Experiments with Spiral Magnetic Motors

Presented at the:

International Conference on Future Energy II

Dr. Ted Loder [1] with input from Dr. Thomas Valone [2]

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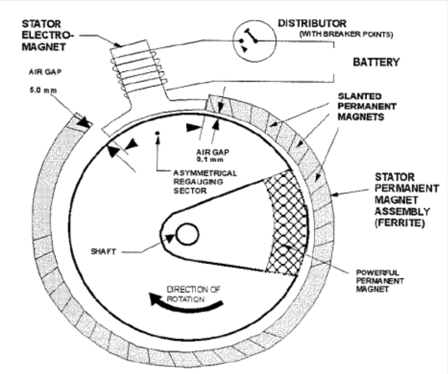
2. President of Integrity Research Institute, Chairman of COFE II



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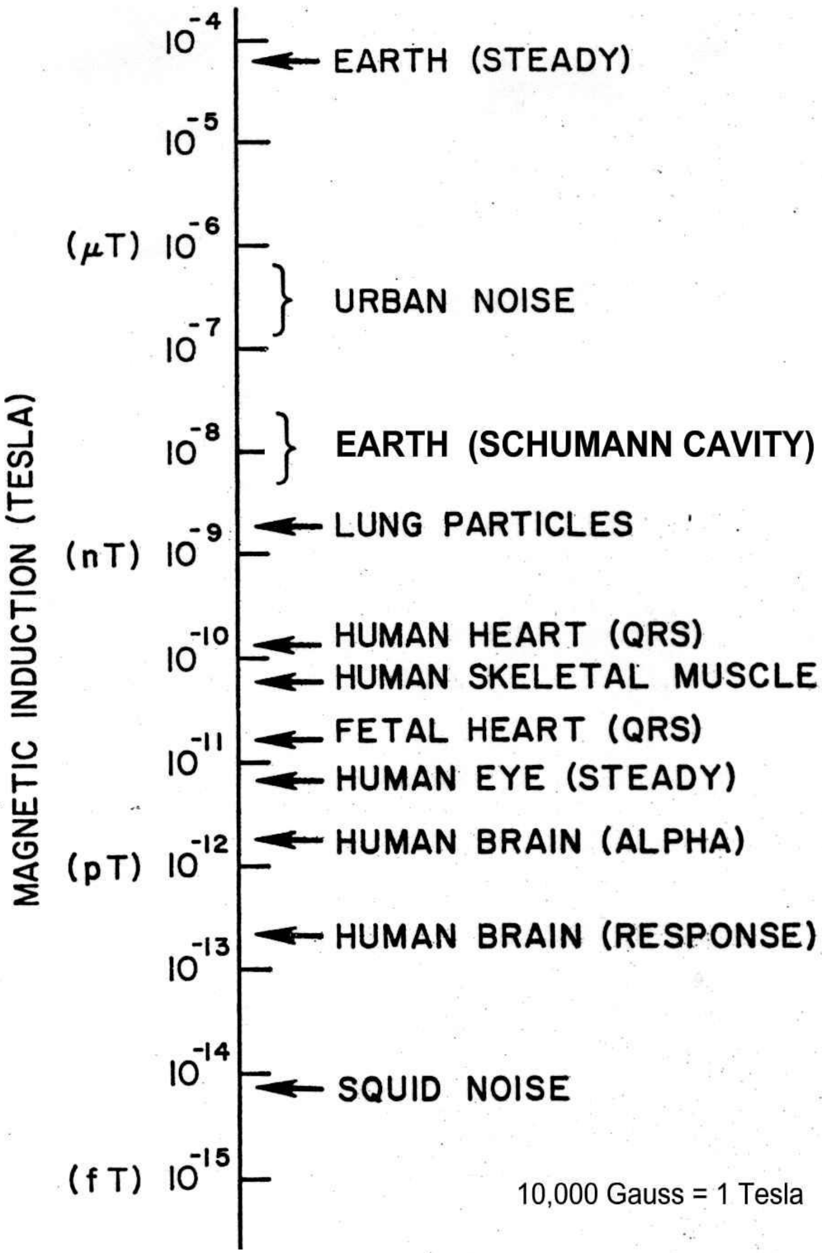
RELATIVE MAGNETIC FIELD STRENGTHS



Magnets, created by spinning electrons, are used to perform useful work in motors and generators every day.

The **magnetic gradient** (dB/dx) or changing magnetic field is known from classical physics to create a force in one direction, similar to but better than a linear motor.

Background

Single-Phase Motors, Linear Motors, and Special Machines

7.3 LINEAR INDUCTION MOTOR

A *linear induction motor* (LIM) can be derived from its rotary counterpart by "cutting" the rotary motor axially and laying out flat the stator (or primary) and the rotor (or secondary), as shown in Fig. 7-2. The rotating magnetic field is thereby transformed into a translating magnetic field, and instead of an electromagnetic torque we have an electromagnetic force or thrust. Whereas numerous topological variations of LIMs are possible, the two common forms are shown in Fig. 7-3.

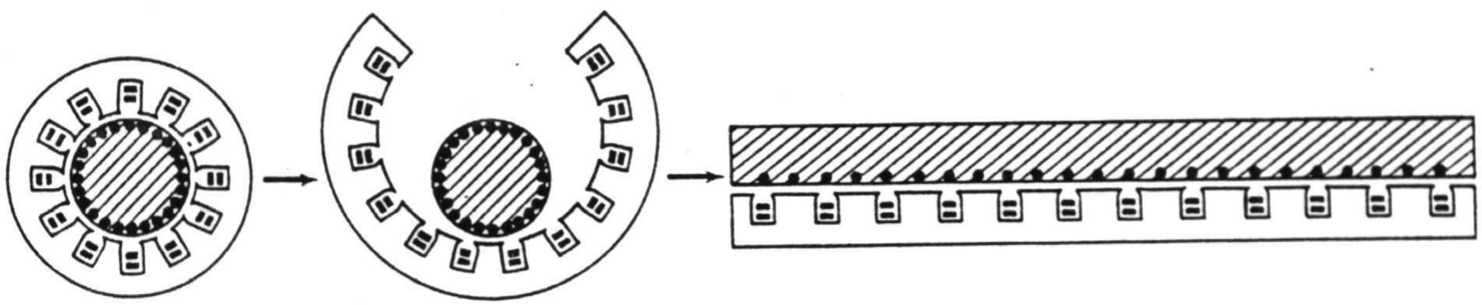


Fig. 7-2

For a refined mathematical analysis certain basic differences between a LIM and its rotary counterpart must be taken into account. In the following, however, we shall consider an idealized model only.

Example of a Linear Magnetic Device

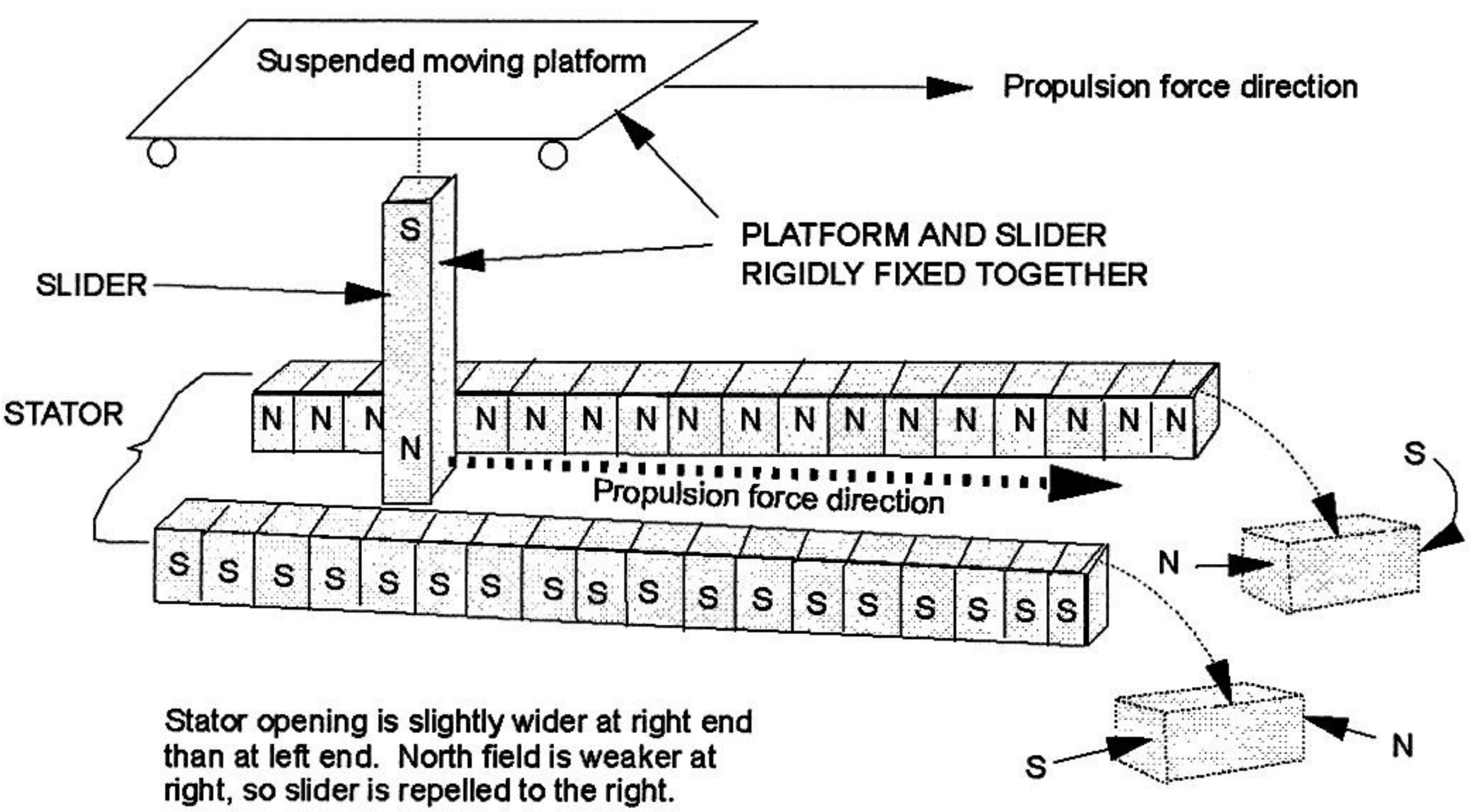


Figure 6-25 Type of conventional linear magnetic movement device.

Bearden, Thomas. 2002. Energy from the Vacuum. 952 pp. Cheniere Press, Santa Barbara, CA

Inhomogeneous Magnetic Fields

The Stern–Gerlach Experiment and Electron Spin

--*Modern Physics*, Schaumm's Outline Series, Gautreau et al., McGraw Hill, 1978

21.1 THE STERN-GERLACH EXPERIMENT

In the *Stern-Gerlach experiment*, performed in 1921, a beam of silver atoms having zero total orbital angular momentum passes through an *inhomogeneous* magnetic field and strikes a photographic plate, as shown in Fig. 21-1. Any deflection of the beam when the magnetic field is turned on is measured on the photographic plate.

Their experimental setup: The magnetic field B is more intense near the pointed surface at the top than near the flat surface below, creating a slope in a graph of B vs. z , which is the gradient dB/dz.

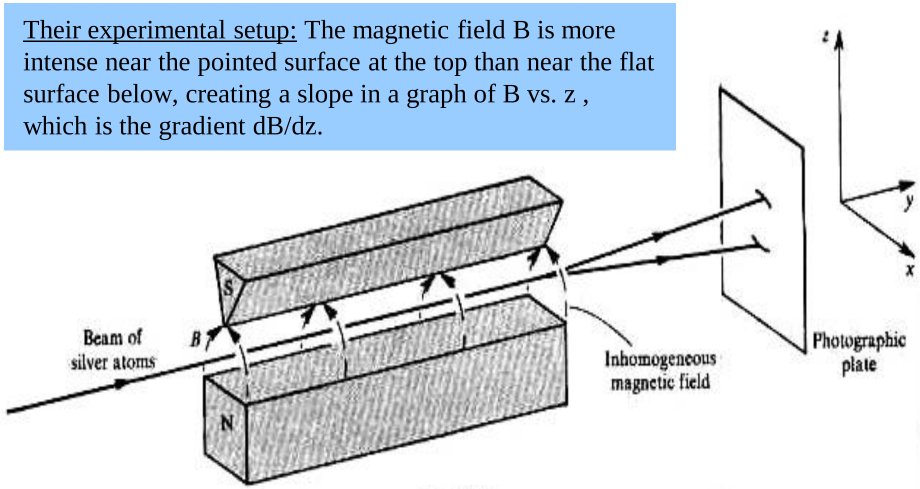
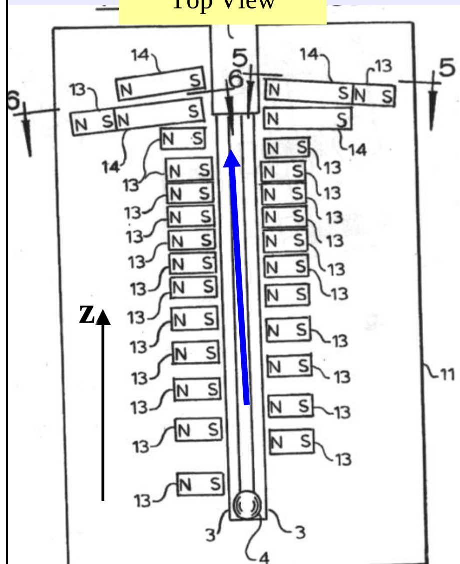


Fig. 21-1

The purpose of the *inhomogeneous* magnetic field is to produce a deflecting force on any magnetic moments that are present in the beam. If a homogeneous magnetic field were used, each magnetic moment would experience only a torque and no deflecting force. In an inhomogeneous magnetic field, however, a net deflecting force will be exerted on each magnetic moment μ_z. For the situation of Fig. 21-1,

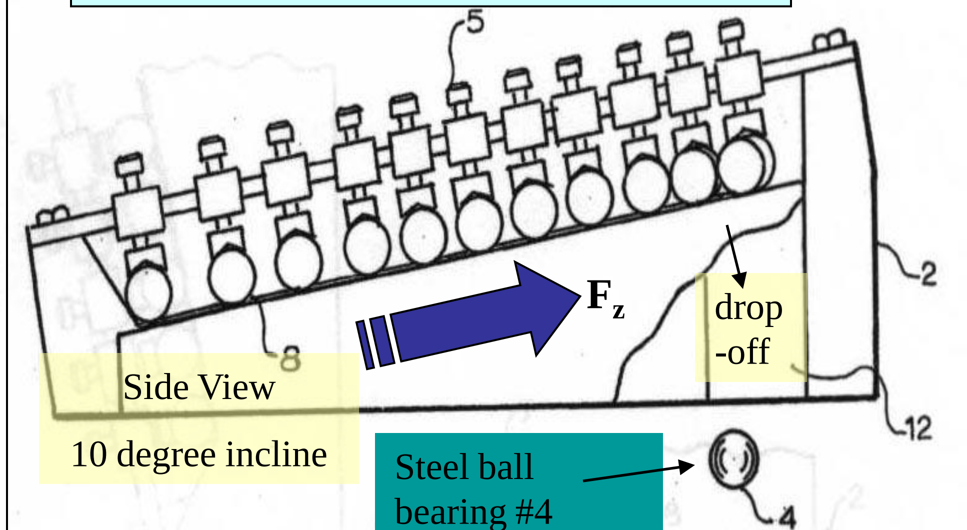
$$F_z = \mu_z \cos\theta \frac{dB}{dz} \qquad (21.1)$$

where θ is the angle between μ_z and **B**, and dB/dz is the gradient of the inhomogeneous field

