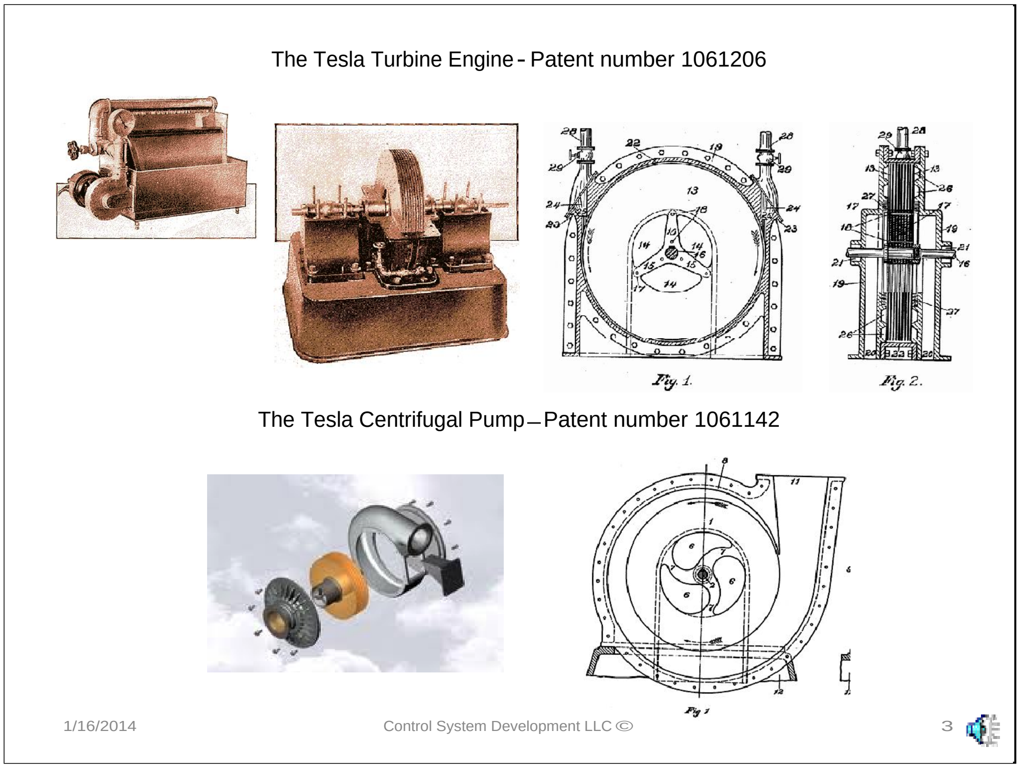
This Slide Show featuring the "Internal Combustion Boundary Layer Turbine Engine (ICBLTE) is accompanied by a narrative. Please turn on your computer speakers to hear what is being said about this remarkable engine. Otherwise the notes presented here below will provide additional information and will mirror the narrative in most respects. For further inquiry please go to the Control System Development LLC website at www.controlsystemdev.com.

The Tesla Turbine Engine

- Dr Nikola Tesla originator of @300 patents in use "everyday by everyone in the industrial world". Amongst which is the Tesla Engine…
- The Tesla Turbine Engine: Dr Nikola Tesla's motive introduction circa 1915. "The Monarch of Machines"
- Tesla Turbine Engine – Turbine engine character
  - Simple Construction – Single moving flat disk assembly
  - Light weight – Elimination of internal components such as pistons, cylinders, valves, manifolds, gearing, etcetera
  - Powerful – Use of entire interior chassis & disks surfaces
  - External Combustion – Steam, compressed air, liquids

"Internal Combustion Boundary Layer Turbine Engine (ICBLTE) is preceded by the "Tesla Turbine Engine". The ICBLTE however incorporates some important differences in that it supports intake, compression, combustion and exhaust in a spatial flow method typically used by conventional turbine engines as opposed to the positive displacement method of the piston driven reciprocating engines. Reciprocating engines incorporate intake, compression, combustion and exhaust each with a separate stroke in the same cylinder at different times using (for a six cylinder engine) less than one sixth of the engine's pressure vessel to convert combustion pressure to kinetic energy. An important difference is that the combustion pressure is exerted within the entire inner surface of the turbine's pressure vessel (chassis) converting this combustion pressure to kinetic energy and the close fitting nature of the "flat disk array" tremendously reduces the outward rush of hot exhaust gases as compared to conventional radial turbine engines thus increasing power and efficiency.

