ADS 37 CFR 1.76 Technical Disclosure

Multi Wheel Turbocharger

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U.S. Patent and Trademark Office
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Alexandria, VA 22313

Project:	**PROVISIONAL PATENT APPLICATION under 37 CFR § 1.53(c)**	
Subject:	**Multi Wheel Turbocharger for Internal Combustion Engines**	
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Reference 1:	**USPTO Customer Number**	**185781**
Reference 2:	**USPTO Application Number**	**63395089**
Reference 3:	**Application Data Sheet 37 CFR 1.76 Multi Wheel Turbocharger**	
Purpose:	**Definition of the Multi Wheel Turbocharger (MWT) invention for patent claim.**	
Date:	**August 03, 2022**	**(USPTO Receipt Date 08-04-2022)**
Prepared for:	**USPTO EFS submission.**	

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Abstract

This patent application presents a turbocharger design for the internal combustion engine (ICE). The invention is named Multi Wheel Turbocharger (MWT). The design integrates the AEV and PLV independently controlled valves. The AEV and PLV are the subject of preceding patent filings.

The objective is to improve fuel efficiency by deployment of DE3C technology. New methods of cylinder deactivation, engine braking, turbocharger speed control, and turbocharger thermal control are created. The MWT details are presented in **3D Solid Model CAD** drawings and text. The design graphics are self-explanatory to readers with basic knowledge of the ICE.

Section 1. MWT Presentation

A. Definition

The multi wheel turbocharger locates a separate exhaust gas driven turbine wheel at the output port of each cylinder. The individual turbine wheels share a common shaft with the turbocharger compressor.

B. Description of Applied Engine Examples

The MWT is applicable to internal combustion engines with straight line oriented cylinders. For purpose of patent illustration, I6 (inline 6 cylinder) engines are depicted. The metrics are 90.2 mm bore, 111 mm stroke, 110.2 mm cylinder spacing, 4.2 liter displacement. All dimensions are relative to these virtual engines and have no specific import to the MWT invention. The 3D modeled engines are not intended to be complete or a mockup of an actual engine. The artwork creates virtual engine frameworks to illustrate the MWT components, location, shape, and function.

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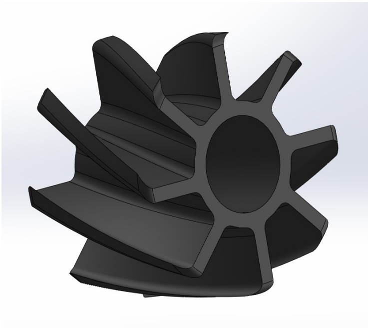
C. The MWT Graphic Presentation.

Figure 1. Turbine wheel, 54 mm diameter, 39 mm length. 20 mm shaft mount I6 assembly.



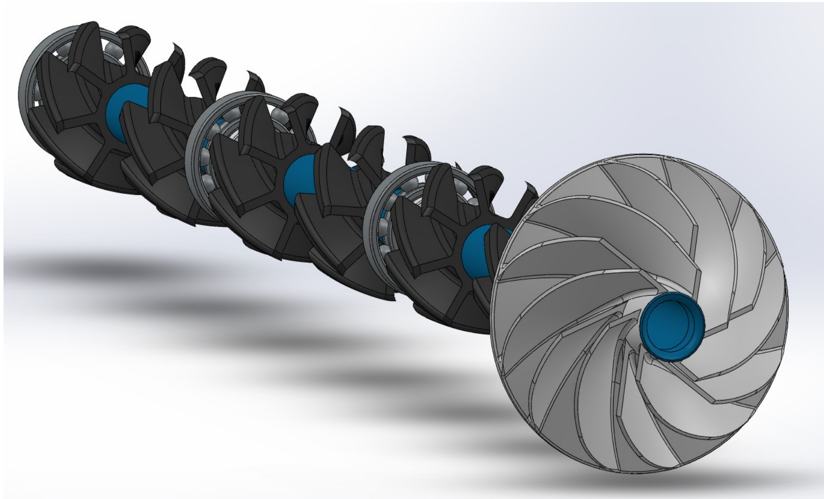


Figure 2. I6 engine turbines and compressor assembly. 105 mm compressor DIA. 730 mm OAL.

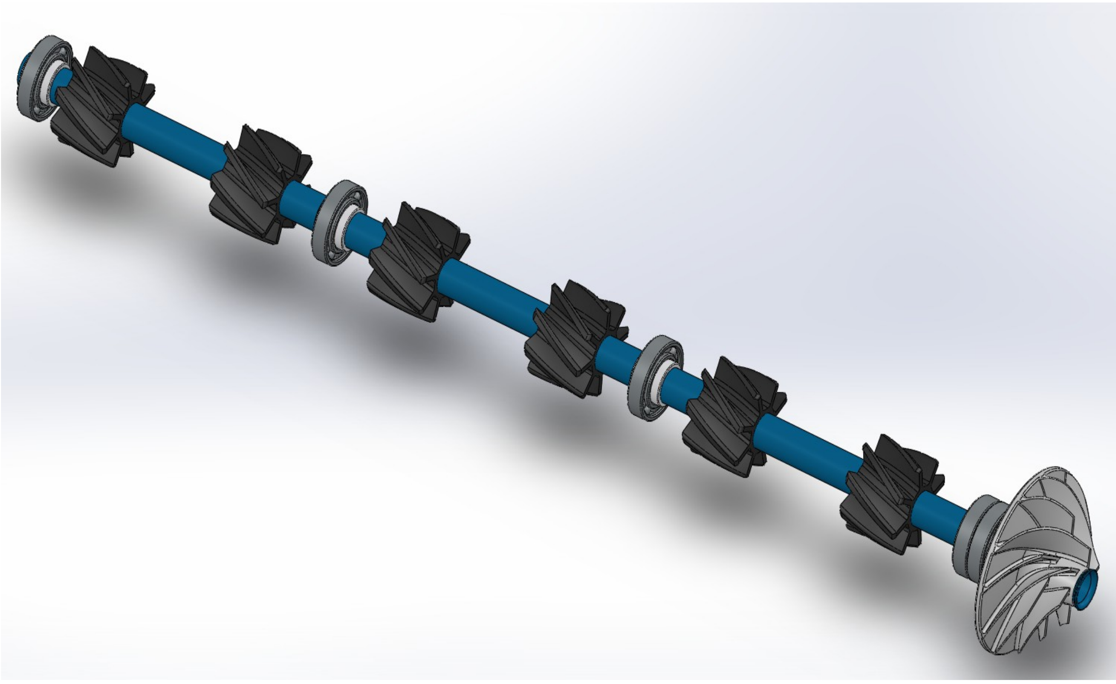


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Figure 3. I6 engine, MWT chambers, bearing brackets, exhaust ducts, and compressor housing.

