Coaxial Capacitor Thruster

Horace Heffner April, 2005

The design of a simple resonant Coaxial Capacitor Thruster experiment which follows indicates a thrust of about 1 kilogram force per kilowatt may be feasible. An “open capacitor” version is shown in Fig. 1. This open capacitor design is known to not produce net thrust, but is provided as a model for the coaxial version proposed later below.

```
 Toroid
o========o:::
          | |
 ---------- -----o-xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx  Capacitor plates
 | B1           P1
 |
 | B2           P2
 ----------------o-xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx


Note -

 B1 and B2 are the bends with partially unopposed self-forces

 P1 and P2 are power supply points

 It is assumed the toroid coil can be taken off vertically
 without inducing a net lateral force.


Fig. 1 - DIAGRAM OF RESONANT OPEN ENDED THRUSTER
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For coaxial versions see Figs. 2 and 3 below.

TOROIDAL CONDUCTOR

Assume the conductor is made of tubing about 0.5 cm diameter. Small radius of the torus is 4 cm. Inner radius of torus is 15 cm. Major radius Mr is thus 19 cm. and outer radius is 23 cm. Total of N = 45 turns Coil area A is about 50 cm^2. Coil conductor length is about 11.3 m. Inductance is approximated by:

L = u N^2 A (1/Mr) (1.26x10^-6 H)

L = (1) (45^2) (50) (1/(19)) (1.26x10^-6 H)

L = 6.71 mH

CAPACITOR

Plate size is 23 cm x 50 cm, giving an area of 1150 cm^2. Plate separation is 0.5 cm, of which 0.12 cm is 20 kV insulation with dielectric constant Ke = 8 and the rest is dielectric constant Ke = 1. Capacitance is given by:

C = Ke (A/d) (8.85x1010^-12 F)

For the insulating layer:

Ci = 8 (1150/0.12) (8.85x10^-12 F)

Ci = 6.79x10^-7 F

For the air layer:

Ca = 1 (1150/0.38) (8.85x10^-12 F)

Ca = 2.68x10^-8 F

Total capacitance:

1/Ct = 1/Ci + 1/Ca

1/Ct = 1.473x10^6 + 3.73x10^7 (1/F)

Ct = 2.58x10^-8 F

ALTERNATE DESIGN FOR CAPACITOR - COAXIAL

A design with similar values can be obtained by making the capacitor coaxial In that case the plate fed by P1 would be the outer sheath and P2 the inner conductor. This has the advantage of minimizing external waste AF radiation. Except for concerns about resistance, the coax can be made as long as necessary to accommodate the desired capacitance.

To approximate an equivalent coaxial capacitor to the above flat plate design we can use an inner diameter of 7 cm and an outer diameter of about 7.5 cm, and length still of about 50 cm. The thrust comes from the fact the trailing end of capacitor is open, which is clear with the flat plate capacitor design, but not so clear with the coaxial design. Proof of that the two are equivalent may require running a high resolution FEA model. However, it appears that both are equivalent, and in any case that this point is comparatively moot in that the principle issue involved, namely waste audio frequency radiation, is a comparatively small issue compared to the issue of whether the basic concept works.

RESONANT FREQUENCY

The resonant frequency f0 is given by:

f0 = 1/(2 Pi (L*C)^0.5)

f0 = 1/(2* 3.1415 * 1/(1.73118x10^-10)^0.5)

f0 = 12,096 Hz

REACTANCE AND IMPEDANCE

Capacitive reactance Xc is given by:

Xc = 1/(2 Pi f0 C)

= 1/(2 * 3.1415 * 12,096 * 2.58x10^-8) ohms

Xc = 510 ohms

Inductive reactance Xl is given by:

$$Xl = 2\ Pi\ f0\ L$$

$$Xl = 2 * 3.1415 * 12{,}096 * 6.71\text{x}10^{-3} \text{ ohms}$$

$$Xl = 510 \text{ ohms (check)}$$

The impedance $Z = (R^2 + (Xl-Xc)^2)^{0.5}$ is thus equal to resistance R.

POWER AND CURRENT

If we assume a coil resistance of 1 ohm per 1000 m, or 0.001 ohms per meter, we have a coil resistance of 11.3 m * 0.001 ohms per meter = 0.0113 ohms. Assume the power supplied Ps = 1500 W. If It is the resonance tank current then the heat Ph dissipated in the coil is given by:

$$Ps = Ph = 1500 \text{ W} = It^2*(0.0113 \text{ ohms})$$

So:

$$It = 364 \text{ A}$$

We have a very high Q coil, because:

$$Q = Xc/R = 510/0.0113$$

$$Q = 1858$$

This gives Is the supply current:

$$Is = It / Q = 636/1858$$

$$Is = 0.196 \text{ A}$$

And the supply voltage:

$$Vs = Ps / Is = 1500/ 0.196$$

Vs = 7653 V

The apparent power in the tank circuit is:

Pt = It * Vt = 7653 * 364 W

Pt = 2.79 MW

MAXIMUM RADIATION FORCE

Note that the above numbers all ignore radiation. Additional power must be supplied to account for any radiation. However, note that, at 1500 W power supplied, that the *force* from any radiation can be ignored. There is 2.94x10^9 photonic watts per kg-f of thrust, so the 1500 watts could only produce 5.1x10^-7 kg-f thrust.

SELF-FORCE OF THE CLOSED END COAXIAL CAPACITOR

Estimating the cap force for a capped coax:

Fc = 1.61x10^-3 N

Fc = 0.165 g-f

Though small, a force of about 1/10 gram is sufficiently large to attempt detection, and to be very useful. Also, this rough design is only to provide sample calculations as a starting point for an actual experiment design. Such a device, or one of approximately the same dimensions can be fairly readily constructed from ordinary copper materials and a custom power supply.

At 2.94x10^9 photonic watts per kg-f of thrust, the 10^-4 kg-f would require 294 kw of broadcast power. This number is way above the 1.5 kw power supplied, but interestingly way below the Pt = 2.79 MW apparent power of the resonant circuit.

It is also notable that by using a larger inductance and capacitance that the frequency could be dropped further and thus Q improved by reducing the skin effect, and also by using a solid conductor for construction of the toroidal inductor. The estimated 0.5 cm wire size corresponds to 4 gage copper, which is 0.2533 ohms per 1000 feet, or 0.831 ohms per 1000 m. Using 3 gage copper, a 10 percent increase in wire diameter, gives only 0.659 ohms per 1000 m, thus improving R by 51 percent and net force by 230 percent, to 0.378 g-f. However, resistance of the capacitor has been ignored, due to its small length. Achieving low resonant frequency involves use of a much longer capacitor, thus capacitor resistance will play a significant role. Increasing capacitance by reducing the capacitor gap width is fruitless because net thrust is roughly proportional to the gap width. The thrust is essentially provided by the fact that some (angular) percent of a closed current loop is open.

CRYOGENIC ALUMINUM

Aluminum has a conductivity of 0.377x10^6 ohm^-1 cm^-1, while copper is 0.596 x10^6 ohm^-1 cm^-1, thus copper provides 58 percent better conductivity, but 250 percent better thrust per watt. Aluminum has advantages over copper for propulsion due to a 70 percent savings in weight. At 21 deg. kelvin high purity aluminum resistance drops to less than 1/500 to 1/1000 times that of room temperature, thus providing an over 100,000 improvement in thrust/watt over copper. At this amplification the 0.1 g-f thrust becomes 10 kg-f. This amply repays the cost of 1500 W of refrigeration, which in space can hopefully be provided at a power cost of less than 10 kW. If so, a thrust/power ratio of about 1 kg-f/kW is achieved.

SUPERCONDUCTING RESONATOR

The lower resonant frequency achieved by use of much larger capacitors and inductors should permit use of superconductors, with a much larger net thrust feasible, and lower refrigeration cost. The major impediment to the use of superconductors may be the radiation from SC surfaces exposed to high voltage gradients.

COAXIAL DRIVE CONFIGURATIONS FOR SHIP

Figs 2 nd 3 show coaxial drives as they might be implemented in a large ship.

