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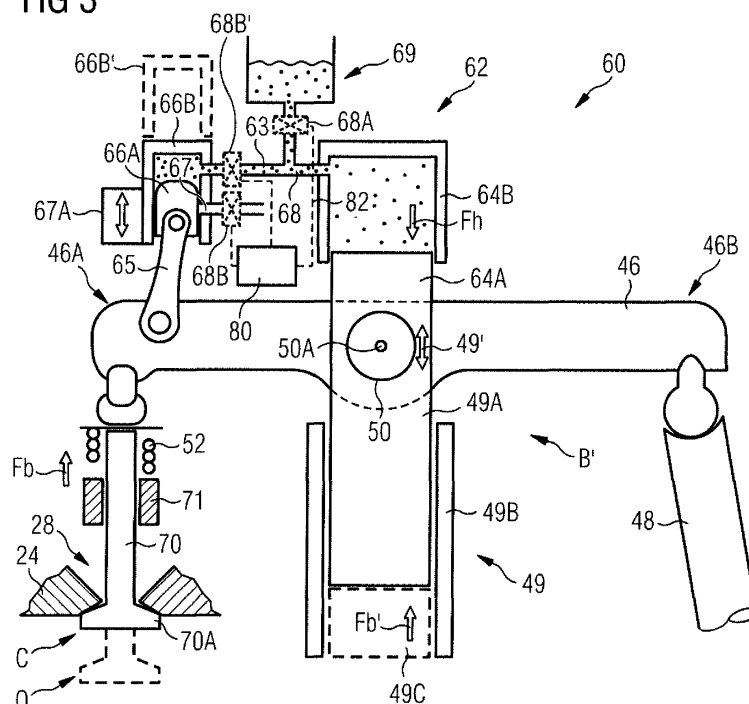
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(54) **VARIABLE VALVE TIMING BY ROCKER ARM ROTATION AXIS DISPLACEMENT**

(57) A rocker shaft unit (49) for an internal combustion engine comprises a rocker shaft (50), and a rocker shaft mount (49A). The rocker shaft (50) is configured to have a rocker arm (46) mounted thereto and to provide an axis (50A) of rotation for a pivot movement of the rocker arm (46). The rocker shaft mount (49A) is configured

to displaceably mount the rocker shaft (50). The configuration allows varying the position of the axis (50A) of rotation by displacing the rocker shaft (50) during the pivot movement. In particular, the configuration may allow for a decoupling of an engine valve operation from a camshaft system.

FIG 3



Description

Technical Field

[0001] The present disclosure generally relates to valve operation systems for an internal combustion engine and, more particularly, to adapting valve timings.

Background

[0002] In internal combustion engines, rocker arm configurations are used to operate intake and exhaust valves. In particular several valves are provided, for example, within a cylinder head, each being operated by a respective rocker arm configuration. For example, an intake and an exhaust rocker arm configuration may control the opening and closing of two intake valves and two exhaust valves, respectively.

[0003] A common camshaft driving the rocker arm configurations may, for example, ensure respective timings. In some embodiments, intake and exhaust valves are driven by specifically shaped cams, thereby enforcing a specific valve timing that provides, for example, a Miller timing with a respective valve overlap.

[0004] There is a variety of valve timing adjustment mechanism known that allow, for example, an operation mode specific adjustment of valve timings.

[0005] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0006] In an aspect of the present disclosure, a rocker shaft unit comprises a rocker shaft, and a rocker shaft mount. The rocker shaft is configured to have a rocker arm mounted thereto and to provide an axis of rotation for a pivot movement of the rocker arm and the rocker shaft mount is configured to displaceably mount the rocker shaft to allow for varying the position of the axis of rotation by displacing the rocker shaft during the pivot movement.

[0007] In another aspect, a rocker system for operating an engine valve of an engine with adjustable closing times comprises such a rocker shaft unit, and a rocker arm for performing a pivot movement around the axis of rotation. The rocker arm is mounted to the rocker shaft and comprises a push rod section for interacting with the push rod, and a valve actuation section for operating the engine valve. The rocker system comprises further a second piston operatively, such as mechanically and/or hydraulically, connected to the rocker arm at an eccentric position with respect to the axis of rotation, for example at the push rod section or the valve actuation section, and a second cylinder, wherein a pivot movement of the rocker arm is accompanied by a displacement of the second piston within the second cylinder. The rocker system comprises further an activatable, for example mechani-

cal and/or hydraulic, operative connection between the first cylinder and the second cylinder for providing an interaction between a movement of the eccentric position of the rocker arm and the rocker shaft mount.

[0008] In another aspect, a valve actuation assembly for operating a valve of an engine with adjustable closing times is disclosed. The valve actuation assembly comprises such a rocker system, a camshaft system comprising a camshaft with a cam lobe, and a push rod interacting with the cam lobe to be displaced in accordance with an actuation movement during a rotation of the camshaft, and an engine valve comprising a valve head, a valve spring, and a valve opening to be sealable by the valve head. The first cylinder, the first piston, the second cylinder, the second piston, and the operative connection form a hydraulic valve timing adjustment system for positioning the rocker shaft in a spatially fixed position of the rocker shaft with respect to the valve opening in a blocked state, and for enabling a displacement movement of the rocker shaft unit in a flexible state.

[0009] In another aspect, an internal combustion engine comprises such a valve actuation assembly, a cylinder head with the valve opening fluidly connecting a combustion chamber with a charge air system, and a valve. The valve comprises a valve stem providing the valve head for closing the valve opening, a valve stem guidance for guiding a movement of the valve stem, and the valve spring configured such that its spring force acts as a spring biasing force, in particular by acting via the valve stem onto the rocker arm. the configuration may allow ensuring, in dependency of the operation mode, that the rocker arm follows a return movement of the push rod or that the rocker arm is decoupled from the camshaft system.

