ADS 37 CFR 1.76 Technical Disclosure

Axial Engine Valve

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U.S. Patent and Trademark Office
U.S. DEPARTMENT OF COMMERCE
Alexandria, VA 22313

Project:	**PROVISIONAL PATENT APPLICATION under 37 CFR § 1.53(c)**	
Subject:	**Axial Engine Valve for Internal Combustion Engines**	
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Reference 2:	**USPTO Application Number**	**63322518**
Reference 3:	**Application Data Sheet 37 CFR 1.76 Axial Engine Valve, March 22, 2022**	
Purpose:	**Definition of Axial Engine Valve (AEV) invention for patent claim.**	
Date:	**March 22, 2022**	**(USPTO Receipt Date 03-22-2022)**
Prepared for:	**USPTO EFS submission.**	

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Abstract

This patent application presents an alternative to camshaft driven spring loaded stem valves employed in the internal combustion engine (ICE). The **Axial Engine Valve** (AEV), presented here, is an improvement of the camshaft driven stem valve for maximizing fuel efficiency. Cam driven stem valves are mechanically linked by fixed sequence camshafts. The AEV, by contrast, is independent. The AEV can vary the lift and timing of one valve isolated from the others. For this characteristic, the AEV optimizes fuel efficiency by strategic variation of lift, timing, duration, and valve overlap. AEVs are free of spring forces and yield a significant reduction of internal rotating friction. AEVs are external to the combustion chamber and allow unlimited design of piston topography. In multi-cylinder engines, the AEV allows variable cylinder firing order and advanced cylinder deactivation strategies. The AEV can equalize duty cycle wear of all cylinders in deactivated cylinder modes. The AEV can simultaneously act as intake port and throttle. Camshaft driven stem valves are not this flexible.

The Axial Engine Valve details are presented in **3D Solid Model CAD** drawings and text. The invention is the product of a quest for a valve system controlled by digital electronic signal. In an AEV equipped four cycle internal combustion engine, the dynamics of cylinder, piston, and crankshaft remain unchanged. The porting system is a radical change. The porting system is PCM controlled, mechanically free, and flexible.

Intake port AEVs, paired with exhaust port **Pressure Lifted Valves** (PLV), create a digital electronic controlled combustion cycle engine (DE3C). **[The PLV is the subject of a separate patent application]** The AEV achieves the four goals listed in the design objectives below. The AEV can be camshaft driven and achieve design goals 1 and 2, however, camshaft limitations apply. Digital electronic control of the combustion cycle extends the life of the internal combustion engine relative to advancing electric technologies. DE3C technology has reliability advantage for aviation reciprocating engine power, fuel conservation advantage for personal and commercial transport power, and like advantages for other difficult to electrify uses of the ICE.

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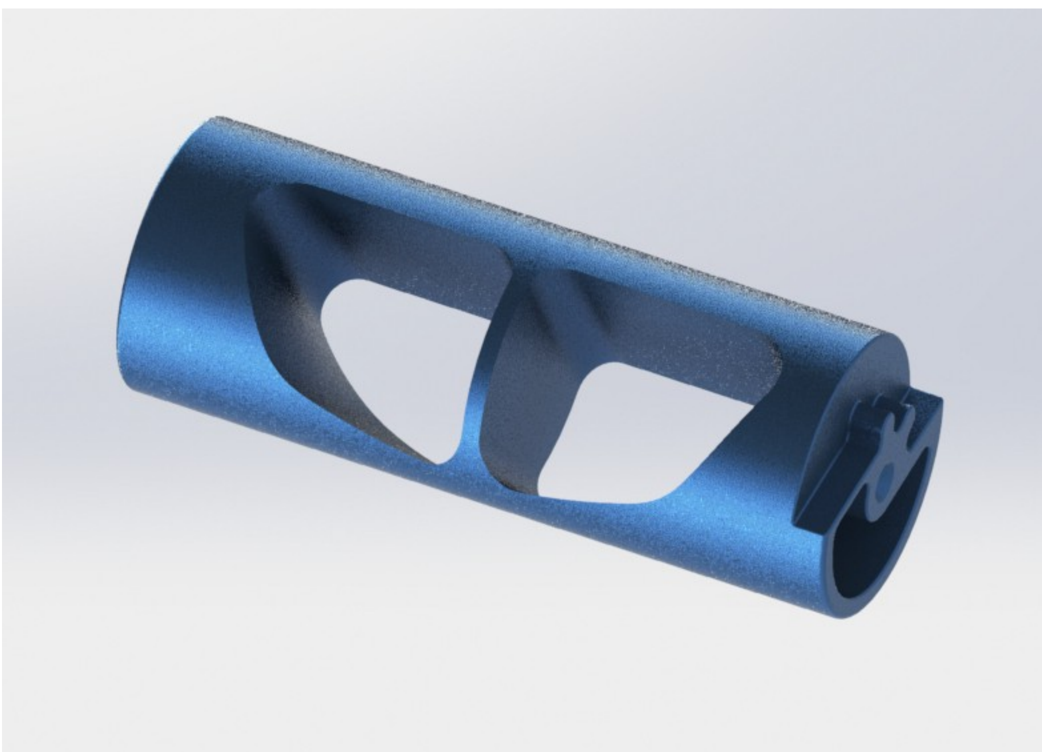
Design Goals – Axial Engine Valve

1. Increase the fuel efficiency of the internal combustion engine.
2. Reduce the internal rotating friction of the ICE.
3. Reduce the number of components of the ICE.
4. Achieve digital electronic control of the combustion cycle.

Axial Engine Valve Example



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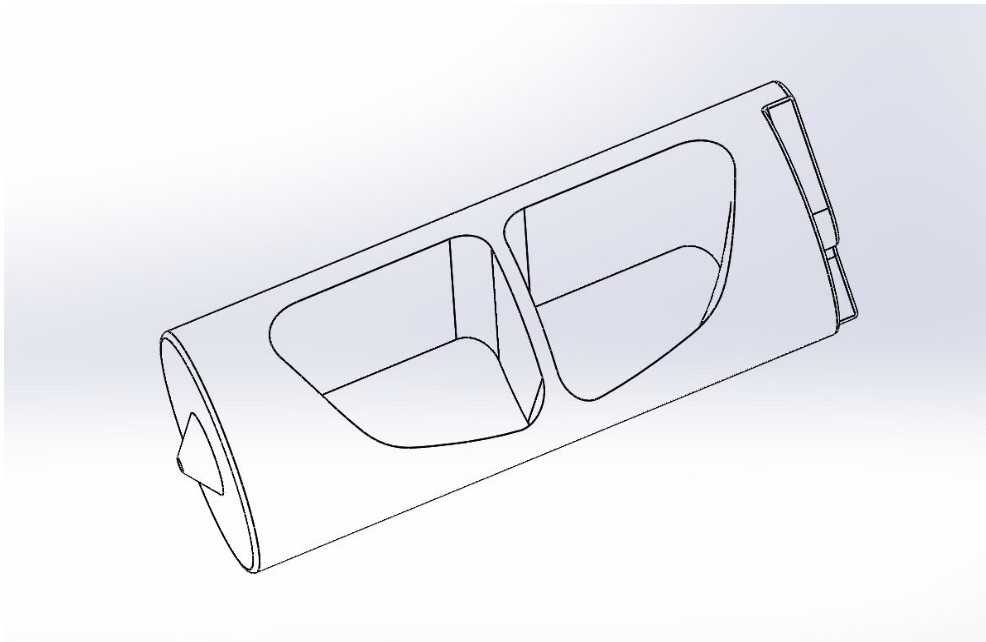

Section 1. Axial Engine Valve (AEV) Presentation

A. Definition

The Axial Engine Valve is a cylindrical ported body positioned at the head of a cylinder. It acts as the intake port in an ICE. The valve port opens and closes by angular movement about the central axis of the valve body. The valve motion oscillates clockwise and counterclockwise and does not exceed 90 degrees. There are no spring forces to overcome in axial engine valve actuation.

B. Description of Example Engine Application

The AEV is applicable to all internal combustion engines of any number of cylinders, cylinder orientations, and fuel types. For purpose of patent illustration, a 90 degree V8 engine (eight cylinders) is depicted. The example borrows the metrics of the Ford 4.6 liter modular V8 engine, 90.2 mm bore, x 90 mm stroke. The dimensions depicted for the valve and sleeve are fitted for this V8 4.6 liter engine example and have no specific import to the overall invention design.

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C. Axial Engine Valve - Physical Properties

Figure 1. The AEV, 38 mm diameter by 103.5 mm overall length.

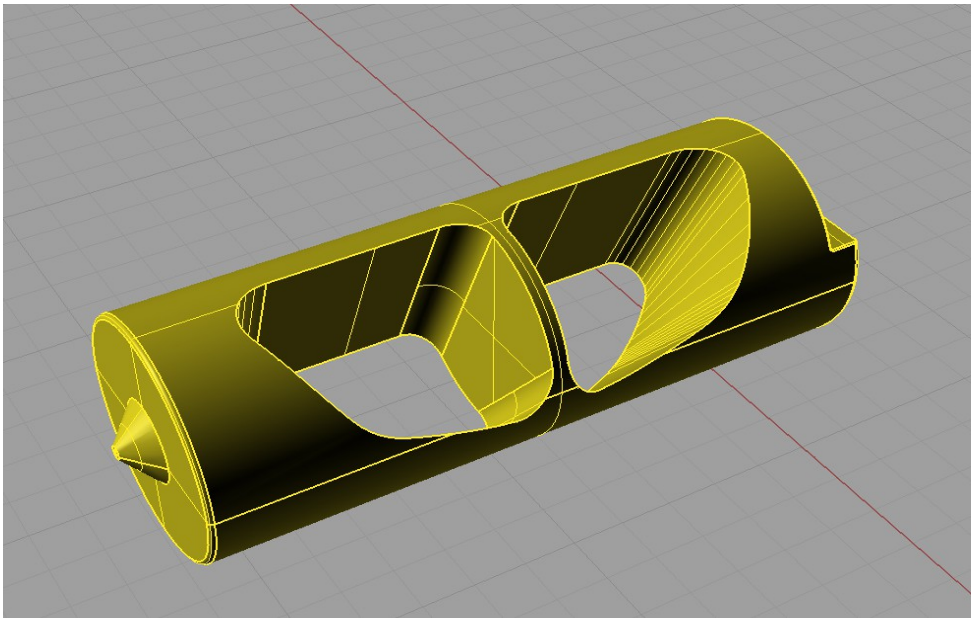

Figure 2. The AEV. Second view.

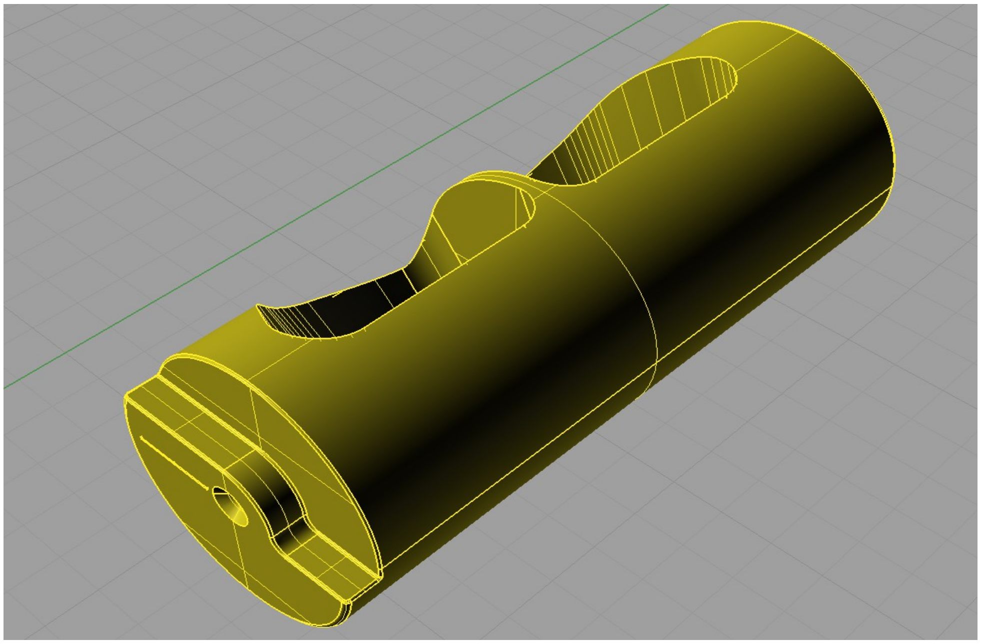

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Figure 3. AEV sleeve. 4 cylinder bank. 40 mm outside diameter by 477.5 mm length. Mirror views.

