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Electric Propulsion Study

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FOREWORD

This final report was submitted by the Science Applications International Corporation, Torrance CA on completion of contract F04611-88-C-0014 with the Astronautics Laboratory (AFSC), Edwards AFB CA. AL Project Manager is Dr Franklin B. Mead, Jr.

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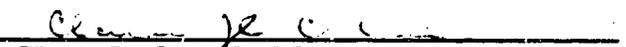
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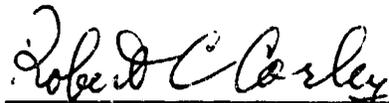
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This report reviews inductive theories and experimental approaches which provide for interactions between gravitational and electromagnetic fields. The theoretical section develops a general relativistic five dimensional theory to the point that electromagnetic effects can be interpreted. Emphasis is placed on modifications to the classical Maxwell equations and field vector equations. The theories are then used to propose specific experimental studies which can verify the electromagnetic and gravitational interactions. Specific recommendations are made for experiments that would both verify the theories and serve as a basis for electric propulsive systems that would convert between electromagnetic and inertial momentum.

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FOREWORD

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The Air Force Task Manager for this task was Dr. Franklin Mead, AL/LSVF. Dr. Dennis Cravens was the Principal Investigator at SAIC. The other principal technical contributor was Dr. Pharis E. Williams, who was consultant on this task.

The author wishes to thank Dr. Pharis Williams and other tireless theoreticians who have spent years slowly working and removing the rocks from the difficult path to the unified field theory as others idly stand by complaining that the road is too rough to travel and may never lead anywhere.

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PREFACE

The primary objective of this task is to outline physical methods to test theories of inductive coupling between electromagnetic and gravitational forces and to determine the feasibility of such methods as they apply to space propulsion. To this end information was sought, assembled and used, first to develop a theoretical approach and finally to suggest some practical experiments that may have propulsive implications. It was found that the lack of reliable experimental results has greatly limited the theoretical understanding and development of inductive theories. However, several experimental approaches are outlined.

The most theoretically satisfying experimental approach is the use of a torsion balance and bolometer system to quantify any differences between radiation pressure density and energy density over a range of light frequencies. Also, it is possible to study the role of divergent currents within segments of a circuit. Several experimental claims having direct application to the coupling problem have been made through the years and seem to have gone unexamined. It may be more useful to confirm or deny these claims than it is to start in a completely new direction.

Four of these claims seem to be interesting enough to examine: 1) T. T. Brown's propulsive forces developed from an asymmetric capacitor charged to high potentials, 2) W. Hooper's $V \times B$ forces with claims of gravitational shielding and field production, 3) examination of forces resulting from divergent currents, and 4) investigations of the Mach principle. All of these have a stigma attached to them due to the establishment's view of the nonexistence of an electromagnetic and gravitational coupling and other historical and personality conflicts. However, if any of these are correct, they could lead directly to futuristic propulsive systems.

A five-dimensional theory is developed in this report to establish a theoretical framework in which experimental approaches can be understood. This is done to give a direction to the proposed experiments.

Note: References to published works are indicated in the text by numbers in parentheses, e.g., (1). They are listed at the end of this document in Section R.

CHAPTER 1
INTRODUCTION

Current chemical rockets are approaching their theoretical limits in terms of specific impulse (Isp). To make any dynamic new advancements in mission abilities we must seek new and nonconventional approaches to propulsion now so that revolutionary concepts are available for future advancements. Such advances as nuclear, solar, and electric propulsion offer very promising Isp performances for near-term applications. The basic limitation common to all such systems, however, is that the traditional Newtonian physics is restricted by the law of conservation of momentum. This means that all such systems, regardless of their power sources, must utilize some fuel in their exhaust.

Conventional physics rules out any departure from the conservation of momentum. Recently, however, physics has seen a multitude of new theories that try to unify all of physics. One specific set of multidimensional theories has approached the unification problem by inductively coupling the electromagnetic (EM) forces with the gravitational forces. Inductive coupling means that a conversion between gravitational and electrical forces is possible. Inductively linked theories indicate that the interactions between the two forces may open methods for the interconversion of electric and gravitational events, just as magnetic and electric events are now interconverted. This means that inductively coupled theories may offer ways to convert charges into masses. This is similar to the way the fourth dimension has supplied a method of converting mass into energy.

The motivation for such a study is the recent advances in unified field theories. Even though there has been no single accepted theory, several things are now clear. If unification of fields is possible then interconversion is likely. It is only a matter of determining the size of the coupling constant. Should such conversion be possible, the power density made available would be 10 orders of magnitude beyond nuclear events. This conversion and inductive linkage of both charge and mass by the new theories may open whole new avenues to propulsion.

Most multidimensional attempts at unification try for unification of all four of the fundamental forces. The emphasis of this report, however, was limited to the unification of gravity with electrical effects. This leads to the possibility of new practical propulsion systems. To this end, the report concentrated on 5-D theories that allow for nonzero coupling. For comparison of the theories, two areas were considered: self energy of a charge and field equations in terms of modification to the Maxwell equations. The reasoning is that these (and not

cosmological studies) are best suited for experimental design and ultimately for practical propulsive systems.

The theoretical section of this report consumed more effort than was originally planned, due to several factors. The most important was the sheer complexity of the theories and the fact that the theoretical works were spread out over many years when the symbolic tensor notation was being developed. Another factor was that on closer examination, many theories which originally attempted unification of forces were constructed so that conservation of inertial momentum was retained. This later point was significant since the conversion of electromagnetic to inertial forces is of prime concern in the development of a novel propulsion system. It was found that most theoreticians have preconceived notions as to the nature of conservation of charge and inertial momentum and have adjusted their theories accordingly.

Historically the most fruitful period for gravitational studies was in the 1930's and 40's. Theoreticians were more likely to conjecture about the nature and interconversion of gravity during that period. During the 40's the emphasis seemed to shift toward nuclear studies. There now seems to be a slow but steady resurgence in gravitational studies. Most studies, however, are now cosmologically based and not based on ground laboratory events. The theoreticians seem to have an aversion to studying possibilities of interconversion of electric and gravitational forces and little funding is currently available. This is a case where there is a high funding leverage potential; even a small increase in funding could drastically redirect the effort. Theoreticians working in this area are a potentially potent "brain power" asset and it is the view of this report that it is beneficial to the national interest to develop this asset. It must be emphasized that such an effort should be targeted at theories that: 1) allow for inductive coupling of forces, 2) have definite experimentally verifiable effects, 3) may lead to new momentum terms, and 4) have gravitational and not nuclear emphasis. Furthermore, a supportive network and an accelerated idea exchange would enhance the development of this national asset.

On the experimental side, several approaches were selected for study. Two studies stand out as being especially worth a closer look. These are the radiation pressure experiment and Biefield-Brown effect studies. The radiation pressure study is recommended since it avoids the complexities inherent in high voltage experiments. In this case even an experiment that fails to detect nonzero coupling may give information useful for absolute laser power calibration and solar sail studies. Several Biefield-Brown studies are now underway. The approach by Woodward is the most pleasing on theoretical grounds and he furnishes the only realistic estimate of a coupling

constant obtained experimentally (0.029 ± 0.006 for the first term of a Taylor series expansion of the gravitational field in terms of energy density).

1.1 BACKGROUND OF THEORETICAL DEVELOPMENTS

In any attempt to unify many laws we must be certain that all concepts are well defined since subtle differences may later cause grave consequences. While at first glance such concepts as length, time, and mass seem to have intuitive meaning, relativity has shown us to be cautious in defining even simple terms.

Length (L), time (T), and mass (M) form the foundation of all units currently used within physics. Other quantities such as acceleration (LT^{-2}), charge ($L^{3/2}T^{-1}M^{1/2}$) and energy ($L^2T^{-2}M$) can be derived from these units. It is possible, in theory, to resolve any physical measurement known into these three fundamental units. Space is unique in having a 3-fold degeneracy. The same length unit is assumed to be usable for all three orthagonal directions. This in effect sets the metric in a local frame such that the curvature is the same in all three directions. With this in mind it should be possible to construct a 5-Dimensional theory based on these units as variables to predict and explain any physical measurement that has these three units as its basis. Since any physical measurement can be resolved into these five components any attempts at higher order dimensions could be compressed into them. Thus, higher dimensional theories will appear to "fold back on themselves" and the higher dimensions may not be required by normal physical measurements once the 5-D theory is perfected.

A 5-D theory could be constructed from length, time, and any variable containing mass–for example, charge, mass, action, entropy, etc. However, such equations would be unduly complex unless the additional variable was chosen so that it was independent of the other four variables. There are several useful choices for such a decision. Charge is independent of position, time, and velocity and may make a logical choice for such a theory. Charge is quanitized and, thus, would not likely give well behaved continuous functions for paths and also it is not likely to give time asymmetries and predictions of fundamental particle structure. Mass density is the initial choice for our additional variable. This choice is consistent with William's Dynamic Theory and will give some intuitive feel for the theory.

Using the philosophy of Mach there are guidelines involved in measurements, physical reality, and the laws of nature. First there must be some kind of comparison between the measuring device and the measured object. To avoid confusion, we seek to arrange things so that

the general variability of the measurement indicates the variation of the measured object and not of our standard. This is arranged by being certain as to the conditions involved during our measurement and having standardized units which have definite meaning. Any intrinsic property of the object must appear as a uniformity (constant) or a law during the measuring process. In other words, we must be able to trace all measuring operations back to a standard or to some physical law. During this process we will either be able to trace our physical observation to a known standard or to an assumed law or else it will appear as an unexplained item outside the prediction of our laws. Current research tries to improve the laws so that few observations are outside our assumed laws and thus explain some unexplained observational measurements.

The alternative to this approach asserts that the assumed laws are traceable directly to fundamental standards of measurement instead of other laws which may not be so based. The Dynamic theory will strive to base its entire foundations on nothing other than standardization of the measurements of length, time, and mass density. Thus when concepts such as charge appear it will be defined in terms of the dimensions of the Dynamic theory instead of other assumed laws and the operation of a current balance. We, like Mach, will not assume space to have any properties that cannot be traced directly to physical objects of the universe and only properties relative to those found in our laws. Therefore, absolute values of position, time, and mass density are not assigned to any objects except our measurement standards and all else are based on relative measurements (or interval) from these standards.

Position is not considered fundamental to a location. Instead distance as described by a standard to some reference will enter the equations. Thus an interval is fundamental and location or position of an object is now a computational result based on physical intervals from other objects within the universe. This is at the basis of Mach's principles. That is, only the relations between real physical objects should appear in a physical theory.

We now have established a need to base our physical law on intervals between real physical laws using the independent units of length, time, and mass density. We must now establish the mathematical form of our interval and establish its general form. Since we wish our theory to unify existing theories we will chose our interval to be expressed as a function of the coordinate differences and expressed so that the distances and intervals are as:

1) a function of pairs of points,
2) positive real,
3) single-valued,

4) continuous and analytic,

5) symmetric to space,

and   6) zero for identical points.

This is done by expressing the interval in tensor notation using the summation convention where repeated subscripts are to be summed over, i.e.

$$ds^2 = g_{\mu\upsilon} dx_\mu dx_\upsilon \qquad (\mu, \upsilon = 0, 1, 2, 3, 4).$$

(1)

This allows immediate applications in a usable mathematical form. Except for Finsler geometry, all current theories use this quadratic definition for the line element.

1.2   MEASUREMENT

Before we incorporate such an interval into our theory we must verify that it is what we mean when we conduct the physical measurements and does indeed allow us to trace all parts of our theory to our standard units. To readily identify the parts of our new interval with existing theories we will identify:

x_0 with time,

x_1, x_2, x_3 with x, y, z coordinates, and

x_4 with an arbitrary function of mass (specifically, mass density).

We will measure an interval of distance by placing an object with a given length next to some measuring device (standard or derivable from a standard of length) with a measuring scale. This is best done by having the object at rest compared with our measuring scale and having all points coincident at the same time. Also we wish to have both an object and scale which are neither changing in length or in other physical properties during the measurement. In effect we have chosen our measurement operation such that

$$dx_0 = dx_4 = 0$$

(2)

for our measurement of length. This is equivalent to saying that the interval was measured at both points at the same time and that matter was not destroyed or created during our measurement of the object. Notice this collapses equation 1 to

$$ds^2 = g_{11}dx_1^2 + g_{22}dx_2^2 + g_{33}dx_3^2 \tag{3}$$

which is the expected 3-D result of classical geometry.

When we measure time we normally take some physical device such as a clock (or fixed stars compared to t. earth or vibration of a molecule) and count time intervals by allowing the device to go through some cyclic motion which brings its interval components back to their beginning position. For example, after the earth has rotated so as to bring back the stars to their original position we count 1 day.

Also we do not wish to allow the device to gain or lose any components during the process. In this way the time interval is measured during a process in which

$$dx_1 = dx_2 = dx_3 = dx_4 = 0 \tag{4}$$

so that equation 1 reduces for a time interval to

$$ds^2 = g_{00}dx_0^2 \quad . \tag{5}$$

If the clock is allowed to move or energy (or mass) is added during the process then equation 4 may become only an approximation and the time interval given by equation 5 becomes only approximate.

Mass density is normally not considered to be measured by a fundamental measurement. Instead we normally think of obtaining mass and length intervals separately. Within the Mach principles, however, mass is an inertial measurement which in an interval or relativistic approach has meaning only in context with other objects within the universe. What we measure is the effects of the universe with that object within that region of space that is under consideration. That is to say, we measure the inertial component of the object which is locally within our region of measurement. Said another way, it is the inertial property felt within a volume that is a result of average mass of the universe coupling to the region under measurement. For practical matters, this can be accomplished by measurements of specific gravity compared to some standard.

The mass density is found within a region by an inertial balance of some type for a specific time and position. This has the effect of setting

$$dx_0 = dx_1 = dx_2 = dx_3 = 0 \; . \tag{6}$$

so that the mass density interval is

$$ds^2 = g_{44} dx_4^2 \; . \tag{7}$$

We notice that the measurement of mass density is to be conducted by comparing our standard to the object to be measured and the measurement should be by inertial methods with both the object and the standard at the same general location and time.

1.3   FORCE FIELDS

The exact geometry of a region can be expressed in tensor form as

$$ds^2 = g_{\mu\upsilon} dx_\mu dx_\upsilon \quad (\mu, \upsilon = 0, 1, 2, 3, 4) \; . \tag{8}$$

Assume an observer is under the mistaken impression that the geometry is

$$ds_4^2 = dt^2 - dx^2 - dy^2 - dz^2 - O d\gamma^2 \tag{9}$$

which he expects from special relativity. After many experiments he finds that this geometry does not coincide with his observational results. He has two choices: 1) to retain his supposed geometry (9) and supplement it with force fields or 2) change the underlying geometry of his physical laws.

Let us suppose he watches the movement of a test particle. He would originally assign a path of

$$\delta \int ds_0 = 0 \tag{10}$$

calculated from the 4-D line element of equation 9 to the expected straight line path of the particle. The particle, however, does not acknowledge this and instead follows a path expressed by

$$\delta \int ds = 0 \tag{11}$$

calculated from the 5-D line element of equation 8. To the observer this appears as a deviation from the predicted line. The deviation is seen as some external or internal force. As long as our predicted interval 4-D is close to the 5-D interval, the force may go unnoticed. But when the interval is significantly different from 4-D element, the deviation appears as a force field. For significant departures from the standard 4-D theory, there needs to be a nonzero term resulting from the added coordinate. For example the mass or energy density needs to change along the interval.

In the cases where experiments have only small changes in mass densities there will be little notice of the deviation from the assumed paths. When the mass density changes become larger there is a deviation from the expected paths. These would become more apparent as the change in mass (or energy) densities increases. As energy densities increase more force fields show up. Such additional fields of force would most likely appear first in processes at high mass densities. The constructed forces required by the mistake in geometry would require factors in the supposed force fields of mass or mass density.

This is exactly what current physics sees in the region of high energies. More force fields are continually required as higher and higher energies are reached. Also the additional forces are usually expressed as mass transfer (as Yakawa potentials, virtual particles with mass or charge). If, as an example, such forces were really from a geometry with self-consistent equations of some 5-D theories (see equations 8 and 11) the force field might appear to have an underlying "eight-fold way" type of symmetry. This should be kept in mind as eight and not four Maxwell-like equations are developed. Thus the trajectory of a particle near a region of high mass density (such as a nucleus, proton, etc.) deviates from a path predicted solely using the special law of relativity. It is hoped that a 5-D theory will reduce the need for additional forces to the fundamental theory.

We are most experienced to think in the 3 dimensions–x, y, z. This is the world in which we conduct our normal day-to-day activities. However, dimensions can be things other than length, width, and depth. People are usually more comfortable in terming them variables instead of dimensions. Engineers talk of having many variables, say eight binary channels, entering a device. They then treat the electronic device as some function that processes the input variables into another set of identities (often similar eight channels). Thus they are working with eight variables or eight dimensions and are attempting to take a point located in an 8-dimensional space into another point located in the same 8-D space. Biophysicists will speak of a conformational map of a protein. Here there may be several hundred variables in the form of bond angles of a

molecule. They then attempt to find a most probable value for each variable which minimizes some function (energy).

In physics we can treat the world as a set of input variables (conditions in the world) where we are attempting to understand some function (physical laws) which changes the input variables to another set of variables (conditions of the world at a different time or place). All physical conditions of the world that are yet known can be expressed in just five variables. Thus all physical measurements can be expressed in five fundamental units–length, width, depth, time, and mass. Any other measured value can be resolved into these five fundamentals.

Stated in terms of linear algebra, the unit vectors of mass-density, time, distance in three orthogonal directions, and their derivatives totally span the space of all physically observable events and objects. For an object (or event) to be considered within a physical theory, we desire that it possess a position, exist in time and have a nonzero mass or energy density. To devoid a physical object of mass (or energy) density seems to border on metaphysics and not physics. Either it exists within some volume and interacts or it is not a real physical item. Any physical event (or object) can be totally described as a function of these five variables and their derivatives. Nothing else is required. For example, the observation of charge is only made manifest by the forces (MLT^{-2}) on a test particle. We ultimately measure lengths, masses, and times with our equipment and they can denote (hopefully completely) any physically conceivable event.

From this outlook it is natural to think of a physicist's job as determining the functions that take an object from a given set of five variables (x, y, z, t, γ) into another condition of the world $(x', y', z', t', \gamma')$. As far as can be determined to date, all physical measurements can be expressed in this way. Thus, five dimensions is a logical choice for working in the physical universe. There are at the present many theories which attempt to describe nature in many dimensions. However, these all apparently end up requiring space to be curved back into itself and the higher dimensions not appearing in "normal" physical events. It has often been said–"If there are more dimensions, where are they?" The answer is we can only "see" five dimensions and to work with more seems a complication. Unfortunately most theories try to force nature into only three or four dimensions. This tacitly admits particles of zero mass (energy) density. Such theories can expect to explain such things as the character and interworkings of particles such as neutrinos.

Once we have assured ourselves that five variables are sufficient to describe the physical universe, we must then try to determine the process that will take one 5-D condition into another. The logical choice seems to be a variational approach. The reason for this is that we would very

much like to have a total system of physical laws which has a finite number of rules. In order to have a finite number of rules we will be required to find some system which will give us the physical outcome of any event after we have studied a set of conditions that are approximately the same. In other words, we would like the outcome of an event to be somewhat similar to the outcome of a similar event. If it were not so, then we would have the never ending task of studying all possible world conditions since there would always be some conditions slightly different from the one we so carefully studied before.

This is basically a way of stating the variational principle. The process of the physical laws should be mostly continuous (piece-wise smooth continuous) so that a small change in the initial conditions can give no more than a small change in the outcome. This is what we mean when we mathematically state that

$$\delta \int ds \qquad \text{is stationary,} \qquad (12)$$

remembering ds is just the path from one physical measurement (expressed in our five fundamental variables) to another physical measurement.

1.4   CHIRALITY - Odd Number of Space-Like Dimensions

For a unification theory to be consistent with the physical world it must satisfy the empirical restraint that it be in agreement with the Yang-Mills force. This means it must lead to chirality within the weak force. Such forces are seen in the case of beta decay. Here there is a force whose spatial mirror-reflected image does not exist in nature. Within many theories this leads to a violation of conservation laws such as charge conversions to account for the apparent nonconservation effects.

The 5-D theory avoids both of these problems of nonconservation and chirality. The theory admits an interconversion between charge and mass. This means 5-D replaces charge conservation with conversion methods. This is similar to the mass-energy conversion of relativity which replaced mass conservation in the classical theory.

Chirality requires that there be an odd number of spatial dimensions. This is because the outcome of testing chirality within an N-dimensional manifold is a result of N mirror reflections of a right-handed object transformed into a left-handed object. If the space has an even number of

dimensions, the even number of reflections return the right-handed object to its original configuration.

Many have used this argument to say a unification theory must have an even number of dimensions. The fallacy is that chirality dictates only that the number of spatial dimensions be odd; not that the space-time dimensions be even. Within the (3+2) 5-D theory the additional dimensions are time-like and not space-like. In other words the signature of our metric is (+---+). Thus there is an odd number of space-like dimensions and chirality is valid.

The even number of the time-like dimensions (time and mass density) do not possess chirality. Thus reflecting to both time reversal and mass reversal leads to a symmetry. Although a reversal of mass is not clear, it is likely to lead to symmetries of antiparticles.

When all spatial (parity), time, and mass density (related to charge through conversion formula) components undergo reflection we see that the entire manifold is reversed. Since ds, our basic interval, is defined from the quadratic ds^2 a reversal of the total function leads to the same results. Thus, charge parity time (CPT) is a good symmetry within a (+---+) D theory.

CHAPTER 2
THEORIES

2.1 INTRODUCTION

A review of various physical theories is given in this section. These were selected because they allow for slight modifications of either general relativity or electromagnetism but reproduce the traditional views as limiting cases. This is important since we have confidence in the standard theories; and experiments show that they are correct in currently practiced cases. Of course, for a breakthrough in technology in this area to occur, there must be some expansion of the theories. The approach taken was to compare some sensible theories to see if some new and useful effects might be found. A comparison of how competing theories treat the EM potential is made along with a review of those theories.

One of the objectives of this task is to design experiments that will be useful in advanced propulsion techniques. For truly innovative EM propulsive methods, the traditional Maxwell equations must be expanded or modified to allow for inductive coupling to gravitational forces. It was determined that the most straight-forward way to compare theories was through their methods of treating the EM potentials and their field expressions. If an advanced EM propulsion approach is to couple to the gravitational potential, it will be reflected in the EM potential and its calculation of self and radiation energy. What is desired is a way that the gravitational potential and coupling can be modified electromagnetically or that momentum can be exchanged between EM and inertial fields.

Although strong and weak nuclear forces exist, it is primarily the gravitational and EM forces that govern most common events. The two theories which best model natural events are the General Theory of Relativity (Einstein's) and Maxwell's Equations of Electromagnetism. Together with thermodynamics they account for all current technology outside of nuclear devices. A single theory that describes all these things has been a long sought prize.