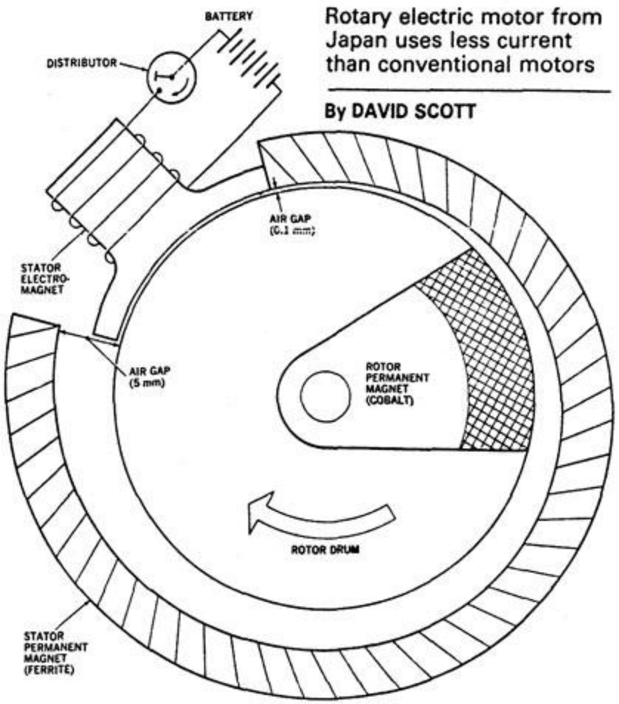


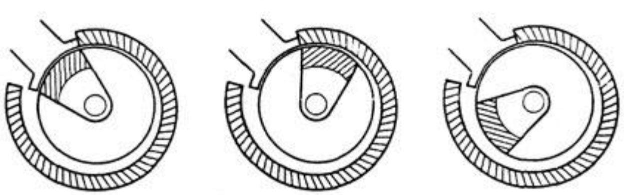
The net **Force** created on the ball bearing = the **magnetic field gradient** multiplied by the induced magnetic moment, as with the Stern-Gerlach Experiment

Hartman Patent #4,215,330



Magnetic "Wankel" for electric cars





Rotary electric motor from Japan uses less current than conventional motors

By DAVID SCOTT

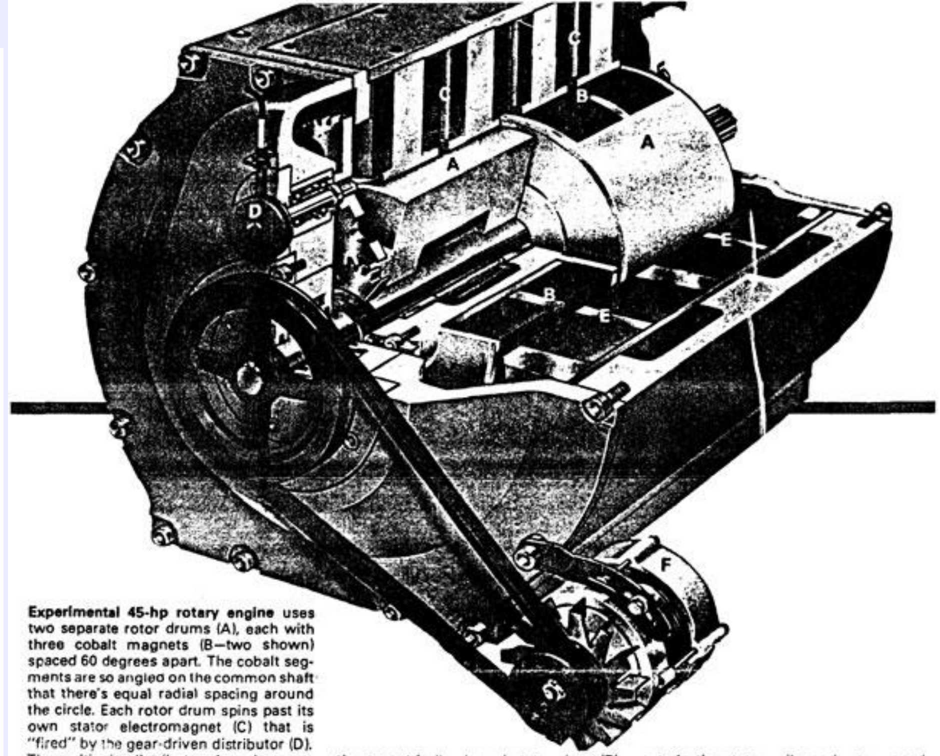
In this time of uncertain gasoline supplies, electric cars look increasingly attractive. So what's keeping them off our roads? Inefficient batteries are the main problem. Battalions of researchers are working to develop better batteries [PS, Feb.] and thus improve the electrics' speed and cruising range. But Kure Tekko, a Japanese engineering firm, has attacked the problem from the other end by developing an engine that reduces the power requirements of electric vehicles. The new engine both weighs less and draws less current than conventional electric motors, so fewer batteries are needed to power the car. Jettisoning batteries, in turn, trims an electric's weight, improving its speed and range.

The Japanese nicknamed the new design the "magnetic Wankel" because the engine's working principles resemble those of a Wankel-type rotary. In fact, the new engine has some things in common with a conventional auto engine. Unlike most electric motors, the rotary electric needs crank starting and has a distributor.

Like the Wankel, the new design is also lighter and smaller than a gas engine of the same power. And the electric rotary is a pygmy when compared to other electric engines. The prototype 45-hp unit weighs only 155 pounds against 440 pounds for a comparable electric motor. The rotary engine is compact enough to fit inside a two-foot cube, says Kure Tekko.

The forces of magnetic repulsion are the key to the new engine's light weight and lowered power demands. Since the engine gets most of its power from the interaction between permanent magnets, relatively small amounts of copper and iron are needed for the electromagnets used. This cuts weight—and costs. The permanent magnets are either cobalt or the plastic-bonded ferrite type—both lightweight. The ferrite magnets can also be made fairly cheaply by injection molding. Finally, most of the engine castings, including the rotor, are made of light alloy.

The prototype engine shown above is still in an early development stage and no performance details have been revealed. But the rotary electric may become more than just an engineer's plaything. Kure Tekko is a sizeable firm that supplies auto parts to Toyo Kogyo, the Mazda maker. Since Mazda is the world leader in Wankel engines, Toyo Kogyo could have more than a passing interest in the Wankel's electric counterpart. ■



Experimental 45-hp rotary engine uses two separate rotor drums (A), each with three cobalt magnets (B—two shown) spaced 60 degrees apart. The cobalt segments are so angled on the common shaft that there's equal radial spacing around the circle. Each rotor drum spins past its own stator electromagnet (C) that is "fired" by the gear-driven distributor (D). The multipoint distributor gives six power impulses per revolution to kick each of the three cobalt segments along. They are propelled the rest of the way by the magnetic forces generated between them and the eccentrically shaped stator rings (E) that cause an ever-widening air gap to face the magnets. The small electric motor (F) crank-starts the rotors. When they are revved up to 200 rpm, the distributor cuts in the stator coils, and rotor speed increases, going up to 5400 rpm. Speed is controlled by pulsing the DC current to the electromagnets as with conventional battery-powered traction motors.

How the magnetic rotary engine works

Rotary electric motor has a small cobalt magnet mounted on the edge of its drum-like rotor. The magnet spans a narrow 60-degree sector of the rotor's circumference. The drum spins within a stator ring composed mainly of a permanent ferrite magnet. But the stator has a 60-degree gap spanned by an electromagnet. A distributor geared to the rotor's center shaft times the flow of current to the electromagnet, energizing it briefly, just as the cobalt magnet swings past the coils. The electromagnet exerts a repulsive force, kicking the rotor on its way. The magnet is switched off, and the rotor's speed is maintained by magnetic repulsion between the cobalt magnet and the stator walls. The cleverly designed stator ring actually adds impetus to the rotor's swing. The ferrite ring is not a circle but is a section of a spiral, so its radius gradually expands in the direction of the drum's spin. Thus the stator's eccentric outer curve encloses a wedge-shaped space between it and the spinning rotor. (This area is similar to the Wankel's elongated combustion chambers.) The dimensions of the tapered air gap increase gradually, starting at a tight 0.1 mm and slowly expanding to 5.0 mm. The moving cobalt segment always has more space between its leading edge and the stator than there is at its trailing edge. Since the repulsive force between magnets is strongest when they are closest together, the cobalt magnet gets a constant boost from the rear. The magnet is speeded on its way by this superior thrust along its trailing edge. The rotor thus travels a full 300 degrees of its path without consuming energy from the battery. At the end of this freeloading spin, the electromagnet is again switched on. Just as the cobalt magnet swings by, it gets another powered thrust to begin the next rotary cycle (cycle is illustrated at lower left). The impulse is precisely timed to start after the cobalt magnet reaches top dead center, so it gets boosted off in the right direction. Two or more of these magnetic rotary modules can be combined to make an energy-efficient automotive power plant.

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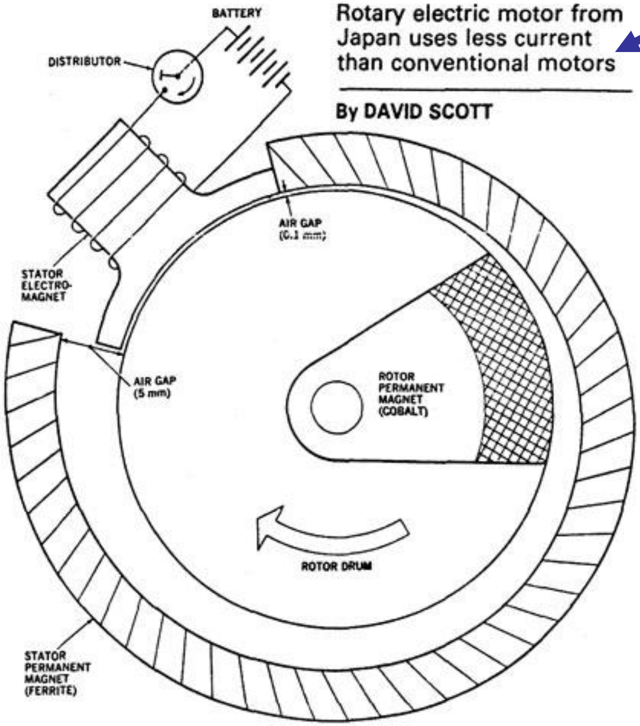

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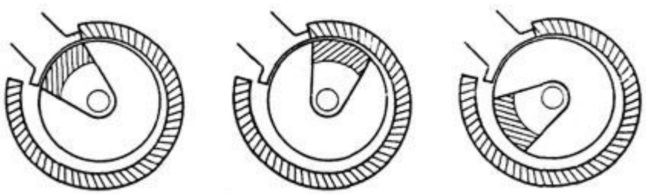

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Spiral Magnetic 'Wankel' Uses Less Current than Conventional Motors even with a coil actuator.

"In this time of uncertain gas supplies, electric cars look increasingly attractive."

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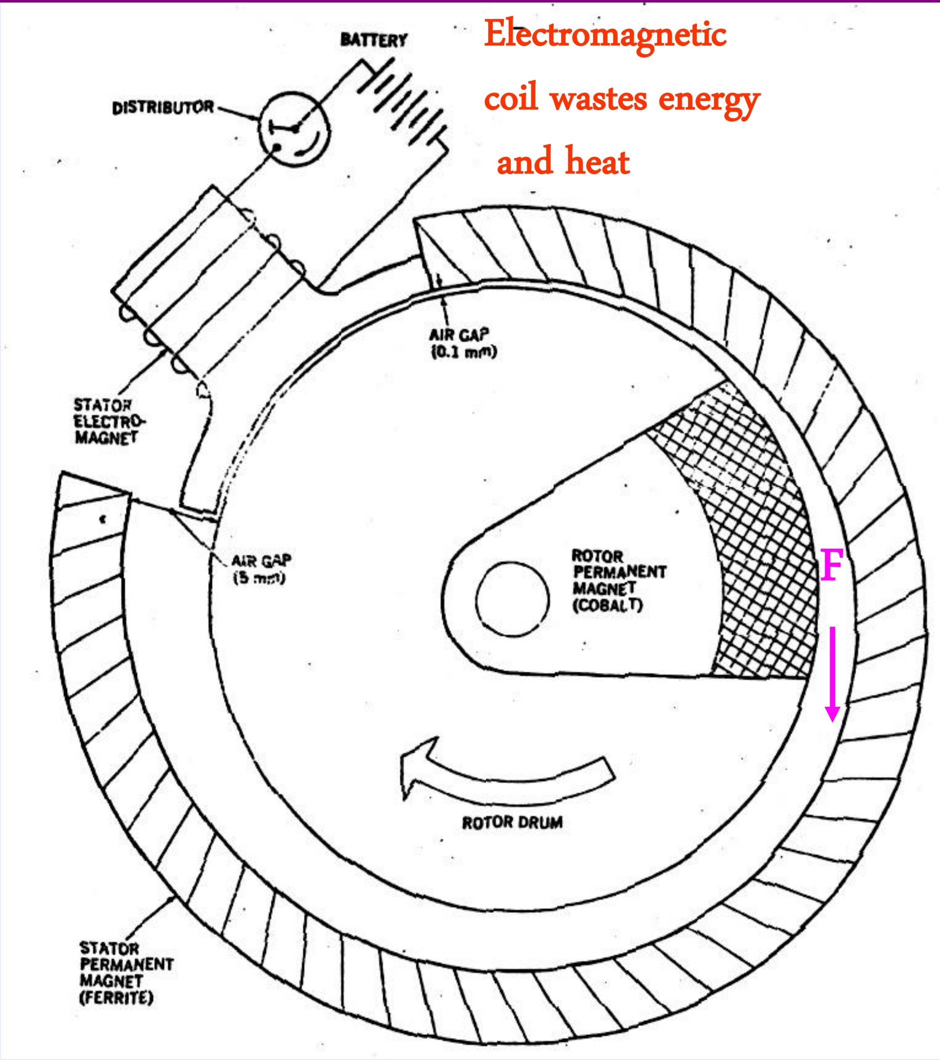
Spiral Magnetostatic Motor
Utilizes Magnetic Gradient

- **Magnetic rotor** repelled from spiral **Stator Magnet** causing **Torque**
- **Light Sensor** triggers the electromagnet to fire giving off a **Magnetic Pulse**
- **Pulse** sends the **Rotor Magnet** past the magnetic field gap
- **Magnetic Gradient** also used in the Stern-Gerlach physics experiment

Inhomogeneous magnetic fields (dB/dθ) create the <u>circumferential force</u> (F)



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Kure Tekkosho Patents

<u>Inventors: Kuroda Takeshi, Ono Gunji, Sagami Eiji</u>

1980 JP 55144783 Permanent Magnet Prime Mover

JP 55114172 Electromagnetic Drive Machine

JP 55061273 Rotary Power Generator

JP 55053160 Magnetic Motive Power Machine

JP55061274 & JP55136867 Magnetic Power Machine

JP 55115641 Flywheel Utilizing Magnetic Force

JP 55111654 Electromagnetic Power Unit

JP 55106084 Magnetic Drive Machine

JP 55071185 Magnetic Power Generator

JP 55053170 Power Machine by Use of Magnetic Force

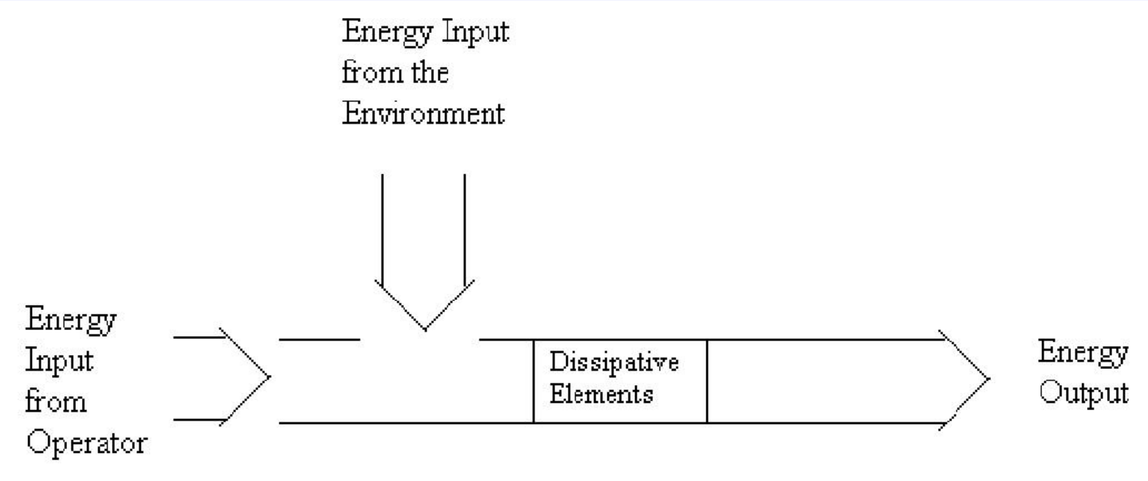
Coefficient of Performance - COP

Coefficient of performance is an energy transfer term that defines the measure of output power divided by the operator's input power. COP is used to describe any machinery that has additional energy input from the environment.

$$COP \equiv \frac{P_{Out}}{P_{In(Operator)}}$$

Unlike the term "efficiency", the COP defined above can be greater than one. COP is usually greater than efficiency, but will be equal to efficiency if the environmental energy input is zero.