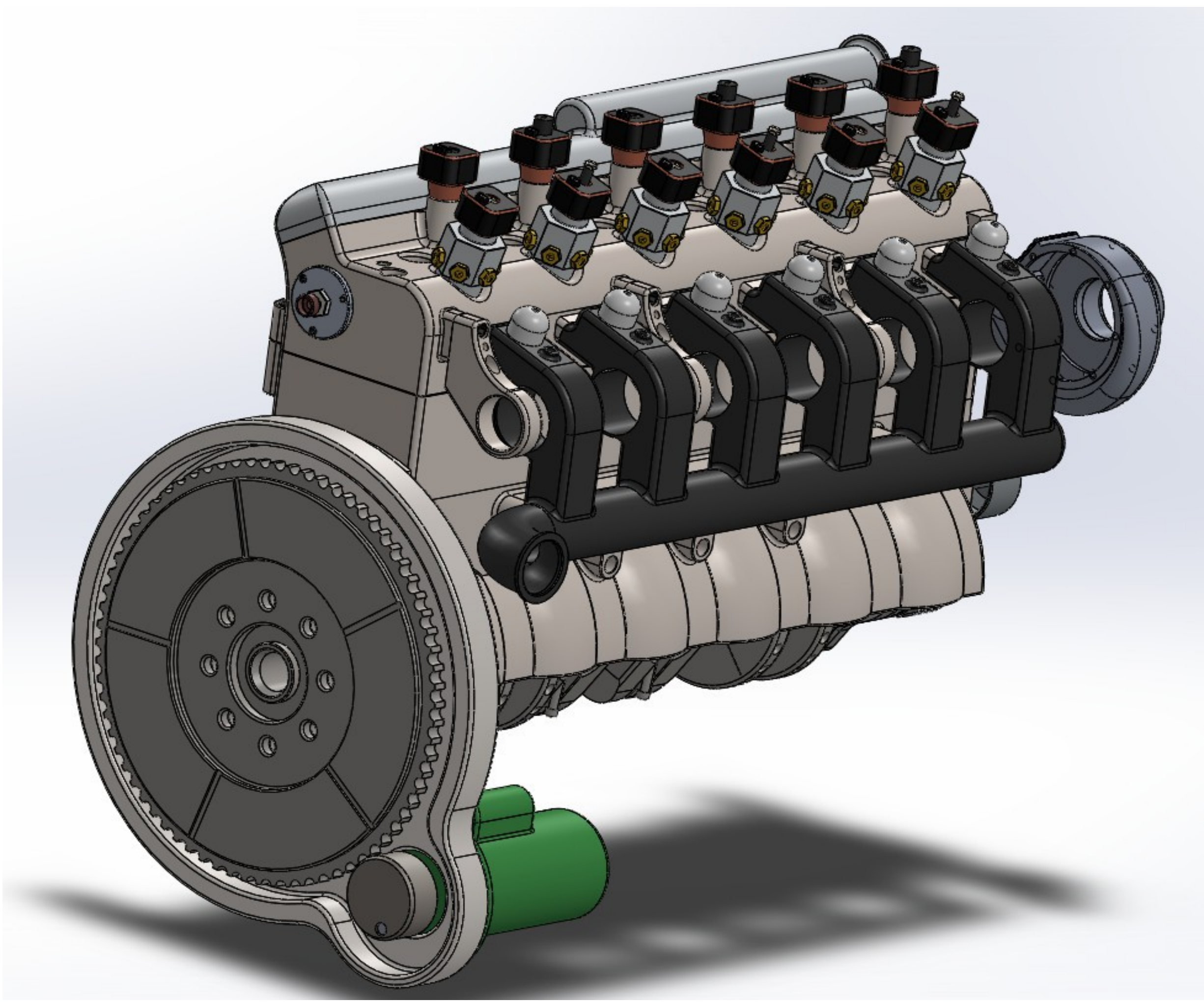

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Figure 4. Turbine chambers and exhaust ducts.

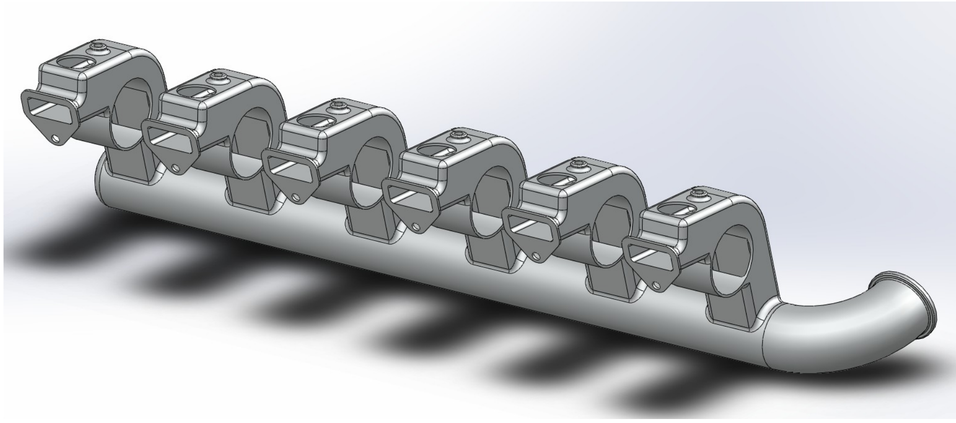

Figure 5. Turbine chambers and exhaust ducts – section view 1.

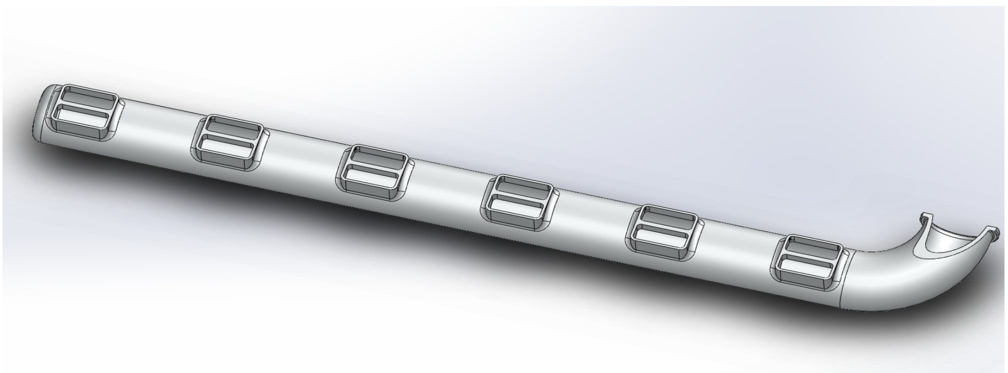

Figure 6. Turbine chambers and exhaust ducts – section view 2.

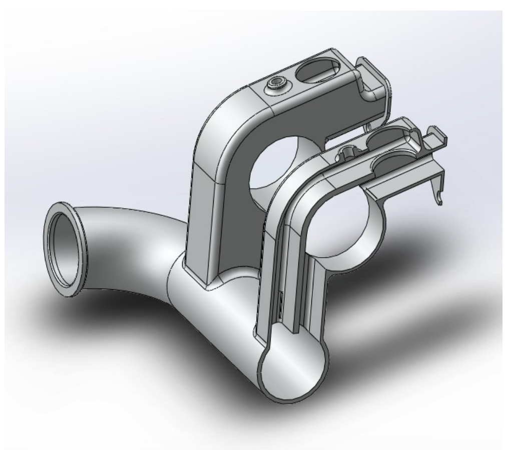

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Figure 7. I6 cylinder head – with AEV.

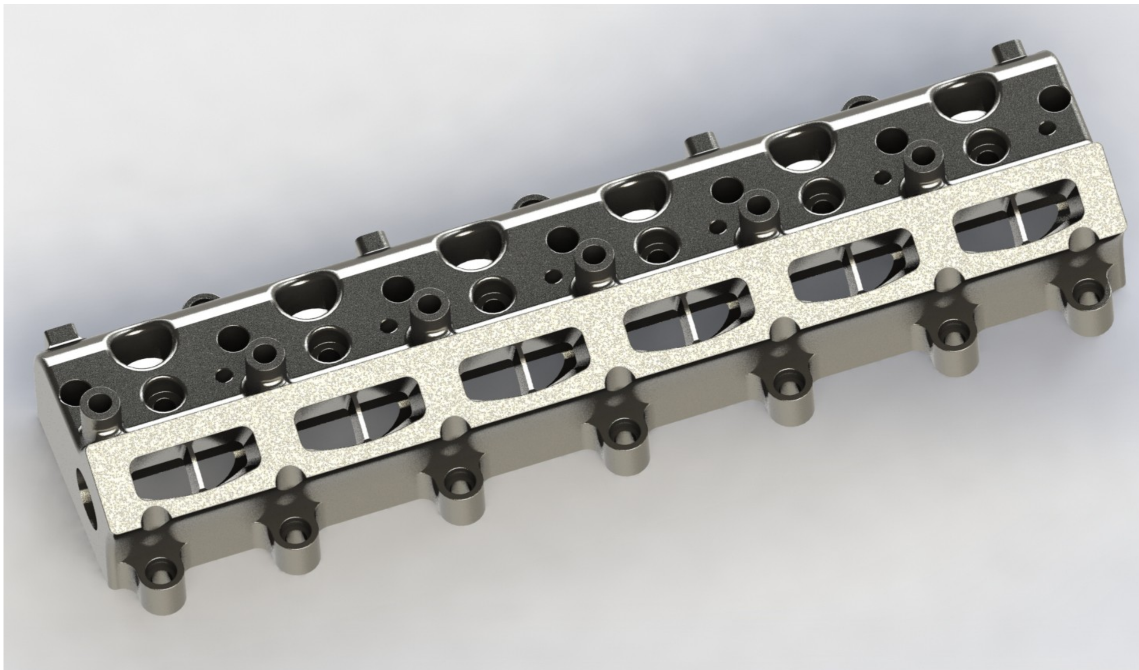

Figure 8. I6 cylinder head – dual PLV – diesel specific.