General Relativity is based on the generalization of the metric (tensor) properties of 4-D space time which in turn accounts for the existence of the gravitational interactions. Maxwell's equations govern all EM interactions between charged quantities. In the 1920's Kuluza found that a 5-D view of the universe seemed to couple both the gravitational and the EM interactions. The goal was to form a physical picture of the universe that was based on a geometric regularity that extended from the cosmic to subatomic universe. Before embarking on a review of 5-D theories it

is first important to understand the constraints on dimensionality (n = number of space-like dimensions). Some of these are strong constraints but most are only matters of convenience.

Constraints:

1) Einstein's equation $R_{\mu n} = 0$ for vacuum energy says that empty space time should be flat. For particles to cause curvature in space time (nonzero Riemann-Christoffel tensor) the space must be $n \geq 3$.

2) Only in $n = 3$ are Maxwell's equations conformably invariant. Conversely if you want modifications to Maxwell's equation, you need to look at $n > 3$.

3) Circular or nearly circular planetary orbits are stable only for $n \leq 3$ for the two-body problem. The existence of old binary systems seems to indicate the orbits must be stable.

5) It is only in spaces of odd n that Huygen's principle is true. Simply stated, in even n spaces, some signals could be retrieved even after the wave front had passed. Signals from distant pulsars seem to indicate that Huygen's principle does hold to a good degree.

It should be noted that these constraints are general in nature and serve only as a guide. They do not rule out the possibility that any additional dimensions are not time-like or have curvatures smaller than present experimental access.

2.2 GENERAL FRAMEWORK OF THEORY

In the initial 5-D theory, the line element was given as

$$ds^2 = \gamma_{ij} dx^i dx^j \quad where \ i, j = 0, 1, 2, 3, 4, \tag{13}$$

with the added constraint that

$$\gamma_{ij,4} = 0. \tag{14}$$

[Notice the convention $x_0 = t$ and $x_1, x_2, x_3 \Rightarrow x, y, z$ is used throughout the report for uniformity regardless of the notation of the original work.] Kaluza called this additional requirement, as expressed in equation 2, the cylinder condition.

Further it normalized with respect to the coordinate so that

$$\gamma_{44} = 1. \tag{15}$$

The result of this approach was that the geodesics in the 5-D manifold correspond directly with the usual 4-D paths of charged particles in a combined gravitational and electromagnetic field. This means, to a weak field approximation, electromagnetism can be considered as part of the geometrical structure of a 5-D manifold. This is derivable from the 5-D variational principle,

$$0 = \delta \int d^5 x \sqrt{-\gamma} \, \mathbf{R} \tag{16}$$

provided we set $\beta = \sqrt{2\mathbf{K}} = \sqrt{16\pi \mathbf{G}}$.

Also the electromagnetic gauge transformation is simply a geometric effect of the coordinate change through the fifth dimension, to wit:

$$\hat{\gamma}_{4\mu} = \gamma_{ij} \frac{\partial x^i}{\partial x^4} \frac{\partial x^j}{\partial x^\mu} = \gamma_{4\mu} + \gamma_{44} \frac{\partial f^4}{\partial x^\mu}, \tag{17}$$

or for the electromagnetic potential

$$\mathbf{A}_\mu = \hat{\mathbf{A}}_\mu - \frac{\partial f^4}{\partial x^\mu}. \tag{18}$$

In such a system the metric tensor, $\mathbf{G}$, has 15 components instead of the 10 in 4-D. It is these extra degrees of freedom that allow the unification. They correspond to ten components of the 4-D metric tensor $g_{\mu n}$, the four components of the electromagnetic potential A_{mn} and the additional one is undetermined and in effect set to 1 by the cylinder condition.

This basic approach has been modified by various writers. It was found that the assignment of physical items to the geometric values should not follow directly from the metric but instead be made through conformed regauging. In Weyl's theory the regauging transformation between metric differs only by a scalar function of the coordinates

$$G_{44} = -\Psi^2.$$
<div align="right">(19)</div>

In the original theories $G_{44} = -1$ but in later theories the scalar was assigned to a scalar field. Several meanings have been assigned to the scalar field: 1) It may represent an undiscovered massless fundamental field. This is similar to the Brans-Dicke scalar-tensor theory. This is the most common interpretation. 2) The field can also be viewed similar to the scalar field of the Klein-Flock-Gordon equation. It is interesting to note that, if the first interpretation is the correct one, then the mass of the field particle must be related by

$$m = (e/2)\sqrt{G}$$
<div align="right">(20)</div>

and the mass would be 10^{-6}g. This is an exceptionally large (weighable on a good pan balance) mass. It is possible to renormalize the theory to yield a given value for the mass but it can not be determined what mass should be selected.

There have been many historical attempts to develop a theory that calculates a finite self-energy. The difficulties are that most attempts are not relativistically invariant. For example, some theories spread the charge out over a nonzero radius, r_0. This is attractive, but the r_0 is relativistically dependent on the velocity of the particle. Thus, the self energy or rest energy (mass) changes in different reference frames. Such theories do not have relativistic invariance. Some theories renormalize to avoid such difficulties. This leads to probabilities that are not conserved in all reference frames. In such theories the particle appears or disappears (changes kernel amplitudes and thus the integrated probabilities) dependent on the velocity of the reference frame. Quoting from R. Feynmann (1): "The difficulty suggested by this problem has never been solved. No modification of quantum electrodynamics at high frequencies is known which simultaneously makes all results finite, maintains relativistic invariance, and keeps the sum of probabilities over all alternatives equal to unity." He also states, "It is possible that we are calculating in a naive manner, and, if all of the consequences of general relativity (such as the gravitational effects produced by large stresses implied here) were included, the effects might cancel out; but nobody has worked all this out."

We will now look at several approaches to the problem. A historical summary of the self energies and potentials resulting from these methods appears in Tables 1 and 2 which follow the discussions.

It has long been known that the self energy of a charged particle is infinite when calculated in 4-space when a $1/r^2$ Coulombic potential is used. The reason is that the $1/r^2$ term tends to infinity as the distance, r, tends to zero. In 4-space one is faced with a dilemma. Either the charge particle is not point-like or the shape of the potential is non-Coulombic. If the first interpretation is taken then all charged particles must have a substructure and there can be no ultimately fundamental charged particle. Five-space offers a solution to the dilemma by allowing the charge to be spread over the added dimension.

The role of this self-energy and vacuum energy terms has led to conjectures to unlimited energy sources. Yet this seems totally unfeasible on thermodynamic grounds. To see several approaches to this self-energy problem we need to turn to some historically proposed solutions. The results are summarized in Table 2. The form of the potential is the basis for several experimental developments. It is perhaps the most fundamental concept required for a microscopic understanding of natural phenomena governed by electromagnetic forces. In unified theories it should be kept in mind that linkage between electric and magnetic forces is expected to generate a similar potential and that potential can be different from the Coulombic.

2.2.1   Born - Infield

Born and Infield (2) approached the problem by trying to solve the difficulty of the infinite self energy of charged particles. This is done by starting with the invariant Lagrangian

$$\delta \int L \, dv = 0 \tag{21}$$

which gives

$$L = \sqrt{-\left|g_{ij} + f_{ij}\right|} - \sqrt{-\left|g_{ij}\right|} \tag{22}$$

using the metric g and the field tensor f. For flat space,

$$L = \sqrt{1 + F - G^2} - 1 \tag{23}$$

where F is twice the classical EM Lagrangian,

$$F = \left(1/b^2\right)\left(B^2 - E^2\right) \tag{24}$$

$$G^2 = \left|\frac{f_{ij}}{g_{ij}}\right| = \frac{1}{b^4}(B \cdot E)^2 \tag{25}$$

and b is Born's absolute field unit. The field equations

$$H = b^2 \frac{\partial L}{\partial B} = \frac{B - G \cdot E}{\sqrt{1 + F - G^2}} \tag{26}$$

and $\quad D = b^2 \frac{\partial L}{\partial E} = \frac{E - GB}{\sqrt{1 + F - G^2}} \tag{27}$

give the equations

$$\nabla \times E + \frac{1}{c} \cdot \frac{\partial B}{\partial t} = 0 \quad , \tag{28}$$

$$\nabla \times H - \frac{1}{c} \frac{\partial D}{\partial t} = 0 \quad , \tag{29}$$

$$\nabla \cdot B = 0 \quad , \tag{30}$$

$$\nabla \cdot D = 0 \tag{31}$$

which are devoid of the normal terms involving charge and current. For an electron at rest

$$D(r) = e / r^2 \quad , \tag{32}$$

$$\varphi(r) = (e/r_o)\int_{r/r_o}^{\infty} \frac{dy}{\left(1+y^4\right)^{1/2}} \quad \text{with} \quad r_o = \sqrt{e/b} \tag{33}$$

and

$$E(r) = \left(e/r_e^2\right)\frac{1}{\sqrt{1+(r/r_e)^4}} \quad . \tag{34}$$

Thus the electric field is finite at all points and does not go to infinite at the origin. The self energy is likewise finite and found to be

$$\varepsilon_{self} = 1.236 \, e^2/r_o \quad . \tag{35}$$

2.2.2 Landé

Landé (3) also worked with explaining the self energy of a particle. He does this by giving an electron a finite radius r_0. For two electrons,

$$E(r) = \left(e^2/r\right)\left(1 - \exp(r/r_e)\right) \tag{36}$$

with

$$r_e = 2e^2/3mc^2 \quad . \tag{37}$$

At $r = 0$ the mutual energy is finite and is

$$E(o) = e^2/r_e \qquad \text{(2 particles)} \tag{38}$$

and the self energy is half of that,

$$\varepsilon_{self}(o) = e^2/2r_e \quad . \tag{39}$$

The modified electric potential is given by $\phi = (e/r^2)(1 - \exp(r/r_o))$. It is the difference between the Coulomb and Yukawa potentials. Thus, the second term was identified with the meson.

2.2.3 Podolsky

Podolsky (4) also approaches the self energy problem with alteration of the Lagrangian. He starts by writing the Lagrangian as

$$L = (1/2)(\mathbf{E}^2 + \mathbf{H}^2) + (a^2/2)\left[(\nabla \cdot \mathbf{E})^2 - \left(\nabla \times \mathbf{H} - (1/c)\dot{\mathbf{E}}\right)^2\right] \qquad (40)$$

or in tensor form

$$L = (1/2)\left[(1/2)F_{ij}^2 + a^2\left(\frac{\partial F_{ij}}{dx_j}\right)^2\right] . \qquad (41)$$

The field equations can be obtained from this Lagrangian as

$$\frac{\partial F_{ij}}{\partial x_k} + \frac{\partial F_{jk}}{\partial x_i} + \frac{\partial F_{ki}}{\partial x_j} = 0 \qquad (42)$$

which is the same as classical theory and gives

$$\left(1 - a^2\frac{\partial^2}{\partial x_i \partial x_i}\right)\frac{F_{jk}}{\partial x_k} = 4\pi J_j \qquad (43)$$

which gives the modified expressions

$$(1 - a^2\square)\ \nabla \cdot \mathbf{E} = 4\pi\rho \qquad (44)$$

and

$$(1 - a^2\square)\ \left(\nabla \times \mathbf{H} - (1/c)\dot{\mathbf{H}}\right) = 4\pi\mathbf{J}/c . \qquad (45)$$

The scalar field then becomes

$$\phi = (e/r)(1 - \exp(-r/a))$$

(46)

which is the same as the result by Landé.

2.2.4   Corben

Corben (5) developed a 5-D theory of electrodynamics. He assigns A_4 with the gravitational potential and J_4 with the mass (rest) density of matter. All the classical relationships of classical relativity and electromagnetic theory are recovered as the components associated with the fifth coordinates (i.e. $\partial/\partial x_4$) tend to zero. Corben assigns to the fifth dimension the relationships between charge and mass. His conclusion is that mass and charge are interchangeable and only the total of their coupled effects is conserved.

Corben's (6) second paper is interesting from the standpoint of energy and momentum conservation. Corben's general approach follows closely from Pauli's work (7).

2.2.5   Flint

Flint (8, 9, 10) attempted a 5-D theory which starts by assuming that the components of the electromagnetic potential are independent of x_4. From this he shows that the fifth component of momentum is then constant and the coordinate becomes cylindrical in character. The theory gives no new effects.

The important point of the work to be noticed here is its converse. Thus, if the components are not independent of x_4, it becomes plausible that momentum may become a function of terms relating components of the fifth dimension.

2.2.6   Ingraham

Ingraham (11) relates the current as

$$J_i = x_4 \frac{\partial}{\partial x_4}\left(\frac{G_i}{x_4}\right) .$$

(47)

The 5-D potential for a particle with velocity **v** and the radius vector **R** is then

(space) $$F_i = \frac{e}{4\pi} \frac{v/c}{\left(R^2 + \lambda^2\right)^{1/2} - (R \cdot v)/c} \quad \text{with } i = 1, 2, 3 \ , \tag{48}$$

(time) $$F_o = -\varphi = \frac{r}{4\pi} \frac{-1}{\left(R^2 + \lambda^2\right)^{1/2} - (R \cdot v)/c} \ , \text{and} \tag{49}$$

(extra) $$F_4 \equiv 0 \ . \tag{50}$$

Lambda is taken here to be x_4. The potential becomes

$$\varphi(r) = \frac{e}{4\pi} \frac{1}{\left(R^2 + \lambda^2\right)^{1/2}} \ . \tag{51}$$

The charge density is found to be

$$\rho(r) = \frac{e}{4\pi} \frac{3\lambda^2}{\left(R^2 + \lambda^2\right)^{5/2}} \ . \tag{52}$$

The finite λ effectively spreads the charge over a radius less than 2λ. The electric potential becomes

$$E(r) = -\nabla \varphi = \frac{e}{4\pi\varepsilon_o} \frac{r}{\left(R^2 + \lambda^2\right)^{3/2}} \tag{53}$$

and the self energy is

$$\varepsilon_{self} = (1/2) \int E^2 dv \tag{54}$$

or

$$\varepsilon_{self} = \frac{3e^2}{128\lambda} \quad .$$

(55)

2.2.7 Arctan Potential

One approach developed for this work is to use a 5-D radius vector in the electrostatic potential,

$$\varphi = \frac{a}{4\pi^2} \frac{1}{r^2 + x_4^2} = \frac{a}{4\pi^2} \frac{1}{R^2}$$

(56)

and allow the fifth coordinate to only range from λ to ∞ . The electrostatic potential is then

$$\varphi(r) = \int_\lambda^\infty \varphi(R) dx_4 \quad ,$$

(57)

$$\varphi(r) = \frac{e}{2\pi^2 \varepsilon_o} \int_\lambda^\infty \frac{dx_4}{r^2 + x_4^2} \quad , \text{ or}$$

(58)

$$\varphi(r) = \frac{e}{4\pi\varepsilon_o r} \left[1 - \frac{2}{\pi} \arctan(\lambda / r) \right] .$$

(59)

This remains finite at the origin with the value

$$\varphi(o) = \frac{a}{4\pi^2\lambda} \quad .$$

(60)

It reduces the Coulomb potential for large r's:

$$\varphi(r > 0) \Rightarrow \frac{e}{4\pi^2\varepsilon_o r^2} \quad .$$

(61)

The charge density of this function is

$$\rho(r) = \frac{-\lambda e}{\pi^2 \left(r^2 + \lambda^2 \right)^2} \quad .$$

(62)

The self energy for the 5-D particle is then

$$\varepsilon_{self} = e^2 / 4\pi^2 \varepsilon \lambda .$$

(63).

2.2.8 Milne

Milne developed a considerable body of work (12) on the theoretical approach to field unification. His approach involved a second time-like component. He made a very interesting observation: It is impossible to use a moving test charge to measure the magnetic field without its own velocity, relative to the velocities of the other charges present in the field, bringing into apparent existence distinct additional currents. This is a very deep insight and has not been generally recognized. The important point is that either: 1) the theory is not relativistic invariant or 2) it is not consistent with quantized charged. The second case is often overlooked and it is tacitly assumed that a test charge can be made arbitrarily small. Yet it is known that charge is quantitized and is invariant to all transformations. This means that any theory which hypothesizes an arbitrarily small test charge is fabricating a nonphysical quantity. Within Milne's theory, the force between two electrons is

$$F = \frac{e^2}{2r^2}\left\{\left(1+\frac{W^2}{mc^2}\right)^2 \exp\left[-\left(e^2/mc^2r\right)\right] + \exp\left(e^2/mc^2r\right)\right\}$$

(64)

where W is the kinetic energy of electrons. The important factor in the potential is the exponential term, which goes as $\exp(a/r)$ instead of $\exp(r/a)$ as in the earlier work. This imparts a well behaved nature to energy calculations.

Notice that for the case of $W << mc^2$ and $r >> e^2/mc^2$ the potential reverts to the Coulomb

$$F = e^2 / r^2 ,$$

(65)

for two charges with $r < e^2/mc^2$,

$$F(r) = \left(e^2/2r^2\right)\left(1+W/mc^2\right)^2 \exp-\left(e^2/mc^2r\right) ,$$

(66),

-24-

with the modification being a result of the kinetic energy W. This modification only appears in dynamic systems. This is a very pleasing result but unfortunately appears to get lost in philosophical debates on Milne's work.

2.2.9 Williams

Williams has advanced a 5-D theory starting from thermodynamics (13, 14, 15). This is a unique approach and does not appear to have been stated elsewhere. He has combined the thermodynamic laws with mechanical systems to give a unified 5-D theory. He has expressed the electrostatic potential as

$$V(r) = \frac{A}{r^2}\left(1 - \frac{\lambda}{r}\right)\exp(-\lambda / r) \, , \tag{67}$$

where λ is a fundamental constant that is particle dependent.

The particle's self energy can then be calculated by

$$\varepsilon_{self} = (1/2)\int E^2 dv \, . \tag{68}$$

Williams has used this potential to calculate atomic mass defects. The results are generally better than standard models.

Table 1. Comparisons of Potentials

Coulomb

$$E_A(r) = 1/r^2$$

(69)

Truncated Coulomb

$$E_B(r) = 1/r^2; r \geq r_o \qquad E_B(r) \equiv 0; r < r_o$$

(70)

Born-Infield

$$E_C(r) = \left(e/r_o^2\right) \frac{1}{\sqrt{1 + (r/r_o)^4}}$$

(71)

Coulomb with Yakawa

$$E_D(r) = \left(e/r^2\right)\left(1 - \exp(-r/r_o)\right) \quad \text{with} \quad r_o = 2e^2/3mc^2$$

(72)

Ingraham

$$E_E(r) = \frac{e}{4\pi\varepsilon_o} \frac{r}{\left(r^2 + \lambda^2\right)^{3/2}}$$

(73)

Williams

$$E_F(r) = \frac{1}{r^2}(1 - \lambda/r)\exp(-\lambda/r)$$

(74)

Milnes

$$E_G(r) = \frac{e}{2r^2}(1 + K.E.)^2 \exp-\left(e^2/mc^2 r\right)$$

(75)

Arctan

$$E_H(r) = \frac{e}{\pi\varepsilon_o r^2}\left(1 - \frac{2}{\pi}\arctan(\lambda/r)\right)$$

(76)

Table 2. Comparisons of Self Energies

Coulombic: infinite (77)

Born Infield: $1.236\, e^2 / r_o$ (78)

Landé: $e^2 / (2r_o)$ (79)

Podolsky: $e^2 / (2r_o)$ (80)

Ingraham: $3e^2 / (128\lambda)$ (81)

Arctan: $e^2 / (4\pi^2 \varepsilon_o)$ (82)

2.3 DEVELOPMENT OF 5-D EM EQUATIONS

One goal of this work is to expand such 5-D theories to provide a useful set of field expressions and see where they may lead. Specifically, we wish to see how changes in the classical Maxwell expressions may result from such theories. The expression will be developed into classical differential form to facilitate the understanding of expected physical effects. Conventional coordinate-based tensor symbolism will be used. A brief review of the symbols appears in Appendix A.

The line element is given by

$$ds^2 = g_{ij}\, dx^i\, dx^j \qquad \text{for} \qquad i,j = 0, 1, 2, 3, 4 \ , \tag{83}$$
$$x^0 = ct \ , \tag{84}$$
$$x^{1,2,3} = \text{space} \ , \tag{85}$$
$$\text{and} \qquad x^4 = j \ . \tag{86}$$

Williams (13, 14, 15) has started from thermodynamic reasoning and assigned j as mass density. Wesson (16) has assigned

$$j = G\, m/c^2 \cdot \tag{87}$$

The field equations are written as analogs to the 4-D Einstein expressions as

$$G_{ij} = R_{ij} - 1/2\ g_{ij}\ R\ ,\ \text{or} \tag{88}$$

$$= (8p\ g/c^4)\ T_{ij}\ . \tag{89}$$

It is further assumed that the metric is a function of all 5 coordinates and no added cyclic conditions are imposed.

Likewise by analogy, the electromagnetic equations can be quickly obtained from the 4-D expressions by expanding the antisymmetric electromagnetic tensor, $F^{\mu n}$, and the current vector, J^{μ}. The potentials A and the j from Maxwell's theory now form a 5 vector

$$K^0 = j = A^0 \qquad K^i = A^i \tag{90}$$

from

$$F_{\mu\upsilon} = K_{\mu,\upsilon} - K_{\upsilon,\mu} \tag{91}$$

where

$$F_{\mu\upsilon} = \begin{bmatrix} O & iE_1 & iE_2 & iE_3 & iV_4 \\ -iE_1 & O & B_3 & -B_2 & V_1 \\ -iE_2 & -B_3 & O & B_1 & V_2 \\ -iE_3 & B_2 & -B_1 & O & V_3 \\ -iV_4 & -V_1 & -V_2 & -V_3 & O \end{bmatrix} \tag{92}$$

and

$$4\pi J^{\mu} = F^{\mu\upsilon}{}_{,\upsilon}\ . \tag{93}$$

Notice that the symbol V has been used to designate the expected fields derived from the added fifth coordinate. The metric signature has been tentatively assigned the value of (+---+).

These can now be utilized to derive 5-D analogs to the classical Maxwell expressions. By using the Bianchi identities.

$$F_{ij,k} + F_{ij,i} + F_{ki,j} = 0 \tag{94}$$

from which we obtain four field equations

$$\nabla \cdot \mathbf{B} = 0 \ , \tag{95}$$

$$\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0 \ , \tag{96}$$

$$\nabla \times \overline{\mathbf{V}} - a_o \frac{\partial \mathbf{B}}{\partial \gamma} = 0 \ , \tag{97}$$

and
$$\nabla V_4 + (1/c)\frac{\partial \mathbf{V}}{\partial t} - a_\bullet \frac{\partial \mathbf{E}}{\partial \gamma} = 0 \ . \tag{98}$$

The first two are the normal Maxwell expressions. The last two indicate the new role played by the mass terms.

