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Business Plan
Circle Ellipse Engine Company

These pages are only sections 1 and 2 of the complete business plan. Sections 3 through 9 are restricted proprietary information and available following execution of an NDA.

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Company: **Circle Ellipse Engine Company**
Position: **Founder and President**

ABSTRACT

The Circle Ellipse Engine is a unique, patented, internal combustion engine design based on my life experience. I have been fortunate to receive several patent awards throughout my 40 years of experience as an engineer and scientist in radar, sonar, satellite communications, medical devices, space transportation, and military parts reinvention. I capped my career with 10 years of continuous work developing another patented rotary engine. The past 5, now retired, I crystallized my thinking and approach to invent this incredibly simple, low-cost fossil fuel Circle Ellipse Engine.

The Circle Ellipse Engine reinvents the functionality of the centuries-old reciprocating engine. Instead of pistons, driven by the rotation of a crankshaft, the Circle Ellipse Engine offers continuous power every revolution. Its relationship of an elliptical surface surrounding a round rotor forms the necessary 4-step Otto-Cycle geometry every rotation, at half the RPM of a reciprocating engine. This eliminates the crankshaft, camshaft, valve lifters, rocker arms, connecting rods, wrist pins, timing chains, and a host of other components, significantly reducing engine size and weight. It is ideal for insertion into every application where small size and weight are primary factors, such as unmanned aerial vehicles (drones).

This is my first business plan. Because I am an engineer/scientist, the plan might include too much technical detail, and it might not include everything required by the investment community. All material presented is based on factual data. I look forward to your review comments, and questions. You will find me easy to work with and receptive to your suggestions.

I am confident that you will have a positive reaction to this business plan. With your financial support, we can make innovative, reliable, and profitable Circle Ellipse Engines together to address market opportunities where continuous power, light weight, small size, low vibration, and extended durability are paramount.

Robert Grisar
Circle Ellipse Engine Company
Founder and President

BUSINESS PLAN: THE CIRCLE ELLIPSE ENGINE

"Build a better mousetrap and the world will beat a path to your door." This was credited to Ralph Waldo Emerson seven years after his death in 1889.

1.0 EXECUTIVE SUMMARY

The Circle Ellipse Engine Company (hereinafter called the Company) is a development-stage organization formed 4 June 2017, coincident with the assignment of provisional patent number 15/613,237 for the Circle Ellipse Engine by the U.S. Patent and trademark (USPTO) Office.

The Company is engaged in the business of designing, developing and building a working prototype of the Circle Ellipse Engine as a marketing aid to demonstrate the cost and performance benefits to interested organizations, either by:

- Leveraging a relationship with other established engine manufacturers or end users; either by licensing or charging a royalty per unit; or
- "*Go-it-Alone*" – essentially become an independent marketing, sales, and manufacturing organization.

I believe that the Circle Ellipse Engine is the *BEST MOUSETRAP*, and a viable and profitable alternative to other internal combustion engine types -- reciprocating and rotary, because of its extreme simplicity, light weight, small footprint, and low noise/vibration. This makes it an incredible fit for all applications where size, weight, and negligible vibration are critical – aviation, automotive, and ships. The significant size and weight reduction makes host equipment lighter and smaller, leading directly to improved fuel usage and higher cargo carrying capacity.

I am the founder of the Company, and only employee. I have more than 15 years experience with conventional internal combustion engines and U.S. Weapon System propulsion. I previously have been awarded several U.S., Canadian, and EU patents for the RadMax rotary engine. The Company is currently operating out of my home in Ruskin, FL.

The Company does not have any revenue at this time. It seeks venture capital to fabricate a demonstration prototype of the Circle Ellipse Engine as a marketing and performance aid.