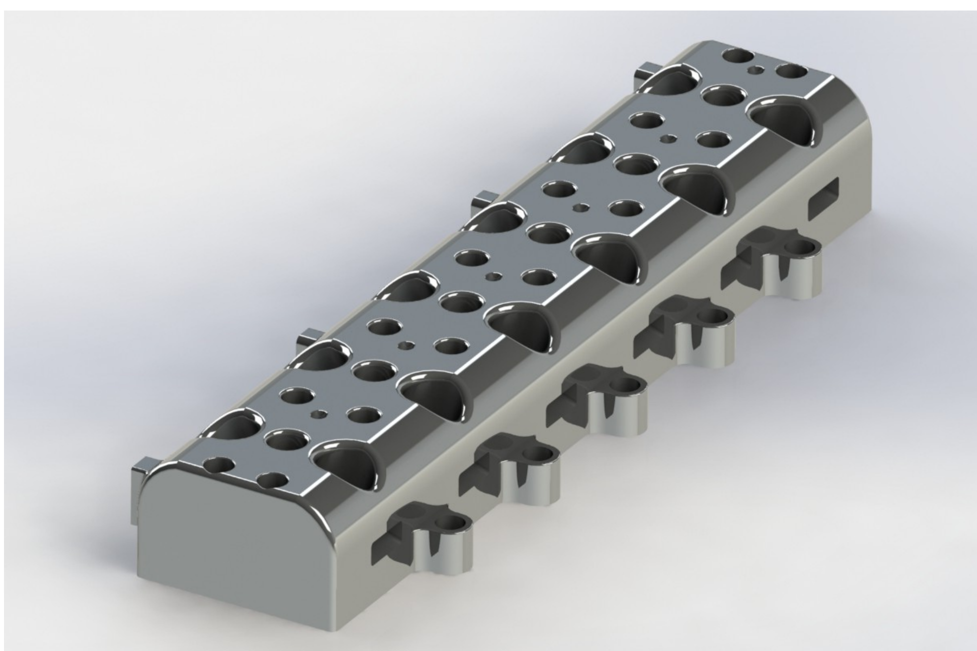

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Figure 9. I6 Cylinder head – dual PLV - bottom.

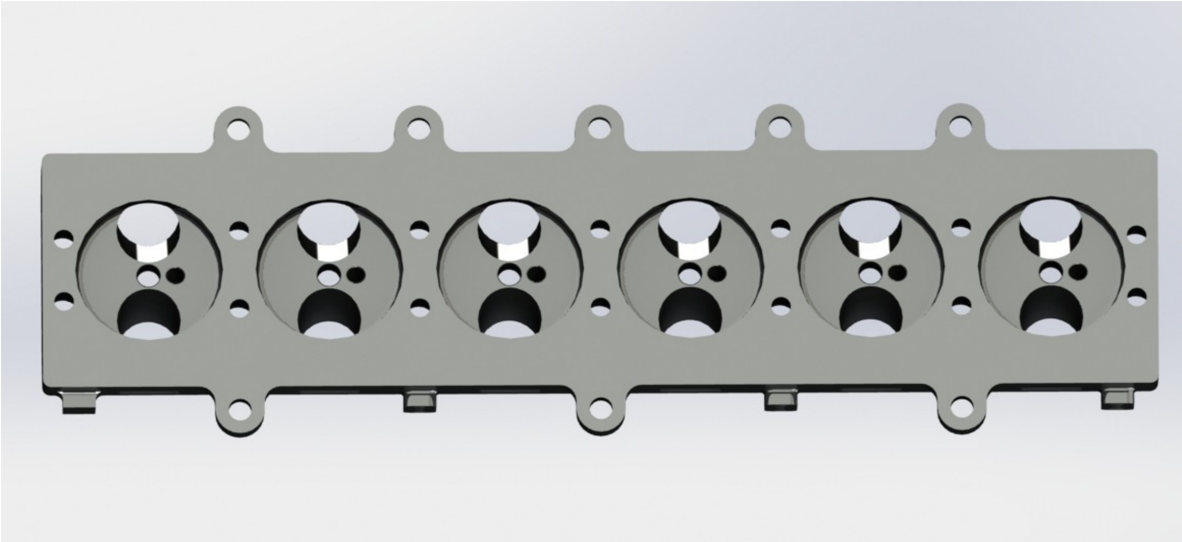

Figure 10. I6 gasoline engine, with MWT.

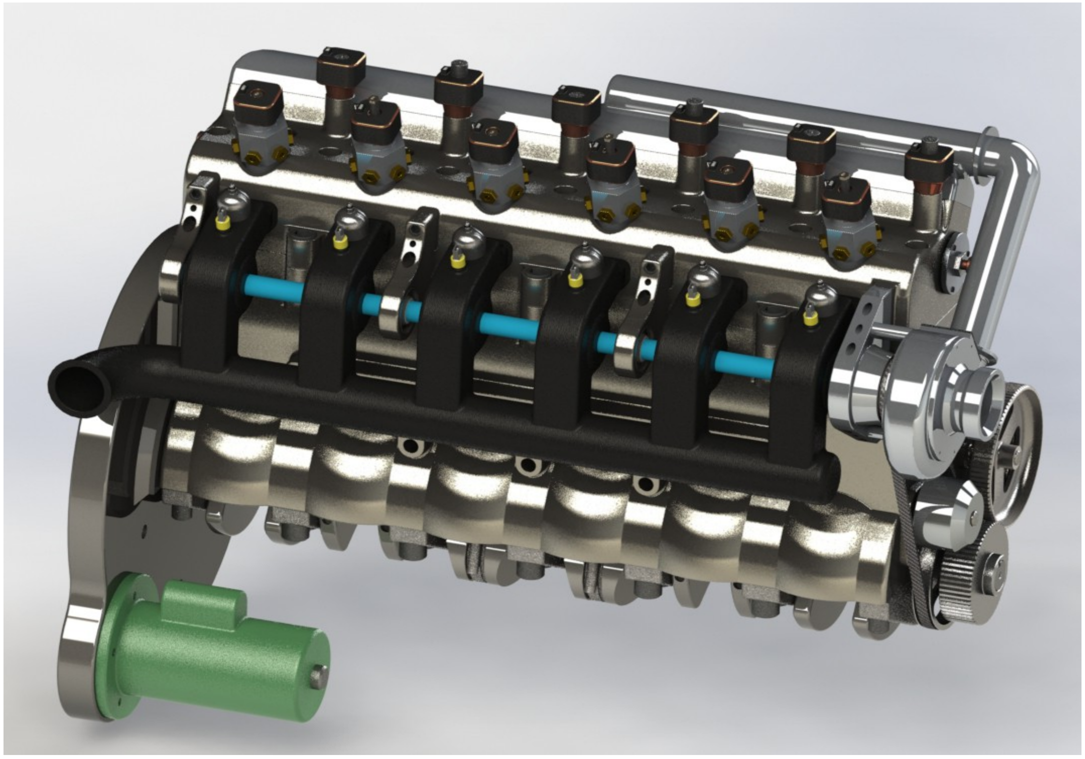

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Figure 11. MWT isolated view.

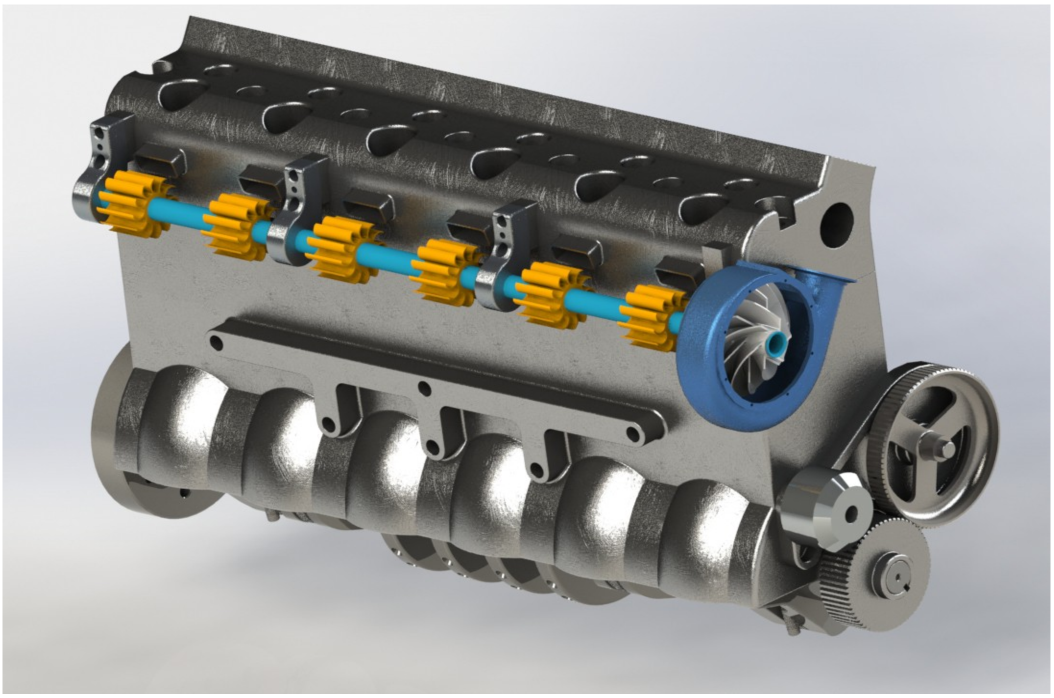

Figure 12. MWT zoomed isolated view.