```
------------
|          |
|          --------------------------------
|===T-------------------------------
|          --------------------------------
|          |
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Note - T represents power, oscillator, and toroidal coil unit
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Fig. 2 - Open ended coaxial drive with bulged power housing

```
------------
|          |
|          --------------------------------
|===T-------------------------------      |
|          --------------------------------
|          |
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Note - T represents power, oscillator, and toroidal coil unit
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Fig. 3 - Closed ended coaxial drive with bulged power housing

The toroidal coil and oscillator (denoted "T") can be enclosed in a bulge at the end of the coaxial coil. External power could be supplied by leads inside a smaller "head" coaxial lead, denoted "===", or the power unit, probably a nuclear reactor, could be enclosed within the bulged power housing itself.

It is notable that, provided the central conductor terminates well before the end of the coaxial sheath, an end cap on the sheath should have no effect other than to capture or reflect any radiation. As shown above, this can only have negligible effect on thrust.

DISPLACEMENT CURRENT

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There is always a displacement current, even between vacuum plates. The displacement current is exactly equal to the current to the capacitor, regardless of the presence of a (non-vacuum) dielectric or not. A little proof follows that the H generated by the changing E of a capacitor is identical to that from a conductor current, i.e. the displacement current is equal to the capacitor current.

Gig. 4 shows the basic picture.