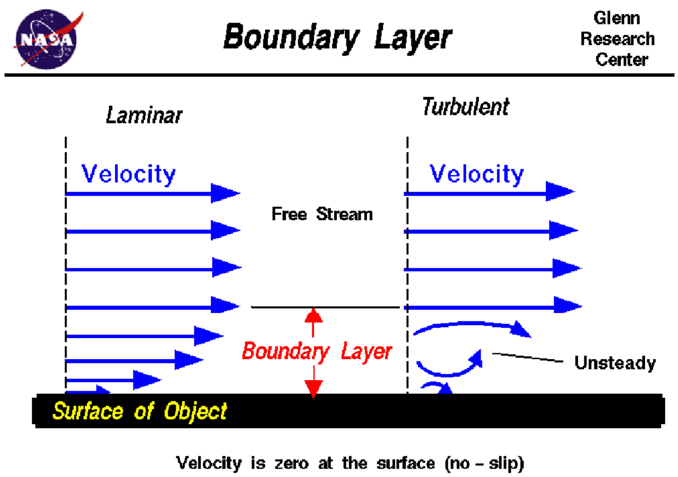


Dr Nikola Tesla the original inventor of the "Tesla Turbine Engine" and the "Tesla Centrifugal Pump" versions of which are shown in this slide, referred to this machine as "The Monarch of Engines". For those who are not familiar with the contributions of Nikola Tesla, Dr Tesla is the single most important scientist and engineer of the 20th Century because billions of people in the industrialized world use the derivatives of his nearly 300 inventions every day. Among these inventions are AC electrical power generation and distribution, AC induction motors, radio and tuned circuitry, electric automobile ignition and a documented experimenter with fluorescent lighting and X-Rays before their later formal claims to discovery by other people. Tesla's engines operate on the principal of drag and laminar working fluid vortex flow. These principals represent a paradigm shift from conventional reciprocating and turbine engine technology.

Tesla Turbine/ICBLTE
Theory of Operation

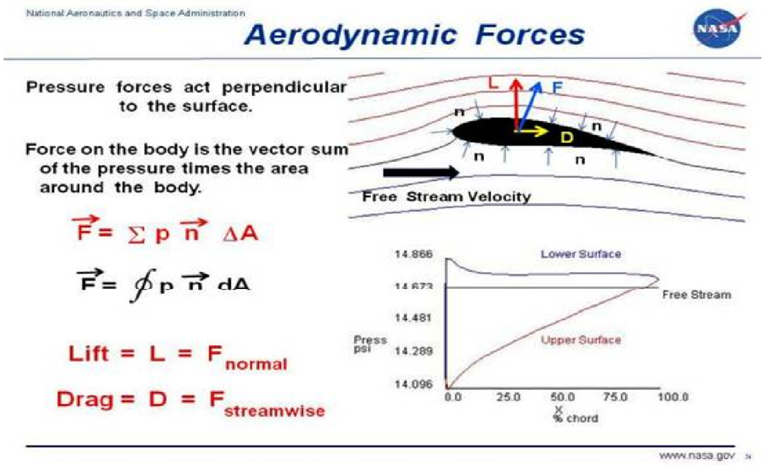
- Power Output = High Speed(ν) & Low Torque(τ)
  - Power = $\nu \cdot \tau$ (where ν is in radians/second)
- Fluid Drag - Engine and Pump Operational Mode
  - Normal – perpendicular impingement or resistance
  - Lateral – parallel adherence
  - Parasitic – turbulence or wake disturbance
- Fluid Adherence - Fluid Viscosity - Fluid Drag
  - Liquid boundary layer
  - Gaseous boundary layer

"Power" is a word used by all but understood by very few. Power is the rate of expending energy, when energy is expended slowly then the power of the system is low and conversely when the rate of energy expenditure is high the system power is high. Fluid drag, for example, is the consequence of a fluid stream impinging upon a solid where the leading edge of the solid feels drag normal (perpendicular) to its surface, the surfaces parallel to the fluid stream feels drag in the direction of the fluid stream and the fluid leaving the object will have wake turbulence as a result of having passed around the object. The object in the fluid stream will be compelled to move in the direction of the fluid stream by the forces imposed by drag. All fluids tend to adhere to fluid and solid surfaces, all fluids have a measure of viscosity and when these fluids are in motion they tend to drag all (solid) surfaces in the direction of fluid motion proportional to their relative motions.