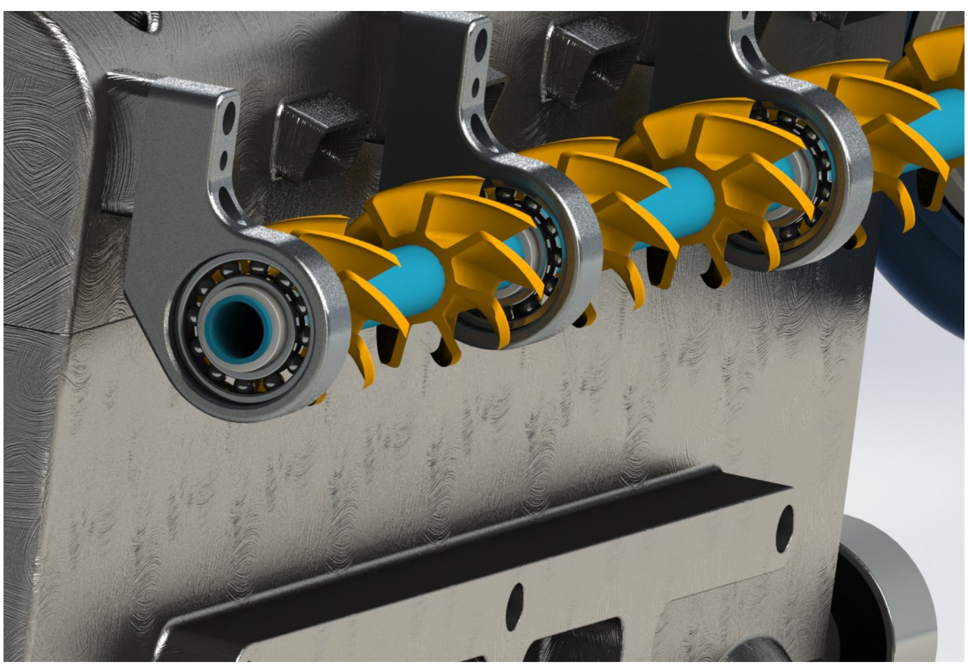

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Figure 13. MWT. Ghost view.

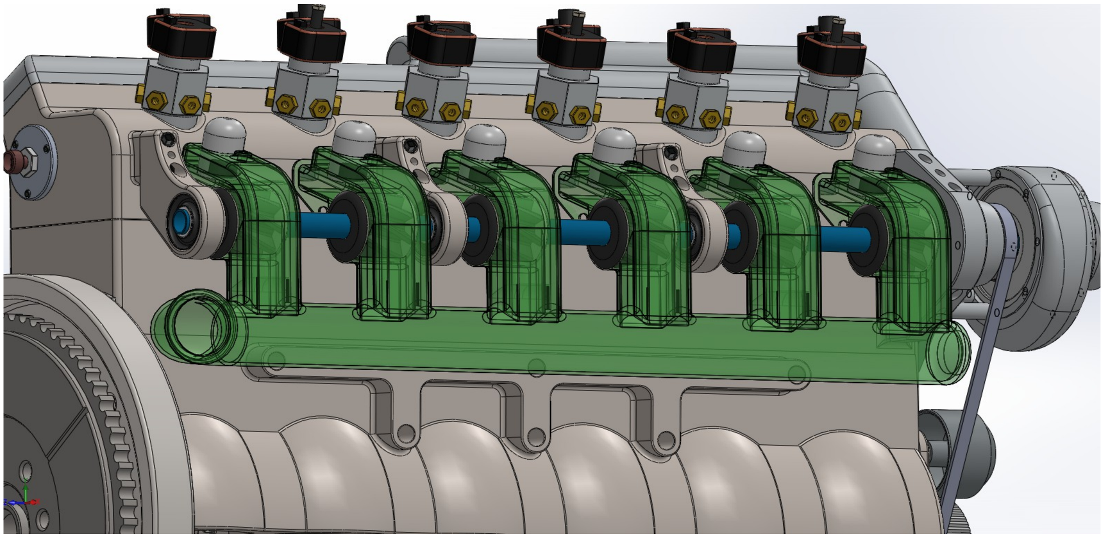

Figure 14. I6 with MWT. Components isolation view, exhaust side.

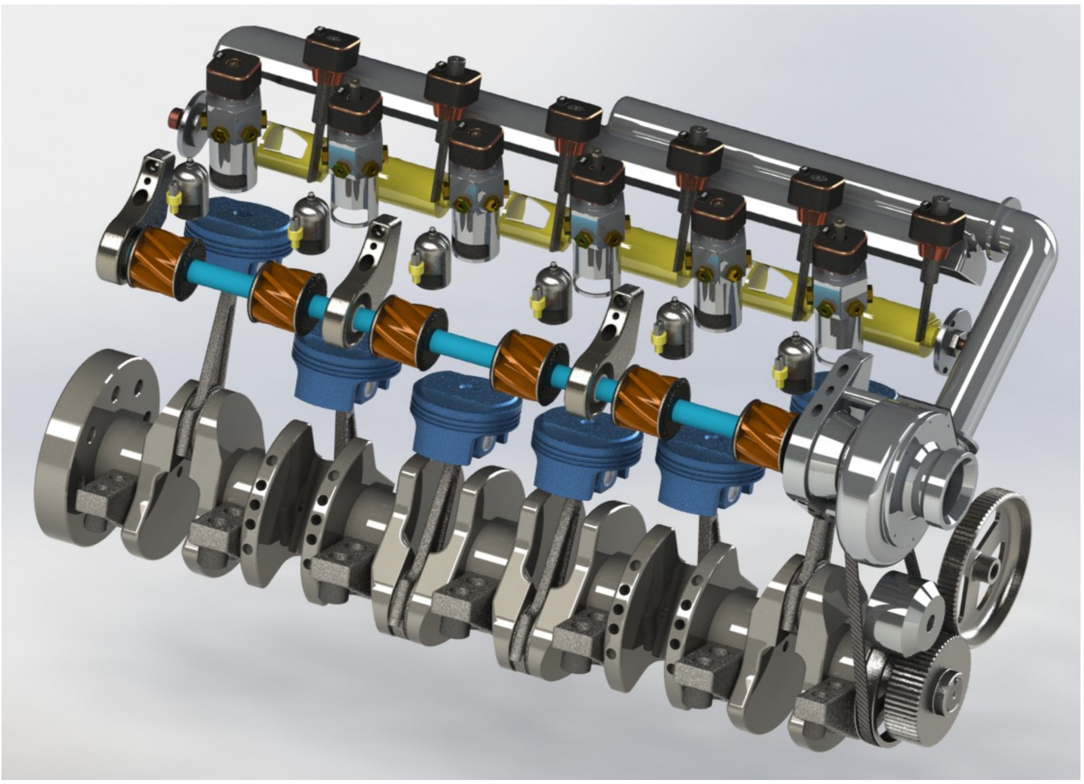

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Figure 15. I6 with MWT. Component isolation, intake side.