[0010] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0011] The accompanying drawings, which are incorporated herein and constitute a part of the specification, illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure. In the drawings:

Fig. 1 shows a schematic cross-sectional view of an internal combustion engine with a camshaft driven rocker arm based valve drive;

Fig. 2 shows a schematic illustration of exemplary valve lift curves;

Fig. 3 shows a schematic illustration of an exemplary hydraulic valve timing adjustment system at a covered state of a control opening; and

Fig. 4 shows a schematic illustration of an exemplary hydraulic valve timing adjustment system at an uncovered state of the control opening.

Detailed Description

[0012] The following is a detailed description of exemplary embodiments of the present disclosure. The exemplary embodiment described herein and illustrated in the drawings are intended to teach the principles of the present disclosure, enabling those of ordinary skill in the art to implement and use the present disclosure in many different environments and for many different applications. Therefore, the exemplary embodiments are not intended to be, and should not be considered as, a limiting description of the scope of patent protection. Rather, the scope of patent protection shall be defined by the appended claims.

[0013] The present disclosure may be based in part on the realization that selectively allowing a rocker shaft to shift in its position (e.g. being displaced away from the cylinder or parallel to a cylinder or generally shifted with respect to the valve opening) may allow influencing the valve closing and opening times. It was further realized that this may be advantageously used to differentiate engine operation at varying loads such as at part load, start-up, or full load operation.

[0014] It was further realized that shifting the rocker shaft during a combustion cycle may allow adapting the valve opening, in particular the valve closing times. Moreover, it was further realized that one may hydraulically shift the rocker shaft driven by and in dependence of the rocker arm position.

[0015] Referring to the drawings, exemplary embodiments are disclosed that illustrate the herein disclosed adjustable valve timing concepts that can be employed, for example, in the internal combustion engine of Fig. 1.

[0016] Specifically, in Fig. 1 an exemplary embodiment of an internal combustion engine 10 is illustrated that uses a camshaft driven rocker arm system for valve actuation exemplarily for a pre-combustion chamber ignited gaseous fuel operation. Engine 10 may include features not shown, such as a fuel system, an air system, a cooling system, drivetrain components, etc. For the purpose of the present disclosure, engine 10 is exemplarily considered to be a four-stroke gaseous fuel internal combustion engine. One skilled in the art will recognize, however, that engine 10 may be any type of engine (two-stroke, turbine, gas, diesel, natural gas, propane, etc.). Furthermore, engine 10 may be of any size, with any number of cylinders, and in any configuration ("V", in-line, radial, etc.). Engine 10 may be used to power any machine or other device, including locomotive applications, on-highway trucks or vehicles, off-highway trucks or machines, earth moving equipment, generators, aerospace applications, marine applications, pumps, stationary equipment, or other engine powered applications.

[0017] Engine 10 includes an engine block 12 having a plurality of cylinder units 14 (one of which is illustrated in Fig. 1). A piston 16 is slidably disposed within cylinder unit 14 (e.g. within a cylinder liner 15) to reciprocate between a top-dead-center position (TDC) and a bottom-

dead-center position (BDC). A connecting rod 18 connects piston 16 to an eccentric crankpin 20 of a crankshaft 22 such that reciprocating motion of piston 16 results in rotation of crankshaft 22.

[0018] Engine 10 includes further a cylinder head 24 (enlarged in Fig. 1) that is mounted to engine block 12 and covers cylinder unit 14, thereby delimiting a main combustion chamber 26. Cylinder head 24 provides intake and exhaust openings 28 to charge main combustion chamber 26, for example, with a charge air-gaseous fuel mixture and to release exhaust gases out of main combustion chamber 26 into an exhaust gas system (not shown). Engine valves 30 are configured to selectively open and close respective openings 28, e.g. by a valve stem with a valve head (see also Fig. 3). Each cylinder unit 14 may include multiple intake and exhaust openings 28 and respectively multiple intake and exhaust valves 30.

[0019] Engine 10 further may include an assembly configured to initiate a combustion event. As exemplarily shown in Fig. 1, engine 10 may include a pre-combustion chamber assembly 32 (also referred to as pre-combustion chamber ignition device), which is positioned within cylinder head 24, for example between valves 30. Pre-combustion chamber assembly 32 may be configured in a variety of ways. In general, it is an assembly configured to initiate a combustion event within a pre-combustion chamber, and to direct the combustion into main combustion chamber 26.

[0020] The internal combustion engine 10 may include a series of valve actuation assemblies 40 (one of which is exemplarily illustrated in Fig. 1). Multiple valve actuation assemblies 40 may be provided per cylinder unit 14, e.g. for different valve types (e.g. intake or exhaust valve). For example, valve actuation assembly 40 is used to open and close the intake valve(s) and another, for example similar, valve actuation assembly 40 may be provided to open and close the exhaust valve(s).

[0021] Valve actuation assembly 40 includes a rocker arm 46. Rocker arm 46 is pivotally mounted on cylinder head 24 by a rocker shaft unit 49 via a rocker shaft 50 and interacts with engine valves 30 at a valve actuation section 46A and with a push rod 48 at a push rod section 46B.

[0022] Push rod section 46B engages with one end of push rod 48, the other end engages (as exemplarily shown in Fig. 1) with a cam lobe 58 disposed on camshaft 56 to drive (lift) push rod 48 when camshaft 56 is rotated. Camshaft 56 may be driven by crankshaft 22. Camshaft 56 may be connected with crankshaft 22 in any manner readily apparent to one skilled in the art where rotation of crankshaft 22 may result in a rotation of camshaft 56. For example, camshaft 56 may be connected to crankshaft 22 through a gear train (not shown).

[0023] The displacement of push rod 48 corresponds to an actuation movement of push rod 48 that may result in a conventional activation of valve 30, which is herein referred to as a blocked operation mode (e.g. a conven-

tional valve operation via push rod/camshaft configurations having a blocked, i.e. spatially fixed position of rocker shaft 50 with respect to cylinder unit 14). Specifically, the actuation movement includes a lifting movement L and a return movement R. Lifting movement L is caused by the shape of cam lobe 58 and results in a lifting force FI onto rocker arm 46 redirected via the pivot mounting onto the valve stem. Thus, due to engagement with valve actuation section 46A, the valve stem of valve 30 moves from a closed position C to an open position O during lifting movement L (see also Fig. 3).