Notice the constant a_0 is introduced specifically to indicate the degree of coupling between the EM and inertial fields. Additional equations are obtained from the current density expression.

$$F_{ij,i} = 4\pi J_j \tag{99}$$

as three additional equations

$$\nabla \cdot \mathbf{E} + a_\bullet \frac{\partial V_4}{\partial \gamma} = 4\pi\rho \ , \tag{100}$$

$$\nabla \times \mathbf{B} - (1/c)\frac{\partial \mathbf{E}}{\partial t} + a_\bullet \frac{\partial \mathbf{V}}{\partial \gamma} = 4\pi J / c \ , \tag{101}$$

and
$$\nabla \cdot \mathbf{V} + (1/c)\frac{\partial V_4}{\partial t} = \frac{-4\pi}{c} J_4 \ . \tag{102}$$

Equation 101 will become important in locating new effects. The electric field from a region now depends on both the charge density, r, and the change in the mass (energy) density.

Notice that J^i (i = 0, 1, 2, 3) are the classical charge density or current, and that J_4 is a new entity which is a mass density-like flow and dependent on the exact assignment of the fifth coordinate.

A 5-D analog to the continuity equation can be obtained by

$$4\pi J_{i,i} = F_{ji,i} \tag{103}$$

or

$$J_{i,i} = 0 \tag{104}$$

to give

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \mathbf{J} + \frac{a_e \partial J_4}{\partial \gamma} = 0 \quad . \tag{105}$$

This expression is important in looking for nonconservation of charge.

Likewise the 5-D force forces become

$$\mathbf{F}_i = q\left(\mathbf{E}_i + (\mathbf{v} \times \mathbf{B})_i\right) + \frac{J_4 V_4}{c} \quad , \text{ and} \tag{106}$$

$$F_4 = q\left(V_4 - \frac{\mathbf{v} \cdot \mathbf{V}}{c}\right) \tag{107}$$

for particles of velocity v. Notice the scalar-like force that modifies the classical Lorentz force.

To better understand the expected change due to the added physical dimension we must look at some special cases. Without any mass effect (free space)

$$V_i \rightarrow 0 \tag{108}$$

and $\quad\quad J_4 \rightarrow 0 \tag{109}$

and the field equations reduce to the four familiar Maxwell equations.

If all electromagnetic effects could be removed the equations become

with $\quad\quad \mathbf{E}_i = \mathbf{B}_i = 0 \quad$ for $\quad i = 1, 2, 3 \quad . \tag{110}$

From equation 100

$$a_e \partial V_4 / \partial \gamma = 0 \quad , \tag{111}$$

from equation 97

$$\nabla \times \mathbf{V} = 0 ,$$ (112)

from equation 105

$$a_o \partial J_4 / \partial \gamma = 0 ,$$ (113)

from equation 98

$$\nabla V_4 + (1/c)\frac{\partial \mathbf{V}}{\partial t} = 0 ,$$ (114)

and from equation 102

$$\nabla \cdot \mathbf{V} + (1/c)\frac{\partial V_4}{\partial t} = \frac{-4\pi J_4}{c} .$$ (115)

Equations 111 and 102 can be used to help understand V_4 and J_4. From these it is apparent that they are functions linear with respect to the added dimension. From equation 112 it is seen that a divergence in mass from a point is impossible in the absence of charge and magnetic effects. This rules out photon-photon reactions via virtual charged particles. Such terms have plagued QED calculations.

Equations 94, 95, 96, and 98 can be rewritten to stress their correlation with the classical Maxwell formalism. The first two remain unchanged

$$\nabla \cdot \mathbf{B} = 0$$ (116)

and

$$\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0 .$$ (117)

indicating no monopolies and that the line integral of **E** about a loop is proportional to the time change of the magnetic field through the loop. The remaining two make possible new additions to Maxwell's expressions

<div align="center">New Terms</div>

$$\nabla \cdot \mathbf{E} = 4\pi\rho \qquad\qquad -\frac{a_e \partial V_4}{\partial \gamma} \qquad\qquad (118)$$

$$\nabla \times \mathbf{B} - \frac{\partial \mathbf{E}}{\partial t} = 4\pi \mathbf{J} \qquad\qquad -\frac{a_o \partial \mathbf{V}}{\partial \gamma}. \qquad\qquad (119)$$

Equation 118 modifies Gauss's Law to state that flux through a closed surface is proportional to the charge inside only if there is no mass density change within that region. In other words, the effect of particle creation/annihilation within a region must be considered when calculating the flux from a volume. Conversely calculation of mass within a volume must consider the possible flow of electromagnetic energy within the volume (pair production). It can be argued that Gauss's law implies a $1/r^2$ potential and any new terms would alter that potential. The effects are very subtle or appear only in high mass density regions. The new potential does not have divergencies as does the $1/r^2$. Likewise the magnetic field can now arise from changes in the electric flux, movement of charges and the change from V arising from mass effects.

It is interesting to note that Milne (12) pointed out a need to modify just these two Maxwell expressions. He arrived at slightly different terms due to alternate assumptions concerning two time-like coordinates. His viewpoint was that strict relativistic ab initio theories must consider the possibility that in moving reference frames it is impossible to use a moving test charge to measure a magnetic field without its own velocity, relative to the velocities of other charges present in the field, bringing into existence distinct additional currents. Thus, he proposed a modification to these Maxwell expressions when the magnetic field depends on the velocity of the test-charge measuring it. Some have countered this by saying the test charge can be made infinitesimally small. But this is inconsistent with physical reality since charge is quantitized and an infinitesimally small charge is not possible.

This concept is very important. It seems to have been totally ignored in the current literature and only appears in Milne's work. The idea is a theoretic insight directly into the heart of the understanding of charge. Here we have a case of a fundamental physical theory relying on the

existence of a physically impossible quantity. Charge is unique in that it is quantitized and the number of fundamental carriers is a relativistic and probablistic invariant within all physical reality.

2.3.1 Modifications to Maxwell's Equation

Any system which would link EM with other forces must add changes to Maxwell's equations. These equations are perhaps the most experimentally verified ones of physics. Any modifications must be examined closely to see if the modifications violate any known experiment. The four Maxwell equations can be grouped into two sets: electrostatic and electrodynamic, and magnetostatic and magnetodynamic.

Two of the equations come from the Bianci relations (equation 94):

$$\nabla \cdot \mathbf{B} = 0 \qquad \text{exclusion of magnetic monopoles, and} \qquad (120)$$

$$\nabla \times \mathbf{E} = \partial \mathbf{B} / \partial t \qquad \text{E of a loop depends on the B flux through it.} \qquad (121)$$

Both of these equations can be derived directly from the antisymmetric nature of the tensor, $F_{\mu n}$, and Bianci tensor identity. They should hold in all coordinate systems and for all multidimensional spaces. They are valid even under nonsymmetric space-time curvature. The Bianci relations are valid for both simple differentiation and the covarient differentiation of a general tensor so

$$F_{\mu v, \sigma} + F_{v \sigma, \mu} + F_{\sigma \mu, v} = F_{\mu v; \sigma} + F_{v \sigma; \mu} + F_{\sigma \mu; v} = 0 \qquad (122)$$

There appears to be no valid theoretical reason to experimentally test any non-classical or novel effects linked to modifications to these equations.

The two Axiomatic Maxwell equations are separate from the Bianci relations. They are:

$$\frac{1}{c} \partial \mathbf{E} / \partial t = \nabla \times \mathbf{H} - 4\pi \mathbf{J} \qquad (123)$$

which depends on currents in loops plus a displacement current

and $$\nabla \cdot \mathbf{E} = 4\pi \rho . \qquad (124)$$

equation 124 shows that the flux of E depends on charges inside the volume.

These two laws stand on a different theoretical footing than Maxwell's first two equations. They can be traced to the definition of current by

$$F^{\mu\nu}{}_{,\nu} = 4\pi J^{\nu} .$$ (125)

This, however, is not valid within general relativity when the curvature tensor is nonzero. The normal differentiation (comma) should be replaced by full covariant differentiation (semicolon) if the definition is to have meaning in all reference frames. That is

$$F^{\mu\nu}{}_{;\nu} = 4\pi J^{\nu} .$$ (126)

This will include curvature terms, Γ's .

It is interesting to note that all plausible variations to Maxwell's equations investigated here had variations in just these two equations. This was true regardless of the theoretical starting point. (Williams started from the thermodynamics, Chambers from 5-D, Milne from noninfinitesimal test charge, etc.)

It is highly recommended that any experimental project hoping to capitalize on modifications to Maxwell's equations concentrate on these two equations. Targeting these two relations is most likely to demonstrate any coupling between EM and other forces. Modifications are summarized in Tables 3 and 4.

Table 3. Modification of Maxwell's Equations

Maxwell: $\nabla \cdot \mathbf{E} - \rho / E_o = 0$ (127)

Trocheris: $\nabla \cdot \mathbf{D} - 4\pi\rho = \nabla \cdot \left[\dfrac{2\omega\theta}{c} \mathbf{r} \times \mathbf{H} \right]$ (128)

Williams: $\nabla \cdot \mathbf{E} - 4\pi\rho = \partial V_4 / \partial \gamma$ (129)

Milne: $\nabla \cdot \mathbf{E} = (1/c)\, \partial a / \partial t$ (130)

Lucak: $\nabla \cdot \mathbf{D} - 4\pi\rho = -\xi / c \left[\dfrac{\partial q}{\partial t} + \mathbf{V} \cdot grad\ \mathbf{q} \right]$ (131)

Chambers: $\nabla \cdot \mathbf{E} - \rho / \varepsilon_o = \dfrac{\partial |\mathbf{R}|}{\partial x_5}$ (132)

Table 4. Modification of Maxwell's Fourth Equation

Maxwell: $c^2 \nabla \times \mathbf{B} - \mathbf{J} / \varepsilon_o - \dfrac{\partial \mathbf{E}}{\partial t} = 0$ (133)

Trocheris: $\nabla \times \mathbf{H} - 4\pi \mathbf{J} / c - 1 / c \dfrac{\partial \mathbf{D}}{\partial t} = \dfrac{-2\omega\Theta}{2} \left[\nabla \times \mathbf{r} \times \mathbf{D} + (1/c) \dfrac{\partial}{\partial t} \mathbf{r} \times \mathbf{H} \right]$ (134)

Williams: $\nabla \times \mathbf{B} - 4\pi \mathbf{J} - \dfrac{\partial \mathbf{E}}{\partial t} = -\dfrac{\partial \mathbf{V}}{\partial \gamma}$ (135)

Milne: $\nabla \times \mathbf{H} - 1 / c \dfrac{\partial \mathbf{E}}{\partial t} = grad(\mathbf{a})$ (136)

Lucak: $\nabla \times \mathbf{H} - 4\pi \mathbf{J} / c - 1 / c \dfrac{\partial \mathbf{D}}{\partial t} = \dfrac{-\xi}{c} \left[\dfrac{\partial \mathbf{F}}{\partial t} + \dfrac{V_x \partial \mathbf{F}}{\partial x} + \dfrac{V_y \partial \mathbf{F}}{\partial y} + \dfrac{V_z \partial \mathbf{F}}{\partial z} \right]$ (137)

Chambers: $\nabla \times \mathbf{B} - \mu \cdot \mathbf{J} - \left(1 / c^2 \right) \dfrac{\partial \mathbf{E}}{\partial t} = \dfrac{\partial \mathbf{Q}}{\partial x_5}$ (138)

2.3.2 Lorentz Forces in 5-D

The Lorentz force is given by the familiar expression

$$\mathbf{F} = q\left(\mathbf{E} + \mathbf{v} \times \overline{\mathbf{B}}\right).$$ (139)

It is a postulate separate from the Maxwell expressions but yet consistent with those expressions. It can be obtained by the Biot-Savart Law

$$d\mathbf{F} = I \, d\mathbf{l} \times \overline{\mathbf{B}} / c$$ (140)

for two loops of stationary currents if one current produces a B field which then exerts a force of dF on the current when a current of I dl passed through a small element of the second. Since the Lorentz expression contains the observed velocity v it is not clear that it is rigorously valid at v approaching c.

Several researchers have suggested that the Lorentz expression be dropped and a return be made to the Ampere force laws for interacting currents. Most either do not see any difficulties or do not think that the effort is justified. Recently Peter Graneau has conducted experiments that seem to support a return to Ampere force laws.

The forces can be approached from a theoretical view as arising from

$$\text{Force} = dp/d\tau, \tag{141}$$

and in full tensor notation for any n - space

$$m\left[\frac{d^2x^\alpha}{d\tau^2} + \Gamma^\alpha_{\mu\nu}\frac{dx^\mu}{d\tau}\frac{dx^\nu}{d\tau}\right] = eF^\alpha_\beta\frac{dx^\beta}{d\tau} \tag{142}$$

with $\qquad \text{Force} = F^\mu_\nu J^\nu \tag{143}$

Expressed in 5-D notation of the Dynamic Theory this is written as

$$K^\alpha = F^{\alpha\beta}J_\beta = T^{\alpha\beta}_{;\beta} \, . \tag{144}$$

These force densities become

$$K_o = (i/c)\left[\overline{\mathbf{E}}\cdot\overline{\mathbf{J}} + V_4 J_4\right] \tag{145}$$

$$\mathbf{K} = (1/c)\left[\mathbf{J}\times\mathbf{B} + J_4\mathbf{V}\right] \tag{146}$$

and $\qquad K_4 = -(1/c)\left[\mathbf{J}\cdot\mathbf{V}\right] \, . \tag{147}$

Within the Dynamic Theory of Williams (13) the J_4 is the "mass charge" that is similar to the "weight" of the material and the V's are related to the "gravitational potential." The important feature is that the classical Lorentz style forces are now seen to contain additional terms.

It is hard to interpret the expressions above for the general case. However in the Dynamic Theory where mass density is taken as the additional dimension, the J_4V term is apparently the Newtonian Force

$$F = \frac{J_4}{c}\mathbf{V} \Rightarrow m\mathbf{\bar{a}} \tag{148}$$

and V can be considered to be the gravitational field strength of the transverse gravitational component. The $J \cdot V$ term is more difficult. Also one must remember that the expression must properly be transformed and may require the use of curvature terms ($\Gamma' s$) for the general case. The K_y is especially interesting since it would seem to be the force in the "direction of mass density" and may tend to decrease the expected "pinching" that would be expected from the E and B fields alone (notice sign). If this is correct we might see dispersive forces at high currents in conditions that otherwise would compress the material. These terms may become important in designing of efficient EM propulsive devices that operate with high currents or with highly divergent flows.

2.3.3 Wave Propagation in 5-Space

It is extremely difficult to derive and understand the nature of the propagation of 5-D waves. This is due to several factors. One, is the complications of assigning physical understanding to the mass terms equivalent to optical properties such as the index of refraction. A more severe complication is the mathematical complexity arising from retaining mass effects in the wave formalism while having to treat Christoffel terms in the geodic trajectories.

The following will proceed by setting space curvature terms to zero but retaining the 5-D form of the wave expression. The propagation of the wave will proceed by using

$$\delta \int ds \quad \text{as stationary.} \tag{149}$$

The trajectory becomes

$$\frac{dv^\sigma}{ds} = \Gamma^\sigma_{\mu\upsilon}V^\mu V^\upsilon = 0 . \tag{150}$$

Proceeding by mathematical analogs to 4-D, a solution can be expressed as

$$A(r,t) = a_\kappa \exp\left\{\frac{-2\pi i}{\lambda}\left(\bar{1}\cdot\bar{r}\right)\right\}$$

(151)

where $\bar{1}$ is the direction cosine of the wave:

$$\bar{1} = \left(c, -k_1, -k_2, -k_3, -k_4\right)$$

(152)

with

$$l_\mu l^\mu = 1 \quad \text{(units: } c = 1\text{)}$$

(153)

for propagation along x_1 and thus

$$A(r,t) = a_\kappa \exp\left\{-\frac{2\pi i}{\lambda}\left(ct - kx + k_4 m\right)\right\} .$$

(154)

The first and second derivative of k must be zero for the direction of the ray to be constant at an arbitrary 5-D point. Otherwise there would be an uncertainty that would enter the expression for phases.

Placing this into the field equations, 95, 96, 97, 98, 100, 101, and 102, the solution becomes for flat space

$$B_x = B_y = V_z = J_z = 0 ,$$

(155)

$$B_z = (ck/\omega)E_x ,$$

(156)

$$E_x = E_o \exp\left\{i\left(\omega t - kx + k_4 m\right)\right\} ,$$

(157)

and

$$J_4 = \frac{ck}{4\pi}V_x - \frac{\omega}{4\pi}V_4 .$$

(158)

For a wave propagating along x ,

$$E_y = (\omega/kc)B_z ,$$

(159)

$$V_x = \frac{a_o c k_4}{\omega}\left(1+\left(\frac{k}{a_o k_4}\right)^2\right)E_x \ ,$$

(160)

$$V_y = \frac{a_o c k_4}{\omega}E_y \ ,$$

(161)

$$V_4 = k \ / \ a_o k_4 E_x \ ,$$

(162)

$$J_x = \frac{a_o k_4}{k}J_4 \ ,$$

(163)

and

$$J_y = \frac{a_o k_4}{k}J_4 \ .$$

(164)

2.3.4 Limits to Conversion Rates

The trajectories for light can be obtained by the imposing a stationary condition for the line element in equation 10,

$$\delta \int ds^2 = \delta \int g_{ij}dx^i dx^j = 0$$

(165)

or using flat Euclidean space

$$ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 + \left(1 \ / \ a_o\right)^2 d\gamma^2$$

(166)

with a_o a real constant for a metric signature (+---+) and a_o a pure imaginary constant for a (+----) signature. For flat space

$$\frac{\partial \lambda}{\partial t} = a_o c \sqrt{1 - \left(v^2 \ / \ c^2\right)} \ .$$

(167)

This sets a limit on the time rate of mass conversion. The added function of mass as a fifth dimension has placed a limit as how quickly mass and energy can be converted. This is very reasonable since mass cannot move with unlimited velocity. This leads to a natural cutoff for self energy calculations and can avoid some divergences in a way consistent with general relativity.

The maximum rate of conversion will occur for real a_o when v=0. At zero velocity the conversion rate is $\dot{\gamma}_{max} = a_o c$ and no conversion is possible at v = c. This means that no particles can be created that have velocities v = c. The result is that infinities arising in self-energy

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calculations, corresponding to infinite kinetic energies for virtual particles, are avoided. Likewise photons would not be expected to spontaneously be converted to mass while traveling at $v = 0$. This avoids divergences due to vacuum terms. There could be conversion of photons when they interact with matter such that the refractive index is $h > 0$ and thus $v < c$.

Conversely the velocity of light, v_0, can be expected to rely on the rate of mass conversion. That is

$$v_o = c\sqrt{1 - \frac{g_{44}\dot{\gamma}^2}{a_o^2 c^2}} \ . \tag{168}$$

The limiting rate for mass conversion is an exceptional important concept. It is ultimately tied to thermodynamics and the "arrow of time." Williams has calculated the maximum conversion rate for uranium in an atomic reaction and finds that it is consistent with the mass conversion principle. It is plausible that the concept can be employed to limit production of virtual particles in self-energy calculations. The fact that infinitely massive particles are excluded from formation in infinitesimal time intervals severely limits such calculations. This is a major theoretical point. Infinities have plagued such calculations since the 1920's due to the failure of excluding such terms in a relativistic consistent method. It is only with 5-D theories that use mass density as the additional component that this appears possible.

The change in the velocity of light would be expected only where a large change of mass density would be occurring. The phase velocity can be written as

$$V_p = (1/k)\left(\omega + \frac{k_4}{-\gamma^2}\dot{\gamma}\right) \ . \tag{169}$$

2.3.5   Reduction to Newton's Laws - PPN

One very good approach to testing theories of gravity is the parametrized post-Newtonian (PPN) formalism (16). This allows many theories to be tested parametrically by a single general theory. Estimates of the parameters can rule out entire classes of theories and determine which, if any, theories are more likely to be correct.

The reasoning behind the PPN formalism is that all metric-based gravitational theories must predicted the same $g_{\mu n}$ metric in the weak field slow motion limit since Newton's Laws should be recoverable from all practical theories. The PPN approach begins by a mathematical expansion of the metric in terms of dimensionless Newtonian gravitational potentials. There are 10 parameters used in the expansion. The general metric given in PPN formalism is rewritten so that the 10 general parameters replace the 10 degrees of freedom within the metric with the PPN parameters. For this study the parameters α_3, ξ_1, ξ_2, ξ_3, and ξ_4 are called to question. These are the ones linked to the breakdown of global conservation laws of linear and angular momentum. Will (17) has shown that any 4-D metric theory conserves these momentum components if and only if α_3, $\xi_1 = \xi_2 = \xi_3 = \xi_4 = 0$. Such a theory is called a conservative theory. The use of the PPN formalism has been very successful in comparing and classifying alternative metric theories of gravity.

An interesting effect that may find use in propulsion is that theories with $(\alpha_3 + \xi_2) \neq 0$ predict that the center of mass of a binary system may self accelerate in the direction of the system's periastron. This acceleration has been given by Will (20) as

$$\vec{a}_{cm} = \frac{\pi n_1 m_1 m_2 (m_1 - m_2) e}{P m^{3/2} a^{3/2} (1 - e^2)^{3/2}} (\alpha_3 - \xi_2) \vec{n}$$

(170)

where $\vec{n}$ is a unit vector directed from the center of mass to the point of periastron of m (most distant part of orbit). Current experiments place an upper limit on α_3 as $< 2 \times 10^{-5}$ and a weak limit of ξ_2 as < 100. There is no fully developed theory with $\xi_2 \neq 0$.

In a binary pulsar such as PSR 1913+16, the acceleration would be manifested in both a changing Doppler shift and a secular change in the observed pulsar period. The ratio of the time change of pulsar period to the orbital period, $\dot{P}/P$, has been placed near 4.6×10^{-9}/yr. If this ratio can be tracked over time it could distinguish between changes due to energy loss and ξ_2, if the ratio $\dot{P}/P$ is constant. If however the ratio changes linearly with time, then a secular acceleration of the center of mass is likely and $\xi_2 \neq 0$. This could be functional in any future propulsion system but the effect would be small for any practical rocket size.

It is suggested that the period and Doppler shift of PSR 1913+16 or a suitable pulsar be tracked over an extended time (decades). This could be relatively easy and inexpensive to accomplish.

2.3.6   Thermoelectric Potentials in Gravity Fields

It now appears likely that the thermoelectric potentials of a couple can be altered by a gravitational field. This work is from J. Anadan of the Max Planck Institute fur Physik und Astrophysik at the Werner Heisenberg Institut fur Physik, Munich, W. Germany (18). The best discussion of the effect appears in Phys. Lett . 105A, 280 (1984). A brief description follows.

The general relativistic equations can be developed such that the density of total kinetic energy flow

$$W_e^v = kP^{vp}\left(\partial_p T - a_p T\right) - (\pi\zeta / e)J_e^v$$
(171)

by using the projection tensor $P_{\mu\nu} = g_{\mu\nu} - t_\mu t\upsilon$ and the conduction electron density

$$J_e^\mu = P^{\mu\nu} J_\nu$$
(172)

which gives the total kinetic energy

$$W_e^\mu = P^{\mu\nu} W_\nu$$
(173)

with

$$J_e^\upsilon = \sigma E^\upsilon + \frac{\sigma}{e} P^{vp}\left(\partial_p \zeta - a_p \zeta\right) - \sigma\varepsilon P^{vp}\left(\partial_p T - a_p T\right).$$
(174)

Here, k, s are the thermal and electric conductivities, T the temperature, ζ the chemical potential, p the Peltier coefficient, e the electrical charge, and

$$a^\mu = t^\upsilon t^\mu{}_{;\mu} \leftrightarrow a_p.$$
(175)

Anadan has shown that these general relativistic expressions give a Peltier and Seebeck effect that is modified in a gravitational potential (also apparently correct for an accelerating frame).