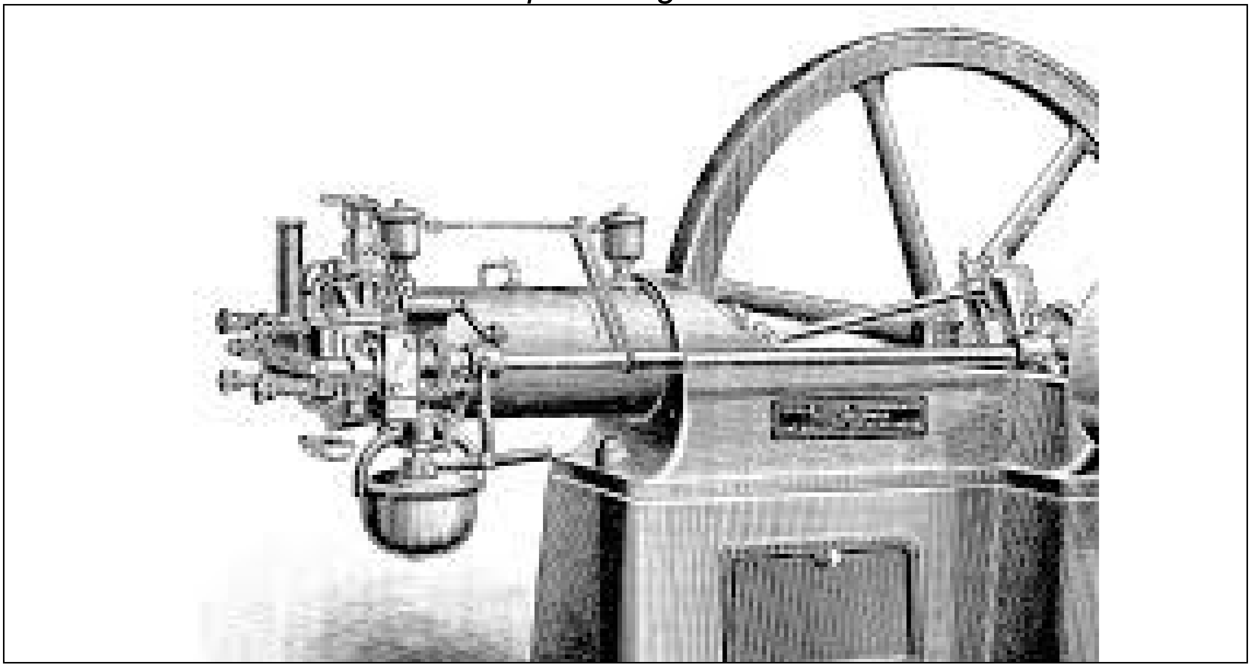
2.0 BACKGROUND OF THE INVENTION

2.1 Historical Background of the Reciprocating Mechanism

Various forms of the two-cycle reciprocating mechanism have been identified as far back as Proclus (second century AD) and earlier in the work of Eudoxus (408-355 BC).

In the 14th century, two Italians, Giovan Battista Amico (circa 1511 to 1538) and Girolamo Fracastoro (circa 1476-1553) each discussed a reciprocating mechanism. They made references to Greek authors such as Proclus, Eudoxus, or Callippus. It appears that there was a whole family of geometrical reciprocating devices that existed all the way back to the early Greek civilization.

Figure 2.1 Early External Stationary Combustion Engine Using Reciprocating Motion



2.2 First Successful Internal Reciprocating Combustion Engine

Nikolaus August Otto of Germany succeeded in making a practical internal combustion engine in 1876. And Gottlieb Daimler is credited for making an automobile utilizing an internal combustion engine in 1886.

Both Otto and Daimler created the reciprocating internal combustion engines. Since then, the development of the internal combustion engine mainly consists of engines that use the reciprocating mechanism.

Daimler, and his lifelong business partner Wilhelm Maybach, were two inventors whose goal was to create small, high-speed engines to be mounted in any kind of locomotion device. In 1883 they designed a horizontal cylinder layout compressed charge liquid petroleum engine that fulfilled Daimler's desire for a high speed engine which could be throttled, making it useful in transportation applications. This engine was called Daimler's Dream.