- **Slip** – differential velocity of the solid surface versus the velocity of the fluid stream above the boundary layer
- **Lateral Drag** – the force applied to a solid object parallel to the fluid stream flow

The adherence of a fluid to a surface forms a "boundary layer" such that its "stickiness" tends to "drag" the surface in the direction of fluid movement. The phenomena of "boundary layering" and "drag" are coincident in fluid dynamics. Turbulence (unsteadiness) introduced by any of many conditions, defeats the fluid adherence in the boundary layer and prevents drag which as in the case of an aircraft wing disturbs laminar fluid flow (Coanda Effect) and prevents lift.



- **Coanda Effect** – The tendency of a fluid stream to be attracted to a nearby surface. Adherence to a surface is by virtue of "boundary layering" resulting in "parallel drag" where the fluid stream tends to move the surface in the direction of its travel.

Drag is a characteristic that becomes an important consideration with aircraft and other high speed vehicles (cars, trains, etcetera) design. projectile trajectories and the internal ICBLTE working fluid flow. Laminar flow through the boundary layering increases lateral object drag. In the example of the wing, shown in this slide, the shape of the fluid stream above and below the wing chord is the result of air stream adherence to boundary layering. Notice the downward direction of the fluid stream as it leaves the wing. The downward thrust of the fluid stream, a major contributor to the wing lift (L), is directly the result of boundary layering (Coanda Effect).

INTERNAL COMBUSTION BOUNDARY LAYER TURBINE ENGINE (ICBLTE)

- Modular (Staged) Construction
  - Single or Multiple Main Stage(s)
  - Auxiliary Pre-Stages (compression)
  - Auxiliary Post-Stages (exhaust/evacuation)
- Differential Flat-Disk Construction – Single Stage
- Multi-Fuel Usage – Liquid, Gaseous, Particulate
- Scalable Size – Power output is proportional to size
- Pressure Chassis & Disk Surfaces - Powerful
- Continuous-Burn Combustion – Smooth operation

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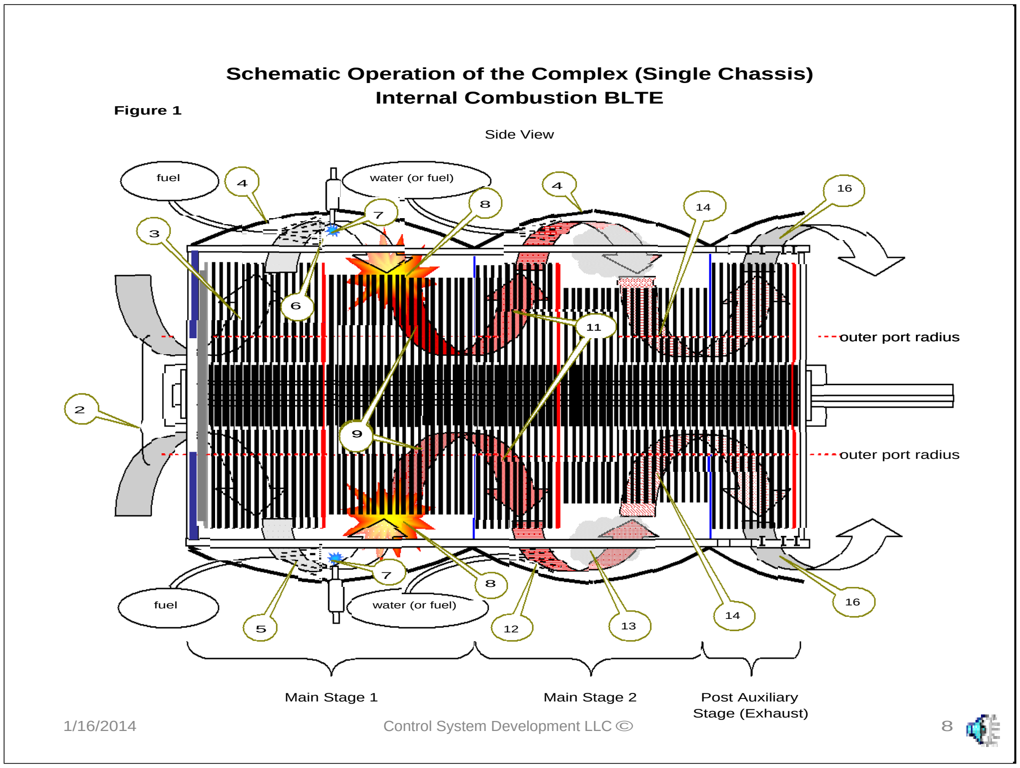
The ICBLTE is proposed as either a "complex" engine composed of multiple stages enclosed in a single chassis or as a "modular" engine composed of multiple main and auxiliary stages. The ICBLTE is extremely simple in its construction but presents a different thought analogy for the purpose of analysis. Due to the lack of intricate and complex internal components the ICBLTE is scalable from very large to very small, adaptable to various fuel types, uses a continuous-burn smooth mode of operation and because the entire internal wall of the chassis is a pressure vessel during the cycles of the combustion process it has the capability of phenomenal power output.