If a current flows through a circuit formed from two different conductive wires, then the heats U_1, and U_2 produced per unit time at the upper and lower thermocouple junctions are related by

$$U_2 = -(1 + aH/c^2)U_1 \tag{176}$$

where H is the height of the junctions and a the acceleration (g). Notice that the heat flow is not equal at the two junctions. Also, if the temperature at the two junctions is maintained at T^1 and T^2 then the e.m.f. across a connecting circuit would be

$$V = (\varepsilon_1 - \varepsilon_2)\{T_1(1 + gH/c^2) - T_2(1 + gH/c^2)\} \ . \tag{177}$$

2.3.7 Field Vectors and Equations in 5-D

We now turn our attention to developing the field vectors. To work with the wave propagation and forces it is convenient to define the five current as

$$J_i = (ic\rho, J_1, J_2, J_3, J_4) \tag{178}$$

and the five potential vector as

$$A_i = (i\varphi/c, A_1, A_2, A_3, A_4) \ . \tag{179}$$

There are two assumed conditions that simplified theoretical progress. They are usually tacitly assumed but we need to take special note that they are separate postulates. The first is the continuity equation,

$$\frac{\partial J_i}{\partial x_i} = 0 \tag{180}$$

which governs the flow of charge, and the second is the Lorentz condition,

$$\frac{\partial A_i}{\partial x_i} = 0 \tag{181}$$

which governs the flow of the potential field. The A's may be theoretical constructs or physically real. What is more physical is the antisymmetric field tensor

$$F_{ij} = \frac{\partial A_j}{\partial x_i} - \frac{\partial A_i}{\partial x_j} \tag{182}$$

as discussed elsewhere. We have already developed the Maxwell-like equations starting from

$$\frac{\partial F_{ij}}{\partial x_k} + \frac{\partial F_{jk}}{\partial x_i} + \frac{\partial F_{ki}}{\partial x_j} = 0 \tag{183}$$

and using for the current density, J

$$\frac{\partial F_{ij}}{\partial x_j} = \mu_o J_i \ . \tag{184}$$

Equation 183 is a tensor identity based on the antisymmetry of F_{ij} and equation 184 comes from the variation of the action. Using equations 183 and 184 and recalling that the field tensor A is defined by equation 182, we obtain

$$\frac{\partial^2 A_j}{\partial x_i \partial x_j} - \frac{\partial^2 A_i}{\partial x_j \partial x_i} = \mu_o J_i \ . \tag{185}$$

By using the Lorentz condition, equation 181, the first term is zero and we are left with

$$\frac{\partial^2 A_i}{\partial x_j \partial x_i} = -\mu_o J_i \ . \tag{186}$$

It is convenient to introduce a 5-D analogy with the del operator:

$$\star^2 = -\left(1/c^2\right)\frac{\partial^2}{\partial t^2} + \nabla^2 + \frac{\partial^2}{\partial x_4^2} \ . \tag{187}$$

Notice that the zeroth component is the customary $(i/c)\tau$ and x_4 is our fifth (additional) coordinate, written in units of length so that $a_o\gamma \rightarrow x_4$. With this notation, equation 186 becomes

$$\bigstar^2 A_i = -\mu_o \dot{J_i} . \tag{188}$$

Returning to the vector identity, we rewrite it as

$$\frac{\partial F_{ij}}{\partial x_k} + \frac{\partial F_{jk}}{\partial x_i} - \frac{\partial F_{ik}}{\partial x_j} = 0 \tag{189}$$

by use of antisymmetry (equation 182). Now differentiating with respect to x_k gives

$$\frac{\partial^2 F_{ij}}{\partial x_k \partial x_k} + \frac{\partial^2 F_{jk}}{\partial x_i \partial x_k} - \frac{\partial^2 F_{ik}}{\partial x_j \partial x_k} = 0 . \tag{190}$$

Using the definition of the current vector (equation 184) gives

$$\frac{\partial^2 F_{ij}}{\partial x_k \partial x_k} + \mu_o \left(\frac{\partial J_j}{\partial x_i} - \frac{\partial J_i}{\partial x_j} \right) = 0 \tag{191}$$

or

$$\frac{\partial^2 F_{ij}}{\partial x_k \partial x_k} = \bigstar^2 F_{ij} = \mu_o \left[\frac{\partial J_i}{\partial x_j} - \frac{\partial J_j}{\partial x_i} \right] . \tag{192}$$

These give the three vector equations and the one scalar equation:

from $(i,j) = (1,2),(2,3),$ and $(3,1)$:

$$\bigstar^2 \mathbf{H} = -\nabla \times \mathbf{J} , \tag{193}$$

from $(i,j) = (0,1),(0,2),$ and $(0,3)$:

$$\bigstar^2 \overline{D} = \nabla \rho + \varepsilon_o \frac{d\overline{J}}{dt}, \tag{194}$$

from $(i,j) = (4,1),(4,2)$, and $(4,3)$:

$$\bigstar^2 \overline{V} = \mu_o \left(\nabla J_4 - \frac{\partial \overline{J}}{\partial x_4} \right), \tag{195}$$

and the scalar expression from $(i,j) = (4,0)$:

$$\bigstar^2 V_4 = \mu_o \left(-c^2 \frac{\partial \rho}{\partial x_4} - \frac{\partial J_4}{\partial t} \right). \tag{196}$$

The first two of these equations are just 5-D expressions of the classical wave equations.

2.4 CONSERVATION LAWS

In the following we will discuss the theoretical foundations of the primary conservation laws. The point is made that both parity and angular momentum are not true tensor quantities. This means that there is no overwhelming theoretical reason why they must be conserved in cases involving inversion. Parity has been experimentally shown not to be universally conserved and it is plausible that angular momentum may likewise be violated by some specialized cases. This may lead to massive amounts of energy conversions or changes in orbital angular momentum. This is, however, only a theoretical "opening" and no practical experimental approach seems to lead directly to propulsive systems in the foreseeable future.

The goal of an advanced propulsion unit is to achieve the maximum integrated thrust over the life of the mission. Since chemical and nuclear systems are rapidly reaching their theoretical maximum performance values any advanced system must perform in ways that exceed such assumed theoretical limits to performance. Just as engineers must continually "push the envelope" in development we must push the theoretical envelope in the hope of locating where advances may be made.

The limits to most propulsion systems can be traced to our present understanding of the physical conservation laws. These laws are the foundations of modern physics and cannot be

lightly discarded. Instead we must come to an understanding as to their theoretical origins before we can hope to find ways around them. They are normally never questioned but instead assumed "a priori." The only successful attempts to derive the conservation have been by symmetry studies and it is there that we must turn for our investigation. We later see that if the symmetry of a system can be broken there may be a theoretical rational to consider departures from the familiar conservation Laws.

2.4.1   Conservation of Energy

Energy conservation theorems in physics can only be assumed or related by symmetry properties. Consider the fact the Newton's and Maxwell's equations do not change with time. This symmetry of time gives rise to the conservation of energy. Quantum mechanically, if H is the Hamiltonian of an isolated system then the homogeneity of time implies that H is not an explicit function of time. Therefore,

$$\frac{dE}{dt} = \langle (i/\hbar)[H,E] + \partial E/\partial t \rangle = \langle (i/\hbar)[H,E] + \partial E/\partial t \rangle \quad , \tag{197}$$

$$\frac{dE}{dt} = (i/\hbar)[H,E] + 0 \quad , \tag{198}$$

$$\frac{d\langle E \rangle}{dt} = 0 \qquad \frac{dH}{dt} = 0 \quad , \tag{199}$$

and E is a constant of motion. The homogeneity of time and invariance of our physical laws give rise to conservation of energy. Thus, if new energy sources are found (as was nuclear) the terms are added to our physical laws, in that way the physical laws we know are derived indirectly from our desire to keep them consistent with time.

A more technical and rigorous approach was given by Emmy Noether (19). By looking at transformations of the action integrals, she showed that every parameter associated with transformation, that leaves the action integral invariant, leads to a corresponding conservation law. For the case of conservation of energy, we can choose a system whose Lagrangian does not depend explicitly on time, t. The transformation chosen is

$$t \rightarrow t' + \alpha \tag{200}$$

where α is an infinitesimal constant. The Langrangian is the

$$L = L(qi, qi', t' + \alpha) ,$$ (201)

since the Lagrangian is derived from physical laws whose form does not change in time. The variational integral is then

$$A = \int_{t_1-\alpha}^{t_2-\alpha} L(qi, qi',) dt'$$ (202)

and the transformational problem becomes for an infinitesimal a

$$L\left(q_i, q_i'\right) = L\left(q_i, q_i'(1 - \alpha')\right)$$

$$= L\left(q_i, q_i'\right) - \left(\sum_{i=1}^{n} \frac{\partial L}{\partial q_i'}, \dot{q}_i\right)\alpha$$ (203)

so

$$A = \int_{t_1}^{t_2} L\left(q_i, q_i'\right) - \int_{t_1}^{t_2}\left(\sum_{i=1}^{n} \frac{\partial L}{\partial q_i} \dot{q}_i - L\right)\alpha' dt' .$$ (204)

Using variational procedures of least action

$$\frac{d}{dt}\left(\sum_{i=1}^{n} \frac{\partial L}{\partial \dot{q}_i} - L\right) = 0$$ (205)

or

$$\sum_{i=1}^{n} \rho \dot{q}_i - L = E$$ (206)

which is the well known energy theorem of classical physics. In short the symmetry of time (homogeneity, invariance to infinitesimal translations) has given the physical effect of conservation of energy.

There is no known way to alter time symmetry. Thus, there can be no way around energy conservation if we insist that our physical laws are time invariant.

2.4.2   Conservation of Linear Momentum

We now direct our attention to conservation of momentum. Here is where a propulsion system finds its greatest limitations and where breakthroughs may just be possible. The conservation of momentum for an isolated system depends on the homogeneity of space. Consider a region in space removed from other objects. Now enclose the region with a box and conduct a virtual displacement of the box (transform space coordinates with $\Delta t=0$). There is no experiment confined to the box that can reveal its new location without making references outside the box. This means that the physical laws of an isolated system of particles can only depend on their relative orientations and not on their distances from some arbitrary point. For example, the Hamiltonian can always be transformed to a system omitting the arbitrary point, i.e. center of mass, etc.

Mathematically, the displacement operator D(d) is given by

$$D(d) = I + \frac{id\hat{\rho}_x}{\hbar} \tag{207}$$

for an infinitesimal displacement d and density I. Solving for $\hat{\rho}_x$, we get

$$\hat{\rho}_x = (\hbar / id)[D(d) - I] . \tag{208}$$

The Hamiltonian of a system commutes with a displacement since it cannot depend explicitly on an arbitrary point of origin. Thus

$$\frac{d\langle \rho_x \rangle}{dt} = 0 \tag{209}$$

and the conservation of momentum is found to have its origins in the homogeneity of space.

Noether's principle can be easily extended for momentum. Writing the classical action

$$A = \int_{t_1}^{t_2} (T - v)_{dt} \tag{210}$$

with the kinetic energy reflecting the translation in space

$$T = (1/2)M\left(\dot{X}' + \dot{\alpha}\right)^2 + \left(\dot{y}' + \dot{\beta}\right)^2 + \left(\dot{z}' + \dot{\Theta}\right)^2 \tag{211}$$

so

$$A = \int_{t_1}^{t_2} L \, dt + \int_{t_1}^{t_2} M\left(\dot{x}\dot{\alpha} + \dot{y}\dot{\beta} + \dot{z}\dot{\Theta}\right) dt \tag{212}$$

so

$$m\dot{x} = \text{Constant} \tag{213}$$
$$m\dot{y} = \text{Constant} \tag{214}$$
$$m\dot{z} = \text{Constant} \tag{215}$$

which is the law of conservation of momentum.

Conservation of momentum is seen to be intimately related to the symmetry of space. This will be valid as long as space is homogeneous or the system is totally isolated. If the system is near an external object then homogeneity is lost and momentum can be "relayed" between the objects (for example, gravity assisted spacecraft trajectory techniques). Also, if material or radiation are absorbed or emitted by the region, momentum can be altered (for example, photon, EM systems).

2.4.3   Conservation of Angular Momentum

The conservation of angular momentum is perhaps the most theoretically interesting (parity is also interesting but already has been proven not strictly conserved). This is because there are definite theoretical arguments that can call it into question. The symmetry that dictates conservation of angular momentum is the isotopy of space. In other words space is supposed to be unchanged by a rotation about some fixed axis in space. That is all spatial axes are the same. Present cosmic background studies show that the 3°K background radiation is almost the same in all directions.

-51-

Such studies are often used in support of the big bang theory. Astronomers have termed the hypothesis, that the universe is spatially homogeneous and isotropic, the Cosmological Principle.

From time to time microwave studies have indicated a small anisotopy in the radiation background. Such departures are known to be less than 1% of the total background. The important point, however, is that space in our local galaxy is not isotropic. In fact, it is easy to tell that the solar system is in a galaxy which has a net angular momentum in reference to observable distant galaxies. There is, therefore, a distinguishable axis.

Although it may be hard to distinguish the exact position of a space point with respect to far stars, it is relatively easy to distinguish how a system is rotated in comparison to the "fixed" stars. As the conservation of angular momentum is developed, notice that it will likely only be valid if space is isotropic. Departures become "reasonable" if the large region containing the system departs from rotational symmetry.

For the conservation of angular momentum we must consider a Lagrangian that is rotationally invariant. If the potential energy V is the result of "central forces," then V depends only on the distances between the two particles, i.e. on the spatial quantity

$$r_{ik} = \sqrt{(x_i - x_k)^2 + (y_i - y_k)^2 + (z_i - z_k)^2} .\tag{216}$$

This is true if not only a constant translation, but also a constant rotation, of the reference system leaves both potential and kinetic energy unvaried. An infinitesimal rotation of the coordinates may be written in terms of the arbitrary infinitesimal vector, Ω.

$$r_1 = r^1 + \Omega \times r^1 .\tag{217}$$

If Ω is made a function of t then the kinetic energy is

$$T = (1/2)m\dot{r}^2 = (1/2)m\left(\dot{r} + \dot{\Omega} \times r\right)\tag{218}$$

$$T = (1/2)m\dot{r}^2 + \dot{\Omega}m(r \times \dot{r}) .\tag{219}$$

Thus by least action,

$$m(\mathbf{r}\times\dot{\mathbf{r}}) = \mathbf{r}\times m\mathbf{v} = L,$$

(220)

so the total angular momentum is a constant. It is only if the center of mass is at rest with respect to the origin, that the angular momentum will be independent of the point of reference.

For an observer in space, it is very difficult to quickly determine the absolute time, position, or velocity. However, an absolute rotation can be determined quickly. Stated in astronomical terms, the homogeneity of space and time is close enough to preclude determining instantaneous displacement in time and space, but the isotropy of space is not uniform enough to preclude determination of an instantaneous rotation. This gives a theoretical opening for possible departures from conservation of angular momentum.

To break the symmetry of space, a system merely has to rotate. In this way a preferred direction in space is set up. The effect is expected to be second order, but it definitely is within theoretical possibilities. Pulsars and quasars may be naturally occurring cases of interconservations between spin and energy.

Other than Kerr metric approaches, relativity avoids rotating frames of reference and nowhere has there been a good study on $I\omega^2$ energy terms allowing angular momentum to interact with the energy and gravitating mass in relativistic problems. Forward has suggested that an interconservation between angular momentum and energy may be of the order of

$$E = Lc/\Lambda, \qquad \Lambda \approx 1.6 x 10^{-34} m$$

(221)

which is equivalent to 1/2 ton of TNT for the angular momentum of each orbiting electron.

2.4.4   Conservation of Parity

Conservation of parity was held in high regard until experimental results revealed that it was not conserved in beta decay. For objects such as cannon balls and colliding particles, it can be seen that the laws that dictate their paths are the same for a mirror image of the objects. In quantum mechanics the concept of conservation of parity is very useful. From the famous Co-60 beta decay experiment (20, 21) (discussed below), it is now recognized that parity is not always conserved.

The important point is that the conservation theorem may not be valid if the system is selected in such a way as to "break" the underlying symmetry supporting the theorems.

The Co-60 experiment will serve as a well documented example of departure from conservation theorems and the spin alignment of nuclei. Consider a quantity of Co-60 placed within a magnetic field. The magnetic field aligns the nuclear spins of cobalt such that the magnetic field of the coil and the nuclear magnetic moment are parallel. Experimentally it was found that the emission of beta particles was greater along one direction of the coil.

Experimentally the direction of the current in coil was reversed to effect a mirror image. It was found that direction of the maximum beta ray intensity was reversed. Conservation of parity would have required no change and, thus, equal intensities in both directions. In relativistic terms this can be traced to the fact that whereas translation, linear momentum, acceleration, electric fields, etc. are tensor quantities, angular momentum, spin, magnetic field, etc. are pseudovectors. For pseudovectors, scalar products change sign on some coordinate inversions. For example, electromagnetic energy terms like H^2 and E^2 are scalars but those like $E \cdot H$ are pseudovectors and may not be invariants since parity is not conserved. Simply stated, the experimental evidence that parity can be violated establishes the fact that quantities based on pseudovectors need not be conserved in all cases. It also points the way to where to look for departures from conservation. Also note that simple phenomena involving electromagnetic and strong or weak nuclear events alone do conserve parity. It is not until more complex events involving several forces does the parity - pseudovector question come to play.

2.4.5   Conservation of Pseudovectors

Ordinary polar vectors transform by

$$a_i' = a_{ik} a_k$$

(222)

but the so called axial or pseudovectors transform according to

$$a_i' = a a_{ik} a_k$$

(223)

where

$$a = \det|a_{ik}| \ .$$

For all proper rotations, $a = 1$ and the axial vector transforms just like a polar vector. The scalar product of two axial vectors is a scalar. The scalar product of a polar and axial vector is a number which can change its numerical sign on reflection. When odd number coordinates are reversed we have $a = -1$. A common example is the magnetic moment or magnetic field vector, H. Physically this means that the pseudovector would behave just like a full vector for simple translations and rotation (hence Galilean coordinates and Lorentz transformations). It would not however, act the same for coordinates other than Galilean or for inversion.

This means that experiments designed to circumvent conservation theorems (i.e. angular momentum) should:

1) involve two or more fundamental forces
2) possess broken symmetry (odd parity)
3) involve the use of pseudovectors
4) align the axis of broken symmetry with inversion characteristics of the pseudovector.

The conservation of angular momentum is a deep-seated physical principle of great use. It can be shown that, although energy and linear momentum are true tensors, both parity and angular momentum are pseudotensors. Angular momentum is thus not required to be conserved under inversions and in noninertial reference frames. Careful high accuracy experiments are needed to be undertaken to check the validity of angular momentum conservation since it apparently stands as a separate postulate.

The conservation theorems are at the very heart of modern physical theories. The conservation of charge, energy, linear momentum, angular momentum, isospin, etc. are often the tools used to show reason and utility among competing theories. Often they are treated as unassailable but occasionally a return to the foundations leads to unexpected revision of theories. For sometime parity was considered as a fundamental conserved quantity. In the light of the Co-60 Beta decay we now understand that parity can be violated and that CPT is a more fundamental symmetry in nuclear and weak interactions.

In retrospect, many point out that parity should not have been expected, from first principles, to be conserved. This section will seek to call into question our assumption that angular momentum is required to be conserved. We will find that both angular momentum and parity stand on equal theoretical footing within a relativistic and symmetry view. It is hoped that some experimentalist will be moved to test this nonconservation possibility.

Before we understand the concept of nonconservation and symmetry breaking we must be sure of our view as to what is meant by conservation. For a quantity A to be conserved it must satisfy the tensor expression

$$\frac{\partial A_\mu^v}{\partial x_v} = 0 \; .$$

(225)

In flat space-time where the coordinates can be labeled x, y, z, t this can be written as

$$\frac{\partial}{\partial t} A_\mu^o + \frac{\partial}{\partial v} A_\mu^1 + \frac{\partial}{\partial y} A_\mu^2 + \frac{\partial}{\partial z} A_\mu^3 = 0 \; .$$

(226)

Multiplying by dx dy dz and integrating over that volume this becomes

$$\frac{\partial}{\partial t} \int\!\!\int\!\!\int A_\mu^o + \frac{\partial}{\partial y} A_\mu^2 + \frac{d}{dz} A_\mu^3 = 0 \quad \left\{ \begin{array}{l} surface \\ boundry\,terms \end{array} \right\}$$

(227)

with the boundary conditions arising from the three space terms. Physically we say that the quantity within the region depends on the movement of that quantity across its spatial boundaries. Thus, there can be no change of that quantity except there can be transport of the quantity across the spatial boundaries of the volume. For a tensor A_μ^v there is clearly a corresponding conservation law.

Within a general relativistic viewpoint, any physical principle expressible as a tensor expression should hold in all reference frames, both inertial and noninertial. For quantities such as mass and linear momentum tensor expressions are easily expressed. This means that their physical relationships are invariant to alteration from any arbitrary frame of reference, so long as they are

written in tensor form. The reason for this is that all tensors must transform in a way that is linked to the coordinates.

Quantities such as parity and angular momentum, however, are not "true" tensors or "true" vectors. Instead they are quantities termed pseudotensor pseudovectors or axial vectors. For most transformations, there is no practical difference between pseudovectors and "true" vectors. In fact, both work equally well under proper (spatial) rotations, translations, and in general Galilican and Lorentz transformations. As a result it is usually assumed that such quantities are always the same as true vectors. However this is not the case.

In fact the cross product of any two true vectors is a pseudovector. The difference between the two kinds of vectors can be seen in improper rotation or in pure inversions of coordinate systems. Consider

$$C = A \times B \qquad (228)$$

where

$$C_i = A_j B_k - A_k B_i \; . \qquad (229)$$

Upon an inversion of the coordinate system, both A and B change sign which means C does not change sign. The entire cross product changes sign as we go from a right hand to a left hand coordinate system. The angular momentum of a particle is usually expressed as the cross product of the particle's momentum, p, with the radius vector, r, from the origin:

$$L = p \times r \qquad (230)$$

and by convention we use a right hand rule to determine the sign of the pseudovector. In fact, a series of infinitesimal rotations can be expressed only by pseudovectors, but finite rotations cannot be expressed in that form. Thus, angular momentum can be expressed only as a pseudovector. Often complex systems cannot be expressed as pseudovectors owing to the noncommunitivity of finite rotations.

At first one may wish to argue that an inversion can never correspond to a physical displacement of a rigid body. But to say that this is the case for all physical events assumes two

things. First, that all physical events take place with strictly rigid bodies and second that only space rotations are used. Since one of the four coordinates must be time-like, some events may well enter transformations as a partially imaginary rotation and hence have inversion properties. For example, if a force is velocity dependent both space (real) and time (imaginary) components can enter the transformation leading to inversion-like effects.