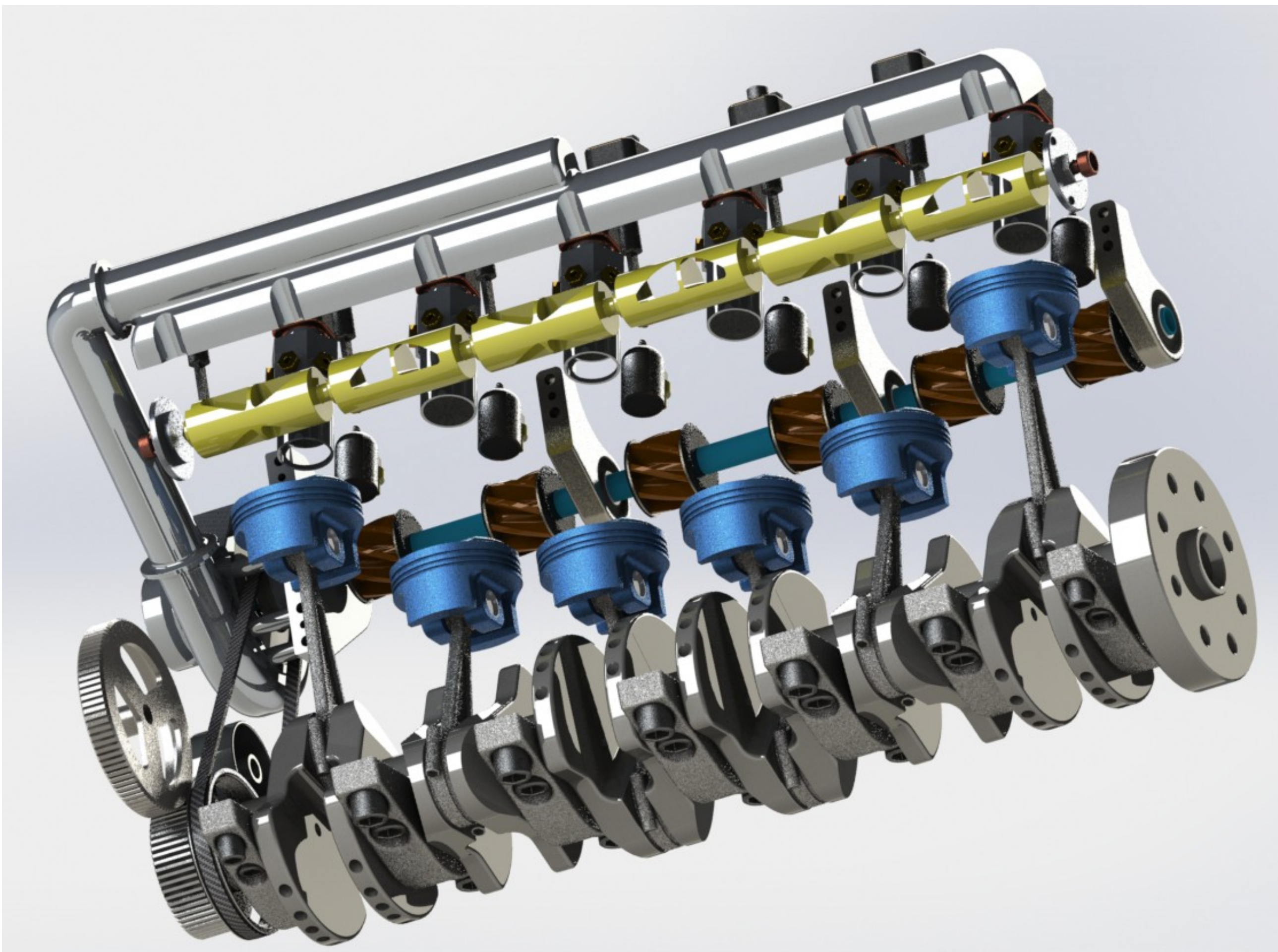

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Figure 16. I6 with MWT – cross section view.

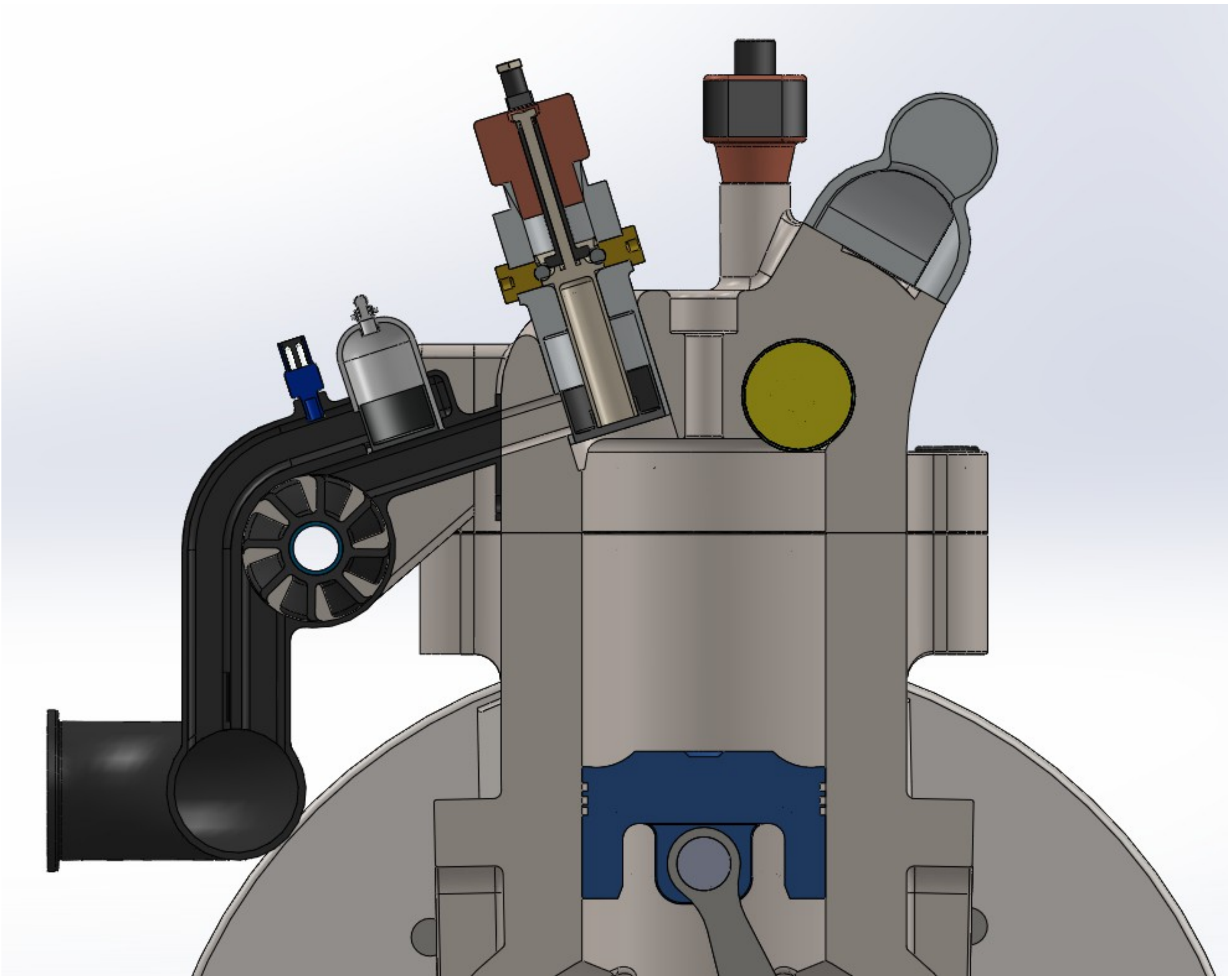

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Figure 17. I6 with MWT – cross section oblique view.