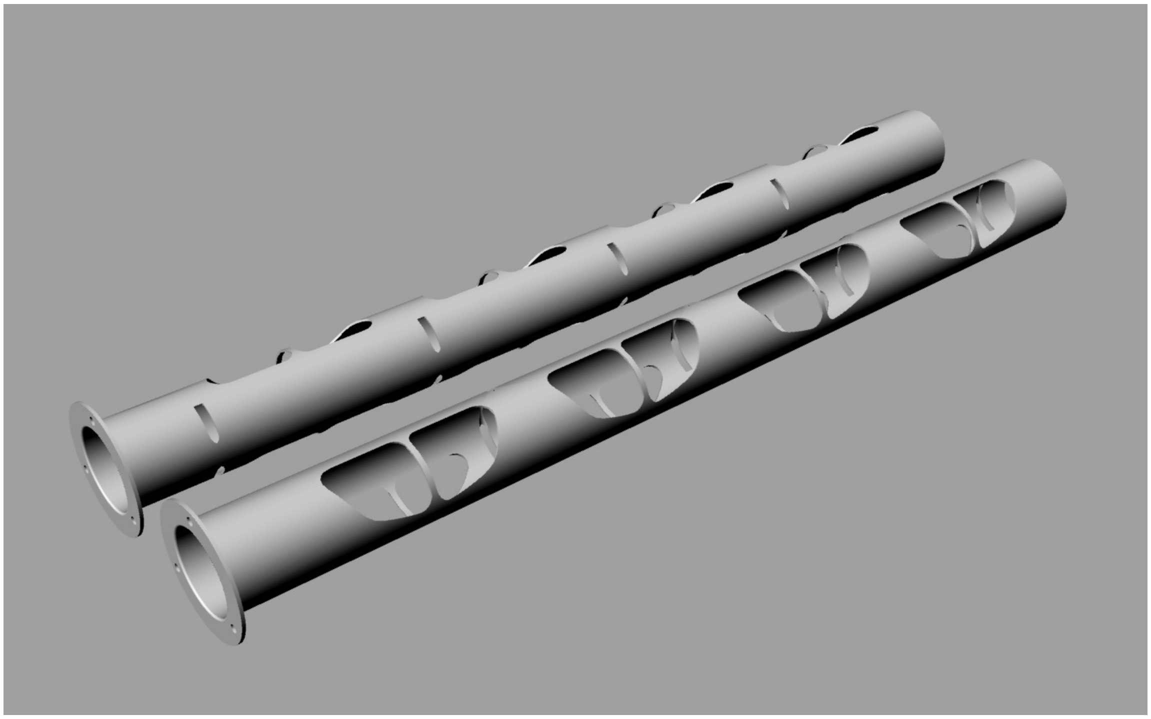

Figure 4. AEV sleeve loaded with four valves and line drawn mirror image sleeve.

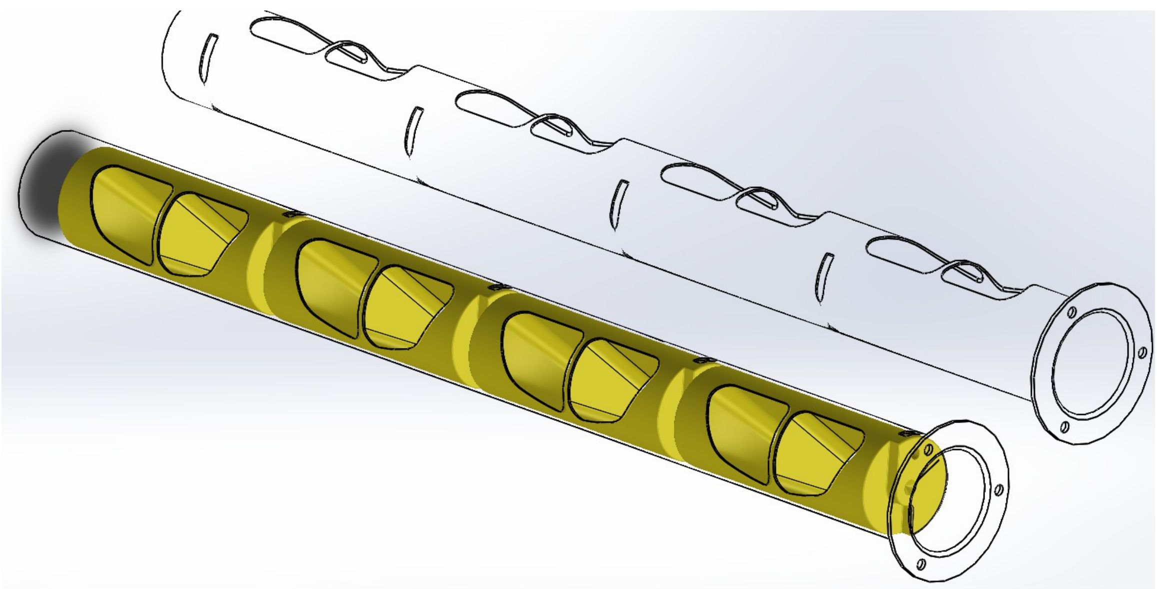

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Figure 5. Mono-block casting, 4 cylinder bank. Cylinder head and and block integrated into single aluminum die-cast body. Top view.

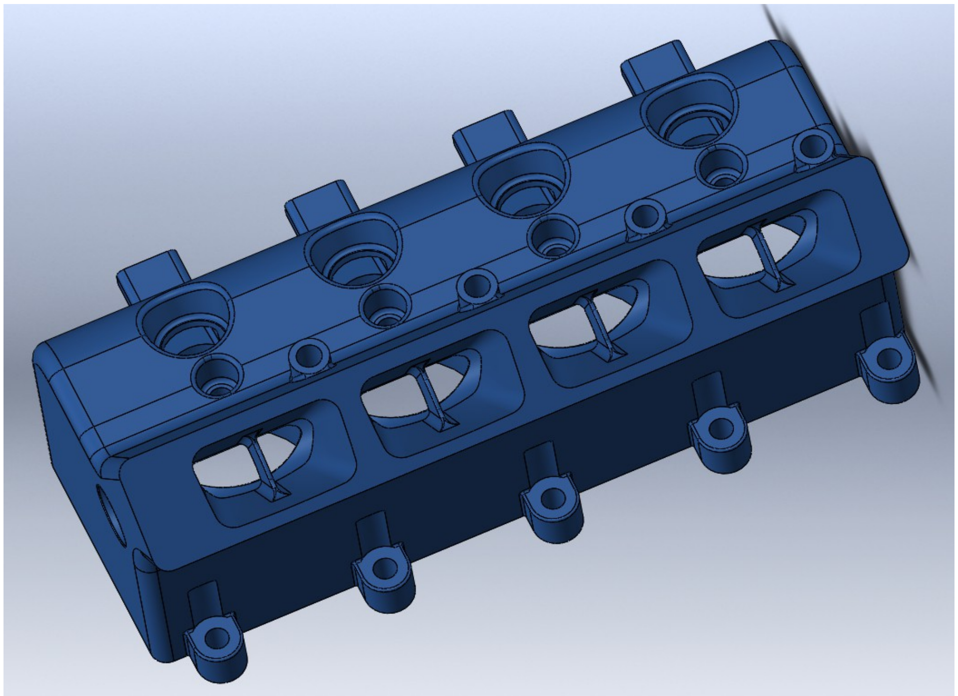

Figure 6. Mono-block, bottom view.

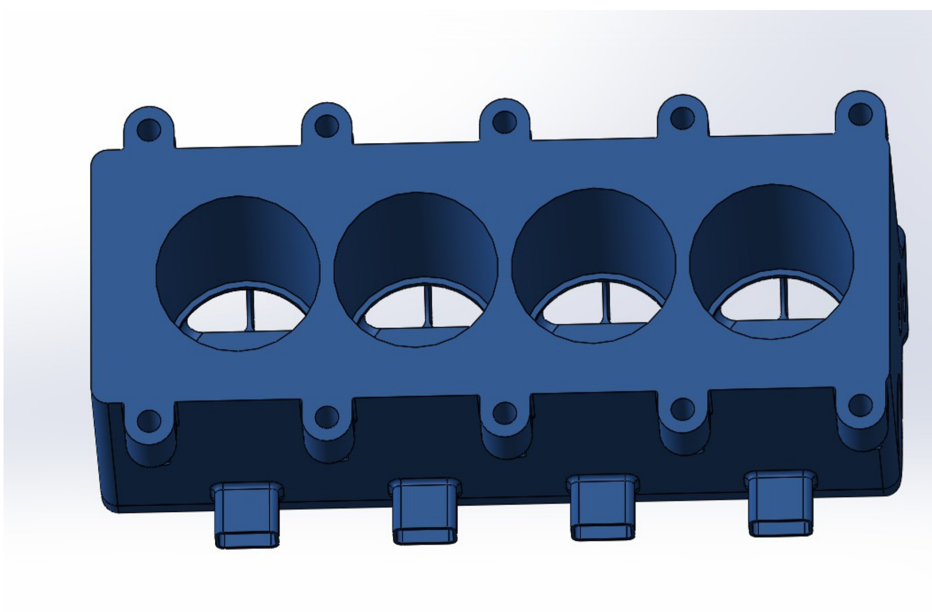

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Figure 7. Mono-block, section view.