Figure 2.2 Daimler's Dream Engine, circa 1885

Features of the 1885 Engine include:

- a single horizontal cylinder of 264 cc (16 cu in)[15] (58×100 mm, 2.28×3.94 in)
- air cooling
- large cast iron flywheel
- surface carburetor
- hot-tube ignition system (patent 28022)
- cam operated exhaust valves, allowing high speed operation
- 0.5 hp (370 W)
- 600 rpm running speed, beating previous engines, which typically ran at about 120 to 180 rpm
- weight of around 50 kg (110 lb)
- height of 76 cm (30 in)

2.3 Modern Reciprocating Internal Combustion Engine

However, satisfying all the requirements for a practical internal combustion engine is not simple. The gasoline internal combustion engine is a marvel of performance. Recent advances in fuel management have improved the potential power to displacement from 60 HP per liter, to approach 100 HP per liter. Significant achievements in Critical Pollutant Emission Control Technology Development have been implemented largely in response to the zero-emission vehicle (ZEV) regulation.

Many manufacturers have been marketing passenger cars and SUVs that meet the 2025 Low-Emission Vehicle III (LEV III) regulations criteria pollutant fleet average requirement of super ultra-low emissions vehicles (SULEV30) for over a decade. Sixteen manufacturers certified 74 vehicle models to the SULEV30 standards in 2016.

Figure 2.3 Modern Implementation of a V-8 Internal Combustion Engine

The LS3 6.2L is the 430-hp standard engine in the Chevrolet Corvette. It is a fantastic combination of high technology and uncompromising performance. The LS3 crate engine includes the EFI intake manifold assembly with injectors and throttle body, exhaust manifolds, water pump, and balancer.

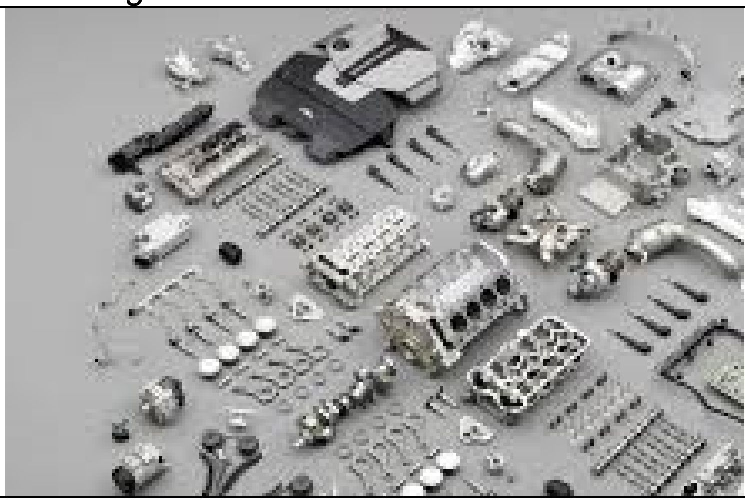
The LS3 is filled with components designed for high performance and longevity. The aluminum block is filled with a sturdy reciprocating assembly that combines with L92-type rectangular-port heads to deliver a 10.7:1 compression ratio.

Figure 2.4 Complexity of the Reciprocating Gasoline Internal Combustion Engine

Consider the complexity of the reciprocating gasoline internal combustion engine.

An exploded view of the component parts is shown in the adjacent picture.

The count exceeds 1,000 parts.



It is not appropriate to conclude, however, that the mechanism of the internal combustion engine must be of the reciprocating type solely because the early history of the internal combustion engine was primarily that of the reciprocating one.

2.4 The Rotary Internal Combustion Engine

As the matter of fact, there have been numerous challenges made to the reciprocating internal combustion engine. That course of development led to numerous attempts to create a practical rotary engine.

The casual idea of a rotary engine and automotive applications demand far more rigorous requirements. This explains the reason why many efforts in the past for perfecting a practical rotary engine did not succeed.

