UNDERSTANDING THE ROTATING MAGNETIC FIELD

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TESLA, PHYSICS AND ELECTRICITY

Research into the works of Nikola Tesla reveals electric phenomena that behave contrary to the theory of electricity in present use. Explanation of Tesla's inventions has been given from the standpoint of physics, yielding many misconceptions. The science of physics is based on phenomena surrounding particles and mass, which finds little application in the study of electric phenomena.

The explanation of Tesla's discoveries are to be found in the science of electricity rather than the science of physics. The science of electricity has been dormant since the days (1900) of Steinmetz, Tesla and Heaviside. This is primarily due to the vested interests which we may call the "Edison Effect".

Charles Proteus Steinmetz

To assist in the understanding of Nikola Tesla's discoveries, thereby putting his inventions to work, a theory of electric phenomena applicable to these discoveries must be developed.

A starting point of such a theory has been developed by C.P. Steinmetz. Steinmetz was employed by the Edison/Morgan Company, General Electric, to decipher the Tesla patents, thereby evading these patents. With unlimited funds for research and a keen insight into electric phenomena, Steinmetz is a most significant contributor to the knowledge of electricity. His work is presented in three volumes:

I) "Theory and Calculation of Alternating Current Phenomena", third edition, 1900, McGraw-Hill, New York.
II) "Theory and Calculation of Transient Electric Phenomena and Oscillations", third edition, 1920, McGraw-Hill, N. Y.
III) "Electric Waves, Discharges and Impulses", second edition, 1914, McGraw-Hill, N.Y.

These serve as an introduction to the theoretical understanding required.

INTENT OF PAPER

This paper serves as a preface to a theoretical investigation of N. Tesla's discoveries by the examination of the rotating magnetic field and high frequency transformer. It is assumed that the reader is acquainted with the commonly available material on Tesla, and possesses a basic knowledge of mechanics and electricity.

THE ROTATING MAGNETIC FIELD

THE GENERALIZED ELECTROMECHANICAL TRANSFORMER

In the general electromechanical transformer energy is exchanged between mechanical and electric form. Such an apparatus typically employs a system of moving inductance coils and field magnets.

FIG. 1

SINGLE POLE

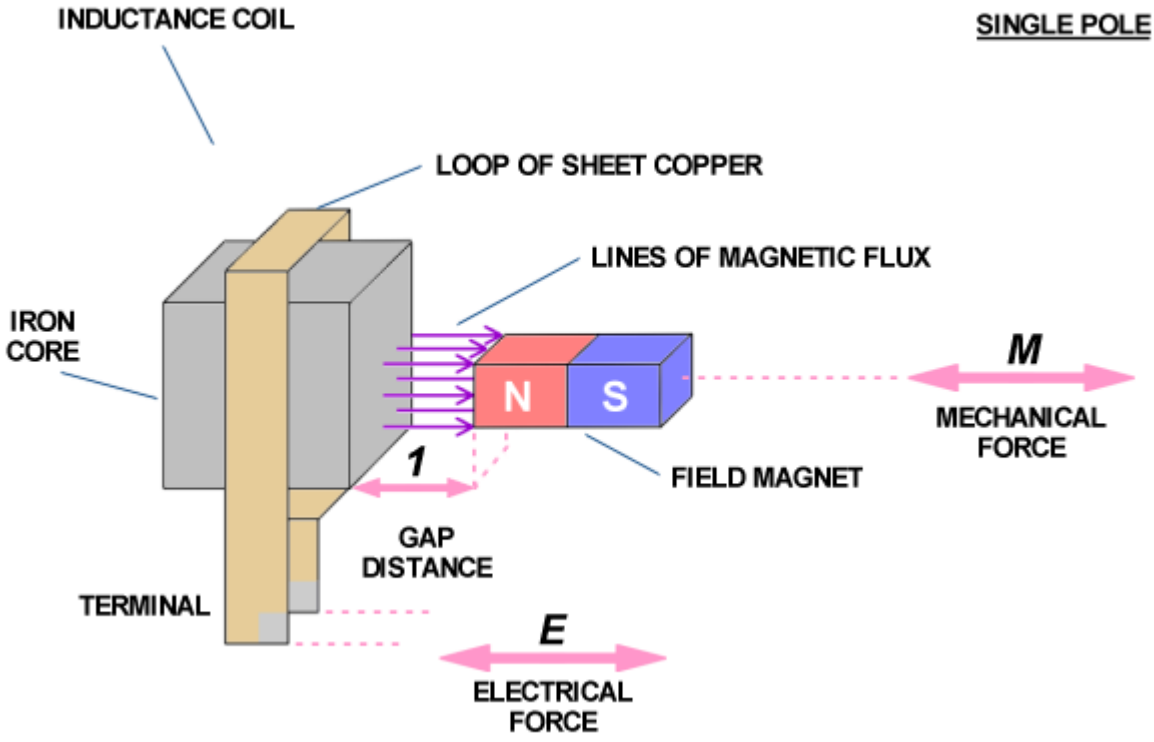
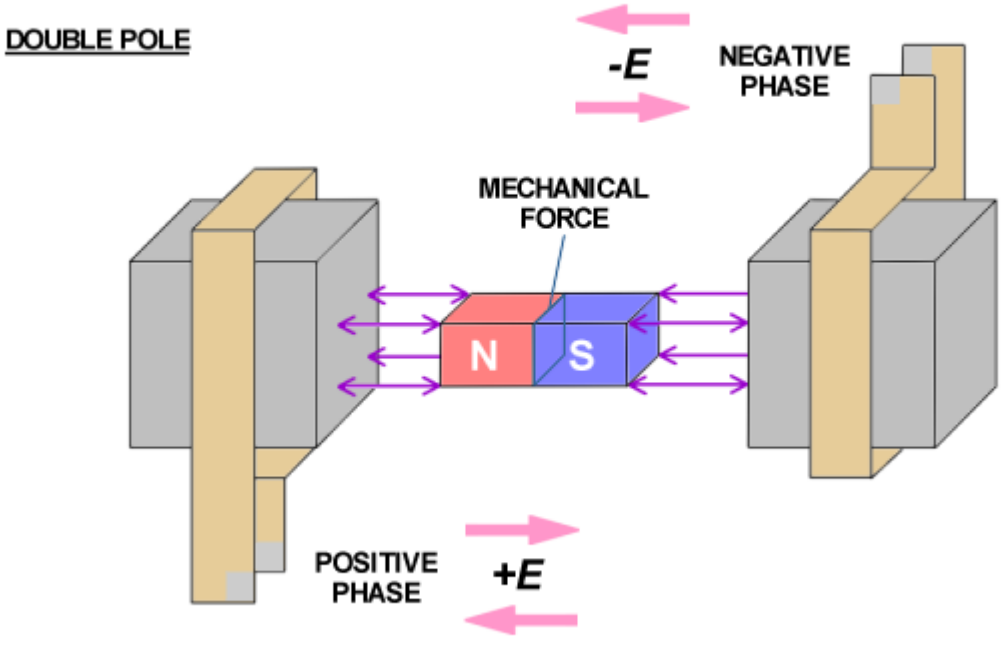