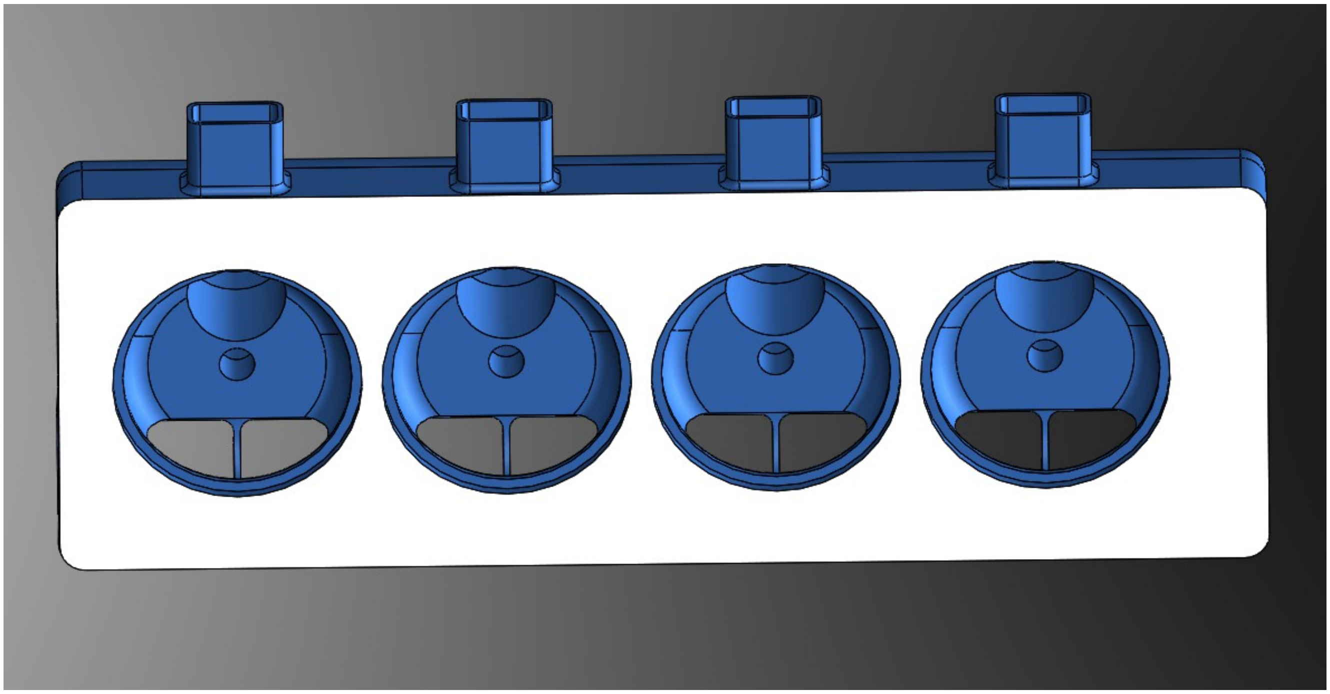

Figure 8. Mono-block casting. Section view. AEVs installed, two open, two closed

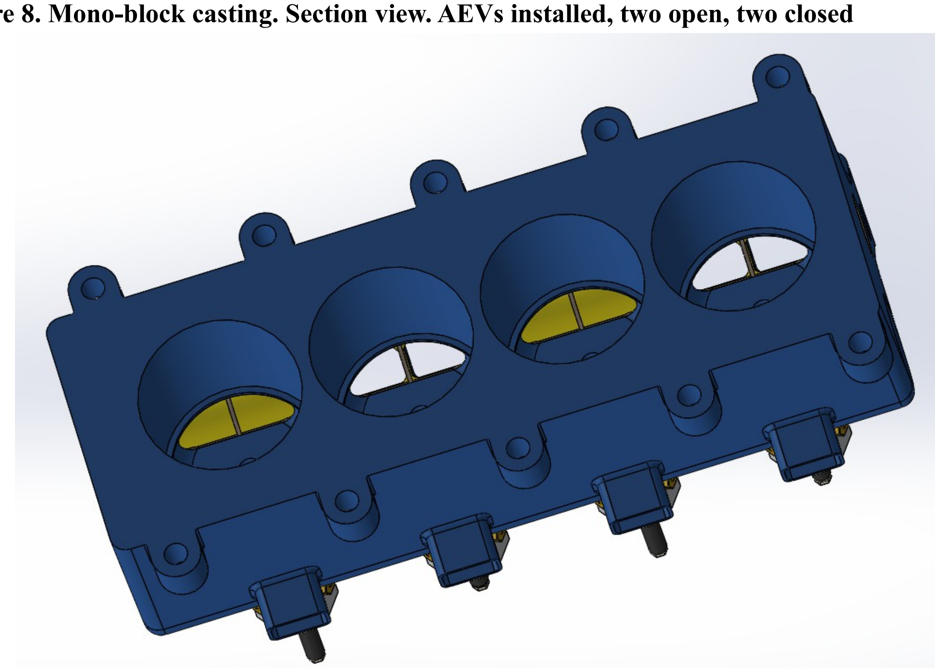

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Figure 9. Mono-block ghost view. AEVs and sleeve installed.

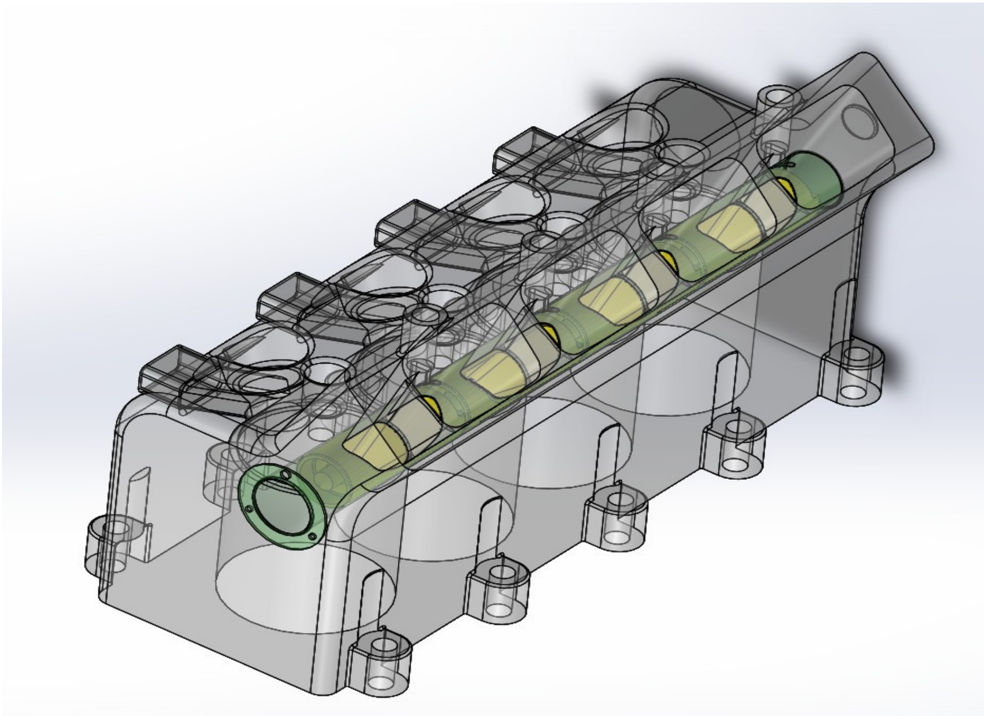

Figure 10. Mono-block ghost view. AEVs, sleeve, and linear drivers installed.

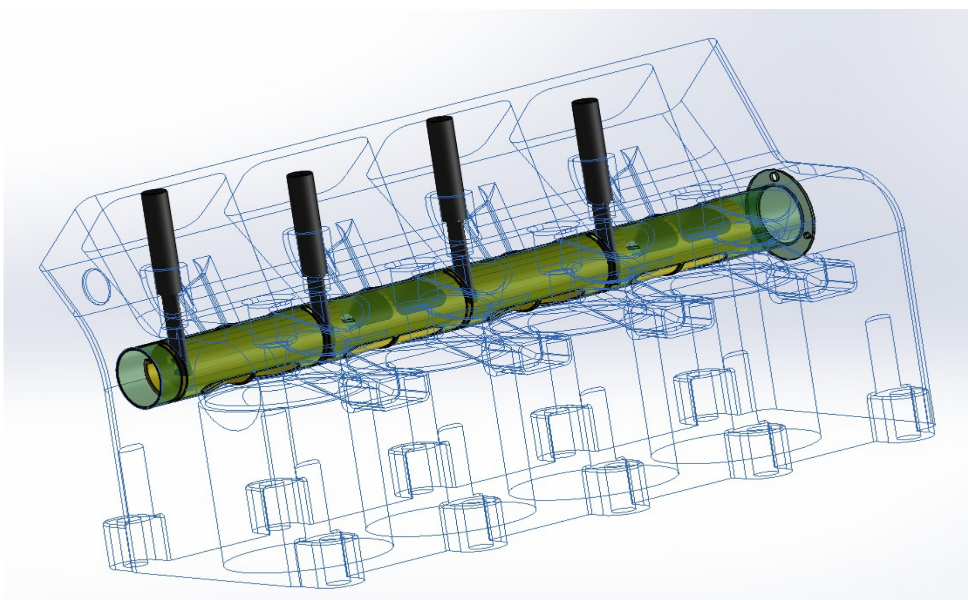

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Figure 11. Mono-block with AEVs, sleeve, linear drivers, and PLVs.

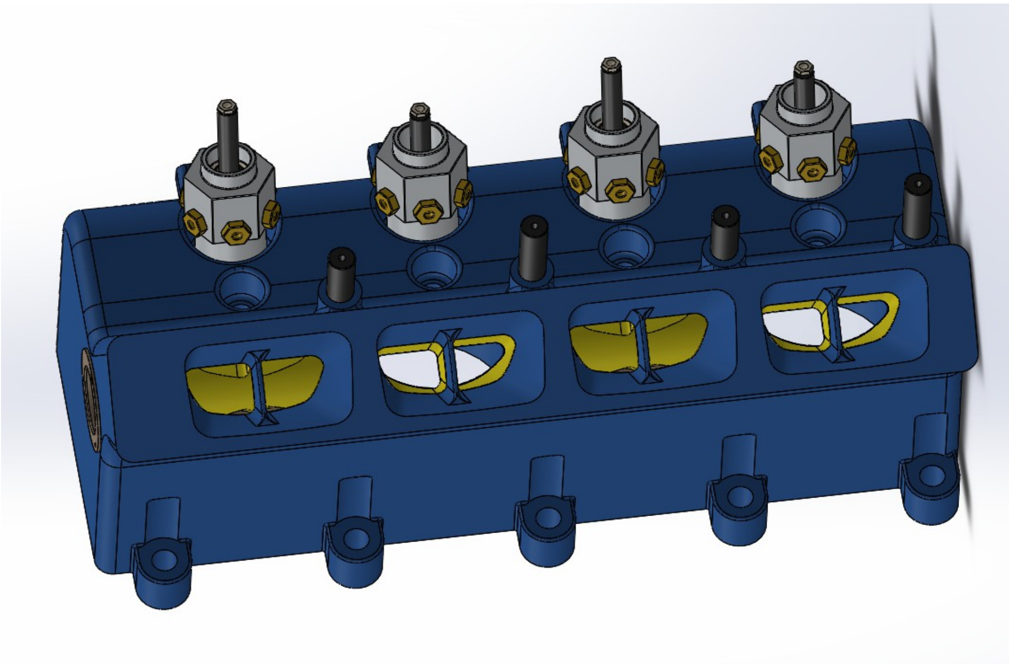

Figure 12. Mono-block, perspective view.

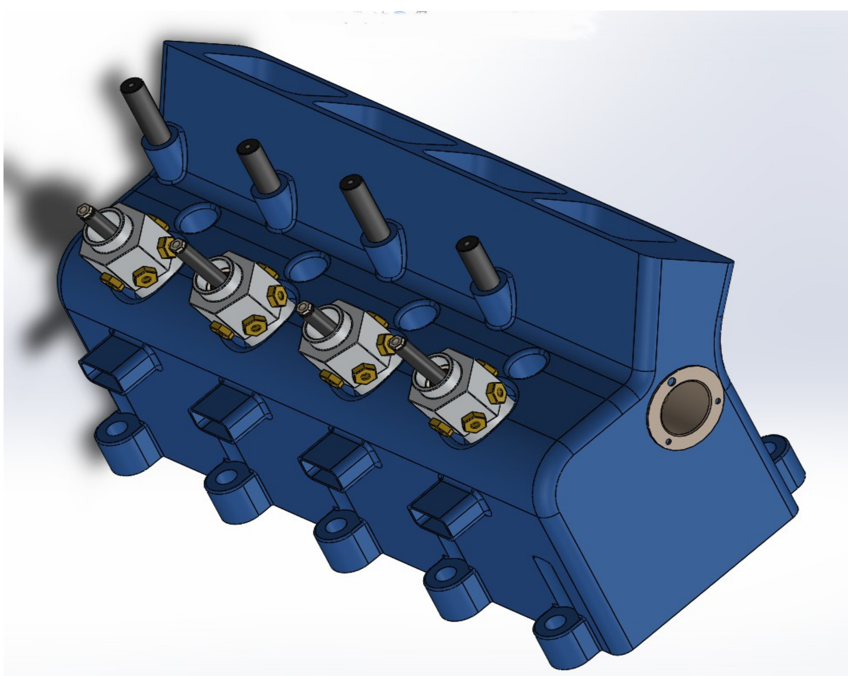

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Figure 13. Mono-block diametrical section view. AEV closed. (PLV open).