There are solid reasons why the NSU-Wankel type rotary engine invented by Felix Wankel became the only practical rotary engine. First, its principle is superior. Secondly, enormous and untiring efforts have been made to make it work by many of its licensees.

These accomplishments are laudable, and are planned for incorporation in the Circle Ellipse Engine.

Figure 2.5 Mazda Implementation of the Wankel Engine, Shown with End Plate Removed

	• Origin: Closely based on 3rd generation (FD3S) RX7's 13B-REW Special 3 rotor parts based on 13G design • Capacity: 654cc x 3 rotors = 1962cc • Compression ratio: 9.0:1 • Turbo Boost: 0.7 Bar (=10.29 PSI) • Induction: Turbocharged (twin sequential) / intercooled (intercooler mounted near car's radiator), EFI (2 injectors/rotor) • Exhaust: Peripheral Exhaust Port • Power/RPM: 280ps@6500rpm • Torque/RPM: 41kgm@3000rpm • Dimensions: 672mm L, 549mm W, 520mm H • Weight: 350kg With all accessories & manifolds

No matter how innovative an invention may be, there is no invention that is absolutely perfect. The case of the NSU-Wankel type rotary engine is one good example of untiring enthusiasm and effort having prevented an excellent invention from falling into oblivion.

Figure 2.6 Complexity of a Disassembled Rotary Engine

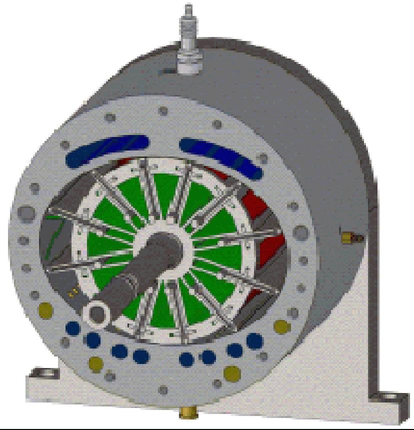
This is a similar view of the Mazda implementation of the Wankel Rotary Engine. There are fewer parts. However, the complexity is high. The cavity in the housing is called an epitrochoid. It is expensive and difficult to machine. The rotor has an internal hub that rotates three times the engine RPM.	

So far I have identified two unique types of gasoline internal combustion engines – reciprocating and rotary.

2.5 The Third Approach (aka Third Time is the Charm)

This Business Plan addresses the birth of game-changing technology – a third alternative for the gasoline internal combustion engines – the Circle Ellipse Engine.

Figure 2.7 3D Solid Model of the Circle Ellipse Engine, End Plate Removed

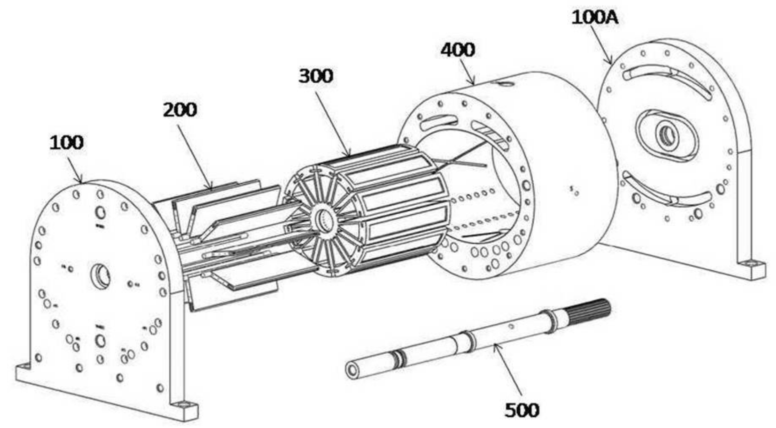
	A 3D solid model of the Circle Ellipse Engine is shown with one end plate removed. Colors are used to highlight functions. Water passageways (blue), cooling and lubricating oil (green), air/exhaust (yellow), and combustion (red). The design incorporates more than a century of improvements in the reciprocating internal combustion engine, with the inherent benefits of a rotary (small size, light weight, vibration-free). Normally a critical element, the engine integrates sealing technology from Mazda's implementation of the Wankel Engine.

