July 4, 2010

To Mr. **John Twin**, UKIPO examiner

Application No: **GB1004212.5**
Titled: **Variable compression ratio engine**
Applicant's reference: VCRPathead

This is the reply to your letter of June 14, 2010:
Combined Search and Examination Report under sections 17 and 18(3).

In the search report the following three documents:

1. WO/97/36096A1 (Condamin)
2. WO 2008/153192 A1 (Toyota)
3. US 2004/0035376 A1 (IAV)

are referred as belonging into the "X" category (i.e. they are regarded as "Documents indicating lack of novelty or inventive step").

In the following it will be proved that these three documents do not belong in the X category. At most they belong in the "A" category (i.e. they are "Documents indicating technological background and/or state of the art").

Novelties (and inventive steps) of the present invention as compared to the referred inventions:

a. To pass, without loading the cylinder block, the heavy "gas pressure" forces applied onto the cylinder head "directly" to the crankshaft by the shortest way.
b. To substantially reduce the bending moments created into the cylinder head structure by receiving the strong gas pressure forces applied on the cylinder head by a single control shaft mounted just above the combustion chambers.
c. To substantially reduce the heavy loads in the "connection" between the cylinder block and the cylinder head.
d. To exploit the "empty" space into the conventional cylinder head (as well as the existing covers and sealing means) for hosting the parts of the VCR mechanism.
e. To keep both, the height and the width of the VCR engine smaller.
f. To keep the weight of the engine smaller.

g. To maximize the rigidity / stiffness of the structure by eliminating the bending moments of the referred inventions.
h. To limit the additional resonance modes by eliminating the heavy bending loads created into the VCR engine structure.
i. To eliminate the synchronizing mechanisms and the lash and flexibility they involve.
j. To optimize the shape of the parts involved according the loads they carry (a pillar, for instance, has the ideal form to carry extreme tension loads).
k. To minimize the construction cost by utilizing fewer, smaller, lighter and simpler parts.
l. To lower the overall complexity.
m. To make a VCR engine closer to the conventional.

Etc.

To further explain the aforementioned, a comparison of the referred inventions to the present invention is below.

Compared to Condamin VCR engine.

It is interesting to follow the path the heavy force applied upwards onto the cylinder head (by the high pressure gas into the combustion chamber) has to "travel" in "Contamin VCR engine" (1st referred document) until to be taken by the crankshaft:

a. From the cylinder head this force passes to the cylinder block (2) through the tightening screws at the two sides of the cylinder head.
b. The cylinder block extends downwards in order to embrace (hole 21), without touching it, the crankshaft and goes deep into the carter (oil pan). Through the cylinder block (2), the force from the cylinder head arrives to the bottom of the engine, well bellow the crankshaft, where the control shaft interconnects the cylinder block with the crankcase.
c. From the control shaft the heavy force goes at the opposite direction (from the control shaft bearings (15) to the crankshaft main bearings (28)), to finally arrive to the crankshaft.

The cylinder block needs to extend downwards, well below the crankshaft, also the crankcase has to extend downwards to meet the extension of the cylinder block deep inside the carter; this is the solution given to interconnect, by the control shaft, the crankcase block with the cylinder block.
The travel of the heavy gas pressure forces from the cylinder head to the crankshaft is twice as long as in the present application.

The moving block comprising the cylinder head, the cylinder block and the control shaft, Fig 1 of Contamin VCR, is as heavy as a complete engine because it has on it everything a conventional engine has, except the crankshaft (yet the weight of the crankshaft is compensated by the weight of the parts of the moving block below the crankshaft).
The crankshaft block is as heavy as a typical crankcase: besides the robust structure around the crankshaft main bearings, it also needs similarly robust structure deep below, at the bottom of the oil pan, where the control shaft is to be pivotally mounted.
The unconventional vertical separation of the crankcase adds weight as compared to the conventional engine design, wherein the robust structure of the crankcase ends at the height of the crankshaft axis, where the crankshaft bearing caps are secured. The parts underneath the crankshaft add height (i.e. reduce the compactness).

In comparison to the Condamin VCR engine, the proposed VCR engine is actually a conventional engine with a few minor modifications:

- It needs a control shaft pivotally mounted into the cylinder head above the combustion chambers,
- It needs some projections (comprising pillars and bridges) of the crankcase into the cylinder head for supporting the control shaft by short connecting rods,
- It needs some side bearings/sliders on the crankcase, at the height of the pistons, to take the thrust loads.

The height and width of the engine are the same to those of the conventional non-VCR engine.
The lower crankcase and the oil pan are the conventional ones.
The cylinder head is, essentially, a conventional cylinder head.