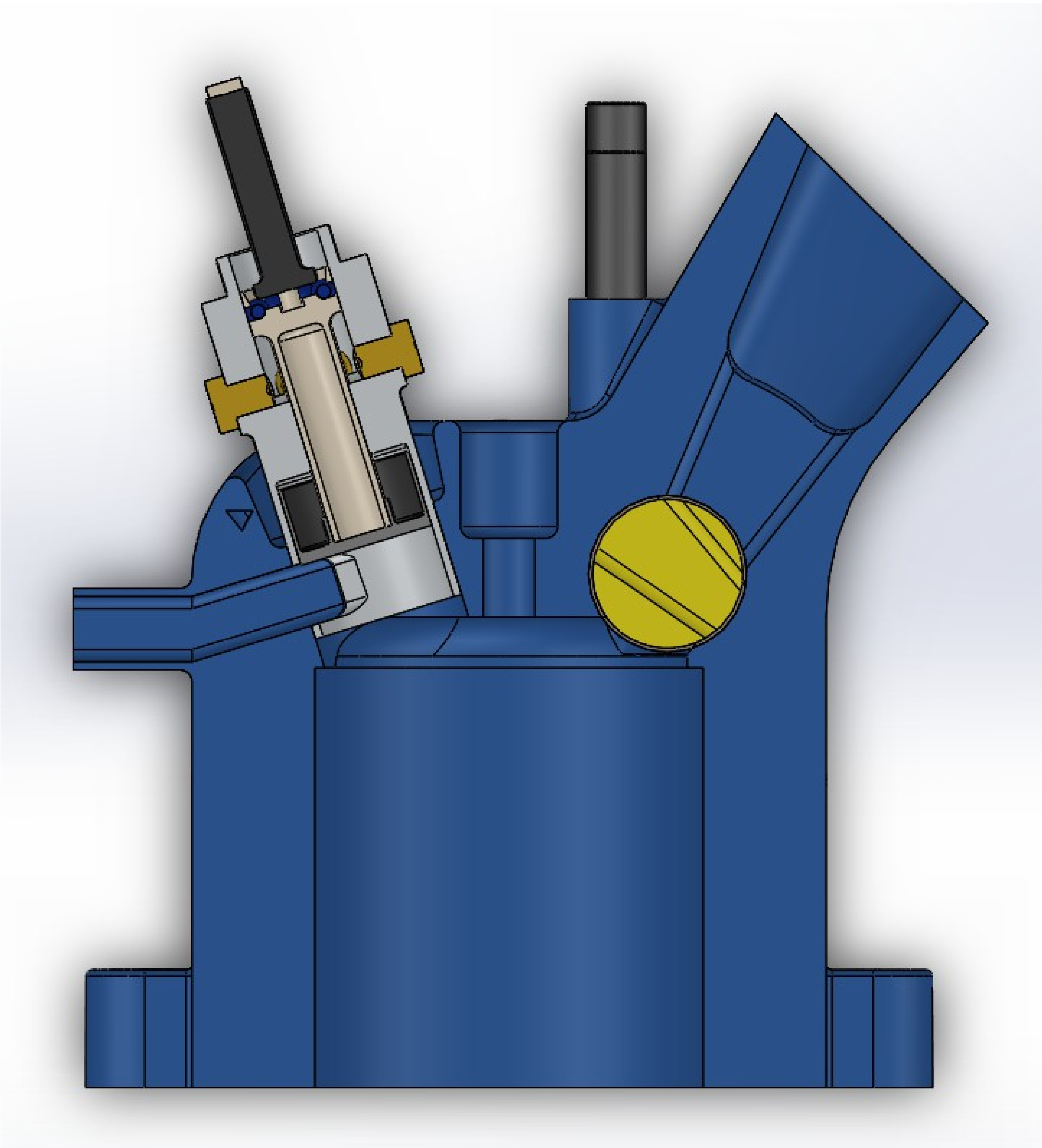

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Figure 14. Mono-block oblique section view. AEV closed.

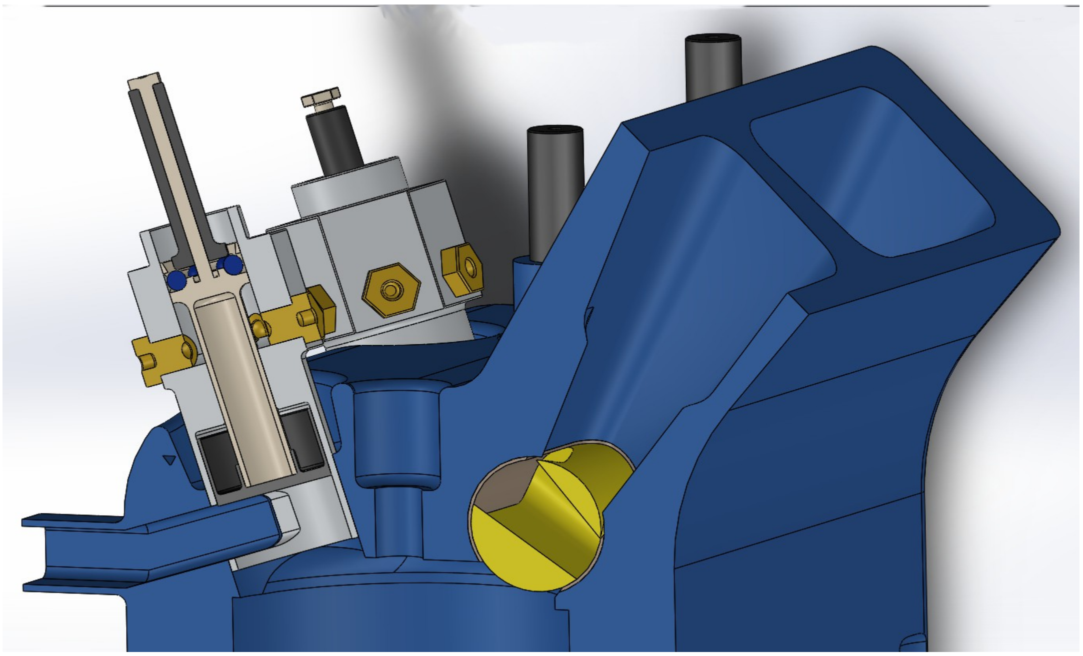

Figure 15. Mono-block oblique section view. AEV open.

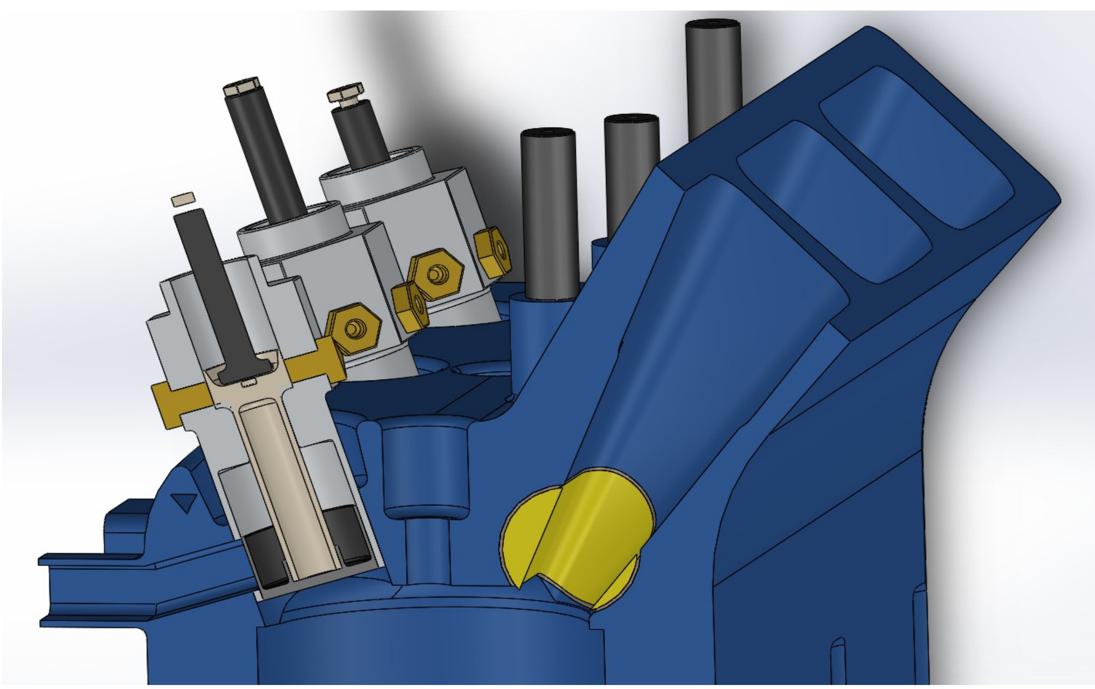

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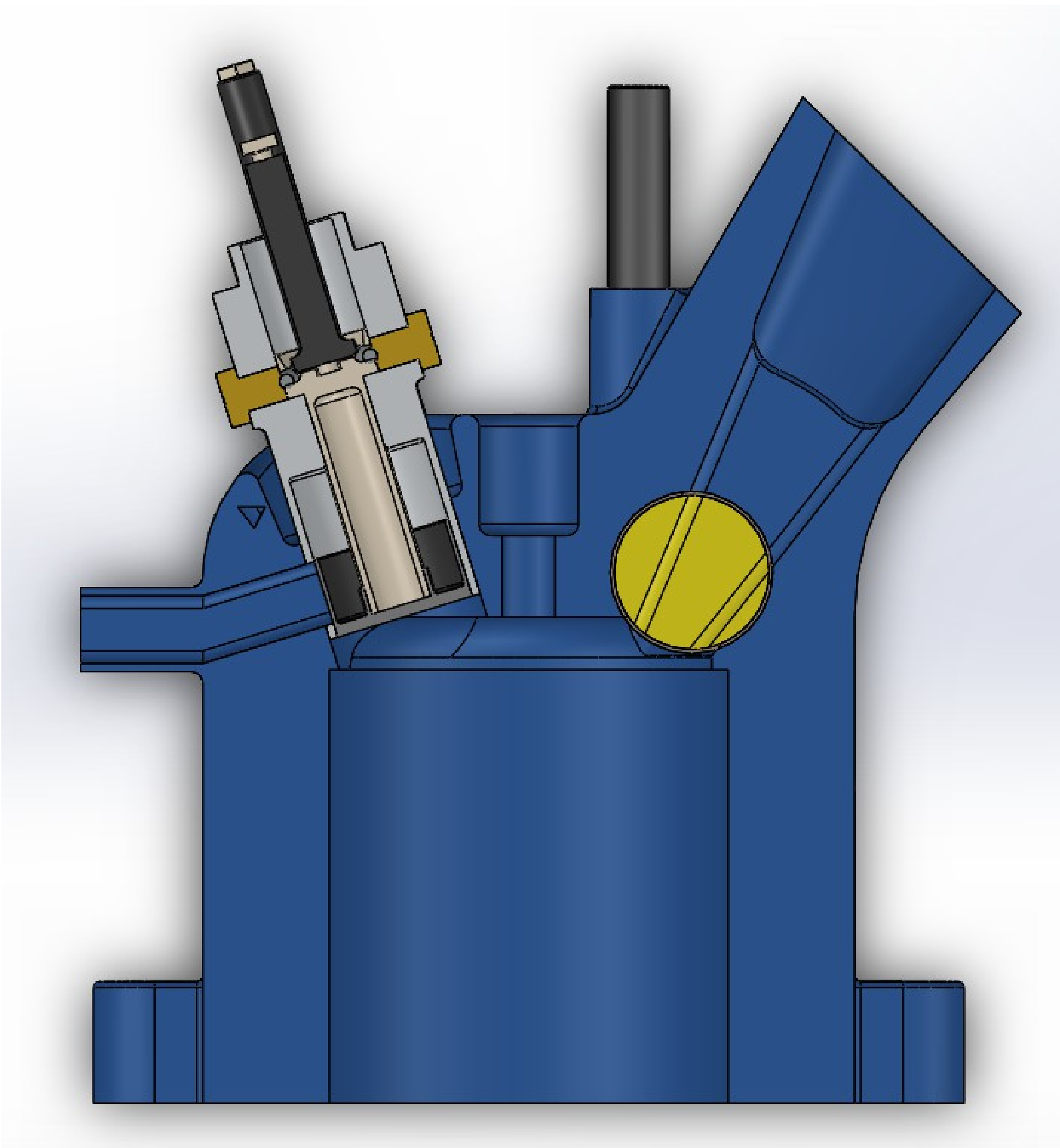
Figure 16. Mono-block diametrical section view. AEV open. (PLV closed).