Such effects would not be expected in Galilean or Lorentz transformations. In inertial frames pseudovectors act the same as true vectors where ordinary vectors transform as (summation convention)

$$dA_i = \alpha_{ij} dA_j \tag{231}$$

pseudovectors transform as

$$dA_i = |\alpha| \alpha_{ij} dA_j \tag{232}$$

where $|\alpha|$ is the determinant of the transformation. For proper rotation $|\alpha| = 1$ and the pseudovectors behave the same as ordinary vectors. In general for inertial frames, the determinant of the metric g will be constant and there is no real variance between the two. However, for improper rotations or transformations involving inversion components $|\alpha| \neq 1$. In general, for noninertial frames the components of the metric will not be constant and the pseudovector is no longer transformed like an ordinary vector. Another way to look at it is that in noninertial frames the elements, g_i of the metric vary from region to region. Thus, a pseudotensor's value can vary due to the $|g|$ in equation 83 as it is transported as transformed to various regions.

2.4.6 Conditions for Nonconservation

Emmy Noether approached conservation from the transformation properties of the action integral. She found that the conservation of energy could be recovered from verifying that the action integral was dependent only on relative time difference and not absolute time. Thus, she saw that the symmetry of time gives rise to the conservation of energy. Likewise, it was discovered that conservation of linear momentum for an isolate system depends on the homogeneity of space and conservation of angular momentum on the isotropy of space.

If a region does not possess the proper symmetry then it is not clear as to why conservation laws would be required to hold a priori. For example, if a region was not isotropic to space and time then it is not clear that conservation of angular momentum could not be violated. For a hypothetical single isolated body alone in a universe clearly the space would be symmetric. For a real object in a real universe, however, it may be possible to have a region or reference frame which is not isotropic.

Consider the following simplified thought experiment. An observer is in deep space several light years away from the nearest stars. Only with great difficulty could he tell if his watch was changed by a few years since there is little to indicate the absolute time. Likewise, a displacement of thousands of kilometers or even a change of velocity of a few km/hr would go unnoticed. Such operations illustrate the close homogeneity of space and time and thus hint at the conservation of energy and linear momentum. On the other hand, our observer would quickly be able to tell a rotation of a few milliradians or a change in angular speed by observation of the distant stars. In other words, isotropy of space in our galaxy is not exact and not as nearly perfect as the homogeneity of time and space. Another way to understand the problem is to ask: When does a space traveler detect a Coriolis force? The answer is, only when there is motion relative to some external frame such as the fixed stars.

In fact for any object rotation, compared to the fixed stars there is not an isotropic nature to space. Admittedly for a "stationary" object there is little preference in direction. So for an object initially at "rest" the concept of conservation of angular momentum should be good. However, as the object begins to rotate compared to an external environment it can no longer be considered isolated and Machian arguments become important.

The theorems of conservation of energy, linear momentum, angular momentum, charge and parity lay at the foundations of physical theory. Noether showed that such conservation theorems can be considered as results from symmetry properties and the action (line integral) principle. We have a choice of considering conservation or action and symmetry as the starting postulate. The action principle is extremely useful since it allows us to develop many properties. It allows calculations of events without having to experimentally investigate all possible paths. It also develops a continuum and predictable outcomes from investigation with near identical end points.

It is well known that conservation of energy follows from the homogeneity of time, conservation of linear momentum from the homogeneity of space, conservation of angular

momentum from the isotopy of space, and conservation of parity from space inversion. The experiment involving beta decay of Co-60 in magnetic fields has shown that parity is not always conserved. There have not been any well documented violations of the other conservation theorems, and they are often considered physical laws as was parity before violations were discovered.

The violation of parity can be theoretically justified since parity is a pseudovector and not a true vector. Within a general relativistic viewpoint only tensor quantities should be used to express valid physical laws. In the case of pseudotensors, Galilean and Lorentz transformations leave physical laws unaltered but more general transformations, such as inversion and noninertial frames, can alter the expressions. This brings us to question the absolute validity of conservations on angular momentum since it, too, is a pseudovector.

Conceptually the conservation laws are relatively simple. On a particle side the conservation of energy, linear momentum, and charge seem theoretically to be extremely sound. For example, imagine an observer in deep space. The observer could not easily distinguish the difference if suddenly his clock was offset by a small Δt (E conservation), his position displaced by a small Δr (p conservation), or his charges were all reversed Δq (conservation). However, small rotation with respect to distant stars could be quickly distinguished (L conservation). There would, of course, be no possibility if the observer was entirely isolated but in practice this is rarely the case. The pseudovector properties of angular momentum can be seen in another way. The conservation of angular momentum relies on the isotropy of space. However, a rotating object has a preferred spatial direction compared to the distant masses of the universe. The Mach principle is an example of such considerations. Development of such principles mathematically and experimentally is a more difficult task since it involves noninertial reference frames.

2.5   VACUUM FLUCTUATIONS

A relatively new approach to the understanding of gravity has recently been studied by H. Pathoff. Gravity is seen as a Casimir-like effect in which the vacuum fluctuations give rise to gravitational effects. However, it does not seem to lead to a practical inertial propulsion system anytime in the near future.

One attempt at unifying gravity with electromagnetic effects has been to consider zero point fluctuations of the quantum vacuum state. Some early qualitative work was done by the Russian physicist Andrei Sakharov (22). In such systems gravity is not a separate force but arises from

electromagnetic fields when a detailed analysis is conducted that includes the fluctuations of the quantum vacuum.

In brief, gravity is supposed to be similar to Van der Waals or Casimir forces working on virtual states within the vacuum zero energy state. This arises from the fact that quantum calculations show a residual energy of $\frac{1}{2}\hbar\omega$ for a total vacuum. It is well known that even within our most precise physical theory, Quantum Electrodynamics (QED), that there is a divergence of energy at extremely high frequencies. This has led to an "arbitrary" cutoff frequency ω_c and is imposed so that integrals which sum energies will not reach infinity. Sakharov suggested that the cutoff be chosen such that

$$\omega_c = \sqrt{\frac{\pi c^5}{\hbar G}}$$

(233)

so that

$$G = \frac{\pi c^5}{\hbar \omega c^2} \, .$$

(234)

Puthoff (22) has recently also calculated such values based on frequency spectra arguments considering zero-point fluctuations. This placed into consideration the possibility of gravity as being "already unified" and a result of known electromagnetic fields. Gravity is then considered as being due to variations in the zero point energy of the quantum vacuum due to mass distribution.

The argument is that the frequency cutoff is so small that it is beyond practical measurement. "The path integral (method) did not then provide, nor has it since provided, a truly satisfactory method of avoiding the divergence difficulties of quantum electrodynamics." "No modification of quantum electrodynamics at high frequencies is known which simultaneously makes all results finite, maintains relativistic invariance, and keeps the sum of the probabilities over all alternatives equal to unity." However, Dirac (24) has pointed out that such divergences indicate a very fundamental weakness in the theory.

Within 5-D views the arguments take on a slightly different view. Instead of the cutoff frequency, ω_c, there is in "cylindrical" Kaluza-Klein theories a fundamental radius, r_4, related to

the scale of compactification. The fundamental electric charge e, is related to the classical radius of the charge by:

$$e = \sqrt{\frac{16\pi G}{r_4}} .$$

(235)

In most reasonable KK theories, the r_4 is time dependent and shrinks with the increasing age of the universe. This confirms Dirac's large number hypothesis: that the electromagnetic and gravitational coupling constants increase with the age of the universe and that G (or h/2π) may vary with time.

The two methods may be linked by considering the Casimir effect (25). The Casimir effect can be thought of as an attraction of two conducting plates due to the zero-point vacuum fluctuations. Since some EM modes between the plates are not available to the vacuum fluctuations, there is an inequality between the EM pressure inside and that outside. This forces the plates together when they are separated by small distances.

In 5-D the plates can be thought of as boundary conditions such that $x^4 = 0$. If one does not make the zero-mode approximation in the metric then the potential arising from the massive spin 2 excitations within the cavity leads to $0 \leq x^4 \ll r_4$. This causes the Casimir forces to compactify the fifth dimension to the order of the Planck length. Thus, the Casimir effect can be used to justify compacting the added dimension.

The extremely small scale of the effect leads to doubt that a particle experiment can be achieved within the next few decades. It is conceivable, within the viewpoint of gravity as a Casimir-like effect, that inertial or gravitational mass may be altered when placed within a "Casimir cavity." However, it is likely that the effects would be on the order of the Planck length cavity size. This would not seem accessible. Perhaps a Mössbauer-type experiment on decaying particles in a cavity would be possible, but even this may not be a practical experiment. It is recommended that the area be reviewed once every 5 years (or so) for theoretical developments but otherwise be left alone for now.

2.6 QUANTUM CONSIDERATIONS

In this section we will develop an aproach that may avoid the singularities of QED. An attempt is made to gain mathematical consistency between quantum mechanics and general relativity. Covariant differentiation is applied to quantum mechanical communication Poisson brackets to yield an added curvature term to the standard uncertainty expression. The added te.m is evaluated in terms of the Schwartzschild solution and is found to show promise to resolve divergences within quantum electrodynamics while retaining normal probabilities and relativistic covariance. It is unlikely that the principles will find direct application in a new propulsive system. It does however give an alternate view to the self energies and vacuum energies. This theory was originally produced from William's 5-D theory but it may equally apply to 4-D theories.

There have been many attempts to unify General Relativity (GR) with Quantum Mechanics (QM). These have typically centered on modifying GR to accommodate QM. The rigorous mathematical approach of GR makes modification of GR a likely target for proposing alternate conjectures and premises. However the early metric theories of Einstein hold a unique mathematical simplicity and beauty.

The alternative approach here will be to modify QM at the most fundamental level possible to bring it into consistency with GR. The framework for this method is based on the traditional Einstein relativistic approach, the commutator formalism of Dirac (26) and the path integral methods of QED of Feynman (27). All three have proven historically to be fundamental approaches possessing great utility. They also yield theories compatible with experimental evidence starting from only a few basic mathematical principles and assumptions.

The divergences arising within quantum electrodynamics have long resisted conventional methods or resolution. The introduction of special relativistic approaches has reduced such divergences so that they are only divergent to terms logarithmic with integral cutoff values. The renormalization of the QED expressions has made the theory one of the more experimentally verified within physics. However, the divergences remain within the formal mathematical expressions. These divergences have been a major obstacle to unification efforts and it has been suggested by Dirac (24) that they indicate a need for a deep seated alteration of the theory. The approach taken here involves introducing general relativity (GR) at the most fundamental point possible within the quantum mechanical (QM) theory.

Most formal developments of quantum mechanics are patterned after the work of Dirac (26). The method uses a correspondence principle and links the QM development to the Hamiltonian methods of classical physics. The most fundamental departure from classical physics by QM is the introduction of noncommutation of position and momentum operators. The quantum commutation brackets are developed from the classical Poisson brackets,

$$\{f,g\} = \frac{\partial f}{\partial q_\mu}\frac{\partial g}{\partial p_\mu} - \frac{\partial f}{\partial p_\mu}\frac{\partial g}{\partial q_\mu} . \tag{236}$$

Within traditional QM theories these are expressed as operators and take the common form of

$$\left\{q_\mu, p^\upsilon\right\}\psi = \int_\mu^\upsilon i\hbar\,\psi d\tau . \tag{237}$$

This commutation bracket furnishes a possible clue to a QM and GR connection. Notice that the noncommutation of the quantum operators has its roots within the classical Poisson bracket. It is well known within GR (28) that the order of differentiation is important exactly in the cases of nonzero curvature. The vanishing of the Riemann-Christoffel curvature is the necessary and sufficient requirement for the commutation of covariant differentiation. If the principle of covariance is used as a basic tenet of general relativity then we may expect a connection to QM through the commutation brackets when covariant differentiation is used.

Specifically, the underlying Poisson brackets must be expressed in terms of covariant differentiation. Thus

$$p_\mu = m g_{\mu\upsilon} \dot{q}^\upsilon \tag{238}$$

$$p^\mu = g^{\mu\alpha} p_\alpha = m g^{\mu\alpha} \dot{q}_z . \tag{239}$$

The Poisson brackets become

$$\left\{q_\mu p^\upsilon\right\} = \left[\frac{\partial q^\mu}{\partial q^\alpha} + \Gamma^\mu_{\beta\epsilon} q^\beta\right]\frac{\partial p^\upsilon}{\partial p^\mu} . \tag{240}$$

$$\left\{q_\mu p^\upsilon\right\} = \frac{\partial q^\mu}{\partial \rho^\alpha}\left[\frac{\partial p^\upsilon}{\partial p^\alpha}\right] ,$$

(241)

$$\left\{q_\mu p^\upsilon\right\} = \frac{\partial q^\mu}{\partial \rho^\alpha}\left[\frac{\partial p^\upsilon}{dq^\alpha} + \Gamma^\upsilon_{\sigma\alpha} p^\alpha\right] ,$$

(242)

where q^α is an operator, not a scalar. Simplification gives

$$\left\{q^\mu, p^\upsilon\right\} = i\hbar\left[\delta^\upsilon_\mu + \Gamma^\upsilon_{\beta\mu} q^\beta\right] .$$

(243)

This is similar to the traditional commutator for zero curvature but is now consistent with the principle of covariance.

The quantum mechanical commutators can now express an additional factor which arises from curvature of the space. To get a better understanding of this new term we may assume a point mass for the particle under consideration. This allows application of the well known Schwartzschild solution for the particle (37). Using the traditional 4-D spherical symmetric expression

$$ds^2 = e^{2\upsilon} dt^2 - e^{2\lambda} dr^2 - r^2 d\Theta^2 - r^2 \sin^2\Theta dp^2 .$$

(244)

gives the familiar metric,

$$g_{00} = e^{2\upsilon} \qquad g_{11} = -e^{2\lambda} \qquad g_{22} = -r^2 ,$$

(245)

$$g_{33} = -r^2 \sin^2\Theta ,$$

(246)

$$g_{\mu\upsilon} = 0, \quad \mu \neq \upsilon ,$$

(247)

$$g_{00} = 1 - 2m/r .$$

(248)

These can be applied to equation 243 to develop the required modification to the normal uncertainty relations by the replacement

$$\hbar \rightarrow \hbar' = \hbar[1 - 2m/r] \qquad (249)$$

where m is a constant of integration and is taken to be the rest mass of the particle. The important feature of the expression is that QM can now be expressed in a method consistent with the principle of covariance. Further, the departures from the theory only take place within distances on the order of the Schwartzschild radius. The added term has little effect at the larger distances normally encountered in electrodynamics.

The effects of this General Relativistic curvature term on QED can be best seen by starting from the path integral approach. The path integral approach has been taken by Feynman (1, 27) to develop QED in a very clear, intuitive, and formal way. It basically considers all possible paths that a particle can take in order to go from one 4-D point to another. Each path carries a phase factor which is expressed as

$$e^{iS/\hbar} \qquad (250)$$

where S is the action of the particle. Feynman uses the Lagrangian method for expressing the action

$$S = \int L \, dt \qquad (251)$$

and then develops a very intuitive approach to QED by the method of path integrals (36). The classical path of a particle can be expressed as the path of least action. Paths near the classical path have nearly similar phase factors. A path removed from the classical one experiences rapid changes in the phase. (The variation of the action is a minimum near the least action path but remote paths have a large variation.)

The probability of a particle going from one point to another is then calculated from the square of the sum of all amplitudes which carry $\exp(iS/\hbar)$ as a phase factor. The regions removed from the classical action contribute little to the probability since in those regions the phases are widely different. This results in the cancelling of terms within the sum, for regions of any considerable size, and the QM effects are seen only when the action is within $\hbar$ of the classical path.

Returning to equation (249), the added GR term should be considered within the phase expression of QED for consistency with GR. For an isolated particle with nonzero mass this gives the replacement

$$e^{iS/\hbar} \rightarrow e^{iS/\hbar'} \rightarrow e^{iS/\hbar[1-2m/r]}$$

(252)

for the QED phase factor of each path.

To understand the importance of such phase factors, consider regions approaching the Schwartzschild radius. In such regions the $\hbar$ becomes small and the phase between action paths begins to increase its variation. Thus, those regions will contribute little in probability calculations owing to their wide variation of phases. It can now be seen that the QM effects cancel in regions in space closer than the Schwartzschild radius in the same way they cancel in regions removed more than $\hbar$ from the classical least action path in momentum space.

The QED calculations remain unaltered for regions much further removed than the Schwartzschild radius of the particle. This is exactly where QED has shown its great utility. Also the terms within the probability and energy calculations for very close regions no long diverge. Instead they cancel due to phase terms. We have substituted the least action principle with a maximum probability principle and a principle of covariance. (This may open a likely method of incorporating entropy and thermodynamics into the theory.)

The suggestion here that $\hbar$ be replaced by terms containing a curvature term should not be treated lightly. It appears to be a very fundamental and deep lying variation at the very foundations of QED. The reason for this is that it alters the fundamental path integral,

$$K(b,a) = \int_a^b e^{iS(b,a)/\hbar'} d\tau$$

(253)

which expresses the sum of all possible paths to arrive at point b from point a. This means that not only are most of the divergences in energies avoided in a relativistic covariant manner, but also the normality of the probabilities are retained. The probability is simply proportional to the absolute square of the kernel

$$P(b)dx = |K(b,a)|^2 dx .$$

(254)

It is now apparent that the modification suggested here appears to be a valid relativistic way to avoid QED divergences while retaining a normal probability for the states. It also produces mathematical consistencies within QM, GR, and QED from a fundamental mathematical approach using the most basic principles of each.

It is interesting to note that the GR term would normally be considered as small. However, the necessary and sufficiency arguments regarding the vanishing of the Riemann-Christoffel tensor require that it be nonzero or the position and momentum operators of QM would be expected to commute. In other words, the curvature term is important precisely when QM is required due to noncommutation of the operators. In fact, the Riemann-Christoffel curvature term is one of the few places within common mathematics where noncommutation is encountered in a natural manner. Also, notice that the additional term appears to become important in exactly those regions where QED has encountered difficulties. Although the full QED calculations of self energy are not yet complete, simplified numerical solutions indicate that the added term gives self-energies near the traditional QED calculations that terminate their integrations near K_{max} of about $mc/\hbar$. Such cutoffs have long been used ad hoc for such calculations to give reasonable results.

2.7 COMPATIBILITY OF 10-D STRING THEORIES

Very little work has been done in the area of compactification of 10-D theories to five dimensions. Most work has focused on reducing the theories into 4-D. This is because most theoreticians do not see five physical dimensions as required by nature. Recently much attention has been given to 10-D string theory. It is hoped that such string theories would yield a viable unification theory. Much of the excitement has now died down as its inherent difficulties have been realized. Most of this difficulty can be traced to the fact that there is no unique way to reduce the 10-D theory to 4-D. From the 5-D point of view this is understandable, since a limited vector manifold of space and time alone can never span all physical observations. A fifth component of a function of mass or charge is required.

The curious feature of 10-D string theory is that the type IIB superstring is the most super-symmetric of the simplest chiral string theories. One might expect that it would be at the focus of current research. However this has not been the case. Again it appears to be avoided because, in general, theoreticians are predisposed to compactify to four and not five dimensions. In the low energy field theory limit, it possesses no Yang-Mills fields and should be approached from a Kaluza-Klein mechanism.

The irony is that the IIB weak field limit readily compactifies to five dimensions. This can be seen (29) when given the expectation values

$$F_{\mu\nu\rho\sigma\lambda} = -m\,\varepsilon_{\mu\nu\rho\sigma\lambda} \tag{255}$$

and

$$F_{mnpqr} = +m\,\varepsilon_{mnpqr} \tag{256}$$

with the Greek subscripts ranging from 0 to 4 and the English subscripts ranging from 5 to 10. The Einstein equations then follow quickly as

$$\Re_{\mu\nu} = -4m^2 g_{\mu\nu} \tag{257}$$

and

$$\Re_{mn} = +4m^2 g_{mn} \tag{258}$$

and we can find two separate spaces for bosons and fermions.

2.8   MACH'S PRINCIPLE

In Newtonian physics the three laws of motions are developed only within a preferred reference frame. Newton invoked the concept of "absolute space and time" to explain this preferred frame of reference. It is only within this absolute space that particles are restrained by inertia and undergo rectilinear motion with constant velocity. A motion which deviates from linear motion or from a constant velocity relative to this absolute space, implies the existence of force acting on the particles. The inertial resistance of the particle to forces is interpreted to be due to the restraining effect of the absolute space on the particles. This restraining effect is termed "inertial force." Newton essentially proposed that inertial forces on an object arise via a local interaction of the object with absolute space.

Instead of assigning the source of the force to space there is an alternative: It is the fixed stars that give rise to the inertial forces. In Newton's famous rotating bucket experiment (30), Newton concluded that outside matter made no contribution to inertial forces. Yet it remains possible that the inertial forces could be caused by the mass of fixed stars since their far greater mass overshadows the proximity of anything on earth to the rotating bucket. Today most modern textbooks on mechanics define an inertial reference frame to be a system of coordinates traveling at constant velocity relative to the fixed stars. Essentially, the inertial forces on a particle arise from

an interaction of the particle with the rest of the matter in the Universe. The idea of absolute space is to be avoided since it is entirely unobservable. In a universe of only one object how can rotation be defined? Yet in our universe of many distant stars and galaxies rotation is easily detected.

Newton's concepts were closely reexamined by Ernst Mach (31) in 1883. Mach suggested that the shape of the surface of the water in the bucket may depend on the rotation of the vessel "if the sides of the vessel increased in thickness." Thirring calculated such effect using general relativity. Thirring used a weak field approximation to find that a slowly rotating mass shell as on the bucket above drags along with it the inertial frames. In such an approximation the result is only valid when the induced rotation is small compared to the rotation rate of the container. The strong field solution to the problem is still not verified. It is this strong field solution that can be viewed as a manifestation of Mach's principle of relativity.

Mach's principle influenced the formulation of Einstein's theory of relativity. The basic ideas were that relative motion was dictated by the inertia and inertial forces produced by matter in the rest of the universe. Einstein enumerated three characteristic effects expected by the Mach principle:

1) If masses are accelerated then a body should experience a force in the same direction as the acceleration of the mass.

2) A rotating body should generate a "Coriolis field" which deflects masses in the sense of rotation as well as a radial centrifugal field.

3) The inertia of a body should increase if masses are accumulated nearby.

The first two effects are well known in general relativity and are called "dragging of inertial frames." This is reasonable to expect from general relativity since the structure of space time is intimately tied to matter. Thus, the fabric of space time is attached to the matter in it. If some matter is moved then the fabric also moves and drags the rest of the matter with it. The magnitude is directly dependent on the amount of matter in the field.

Even today there is much controversy over the precise formulation of the Mach principle within general relativity. It is even questionable whether or not general relativity is compatible with the concept. Sometime the principle is used to set boundary conditions. Sometimes it is used for entirely new formulation of relativity. This has led to confusion.