[0024] Assuming non-fixed connections between rocker arm 46 and push rod 48 as well as rocker arm 46 and the valve stem, return movement R will not automatically result in a closing of the valve (e.g. return of the valve stem into closed position C of valve 30). Therefore, valve actuation assembly 40 may include - as a biasing force providing unit - for example, a valve spring 52 that provides a biasing force Fb onto the valve stem of valve 30 towards the closed position and, thus, generally counteracts against lifting force FI. Once the maximum extension of cam lobe 58 is reached, biasing force Fb enforces closing of the valve as well as return movement R. In consequence, opening 28 is closed via the respective valve head.

[0025] Thus, the blocked operation results in an oscillation of rocker arm 46 about its pivot point in dependence of the shape of cam lobe 58 and in respective opening duration of valve(s) 30.

[0026] One skilled in the art may recognize that camshaft 56 may include additional cam lobes to engage with additional push rods in order to actuate additional engine valves.

[0027] Fig. 2 shows a plot of exemplary valve lift curves. In particular, Fig. 2 shows an exhaust valve curve 72 extending from about 140° to 370° crankshaft angle during an exhaust stroke, and an intake valve curve 74 extending from about 350° to 490° crankshaft angle during an intake stroke. The schematically indicated valve lift curves 72 and 74 illustrate as an example an extreme Miller valve timing that reaches a high efficiency and may be applied, for example, at full load. In Fig. 2, the operation at full load is indicated by reference F. However, those valve lift curves 72 and 74 may not be optimal to start engine 10 or to operate the same at part load as then a relative small load acceleration may be present.

[0028] As an example for part load operation (start of the engine), a filling optimized lift curve 76 for an intake valve is schematically included in Fig. 2. Filling optimized lift curve 76 extends, for example, from 350° to 570° crankshaft angle and allows to increase the filling of main combustion chamber with charge air. Filling optimized operation may reduce the risk of knocking at part load such that a larger power output and improved load acceleration may be achieved. In particular when operated as a separate power supply, this aspect may affect the combustion tuning.

[0029] As an exemplary configuration, for part load op-

eration, the blocked operation mode (indicated with reference B in Fig. 2) is implemented by a specific shape (broad shape) of cam lobe 58. Accordingly, during start of the engine (part load operation) blocked operation mode is activated.

[0030] The configurations explained in the following may allow adaptation of valve timings, for example, for the full load operation of engine 10 in Miller-like manner.

[0031] With reference to Fig. 3, a schematic illustration of a valve actuation assembly 40 is exemplarily illustrated. Valve actuation assembly 40 includes inter alia components such as camshaft 56, cam lobe 58, and push rod 48 (camshaft system exemplarily shown in Fig. 1).

[0032] Moreover, valve actuation assembly 40 includes a rocker system 44 including rocker arm 46 and rocker shaft unit 49 comprising rocker shaft 50 configured to provide an axis 50A of rotation for the pivot movement of rocker arm 46.

[0033] Rocker shaft unit 49 further comprises a rocker shaft mount 49A for mounting rocker shaft 50. Specifically, rocker shaft mount 49A is configured to provide the possibility to displace rocker shaft 50 to vary the position of rocker shaft 50 such as the relative position with respect to valve opening 28 and the distance to the cover face of main combustion chamber 26 (the latter illustrated by arrow 49' in Fig. 3).

[0034] Rocker shaft unit 49 may further comprise a guide structure 49B for guiding rocker shaft mount 49A during such a displacement movement.

[0035] In some embodiments, rocker shaft unit 49 may further comprise a force generating unit 49C, which is configured to provide a biasing force Fb' counter-acting a hydraulic force Fh as discussed below in more detail. Biasing force Fb' may in particular be set for enforcing the displacement and allowing a return movement and/or may be provided to supplement biasing force Fb generated by valve spring 52.

[0036] In addition, valve actuation assembly 40 comprises a hydraulic valve timing adjustment system 60. Hydraulic valve timing adjustment system 60 of Fig. 3 is based on a hydraulic system that is configured, for example, to be fluidly connected to an engine oil system (not shown) and/or to be part of a separate hydraulic system. Hydraulic valve timing adjustment system 60 is configured to control the position of rocker shaft mount 49A, and in particular decouple the pivot movement of rocker arm 46 from the camshaft system. Specifically, hydraulic valve timing adjustment system 60 is configured to position rocker shaft 50 in a spatially fixed position with respect to valve opening 28. A respective blocked state B' is shown in Fig. 3 and illustrated by rocker arm 46 in dashed lines in Fig. 4. Moreover, hydraulic valve timing adjustment system 60 is configured to bring rocker shaft mount 49A in a flexible state F' (illustrated in Fig. 4 by rocker arm 46 in solid lines). Flexible state F' enables a displacement movement of rocker shaft 50.

[0037] For example, hydraulic valve timing adjustment system 60 comprises a first piston 64A housed in a first

cylinder 64B, for example a hollow-cylinder. First piston 64A is mounted to rocker shaft unit 49, for example to rocker shaft mount 49A on top of rocker shaft 50 as shown in Fig. 3.

[0038] Hydraulic valve timing adjustment system 60 may further comprise a second piston 66A housed in a second cylinder 66B. Second piston 66A is connected to rocker arm 46 at an eccentric position with respect to axis 50A of rotation. For example, second piston 66A may be connected to valve actuation section 46A (as shown in Fig. 3) such as via a mechanical connection 65. In some embodiments, it may be connected to push rod section 46B of rocker arm 46. The eccentric connection may provide a cyclical synchronization of hydraulic valve timing adjustment system 60 with camshaft 56.

