Considerations on Sergy Alexeew's TPU Scheme

Cyril Smith, February 2016

1. Introduction

This paper looks into the toroidal power unit (TPU) by Russian inventor Sergy Alexeew. His device uses sequential pulsing on a series of coils to create moving fields, but the same effect could be achieved using sine waves with 90º phase shift.

2. Construction

The images are taken from the Russian document TPU_Serg+comment_Michail.pdf. The TPU is constructed as follows. Some home-made Litz wire is wound onto a former creating three complete turns, figure 1.

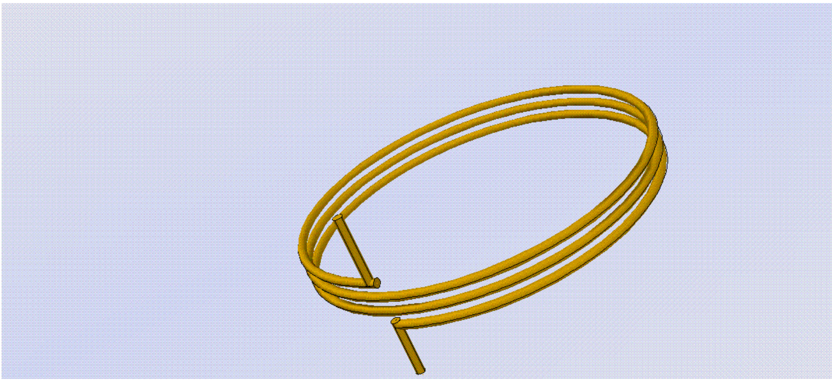


Figure 1. Inner coil of Litz wire

Over this is placed some plastic insulation, figures 2 and 3.

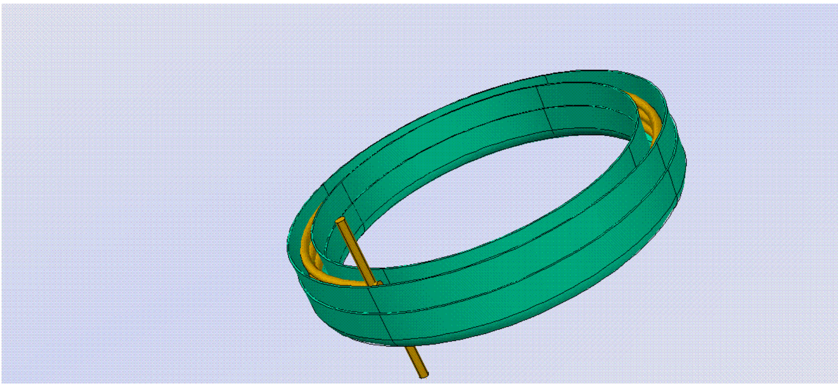


Figure 2. Plastic insulation

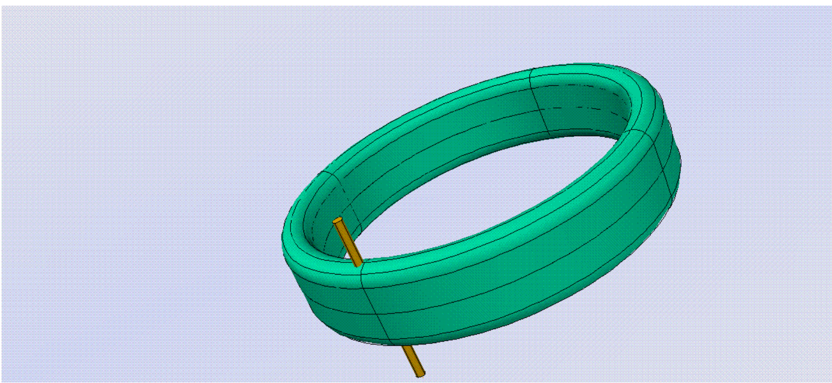


Figure 3. Plastic insulation fully covered.

Next is a layer of aluminum foil over the surface but arranged so that it does not form a shorted turn to a toroidal coil (note that gap around the inner surface), figure 4.