It is so evolutionary and so simple, the first question should be why hasn't this been done before? The answer is not so simple. It required ten years of beating my head against the wall trying to solve the five significant challenges of all internal combustion engines in the RadMax implementation. These are lubrication, cooling, sealing, mechanicals, and thermodynamics.

I stepped away from the challenge for five years. With that lengthy pause, I was able to rethink the requirements and solve all the challenges in the Circle Ellipse Engine implementation. It required very complex transcendental mathematics to evolve into something so simple, and easily translatable into CNC machining computer files.

Last, consider the Circle Ellipse Engine. This diagram was reproduced from the June 4, 2017 provisional patent filing with the USPTO.

Figure 2.8 Major Components of the Circle Ellipse Engine

	• 100 End Plate (100A same as 100) • 200 Vanes • 300 Rotor • 400 Housing • 500 Drive Shaft The small component count is incredible. Only five unique major assemblies and the parts are symmetrical and scalable.

In nurturing the development of the Circle Ellipse Engine design, I adopted all the strengths of both reciprocating and rotary engines, while addressing the shortcomings of both.

The left two columns of Figures 2.9 and Figure 2.10 were duplicated, unchanged, from Army Research Laboratory report “A Review of Heavy-Fueled Rotary Engine Combustion Technologies” number ARL-TR-5546 by Chol-Bum M. Kweon, dated May 2011. The third column contrasts the advantages and disadvantages of rotary engines with that of the Circle Ellipse Engine.

Figure 2.9 Advantages of Rotary Engines (Columns One and Two) and Circle Ellipse Engine Implementation (Column Three)

Advantages		
Effects	**Causes**	**Circle Ellipse Engine**
High specific power density High power-to-weight ratio High power to volume ratio	Higher operating speed possible by rotation More air in and more fuel in per time More power output per engine total weight One power pulse per shaft rotation	12 power pulses per shaft rotation
Smooth operation	Continuous unidirectional motion No reciprocating parts such as connecting rods and conventional Crank shaft with weight balances, only the rotor geared directly to the output shaft; eccentric shaft shape counterbalances the offset rotor to eliminate high-speed wobbling. Ease of balancing. One power pulse per shaft rotation.	Perfectly balanced, no counterbalance required, no high speed vibration No balancing required 12 power pulses per shaft rotation
Simple design	Very few parts and no valves and valve trains. Half the number of parts of reciprocating engine (four-stroke).	25% of number of parts of reciprocating engine (four-stroke)
Compact size and lightweight	Fewer parts. Less volume occupation. About a third of the bulk and weight of a reciprocating engine (four-stroke).	About 25% of the bulk and weight of a reciprocating engine (four-stroke).
Low vibration levels	Three power strokes per each rotation of eccentric output shaft, which leads to extremely low torque oscillation and vibration.	12 power pulses per shaft rotation. Completely symmetrical. No low torque vibration or oscillation

Figure 2.9 Advantages of Rotary Engines (Columns One and Two) and Circle Ellipse Engine Implementation (Column Three) (Continued)

Lower noise	Slower fuel burning rate and less mechanical noise. Depends on engine calibration.	No engine calibration required
More mixing time	One-third of output shafts speed (slow rotor speed) suited for stratification. Three power pulses per rotor rotation/three shaft rotations per rotor rotation.	12 power pulses per shaft rotation. There is no complex internal rotor turning at three times the output shaft speed
Higher volumetric efficiency	No valve restrictions.	Same
Multi-fuel capability	Separates combustion region from intake region, which prevents localized hot spots from forming; prevent pre-ignition or detonation.	Same
Lower cost	Simple design and smaller size, which results in lower manufacturing costs.	Same
Lower NOx	Lower flame temperatures.	Same
Easier design of emissions control devices	Compact size.	Same
Non-reversibility of seal paths	One direction rotation.	Same
Sizing flexibility	Just add additional rotors.	Engine scalable to any requirement
Mechanical simplicity	Fewer parts and reciprocation parts.	Same
Reliability	Fewer overall stress points. Positive net torque through the shaft.	Same