[0039] Moreover, second cylinder 66B comprises at least one control opening 67 to release hydraulic fluid from second cylinder 66B. Specifically, control opening 67 is positioned within the sidewalls of second cylinder 66B to be covered (as shown in Fig. 3) and uncovered (as shown in Fig. 4) by second piston 66A during the pivoting movement of rocker arm 46. In addition, second cylinder 66B may itself be mounted in a displaceable manner to allow for adjusting the relative position between control opening 67 and second piston 66A during the pivoting movement of rocker arm 46 and the corresponding movement of piston 66A. A respective displacement unit 67A is indicated in Fig. 3.

[0040] Moreover, hydraulic valve timing adjustment system 60 comprises an exemplary hydraulic connection 68 hydraulically connecting first cylinder 64B and second cylinder 66B (specifically the inner volume thereof), thereby providing a hydraulic interaction between rocker shaft unit 49 and the eccentric position at rocker arm 46.

[0041] In some embodiments, hydraulic valve timing adjustment system 60 may further comprise a supply valve 68A for a fluid connection with a hydraulic fluid source 69 (e.g. the engine oil system). In addition or alternatively, a block valve 68B may be provided to be able to block or even to control the release of hydraulic fluid through control opening 67. This may allow, in particular, adjusting the dynamics of the closing of valve 30. A further block valve 68B' may be provided between first cylinder 64B and second cylinder 66B.

[0042] As further shown in Fig. 3, supply valve 68A and block valves 68B, 68B' may be connected to a control unit 80 via control lines 82. In general, control unit 80 may be configured to activate the valves to take on/ to support taking on blocked state B or flexible state F. Similarly, displacement unit 67A may be controlled by control unit 80.

[0043] In general, the geometries of the joints between rocker arm 46 and valve stem 70 as well as rocker arm 46 and push rod 48 may be configured such that, during the respective mechanical movements of rocker arm 46 and push rod 48, the respective joint parts will be brought into or maintained in proper position with respect to each other to properly interact as a joint when needed.

[0044] In general, any tilt of push rod 48 may vary in dependence of the displacement. To ensure that push rod 48 and rocker arm 46 will be properly positioned during the operation, one of the joint parts may comprise, for example, a cone-like shape. Alternative configurations may be apparent to the skilled person to maintain proper joint alignment despite temporal introduction of a gap between the joint parts.

10 Industrial Applicability

[0045] In the following, operating an internal combustion engine under variable valve timing conditions using the hydraulic displacement of a rocker arm as described in connection with the foregoing figures.

[0046] Modifying the mechanical boundary conditions within hydraulic system 62 allows modifying the valve closing and/or opening times. Specifically, hydraulic boundary conditions may be provided that during opening of engine valve 30 provide a control via the camshaft system, and during closing of engine valve 30 provide a decoupling from the camshaft system.

[0047] When starting engine 10, a filling optimized lift curve such as valve lift curve 76 shown in Fig. 2 may be desired for the exhaust valve operation. Accordingly, cam lobe 58 of camshaft 56 may be configured to provide such a broad opening duration. As long as the valve operation should be controlled by that specific cam lobe 58, axis 50A of rotation is fixed in its spatial condition with respect to push rod 48 as well as valve opening 28. Accordingly, hydraulic valve timing adjustment system 60 provides the condition in which hydraulic force F_h and biasing force F_b ensure a stable position of axis 50A of rotation. For example, hydraulic fluid source 69 may fill the hydraulic system with a hydraulic fluid at a preset pressure such that first cylinder 64B is pressurized under a preset pressure that counteracts biasing force F_b .

[0048] Having pressurized hydraulic fluid within hydraulic valve timing adjustment system 60 while control opening 67 is closed by second piston 66A (i.e. hydraulic valve timing adjustment system 60 being in a closed state), first piston 64A (and thus rocker shaft unit 49) is pushed out of first cylinder 64B until a mechanical stop stops the movement. In that state, rocker shaft unit 49 is in a spatially fixed position as indicated in Fig. 3. In general, in blocked state B' as described above, no displacement is possible such that the mechanical boundary conditions are stationary and the valve actuation is defined by cam lobe 58.

[0049] Accordingly, the actuation movement of push rod 48 will result in the required movement of valve stem 70 along a valve stem guidance 71.

[0050] Moreover, the hydraulic system is configured such that the oscillation of second piston 66A within second cylinder 66B does essentially not affect the movement of rocker arm 46. For example, second cylinder 66B is moved away from second piston 66A (in Fig. 3 illustrated as a second cylinder 66B' in dashed lines) and/or

block valve 68B is opened (connected to a reservoir) while block valve 68B' is closed.

[0051] In contrast to the blocked state B', in flexible state F' at least temporally the boundary conditions change by opening control opening 67 when piston 66A passes by control opening 67. Then the pressure within the hydraulic system drops. Accordingly, the equilibrium between hydraulic force F_h and biasing force F_b is no longer present and the position of axis 50A of rotation may be displaced, thereby affecting the closing and opening of engine valve 30. In other words, while blocked state B' corresponds to a first (fixed) position of axis 50A of rotation, flexible state F' corresponds to a movability of axis 50A of rotation.

[0052] Referring to Figs. 3 and 4, valve spring 52 provides biasing force F_b . Once hydraulic force F_h is smaller than in the blocked state, biasing force F_b pushes rocker shaft mount 49A upward, partly tilting the same such that push rod section 46B may be spatially stable, while valve actuation section 46A and axis 50A of rotation may move upward. In particular when control opening 67 is unblocked long enough by second piston 66A that rocker shaft mount 49A can move up enough to close valve 30, the closing of valve is decoupled from push rod 48.

[0053] Depending on the pressure of the pressurized fluid as well as the size of control opening 67 provided at second cylinder 66B, the movement and reaction of the pistons may vary such that the operation can be (pre)adjusted by respective selection of those parameters.