Observe the cycling of the working fluid through the ICBLTE. The amount of intake air is dependent on the disk assembly speed so that the power range is enormous (many times that of a reciprocating engine) and limited by the intake orifice size and material capabilities. For a particular assemblage of ICBLTE components there is a "most efficient operating speed" but the power output may range far "above or below" the optimum efficiency speed point. The ICBLTE due to its low internal friction, may operate at extremely low speed using very little fuel for idle or hot stand-by. The second main stage is shown using water as a expandable working fluid is suitable for a stationary unit but secondary injected fluids may also be air for complete combustion fuel for afterburner operation or both.

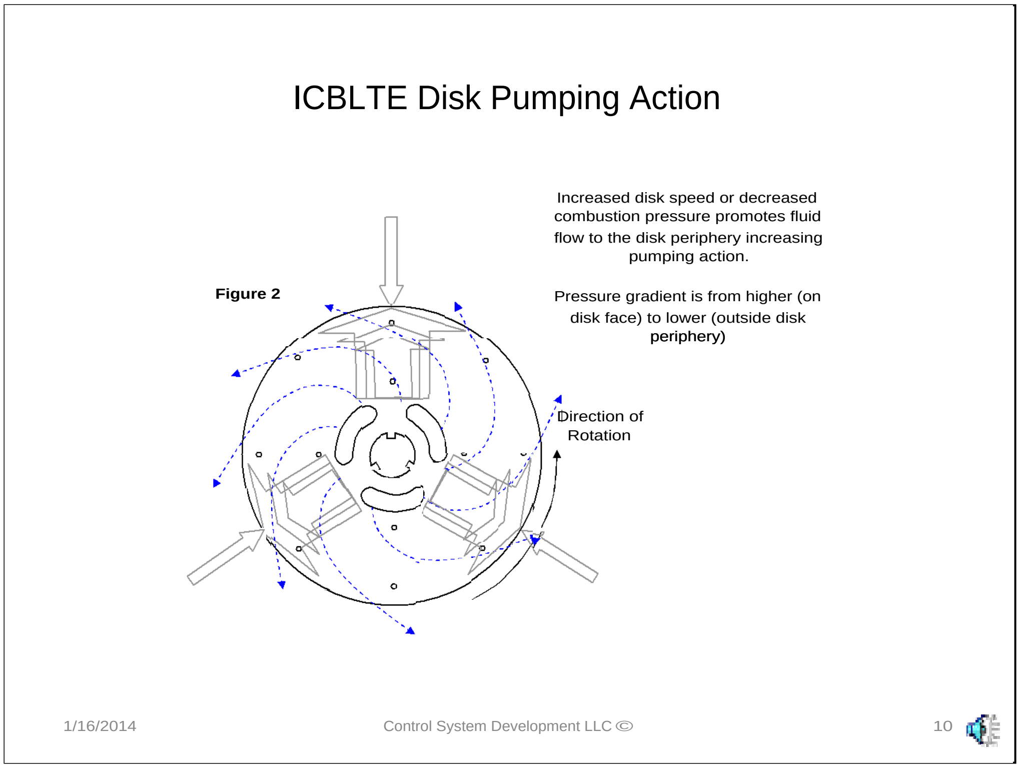
Complex (Single Chassis) BLTE Operation Description:

1) Stage 1
2) Air Intake Centrifuge Compression/Intake Ports
3) Air Compression (Stage 1 - larger compression disks)
4) Chassis Containment/Pressure Vessel
5) Fuel Injection
6) Flame Barrier
7) Ignition
8) Combustion Power Production
9) Exhaust/Power Extraction Flow (Stage 1 - smaller power recovery disks)

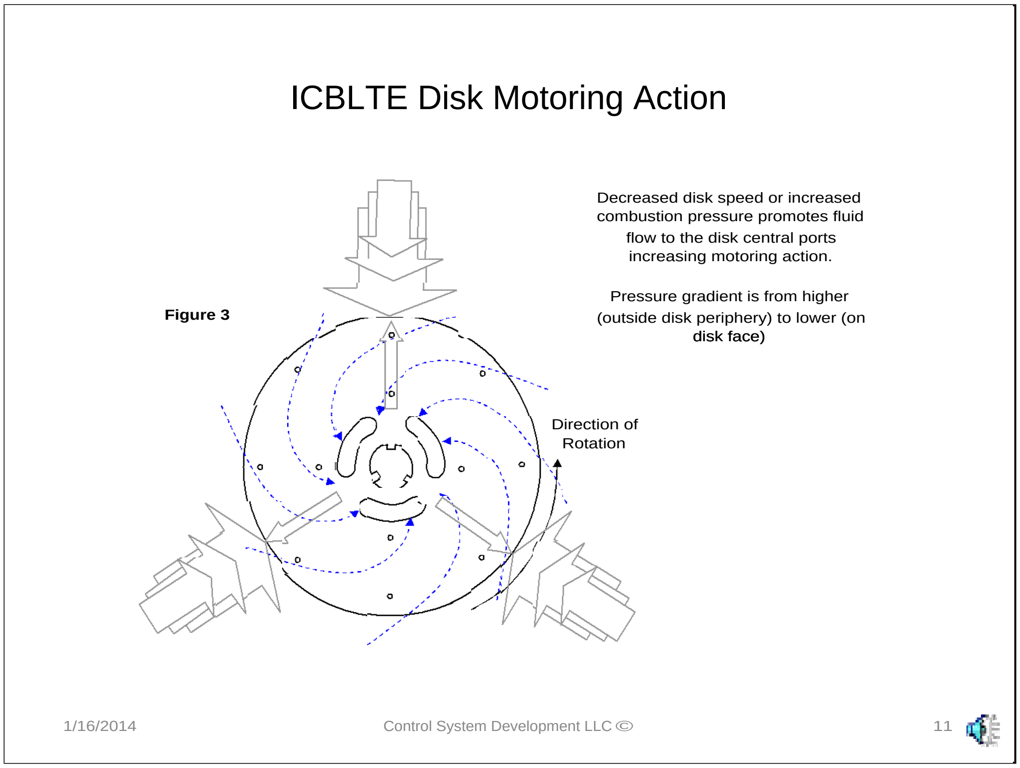
10) Stage 2
11) Exhaust Evacuation (Stage 2 - larger compression/evacuation disks)
12) Power Boost Water/Air Injection (or after-burn Fuel Injection)
13) Water Vaporization/Air Expansion (or auxiliary ignition for Fuel Injection)
14) Exhaust/Power Extraction Flow (Stage 2 - smaller power recovery disks)

15) Auxiliary Stage
16) Exhaust Evacuation (optional)