End Section 1. Presentation

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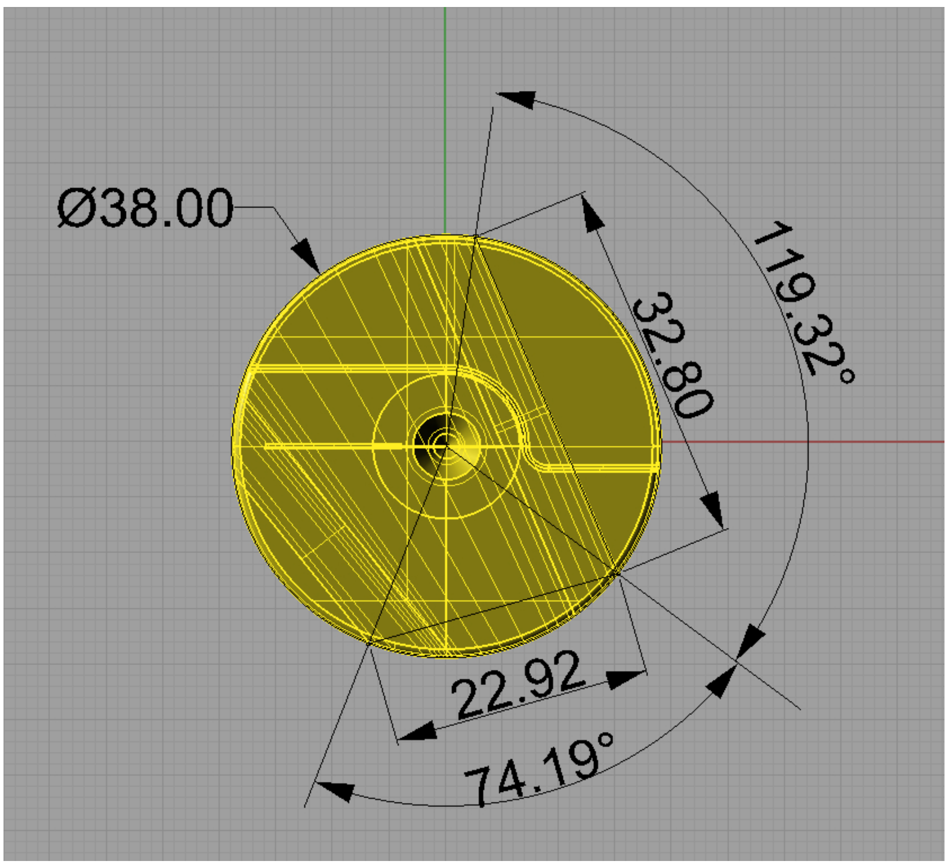
Section 2. AEV Engineering Considerations

This section is ancillary to the scope of patent examination. It amplifies description of the AEV invention and covers details of fabrication and implementation.

A. AEV Actuation

Figure 17. 38 mm AEV indexing metrics.



In Figure 17 above, the port channel is ghosted in. The 22.92 mm dimension represents the air/fuel passageway in the AEV, valve sleeve, and mono-block. The 32.8 mm dimensions represents the seal side of the AEV and closes the port. The seal angle must always be greater than the port angle. In the example 4.6 liter engine, the 119 degree seal arc well overlaps the 74 degree port opening.

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The V8 engine example of Section 1. uses a rack and pinion drive. It is intended that a Voice Coil Actuator (VCA) will operate the AEV. The VCA is suited for it's durability, resolution, and closed loop position feedback. Presented here for rack and pinion drive is a curvilinear tooth design which offers high contact surface, zero backlash, high wear resistance, ease of lubrication, and high strength. The AEV, with no spring load, only requires force necessary to overcome it's rotational inertia and journal drag in the valve sleeve. The valve sleeve is intended to be lubricated.

Figure 18. Axial Engine Valve with pinion drive teeth.

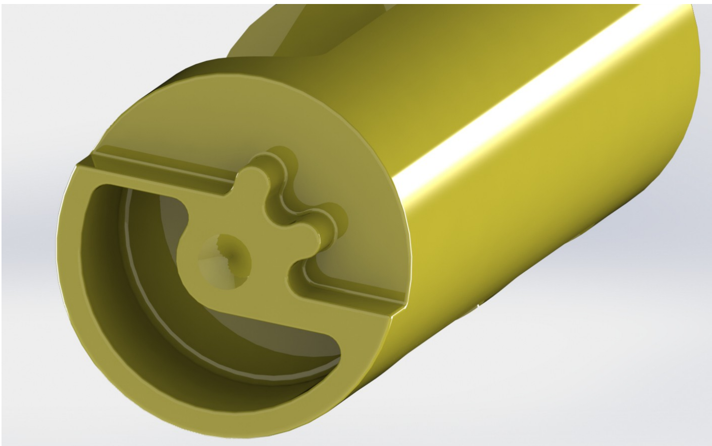

Figure 19. Voice Coil Actuator linear drive armature with mating teeth.

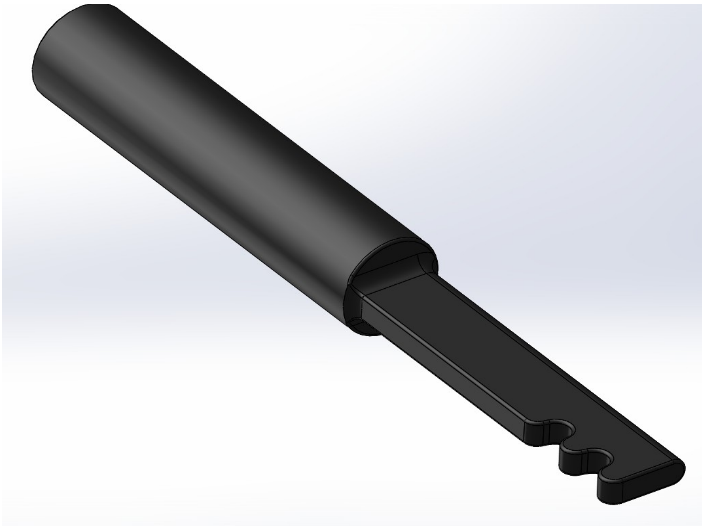

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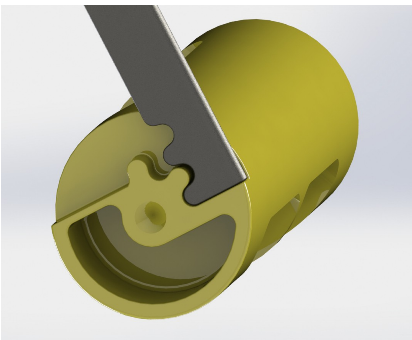
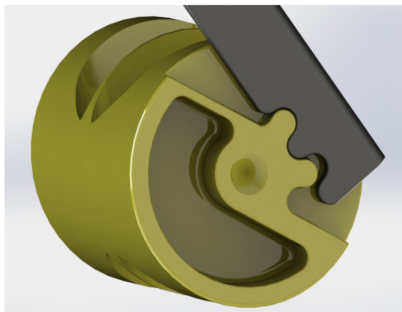
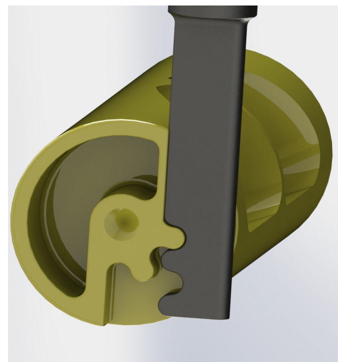
Figure 20. Full open, mid-point, and full closed AEV positions.







The design minimizes the number of parts. The valves locate radially in the valve sleeve and axially by front to back abutment of the convex and concave mating centers. Spring loaded micrometer screws at each end of the valve sleeve are adjusted manually to align the center bridges of the valves with the center bridges of the mono-block. The locating screws are then fixed by locking nut. Replacement of the valves and sleeve cartridge requires mid-level skill and short time.

The rotary oscillation motion is mechanically limited to 90 degrees. The radial valve opening angle must be smaller than a 90 degree arc segment of valve circumference, for combustion seal. The AEV maximum port size is determined by combustion chamber surface geometry.

In the example V8 engine the maximum travel of the AEV actuator rod is 1.09 cm (.429 inches) for full open valve. This displacement is similar to the cam lift in an ICE. High speed linear actuation is necessary for WOT operation. A 24 volt DC VCA outperforms a 12 volt actuator. Dual voltage electrical systems are employable in motor vehicles. DC voltage doubler circuity can be integrated into the electrical system. The intake AEV will modulate aperture with exception of WOT. Again, with no valve spring load to overcome, open and close forces are identical and low compared to other known valve designs.

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B. Mass and Materials

The AEV is a high speed engine part. The valve indexes at high repetition rate. The AEV should exhibit the following properties:

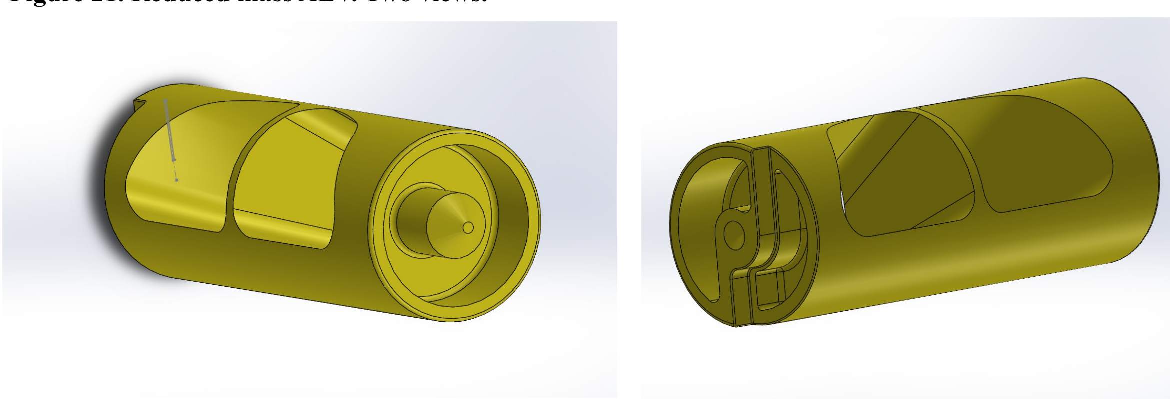
- High temperature tolerance
- No deformation under combustion force
- Low mass
- Low friction
- High wear resistance

High silicon content 2618 and or 4130 type aluminum can satisfy the properties listed above. These hyper-eutectic alumina are used successfully in piston manufacture. The mass of the AEV depicted in Figure 1. (61.81 cm3 volume) is listed for several materials.