Energy flow for machines described by COP



From: M. Walters M.R. Zolgahdri, A. Ahmidouch, A. Homaifar. Introducing the Practice of Asymmetrical Regauging to Increase the Coefficient of Performance of Electromechanical Systems.

The Problem

- In the previously built spiral magnetic motors, electrical power must be input to the system to create a switched magnetic pulse. This pulse is needed to help the rotor traverse the gap (detent) between the end of the magnetic stator arc and the beginning of the stator spiral.

Hence the term: ESLIM (Electromagnetically-Stimulated Linear Induction Motor).

- With both a linear version and a spiral version, the conservation of energy needs to be stated again:

- Valone's Rule #1: Electric input energy, or its substitute, is always necessary with a basic Archimedean spiral magnetic gradient motor.

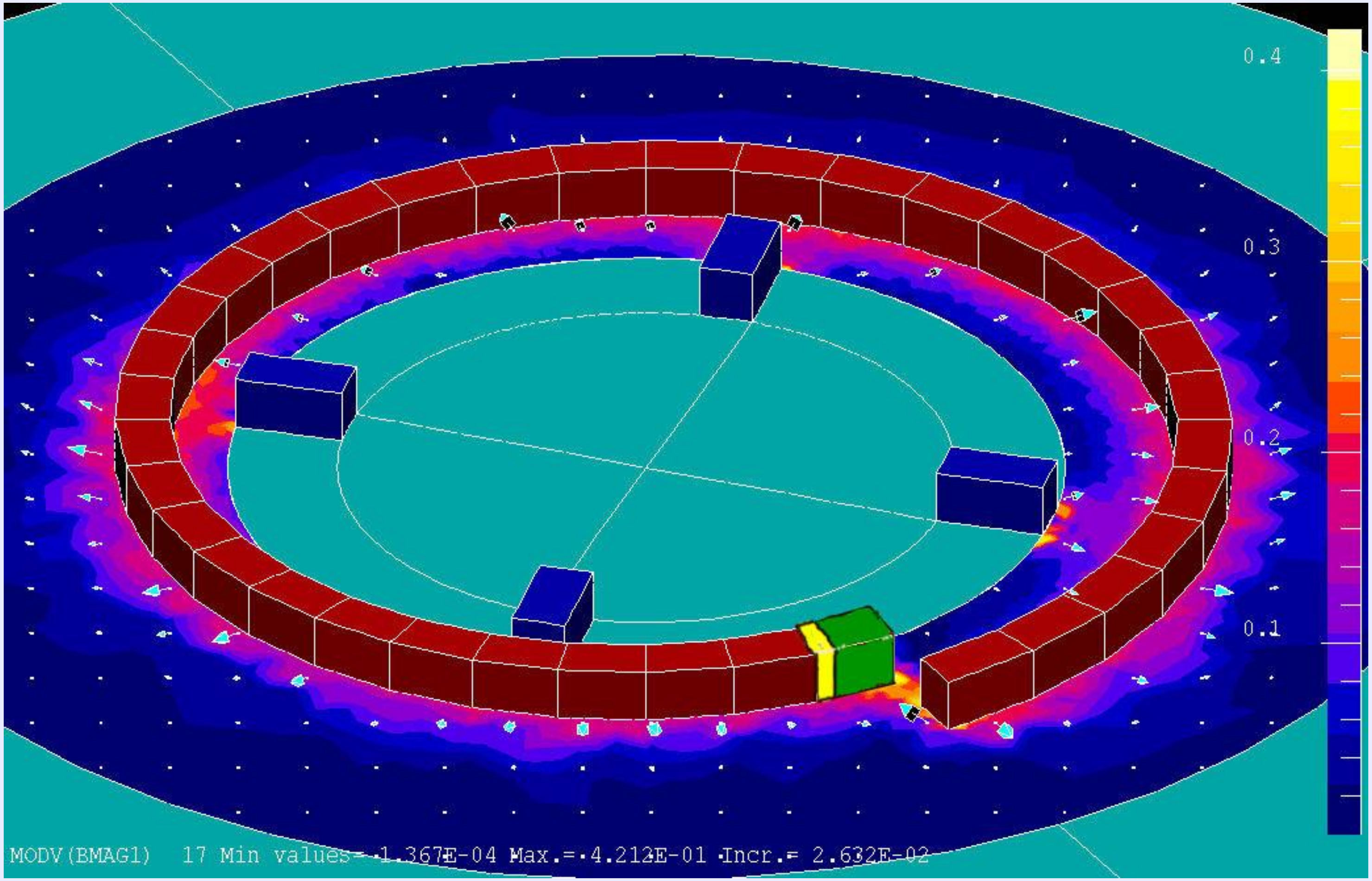
The Problem, cont.

• The input energy is needed because of the powerful end effect which tends to pull the rotor backwards or repel the rotor as it reaches the detent region.

• In summary, no matter what the speed of the rotor in a ESLIM design configuration, the end effect will either pull or repel the rotor with the same force the rotor accumulated during its circuit, thereby satisfying the conservation of energy.

• Thus a more creative approach is necessary to transform the motor into a Magnetic Linear Induction Motor (MLIM), which can be configured either in a linear or spiral manner.

Computer model of magnetic fields for a conceptual MLIM



Blue - Rotor magnets, Red - Stator magnets, Green - GMM-PZT, Yellow - Weigand switch for MR-PZT

The principle of a magnetic gradient force is converted from the linear case to dB/dθ in the circular case. The radial magnetic field increases its attraction as the rotor turns through one complete cycle. (Valone, 2005)

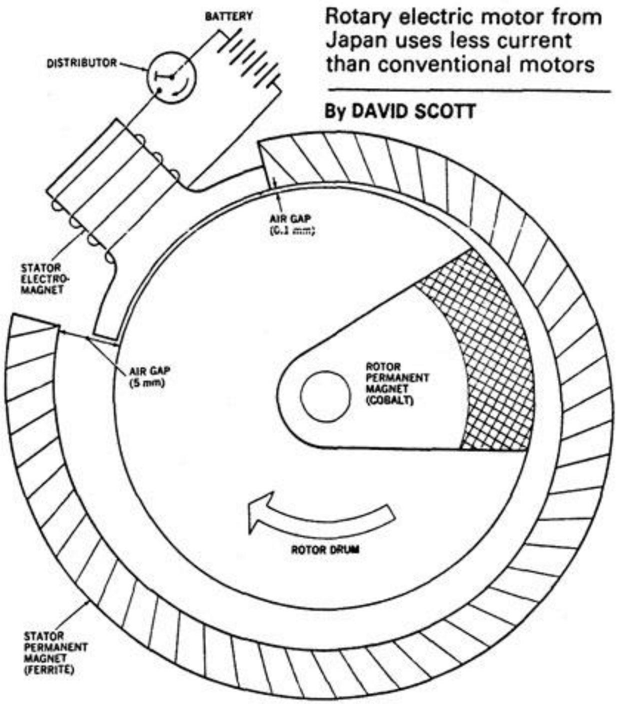
Note that this model is designed in the attractive mode.

Spiral Motors, a very short history

Before we look further at the problem,
let us look at several examples of spiral motor
that have been built.

Kure Tekkosho, A Japanese firm

Magnetic "Wankel" for electric cars



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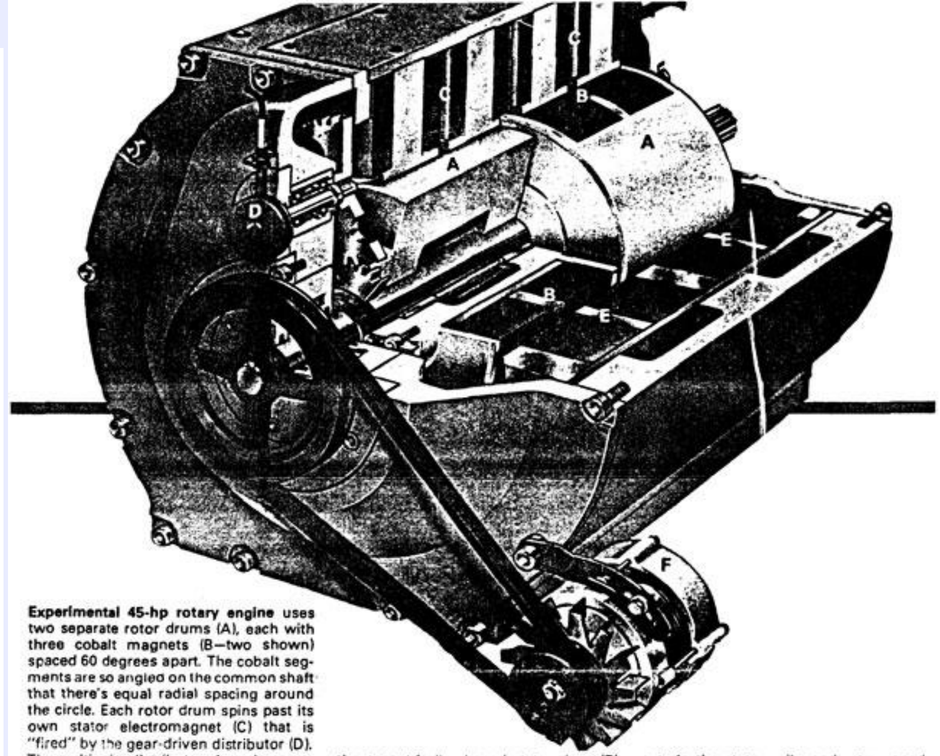

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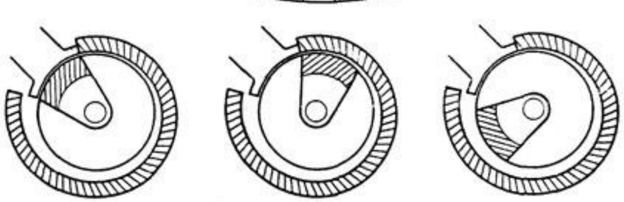

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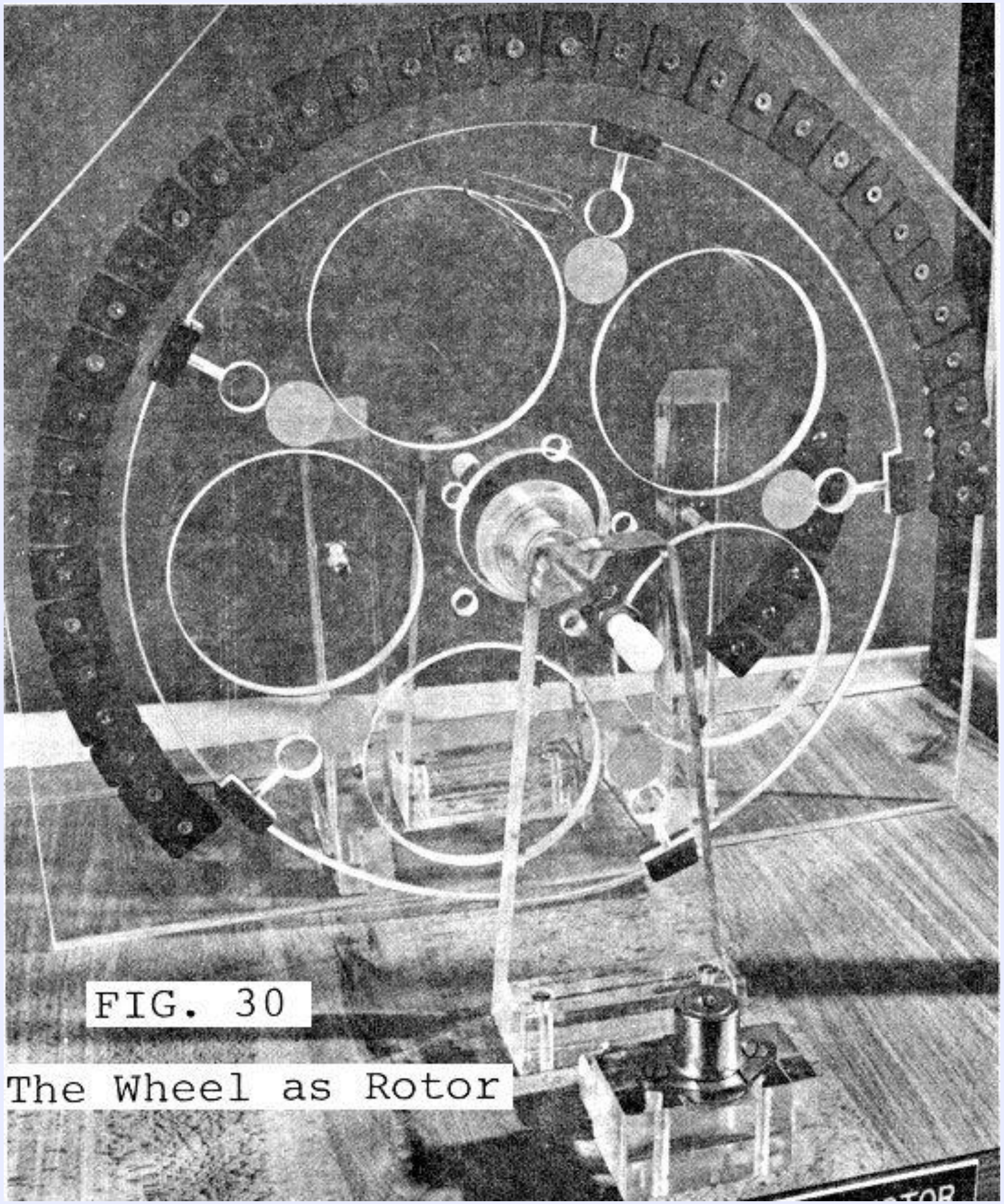


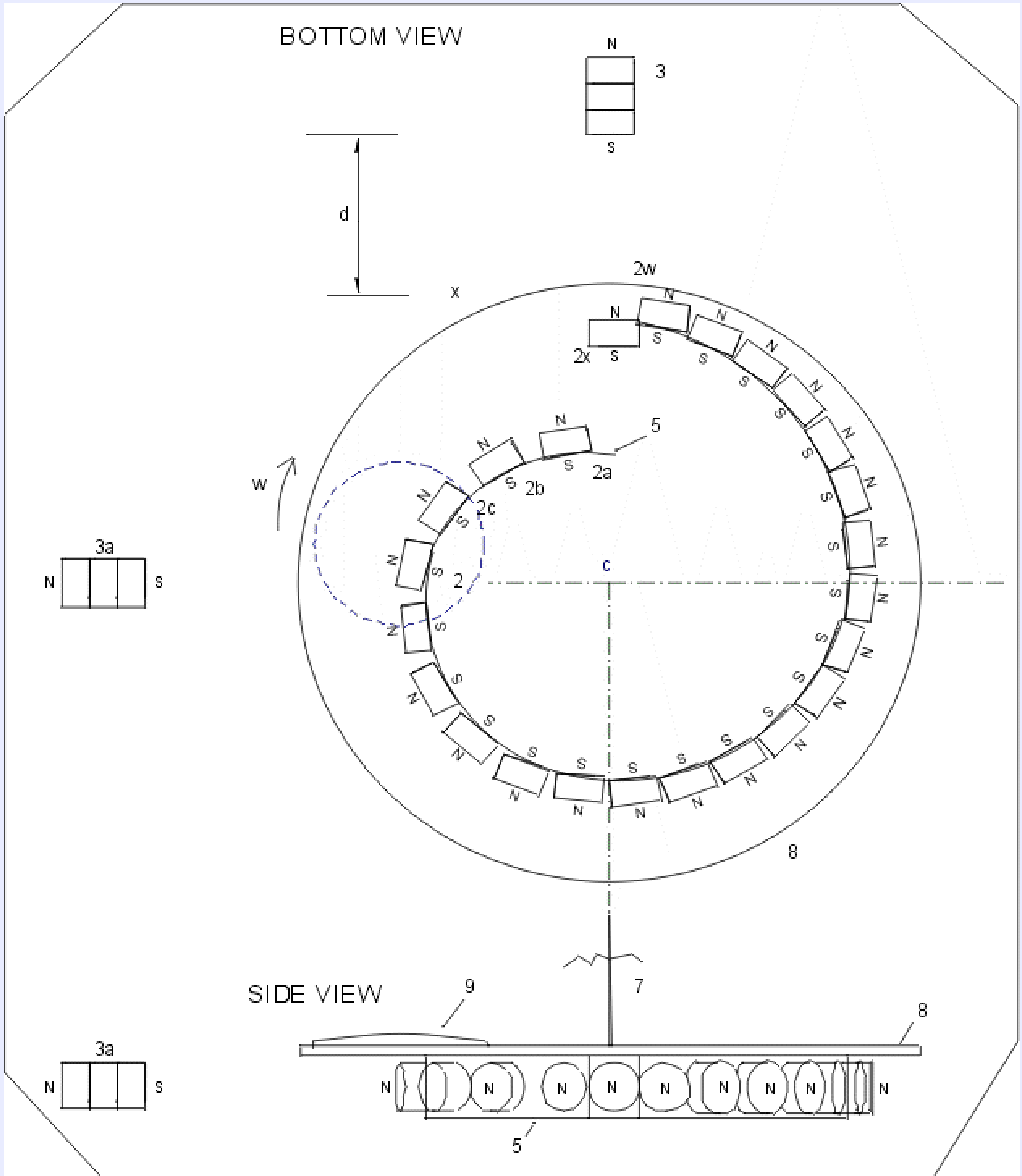
FIG. 30

The Wheel as Rotor

Magnetic “Wankel” motor built by Paul Monus inspired by the Japanese firm of Kure Tekkosho.

