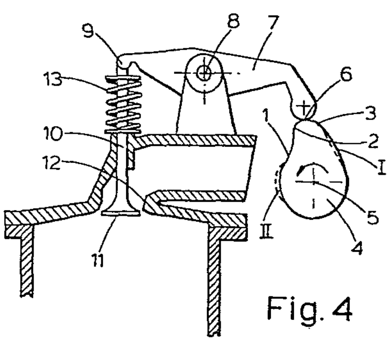

Fig. 4

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Title: Valve-control mechanism and machines including such a mechanism.

The invention relates to cam-driven valve-control mechanisms and to machines having such mechanisms.

In machines in which cam-driven valves are used as flow-controlling devices, these valves function by periodically influencing the flow of medium. The medium may be any fluid, such as a liquid, a gas, or some other substance of a rheological nature, such as, for example, a paste. Usually this periodic motion of the valve is derived from a rotating cam in contact with the valve-mechanism, whereby the profile of the cam controls the motion of the valve in an intended manner.The cam may drive the valve directly by contact with the valve stem, or alternatively indirectly via a rocker, a rocker-pushrod mechanism or any other suitable means. As a consequence of production tolerances, temperature variations, and other factors, the mechanism usually shows some geometrical play. Due to the motion there are, apart therefrom, the effects of dynamics and deformation of the constituent parts of the valve train.For the period that the valve should be at rest, i.e. outside its working-cycle, contact between the valve and its cam has to be interrupted, resulting in additional play in the mechanism. All types of followers, such as rollers, flat or knife-edges suffer from the disadvantage that they do not provide the required compensation of the play, nor have any positive effect on the other influences mentiond.

These cam-driven valve-control mechanisms are found for example, in pumps, compressors, internal combustion engines with two-stroke or four-stroke working cycles, and hydraulic and pneumatic motors.Though not limited thereto, there application is usually related to machines with at least one reciprocating piston.

The play and all other negative factors in the above-mentioned mechanisms cause a number of drawbacks when operating a machine comprising such cam-controlled valve. Thus, on closing, as a consequence of the above factors in the mechanism, the valve will hit its seat with considerable force. In combination with the springs, which are present in valve-systems of this type, this may result in highly undesirable valve bouncing or vibrations during the total valve motion cycle. This will result in undue wear and may even result in mechanical failure due to breakage. Also the bouncing of the valve causes inadvertent opening and closing of the valve, resulting in disrupted control of the medium flow. The above discussed consequences during closing of the valve equally occur during opening of the valve with similar drawbacks, resulting from the play and the other negative factors.

The combined effects of loss of adequate control over opening and closing of the valves are, together with increased wear, particularly prominent in those machines in which these valves are used for controlling both the inlet as well as the outlet flow. In most instances an overlap will occur, such as for example in reciprocating piston compressors of some types. In those cases the motion of the valves in their actual behaviour results in substantial variations in the pressure and the time at which the compression is started, and similarly with respect to the time and pressure at which the compression is released. This causes quite considerable variations in conditions as is illustrated in Fig.1 of the accompanying drawings. In Fig.1 the pressure is indicated along the vertical axis and the volume along the horizontal axis. The solid line represents the desired situation whereas the dashed line represents what is actually obtained. Since all instabilities in flow, variations in ultimate pressure and wear, result in a considerable loss of energy, it is evident, that remedial measures producing improvements of these damaging factors, will result in machines with a higher reliability, with lower wear and with better efficiency. This last result applies especially to internal combustion engines, as the result is a better control of the cylinder contents, when the effect of valve play and valve-dynamics on valve-controlled flow are eliminated or at least substantially reduced. These improvements would result in a lower waste of energy and consequently in improved efficiency. This effect would be especially noteworthy for diesel-engines.In diesel-engines the commencement of combustion, which is entirely controlled by the pressure in the cylinder at the beginning of the fuel-injection, as well as the duration thereof, which is also a function of the pressure at the end of the compression stroke, markedly affects the efficiency. In addition uncontrolled overlap may well result in loss of medium. These effects are illustrated in Fig.2 of the accompanying drawings in which the same parameters are plotted as in Fig.1, and in which the solid line again represents the desired situation, whereas the dotted line represents what is actually obtained.

According to the invention there is provided a valve-control mechanism comrpising at least one cam for controlling the motion of a respective valve, wherein the or each cam is provided with a post-cam at the descending part of its profile, causing compensation of the play of the valve-control mechanism while the valve is still resting on its seat, preceded by the main valve actuating portion, which is corrected for the interaction of medium and valve dynamics, and/or with a pre-cam at the ascending part of its profile causing compensation of the play of the valve-control mechanism while the valve is still resting on its seat prior to opening of the valve.