The confusion is avoided in the bi-metric formulation and we are led to a natural interpretation of Mach's Principle. The boundary conditions say that the two metrics are the same at infinite distances. When g is specified it imposes a covariant boundary condition on the admissible solution to the gravitational field equations. By formulating the covariant equations for g in terms of the total matter and energy density of the universe, one has the inertial structure of space time determined by the mass-energy distribution of the universe. This is simply a covariant statement of the Mach effect. The boundary conditions relating $g_{\mu\nu}$ with $\gamma_{\mu\nu}$ serve to eliminate some of the solutions to the field equations. The ones remaining are covariant and relate space time with a mass density function.

All three basic Machian effects predicted by Einstein can be recovered from bi-metric formulation of 5-D relativity theory. They depend only on the gravitational force equation in the approximation of low (slow) velocity relative to the fixed stars. Recall that the motion of an object in a gravitational field can be written in terms of the geodesic,

$$\frac{dv^{\mu}}{ds} + \Gamma^{\mu}_{v\sigma} V^{v} V^{\mu} = 0 \tag{259}$$

where V^{μ} is the velocity along μ
such that

$$g_{\mu\nu} V^{\mu} V^{\nu} = 1 . \tag{260}$$

Multiplying by the mass gives the momentum expression

$$\frac{dp^{v}}{dt} = -p^{\sigma} \Gamma^{v}_{\sigma\lambda} V^{\lambda} \tag{261}$$

with $\qquad p^{v} = mV^{v}$ $\tag{262}$

and $\qquad m = m_{o} d\tau / ds$. $\tag{263}$

This is the force equation written for the background space time. The term on the right of equation 261 is the gravitational force acting on a particle of momentum p relative to the fixed stars.

For the case where the mass is held approximately constant, the equation can be rewritten as approximately (for low gravitational potentials)

$$\frac{dv^k}{d\tau} = (1/2)g^{kl}g_{oo;l} - g^{kl}g_{ol;o} - g^{kl}g_{li;o}V^i - g^{kl}\left(g_{ol;i} - g_{oi;l}\right)V^i \quad . \tag{264}$$

The metric element g_{oo} now transforms like a scalar and the g_{oi} like the components of a three vector.

This expression is the key to understanding the Mach principle. It becomes clear as the equation is viewed from the post-Newtonian approximation (PPN). The first term is a gradient and gives rise to Newton's Law of gravity as well as a centrifugal force term if the system is rotating. The second and third terms are time derivatives and are nonzero only if the source of the gravitational field is accelerating. It gives rise to the dragging of inertial frames. The last term is a vector product of the three velocity vectors and the curl. It leads to a Corioiis force field term if the source is rotating. The force is directed along the direction of rotation of the source.

The last prediction made by Einstein can be seen from the fact

$$m = m_o\sqrt{\gamma_{oo}\Big/g_{oo}} > m_o \tag{265}$$

(recall clocks run slower in gravitational fields so $\gamma_{oo} > g_{oo}$). Consequently, for a mass in the background frame, the inertia of the mass will increase as other masses are brought near. This demonstrates that the bi-metric formulation similar to that of Rosen is consistent with Mach's principle.

2.9   ROSEN'S BI-METRIC THEORY

The concepts of energy, momentum, angular momentum, and center of mass motion are best explained through the killing field structure and the underlying Reimannien space time. This can be done by introducing a second metric tensor, $\gamma_{\mu\nu}$ into the general relativistic approach. This is similar to the consideration of force fields that was discussed in Section 1.3. This second metric does not change the physical consequences of general relativity, but it does provide a background space time relative to which the conservation laws for the gravitational fields can be formulated and discussed. The existence of this second metric enables one to redefine the gravitational force,

which Einstein had turned into geometry. The existence of the gravitational force then leads directly to the concept of gravitational energy and gravitational energy density. The second metric can be interpreted as representing an inertial space time since formally the inertial effects appear relative to $\gamma_{\mu\nu}$ and not $g_{\mu\nu}$

The introduction of bi-metric relativity enables one to use the Noether theorem to formulate covariant continuity equations from the bi-metric expressions. To discuss this concept in general relativity one must introduce an assumed background framework. The killing field structure gives intrinsic meaning to the conservation laws it forms. This is equivalent to the introduction of absolute objects into general relativity and is intimately connected to the Mach principle.

N. Rosen (32) was the first to formally introduce the second metric into the formalism of general relativity. His goal was to distinguish between inertial and gravitational forces by comparing the two metrics, $\gamma_{\mu\nu}$ and $g_{\mu\nu}$. To understand Rosen's rational we must realize that gravitational forces do not exist in general relativity. Einstein successfully geometrized the gravitational field into pure geometry. To recreate forces one must introduce some background metric tensor field or external reference frame to compare motions. By comparing the effects of gravitational space time (described by $g_{\mu\nu}$) with the effects of the background space time (described by $\gamma_{\mu\nu}$) one can assign the deviations of a physical system from its motions in the background space time to gravitational forces.

The second metric defines an inertial system in the same way that inertial effects occur in special relativity. The metric $g_{\mu\nu}$ defines the path of an object in a gravitational field The deviation of this path from the geodesic (expressed in the $\gamma_{\mu\nu}$ reference frame) defines the gravitational force acting on the particle. This gravitational force in turns leads directly to the concept of a gravitational stress-energy density tensor. This forms the bases of the bi-metric formulation.

Weinberg (75) calls the force seen in such comparisons the gravitational force since it can be written as

$$F^\nu = m_o \frac{d^2 x^\nu}{ds^2}$$

$$F^\nu = m_o \left(\frac{d^2 x^\nu}{ds^2} + \Gamma^\mu_{\nu\lambda} \frac{dx^\nu}{d\tau} \frac{dx^\lambda}{d\tau} \right)$$

(266)

This means that the force is the gravitational force acting on an object relative to a flat background. This is exactly what is needed to formulate a covariant Noether theorem for the gravitational field. Since all partial derivatives of $g_{\mu\nu}$ can be written in terms of Christoffel symbols, one can introduce the $\gamma_{\mu\nu}$ into general relativity in such a way that only covariant derivatives appear. Recall that the covariant derivatives consider the curvature of space while ordinary derivatives ignore the changes of the coordinates in space. It is the curvature terms (Γ's) that hold the corrections that appear as a force. We see the curvature as a force in the inertial framework expressed by $\gamma_{\mu\nu}$.

The logical selection for a reference frame is the fixed stars. There are several reasons for this selection. One is that in regions far removed spatially from any local source of gravity the gravitational forces should tend to zero. The curvature terms then vanish at large distances from the local gravity source. This means that $g_{\mu\nu}$ and $\gamma^{\mu\nu}$ become identical at large distances from the object considered. The Mach Principle finds a natural expression in terms of the bi-metric formalism. The principle is a statement concerning the effects of matter on the inertial properties of other matter in the universe. The principle has taken many confusing and contradictory forms in the literature.

2.10 NONCONSERVATION

To derive the conservation conditions within the Dynamic Theory we need to introduce the energy-momentum tensor which is

$$T_{ik} = \left(\frac{1}{\mu_o}\right)\left(F_{ik}F_{kl} - \left(\frac{1}{4}\right)F_{jm}F_{jm}\delta_{ik}\right) \quad . \tag{267}$$

The most general conservation laws are the expressed as

$$\frac{\partial T_{ik}}{\partial x_k} = J_k F_{ik} \tag{268}$$

which is normally seen equal to zero but in general this is not required.

The conservation law resulting from the fifth dimension is identically satisfied by the Maxwell expressions. When the conservation law which governs changes in time is solved we obtain

$$\nabla \cdot S + (\tfrac{1}{2})\frac{\partial}{\partial t}\left(B^2 + E^2\right) - E \cdot \left(J + \left(\frac{1}{\mu_o}\right)\frac{\partial V}{\partial \gamma}\right) = 0 \tag{269}$$

where S is the Poynting vector, E x B. The first two terms are the classical expression. They specify that the flow of energy in a volume is proportional to the change in electric and magnetic fields (squares) in the volume. In the 5-D theory there is an added term related to $\frac{\partial V_4}{\partial \gamma}$. This can be associated with a current and is associated with creation and annihilation of charge. This term also appeared in the Maxwell-like expression. The term signifies the change in charge density due to creation or annihilation of charge. This interpretation has been common in almost all unconstrained multidimensional theories.

The trend among theoreticians is to constrain the theory in some way to exclude nonconservation. Here we wish to see if there is a way to induce this non-conservation. The key seems to be the $\frac{\partial V}{\partial t}$ terms. This enters the charge, momentum and energy conservation expressions.

Returning to the last term of the Poynting expression above, notice it also appeared in the Maxwell-like equation (101) which can be rewritten explicitly as

$$a_o \frac{\partial V}{\partial \gamma} = 4\pi J / c - \nabla \times B + \left(\tfrac{1}{c}\right)\frac{\partial E}{\partial t} \quad . \tag{270}$$

Placing this into the Poynting expression (in suppressed units)

$$\nabla \cdot S + (\tfrac{1}{2})\frac{\partial}{\partial t}\left(B^2 + E^2\right) - E \cdot \left(\dot{E} - \nabla \times B\right) = 0 \quad . \tag{271}$$

<center>New Term</center>

This means that interesting energy and momentum flows are expected for $E \cdot \dot{E}$ terms and $E \cdot \nabla \times B$ terms. In other words, where the electric fields are rapidly changing or where there is a curl

<center>-75-</center>

(rotation) of the magnetic field reacting with electric fields. (The electric field should be perpendicular to the axis of rotation.) These areas have been exactly where anomalous experimental claims have occurred. The $E \cdot \dot{E}$ term will be considered in the Biefield-Brown discussion for charging capacitors. The curl term is curious. It may be an expression that may come to bear in rapidly rotating systems of magnets. Notice a rapidly rotating magnet reacts somewhat like a charge. The $E \cdot \nabla \times B$ term is a triple scalar product. It is the same as the divergence of the Poynting vector.

The generalized expression (α, β, σ are general arbitrary coefficients),

$$\nabla \cdot S + \alpha \frac{\partial}{\partial t}\left(B^2 + E^2\right) + \beta E \cdot \dot{E} + \sigma E \cdot \nabla \times B = 0 \tag{272}$$

is very useful in deciding what kinds of experiments should produce new results. In energy related experiments, the new terms due to the added dimension is expected in cases of changing electric fields and rotating magnetic fields. The other expected place is where the mass (or energy) density is changing.

2.11 PARTICLES IN 5-D SPACES

The field expression for V_4 was found in equation 196 as

$$\star^2 V_4 = \mu_O\left(-c^2 \frac{\partial \rho}{\partial x_4} - \frac{\partial J_4}{\partial t}\right). \tag{273}$$

By setting the charge density and all currents to zero it becomes

$$\star^2 V_4 = 0. \tag{274}$$

This can be solved by first taking the Fourier transform with respect to mass density to give

$$\left[\nabla^2 - \frac{1}{c}\frac{\partial^2}{\partial t} - k^2\right]A_i(\vec{r}, t, k) = 0, \tag{275}$$

then taking the Laplace transform on time (with all first and second order terms zero at the boundaries) to give

$$\left[\nabla^2 - \left(S^2/c^2\right) - k^2\right] A_i(\bar{r}, s, k) = 0,$$

(276)

When $S = i\omega$ the solution is of the form

$$V_4 \Rightarrow \frac{-c\sqrt{k^2 - \left(\omega^2/c^2\right)}r}{r}.$$

(277)

This function is related to finding a given rest mass within a given volume. It appears to be the quality that we associate with a real particle. The function is damped for $K > \omega/c$ but it becomes oscillatory for $\omega > ck$. For frequencies

$$f > \frac{c}{\pi r_o} \sim 3.4 \times 10^{22} Hz$$

(278)

the quantity V_4 will rapidly die out. This indicates that if r_o is of the order of a classical electron radius and is indicative of most elementary particles, then only particles with rest mass under 140 MeV should appear stable. If this is correct then protons (940 MeV) would be expected to either be unstable or have a radius smaller than one tenth of the classical radius of an electron.

CHAPTER 3
EXPERIMENTS

3.1 APPROACH TO SELECTION OF EXPERIMENTS

The multidimensional theories in this report are still unverified. One approach would be to find an experiment that would prove or disprove the theories and then try to make use of the information to design a technology using the effect. An alternative is to try to look for desired technology using the nonclassical effects predicted by the theories and then design experiments that best demonstrate the effect. The best experiment from the first view is the Radiation Pressure experiment. The best from the later view is the charging capacitor (Biefield-Brown) approach.

A number of experiments that would test for the inductive coupling are outlined. Most seem to be more expensive to conduct than does their probability for success would warrant. A few experiments are outlined that seem to be practical and may offer some measure of promise for success. Recommendations are offered after a brief description of each experiment.

The experiments and methods are presented according to their feasibility of verifying an inductive coupling that may lead to a propulsive system, since that was the primary objective of this task. Of the new experiments suggested here, the radiation pressure and density approach is the most highly recommended. Of the existing studies, the work of Woodward is seen to be the best and most direct approach to verifing nonzero coupling. Some experiments leading to new methods of propulsion and power are included in the list even though they are classical in nature and not 5-D based. They are included since they were found during the task and were determined to warrant more attention than they are currently receiving. A subjective comparison of experiments can be seen in Table 5. Additional experiments of more doubtful quality are listed in Appendix D.

Table 5. Comparison of Experiments

EXPERIMENT	$	PROPULSION	POWER	PRACTICALITY	SPINOFFS
1 Radiation Pressure	3	3	3	4	
2 Biefield-Brown	3	5	1	(3,4)	propulsion
3 Conductive Submarine	2	3	3	(3,4)	propulsion
4 Gravitational Rotor	2	5	3	3	propulsion
5 Spin Aligned Nuclei	2	3	5	3	propulsion
6 Noninductive Coils	3	3	3	3	
7 EM Transparency	3	1	1	3	communications
8 Magnetic Loop	3	3	1	3	
9 Speed of Light	1	1	1	2	
10 Charged Torque	3	1	1	3	
11 Thermoelectric/ Gravitational	2	1	3	3	
12 Binary Pulsar	2	3	1	4	orbital changes
13 Proton Scattering	1	1	1	2	
14 Inertial Mass	3	1	1	3	

Ranking Key:

cost ($)	1: high	2: mod-high	3: moderate	4: low-mod	5: low
propulsion	1: no		3: possible		5: yes
power	1: no		3: possible		5: yes
practicality	1: new process	2: new device	3: devices can be made	4: existing machine	5: existing data

3.2 RADIATION PRESSURE

Five dimensional theories suggest that there is a difference in radiation pressure and radiation energy density due to the new terms. One way to test this is by the comparison of the radiation pressure with bolometer readings. Some difficulties can be avoided by using the fact that the effect depends on the square of the frequencies and may be isolated by using experimental designs using two frequencies.

Classically the expressions for the radiation energy density and pressure are identical. This is not the case for five-dimensional waves that include three transverse components (electric, magnetic and gravitational). In the Dynamic Theory, the energy density, E_d, is given by

$$E_d = \frac{1}{8\pi}\left[E^2 + B^2 + V^2\right] \tag{279}$$

and the radiation pressure expression, E_p is found to be

$$E_p = \frac{1}{8\pi}\left[E^2 + B^2 - V^2\right]. \tag{280}$$

This difference may lead to an experiment to compare the two expressions. The classical experimental approach dates to Nichols and Hull at Dartmouth College (1901-1903), who measured the radiation pressures using a torsion balance. They did this by allowing a beam of light to fall on a mirror mounted to a torsion fiber so that it could react to the radiation pressure. The experimental results reported in Halliday and Resnick (33) were 7.01×10^{-6} N/m^2 for the radiation pressure and 7.05×10^{-6} N/m^2 for the radiation energy density. This was considered very good experimental technique at the turn of the century. If their numbers are accurate there is a 5% difference in the two values. The difficulty in the experiment is in the calibration of the bolometer. There may be a way around this impasse.

From the Dynamic theory, the energy density calculated by Williams is

$$E_d = \frac{1}{8\pi}\left[(1 + \mu\varepsilon) + \frac{2A^2}{\omega^2}\right]E_y^2, \tag{281}$$

where $A = a_0 c k_4 e$ and ω is the frequency. The radiation pressure is given by

$$E_p = \frac{1}{8\pi}(1+\mu\varepsilon)\frac{F^2}{y} .$$

(282)

The ratio between the two is

$$E_d / E_p = 1 + \frac{2A^2}{\omega^2(1+\mu\varepsilon)} .$$

(283)

The ratio depends on the frequency of the light. Thus, if we conduct experiments to measure the ratio over a range of frequencies, then it will be possible to determine the coupling constant a_0 without being limited by the bolometer calibration accuracy.

For example, some lasers and light sources have several emission lines. Assume we have a light source that emits two distinct frequencies and that they are emitted at a fixed (or slowly changing) known ratio of intensities. We now construct a Nichols/Hull experiment in which both the mirror and the bolometer have a relatively flat response over the range of frequencies. The experimental design will be similar to Figure 1.

A light source (#1) with two separate emission lines is allowed to shine on a diffraction grating (#2) which splits the light into different paths for the two frequencies. A neutral density filter (#3) is adjusted along one path so that the radiation pressures at the torsion balance (#6) from the two frequencies are equal. Two beam splitters (#4 and 5) are placed along the path so that a fraction of the beam can be received at the bolometer (#8). Either frequency can be selected for the bolometer by a slit (#7).

The first step in the experimental protocol is to balance the torsion developed by the two light beams. This is done by adjusting the filter (#3). The energy at the bolometer is then read for both frequencies separately. The diffraction system (#2) would then be readjusted so that the paths taken by the two beams are reversed. Again the bolometer reading would be recorded for each frequency. Finally, the diffraction system would be replaced by a beam splitter and filter so that a single frequency would travel along both paths.

Classically, we would expect the bolometer readings to be equal when the torsion system is balanced. Any deviation admits the possibility of unequal pressure and density values.
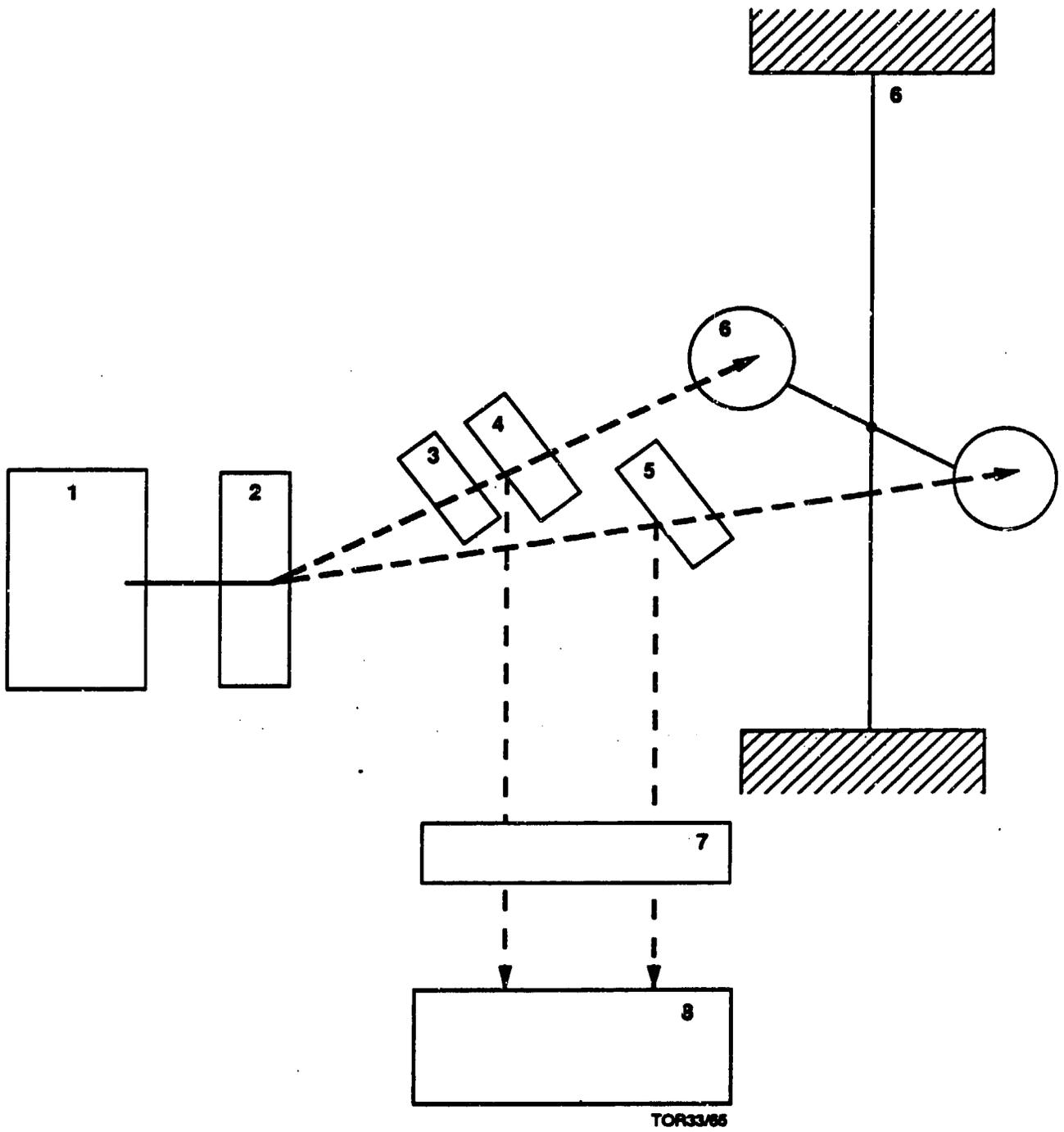
Figure 1. Radiation Pressure/Density Experiment

TOR33/85

It should be noted that this experimental approach also allows for balancing the energy received at the bolometer and then reading any torque with the torsion balance. This would be a useful check to the technique. A larger signal-to-noise ratio can be obtained by using modern high intensity lamps and lasers than were available to Nichols and Hull.

Requirements for this experiment include:

Materials-
- laser (double frequency),
- beam splitters,
- torsion balance,
- bolometer (flat frequency response),
- vacuum enclosure,
- neutral density filter,
- wave length calibration,
- diffraction grating,
- monochrometer,

and Expertise in -
- optical measurements,
- vacuum technology,
- mechanical construction of torsion system.

RECOMMENDATION- This approach has much to recommend it. First, it is potentially a very clean experiment. Unlike most of the other approaches, it avoids high electric fields, high vacuums, and sensors sensitive to environmental interference. Second, it can be useful even if its sensitivity is too low to detect a nonzero coupling coefficient. Third, there is some historical basis to believe some effect may be present. Studies of radiation pressures would become useful in absolute laser power measurement and solar sail applications. Experiments such as this often require few equipment expenditures when conducted at the right site. It is suggested that consideration be made for adding such an approach to a USAF Summer Faculty Research program, to existing radiation pressure studies in solar sail research, or to other similar programs.

3.3 BIEFIELD-BROWN EFFECTS

In the 1930's T.T. Brown experimented with capacitors which seemed to demonstrate a nonzero coupling between electric and gravitational fields. He received several patents (British

300311, U.S. 3187206, 3022430, 2949550, 3018394, and 1974483) for the claimed effect. The work has usually been discounted, the results being attributed to ion wind and corona discharge from the high voltage (to 100 kV) employed. Brown claimed forces were developed within his asymmetric capacitors upon application of large static potentials. He also claimed the forces were proportional to the capacitance, weight of the dielectric, charging potential, and divergence of the electric field. A great deal of popular (but little technical) literature has developed from his work. It is now common to call any apparent mass effects on charged (or charging) capacitors the Biefield-Brown effect.