Material	***Mass** (61.81 cm3)*	***Coefficient of Expansion***	***Mass** (47.54 cm3)*
Chrome Stainless Steel	482.09 grams	1.10e-005/K	370.8 grams
2018 Aluminum Alloy	173.06 grams	2.20e-005/K	131.11 grams
4032-T6 Aluminum	165.64 grams	1.94e-005/K	127.40 grams
Magnesium Alloy	105.07 grams	2.50e-005/K	080.20 grams

As a first order of mass reduction the AEV body is cored out with simple cavities. The volume reduces to 47.54 cubic centimeters and the respective masses are in column four above. By use of finite element analysis, low mass and high strength can be optimized by the engine builder conjunctive with selection of best material. Figure 21. below, depicts the simple mass reduction cavities. The examples drawn are not an FEA optimized state of mass reduction.

Figure 21. Reduced mass AEV. Two views.



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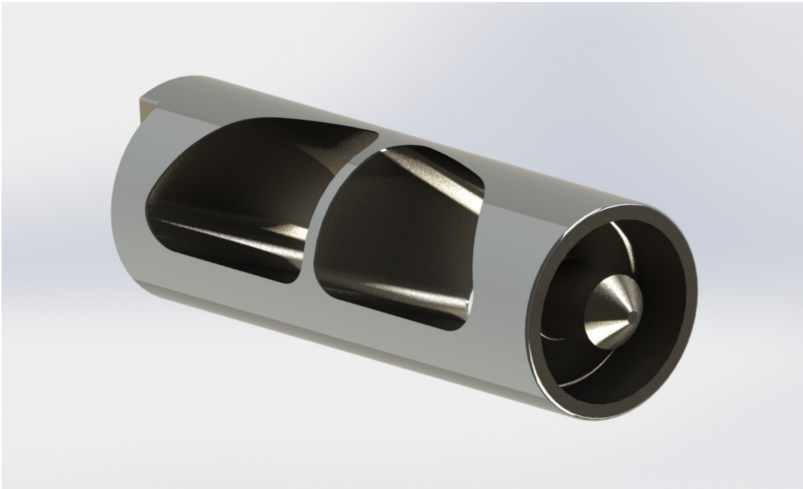
C. Design Strength

Internal combustion engine cylinder head pressures can reach 125 bar (1800 psi). Pressure of this magnitude is normally generated by forced induction (turbo or super charged) in competition specific engines. The center bridge in the AEV is in line with the intake channel bridge of the mono-block, Figure 5. Both ensure the AEV does not deform or lose seal under pressure. The AEV has solid journal support at each end. The torque and horsepower target of an engine determines AEV geometry and material. Cylinder bore and AEV diameter have a direct proportional relationship.

D. AEV Friction

It is intended that the valve sleeves be ported for lubrication. The end gap between valve bodies is 3 mm in the example 4.6 liter V8. The gap will pool engine oil. Material selection for AEV and sleeve are closely related. Both materials should polish to a fine micro inch finish. The valve sleeve will be fabricated from suitable malleable steel, duranickle, or other metal. Ferrous metals can be coated with a wear resistant physical vapor deposition layer, such as titanium nitride. For AEVs, 4032 hyper- eutectic aluminum has low thermal expansion and high strength. There are hard anodize and ceramic coatings which can be applied to valves for heat, flame, and wear resistance. A valve material choice may be chrome steel jacketed magnesium. Steel holds a fine micro-inch finish and has the same properties as the cylinder wall. The steel jacket would be about 1 mm thickness. The valve and sleeve will be engineered for a hot part close tolerance fit and low sliding friction.

Figure 22. Full Metal Jacket AEV. Chrome Steel /Magnesium Core 107 grams.



AEVs can be bearing mounted in the sleeve for reduced friction. Thermal tolerances, lubrication, and other engineering is at the discretion of the engine builder.

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Figure 23. Bearing mounted AEV.

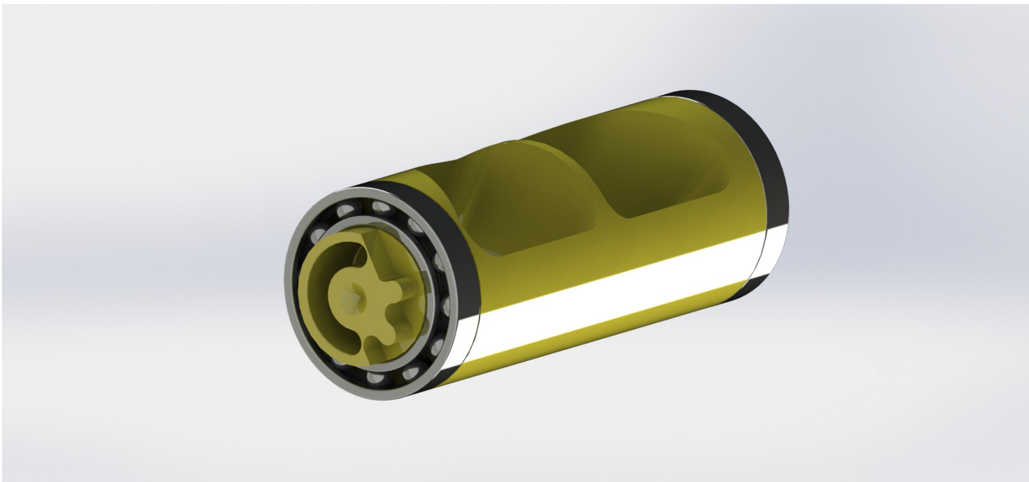
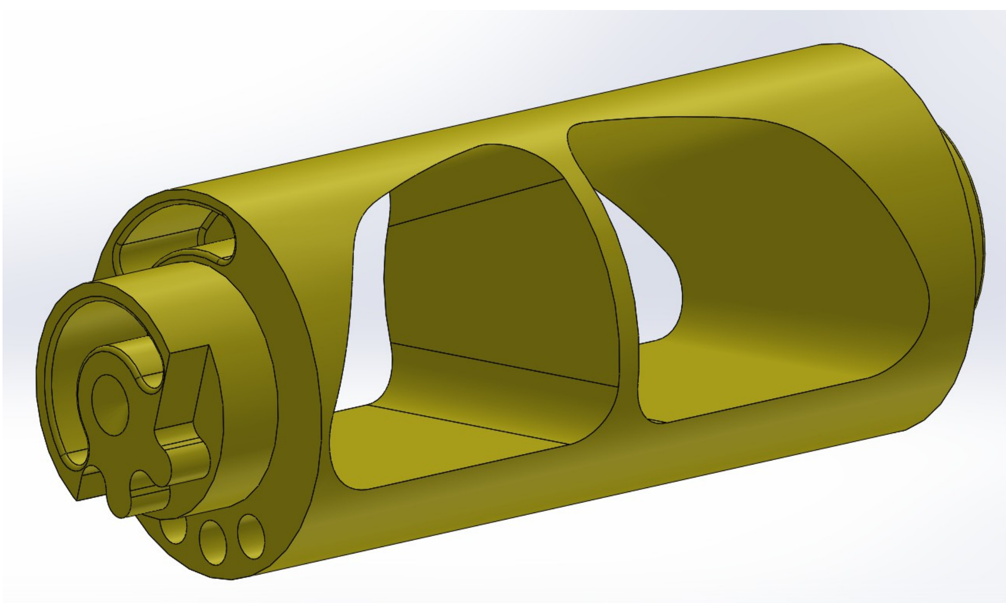


Figure 24. Bearing mounted 38 mm AEV, titanium nitride coated magnesium. 68 grams.



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E. AEV and Engine Performance

The more air-fuel mixture drawn into a cylinder, the more power is generated. In Figure 25. below, the two circles represent the dual intake valve area of the Ford 4.6 liter V8 3 valve engine, 2.70 $in.^2$ total. The AEV area (yellow frame) is 1.84 $in.^2$ total or 68 % of the cam driven valve area. In natural aspirated intake, the stem valves produce more power at wide open throttle (WOT). The volumetric efficiency of an AEV engine will fall off above 4000 rpm. Use of turbo charging is fundamental to fuel efficiency. Energy in the exhaust gas flow, otherwise wasted, is captured to pressurize the intake air. A turbo will compensate for the reduced volumetric efficiency of the AEV at WOT. AEVs offer better fuel efficiency in transport and traffic driving and can produce adequate WOT performance by turbo boost. Figure 27. below illustrates this point.

Figure 25. Overlay of dual stem valve intake area on AEV area.

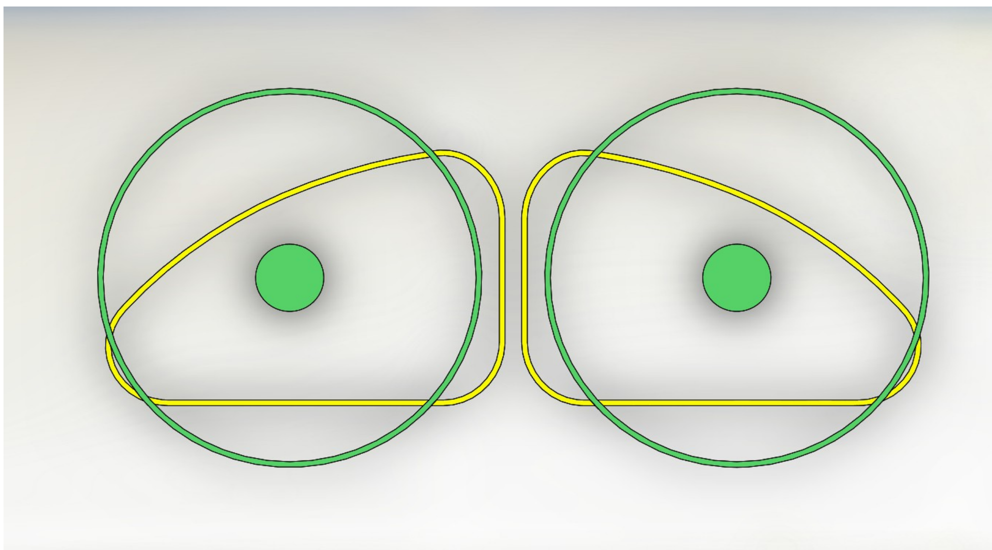

Figure 26. Ford 4.6 liter V8, IMCV (intake manifold control valve). Two views.