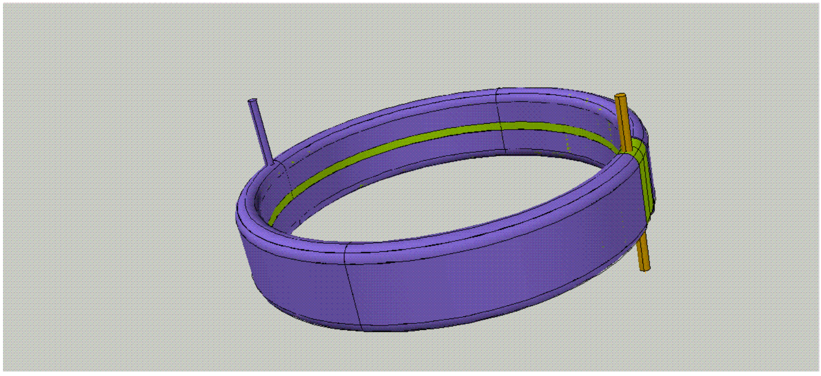


Figure 4. Aluminum foil covering.

A further layer of insulation is applied over the foil, figure 5. Note the connection to the foil is missing from this and subsequent images.

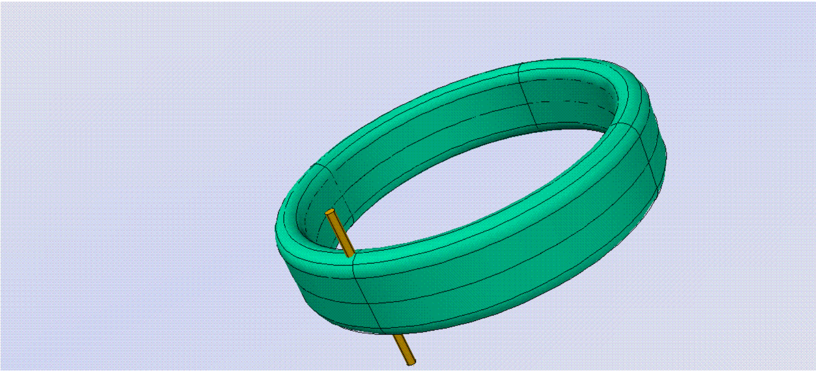


Figure 5. Insulation over the foil.

Next a toroidal coil is wound over the entire circumference of this ring, figure 6. This is the collector coil.

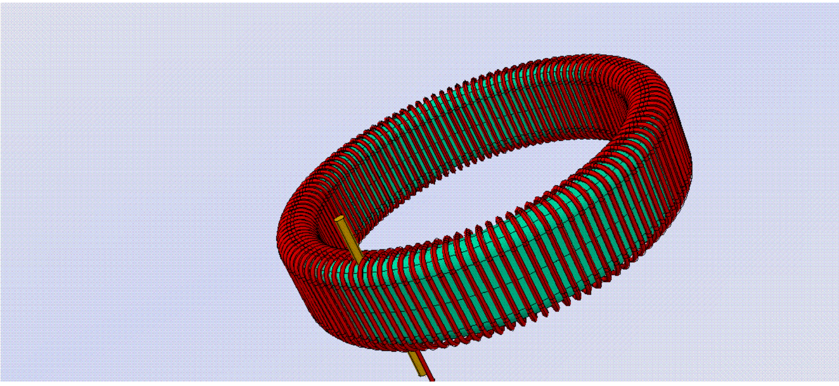


Figure 6. Toroidal coil

Finally four drive coils are wound each covering a 90 degree segment of the ring, figure 7.

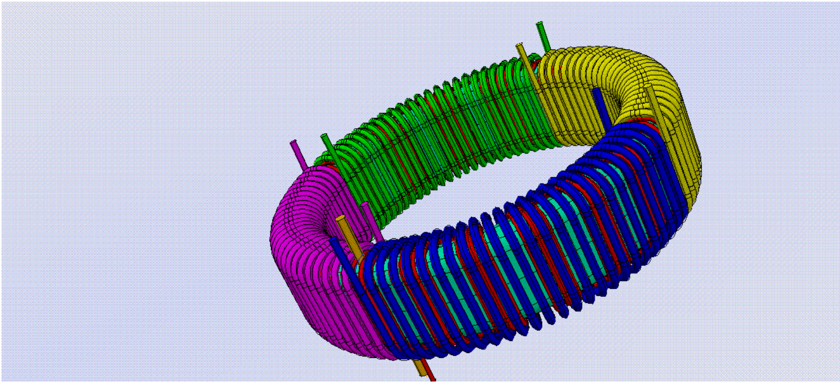


Figure 7. Drive coils

The drive coils are driven by a series of pulses as shown in figure 8. *U1, U2* etc refer to the drive coils numbered in sequence around the ring. Note that the *U2* pulse overlaps *U1* and so on around the ring. This sequencing is important.