[0054] In other words, to modify valve operation timings, hydraulic valve timing adjustment system 60 allows shifting the position of axis 50A of rotation of rocker shaft 50. For example, second cylinder 66B is moved towards second piston 66A (and - if present - block valve 68B may be opened together with block valve 68B') such that pressurized fluid from within hydraulic system 62 may leak through control opening 67 once second piston 66A slides by control opening 67 during the opening interaction with cam lobe 58. As long as push rod 48 dominates the movement of second piston 66A, hydraulic fluid will be released and rocker shaft 50 will move upward. Valve head 70A will similarly move upward due to the biasing force of valve spring 52 such that engine valve 30 closes earlier.

[0055] Thereby, also control opening 67 may become covered as well. Then, hydraulic force F_h will built up again within first cylinder 64B counteracting biasing force F_b , and rocker shaft mount 49A can be pushed downward (e.g. with valve actuation section 46A being now the stable point). Accordingly, rocker shaft 50 is brought again into the fixed position, and the actuation movement of push rod 48 may again result in opening engine valve 30 in dependence of the cam lobe 58. In consequence, as shown in Fig. 2 left side, a valve 30 may be open during a shorter time, e.g. enabling Miller timing.

[0056] In general, as will be apparent to the skilled person, the time when the piston passes control opening 67

depends on the position of cylinder 66B and, accordingly, the hydraulic behavior may be adjusted by positioning cylinder 68B.

[0057] In addition, valve timing may be actively influenced during each combustion cycle by controlling the opening of supply valve 68A and block valves 68B, 68B' and displacement unit 67A via control unit 80, e.g. via control lines 82.

[0058] As illustrated above, hydraulic valve timing adjustment system 60 can be used to interact with rocker arm 46 and to provide a displacement of the rocker arm independent of the crank angle/pivot motion. In particular, the valve closing of an engine valve can be shortened. In similar configurations, also the opening of an engine valve may be adapted. In general, providing respective mechanical/hydraulic systems and/or controllable valves (as described above) may allow selectively activate and controllably adjust the specific opening and closing times of the respective engine valve.

[0059] While Fig. 3 illustrates a configuration, in which the first piston is decoupled from the pivoting motion, in some embodiments, the first piston and the second piston may be subject to the pivoting motion of the rocker arm.

[0060] In some embodiments, one or more cylinder units 14 of engine 10 may be provided with respective valve timing adjustment systems, thereby improving, for example, the starting behavior of engine 10.

[0061] The herein disclosed concepts may be used, for example, in gas engines manufactured by Caterpillar Energy Solutions GmbH as well as in engines manufactured by Caterpillar Motoren GmbH & Co. KG.

[0062] Although the preferred embodiments of this invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. A rocker shaft unit (49) comprising:

a rocker shaft (50); and
a rocker shaft mount (49A), wherein
the rocker shaft (50) is configured to have a rocker arm (46) mounted thereto and to provide an axis (50A) of rotation for a pivot movement of the rocker arm (46) and
the rocker shaft mount (49A) is configured to displaceably mount the rocker shaft (50) to allow for varying the position of the axis (50A) of rotation by displacing the rocker shaft (50) during the pivot movement.

2. The rocker shaft unit (49) of claim 1, further comprising:

a first piston (64A) operatively, such as mechan-

ically and/or hydraulically, connected to the rocker shaft mount (49A); and
a first cylinder (64B),
wherein a displacement of the first piston (64A) within the first cylinder (64B) is accompanied by a displacement of the rocker shaft (50).

3. The rocker shaft unit (49) of claim 1 or claim 2, wherein the rocker shaft mount (49A) is configured as a guide that provides a stop position at one end, the stop position corresponding to a first position of the axis (50A) of rotation.

4. A rocker system (44) for operating an engine valve (30) of an engine (10) with adjustable closing times, the rocker system comprising:

a rocker shaft unit (49) of any one of the preceding claims;
a rocker arm (46) for performing a pivot movement around the axis (50A) of rotation, the rocker arm (46) mounted to the rocker shaft (50) and comprising a push rod section (46B) for interacting with the push rod (48), and a valve actuation section (46A) for operating the engine valve (30);
a second piston (66A) operatively, such as mechanically and/or hydraulically, connected to the rocker arm (46) at an eccentric position with respect to the axis (50A) of rotation, for example at the push rod section (46B) or the valve actuation section (46A);
a second cylinder (66B), wherein a pivot movement of the rocker arm (46) is accompanied by a displacement of the second piston (64A) within the second cylinder (66B); and
an activatable, for example mechanical and/or hydraulic, operative connection (63) between the first cylinder (64B) and the second cylinder (66B) for providing an interaction between a movement of the eccentric position of the rocker arm (46) and the rocker shaft mount (49A).

5. The rocker system (44) of claim 4, wherein the second cylinder (66B) comprises a control opening (67) for releasing hydraulic fluid from within the second cylinder (66B), wherein the control opening (67) is positioned within the second cylinder (66B) to be coverable and uncoverable by the second piston (66A) in dependence of a rocker arm pivot movement.

6. The rocker system (44) of any one of claim 4 or claim 5, wherein the size of the control opening (67) and/or its position of the control opening (67) with respect to the rocker arm (46) is configured such that a leakage out of the second cylinder (66B) is provided at a preset rate and/or pivot angle range for displacing the rocker shaft mount (49A).

8. The rocker system (44) of any one of claim 4 to claim 6, further comprising:

a displacement unit (67A) configured to displace the second cylinder (66B) and displaceably mounted to allow for a displacement of the second cylinder (66B) with respect to the second piston (66A) to change the position of the control opening (67) with respect to the range of movement of the second piston (66A) resulting from the pivot movement of the rocker arm (46).

9. The rocker system (44) of any one of claim 4 to claim 6, further comprising:

a mechanical connection (65) between the rocker arm (46) and the second piston (66A), and/or wherein the first piston (64A) is mounted to the rocker shaft unit (49) or the rocker arm (46).