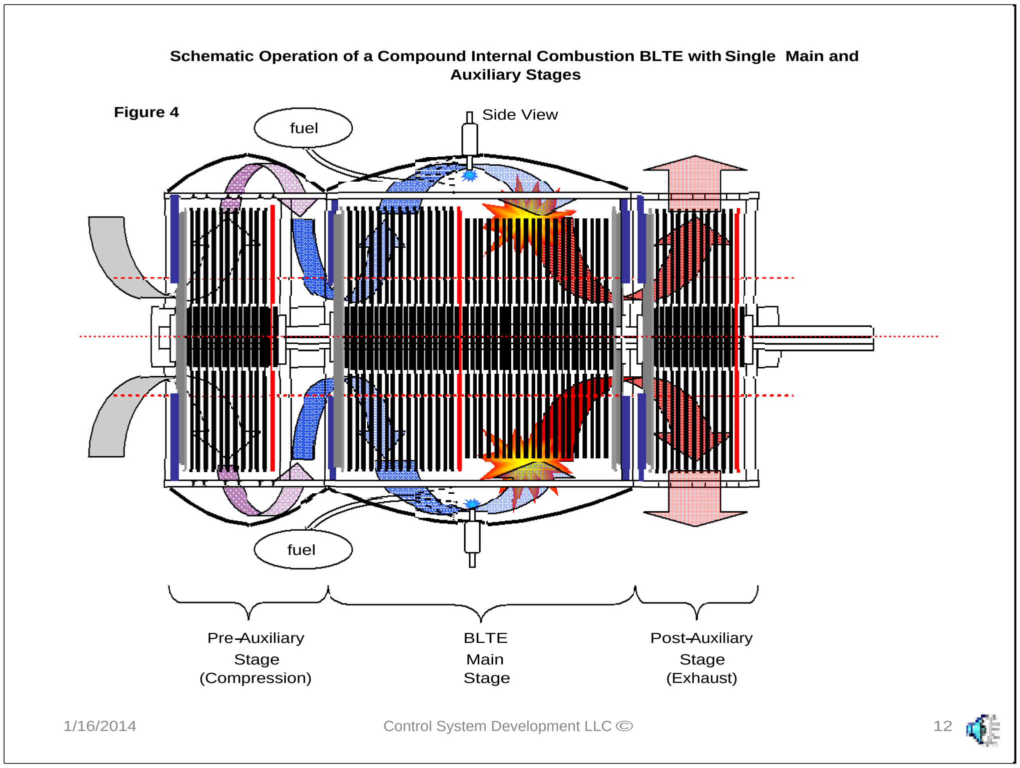
ICBLTE stages 1 and 2 can individually support intake, compression, combustion and exhaust or all of the functions to allow stand alone operation. Concatenation of stages can increase engine power and efficiency by allowing introduction of after-burn fuel, air or water. Pre-auxiliary (compression, not shown) or Post-auxiliary (evacuation or exhaust) stages increase engine power and efficiency by increasing compression pressure or by reducing turbine pumping pressure. The modular nature of the ICBLTE has flexibility beyond that of any existing fuel conversion engine available.



A freely turning disk stack will act as a centrifugal pump developing a fluid pressure at its periphery. This pumping pressure is present with or without the presence of combustion but under the combustion pressures must be overcome to enable the turbine disk assembly to generate power from the working fluid vortex flow.



The combustion pressure at the disk periphery forces the working fluid onto the disks and towards the disk assembly's central ports producing an inward spiraling vortex confined to the boundary layer of the turbine disk assembly. Work is developed from the working fluid vortex by virtue of the conservation of angular momentum as the circumference and velocity of the working fluid decreases ultimately exiting through the central ports.



Power equals torque x speed (Power = $\tau \cdot V$). Conventional reciprocating (piston driven) engines are high-torque low-speed devices where the method of generating high torque uses sealed, positive displacement pistons and cylinders that generate tremendous friction and produce very low efficiency in the area of 18% to 22%. Because no internal components of the ICBLTE are in contact with the chassis except the support bearing surfaces, very little internal friction is produced and very high efficiency can be expected starting in the area of 45% (as experimentally measured) and upwards. The ICBLTE is a low to medium-torque high-speed engine that has the capability of producing a much higher power output than similarly sized reciprocating engines which is characteristic of turbine engines. As compared to conventional radial-flow shaft output turbine engines, the ICBLTE is far more efficient at equivalent power levels due to the restricted exhaust characteristic of its closely arranged disk stack which cannot be realized in conventional turbines due to the angled nature of blades fixed at the periphery of the compressor and turbine disks. All of these engines are heat engines, the more heat exhausted, radiated into the ambient or removed by various cooling techniques, the more inefficiently these engine will operate which means more fuel consumption for the a given power output. The analogy is placing a device on-board a sailing ship which diverts or prevents the wind from fully engaging the sails instead of constructing the ship to use the full force of the wind energy.