There is little theoretical support for effects generated by static fields. Most theoretical approaches require the use of time varying fields. It is doubtful that Brown had a well filtered 100 kV DC power supply during his work. This would mean that he could have been seeing an event initiated by time varying fields. Currently at least two groups are pursuing work to demonstrate gravitational field effects with capacitors. The one is led by Dr. J. Woodward and the second is led by Bob Talley.

These approaches can be understood from the viewpoint of 5D theories. Recall that the line element, ds, holds all the physical theory. It expresses how an event or object changes in space or time. In four dimensions the element is simply the square root of the sum of the squares of the changes in coordinates (i.e. $dx^2 + dy^2 + dz^2 - dt^2$). In five dimensions there is an added term due to the change in the added coordinate. In the Dynamic Theory this is taken as the change in the mass density (and hence the energy density). Any effects not currently seen in our 4-D theories must be a result of the newly added coordinate. Thus, novel effects can be seen only when there is a change in the mass or energy density within the experiment. This can take one of two forms. Either the energy density can change in time during the experiment or the mass density could change as a function of the spatial coordinates. The first effect is much easier to handle experimentally and to treat theoretically. Such an effect would appear as a change in the inertia or mass of the object in the local field or the change in a dynamic property of a moving object.

CHARGING CAPACITORS - Dr. Woodward's work at California State University (Fullerton, CA, (34) is perhaps the best currently running experimentation to test for nonzero coupling of the fields. He has taken an empirical view of the coupling and has described the gravitation field, F, as a power series:

$$\nabla \cdot F = 4\pi G\left[\rho_m + \beta\frac{\partial f(E)}{\partial t} + ...\beta_n\frac{\partial^n E}{\partial t}\right]$$

(284)

where G is the gravitational constant, ρ_m the mass density, c the speed of light, f(E) an arbitrary function of energy density, and ∂^n/∂_t the nth derivative with respect to time used in the Taylor series expansion. The β is the coupling constant which he has experimentally measured as 0.029 +/- 0.006. It should be noticed that the expression reduces to the classical expression of the gravitational field in the case where the coupling goes to zero.

Theoretically the above expression has much to recommend it. For one it is a simple empirical expression which can be derived from a large class of scalar-vector-tensor unified field theories which admit nonzero coupling. For the case where the function is simply the energy density and n=1, the formula is similar to equation 272 with E taken as a measure of the energy density.

Woodward's experimental approach is to rapidly charge a capacitor and measure its gravitational attraction by strain gages. In his initial studies he used plastic dielectrics of about 350 gm, fields of $\sim2\times10^6$ volts per meter and switching times of 100 milliseconds. He received signals corresponding to charges of a few hundredths of a gram. It appears that the experiment was done with proper technique but it suffered from seismic noise.

Woodward is getting some results. The difficult is in seismic isolation and sensitivity of his sensors. With a limited amount of funds his work could be improved about an order of magnitude with currently commercially available sensors.

The use of new materials can greatly increase the sensitivity of the system. Pennwalt (at Valley Forge, Penn.) has very recently produced an array of new dielectric materials. The company is working with Maxwell Laboratory of San Diego, CA, for the development of state-of-the-art capacitors. The materials are basically made from polymeric $-CH_2CF_2-$ units. The properties can be enhanced by loading the plastic with titanates or quinones to increase the dielectric constants. The materials have very high breakdown voltages and orientation of the molecules is possible (during formation). Thus, they display very large energy density possibilities. Unfortunately much of the work is sensitive due to SDI applications (supported by DNA) or it is proprietary. In the absence of specific information, this report suggests candidate materials can likely be produced

by doping materials (such as Teflon and analogs) with high dielectric materials. Such materials have been studied by Herbert Pohl and others (35). Cravens' Laboratory has disclosed the use of ground ceramic superconductive particles within polystyrene for use as a dielectric. The material can be switched by external thermal and magnetic effects. The lab is also working on dielectrics that can be switched optically. The figure of merit for the charging capacitor experiment is the power density per mass. Work on preparing dielectric materials best suited for the charging capacitor experiments runs parallel to work on fast switching of large electrical surges. Such properties are useful in ion weapons, pulsed plasmas, electromagnetic pulses and other defence related activities. If there is a nonzero coupling in the second term of the Taylor series expansion for the gravitational force, then AC currents can be expected to result in apparent mass changes. Such changes would be proportional to the square of both the applied potential and the frequency. The effect would have a nonzero change in inertia when integrated over an entire cycle.

This approach is exceptionally interesting in regards to propulsion advances. In effect, it changes the gravitational field interaction due to both energy (hence mass) density and the time rate of change of that density. In other words, power density levels may be tied to gravitational field interactions. This is consistent with the view taken in the theoretical section (see Section 1.3). Recall that there is a term in the fundamental line element resulting from the change in mass (and hence energy) density. It is during processes of changing mass or energy density that the 5-D nature is expected to be detected.

Requirements for this experiment include:

Materials-
> high dielectric materials,
> fast switching (millisec) power supply at
> moderate voltages (kV),
> momentum transducers,
> seismic isolation,
> data acquisition,

and Areas of Expertise in -
> material selection,
> electronic interference,
> seismic interference.

RECOMMENDATION- Due to the recent progress and the apparent theoretical validity of Woodward's approach, it is recommended that efforts be made to encourage and support his work. It appears to be the best experimental project aimed at nonzero coupling that is now underway.

CHARGED CAPACITORS - Veritay Technology, Inc. has been conducting research (36) under the SBIR program for the USAF (AF87-192). The goal is to verify and to quantify the conversion of electrostatic energy directly into a propulsive force in vacuum environments. They have approached the problem by using charged capacitors as did Brown in his original work. They have tried to isolate the effect from ion winds by placing an asymmetric capacitor within a vacuum. Further, they have studied the effect as a function of pressure within their vacuum chambers. They worked over a range of pressure from 10 torr to 10^{-1} torr and voltages up to 1.5 kilovolts. Below 1 torr the forces were seen to be independent of the pressures. The force upon the capacitor was found to be

$$F = 3.55 \times 10^{-8} \, V^{0.722} \tag{285}$$

where F is the force expressed in newtons and V is the voltage in kilovolts. The input power of 0.4 milliwatt generated a thrust of 10^{-7} newton for a thrust-to-power ratio of 2.5×10^{-4} newton/watt (.56 micropound/watt).

It is difficult to see from the inductive theories how static fields can lead to changes in the dynamic properties of a system. In Veritay's approach, a static potential in the kilovolt region is applied to an asymmetric capacitor. There is a spatial divergence in the electric field and energy density within that field. Within the Dynamic theory a divergence in charge current flow is required to produce a flow in mass (see Appendix E for a development). This would indicate a current flow would be required to generate a propulsive force. It should be pointed out that T. T. Brown work often used "leaky transformer oil" (i.e. with water absorbed) or air/vacuum capacitors which allowed a nonzero current flow. This may have supplied a current flow within the capacitors. Briefly stated a time changing electric field may be expected to give rise to changes in the inertia or mass of an object and a time varying divergent field may be expected to give rise to a propulsive force. The theory does not seem to predict mass changes resulting from static fields nor propulsive forces from nondivergent fields. If this interpretation is correct then a vertically supported torsion fiber system could be expected to see results only if the asymmetric capacitor was pulsed. The difficulty then would be to design a system with a proper frequency response and to supply the current to the device without affecting the restoration forces of the torsion fiber.

The current experimental design is not conducive to seeing terms which rely on the time variations of the electric field. It is, however, conducive to testing spatially inhomogeneous electric fields. A torsion fiber system with a vertical axis is capable of seeing impulses but not changes in the inertial mass. To detect mass variations a horizontal axis is required.

RECOMMENDATION - It is recommended that Veritay's work be monitored closely as to new results. It is further suggested that they be encouraged to investigate the theoretically more promising nonstatic electric field. Better vacuums should be achieved to remove the possibility of ion wind. Since the effect is proportional to the dielectric constant, they should be encouraged to use a range of materials.

3.4 CONDUCTIVE SUBMARINE

Peter Graneau has studied possible modifications to Ampere's Law (37, 38). Most researchers do not take his theoretical work seriously. The important thing, however, is that he has claimed to have observed departures from classical electromagnetics. He detects departures from the Lorentz forces at high current levels. In one experiment (?8) Graneau passes a current through a mercury filled trough. Located in the mercury is a pencil shaped copper rod. Longitudinal forces are developed as large currents pass through the lengthwise trough to the conductors. This observation is consistent with the view that inertial forces can be developed by a divergence in current flow. It should be noticed that the propulsive force only develops relative to the conductive media. It is, therefore, unlikely that the effect could be used as a space propulsion device, although oceanic and atmospheric applications seem reasonable.

The movement of the "sub" in the conductive medium must be quantified. This includes calculation of the drag on the sub. This can be accomplished both by calculation and by direct experimental measurement by propelling the sub by a known force. The drag can be varied by adding material to the solution. For example, glycerine, guar, or other materials can be added to increase the viscosity. This would allow the drag to be mathematically modeled so that other effects could be isolated.

The conductivity of the solution can be controlled by changing the concentration of the conductive salts in solution. In this way the relative conductivity between the medium and the sub can be varied. The salt concentration can allow for variations between the relative density of the sub and the medium. High concentrations of salts must be used to achieve large current densities.

They must be chemically compatible with the sub. A gold or silver-plated sub is recommended. Temperatures should remain constant during the process.

One way to monitor the kinetic moves of the sub is by the use of photogates. Both the velocity and acceleration of the sub can be monitored by a suitable array of photogates. These must use optical frequencies and not IR or other frequencies absorbed by the medium.

Requirements for this experiment include:

Materials-
> conductive salts,
> temperature bath,
> high current source,
> small machine lathe,
> photogates (optical),
> event recorder,

and Expertise in -
> electronic connections,
> electrochemistry,
> fluid flows.

RECOMMENDATION - This is a relatively inexpensive experiment to set up. It requires only readily available materials. It is suggested that only a preliminary study be considered initially until the validity of the longitudinal forces is established.

3.5   GRAVITATIONAL ROTOR

It can be seen from the 5-D equations for charge conservation. (equations 103 to 105) that electromagnetic effects can create a gravitational mass density. This is in keeping with the principle that the goal of unification efforts is to write a single expression that relates all the fundamental forces. In Williams' technical consultant report this principle has been applied to create torque on a conductive member which has a divergence in its current flow. There was a small attempt made to measure such an effect. Appendix B gives a detail development of the principle. Two cones (naps of right cones) were joined at their bases. Electrical contact to the copper cones was made through two rods immersed in a mercury. As current was passed through the device the rotational torque was measured by a optical lever by a laser. The experiment failed to witness any large effect but it

was a relatively insensitive device. Due the symmetry of the device, some calculations of the torque yield zero as the expected value. This is due to the symmetry of the device.

The overall theoretical base for the experiment is sound but the mathematical complexity of the theory does not yield itself to a simple apparatus. This report concludes that the "conductive submarine" may be a more practical method. The torque measurements in this approach require a small static balance be measured. The submarine (see Section 3.4) can be read as an integrated value of a total length of travel. The later is much easier to measure. When the two cone geometry was calculated independently, it seemed that the divergence at one cone cancelled the convergence of the other cone.

RECOMMENDATION - This approach scores high due to the theoretical underpinning. However, it is not recommended at this time. Should better calculations of the divergent fields and material structure be developed this approach should be reconsidered.

3.6 SPIN ALIGNED NUCLEI - MAGNETIC AND ROTATIONAL ALIGNMENT

MAGNETIC ALIGNMENT- Paul Brown is currently researching the extraction of power from decaying nuclei by magnetic methods and ion absorption by conductors. This work was initially motivated by an investigation of H. Moray's work. Beginning in the 1920's and until the 1950's T. Henry Moray worked on devices which were claimed to produce substantial power outputs from relatively small and light systems. The original claims of the late 20's were documented by various independent sources and signed witness reports. The early documented power outputs were from 100 to 600 watts. Later claims ranged as high as 50 kW but these have not been supported by individuals not connected directly with Moray. The following is a list of relevant points gleaned from the witnessed reports and from Moray's book (39).

1) Power outputs of 100 to 600 watts.

2) Photography was often difficult.

3) A ground and antenna were required.

4) Tuning was often required.

5) The devices were sealed except for air cooling, antenna connections, ground wire and output connections.

6) Moray is known to have worked with Ra and other radioactive materials.

7) Moray claimed to be detecting extremely high frequency sources (his claim was cosmic rays).

8) R. L. Judd and Carl Eyring observed the device and its construction (30's) and concluded power was obtained by electromagnetic induction in a tuned circuit.

9) "Moray valves" were originally constructed from a "Swedish stone" that led to studies of radium.

10) The diodes used were primarily of germanium but included other materials.

11) Moray described the device as a high speed oscillating energy resonator.

The following is a tentative hypothesis, based on the above facts and other historical facts. The devices were high frequency resonant devices that were tuned so that the average times between nuclear decay of an included source was approximately matched to the period of the circuit. In this way the energy from the radioactive alpha decay of a radium source can be captured as electrical impulses, which in turn set up electrical oscillations and could then be rectified.

There would be several ways in which Moray could have achieved such a conversion and it is likely that the process evolved as follows. Initially the antenna served to create a bias across a diode junction so that there would be unequal flow of charge particles and ions resulting from a radioactive decay. This bias is produced from the atmospheric potential available between the antenna and the ground. Moray makes several references to the atmospheric potential. There is reason to believe that some of his antenna wires were doped or coated with radioactive materials. This method is common for studies of atmospheric potentials since the localized ionization from the radiation near the antenna increases the available current. Tube technology was current during this era and the availability of an atmospheric bias could be employed to rectify low level currents. Under the correct gas pressures the "effective range" (nuclear term) of the alpha emission may be matched to the electrode spacing for a diode or triode system to yield a "cold cathode" system. In the 30's high speed solid state rectification was unknown. Moray employed germanium with bismuth and undisclosed dopants as a rectifying agent.

A preferred embodiment would be to locate an alpha or beta emitter with little gamma radiation within a concentric solid state dipole so that the radiation can be directly captured and rectified in one device. The device is analogous to a photovoltaic cell where the ionization is achieved by radioactively released charged particles instead of photoexcitation. Better efficiencies could be achieved by absorption of the high energy radiation within a shield so that lower level secondary particles would be produced.

It is apparent from Moray's work that he was attempting direct conversion of radioactive energy to electrical energy. The initial form was similar to what is now called the Burk Cell (U.S. Pat. #3,409,820 and 3,530,316) and used atmospheric potential to supply the voltage bias. The device developed to a beta cell similar to that of U.S. patent #2,552,050 involving a method similar to that of U.S. patent #3,094,634 involving a semiconductive junction. The final form was apparently a resonant type of device similar to Paul Brown's recent Resonant Nuclear Power Supply U.S. patent #4,835,433.

Paul Brown's work is the best current research related to Moray's work. He has produced several nuclear batteries with power levels ranging from 65 to 100 watts in prototypes and is now working on a 50 kW system. In his device, a radioactive source is located near or within the inductive coil of an LCR tank circuit. The radioactive energy is such that it supplies energy at levels to sustain oscillations within the circuit. Then the oscillations are transformed to match the load requirements.

The source of the energy is from the kinetic energy of the released radioactive particles. The deacceleration collapses the magnetic field generated by the moving charged particles. The changing magnetic field then accelerates the conduction electrons within the coil. Paul Brown describes the device as a sort of particle accelerator in reverse. The kinetic energy of the radioactive particles produces an electric current via the magnetic field which collapses during deacceleration.

The device works entirely upon classical theories and does not require 5-D inductive theories for its explanation. It is, however, a potentially useful device for space power. Peripheral Systems of Portland, Oregon is working with Brown on marketing the device. A 7 pound prototype using about 2 grams of Sr-90 has generated about 75 watts of power. This is significant considering the half life of Sr-90 is 28 years. The device disclosed in his patent contained one millicurie of Ra, 200 grams of U and 300 grams of Th. When functioning at 86 kHz, it generated 23 amps at 400 volts into a resistive load. The company is just starting up and has not conducted long term tests. They are reportedly seeing some lifetime difficulties with radiation damage to the conductors. There is little documentation on the work and no independent testing of the devices. Only a few prototypes are presently available. Peripheral System is now seeking private support and has made a few moves to seek USN support. Journal articles should be available within the year.

RECOMMENDATION - Paul Brown's approach should be followed and encouraged in regards to power production. Since the mass fraction of a Beta emission is so low, it is doubtful that any beneficial propulsive system could be developed. It does, however, have potential as a power device. The concept of magnetic alignment of decaying particles has an additional potential benefit. Should it be possible to direct most decay product along a chosen axis then shielding restrictions can be relaxed. This could equate to mass savings for a space-based nuclear device. None of the devices seem to involve inductive coupling of fields. This area is not recommended for verification of 5-D theories.

ROTATIONAL ALIGNMENT - Nuclei can also be aligned by rotation (40). Henry Wallace claimed some unusual effects (41-43) assigned to electromagnetic and gravitational couplings. This was in three U.S. patents (#3823570, #3626605, and #3626606). The assertion was that the application of a rotational force on a material of half-integral spin would result in a reorientation of the nuclear structure and could be utilized for "altering its gravitational attraction toward other bodies, separation of isotopes by distinguishing between nuclei according to their nucleon content..." The patents are written in a very believable style which includes part numbers, sources for some components, and diagrams of data.

Attempts were made to contact Wallace using patent addresses and other sources but he was not located nor is there a trace of what became of his work. However, should the work be real it may furnish a novel experimental approach to experimental design. The concept can be somewhat justified on general relativistic grounds since rotating frames of time varying fields are expected to emit gravitational radiation. Even if the work does not give a direct gravitational coupling it may furnish a new method for nuclear spin alignment.

The famous proof of parity violation in the decay of Co-60 may be useful here. It was found that the nuclei of Co-60 could be aligned by a magnetic field and then the nuclei frozen in that aligned state. When the nuclei beta decayed, the direction for the decay products was along the magnetic field. This could form a propulsive device. Since rotating reference frames and magnetic fields are so similar it is plausible that rotations could be used to align nuclei. If this could be performed with suitable, light nuclei a very efficient propulsive system may be possible due to the high energy density. One likely candidate would be Na-22.

This could be the starting point of a very practical experiment with direct propulsion application. Unlike many of the other experiments which require close measurements of mechanical systems this could be designed to measure, primarily, nuclear decay and such

measurement can be very sensitive. The other importance is that if spin polarization can give rise to a preferred direction of decay products then the shielding difficulties of nuclear systems may be minimized

RECOMMENDATION -This would make an interesting study. It is likely that some researchers will pursue this investigation now that it has been pointed out. The development of this approach should be monitored. When and if it is found to be valid (as determined from scientific literature) the implications to nuclear shielding should be reviewed. The presence of high rotational speeds on space vehicles may become important to nuclear events abroad. No action in this area is suggested for AFAL until research shows it to be a real event.

3.7   NONINDUCTIVE COILS

Several authors have suggested that the v x B terms in the Lorentz expression should be called into question. Several unverified experimental claims have been made but only qualitative experimental results have ever been made. An experiment is suggested to test one or several of these theoretical views. This is an area where the experimental procedure is workable and the outcome could have direct results in the area of inertia forces.

During the late 60's William J. Hopper put forth an interesting theory involving the v x B terms of dynamic electrical circuits (44,45,46). There was and still is uncertainty as to the exact physical understanding of the Biot-Savart-Lorentz law and Ampere's law involving the set of the reaction forces. Peter Graneau has studied these expressions. Hooper's view was that there are three different types of electric fields due to the distribution of electric field, and two due to induction.

In Cullwick's extremely insightful work (47), he works through electromagnetic effects from a relativistic approach. His work is one of the only useful works, even to this date, of rotating electromagnetic systems. Cullwick takes great pains to point out that the electric current can be traced to the flow of particles of nonzero mass. As a result linear momentum should be assigned to its flow. He also shows that Maxwell's theories are consistent only with zero mass charge carriers. He then shows that new effects will likely appear as nonlinear departures from Maxwell's equations at high currents or voltages.

At the heart of the issue is the connection of the magnetic field and its source in the charged particles. EM theory is presently consistent with the idea that spinning magnetic dipoles create

effects indistinguishable from charged particles. There has been no critical experiment which can disprove whether a magnetic flux rotates with its source. If it does co-move with its source then it is logical to assume that a motional electric field in a fixed reference frame of the current induces a magnetic field. This concept is likewise consistent with a field-free interpretation such as Ampere's original laws.

Maxwell said in page 574 of his Treatise (48), "As it is of great importance to determine whether any part of the kinetic energy is of the form T_{me}, consisting of products of ordinary velocities and strengths of electric currents, it is desirable that experiments should be made on this subject with great care." The three types of experiments described by Maxwell (Barnett effect, Einstein and DeHass effect, and Tolman-Stewart effect) were originally attempted in Maxwell's time but the instrumentation was not good enough to detect the effects and it was assumed that no inertial masses were associated with the moving charges (electrons). All three effects have since been observed and we now know that electrons do have nonzero mass. However, the equations have never been modified to accommodate these findings. In general the kinetic energy arising from the motion of the conducting electrons is taken as an additional linear term to the magnetic energy of the current and it is small enough to be ignored at low currents and velocities. This is, of course, inconsistent with the current view of the mass of particles coming from their electromagnetic nature. (For example consider pair production.) The existence of EM-related inertial effects of electrons in conductors shows that the conduction current has true momentum equal to the product of the motional electron mass and their mean velocity.

The electro-kinetic energy of a current is

$$\left(\tfrac{1}{2}\right)m_o v^2 = \left(\tfrac{1}{2}\right)L i^2 \tag{286}$$

where L is the inductance and i the current. But this is true only if the mean velocity of the charges is small compared to the speed of light. Cullwick has shown (p. 253 of ref. 47) departures from equation 286 are expected in highly inductive circuits with high currents. The energy becomes instead

$$T = \left(m - m/\beta\right)c^2 \ \sim \ \beta m_o c^2 (\beta - 1) \tag{287}$$

as $v \sim c$ and m is the electromagnetic mass of the total effective conduction charge, β the relativistic factor and m/β the rest mass of the conduction charge. Cullwick develops the following group of equations for differing current values compared to the self e.m.f., α:

$$i \ll \alpha \quad v = i\sqrt{\frac{L}{M_o}} \quad T = \left(\tfrac{1}{2}\right)Li^2 \quad E = -L\frac{di}{dt}$$

$$i = 0 \quad v = c/\sqrt{2} \quad T = 0.586Li^2 \quad E = -1.293L\frac{di}{dt} \tag{288}$$

$$i > \alpha \quad v \approx c \quad T \approx Li^2 \quad E \approx -2L\frac{di}{dt}.$$

For a toroidal coil 10 cm radius of $8\pi \times 10^{-4}$ henries, the current α is about 85 amperes. Cullwick has postulated that electromagnetic field theory may become nonlinear in the case of very intense field. This involves a nonlinearity between E and D and also between H and B in free space in the case of very intense fields.