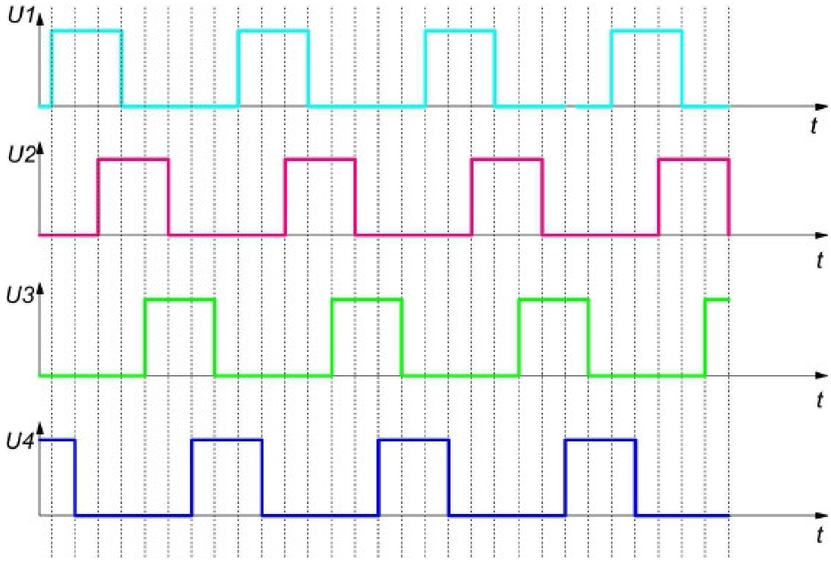


Figure 8. Drive coils pulse sequencing

3. Theory

The aluminum foil is held at a static positive DC potential relative to the collector coil, thus forming a capacitor. The foil, being the positive plate of the capacitor, has a surface depleted of electrons, while the collector coil has excess electrons, as shown in figure 9. Here the red colour denotes a lack of surface electrons and the blue colour an excess of surface electrons. It should be noted that excess surface electrons can be made to move, whereas the exposed positive ions being fixed in the lattice cannot. When considering movement of those surface electrons along the wire they are not impeded to the same extent as the normal conduction electrons in the bulk material, hence can travel at a greater drift velocity than the bulk electrons. If there is a force acting on all the electrons, such as that produced by a changing magnetic vector potential, there will be two conducting channels, one represented by the bulk drift and the other by the surface flow. It is the surface flow that is of interest here.

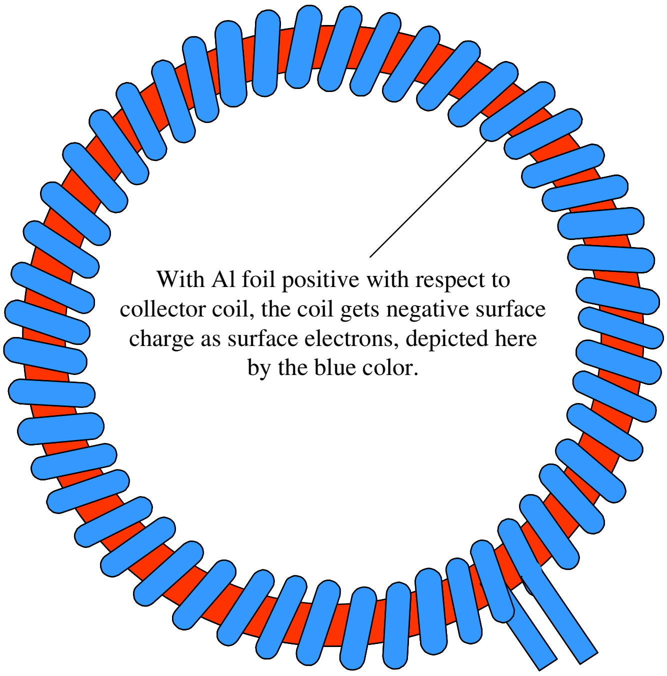


Figure 9. Excess electrons on collector coil

Now consider one of the four drive coils driven with a pulse. It will transformer couple with the turns of the collector coil immediately beneath it as depicted in figure 10.