10. A valve actuation assembly (40) for operating a valve (30) of an engine (10) with adjustable closing times, the valve actuation assembly (40) comprising:

a rocker system (44) of any one of claim 4 to claim 8,
a camshaft system comprising a camshaft (56) with a cam lobe (58), and a push rod (48) interacting with the cam lobe (58) to be displaced in accordance with an actuation movement during a rotation of the camshaft (56); and
an engine valve (30) comprising a valve head (70A), a valve spring (52), and a valve opening (28) to be sealable by the valve head (70A);
wherein the first cylinder (64B), the first piston (64A), the second cylinder (66B), the second piston (66A), and the operative connection (68) form a hydraulic valve timing adjustment system (60) for positioning the rocker shaft (50) in a spatially fixed position of the rocker shaft (50) with respect to the valve opening (28) in a blocked state (B'), and for enabling a displacement movement of the rocker shaft unit (49) in a flexible state (F').

11. The valve actuation assembly (40) of claim 10, wherein the hydraulic valve timing adjustment system (60) is further connectable to a hydraulic fluid source (69) such as an engine oil system providing pressurized engine oil providing a hydraulic pressure within the hydraulic system (62); and/or
a supply valve (68A) for hydraulically connecting and disconnecting the hydraulic valve timing adjustment system (60) from the hydraulic fluid source (69); and/or
one or more block valves (68B, 68B') provided in particular at the operative connection (63) and/or at the control opening (67).

12. The valve actuation assembly (40) of claim 10 or claim 11, further comprising
 a biasing force generating unit providing a biasing force (F_b , F_b') acting onto the rocker shaft unit and counteracting a hydraulic force (F_h) generated by a hydraulic pressure within the first cylinder. 5

13. The valve actuation assembly (40) of any one of claim 10 to claim 12, wherein the biasing force generating unit comprises a valve spring (52) acting onto the valve actuation section (46A), in particular for displacing the valve head (70A) with respect to the valve opening (28), and/or a force generating unit (49C) acting onto the rocker shaft mount (49A). 10
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14. An internal combustion engine (10) comprising:

the valve actuation assembly (40) of any one claim 10 to claim 13;
 a cylinder head (24) with the valve opening (28) fluidly connecting a combustion chamber (26) with a charge air system; and
 a valve (30),
 wherein the valve (30) comprises a valve stem (70) providing the valve head (70A) for closing the valve opening (28), a valve stem guidance (71) for guiding a movement of the valve stem (70), and the valve spring (52) configured such that its spring force acts as a spring biasing force, in particular by acting via the valve stem (70) onto the rocker arm (46), thereby ensuring, in dependency of the operation mode, that the rocker arm (46) follows a return movement (R) of the push rod (48) or that the rocker arm (46) is decoupled from the camshaft system. 20
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15. The internal combustion engine (10) of claim 14, wherein, during operation of the internal combustion engine (10) in one operation mode, the valve actuation assembly (40) is configured to provide a cyclical synchronization of the decoupling of the rocker arm (46) from the camshaft system during closing of the engine valve (30) and a coupling of the rocker arm (46) with the camshaft system during opening of the engine valve (30). 40
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FIG 1