The invention thus provides a way of compensating the play which is present in a conventional cam-driven valve-mechanism, together with the control over valve-dynamics, and accordingly the drawbacks resulting therefrom. This is achieved by altering the ascending and/or descending slope of the driving cam in such a way that the influence of existing plays and vibrations in the cam-driven mechanism are compensated for to the extent that they no longer affect the critical actions of the valve. Thus full control of the functioning of the valve can be established. The hitherto encountered valve-bouncing and vibrations are prevented. The closing of the valve is dealt with by the post-cam, and the opening of the valve is dealt with by the pre-cam.

As a consequence of the post-cam, the valve will smoothly settle on its seat before any play present in the valve-control mechanism is released. In a similar way the opening of the valve can be controlled more accurately by the provision of the pre-cam at the ascending side near the beginning of the profile. Thus it is possible to cause the valve to open at the very moment this action is required, without this being affected by any play present in the valve-control mechanism. Apart from the above the main valve-actuating portion should of course be shaped in such a way that an optimal positioning and motion of the valve with respect to flow-control is achieved.

In a preferred embodiment of the invention the or each cam is generally pear-shaped with a dimple in at least the descending side of the cam, the narrower part serving as the main valve-actuating portion, and most preferably the or each cam is symmetrical along its longitudinal axis for the majority of applications.

It is of importance for good functioning of the valve-control mechanism that the or each cam is designed and arranged so that it compensates the play and the dynamics in the valve-control mechanism up to the moment of closing of the valve or beyond that moment.

In the valve-control mechanism the or each cam is preferably in contact with a roller, a slider, a flat or knife-edge urging the valve. A preferred embodiment is a valve-control mechanism in which the or each cam is in contact with one end of a rocker, the other end of the rocker being in contact with a pushbar carrying a valve at its other end, the pushbar being provided with a spring urging the valve into engagement with its seat.

This preferred embodiment is especially suitable for an internal combustion engine with a two-stroke or four-stroke working cycle.

From a practical viewpoint it is advantageous that each cam is substantially symmetrical in shape.

The invention is further described below with reference to the accompanying drawings in which

Fig.1, as mentioned above, is a graph showing pressure versus volume for a compressor,

Fig.2, as mentioned above, is a graph showing pressure versus volume for a diesel-engine,

Fig.3 presents a preferred embodiment of the cam according to the invention in sectional view, and

Fig.4 presents a sectional view of a cam-driven valve-mechanism according to the invention.

Fig.3 shows a cam in which the solid line profile in the descending part (right hand side) of the cam forms the after-bulge or post-cam and the dashed line represents the conventional shape. In the ascending part (left hand side) the dashed line shows a pre-bulge or pre-am and the solid line represents the conventional form. It will be understood that the extent and the dimensions of every bulge are governed by the prevailing conditions in the particular mechanism in which the cam is used, as will be discussed more fully hereinbelow in connection with Fig.4. In most practical applications the cam is substantially symmetrical in shape, being provided with a pre-cam and a post-cam, the main profile of the cam being adapted to match the dynamics of medium and valve.

The valve-control mechanism according to the invention can be used advantageously in compressors, expanders, fluid pumps, hydraulic or pneumatic motors and in particular diesel-engines and spark ignited engines.

Referring now to Fig.4, there is shown a valve 11 out of contact with its seat 12, driven by a cam 4, which is shaped substantially as illustrated in Fig.3, via a rocker 7. As the cam rotates counterclockwise about its centre of rotation 5, the after-bulge or post-cam 1 will initially compensate any play present. The after-bulge or post-cam 1 will come into contact with a pick-up point 6 of the rocker 7, which rotates about its axis 8. This induced motion of the rocker 7 is passed on by point 9 to a pushrod 10 of the valve 11. A spring 13 has the customary function of inducing the valve 11, once it has left its seat 12, to return to that seat 12. When the after-bulge or post-cam 1 passes the pick-up point 6, the valve 11 is returned to its seat 12, preferably with zero acceleration, thus causing a smooth return of the valve 11 on its seat 12. Only after return of the valve 11 to its seat 12 is the drive-mechanism further released. Any play that may then arise can no longer affect the valve 11 and any occurrence of vibrations is thus avoided.