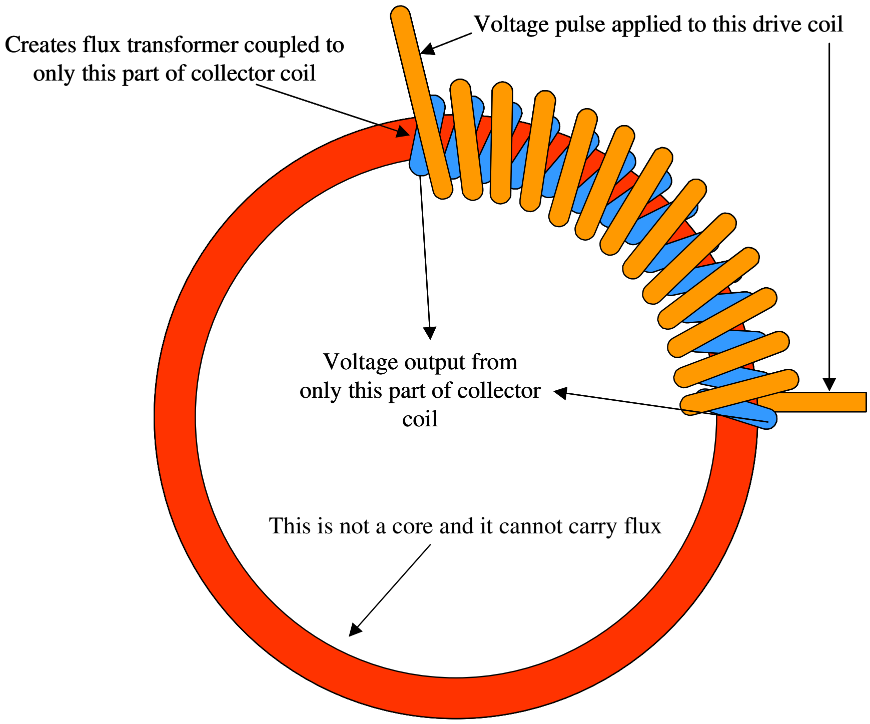


Figure 10. Transformer coupling to part of the collector coil.

Those turns will deliver a voltage pulse to the remainder of the collector coil where no transformer coupling exists. The remainder of the collector coil acts as a load to the transformer output, see figure 11.

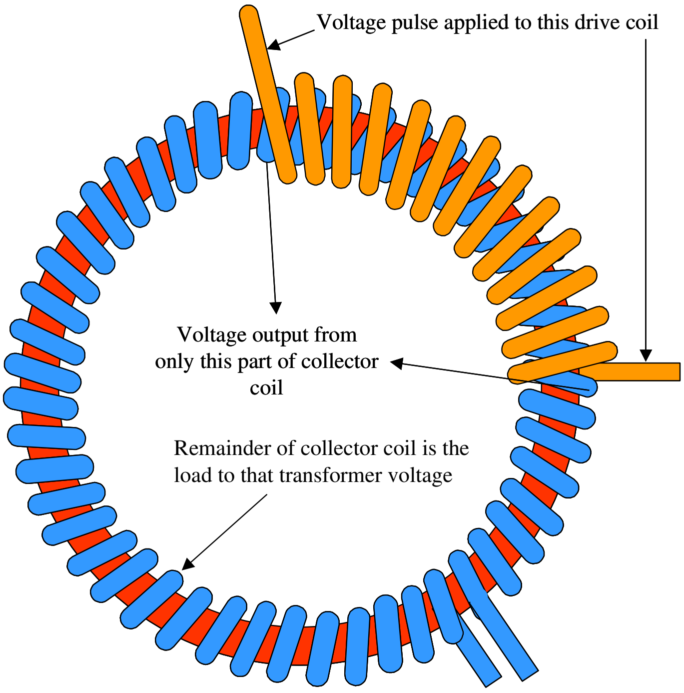


Figure 11. Remainder of collector coil is the load.

Note that this load is inductive wound on Al foil hence it appears as a transmission line so the voltage pulse is delayed from travelling further. The net result is just the pulse voltage across that part of the collector coil, but because of the surface electrons already there this appears as excess electrons at one end and depleted electrons at the other end, see figure 12.