Not OU but used only 80 mW to turn at 1400 rpm.

Paul Monus (1982), "Permanent Magnet Motors --- Build One"



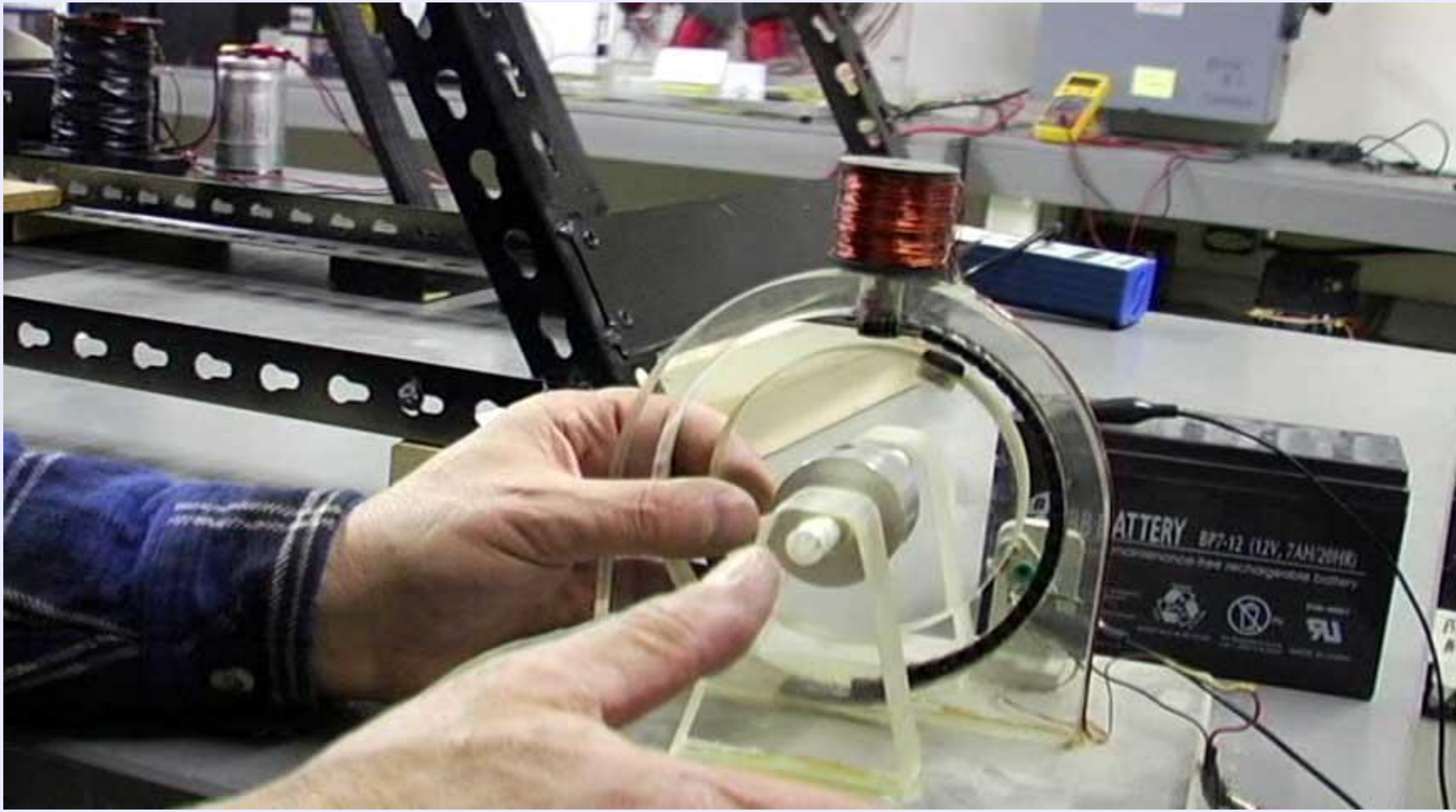
Spiraled Rotor Magnets Motor

Notes:

- Magnets are on the rotor (c)
- Motor is in attraction mode
- Rotor has counterweight (9)
- Magnets on steel shield (5)
- Starts at x opposite stator 3
- Between magnet distances decrease from 2a to 2w
- Magnet 2x helps reset
- Will run 10-11 revolutions so not a free energy device

From Leonard Belfroy's site: http://www.spots.ab.ca/~belfroy/magnetmotors/spiraledRotorMotor.html

Working Replication of a Magnetic Wankel Motor



Note: This motor is not OU but just demonstrates the spiral principle.

http://www.cheniere.org/misc/wankel.htm

Paul Sprain Patent #6954019 (2005)

Apparatus and process for generating energy

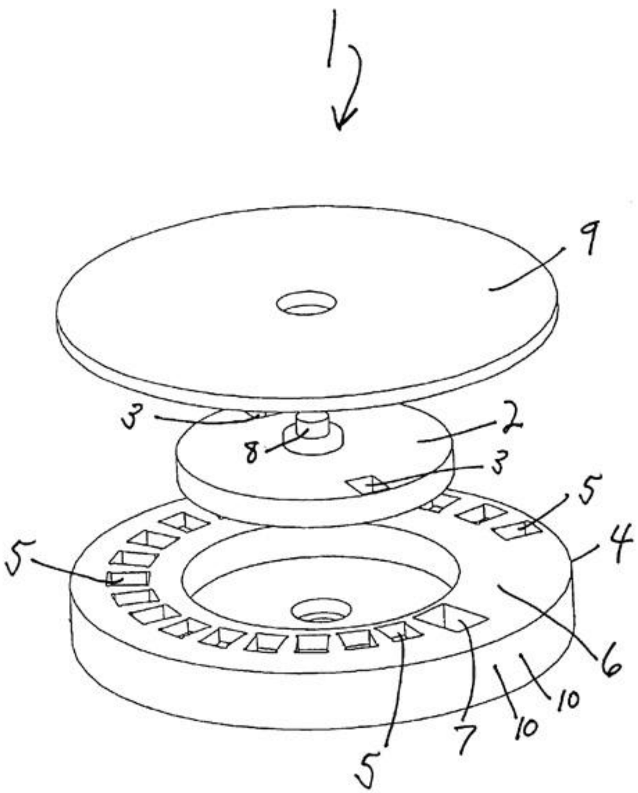


FIG. 1

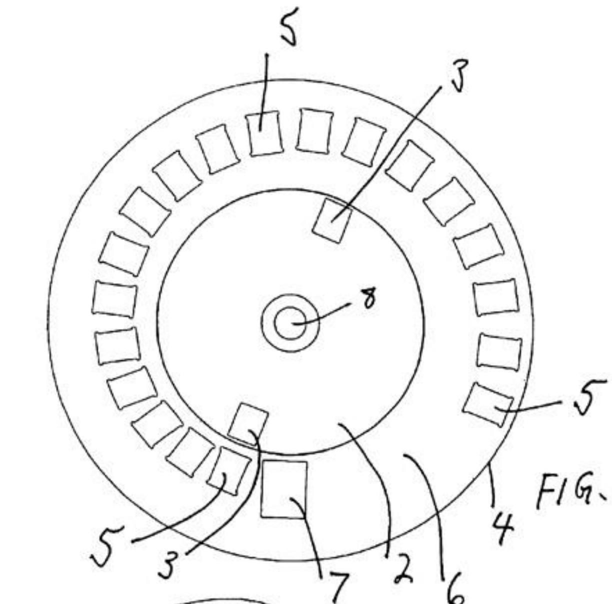


FIG. 2

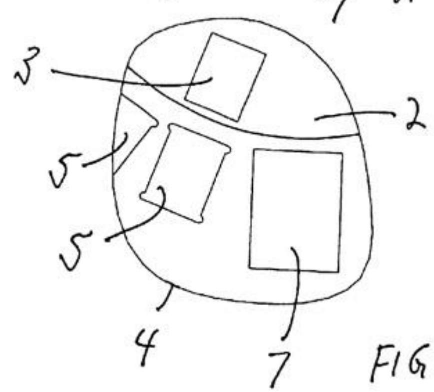
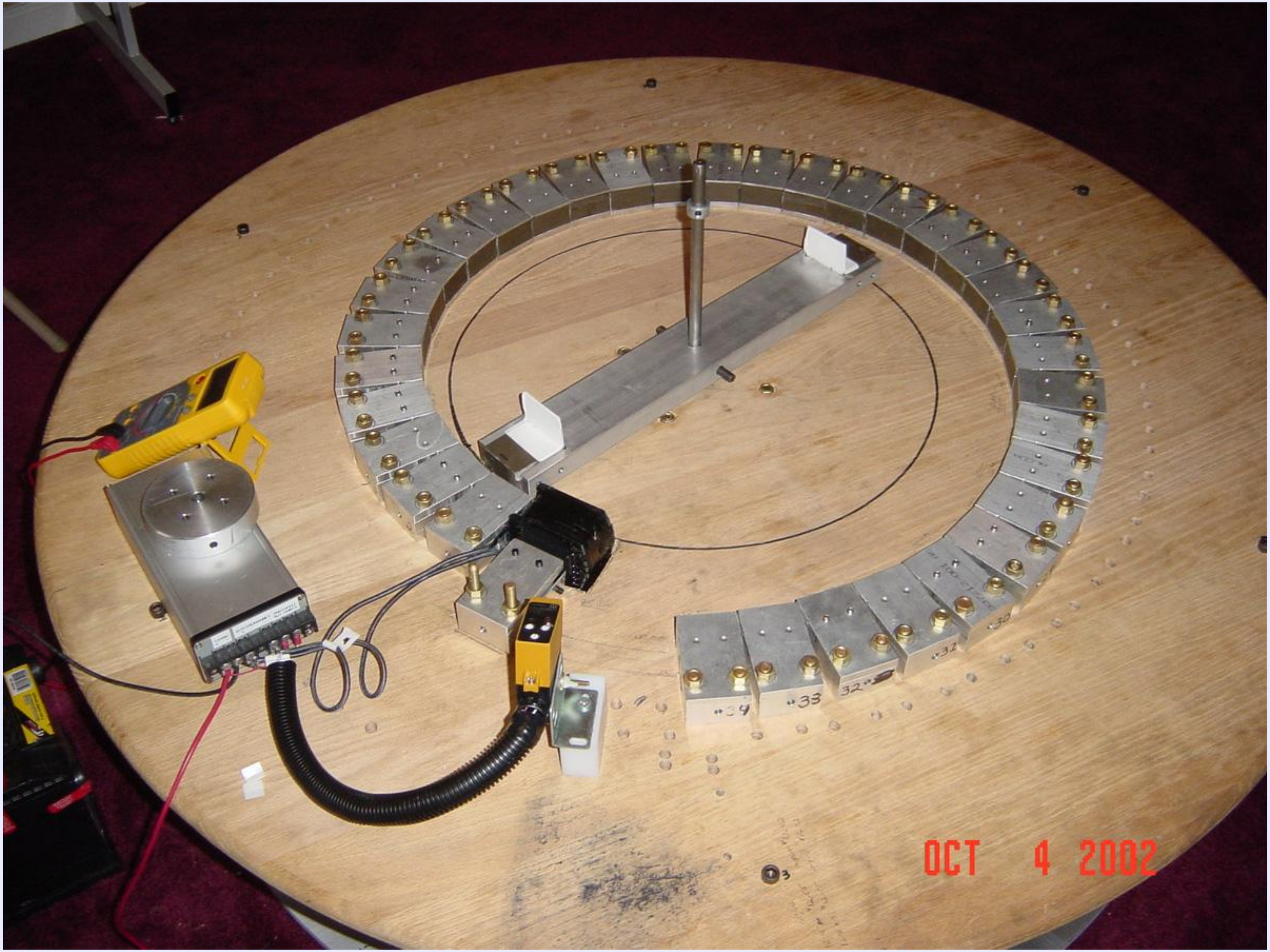


FIG. 3

Paul Sprain’s Spiral Motor



Picture Courtesy of Tom Valone

The Problem*, Solution 1

- The purpose of spiral arrangement is to confine the back EMF to a single portion of the motor. As the rotor enters the spiral detent or gap, it must be suddenly gauged asymmetrically to a magnetostatic scalar potential equal to or greater than the potential at the other end of the spiral gap where the magnetic gap is smallest. (Bearden, www.cheniere.org)

- In other words, the rotor magnet has to be given a "kick" to get by the last magnet (or first magnet) to restart the spiral, this takes energy.

* Remember Valone's Rule #1

Study Aid

Valone's Rule #1:

Electric input energy, or its substitute, is always necessary with a basic Archimedean spiral magnetic gradient motor.*

* Don't forget Valone's Rule #1

The Problem, Solution 1

This sudden increase in the magnetostatic potential (asymmetric regauging) can be accomplished in the following manner:

During the time the stator is rotating, a trickle current is maintained, at a small voltage, through the coil of the electromagnet. Just as the rotor enters the spiral gap, a sensor indicates its position and causes the circuit to abruptly open. This creates a high dv/dt in the coil of the electromagnet. Due to the Lenz law effect, a sharp di/dt is created in the coil, which produces a sharp and sudden increase in the magnetostatic potential called the multi-valued potential.