After having passed the section of the cam between post-cam 1 and pre-cam II in the direction of the rotation, during which period the valve 11 will remain closed, pick-up point 6 enters into contact with pre-cam II (indicated with the dotted line, the solid line being the conventional shape). While passing this pre-cam II any play present will initially be compensated. Only after any play has been compensated will the valve 11 commence to open at exactly the required moment. The ensuing motions of the valve 11 are from thereon controlled by the subsequent section of the cam profile as indicated by 1, 2 and 3 respectively. This main part 1, 2, 3 of the cam profile is adapted in a way that valve dynamics and medium dynamics interact in the favourable way anticipated. Thus the valve will make motions which are dictated by this cam profile. Having gone through this part of the profile pick-up point 6 of rocker 7 will again come into contact with post-cam I, and the cycle as described above will be repeated.

From the above it will be understood that the profiles of the main cam together with the respective bulges, that is post-cam, and if desired also pre-cam, should be adapted to the particular system and within a particular system to the respective dimensions of the mechanism.As a consequence the valve will open smoothly at the desired moment as dictated by the pre-cam, whereafter the valve port will show a variation with time as dictated by the subsequent cam-profile 1, 2 and 3, and subsequently the valve is returned to its seat as dictated by the post-cam, avoiding bouncing and hard hitting of the seat of the valve. During this motion cycle valve dynamics and medium dynamics interact as desired, detrimental wear and damage to valve and seat are prevented as well. Once the valve has thus closed the valve port, during further following of the post-cam the entire valve-control mechanism is smoothly released, thus avoiding any detrimental vibration.

Depending on the machine on which the cam-driven valve-control mechanism is used, the cam will be either symmetrical or asymmetrical. As an example of a machine in which the cam will usually be substantially symmetrical mention may be made of a reversible engine, such as for the propulsion of ships.

CLAIMS:

1. A valve-control mechanism comprising at least one cam for controlling the motion of a respective valve, wherein the or each cam is provided with a post-cam at the descending part of its profile, causing compensation of the play of the valve-control mechanism until the valve is resting on its seat, preceded by the main valve actuating portion, and/or with a pre-cam at the ascending part of its profile causing compensation of the play of the valve-control mechanism while the valve is still resting on its seat prior to opening of the valve.

2. A mechanism according to claim 1, wherein the or each cam is generally pearshaped with a dimple in at least the descending side of the cam, the narrower part serving as the main valve-actuating cam portion.

3. A mechanism according to claim 1 or 2, wherein the or each cam is substantially symmetrical along its longitudinal axis.

4. A mechanism according to any one of the preceding claims, wherein the or each cam is arranged to compensate the play and dynamics of the valve-control system up to the moment of closing of the valve or beyond that moment.

5. A mechanism according to any one of the preceding claims, wherein the or each cam is in contact with a respective roller, a slider, a flat or a knife-edge urging the valve.

6. A mechanism according to any one of claims 1 to 4, wherein the or each cam is in contact with one end of a rocker, the other end of the rocker being in contact with

a pushbar being provided with a spring urging the valve into engagement with its seat.

7. A compressor or expander which comprises a valve-control mechanism according to any one of the preceding claims.

8. A fluid pump or hydraulic or pneumatic motor, which comprises a valve-control mechanism according to any one of claims 1 to 6.