As shown in Fig 2 top and in Fig 3, what is left, by removing the control shaft from the cylinder head, is a conventional DOHC cylinder head.
As shown in Fig 2 bottom, and in Figs 5 and 7, the crankcase below the “pillars” is a conventional crankcase, with conventional oil pan and with conventional crankshaft bearing caps.

The “Search and Examination Report” (remark no. 7 under the “Description and drawings”) indicates that there is a misunderstanding/confusion about “where the control shaft is disposed”. The attached Figs 1A and 1B were created to eliminate the confusion (these Figs are not to be added to the invention). Fig 1A is nothing more than the original Fig 1

after removing the “VCR components” (i.e. the upper crankcase and the control shaft with the small connecting rods). These “VCR components” are shown in Fig 1B. I.e. Fig 1B shows the VCR engine of Fig 1 after removing the “conventional engine components”.
The engine shown in Fig 1A is a conventional engine; in several conventional engines the cylinder block is a separate part, i.e. it is not embodied to the crankcase.
In Fig 1B the upper slice of the crankcase (which is actually a series of “cranes”, each comprising two pillars and a bridge, disposed into the cylinder head) together with the control shaft and the short connecting rods, comprise the modification necessary to change a conventional engine into a VCR engine according the present application.

Compared to Toyota’s VCR engine and to IAV’s VCR engine

In Fig 5, of WO 2008/153192 the VCR engine of Toyota is shown.
It needs a reinforced (i.e. heavy) cylinder block to secure on it the eight block-side force-receiving portions (52).
It also needs a reinforced (i.e. heavy) and wide crankcase wherein the twelve cap portions (51b) are secured.
It also needs two control shafts, with a gear-wheel secured on each of them, and a lash-free mechanism between the gear-wheels to synchronize them.
It also needs covers (as shown in Fig 4) above all these parts that are located actually outside the main engine, at the two sides of the crankcase.
The structure of each control shaft is anything but stiff as it comprises a slim central shaft 53a on which are secured a set of eccentric pins 53b, on the same slim central shaft 53a they are pivotally mounted a number of eccentric pins 53c. In comparison, the single control shaft of the present invention is stiffer yet lighter.
There is a reason why Toyota added the Fig 11 to show the loads generated into the engine structure. The heavy gas pressure force F0a applied on the cylinder head is analyzed in two forces F1a at the two sides of the cylinder block. To keep in place the cylinder block, the crankcase applies two forces F1b. These F1b forces have to travel, through the material of the crankcase, to reach the crankshaft. All these strong eccentric forces create heavy bending moments and deformations. In comparison, the single control shaft of the present invention is located directly above the combustion chambers and, through the pillars, the heavy forces pass directly to the crankshaft by the shortest way.

In IAV's VCR engine the axis of each cylinder is displaced "horizontally" as the compression ratio changes. I.e. it is not possible to support the cylinder block by proper sliders on the upper crankcase. The thrust loads from the pistons onto the cylinder walls combined with the slightest "elasticity" or lash of the synchronizing mechanism between the two control shafts, results in oscillation of the "moving block" (vibrations, noise etc).
As stated in page 1, paragraph [0009], line 8 of IAV's patent Application: "The stability of the crankcase structure is substantially increased by mounting the support bars". I.e. the "two shaft VCRs" (like IAV's and Toyota's) require a substantially more stable (and so heavier and more expensive) crankcase structure. On the same reasoning the "two shaft VCRs" require a substantially more stable cylinder block structure (i.e. a heavier cylinder block). The lower side of the cylinder block of IAV's VCR is away from the two control shafts and is actually "unsupported". The trust forces from the piston skirts onto the cylinder walls create bending moments on the cylinder block: these loads have to be taken by the highly located control shafts, i.e. the cylinder block is vulnerable to vibrations and deformation. I.e. the cylinder block has to be strong at its top end to hold the control shafts, the cylinder block has to be even stronger at its bottom end in order to take the trust loads from the pistons.
In comparison, in the present application (GB1004212.5) the direct pass of the heavy gas pressure forces from the cylinder head directly to the crankshaft bearing caps (without loading the cylinder block), and the side support of the cylinder block by the crankcase sliders (at the height where the piston reciprocate), make unnecessary the increase of the stability of the crankcase structure and allows a lighter cylinder block.