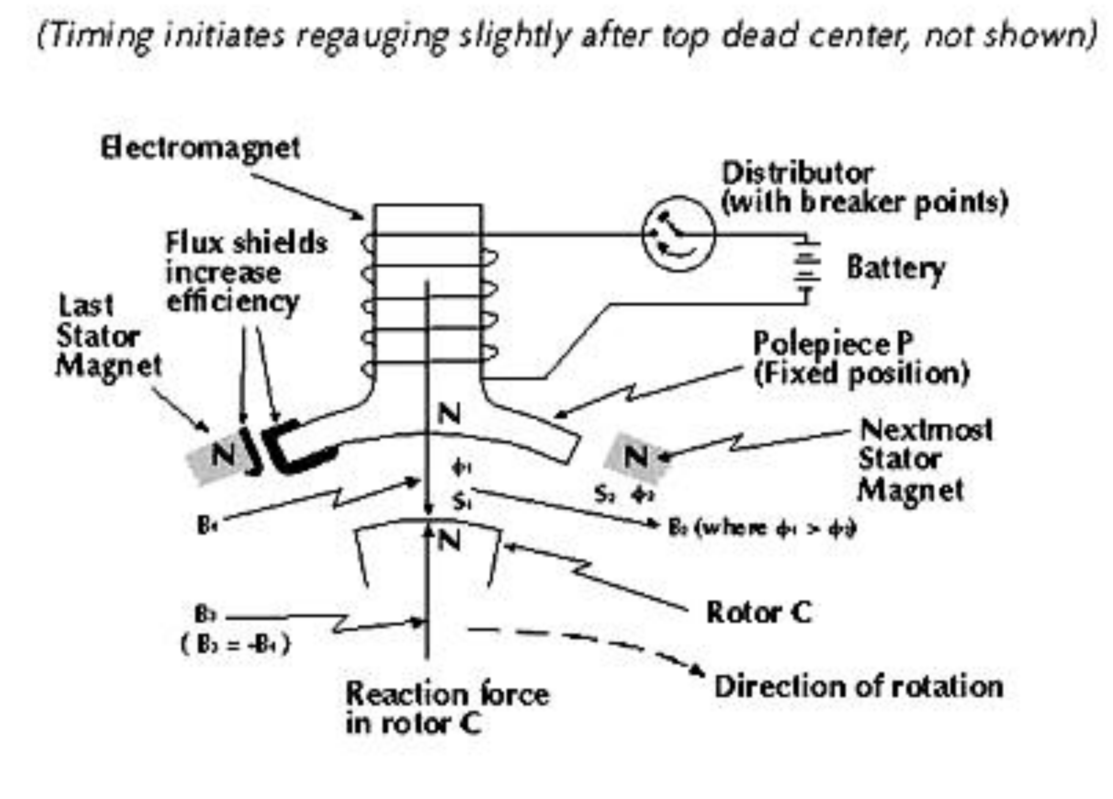
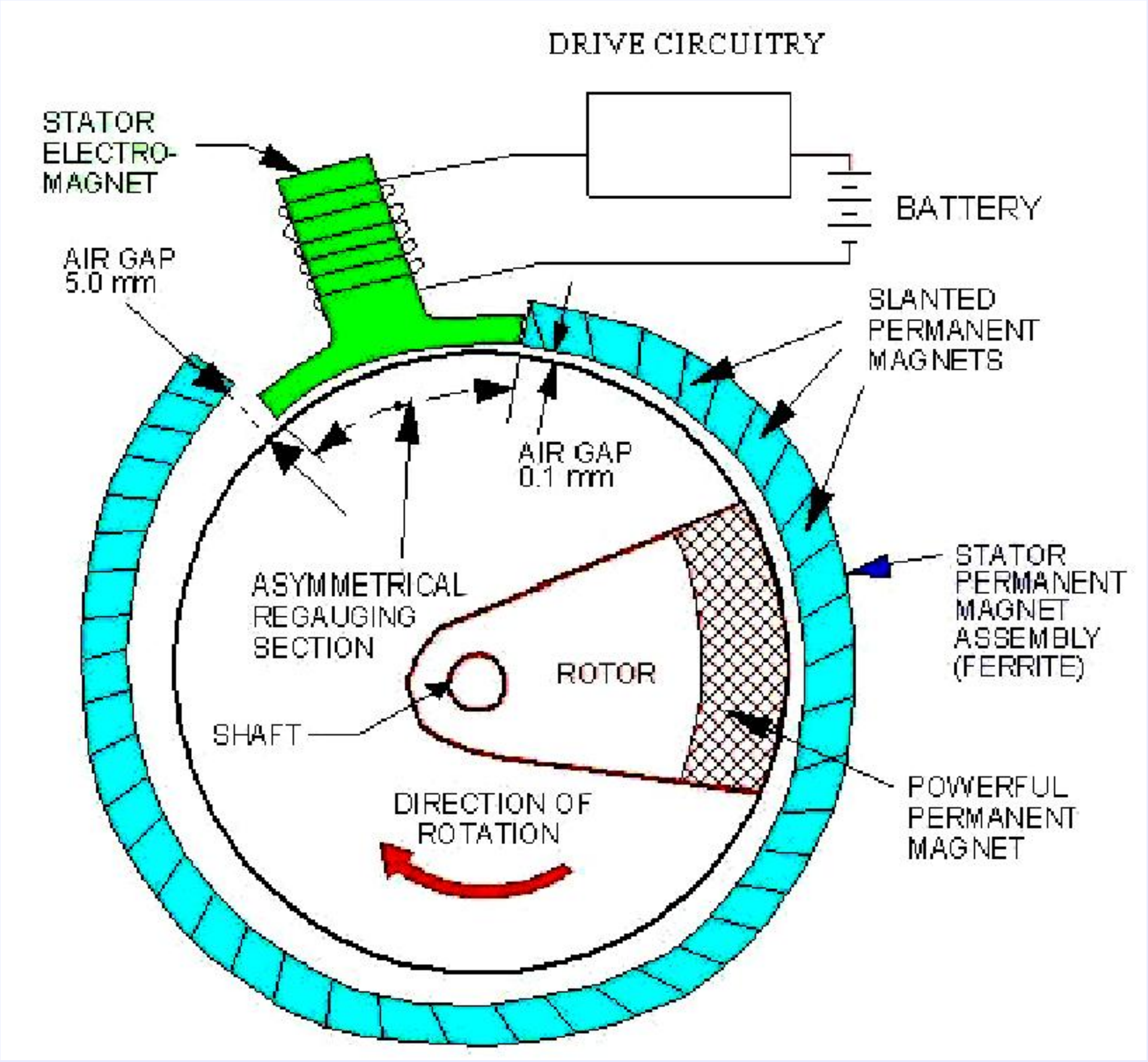


Figure 4. "Regauging Force and Potential Relationships

© 1995 T.E. Bearden

Review: Regauging the Magnetic Rotary Engine



http://www.cheniere.org/misc/wankel.htm

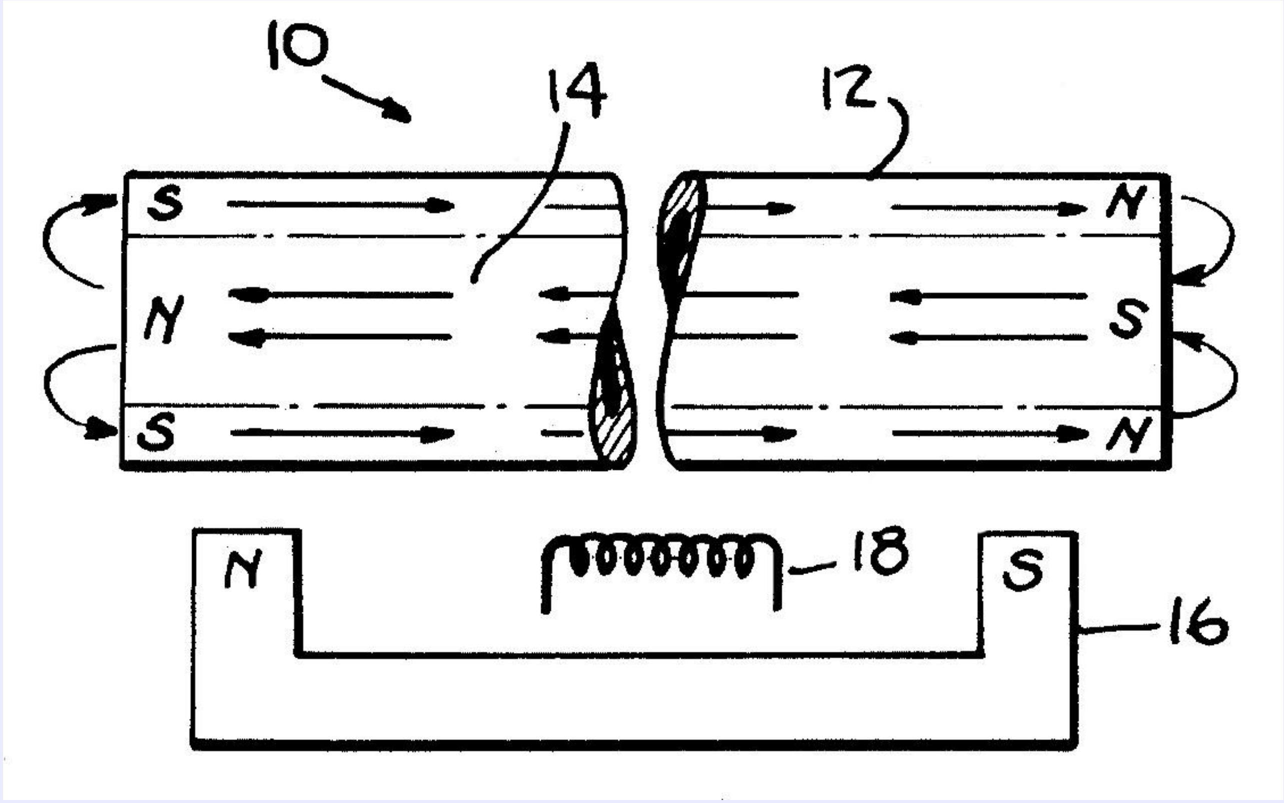
The Problem, Solutions 2 a and 2 b

Since the problem with the ESLIM design configuration is providing the source of power, we address both the power source and it useage.

Source (2a): We suggest (based on Bearden's recommendation) that we utilize magnetic domain switching, the "Barkhausen Effect". This effect is normally overlooked in magnetic motor design and offers a microscopic source of magnetic anisotropy energy.

This effect occurs in "Weigand Wire", where domain switching occurs with the sudden passage of a rotor magnet. If a return switching occurs beside a coil, a sharp current is produced. This is explained further in the next few slides.

Pulse generating wire and sensor for Weigand Ignition System



10. Weigand wire
12. Wire shell (high magnetic coercivity)
14. Wire core (low magnetic coercivity)
16. Permanent magnet causes the flux direction of the core to reverse)
18. Coil in which magnetic pulse is induced creating a voltage pulse

US Patent # 3757754 (1973), John Weigand, Ignition System, Fig. 1.

Wiegand Effect, cont.

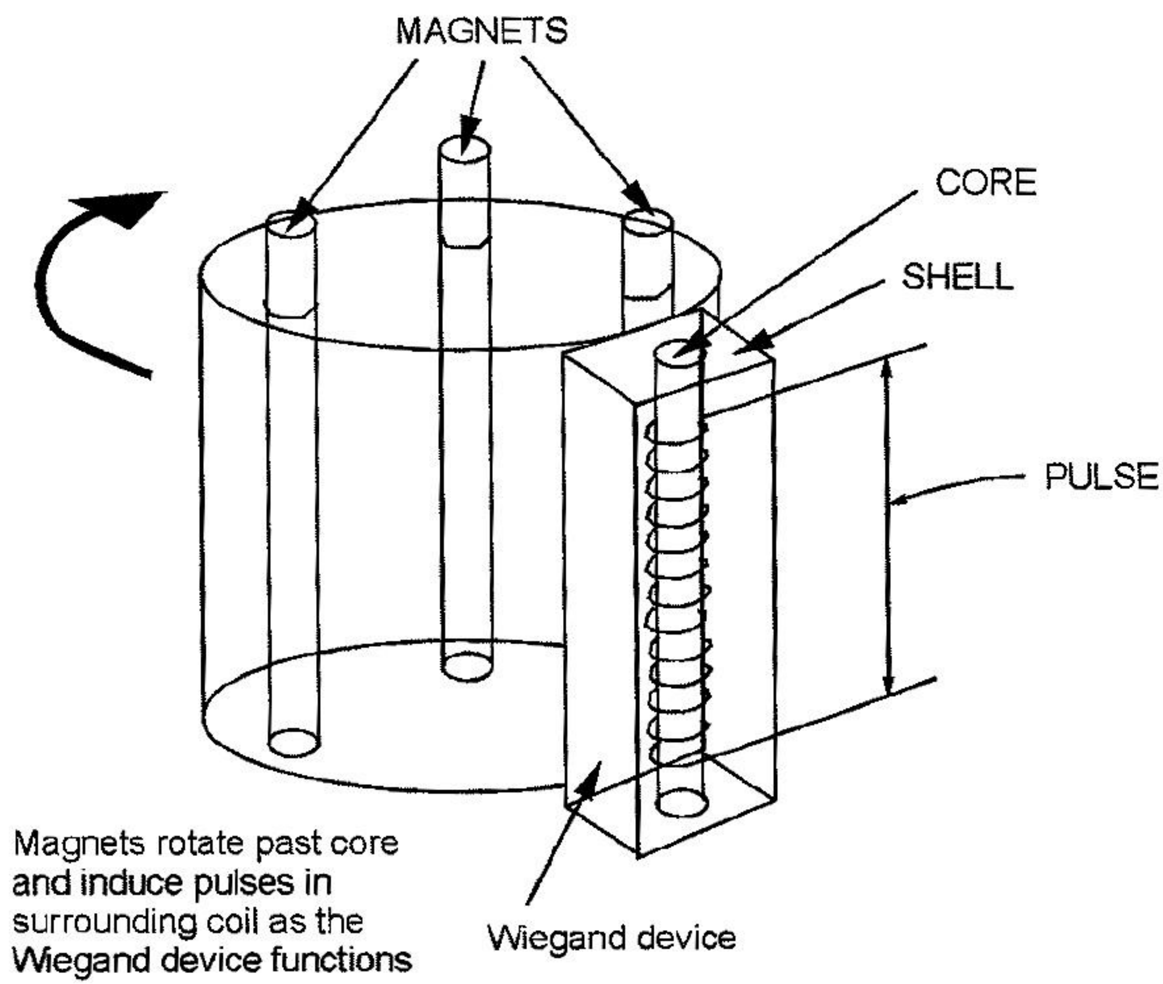
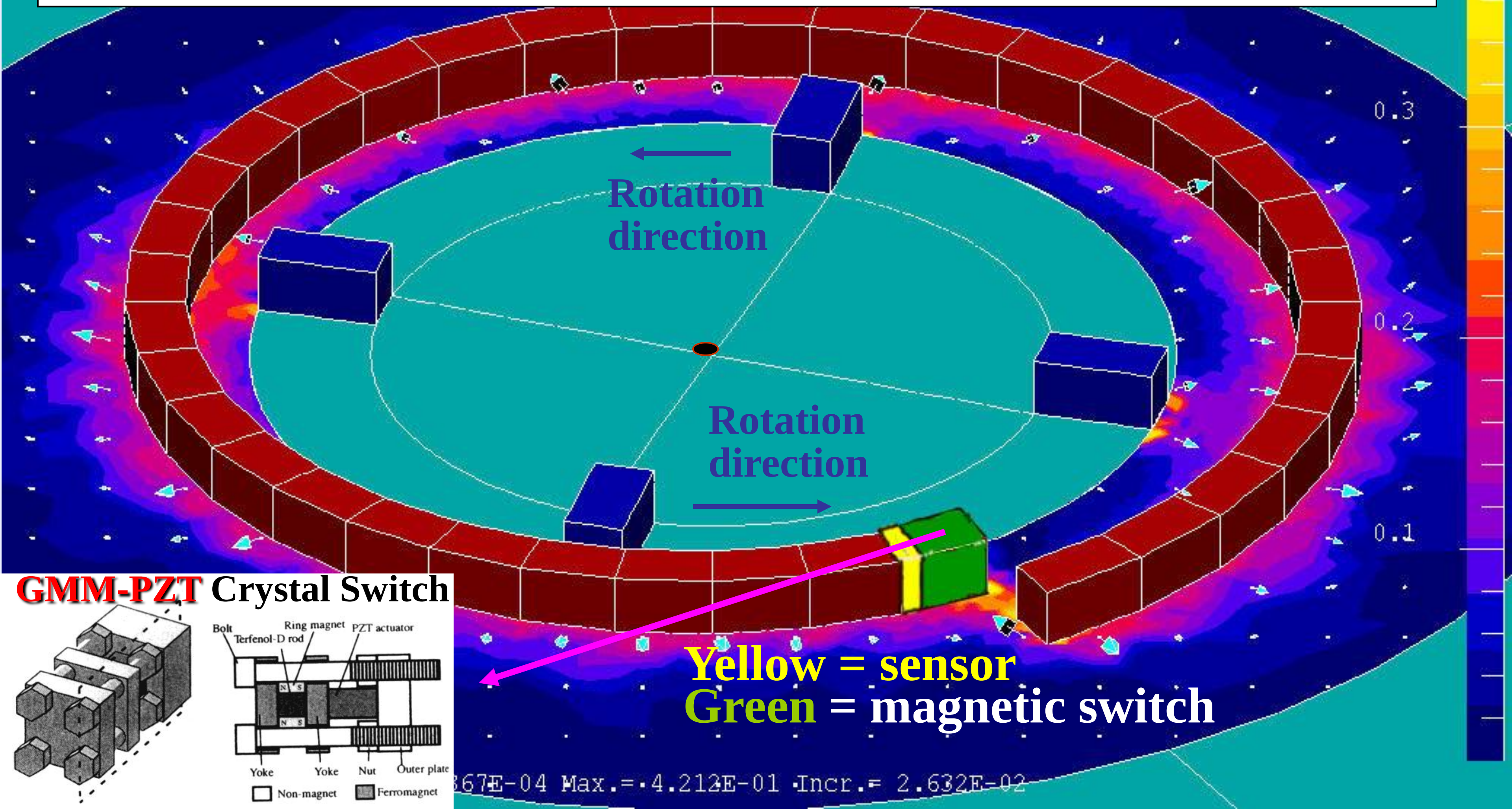


Figure 6-29 Operation of the rotary Wiegand pulse generator.