Figure 2.10 Disadvantages of Rotary Engines (Columns One and Two) and Circle Ellipse Engine Solution (Column Three)

Disadvantages		
Higher fuel consumption	Less efficient; however, improved as the technology evolves. High fuel consumption at low speeds Insufficient torque.	Technology insertion based on continuous improvement in other rotary engines Torque improved based on large rotor diameter
Lower thermal efficiency	High surface-to-volume ratio leading to high heat losses and flame quenching Long and narrow combustion chamber leading to longer flame travel time particularly at low-end torque.	Less heat loss because chamber size reduced 1 per revolution to 12 per revolution Improved due to shorter chamber 1/12 rotor size Shorter combustion chambers Reduced flame travel time at all rpm
Higher oil consumption	Rotary engine burns a lot of oil.	Modern technology provides significant improvement through use of precision flow restrictors
Coolant system weight	For liquid-cooled rotary engine.	Same, as in any water-cooled engine
Maintenance	Constant maintenance	Circle Ellipse Engine designed to preclude periodic maintenance. Recommended cycle for preventive maintenance is every 180 days – Change oil, filters
Manufacturing	Not well established; requires different tooling from reciprocating engines.	Prototype easily fabricated using modern CNC equipment, driven by Circle Ellipse Engine CAD model.

2.6 Description of the Major Circle Ellipse Engine Components

The significant Patent claims are the functions of the housing, end plate, and the pin track.

The housing is round, with an elliptical internal cavity. The cavity incorporates many functions, including air intake and exhaust without valves, valve springs, rocker arms, push rods or a cam shaft. The housing incorporates flow-through passageways for water cooling to maintain thermal stability, oil injection ports to provide consistent, metered lubrication of internal rotating parts, and an oil sump connection that ensures excess oil is swept out of the elliptical cavity each revolution.

The circular Rotor turns inside the Elliptical housing cavity, thus the name of the device. The rotor precisely approaches the minor axis of the elliptical housing, which contributes to the high compression ratio of the combustion chamber. The maximum distance that the rotor is positioned from the elliptical housing is the major axis, determines the maximum combustion chamber height and therefore defines the compression ratio.

The rotor is partitioned into 12 symmetrical segments. Each segment is populated by radial-oscillating vanes. As the rotor turns, a pair of adjacent vanes, each accurately positioned by the pin track in the end plates, forms the leading and trailing walls of each combustion chamber. These combustion chambers execute the Otto Cycle (intake, compression, combustion, and exhaust) every revolution, which makes the Circle Ellipse Engine many times more efficient that a reciprocating engine, which requires two rotations of the crankshaft for the same performance. Further, the Circle Ellipse Engine has 12 combustion events each revolution, as each of the pairs of adjacent vanes pass over the spark plug location.

The mating end plates similarly offer multi-functional capability. They provide for external connections for filtered air, exhaust products, lubrication oil, and sealed bearings. The end plates incorporate water plenums to distribute cooling water to the housing for thermal stability.

Most important, the End Plates feature a pin track, which accurately guides the vanes (the reciprocating element) to the exact position from the internal elliptical surface of the housing. These pin tracks are a mathematical breakthrough, integrating the geometries of the housing, end plates, rotor, and vanes. Unlike other implementations with high friction approaches, the pin tracks are a marvel of simplicity. The resultant [proprietary] equations are easily machined by CNC equipment into the end plates.

Finally, I need to acknowledge the outstanding work that Mazda invested in perfecting its sealing and coating technology in the implementation of the Wankel engine. The Circle Ellipse Engine leverages this fine work and incorporates same in the baseline design.