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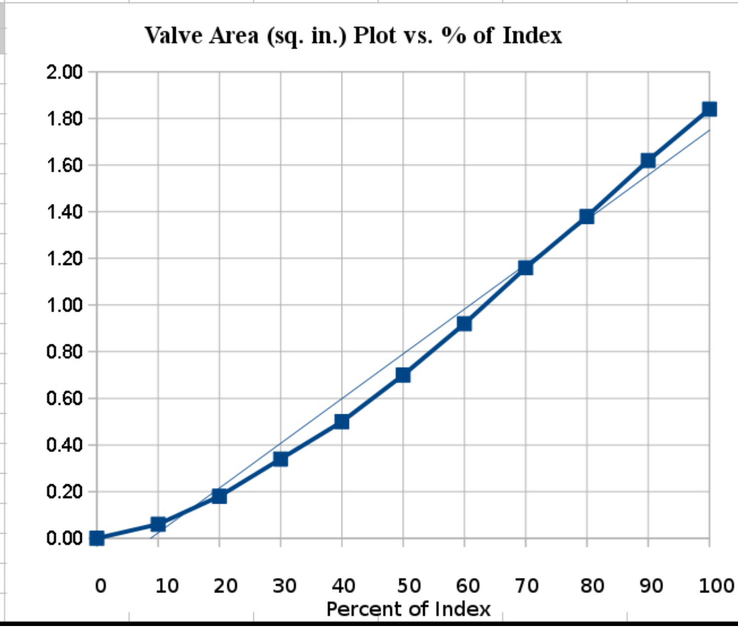
Figure 26. above compares the intake manifold valve stage in the Ford modular 4.6 liter three valve engine and a replacement stage with the IMC valves deleted. The IMC valves do not open until 4000 RPM. Up to this point they are limiting the dual intake valve area by > 66%. The reason is low speed control. A large intake port at low rpm will cause the fuel molecules to drop out of suspension and form droplets which burn poorly and can damage the combustion chamber. The mean gas velocity (mgv) of the intake charge needs to be kept high to maintain suspension of the fuel in the air/fuel mixture. Port size reduction increases the mgv. Figure 27. below illustrates the suitability of the AEV for transport and traffic use. The AEV acts simultaneously as intake valve and throttle body, with a high resolution control of mean gas velocity. It is better suited to PCM control and fuel efficiency maximization than existing cam driven stem valve solutions.

Figure 27. Axial Engine Valve aperture chart.

38 mm Valve Body __4.6 Liter V8 Example Engine

Percent of Index	Aperture Area
00	0.00
10	0.06
20	0.18
30	0.34
40	0.50
50	0.70
60	0.92
70	1.16
80	1.38
90	1.62
100	1.84



VCA devices can control the AEV angular position with a resolution far smaller than that required for drive-by-wire throttle control. The exhaust valve will never vary. It will activate full open or full closed at maximum speed on PCM signals. A VCA driven AEV used as throttle and port should be closed loop with position feedback. The electrical engineering is at the discretion of the engine builder.

The mono-block intake channels in Figure 15. are smooth surfaces, consistent cylinder to cylinder, non bending straight flow air paths, These perfections of air flow, relative to the bending path of stem valve channels, will compensate for some of the 32% smaller valve port area. An airflow bench test can determine the amount of boost compensation needed for high horsepower, if any. End Section 2. Engineering Considerations.

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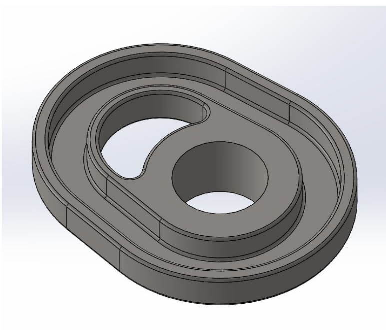
Section 3. AEV Cam Dive

This section is intended for patent examination.

Figure 28. Slotted Cam with Cam track Follower/Driver.



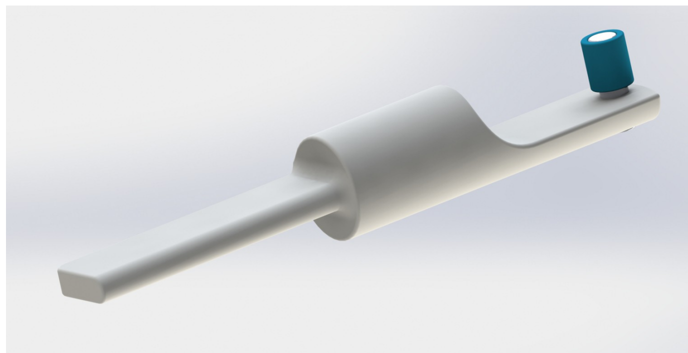


Figure 29. Cam driven AEV drive train.

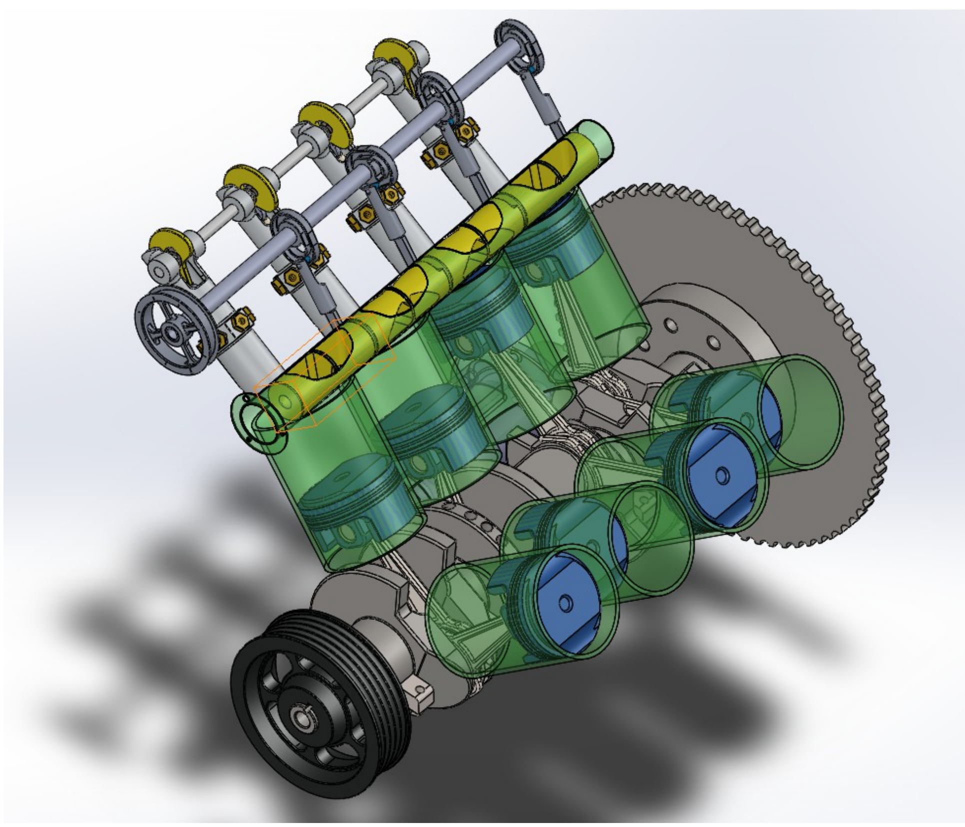


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Figure 30. Cam driven AEV example – internal view.

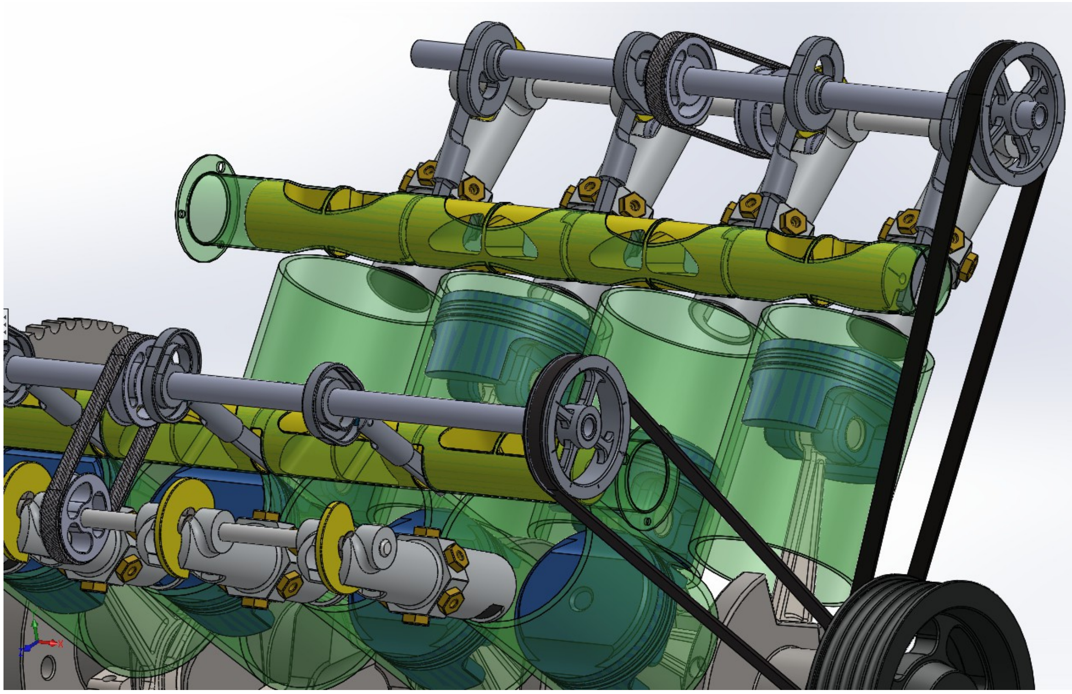

Figure 31. Cam driven AEV example – external view.

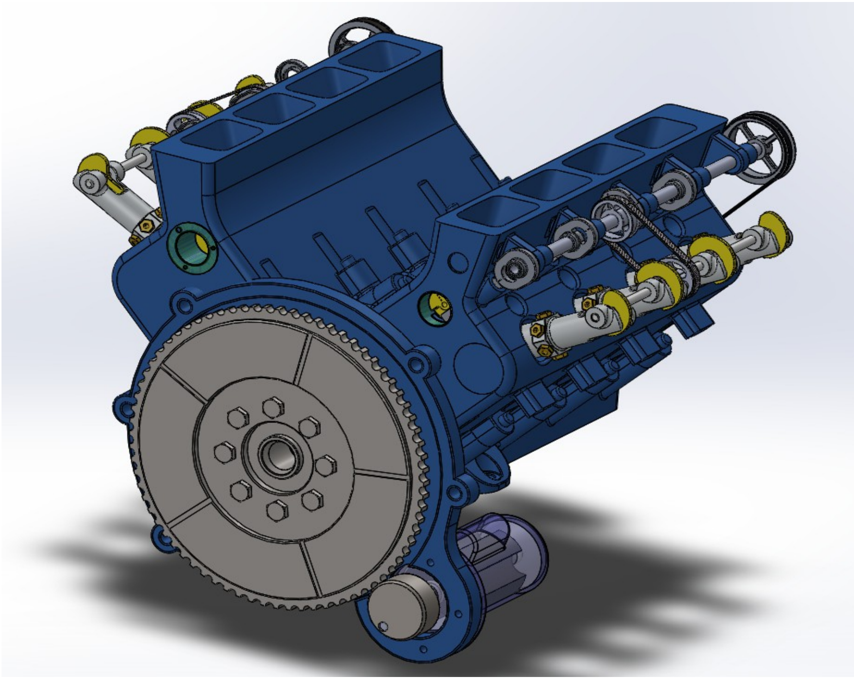

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Figure 32. Cam driven AEV section view – valve open.