The present application (GB1004212.5) proposes a VCR engine that:

- changes the compression ratio as continuously and as widely as Toyota's VCR and IAV's VCR engines,
- needs fewer parts,
- adds less weight,
- needs not synchronizing mechanisms,
- frees the crankcase and the cylinder head and the cylinder block from heavy bending loads,
- needs way less space to get installed and sealed,
- avoids additional vibration modes, etc.

All these involve both, novelty and inventive steps.

Claim 10

Here is the claim 10 (the widest claim) as originally filed:
"A variable compression ratio internal combustion engine comprising at least:
a casing;
a cylinder, said casing and said cylinder are slidably fitted to each other;
a cylinder head secured on said cylinder;
a control shaft disposed into said cylinder head,
the control shaft bears substantially the entire load applied on the cylinder head,
the angular displacement of the control shaft varies the compression ratio by displacing the cylinder head relative to the casing".

> In a few words: "a control shaft disposed into the cylinder head bears substantially the entire load applied on the cylinder head and controls, by its angular displacement, the compression ratio".

Toyota's and IAV's VCR engines are based on a pair of shafts at the two sides of the cylinder block.
And Condamin's VCR engine is based on a control shaft disposed below the crankshaft, at the bottom of the engine, far away from the cylinder head.
None of these describes a VCR engine as defined in claim 10.

In the previous it was proved that the referred documents are not of the X category. At most they are of the A category as they are just "indicating of the technological background and/or state of the art".
The present application does not propose "just another" arrangement. The proposed VCR engine does what the three referred inventions do, i.e. it varies continuously the compression ratio in a wide range. Additionally, the proposed VCR engine is lighter, smaller, simpler, cheaper, quieter, more robust, more reliable and more conventional.

After the previous analysis I expect to receive a new, correct "Search and Examination Report".

And I hope that in the new "Search and Examination Report" you will justify the rejection (if any) of the claims as the PCT and the USPTO do: they explain in details that a claim is rejected under the light of "this Figure" and of "that text".