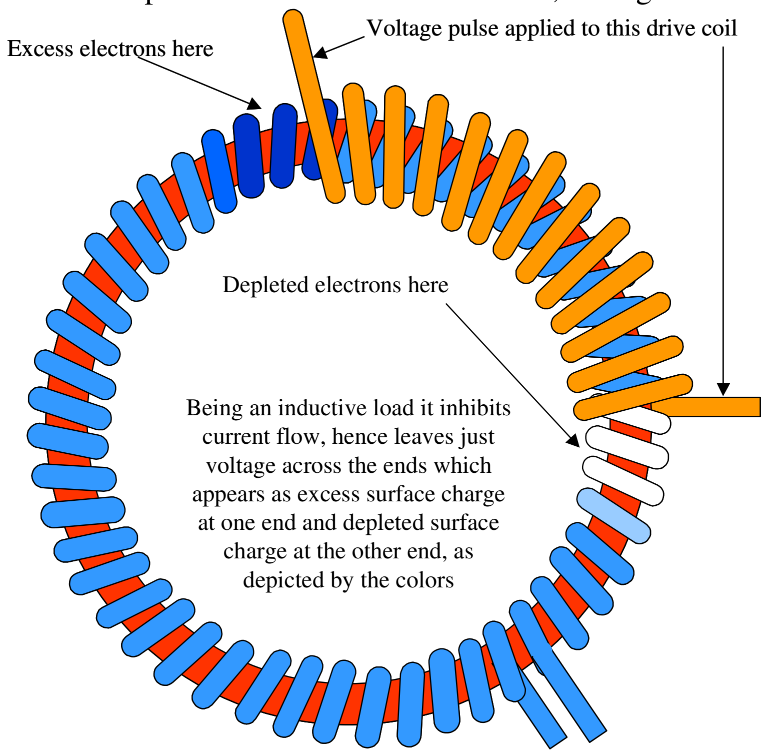


Figure 12. Showing areas of excess and depleted surface-electrons

The next drive coil is pulsed while the first one's pulse is still there, and this drives the excess electrons further along the collector coil as shown in figure 13.

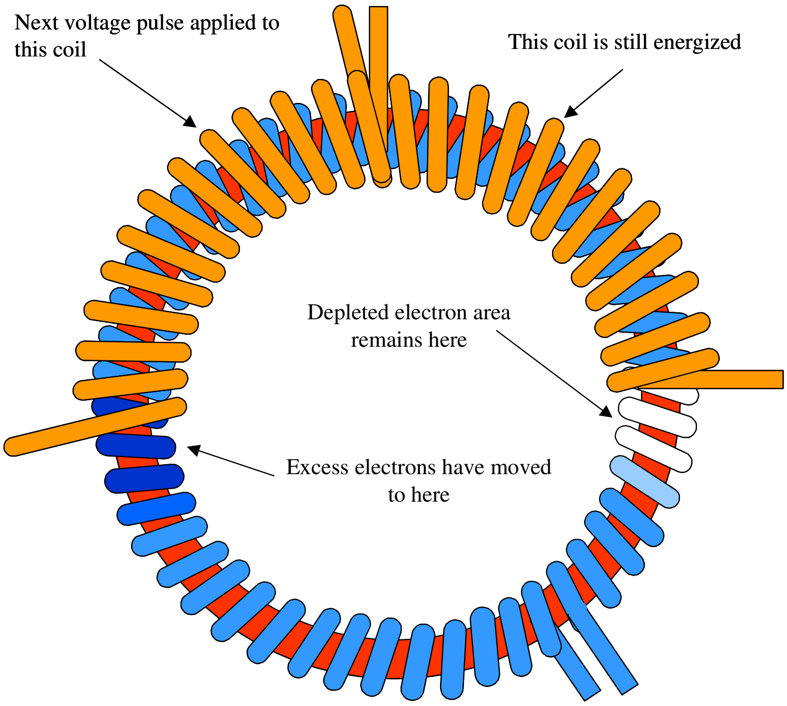


Figure 13. Excess electrons driven further along the collector coil

The first drive pulse now ends, which causes the depleted area of electrons to move to a new position, figure 14.