9. An internal combustion engine, which comprises a valve-control mechanism according to any one of claims 1 to 6.

10. An internal combustion engine according to claim 9, wherein the engine is a diesel-engine.

11. An internal combustion engine according to claim 9, wherein the engine is spark ignited.

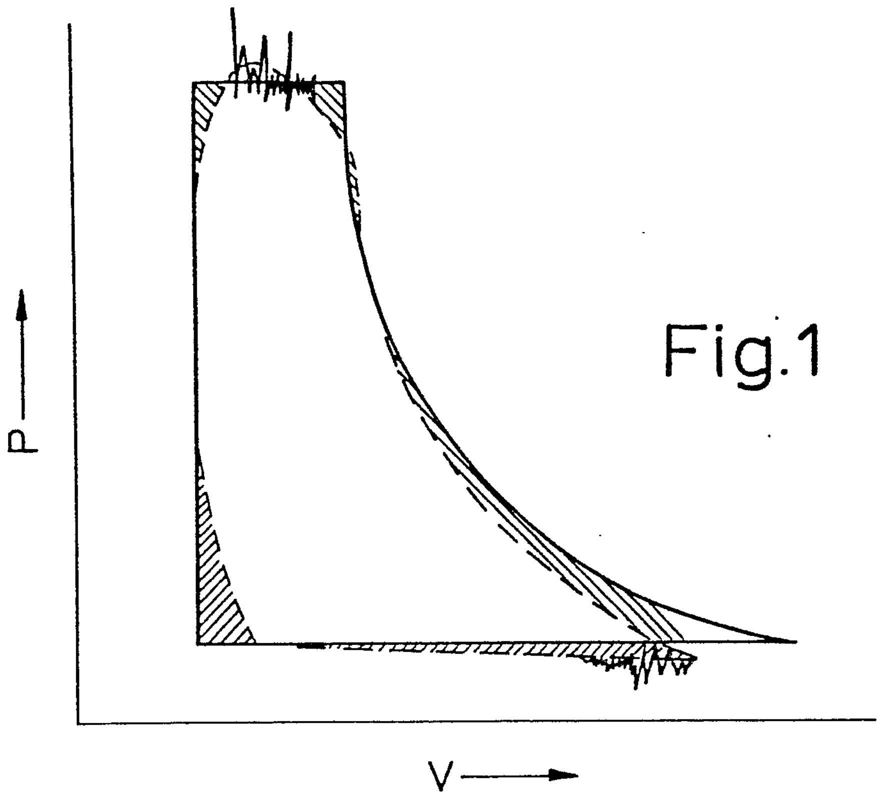

Fig.1

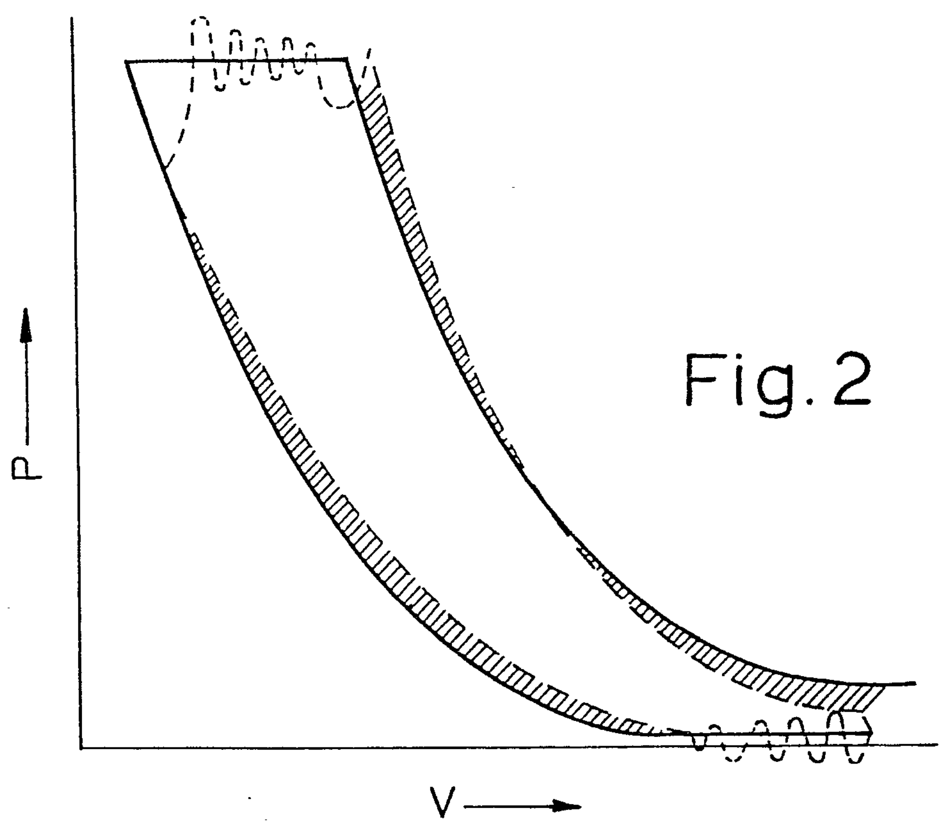

Fig. 2

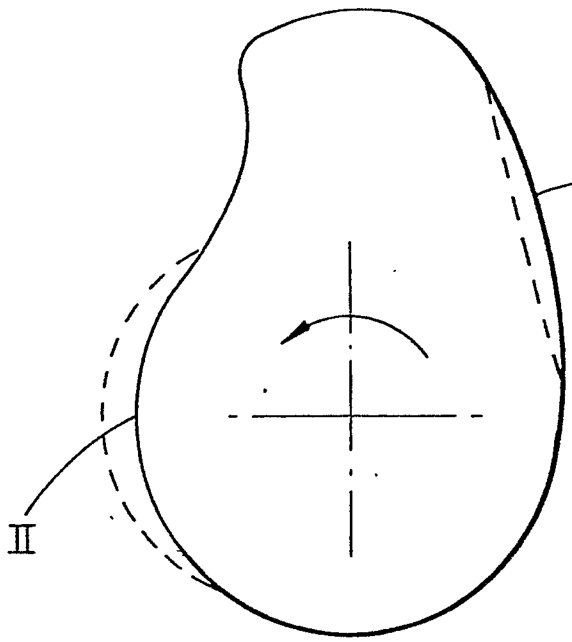

Fig. 3

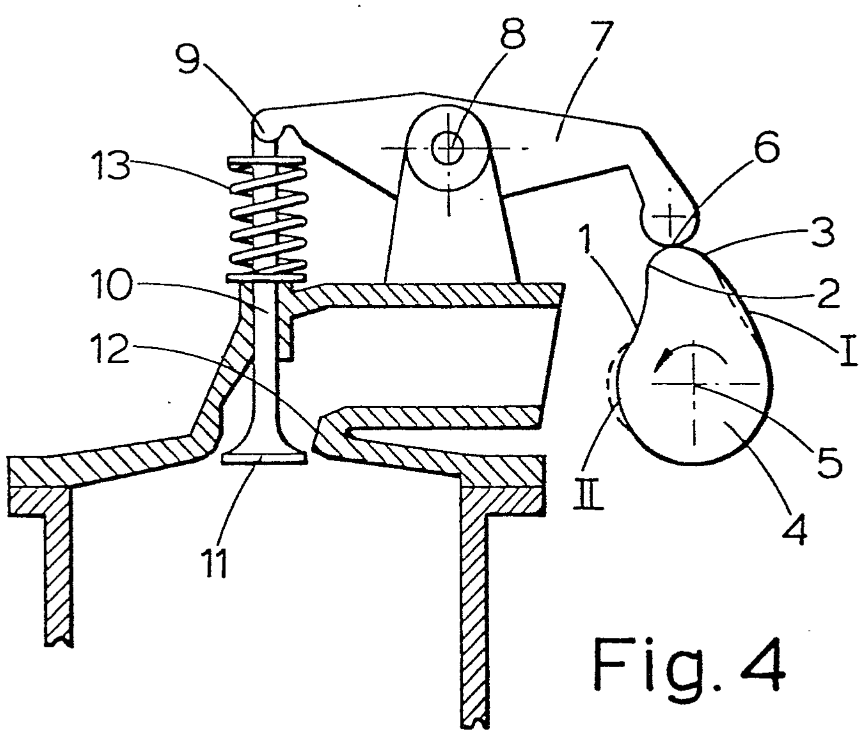

Fig. 4

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Application number

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EUROPEAN SEARCH REPORT

EP 80 20 1042.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - B - 2 035 462 (VOLKSWAGENWERK AG) * column 1, lines 60 to 67, column 4, lines 11 to 24 * --	1,2,4
	GB - A - 249 706 (A.E. HUTT) * page 1, column 1, lines 32 to 43; fig. 9 * --	1,3,4
	US - A -3 303 833 (A.B. MELLING) * fig. 8 * --	1,3
	DE - U - 6 601 296 (STEINMÜLLER GMBH) * fig. 1 * --	2
A	DE - B2 - 2 429 708 (MAN) --	
A	GB - A - 918 848 (SULZER FRERES) --	
A	US - A - 2 804 863 (W.D. BENSINGER et al.) --	
A	GB - A- 637 950 (AUSTIN) --	
A	GB - A - 629 629 (AUSTIN) --	
A	GB - A - 629 500 (AUSTIN) --	
A	GB - A - 573 294 (AUSTIN) --	
A	US - A - 2 042 967 (R.C. RUSSELL) --	
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CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

F 01 L 1/08

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

F 01 L 1/00
F 16 H 53/00
F 16 K 31/00

CATEGORY OF CITED DOCUMENTS

- X: particularly relevant
- A: technological background
- O: non-written disclosure
- P: intermediate document
- T: theory or principle underlying the invention
- E: conflicting application
- D: document cited in the application
- L: citation for other reasons
- &: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	03-02-1981	SCHLABBACH

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EUROPEAN SEARCH REPORT

Application number

EP 80 20 1042.1

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	GB - A - 299 001 (M. BIRKIGT) ----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.3)