ICBLTE Advantages versus Piston-Driven Engines

- The ICBLTE has one moving internal assembly of disks that is not in physical contact with the chassis. Reduced friction means increased efficiency…
- The ICBLTE is a continuous burn energy conversion source that does not require the massive metal containment of piston driven engines having the same power output. This makes the ICBLTE light weight allowing it to have a high power to weight ratio.
- Without the radiator, pistons, cylinders, valves or associated gear train, the ICBLTE is considerably smaller and more reliable than its reciprocating internal combustion engine counterpart.
- The ICBLTE can be made to produce a large power output for its size since the fuel introduced is not limited by positive displacement cylinder size but instead by how fast the ICBLTE is rotating. The ICBLTE is a lean-burn engine.
- The ICBLTE can operate at low compression ratios or produce higher compression ratios than the reciprocating internal combustion engine or a radial flow turbine engine with the addition of auxiliary compression pre-stages.
- Emissions are also reduced by the capability of the ICBLTE to burn a wide range of fuels such as alcohol, petroleum, bio fuels or blends thereof including solid fuels or combustible particulates.
- The ICBLTE without the internal mechanized complications lends itself to upward or downward scalability, simplicity of production and reduced operational maintenance.

The Tesla flat-disk external combustion turbine came into existence (circa 1915) just as the piston driven gasoline engines had largely replaced the steam driven and the electric vehicles which had previously existed in equal numbers. The introduction of the electric ignition and electric starter made the gasoline powered vehicles too convenient even though then, there were fears expressed regarding reliance on limited fossil fuels. Unfortunately the slow startup time of steam vehicles and long charging time for electric vehicles took its toll as well as the fact that no other practical fuel source presented itself as a cheaper alternative than oil. The Tesla Turbine had neither the materials technology, efficiency of mechanical power transformation from a high-speed engine to low speed equipment or high speed generators required to produce electrical power directly from a Tesla Turbine output. Today all of these technologies are available after nearly 70 years of development for conventional turbine applications. Today with the realization of the detrimental effects of pollution from gasoline engines, the rising cost of oil based fuels and the impending conflicts spurred by oil shortages, the ICBLTE promises 1/2 to 1/3 the consumption of fuel for the same energy and power output. This single device can bring relief to the oil crisis and in addition to that relief, the ICBLTE is not bound to use strictly oil based fuels.

ICBLTE Applications

- **Electrical Power Generation – Commercial, Residential & Portable Emergency Supply**
- **Battery Replacement – Miniaturized & "Gaseous Fueled"**
- **Power Hand Tools – Battery & Power Cord Replacement**
- **Computer Laptop Supply – Battery Replacement Application or Small Portable Power Cord Connected Supply**
- **Personal Power Generation – Provides Power, Heating or Air-Conditioning for ExoSkeletal Power or Portable Use**
- **Automotive – Electric-Hybrid Propulsion (preferably) or Mechanically Geared and Linked Drive**
- **Marine – Direct Replacement for Piston or Radial Turbine Engines**
- **Aircraft – Direct Replacement for Piston or Radial Turbine Engines**

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Considering the efficiency, the pulsed combustion mode and the high internal friction of piston driven engines they can be compared to the melding of a "toaster" and a "jackhammer". In spite of its deficiencies, the piston driven reciprocating engine has taken us far but there was little other choice. Now superior technology looms on the horizon and now is the time to bring the ICBLTE to reality. The piston-driven engine has had over 120 years of development that has gotten it to an abysmal 20% efficiency. An engine efficiency of 20% means that for every 5 units of engine input energy only one unit is output as useful work and of that only 30 to 35% is passed through an automatic transmission to the wheels of an automobile; in total only 6 to 7% of the fuel is used to propel the vehicle. Six percent fuel usage is what provides today's automobiles with the proudly boasted "30 mile per gallon (or less)" performance.