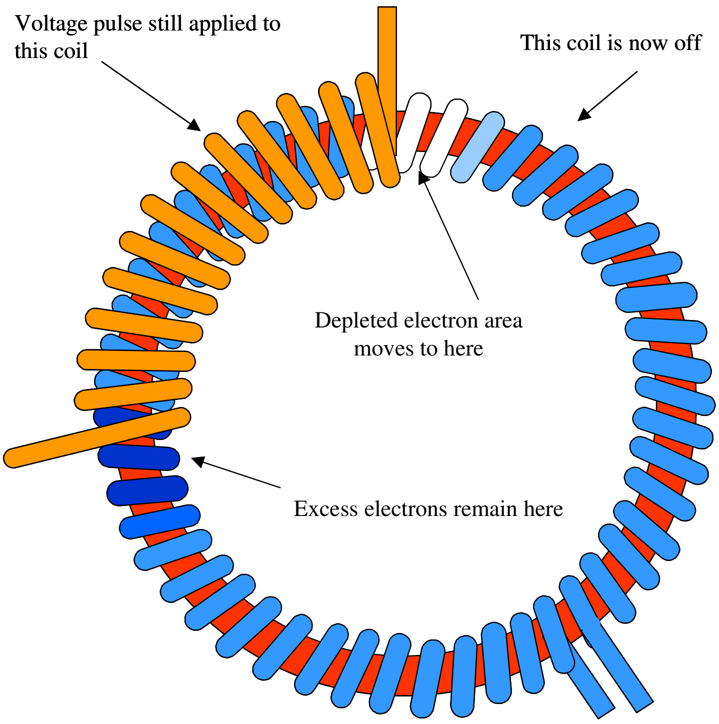
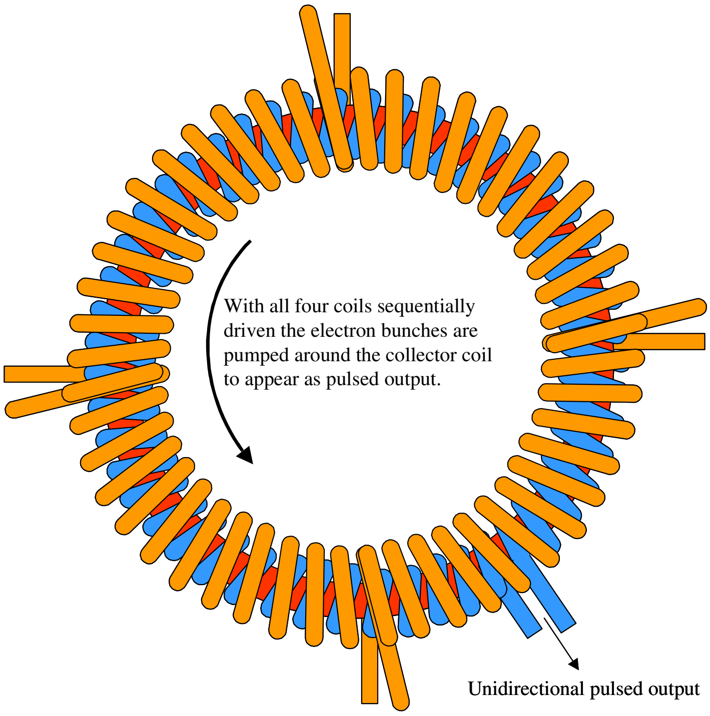


Figure 14. Depleted area moved to new position.

We are now back to the situation shown in figure 12 except the excess and depleted regions have moved through 90 degrees. The continual sequential pumping of the quadrant drive coils causes these areas to be continually moved around the ring in a series of jerks, and that averages to a DC electron or current flow. Where the ring has an electrical break, at the output from the collector coil, the flow passes through any load there as a series of unidirectional current pulses, figure 15.



.Figure 15. Full system flow

4. Further considerations

There has been talk of the positive DC voltage applied to the Al foil as being 12KV. Also the drive waveforms up to 3MHz. The Litz wire bundle is stated as having a diameter of 25mm and is composed of 600 (or more likely 1200) strands of between 30 and 36 awg magnet wire. Now 1200 strands of 32awg wire where each stand is 0.2 mm diameter cannot possibly end up as a 25mm diameter bundle, calculations show it would be only about 7mm diameter. Three turns of that thick wire would occupy about 25mm so the inner "core" is not of circular cross section but rather an elongated cross section, see figure 16.