Thank you
Manousos Pattakos
1st applicant and Inventor

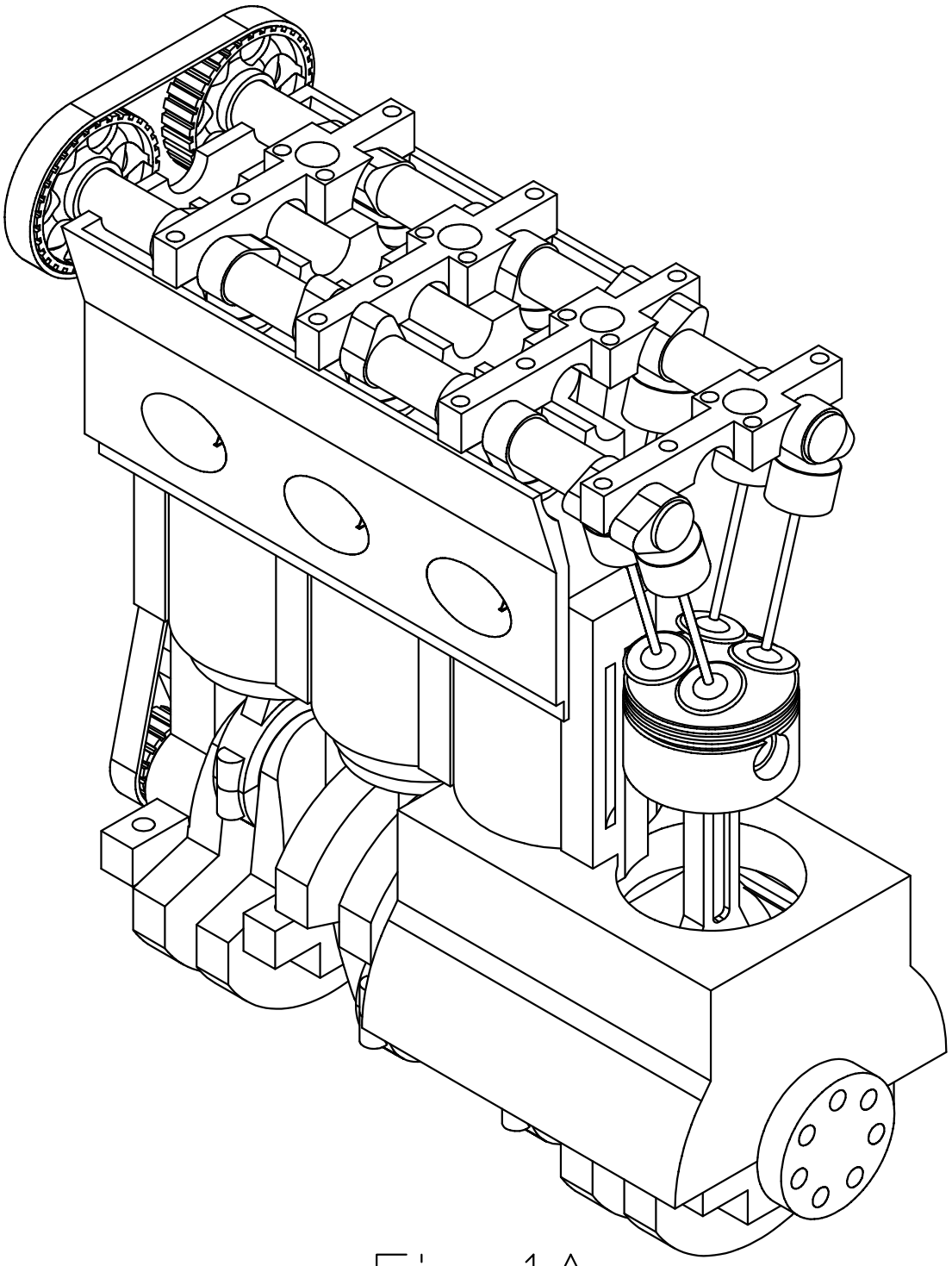

Fig 1A

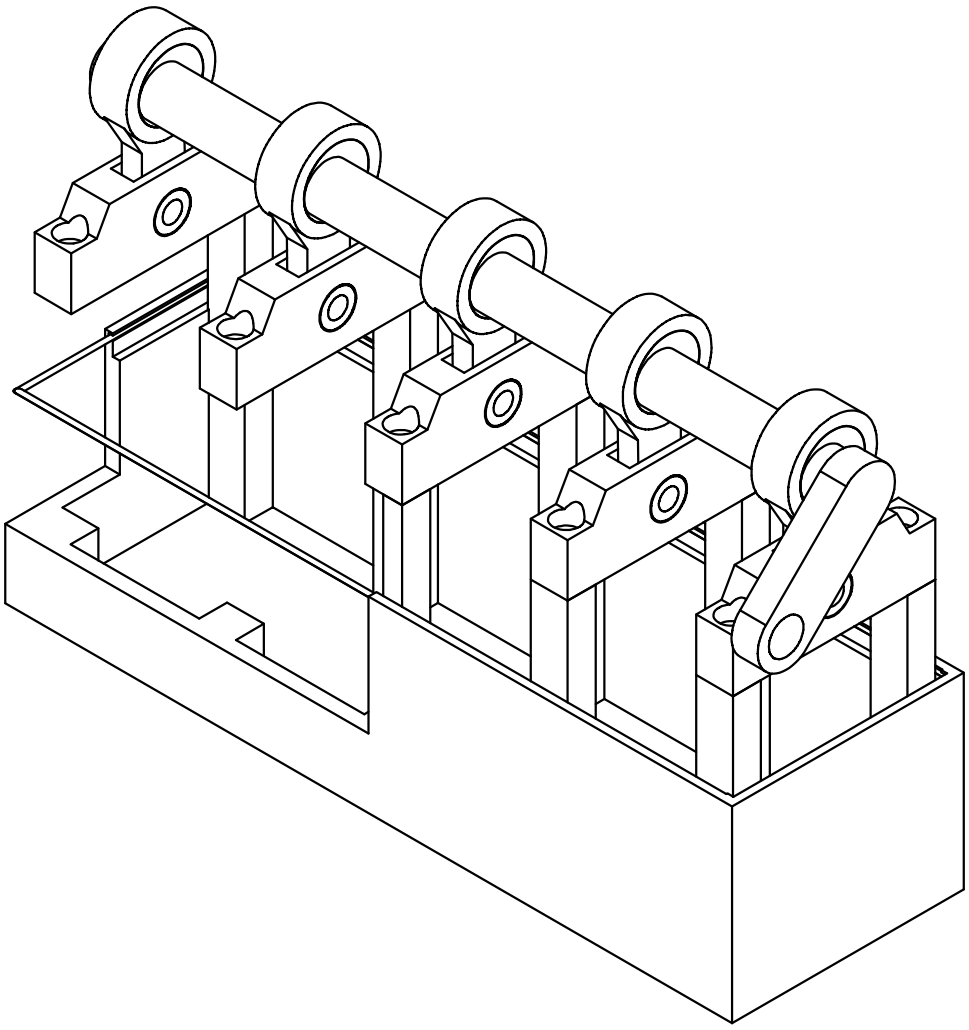

Fig 1B