Development Funding Required

- **Prototype Stage** – 3 levels of development funding
  - Proof of Concept (3-units) non-specific application demonstrator ($150,000 over six months)
  - One Application Specific (6-units) manufacture ready ($450,000 over eight months)
  - Six Applications Specific (3-units each) Manufacture ready ($3,500,000 over three years)
- **Manufacturing Stage** – Target 100,000 units per year @ $1500 per unit (targeting automotive as an example application)
  - Pre-Production of 20,000 units in one year
  - Production of 100,000 units per year

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Presently the ICBLTE is in the prototyping stage of development. The prototyping stage is, from the investment perspective, the riskiest phase of this project, it is also the most profitable in terms of Return on Net Investment (RONA). The boundary layer turbine in the form of the Tesla Turbine has run in the past in an external combustion configuration establishing the principals of operation. In the past as well as presently it has also run as an "internal pulsed detonation mode combustion" configuration, removing all doubts of its viability. Prototyping is typically the phase where physical size, fueling, efficiency and power output are determined with an application in mind. Manufacturing pre-production will establish the manufacturing techniques and logistics for full production operation.

Automotive Example

- **An Automotive Application** – Replaces any piston-driven engine or radial turbine configured to drive a shaft
- **A 50 Hp (37.3 kW) Output** – Constant speed, driving a generator and outputting to a battery bank (DC) and wheel motors (AC)
  - Generator output allows a backup for home, outdoors or power grid
  - Electrical power stored in a battery pack for high-power delivery
  - All wheel drive allows for regenerative braking, traction drive or braking control, drive wheel selection and hybrid operation
  - ICBLTE can operate at 2 to 3 times the rated power output dependent on fueling and air intake but at reduced efficiency from rated values
- **ICBLTE Vehicle Hybrid Efficiency** – of 45% initially, an 80% generator efficiency and an 80% wheel motor efficiency would provide a 28.8% fuel efficiency or "4 times" the efficiency of today's conventional vehicles at approximately 6 to 8%.

A conservative 4 fold increase in efficiency could potentially provide a 120 miles per gallon (MPG) fuel economy. To express a few words regarding fuel economy estimates. "fuel economy" is a marketing phrase used to enhance a perceived vehicle performance. The same vehicle. driven by the same driver, on the same course on different days or on the same day can yield vastly different results dependent on driver mood or handling, environmental changes (rain, temperature, wind, etcetera) and fuel quality. The vehicle manufacturers pick and choose which results are most desirable for marketing. An engine is most effectively characterized by its efficiency (power output relative to power input). 20 Hp will drive a passenger car to 100 mph, 15 to 30 Hp is the average required for city driving and the huge horsepower ratings also a marketing ploy of vehicle companies is used only a few times in the life of a vehicle for passing or in mountainous areas. The consumer burden of large engines are that they inefficiently consume more fuel at all engine speeds than do smaller engines.

ICBLTE Return on Investment

- Investment is available on a per application basis
- Control System Development LLC reserves royalty privileges on manufactured units and components
- Prototype support will avail investors with part patent ownership
  - Independent third-party licensing
  - Ownership manufacturing, sales and marketing
- Licensing on a per application basis
  - Ownership manufacturing, sales and marketing
- Sales and Distribution

Prototyping is the current stage of development, investment in an application prototype at this time will secure for the investor a part ownership of the ICBLTE patent, third party licensing privileges, manufacturing privileges, sales and distribution under an assumed product name. Licensing of the ICBLTE for manufacturing allows the licensee to manufacture this product on a per application basis, management of sales and distribution under an assumed product name.

ICBLTE Offering to the WORLD

- The ICBLTE – more powerful, more efficient, cheaper and more durable than any before…
- Control System Development LLC – International Social Organization
  - DUZ based in Arnham, Netherlands
- Social Entrepreneurship – preferred method of funding
  - Simple, affordable, energy system
  - Engines that last a human lifetime or more
  - Small carbon footprint
  - Efficient heat conversion available to the world's people

The ICBLTE promises to give the WORLD an energy converter of chemical fuels to kinetic energy than has ever existed previously. This engine will significantly lighten the footprint of fuel burning engines, its simple design and construction will allow its availability worldwide operating on widely varied fuel sources. In its vehicle and generator applications, transportation and power will have a significantly wider distribution allowing progress in places not yet supplied by the electric grid. The ICBLTE may enjoy International Social Organizational funding with entities concerned with the well being of humanity's immediate and distant future. The demand is present and now the equipment is present to accommodate that demand. The way forward is "Creativity over Competition" with more efficient, longer-lasting and more powerful energy conversion units…