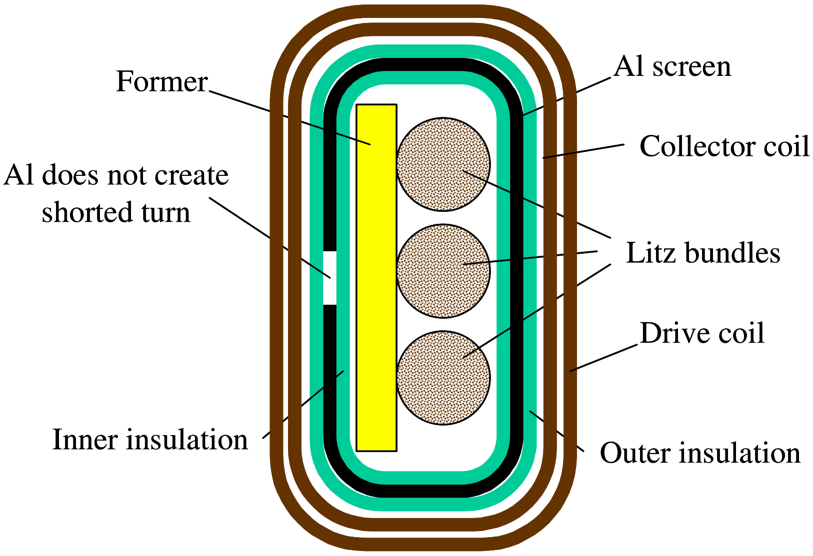


Figure 16. Cross section.

It is the surface charge on the bundle of Litz wire that is of interest, and this would exist only on the outer strands, which for the 7mm bundle is only about 100 wires. The bundle is twisted to obtain about 1 twist per 25mm. That puts about 16 twists below each quadrant drive coil. Since a twist is equivalent to a single turn, effectively the Litz bundle acts like a helical coil than can obtain induced voltage in the same manner as described for the collector coil. Hence the surface charge on the Litz wire gets pumped along , then being in series with the collector coil they both contribute to the driven output.

5. Calculations

With 2mm of Teflon insulation between the Litz wire and the Al foil we can estimate the distributed capacitance along the wire as over say half the circumference, so we can model the capacitance as a long strip of length *l*, width *w* and dielectric thickness *t*. Since $C = \frac{K\varepsilon_0 wl}{t}$ it follows that the capacity per unit length is $C_l = \frac{K\varepsilon_0 w}{t}$ Farads/meter where *K* is dielectric constant and ε_0 the permittivity of space. For the 7mm diameter bundle we get *w*=11mm as the half circumference and since *t*=2mm and *K*=2 the capacity becomes close to 100pF per meter. At the quoted DC voltage of 12KV that is a distributed surface charge Q_l of about 1.2 micro Coulombs per meter of wire length. If that surface charge is moving along the wire at velocity *v* m/S the current *i* is given by $i = Q_l v$. With a drive frequency of say 1MHz and a hoop radius *r* of 100mm the drive velocity $2\pi fr$ is 628Km/S. Hence the driven surface current *i* is about 0.75 amps. That's fits in with the Russian claim of about 1 amp. Note this calculation is for the Litz wire and assumes all the surface charge is driven along, but the quantity actually driven will depend upon the transformer coupling from a quadrant drive coil to the effective 16 turns of Litz wire beneath it. With the Litz only occupying a small area of the magnetic field, the induced pulse voltage on those 16 effective turns will not be very large, so there could be a stumbling block there.

For the collector coil things are better because (a) it has all the magnetic field area passing through it and (b) it has larger surface area hence greater surface charge. We can estimate the distributed capacitance C_l taking *w* to be the circumference of the elongated shape in figure 16 as about 80mm, whence it becomes about 300pF per meter. That yields a surface charge of around 4 microCoulombs/m and a driven current of about 2.6 amps. But again that assumes all the surface charge moves. What is clear is that the higher the transformer coupled pulse output voltage appearing across a quadrant the greater the amount of surface charge that gets pumped. This suggests that the four drive coils, each occupying one quadrant, should consist of the minimum number of turns in order to get a step-up ratio. Something like four turns over each quadrant. The output coil can then consist of a large number of turns of fine gauge magnet wire. We await results of experiments with baited breath.