FIG. 2

DOUBLE POLE



It is desirable that the mechanical energy produced or consumed be of rotational form in order to operate pumps, engines, turbines, etc. The method of producing rotary force, without the use of mechanical rectifiers known as commutators, was discovered by Nikola Tesla in the late 1800s and is known as the rotating magnetic field.

ELEMENTAL PRINCIPLES

An examination of the rudimentary interaction between inductance coils and field magnets will provide some insight into the principles behind the rotary magnetic field.

Consider a simple electromechanical device consisting of a piece of iron with a copper loop winding around it along with a small bar magnet (Fig. 1). Any variation in the distance (1) between the pole faces of the inductance coil and magnet produces an electromotive force (voltage) at the terminals of the copper loop resulting from the field magnet's lines of force passing through the iron core of the inductance coil. The magnitude of this E.M.F. is directly proportional to the speed at which the distance (1) is varied and the quantity of magnetism issuing from the field magnet pole face.

Conversely, if an electromotive force is applied to the inductance coil terminals, the distance (1) varies at a speed directly proportional to the strength of the E.M.F. and the quantity of magnetism issuing from the field magnet pole face. Thus electrical force and mechanical force are combined in this device.

If a flow of electrical energy (watts) is taken from the coil terminals and delievered to a load mechanical resistancy (friction) appears at the field magnet as a result of magnetic attraction and repulsion between the magnet and iron core. Mechanical force applied to the field magnet in order to move it results in power flow out of the coil. This flow of power generates an oppositional or counter electromotive force which repels the field magnet against the mechanical force. This results in work having to be expended in order to move the magnet. However this work is not lost but is delivered to the electric load.

Conversely, if the field magnet is to deliever mechanical energy to a load, with an externally applied E.M.F. to the coil terminals, the field magnet tends to be held stationary by the resistancy of the connected mechanical load. Since the field magnet is not in motion it cannot develop a counter E.M.F. in the coil to meet the externally applied E.M.F. Thus electrical energy flows into the coil and is delievered to the field magnet as work via magnetic actions, causing it to move and perform work on the load.