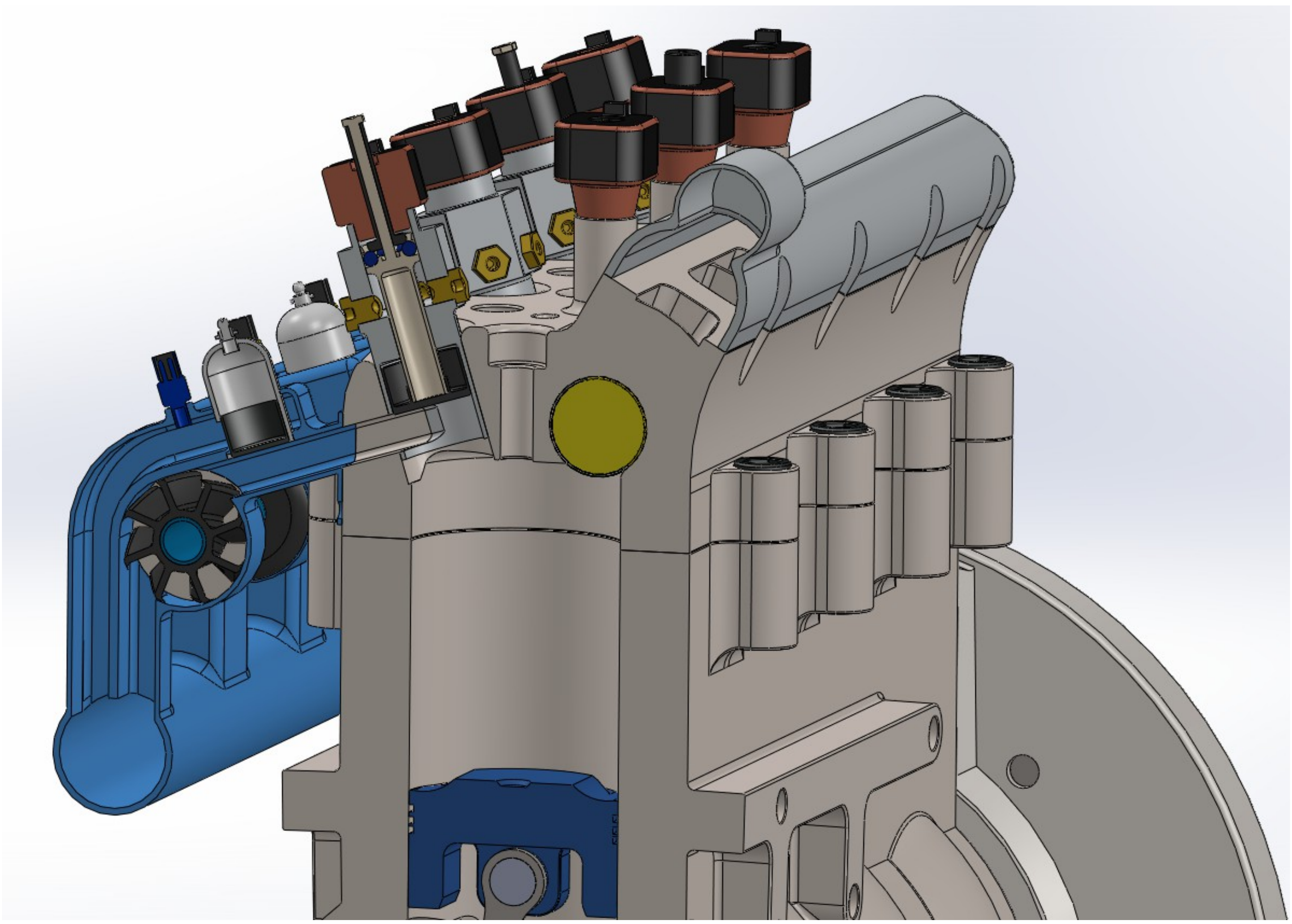

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Figure 18. I6 with MWT – diesel specific head.

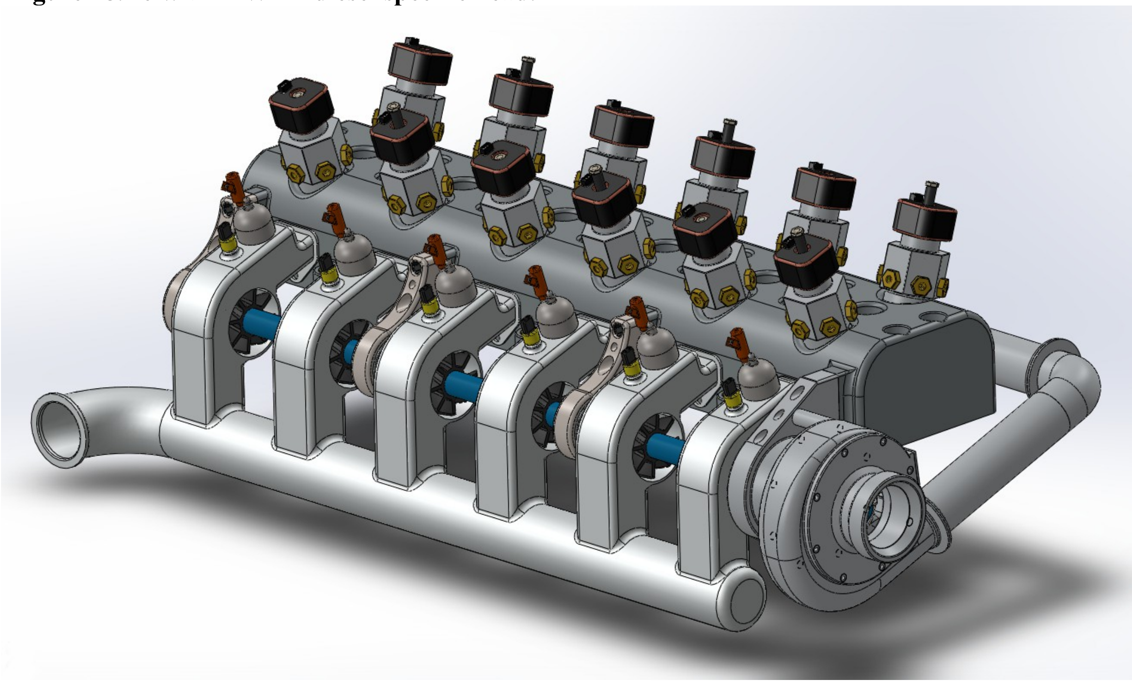

Figure 19. I6 with MWT – diesel specific head – top view.