Bearden, Thomas, 2002, Energy from the Vacuum, 952 pp. Cheniere Press, Santa Barbara, CA

Power Usage (2b):
New Switch for Spiral Motor

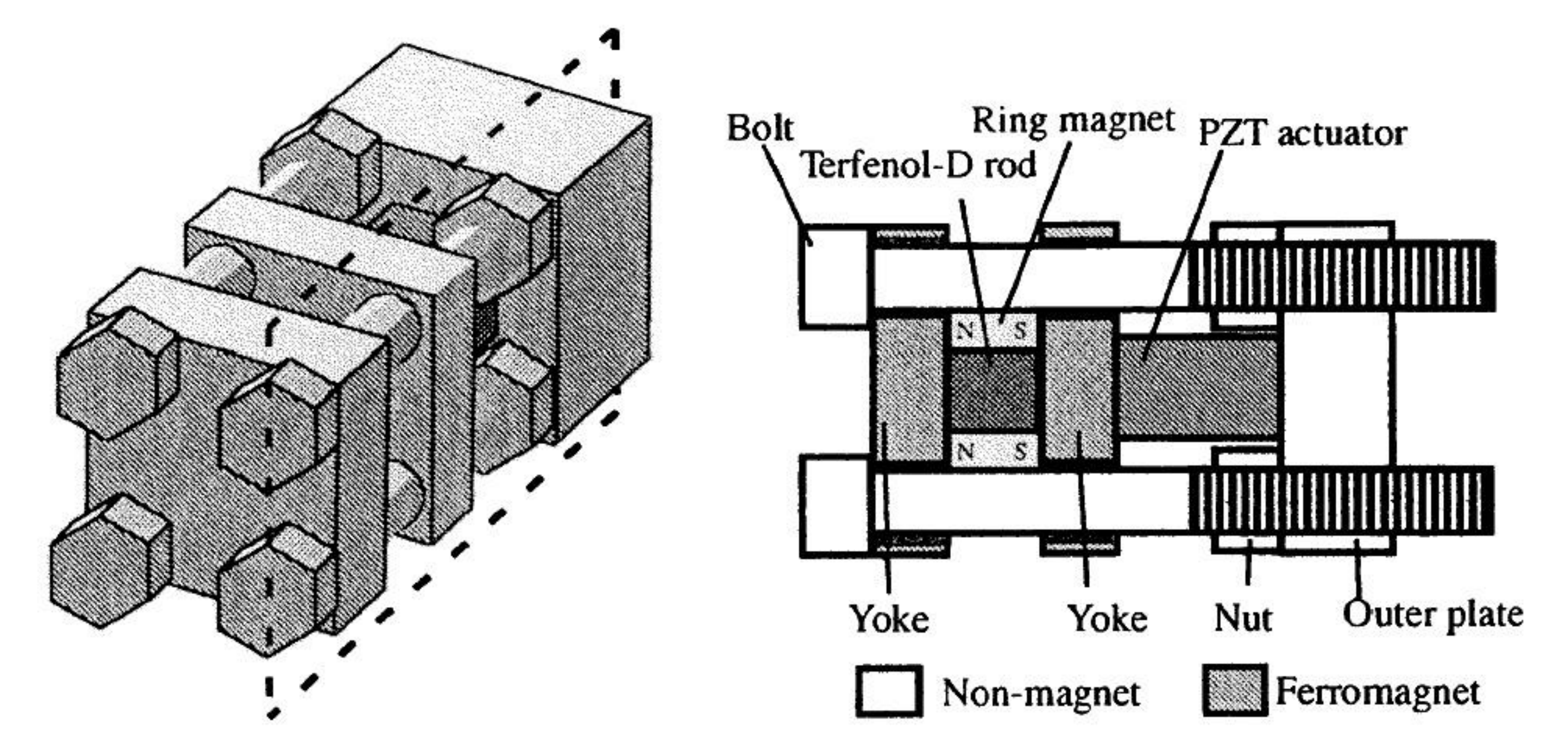
“The amazing thing is that the energy fields of a crystal can be used without plugging it into a power station.” - Dr. Seth Putterman, Nature, May 4, 2005



The Problem, Solution 2 b

Power usage - How to reduce the power requirements

Use a **GMM-PZT Device**



The device includes a giant magnetorestrictive Terfenol-D rod (GMM) coupled with a pizeoelectric (PZT) actuator. It consumes no power to maintain a static magnetic field and shows power savings of up to 78% for pulsed magnetic field production at 10Hz.

Ueno et al. 2003. IEEE *Trans. On Magnetics* 39: 3534 (Fig.1)

Comparison of Electromagnet (Coil) and GMM-PZT Device energy usage in experiments by Ueno et al.

COMPARISON OF POWER CONSUMPTION OF ELECTROMAGNET AND DEVICE IN STATIC AND DYNAMIC OPERATION

	Coil vs. E.M.	GMM-PZT Device
Static operation		
Max input voltage [V]	2	200
Power consumption [W]	3.0	0.0
Dynamic operation (10Hz)		
Max input voltage	2	200
Power consumption	1.2	0.27
Dynamic operation (100Hz)		
Max input voltage	2	200
Power consumption	1.2	2.47

22% of coil power → Power consumption (10Hz)

Goal: Find the sweet spot.

Ueno et al. 2003. IEEE *Trans. On Magnetics* 39: 3534 (Table IV).

The Problem, Solution 3 (additional methods)

- Use other methods that optimize the stator magnetic field array such as a Halbach Array:

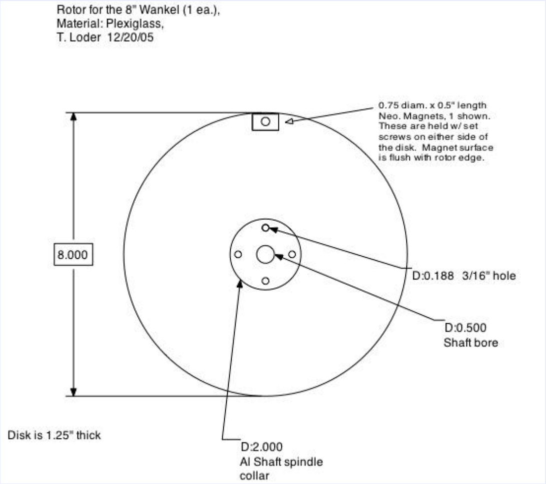
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

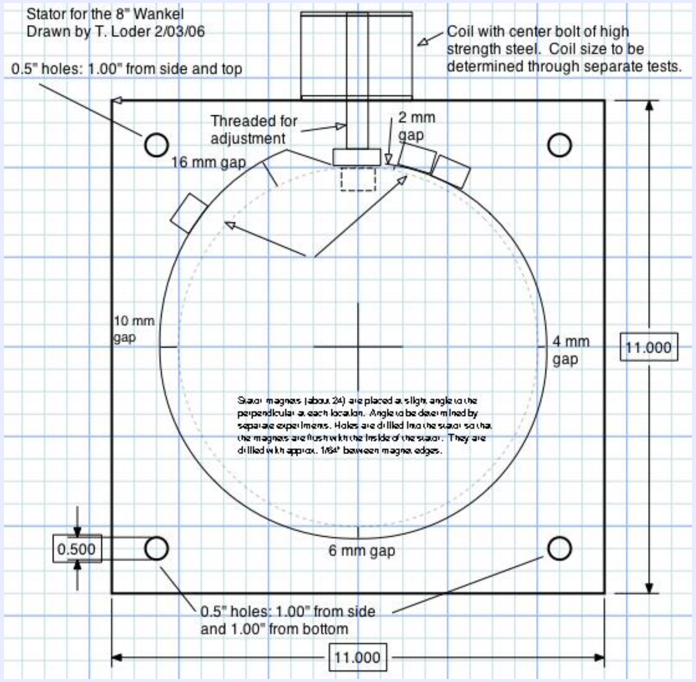
- Or methods that enhance the rotor power such as use of Hysteresis Motor technology in which an iron or steel plate set parallel to the rotor becomes momentarily magnetized during the rotor's passage and helps push the rotor forward.

- Or clever use of magnetic shielding materials and/or magnet placement to alter the attraction or repulsion to help reduce energy needs for the rotor magnet to pass by the detent area.

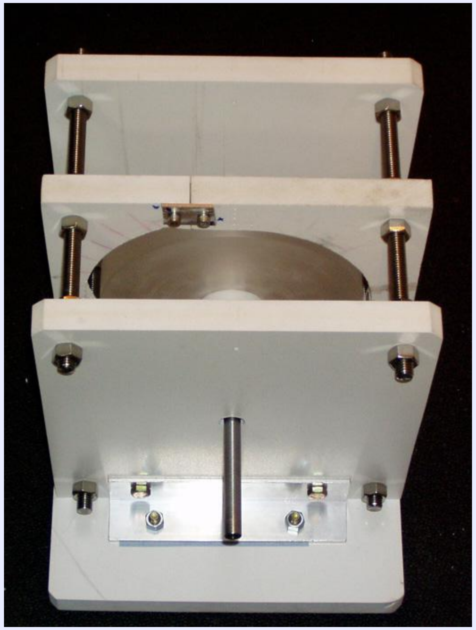
- Use High efficiency generator (Flynn motor/generator?) to produce the power….

So armed with some of this knowledge I began to design my own motor……





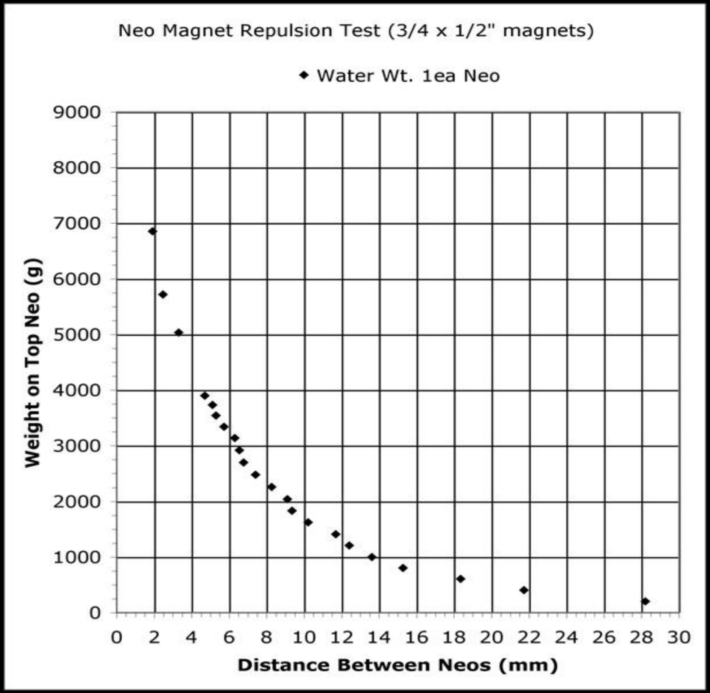
and later the motor sort of looked like the initial design……

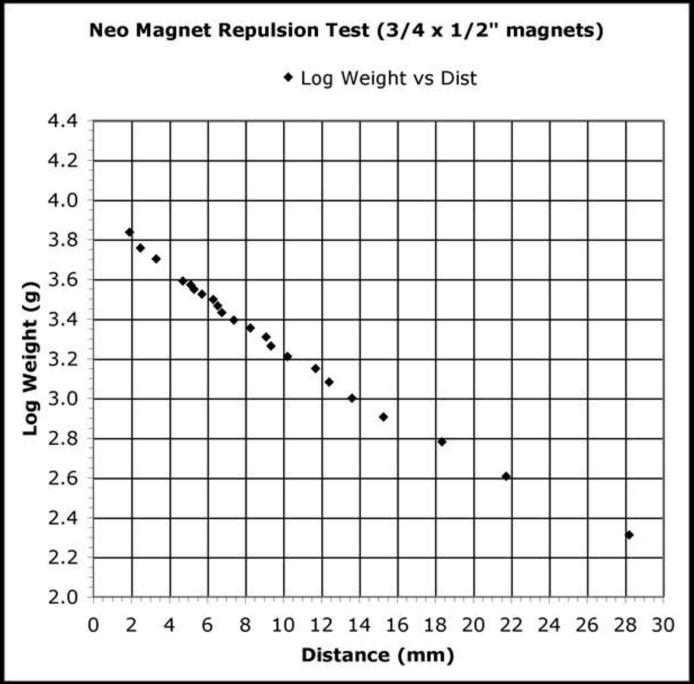


But even later not so……..