Hence, mechanical energy and electrical energy are rendered one and the same by this electromechanical apparatus. Connecting this apparatus to a source of reciprocating mechanical energy produces an alternating electromotive force at the coil terminals, thus a linear or longitudinal A.C. generator. Connecting this apparatus to a source of alternating electric energy produces a reciprocating mechanical force at the field magnet, thus a linear A.C. motor. In either mode of operation the field magnet reciprocates in a manner not unlike the piston of the internal combustion engine. Rotary motion is not possible without the use of a crankshaft and flywheel.

FIG. 3

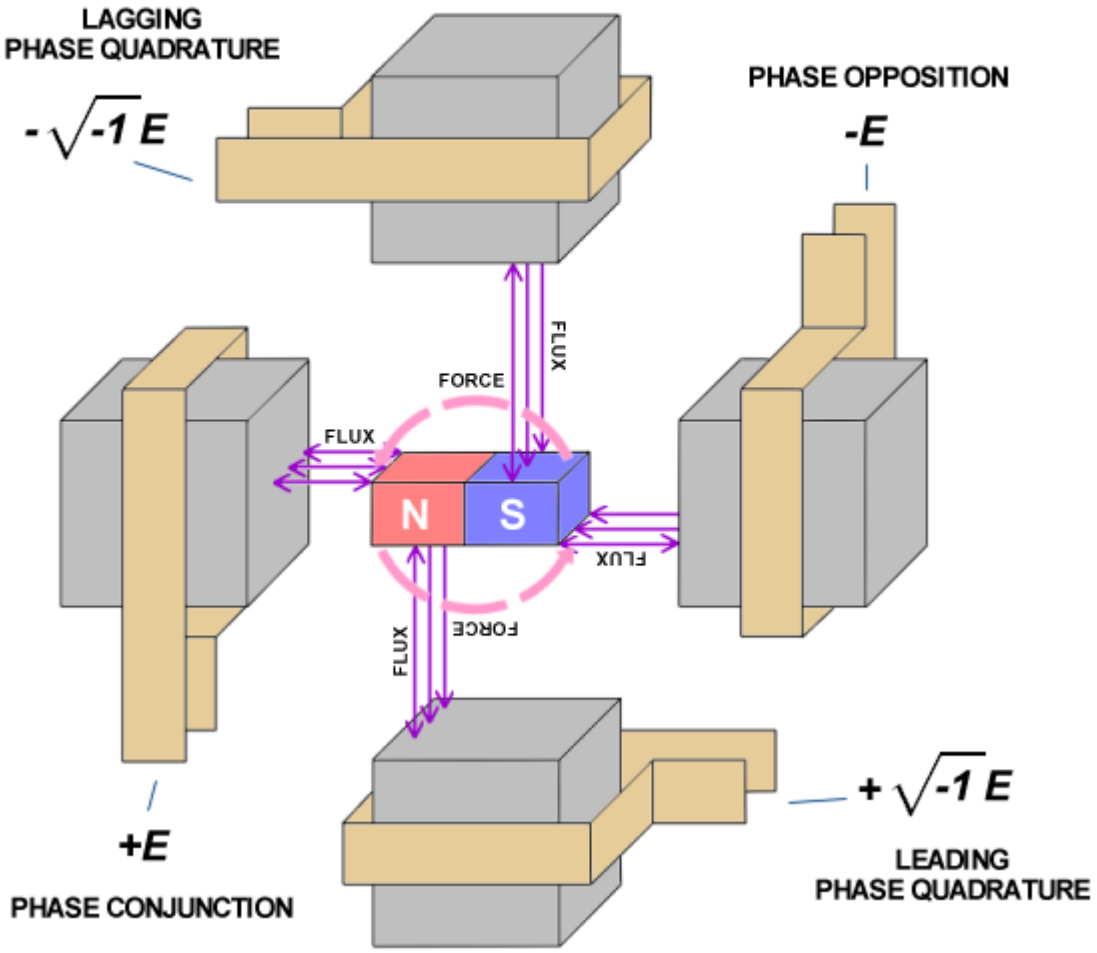
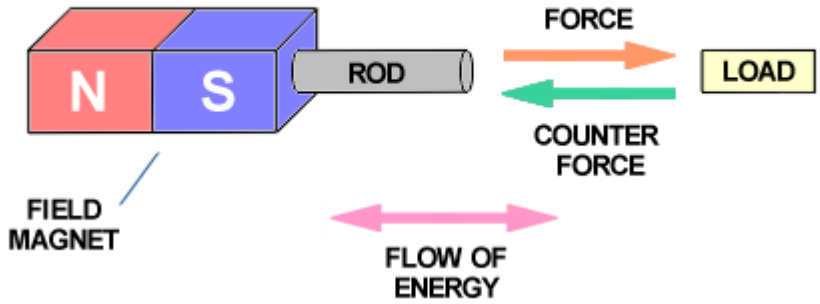