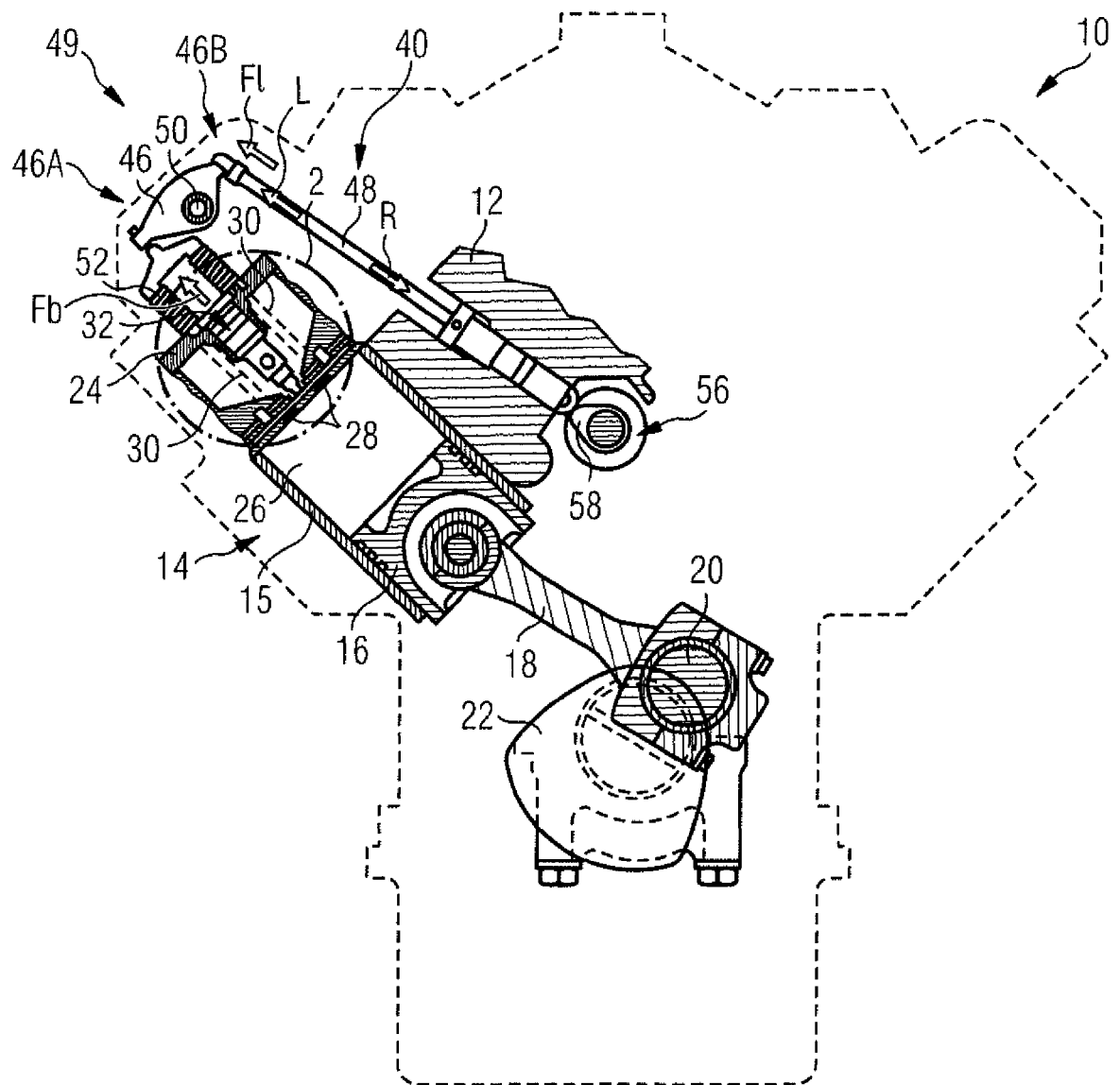


FIG 2

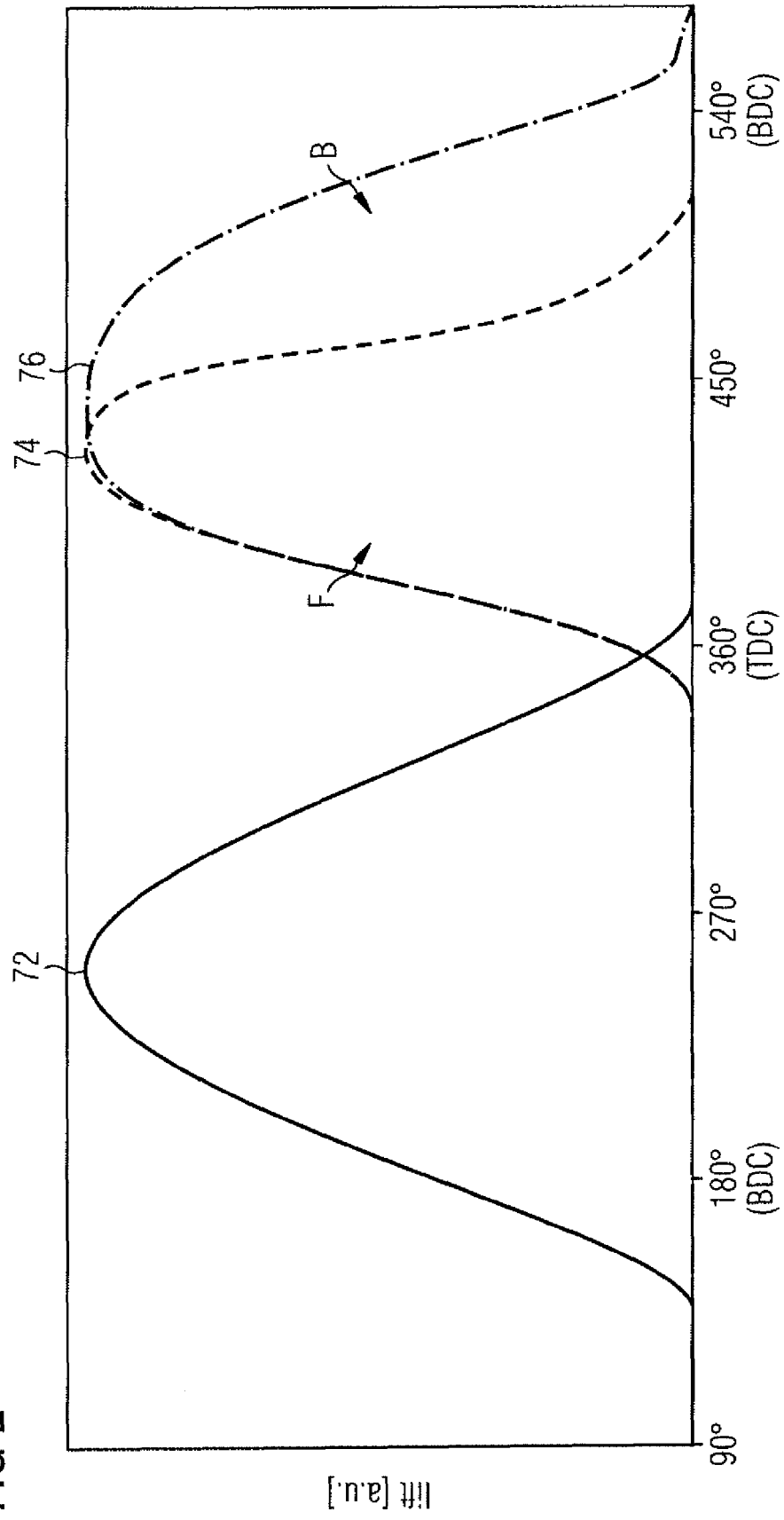


FIG 3

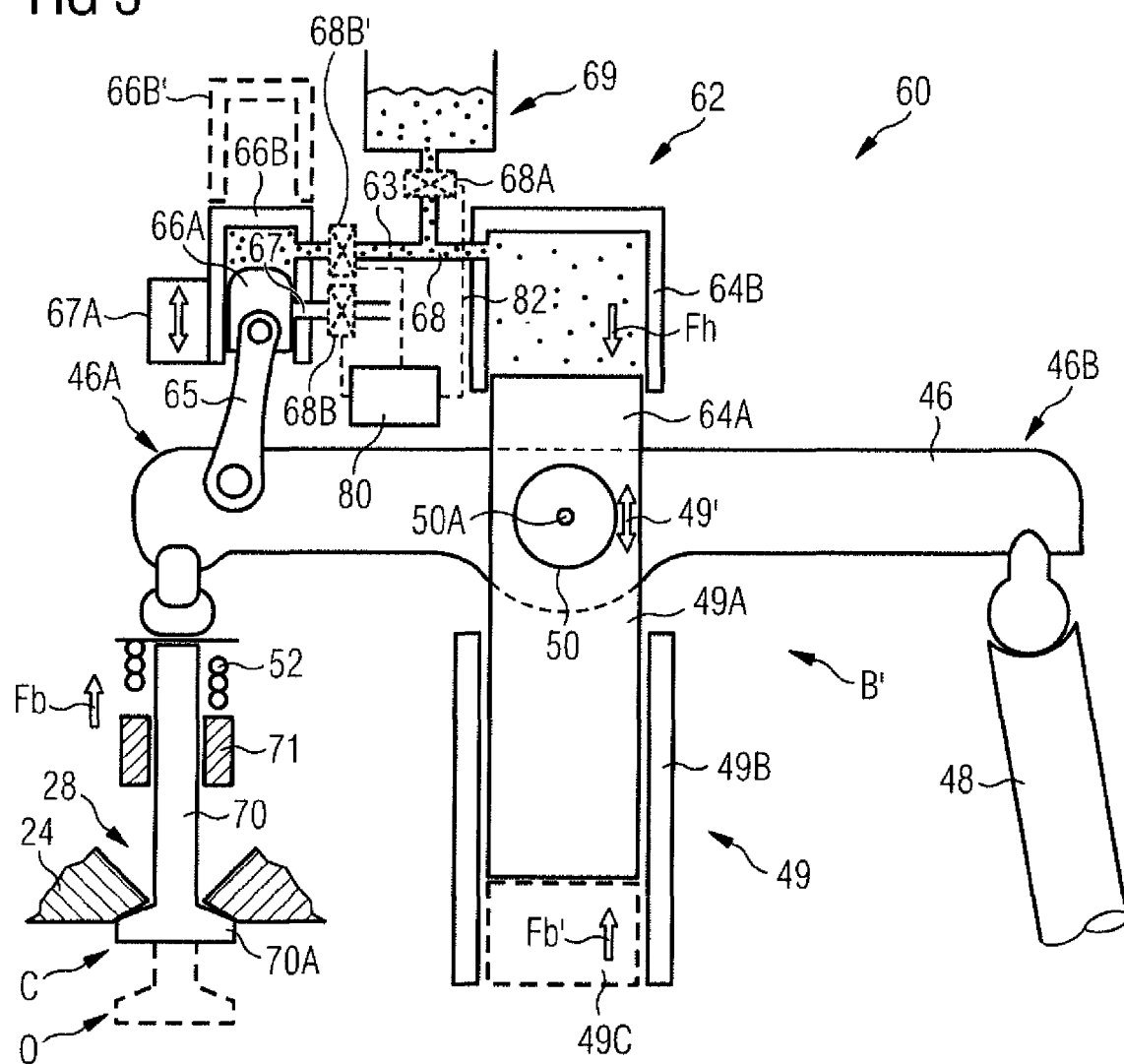
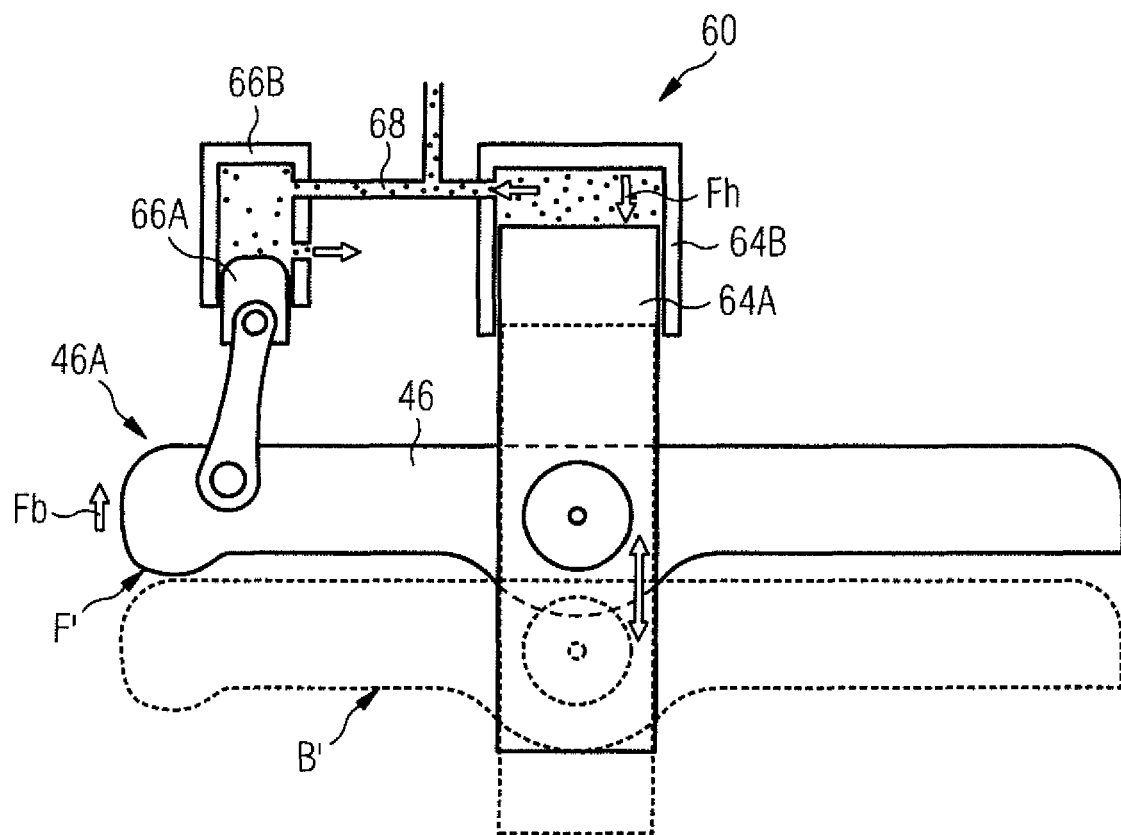


FIG 4





EUROPEAN SEARCH REPORT

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 23 September 2015	Examiner Klinger, Thierry
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82