Measuring a Magnet's Repulsive Force

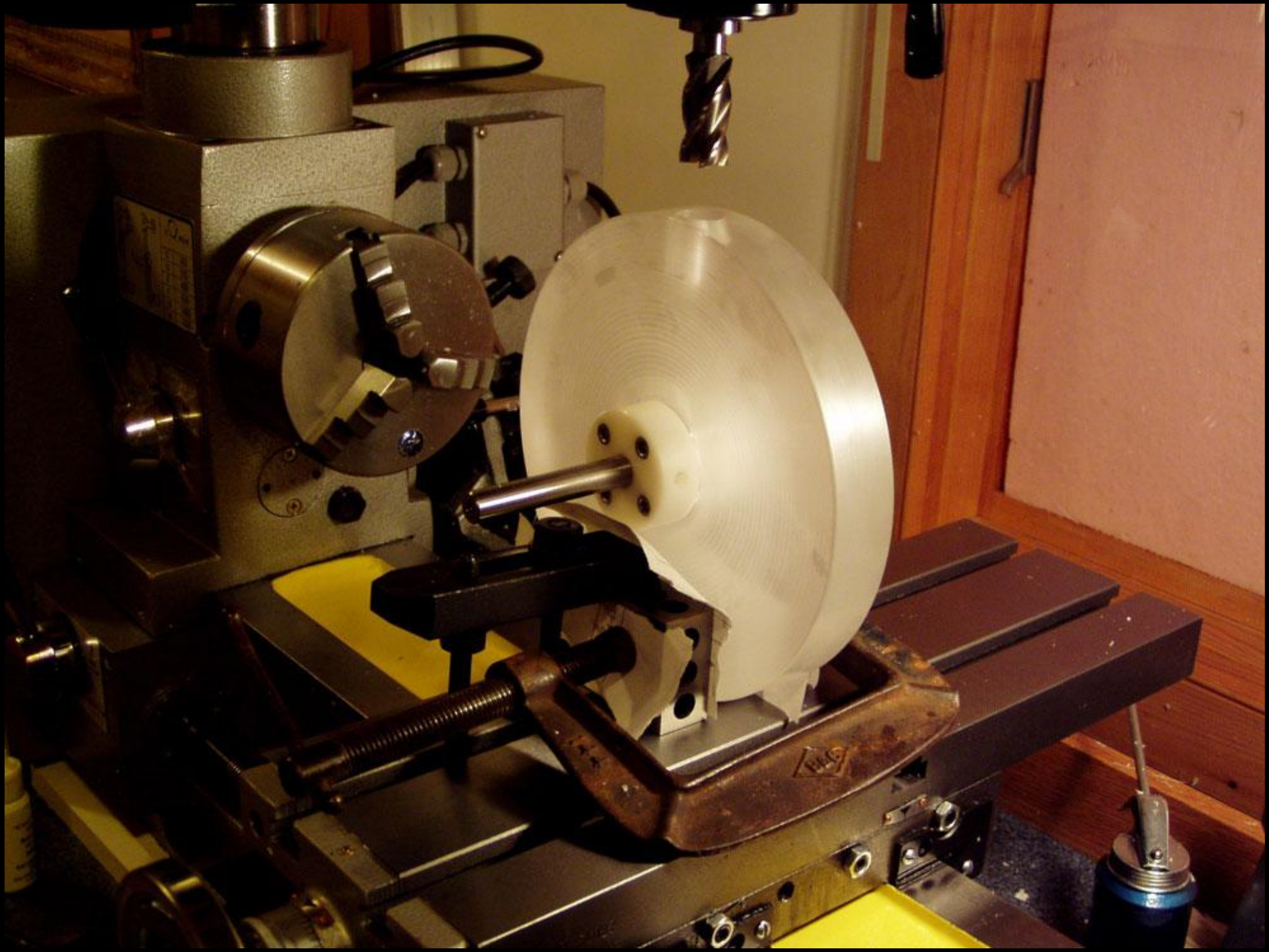
A Quick and Dirty Method





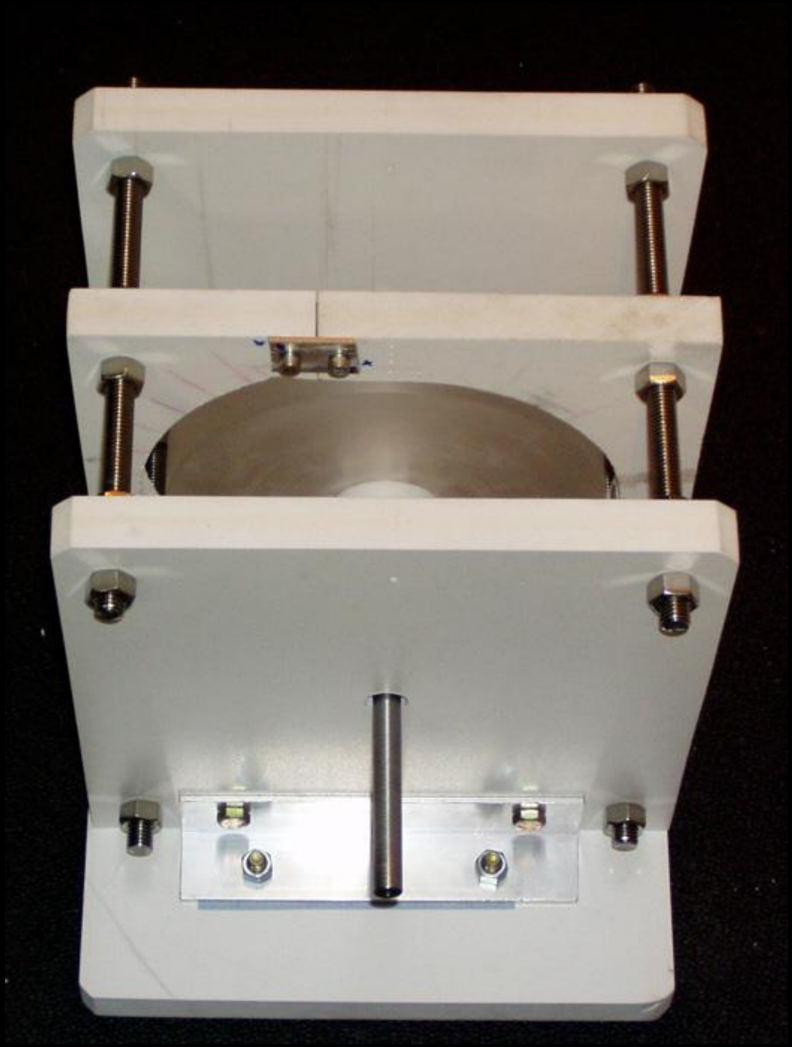
Rotor mounted on steel shaft with magnet hole in top

The hole is designed to hold 2 round Neo magnets (0.75 x 0.5 inches) with the magnet surface flush with the rotor surface.



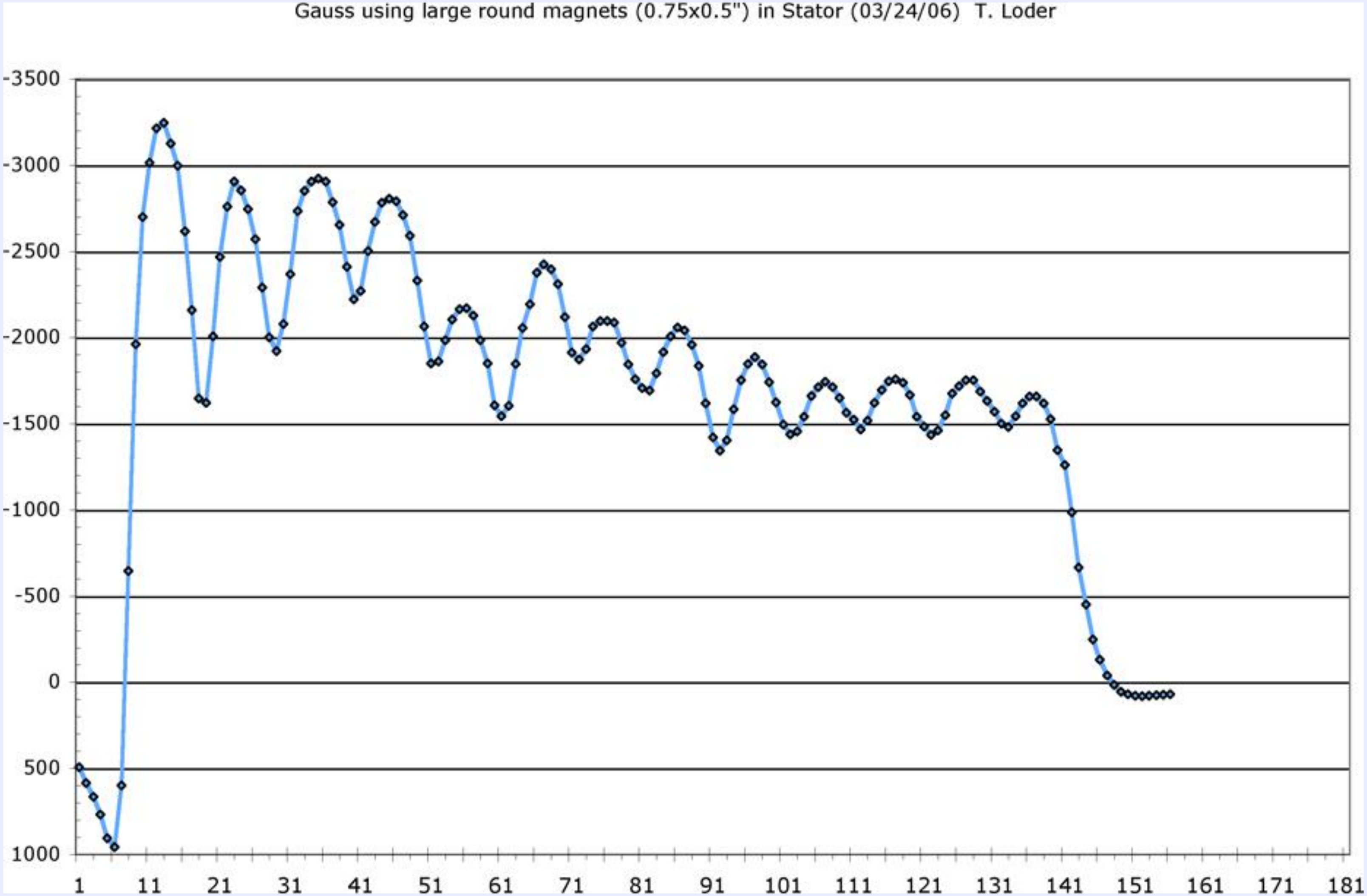
Wankel Version 1 with 0.75" round magnets in stator

Stator inside showing round magnets



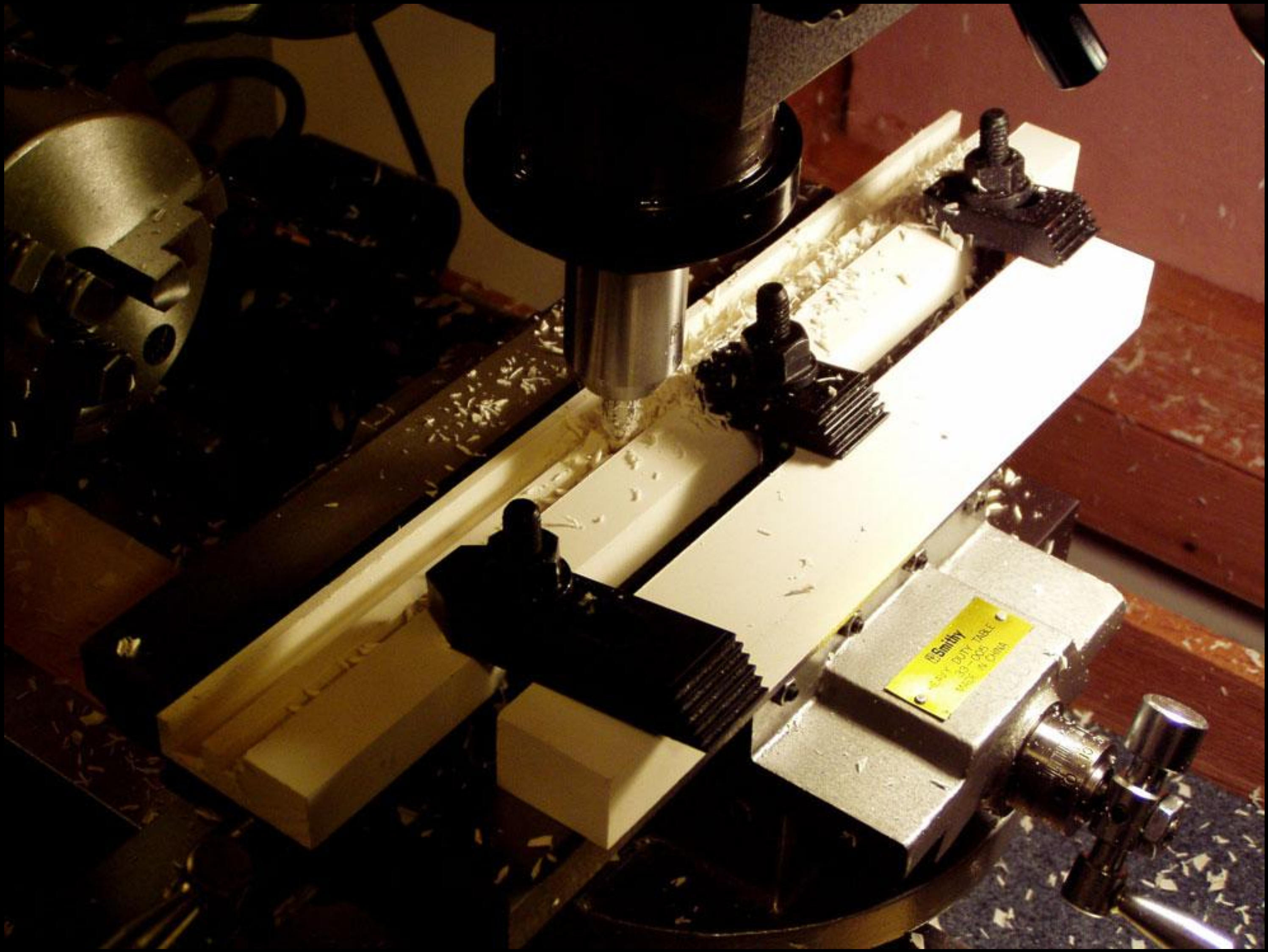
Motor initially assembled

Gauss Field at the Rotor Magnet Surface

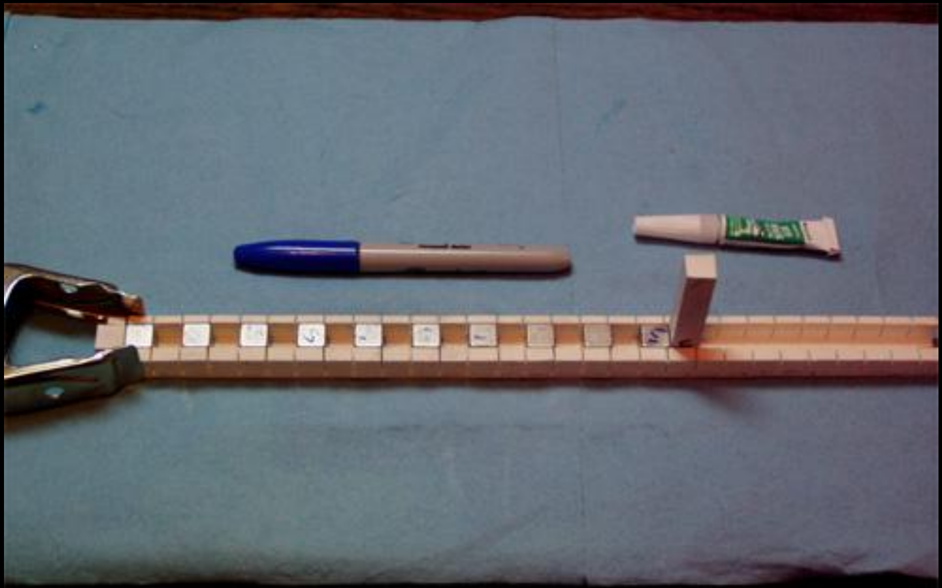


Initial plot of gauss field at the surface of the rotor with Version 1 stator using 0.75” round magnets just touching with a very uneven resulting field.

Machining spiral in Plexiglas stator version 2.0.

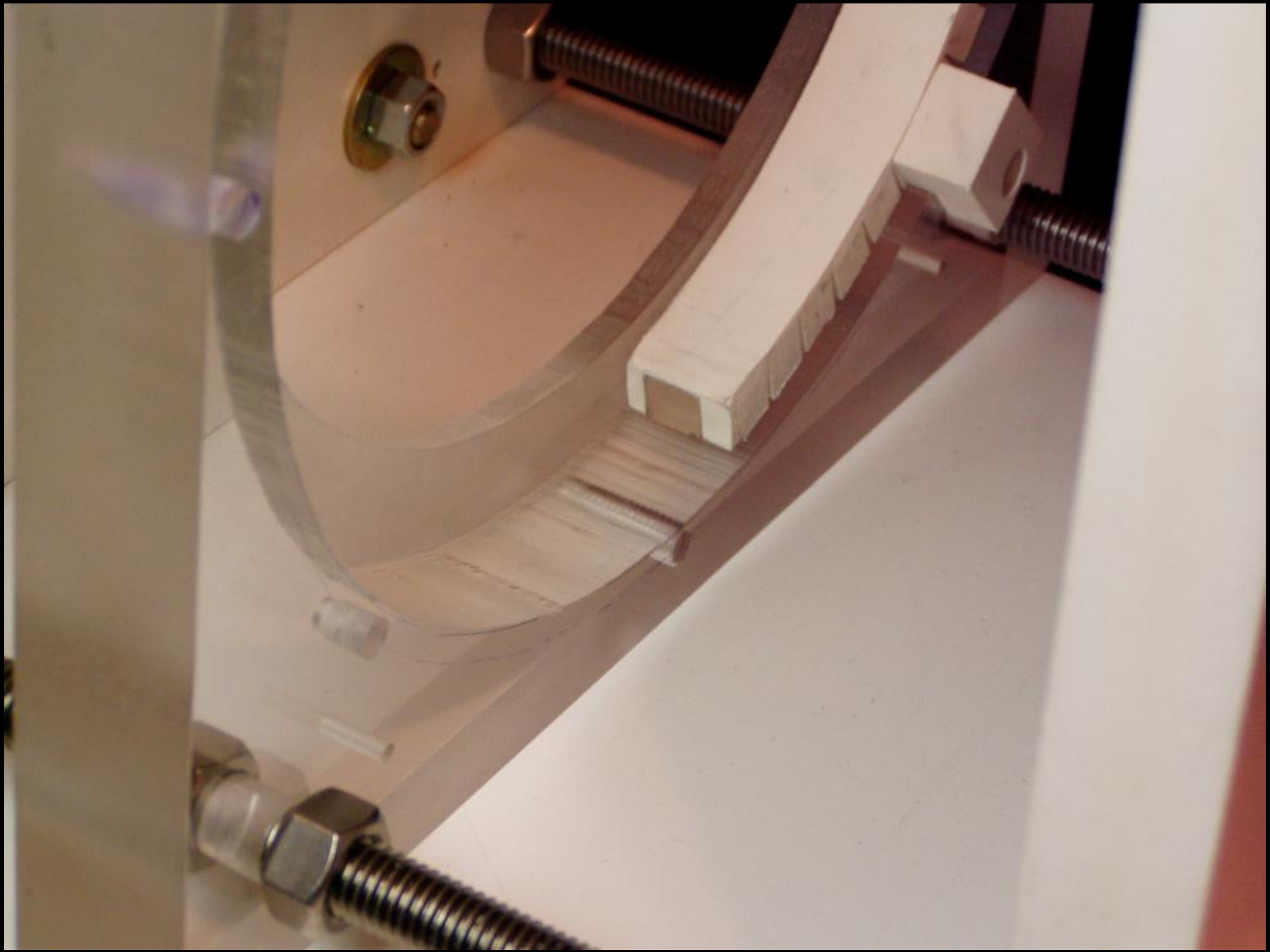


Machining the grooves in the stator magnet holder.
Two of these were used in the stator, holding about 50 magnets.