LAGGING
PHASE QUADRATURE
$-\sqrt{-1}\,E$
PHASE OPPOSITION
$-E$
FLUX
FORCE
FLUX
N
S
FLUX
FORCE
FLUX
$+E$
PHASE CONJUNCTION
$+\sqrt{-1}\,E$
LEADING
PHASE QUADRATURE

FIG. 4


N
S
ROD
FORCE
LOAD
COUNTER
FORCE
FIELD
MAGNET
FLOW OF
ENERGY

Arranging two inductance coils in a line as shown in Fig. 2 and connecting these coils to a pair of alternating E.M.F.s that are out of step by ½ of an alternating cycle with respect to each other results in the mechanical force being directed inwardly into the molecular spaces (inner space) within the field magnet. The field magnet is alternately stretched and compressed by magnetic action and no external force is evident except as vibration and heat. However, arranging two of the pairs shown in Fig. 2 at right angles to each other, connecting each pair of alternating E.M.F.s that are out of phase or step by one quarter cycle (quadrature) with respect to each other produces a rotating travelling wave of magnetism, that is, a whirling virtual magnetic pole. This virtual pole travels from one pole face to the next during the time interval of one quarter cycle, thus making one complete revolution around all the pole faces for each cycle of alternation of the E.M.F.s. The field magnet aligns with the virtual pole, locking in with the rotary magnetic wave, thereby producing rotational force.

An analogy may assist in understanding this phenomena. Consider that the sun appears to revolve around the earth. Imagine the sun as a large magnetic pole and your mind's view of it as the field magnet. As the sun sets off in the distant horizon, it seemingly disappears. However, the sun is not gone but it is high noon 90 degrees, or one quarter, the way around the planet. Now imagine moving with the sun around the planet, always keeping up with it so as to maintain the constant appearance of high noon. Thusly, one would be carried round and round the planet, just as the field magnet is carried round and round by the virtual pole. In this condition the sun would appear stationary in the sky, with the earth flying backwards underfoot. Inspired to thinking of this relation by the poet Goethe, Tesla percieved the entire theory and application of alternating electric energy, principally the rotating magnetic wave.

"The glow retreats, done is the day of toil;
it yonder hastes, new fields of life exploring;
Ah, that no wing can lift me from the soil,
upon its track to follow, follow soaring..."

ROTATIONAL WAVES

The fundamental principle behind the production of the rotary magnetic field serves as the principle behind all periodic electric waves. It is therefore of interest to investigate the discovery a little further.

The apparatus shown in Fig. 1 develops mechanical force along the axis of the field magnet as shown in Fig. 4. Likewise, mechanical counterforce is applied along the axis of the field magnet. Hence, if work is to be drawn or supplied respectively to the field magnet from an external apparatus, a connecting rod is required between the two machines. The flow of energy is along the axis of the rod and thus is in line (space conjunction) with the forces involved. A simple analogy is a hammer and nail. The hammer supplies mechanical force to the nail, the nail transmitting the force into the wood. The counterforce tends to make the hammer bounce off the nail. However, the wood is soft and cannot reflect a strong counterforce back up the nail and into the hammer. Thus the nail slides into the wood absorbing mechanical energy from the hammer which is dissipated into the wood.

The apparatus of Fig. 2 develops mechanical force axially also, but it is entirely concentrated within the molecular space. Any counterforce must push back along the same axis. Thus the work is also along axis like Fig. 4 and is delivered to the molecular structure. The analogy is two hammers striking a steel block from opposite sides, pounding the block and producing heat and vibration within it.

The apparatus of Fig. 3 produces a quite different wave form (Fig. 5). The mechanical force delivered to the shaft is applied at a right angle to the axis in clockwise direction. The counterforce is applied in the opposite rotational sense or counter-clockwise direction at a right angle to the axis. The flow of mechanical energy is still along the shaft as in Fig. 4, however, it no longer pulsates in magnitude with the cycle but it continues, quite like the flow of electric energy in a direct current circuit.

An analogy is a screw and screwdriver. The screwdriver is forced rotationally clockwise by the hand or other motive force. The counterforce appears in opposition, that is counter-clockwise, thereby arresting the rotation of the screwdriver. However, the wood is soft and cannot reflect the counterforce back into the screwdriver. Thus the screw travels longitudinally into the wood, perpendicular to the rotation of the screwdriver.

The form of this wave has been of great interest to a wide variety of fields of endeavor. It has been called the Caduceus coil, spinning wave, double helix, solar cross, and of course the rotating magnetic field. Applications are as wide ranging, from sewage treatment plants and guided missles all the way to the Van Tassel Integratron and astrology.

FIG. 5