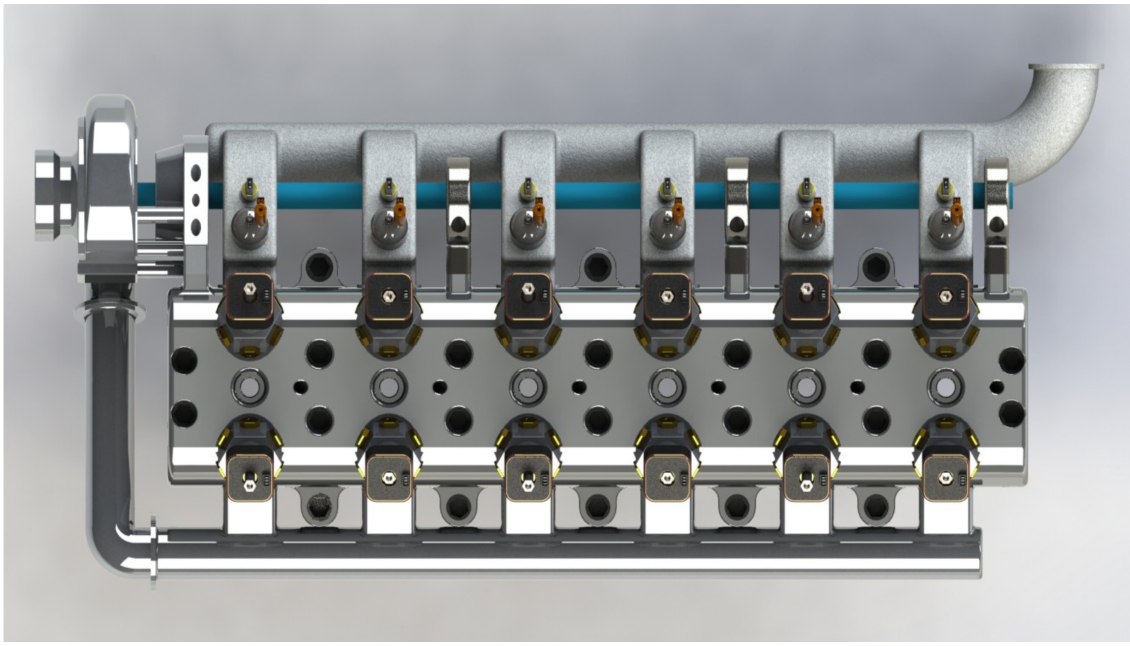

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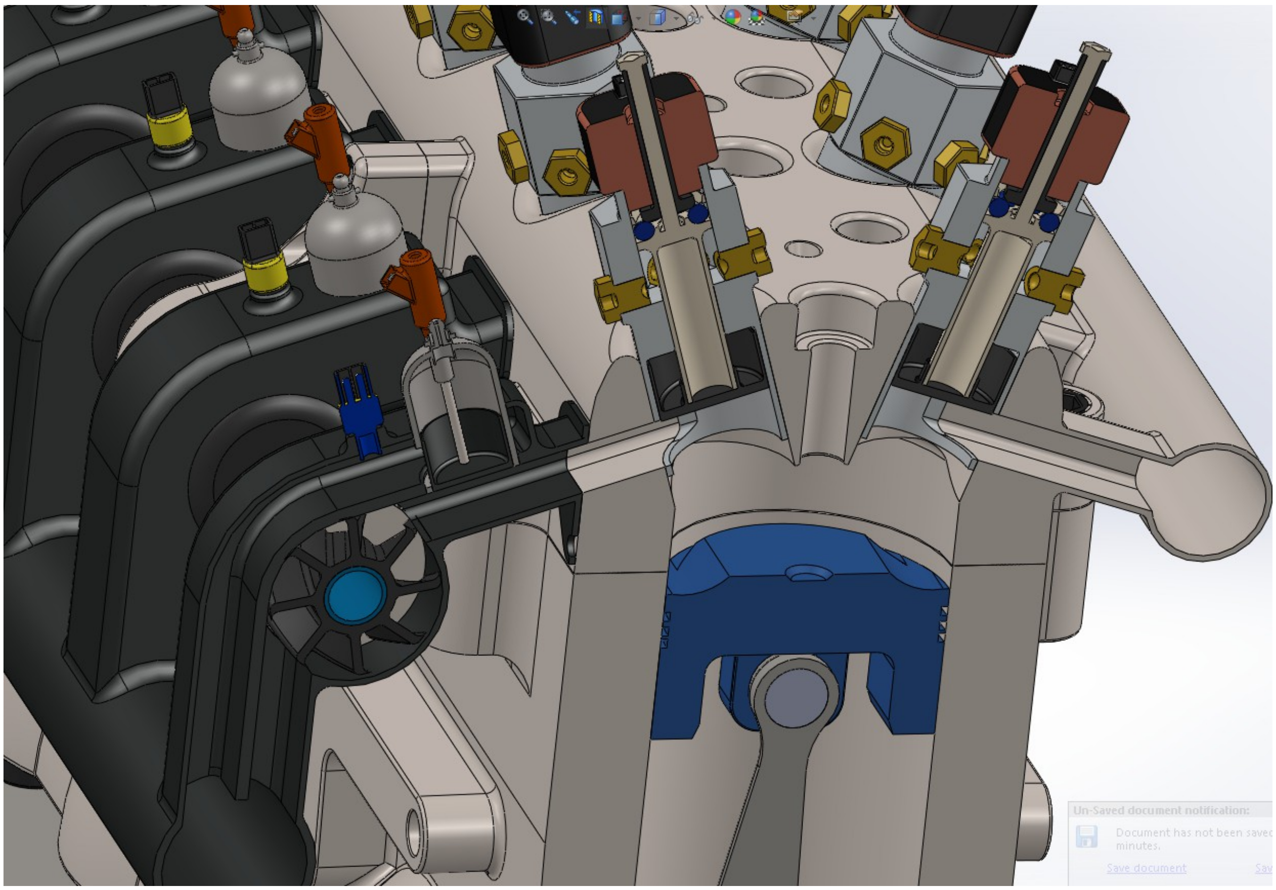
Figure 20. I6 with MWT – diesel specific head – cross section view.



End MWT graphic presentation.

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Section 2. MWT Narrative Description.

The MWT invention does not supersede state of the art turbochargers and is likely less efficient having a higher rotational inertia. The MWT design is significant for it's integration with DE3C engine valves. Digital signal controlled valves can both be open, closed, or one open/one closed at any selected position of crankshaft rotation. This valve independence creates unique cylinder deactivation strategies, engine braking function, and turbocharger shaft speed control otherwise not available.

The MWT converts exhaust gas heat and velocity to rotational motion at each exhaust valve. The exhaust gas energy of all cylinders is collected mechanically by a common shaft. By contrast, in state of the art turbochargers the energy of all cylinders is collected in an aggregate gas stream and applied at a single turbine wheel to convert to rotational energy.

MWT Design Features

- One turbine wheel per exhaust port.
- Multiple turbine wheels mounted on common shaft.
- Hollow shaft to abet cooling with ram air.
- External bearings mounted on ceramic thermal isolator sleeves.
- Straight non-convoluted path to down pipe.
- Inert gas charged by-pass valve between exhaust port and each turbine wheel.
- By-pass sensor signal to PCM for each turbine wheel.
- Mechanical crankshaft drive by timing belt with 1:2 overdrive ratio.
- The belt drive features an overrun sprag clutch on the turbine wheels shaft.
- Double row thrust bearing at compressor housing mount.
- The turbocharger wastegate function is performed by the DE3C valves.
- The turbocharger blowoff valve function is performed by DE3C valves.

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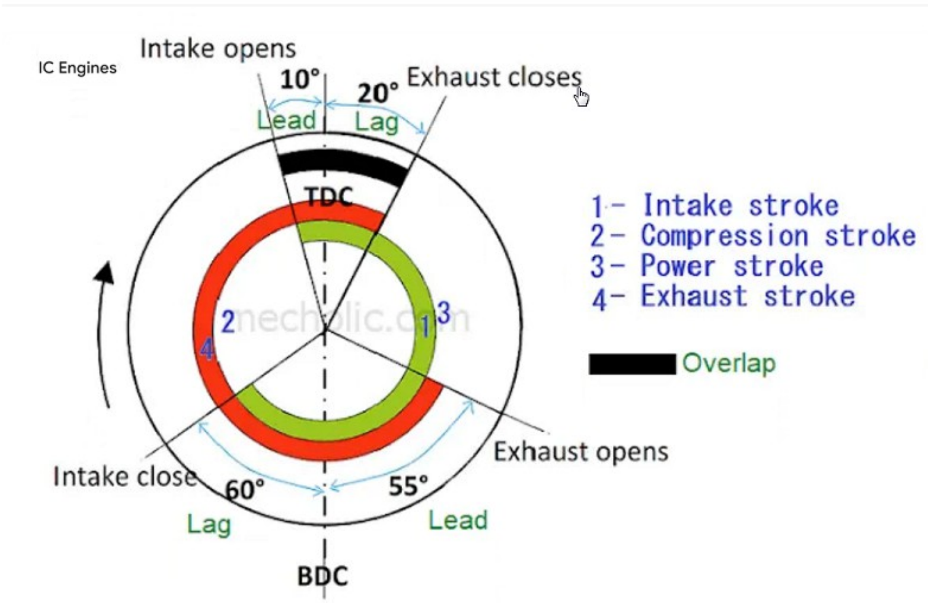
A. MWT Variable Valve Overlap Features

Exhaust Gas Scavenge. An important MWT design feature is the draw function of the port turbine. See Figure 1. When exhaust gas velocity dissipates the turbine wheel creates a draw. The draw accelerates exhaust gas purge from the cylinder. This feature allows an important change to valve timing. See below.

Figure 21. Valve Timing Diagram. (copyright ME2022, www.mecholic.com)



The intake/exhaust valve overlap [black segment] is timed, in spring loaded stem valve engines, to scavenge the burned gasses and cool the exhaust valve. Valve cooling is not required with the PLV. Further, the turbine wheel draw reduces the need for twenty degrees of exhaust valve lag. The result is a more optimal intake stroke. At BDC, the DE3C valves allow for even greater change in valve overlap timing. The 60 degree intake lag can close to 20 or less. An unobstructed port and faster full open valve yield a faster cylinder fill. The intake air mass versus crank angle plot approximates a square wave compared to the trigonometric curve plot of a cam driven stem valve. Closing the intake closer to BDC creates a more complete compression stroke. Likewise, the PLV exhaust gas mass purge outpaces cam driven exhaust evacuation. This allows for a significant reduction in the 55 degree exhaust valve lead and a more complete power stoke. The impact of these are illustrated below.

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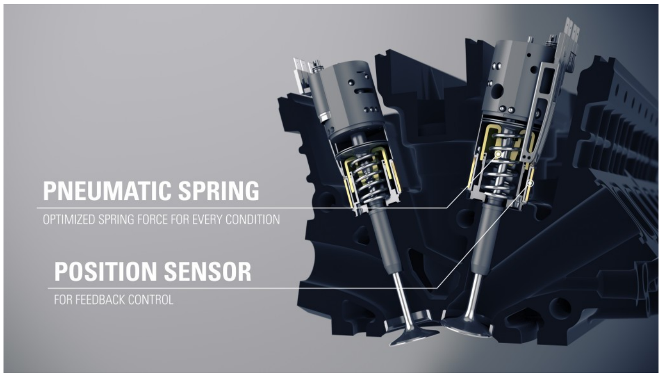
Figure 22. Koenigsegg Automotive AB - Freevalve™



"Freevalve uses electro-hydraulic-pneumatic actuators combined with advanced sensor techniques."
www.freevalve.com/technology/freevalve-technology/

Koenigsegg's actuator technology achieves ICE performance gains unequaled in the automotive industry. 600 HP from a 2.0 liter 3 cylinder twin turbo engine. Without lengthy analysis, the gains are mostly effected by two factors, valve independence (camless), and the optimization of the intake, compression, power, and exhaust strokes as discussed above.