Stator Magnet Gluing

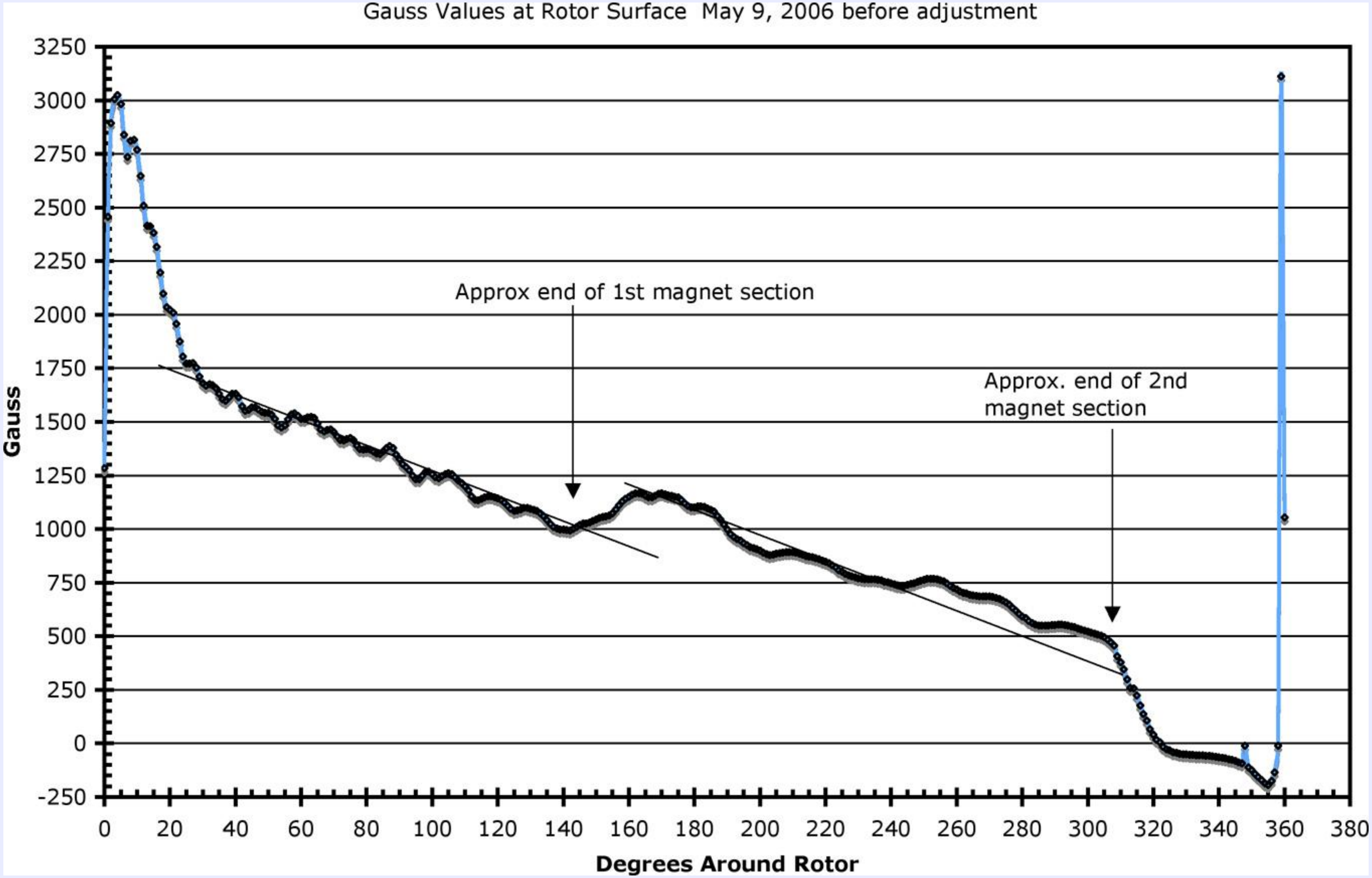
Gluing magnets in grooves in magnet holder. Each magnet was clamped to allow Super Glue to totally set before gluing the next one. The holder labeled TOP was used to align and insert a magnet between the others to overcome the expulsion force of many pounds. Note magnet in the left alignment hole. The process was tricky as the magnets resent being put together with strong repulsion forces.



Stator magnets in holder mounted and clamped in the spiral path.

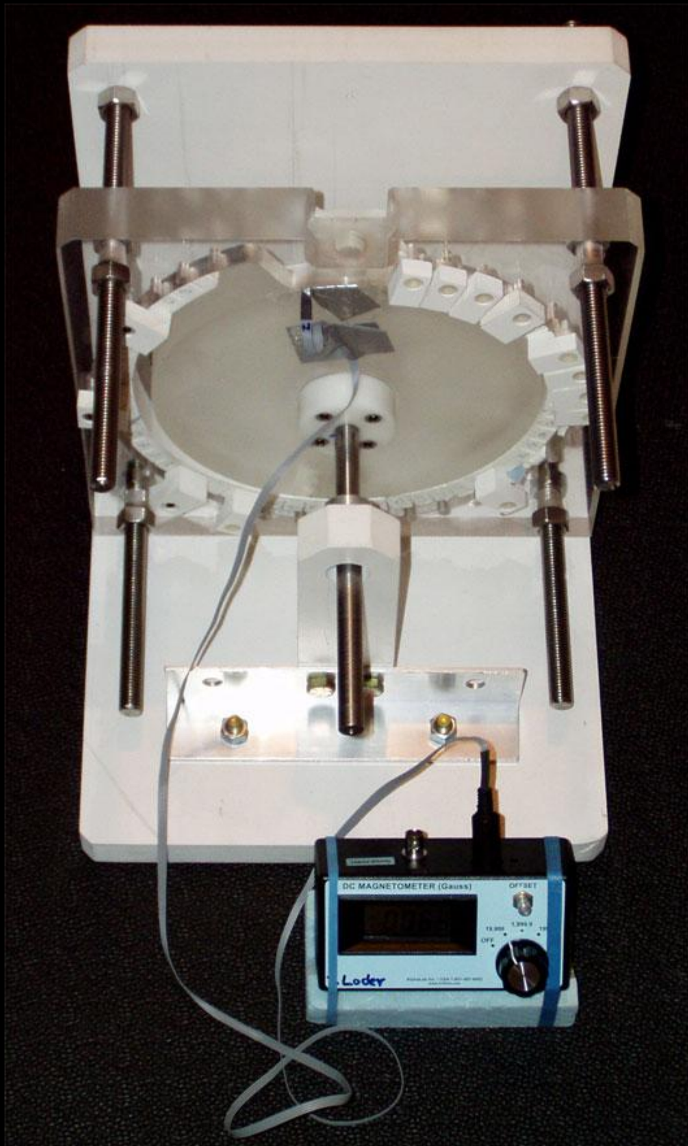
Overall setup used to measure initial gauss field. Readings were typed directly into the computer. Gauss meter is in the center.

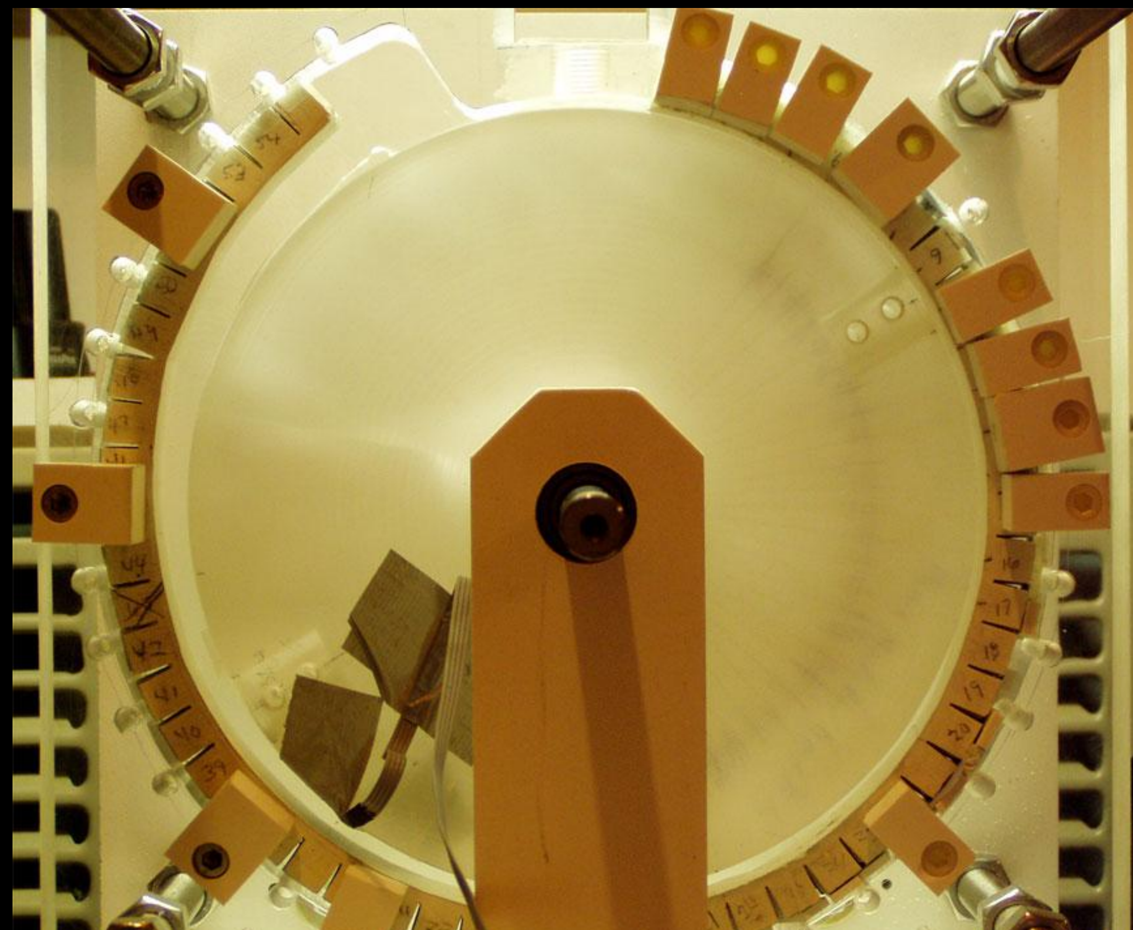
Gauss Field at the Rotor Magnet Surface



Initial plot of gauss field at the surface of the rotor with Version 2 stator using cube magnets and a quasi-Fibonacci Spiral

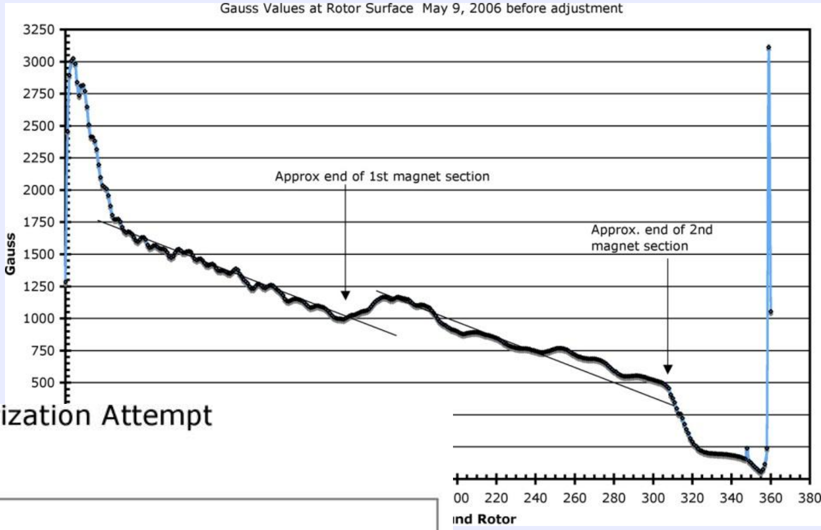
Wankel Version 2 Stator, Attempted Linear Spiral

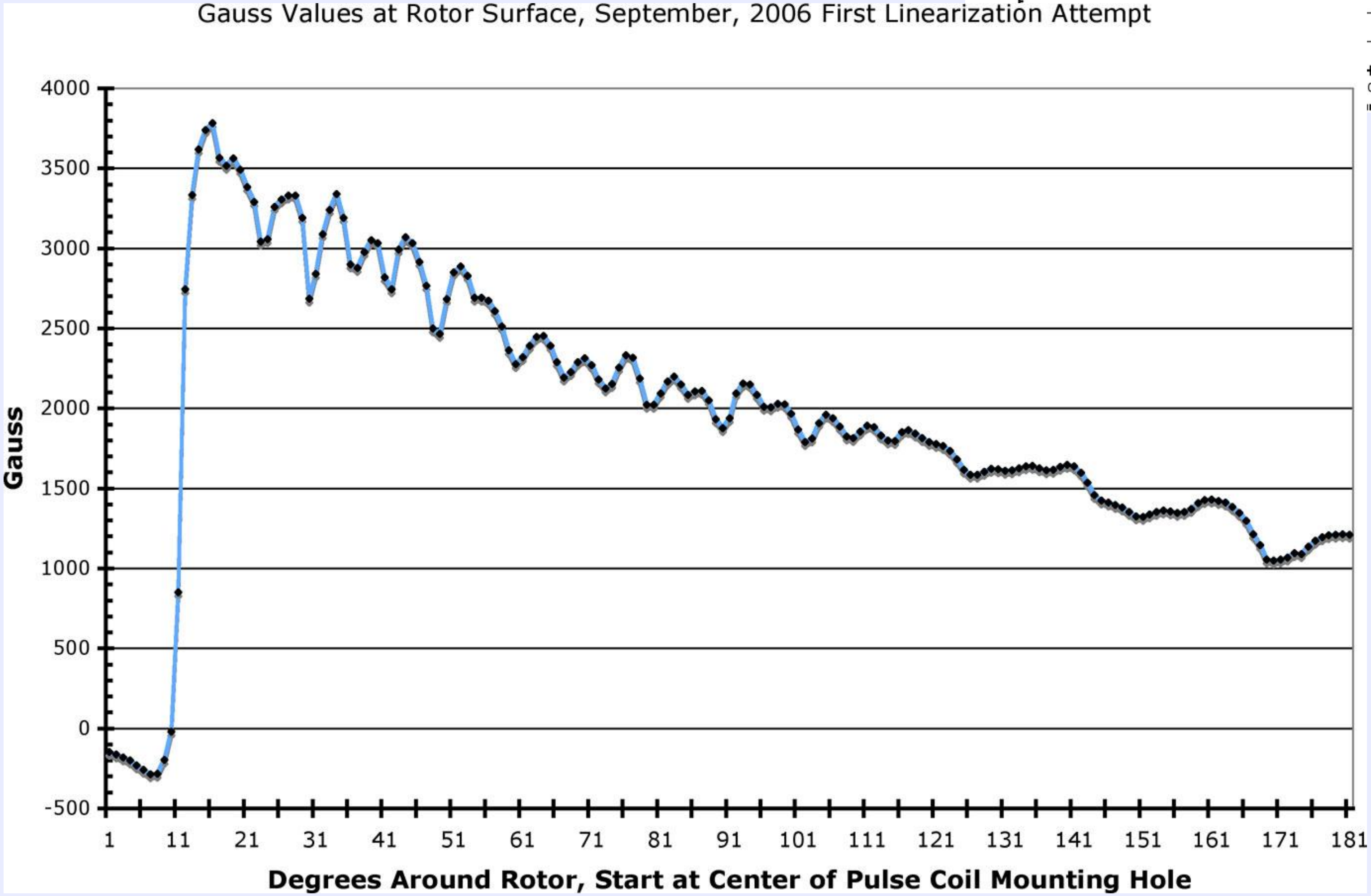




Plot of gauss field at the surface of the rotor with Version 2 stator

First Linearization Attempt Below





Future Work

Some necessary milestones to reach the goal of functioning MLIM (Magnetic Linear Induction Motor) **are:**

1. optimized permeable rotor design with multiple magnet heads (test use of hysteresis motor technology?)

2. optimized stator design with micro-adjustable magnets

3. improved stator magnetic field gradient that is decreasing at a constant rate (linear vs. X-type spiral?)

4. decreased energy input for magnetic field pulsing

5. zero energy input for magnetic field pulsing(self generating)

Future Work, cont.

6. complete disengagement (escape) of rotor after each cycle

7. enhanced initial engagement of rotor to eliminate kick-starting

8. optimized torque by maximizing radial magnetic field change

9. rotation control by mechanical/electromagnetic regenerative braking or other

10. computer animation of optimized total design

This Work to be cont.

The End