```
  xxxxxxxxxxxxxx
   x            x
   x            x P1
   x       -----------
 power        gap          <==== hoped for thrust
   x       -----------
   x            x P2
   x            x
   xxxxxxxxxxxxxx

  Fig. 4 - Diagram of
```

Note: here interpret "@" as the partial derivative symbol below.

The capacitance of the capacitor is:

C = epsilon A/d

where A is the plate area and d is the separation. The conduction current is then:

i_c = C dv/dt = (epsilon A/d) dv/dt

On the other hand, the electric field in the dielectric, be it pure vacuum or not, is, neglecting fringing (which doesn't occur significantly in the coaxial version anyway):

E = v/d

Hence:

D = epsilon E = (epsilon/d) v

@D/@t = (epsilon/d) v/dt

and i_d, the displacement current, is (D normal to the plates) given by
(now using D as a current density vector, S a surface envelope):

i_d = integral over A{ @D/@t dot dS }

= integral over A{ (epsilon/d) dv/dt dS}

= integral (epsilon A/d) dv/dt

= i_c

so i_d, the displacement current, is always equal to the capacitor current i_c.

The interesting thing is the displacement current in a dielectric is due to real charge displacement, while the displacement current in the vacuum is merely due to vacuum polarization, so any thrust balancing has to be due to forces within the capacitor plates. Since the current direction in the coaxial capacitor thruster design is almost strictly longitudinal, it is difficult to see how counter forces can arise.

GETTING REAL

There have been lots of attempts at electromagnetic thrusters and even patents. See US 5142861, Schlicher et al, for example. Nothing has worked, though various schemes have been tested by NASA's Breakthrough Propulsion Physics Program. The fact we are still using rockets is not a good indicator of EM thruster success!

Even a very small net thrust would be of huge value, for satellite repositioning and station keeping.

The principle limitation of photonic thrust is = 2.94x10^9 watts per kg-f of thrust.

A careful examination of Schlicher's patent shows that this is exactly what his design produces. Schlicher's 100 amp ten volt device should thus put out, assuming the thrust is generated by photon emission as implied, at most (1000 watts)/(2.94x10^9 watts) kg-f = 3.4x10^-7 kg-f = 3.4x10^-4 g-f, about a third of a milligram. This is an upper limit that assumes all the power is radiated unidirectional. This is a detectible amount, but not with the equipment portrayed in the Schlicher patent.

A power/thrust ratio that is 100 times larger would be very useful for satellite station keeping and maneuvering. A power/thrust ratio 1000 times larger would be very useful for interplanetary travel. These are very small thrusts in practical terms, and useful only on missions where patience is a virtue, yet no one has been successful in generating them via gaining a purchase on the vacuum.

From the gravimagnetic isomorphism theory, an "electro-gravity drive" approach is just not possible. It appears that "electro-gravity" is an oxymoron. An inertial drive that couples to the vacuum, however, certainly seem to be a very realistic possibility, since such coupling goes on around us all the time in the form of inertia. Hopefully the ideas here may provide some insight as to how some experimentation in that area might be accomplished.

ACKNOWLEDGMENTS

This design was initially proposed in the course of extended discussions of inertial drive possibilities with Francis J. Stenger and Scott Little in 1999.