It is suggested that powering the PLV and AEV with Koenigsegg's Freevalve closed loop feedback electro actuator will bring ICE efficiency to a near climax state. There are notable mechanical differences between DE3C valves and Freevalve. Freevalve employs traditional spring loaded stem valves, that extend into the combustion chamber, and require hydraulic plus pneumatic power to operate, increasing the accessory drive load. The DE3C valves are mechanically more efficient, offer unobstructed porting, run cooler, and have a faster mass flux.

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B. DE3C Cylinder Deactivation.

The inline six cylinder engine is prime architecture for cylinder deactivation. In line six engines are a large percent of diesel engines in manufacture. The I6 is two three cylinder engines joined. The piston rod journals are spaced 120 degrees and have a natural balance in four cycle operation of three adjacent cylinders. It is basic to deactivate half of the cylinders in throttle up, no load, or idle conditions. Alternate firing of front and back three cylinder banks will deliver power with balance and reduced fuel consumption.

Cylinder deactivation technology past and present employs modified valve lifter devices applied to designated cylinders. These devices defeat valve actuation leaving both the intake and exhaust valves closed. The sealed cylinder is subject to internal forces of compression and vacuum with rising and falling piston stroke. Due to friction losses, compression and vacuum loading, the deactivated cylinders draw power from the live cylinders and trim fuel reduction.

Two Cycle Pass Through Deactivation. PCM digital electronic controlled valves allow for sequential cylinder deactivation in a balanced pattern of deactivation. Air, without fuel, and free of compression or vacuum loading, is ported through a deactivated cylinder. The deactivated cylinder protocol is as follows:

Down stroke -	Intake Open / Exhaust Closed
Up Stroke -	Exhaust Open / Intake Closed

The deactivated cylinder is vented, eliminating parasite drag of compression and vacuum in a closed cylinder piston stroke. The intake air passes free, through the deactivated cylinder, in a two stroke cycle.

This allows the engine, when appropriate, to operate on fewer cylinders and simultaneously cool deactivated cylinders. The benefit is foremost fuel efficiency with ancillary reduction of heat. They key features are near zero load of deactivated cylinders and sequential deactivation of every cylinder. Deactivated cylinder firing orders are mapped out to ensure even wear, work, and balance, for all cylinders.

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C. MWT Speed Control.

Crankshaft Drive. The MWT shaft is mechanically linked and driven by the crankshaft. The design example uses an overdrive 1:2 ratio timing belt pulleys. The MWT turbines are half the diameter of a gas driven wheel of a conventional turbocharger. The mechanical drive assists shaft rotation at engine start and idle rpm. The drive link is broken by an overrunning sprag clutch on the turbines shaft at the thrust bearings mount point. In engine drive modes the turbines shaft rpm runs well above 2 x crankshaft rpm.

DE3C Wastegate Integration. State of the art turbochargers employ a wastegate device to reduce excessive gas energy in high power output throttle-up event. The MWT invention features an inert gas loaded pressure relief valve between the PLV and the turbine wheel. There is a separate and parallel tract for the by-pass exhaust gas. The by-pass channel also features a flow sensor signal to the PCM when by-pass is present. Inert gas is preferential to spring force. The activate point can be tuned with higher resolution compared to spring force. The pressure relief valves are serviced and set with the engine at operating temperature.

The individual port pressure relief valves eliminate the need for a wastegate and allow for traditional exhaust header and duct design. Consider that a wastegate is not a turbocharger brake. Over speed conditions are relieved by reducing the turbocharger hot side pressure relative to the cold side compressor pressure. The shaft speed winds down by higher compressor loading. The individual port relief valves do the same and with a faster response time. In a failed state, a relief valve will open. The flow sensor will trigger failure to the PCM. However, engine damage is avoided.

Power Stroke Shorting. At idle or no load engine conditions, turbo lag can be reduced or eliminated by shorting the power stroke. Definition: the exhaust PLV opens prematurely (at or near 90 degrees ATDC). This causes release of partially harnessed combustion energy which accelerates the turbine wheel. It may be necessary to defeat the pressure relief by pass valve. This turbo lag override function can be performed by momentary firing of the deactivated cylinders. The function can be automated in the PCM firing map for rapid throttle input and also operator input, anticipating a power demand.

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MWT Turbine Wheel Back Pressure. See Figure 1. above. The turbine wheel is designed to draw air from the open cylinder, This creates a cylinder scavenge flow bias when exhaust gas output is not forward driving the turbine. When the PLV is closed there is an immediate drag on the turbines shaft system. This drag is regulated by the PCM controlling the duration and number of cylinders with closed exhaust port. When the intake and exhaust are both open there is a cylinder scavenge flow. With throttle-up event at high power output, the turbine wheels shaft speed is controlled by holding deactivated cylinder exhaust valves closed for a duration necessary to slow the turbines shaft.

MWT Compressor Blow Off. An overboost pressure is signaled to the PCM by a plenum pressure sensor. The overboost is relieved by activation of the cylinder deactivation firing map. The two stroke pass through method is modified with both intake and exhaust valves open in sync. High pressure blows through. The cylinder is clean for the next power cycle or deactivation cycle as triggered by the PCM.

The topics above relate to both diesel and gas engines. The variable aperture feature of the AEV is applicable to gasoline power. As noted in the PLV patent, the PLV can be applied as intake and exhaust valve.

Current Regulated Turbo Speed. The MWT external shaft feature allows for mounting of tach-generator, magnetic-clutch, and current generator toroidal bodies at the firewall end. Closed loop turbo speed control is achieved. Wastegate and blow off functions are superseded. There is a predetermined turbo shaft speed to power curve. At any turbo rpm below optimal, nothing is done. At rpm above design speed, the tach signals the PCM to engage the magnetic clutch which spins up the current generator. The increase in rotational inertia slows the turbines. The generator output is shunted acting as magnetic brake. For turbine speed overrun of the inertial drag increase, the tach signal is fed to an op-amp gate which increases the field current of the generator and governs the speed by electromotive force in the stator windings.

Alternative to shunting, which converts the generated current to heat, the current can be fed to a high speed shrouded draw fan which pulls ambient air through the turbines shaft for cooling. At continuous high power output, excess turbo torque is harnessed to cool the turbine wheels.

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D. Engine Braking.

This section is intended for diesel ICEs, however, the methodology can be applied to some gasoline engines. Diesel Exhaust Brake and JVS [Jake Brake] systems are effective and mature technology. The PLV and AEV inventions can inherently implement these two methods.

Exhaust Braking.

The by-pass valves are defeated by solenoid held shot pins. The turbines shaft speed is regulated by magnetic clutch to achieve optimal exhaust gas velocity restriction for effective braking.

JVS Compression Braking.

The valve actuation protocol is straight forward. Exhaust valve closes after TDC / intake opens. Intake closes after BDC. Compression stroke. At TDC, exhaust opens, compression is released. Repeat. Compressed air will cool the turbine wheel. Turbine wheel may act as sound attenuating baffle.

Deactivated Cylinder Braking.

Engine braking by vacuum. Cylinder head back pressure is maximized. The deactivated cylinder braking protocol is as follows:

First Point of TDC:	Both valves closed
Duration of Brake Cycle:	Both valves closed
Point of exit:	TDC then PCM power or deactivation map resumes

The PCM modulates engine brake force by the number of cylinders selected. There is no caustic noise associated. This method is a lesser braking force relative to JVS. However, in steep runaway truck ramp terrain, all cylinders in deactivation may be a satisfactory continuous run mode, with all other brake options at the ready.

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Section 4. Utility Patent Claims.

1. I claim the invention of an internal combustion engine turbocharger with these properties:

- One turbine wheel per exhaust port.
- Multiple turbine wheels mounted on common shaft.
- Hollow shaft to abet cooling with ram air.
- External bearings mounted on ceramic thermal isolator sleeves.
- Straight non-convoluted path to down pipe.
- Inert gas charged by-pass valve between exhaust port and each turbine wheel.
- By-pass sensor signal to PCM for each turbine wheel.
- Mechanical crankshaft drive by timing belt with 1:2 overdrive ratio.
- The belt drive features an over run sprag clutch on the turbine wheels shaft.
- Double row thrust bearing at compressor housing mount.
- The turbocharger wastegate function is performed by the DE3C valves.
- The turbocharger blowoff valve function is performed by DE3C valves.
- Current regulated turbo speed.

End of presentation. List of Illustrations follows.

Very Respectfully Submitted,

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List of Illustrations

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