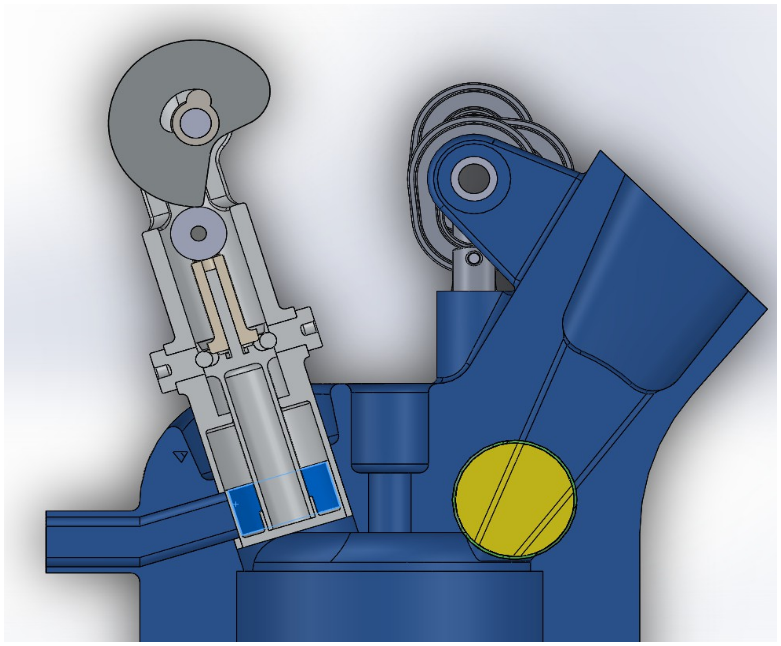
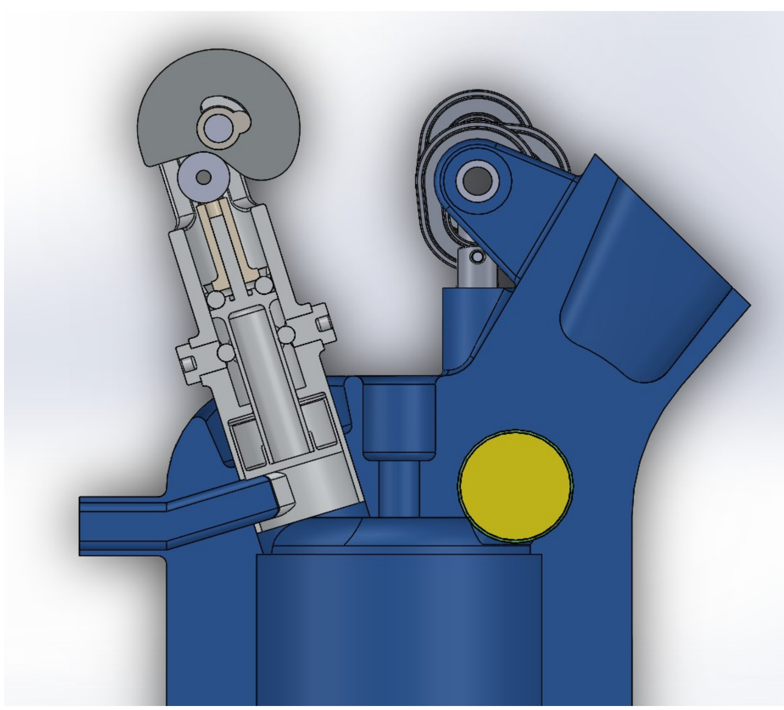


Figure 33. Cam driven AEV section view – valve closed.



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Cam drive does not offer DE3C optimization for fuel efficiency. There are, however, ICE applications where this novel cylinder porting is advantageous compared to spring loaded stem valves. Reciprocating engine aviation is one. Aviation has long periods of static throttle setting. In propeller driven reciprocating engine aircraft there are three basic throttle settings, Ground Idle, Take Off, and Cruise. CHT (cylinder head temperature) is a critical engine gauge. High CHT can be catastrophic. A burned valve will lead to engine failure. The AEV and hot shoe of the PLV have far greater surface area contact with the cylinder head body than stem valves. The journal contact surfaces dissipate valve heat. Additionally, the AEV and PLV are self cleaning. These novel valve designs build a lower maintenance, longer life, higher reliability ICE.

Over the road diesel power, tractor, stationary power generation, rail transport diesel-electric, and marine diesel/gasoline power can all benefit from the reduction of internal rotating friction and the elimination of the stem valve, valve spring, camshaft, and camshaft drive chain. (Design Goals 1 and 2)

In Figures 28, 29, 30, and 31 above, the cam drive train appears light weight and is intended to be. GATES fiber reinforced timing belt drive is adequate. To open a spring loaded stem valve, a force as high as 400 pounds is required to compress the valve spring, albeit momentary. The force to open an AEV is measured in single digit ounces. The AEV/PLV cam drive train will outlive a stem valve drive train. There are no forces of spring, compression, or combustion that affect AEV actuation.

For contrast with Figure 31. above, a DE3C engine example is pictured below, dressed with AEV, PLV, VCA, COP, EFI, and ITB Stack components.

Figure 34. DE3C engine.

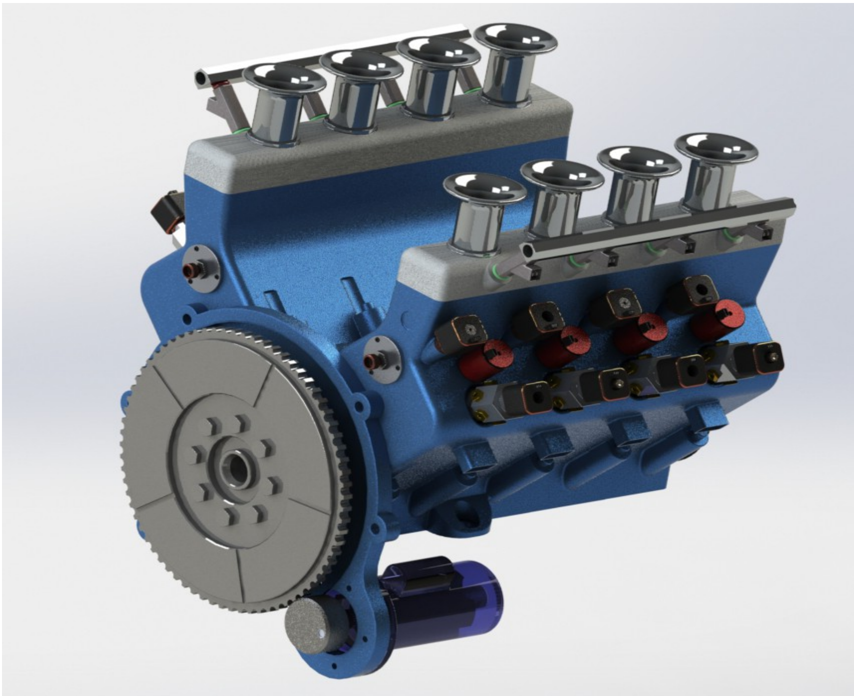

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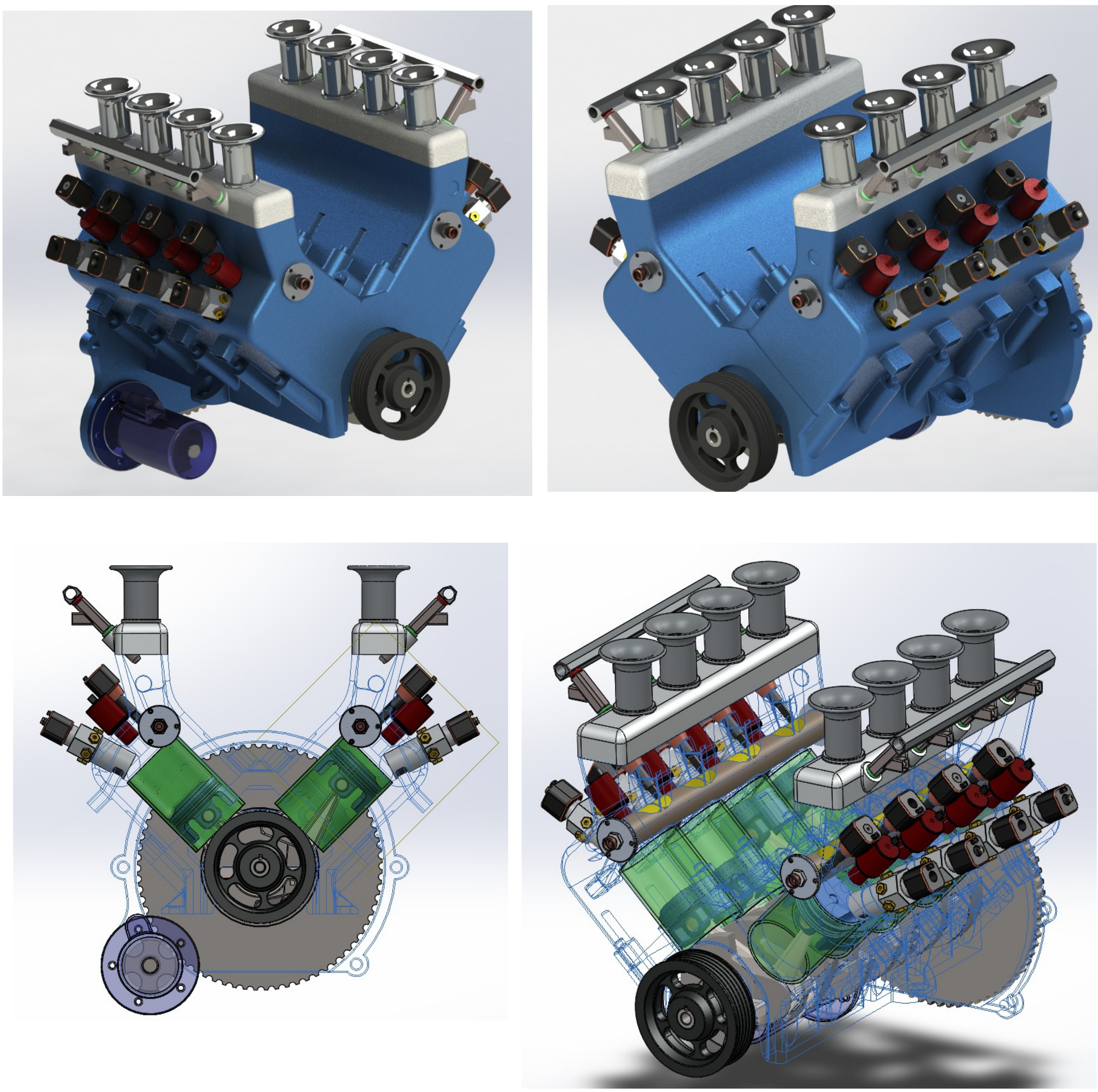
Figure 35. DE3C engine. Various views.



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Section 4. Utility Patent Claims.

1. I claim the invention of a cylindrical ported body, rotating about an axis, for intake and exhaust of gases in an internal combustion engine. The cylindrical body is named Axial Engine Valve.

2. I claim the use of a linear arrangement of multiple self-locating Axial Engine Valve bodies in an aligning sleeve porting gases in and/or out of a multi-cylinder internal combustion engine.

3. I claim the use of a linear motion device* to operate the subject Axial Engine Valve.

4. I claim the use of angular index actuator* to operate the subject Axial Engine Valve.

5. I claim the use of mechanical cam drive to operate the subject Axial Engine Valve.

6. I claim the use of the Axial Engine Valve as combined intake port and throttle in an internal combustion engine.

*powered by electromagnetic, electric current, gas, pneumatic, or hydraulic forces

List of Illustrations follows.

Very Respectfully Submitted,

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List of Illustrations

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List of illustrations continued,