Milne (12) approaches the problem from a different direction. He develops EM theory from relativistic considerations and from some additional philosophical view points. He points out that "it is impossible to use a moving test charge to measure a magnetic field without its own velocity, relative to the velocities of other charges present in the field, bringing into apparent existence additional currents." He then develops EM consistent with the magnetic field of the test particle's velocity. At first one may say this is not required because the test charge can be made to have an arbitrarily small charge. But this is not consistent with quantum mechanics and the known quanitization of charge. It is very satisfying to notice that the potentials that Milne derives from this approach are similar to those of the neo-columbic potentials obtained in William's dynamic theory. In fact these are the only two theories known to the author that have the constant r in the exponential.

Hooper (46) has approached the problem from a experimental viewpoint. He assigns a difference to electric fields generated by differing methods. The specific field we are interested in this report is called the "motional" electric field to differentiate it from other types. He goes to special lengths to differentiate the motional electric field arising from

$$\mathbf{E} = \mathbf{v} \times \mathbf{B} \tag{289}$$

with an induced electric field due to time changing magnetic field

$$\nabla \times E = -\partial B / \partial t \qquad (290)$$

and with static fields related to a stationary electric charge.

To understand Hooper's analysis, consider the Lorentz force from

$$E = v \times B \qquad (291)$$

which Hooper interpreted as E_m, the induced motional electric field. He claimed to have experimentally verified that this field was different from other electric fields and that it was akin to gravitational fields. Unlike electro-static fields this force acts in line with the electric field. One important result is that for a total system the super position of all B fields can be zero but the motional electric field can still be nonzero.

For example, consider a long conductor folded back on itself at its center labeled as b. The current then flows from one end, a, to the center, b, and then finally reaches the other end, c. The magnetic field from the current flow from a to b is B , and from b to c is -B. They must be equal and opposite since each has the same current flow (but in opposite directions). Likewise the velocity of the electric charges must also be equal and opposite. If the B field is calculated from the sum of the parts then its magnitude goes to zero.

If, on the other hand, it is calculated from the superposition of E fields then it sums to a nonzero quantity. It can be argued that either the assumption of superposition of the B field (and hence separability of force fields) is incorrect or Hooper's concept of a motional electric field is correct. Hopper concluded that the magnetic field (associated with currents) moves with the charge carriers within the current. This is consistent with Ampere's law and at variance with the Biot-Savart law.

Hooper produced two patents (U.S. 3,610,971 and 3,656,013) in which he claims to have produced gravitational-like fields from the motional electric field from v x B . The first suggests the use of superconductive materials to obtain large drift velocities (10^{12} times larger than normal conductors). In the second, he rotates magnets about their magnetic axis to generate the effect. He claimed to have conducted a wide range of experiments that verified his interpretation of the theory.

One experiment is especially interesting and it may have implications in the area of propulsion. It is also a very workable design that allows for simple verification of the effect. The description here is based on Hooper's patent (Figures 4. and 6 of patent #3,610,971). A long conductor is folded at its midpoint. It is then coiled in a "pancake" winding so that the resulting coil is noninductive. The following is taken directly from that patent. Hooper's patent Figures 2 through 6 are reproduced here as Figure 2.

It is desirable to have an apparatus with which to experimentally study gravitational and antigravitational phenomena under steady continuous conditions. In Figure 4 of the drawings is shown another modification of the device shown in Figure 2. Here I utilize a noninductive coil wound in the form of a solid, low, thick walled, hollow, right circular cylinder, and indicated generally by numeral 60. DC current is supplied through lines 62 to the coil 60. In the region directly beneath this coil disk 60 I place a similarly shaped nonferrous disk 64, suspended by a carrier 66 to the end of a beam 68. The beam 68 is pivotal about a fulcrum 70 and is counterbalanced by a load 72. For positions of disk 64 below coil 60, the B x v field can only be directed vertically upward when a continuous DC current is flowing in the wires composing the disk 60. It should be noted that this field is practically uniform and parallel close to the disk, hence it is not attractive in its action on neutral matter. Its action on such matter can only change the state of electrical polarization in the matter. Any change thus effected in the state of polarization should cause the earth's gravitational field to act less intensely, on any object placed close to the under surface of the device, causing it to weigh less, become weightless, or to actually be accelerated upward by the antigravitational action of the earth's field.

Figure 5 of the drawings illustrates the manner in which the noninductive device in Figure 2 is wound with wire 22, by turning the linear conductors back on themselves through a 180° turn. Figure 6 illustrates the way the noninductive windings of the device illustrated in Figure 4 is achieved. One very long insulated wire is simply turned back on itself at its midpoint and wound double into a solid coil held together in the shape illustrated (44).

FIG. 2

D.C CURRENT SOURCE — 20

22

16 — LINEAR CONDUCTORS

POLYSTYRENE INSULATION

28 — ELECTROMETER

18

34

32

26ᵃ

30

24

26ᵇ

26

FIG. 3

48

46

44

50

42

A

52 — D.C. CURRENT

40

FIG. 4

60

62

FIG. 5

68

66

70

72

60

62

64
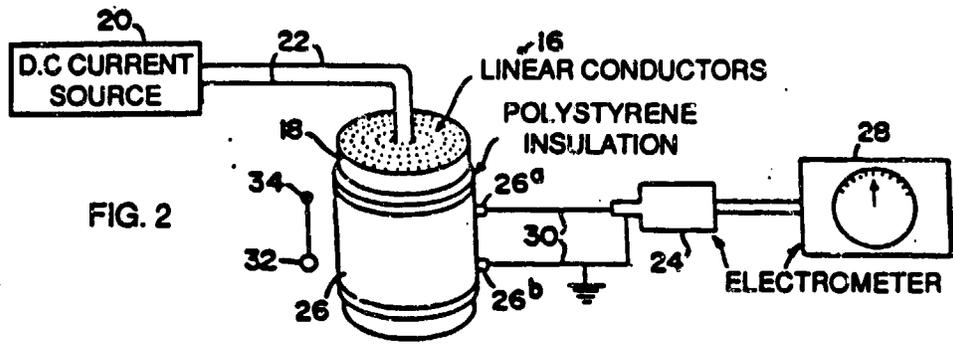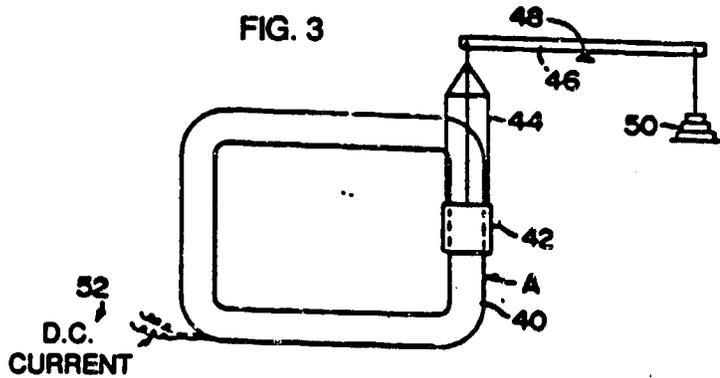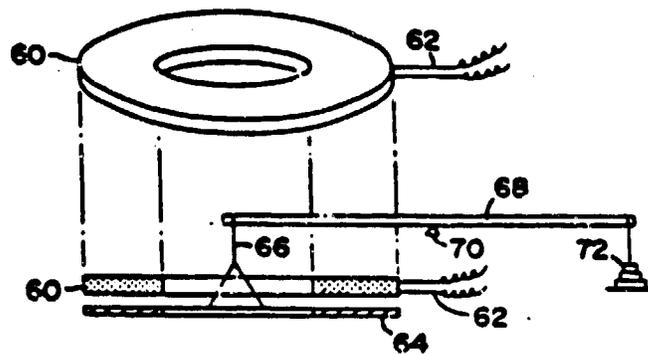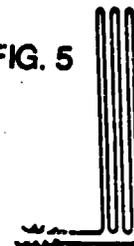
FIG. 6

United States Patent   [11] 3,610,971

Figure 2. Hooper's Patent Figures

-99-

This forms the basis for a recommended experiment. The disk (#64) should be replaceable so that an array of materials could be tried. The coil itself should be of a highly conductive material so that large currents can be used (preferable superconductive for large drift velocities). A high current power supply is required.

Experimentally it is recommended that the gravitational attraction of the suspended disk (#64) be studied as a function of:

1) number of noninductive loop turns,
2) the current through the loop,
3) the mass of the disk,
4) the dielectric constant of the disk,
5) the polarizability of the disk,
6) the drift velocity of the conductors in the loop, and
7) the electric shielding of the disk.

The theoretical rational is very weak but one should recall similar effects may be reached from the study of inertial effect of the current carrier in Cullwick's work, from the magnetic effects of the test particles in Milne's work, from the study of Ampere's equation in Graneau's work, and others. Although the concept is at variance with many established interpretations of EM it is not at variance with any well established experimental evidence. This is a relatively straightforward experiment with few inherent complications. Further, it has been claimed by Hooper and others that gravitational and antigravitational forces have been witnessed in the functioning of the device.

RECOMMENDATION - It is recommended the experiment patterned upon Hooper's patent be reconsidered if some future experimental results are found to be credible.

3.8 EM TRANSPARENCY OF CONDUCTIVE MEDIA

The S-D Dynamic Theory predicts certain frequencies can pass freely through a conductive media without attenuation. This is not admitted by classical theories. Although it is doubtful if such an effect could lead to a propulsion system, it could be very useful for communications during nuclear blasts and reentry blackouts. This can be verified in a practical experiment. The theoretical development appears in Appendix C.

For some frequencies satisfying the conditions set forth in Appendix C, the gravitational or the magnetic component respectively will experience no attenuation. These conditions result in fifth order polynomials in frequency. In some regions the gravitational and/or the magnetic component will experience an amplitude growth. At some frequencies there is growth in the gravitational and/or magnetic component at the expense of the electric component. For this type of transmission the energy originally in the electric component experiences an attenuation and is transferred to the gravitational and/or the magnetic components which experience a gain. The net result is the transmission of energy through the media without loss, only a change in form.

This lends itself easily to experimental verification. Suppose a frequency generator and antenna is located within a superconductive box. Classically there could be no transmission out at any frequency. If the frequency is scanned and there does exist a frequency (or frequencies) related by the 5-D expressions which escapes detection then it would indicate the validity of the approach.

RECOMMENDATION - Locating such effects could be useful in such applications, as transmissions to submarines, and in communications during nuclear blasts and satellite reentry. The experiment is very practical but it is not recommended for AFAL due to its lack of propulsive prospects. It is, nevertheless, a simple uncomplicated experiment.

3.9 MAGNETIC LOOP

It is reported that the basic principle of magnetic propulsion was at one time considered by the USAF as described in AFRPL-TR-72-31. The concept may warrant re-evaluation due to advances in ceramic superconductivity. Very large single turns of low fields should be considered instead of multi-turn loops of high intensity. During searches of electromagnetic propulsion concepts, a very interesting patent (1963 U.S. 3,504,868) was found which provides a way to make orbital maneuvers without the expenditure of fuel (49). The method basically uses reaction forces between the inhomogeneous magnetic field of the earth and that of a superconductive loop carried by a spacecraft. The concept seems reasonable.

The concept was to use reaction forces of magnetic fields to supply the impulse to an orbiting spacecraft at no loss of mass by the spacecraft. The concept appears to be valid and may give very significant savings in upper stage weight for specialized uses, since no propellant weight need be required. The concept does not require advanced field theories and can be understood in classical terms.

Basically it uses a large superconductive coil external to the spacecraft to react with the earth's magnetic field. Engelberger has calculated a 0.08 g force can be obtained by a single loop of niobium tin wire at 4000 A in a polar orbit of 200 km (This was calculated for a single loop of 10 km radius and a wire radius of 2 mm). This would not be large but understand that the force is applied over extended time and does not require the expulsion of any fuel. It does, however, require a power source.

The concept appears to be practical with existing materials and devices and does not require extensive development. It is likely to be usable only for very slow orbital changes. However, it may be a practical device for LEO to space station moves involving large masses. The exact translational force F on a loop has been calculated by Engelberger as function of various orbital angles with respect to the earth's magnetic field:

$$F = \frac{5 \times 10^{-11} NIA}{\left(\frac{r}{r_o}\right)^4} \left\{ -r \cos\beta \cos\alpha + \left(\frac{1}{2}\right) \sin\beta \sin\alpha + \Theta\left[\left(\frac{1}{3}\right) \cos\beta \sin\alpha + \left(\frac{1}{6}\right) \sin\beta \sin\alpha\right] \right\} \tag{292}$$

where N is the number of turns in the loop. I is the current in the loop in amperes and A is the area of the loop in square meters, r is the orbital radius and r_0 the radius of the earth. The orbital angle alpha represents the angle between the magnetic north pole of the earth and the radius vector to the craft. The angle beta is the angle between the radius vector and the normal to the current carrying loop. The current to the loop is switched each quarter of an orbit (at the poles and equator).

A typical application would be the maneuvering of surveillance satellites in polar orbits. Since there is no expenditure of fuels, it would greatly enhance their maneuvering life expectancy. The concept is limited in that it cannot act in an orbit along the magnetic equator and works most efficiently in polar orbits. However, it can maneuver into (not out of) equatorial orbits. As a result, to go from LEO to GEO, it would be necessary to maneuver from a low polar orbit into a high polar orbit then maneuver to GEO. But if weight and not time was critical it could be done.

Engelberger makes several practical suggestions regarding design. First a single large loop is better than many small loops. This minimizes the hoop stresses which tend to expand the loops. For multi-turn solenoids the intense magnetic fields would create large hoop stresses and forces between adjacent turns. Instead a single loop is proposed. The hoop stress on the large single

loop now serves to form a long flexible current bearing wire into a circular shape. He suggests, further, that the superconductor be sleeved within an inflatable tube to reduce temperature fluctuation and serve as a sun shield. The cooling of the loop could be achieved by placing the superconductive material within a concentric tubular layer of conductive material such as bismuth telluride. Cooling can then be achieved by the Peltier effect. With proper materials the cooling material can also serve the role as a mechanical member to resist the induced hoop stresses. It should also be noticed that electrical switching of the current is required. The work being done to the spacecraft is extracted from the current flow within the superconductor. This could be supplied at switching times.

RECOMMENDATION - This approach is not within the framework of inductive coupling and is entirely classical in nature. However, due to its potential and the recent developments in superconductivity it is recommended that a complete analysis of Engelberger's method be undertaken. This should include materials cooling requirements, hoop stresses, mission applications, and use of stress bearing members.

3.10 SPEED OF LIGHT IN A MASS FLOW

Within 5-D theories, the speed of light varies due to a flow of mass density. This is an interesting event but the experiment does not seem practical due to the extreme mass flows that are required and the complexities of other factors. The experiment does not seem to have any direct application to propulsion methods.

In 5-D theories that do not force the cylinder condition, the phase velocity of light is dependent on terms in the fifth coordinates. One of the simplest ways to see this is from analogy to 4D. The 5-D path interval is

$$ds^2 = dt^2 + d\gamma^2 - c^2(dx^2 + dy^2 + dz^2)$$

(293)

which can be rearranged to give for a 5-D geodetic path

$$d\lambda^2 = d\tau^2\left(1 - c^{-2}v^2 + v_4^2\right)$$

(294)

If the velocity is real then

$$v^2 \leq c^2\left(1 + v_4^2\right),$$

(295)

where v is the phase velocity of light in 5-space, c is the velocity of light in free space, and v_4 is the time rate of change of the fifth coordinate. The phase velocity seen in a laboratory 3-space is

$$\omega/k = c\left\{1 - \omega_4^2 / c^2 k^2\right\}^{\frac{1}{2}} \leq c$$

(296)

and the corresponding group velocity is

$$\frac{d\omega}{dk} = c\left\{\frac{k}{\sqrt{k^2 - \omega_4^2 c^{-2}}}\right\} \geq c.$$

(297)

The thing to notice here is that the velocity is dependent on the divergence of the fifth coordinate. If this is taken as mass-density, as in Williams work, or if it is taken as charge density it may be possible to construct an experimental verification. The velocity of light would experience a change in proportion to a divergent flow of mass. The difficulty of the approach is that an extremely large mass flow would be required to observe any effects. An explosive blast could be utilized but no good models exist that would allow separating the effect above and uncertainties in the refractive indexes and other effects.

If the concept is correct then it might be possible to check for these effects at the limb of the sun during a solar flare. Since the effect is dependent on frequency, a signal on two frequencies could be made to pass through a solar flare. This, however, would be complicated and involves being at the right place and time when the event happened.

If on the other hand, the fifth coordinate is related more to charge density, charge to mass ratios, etc. then other possible experiments could be developed. For example an interferometer experiment could use a path where the electric field is time varying and divergent. A phase locked loop could be used to correlate the fringe changes with the divergent fields.

RECOMMENDATION - This experimental approach is not recommended. It would not give clean and unequivocal results. How this could lead to a propulsive system is presently unclear. The

differences between phase and group velocities is, however, interesting and may be of concern in sending signals through large divergent flows (i.e., nuclear blasts).

3.11 CHARGED TORQUE PENDULUM

Erwin Saxl (50) claimed to have modified the period of a torque pendulum by placing it inside an electrical cage and raising the electric potential of the pendulum and connected cage. The change of the period was cited at near 0.2% at a potential of 5 kV. This would seem to indicate a coupling between inertia and electromagnetism. It is not recommended that this experimental approach be followed. An effect of this nature could not have escaped notice by experimentalists.

In the early 1960's, Erwin Saxl conducted a series of experiments which seemed to illustrate a nonzero coupling between EM and gravitational fields. He constructed a delicate torque pendulum consisting of a disk suspended from a wire. The device was held at constant temperature and the period of the pendulum was studied by a photogate as both the pendulum and casing were charged. He observed a change in the period proportional to the square of the applied voltage (with a small negative bias to the curve). The effect was studied by Saxl for 10 years. He concluded that it was a dynamic effect and it occurred with a vertical torque pendulum but it did not occur with a conventional pendulum.

He measured changes to periods on the order of 0.1 sec out of approximately 35 sec. His work and patent are written in a style that sounds detailed and precise and suggests that he was a careful experimenter. There is the possibility that eddy currents or other factors are at work here, but it is not easy to see how they could have entered into this careful experiment.

With present day equipment this experiment could be done with reasonable ease. The construction of Saxl's device is covered in detail in his patent. The experiment seems very straightforward. If the effect is real then it should be simple to place two timepieces in identical chambers and check their deviations compared to each other as a function of their relative potentials. This would allow for a cumulative effect and be easier to detect. This procedure could be carried out on several kinds of timing systems, including torque pendulums, swinging pendulums, quartz timing, etc. Only in systems using inertial based methods of timekeeping would Saxl's claimed effect be seen. The usual controls should be followed including exchanging positions of clocks, seismic isolation, exchanging the roles of potentials and grounds, etc.

If Saxl's observations were correct, then a change of 0.3% (0.1 sec out of 35 sec) at 5 kV should be readily seen once a suitable torque pendulum time piece was located or produced. To quantify the eddy current effects, one would need to supply an external coil to impose a magnetic field. Effects could be measured as a function of the external field and any eddy effects could be subtracted.

Within the Dynamic Theory the gravitational field is expressed as

$$V = \left(\frac{-9.8 \quad volt \cdot coulomb}{m \cdot kg} \right) \tag{298}$$

which also can be expressed as a electric potential through the conversion factor

$$\beta = \sqrt{\varepsilon_o G} = 2.4 \times 10^{-11} coulomb / kg . \tag{299}$$

This conversion factor can be obtained by equating gravitational and electrostatic forces

$$F_g = K_g \frac{m_1 m_2}{r^2} \text{ and } F_e = K_e \frac{q_1 q_2}{r^2} . \tag{300}$$

This is based on separate assumptions but appears to be correct. (There could be a dimensionless coupling constant involved.) With this in mind, the gravitational field of the earth is

$$V = \frac{-9.8 volt \cdot coulomb}{m \cdot kg} \frac{1}{\beta} = -4 \times 10^{11} volts / m . \tag{301}$$

This is an exceptionally high figure and if correct it is difficult to see how any conventional EM process could ever achieve such field intensities to overcome gravity. The important point here is that since a gravitational field can induce red shift and "clock times" then electromagnetic fields can also be expected to generate red shifts due to the interchange of fields through the coupling constant. The effect of the change in the torque pendulum's period due to electric potential is admitted by the theory. It is the magnitude that calls to question the experiment or the theoretical interpretation of the conversion constant.

RECOMMENDATION - It is very unlikely that this is a real phenomenon. It is hard to believe that such a thing could go unnoticed for such a time. It is recommended that no action be taken at this time.

3.12 THERMOELECTRIC/GRAVITATIONAL EFFECTS

This area was discussed in the theoretical section. Unified theories predict that a potential between thermocouple junctions develop in the presence of a gravitational field. The effect would be exceedingly small and it is doubtful if the effect would be worth the effort of preparation. There does not seem to be any propulsive possibilities for such an effect.

RECOMMENDATION - It is recommended that no action be taken on this approach.

3.13 BINARY PULSAR

As discussed in Section 2.3.5, a binary pulsar is expected to be accelerated along the direction of the major axis of revolution. This effect is approximately proportional to the eccentricity of the orbits. Presently all observed binary pulsars seem to have nearly equal mass for their component parts. As a result, their orbits are nearly circular.

RECOMMENDATION - No action is recommended until astronomical observations display binary pulsars with suitably eccentric orbits. At such time the binary system should be monitored for any long term accelerations.

3.14 PROTON SCATTERING

The shape of the potential is relevant to the exact physical model employed. As was seen in Table 1 of the theoretical section, several potential functions are proposed. Unfortunately the effects only appear at distances of 10^{-34} cm. This requires exceptionally high energies.

RECOMMENDATION - Due to the excessive cost and remote likelihood of success it is not recommended that such studies be pursued for the sole purpose of verifying the nonzero coupling terms.

3.15 INERTIAL MASS VARIATION

Thyseen-Bornemisza and Groten of W. Germany (51) have proposed a very practical experiment. They propose to suspend a cylinder shaped mass from a torsion fiber. The period of oscillation for the torsional system is measured for two cases. First with nothing in the adjacent area. Then, secondly, with a large massive concentric layer of mercury located around the torsional system. This would furnish information on any mass induced inertial effect. This is an extremely interesting and theoretically satisfying experiment. It would furnish information on the Mach principle that has long been at the base of many theoretical developments. The effect would no doubt be small and very large masses would be required. Although it does not lead directly to a propulsive system, it would be a rewarding study for someone to do.

RECOMMENDATION - No AFAL action is suggested at this time. However, the Mach principle plays an extremely fundamental role in unification studies. Should an experiment by external agencies be done with positive results, then this area should be reconsidered.

3.16 AN IMPROPER EXPERIMENT

This is a discussion of an incorrectly developed experiment that was often found to be proposed as a nonconservation of momentum approach. It has its roots in the momentum imparted to the EM field which must ultimately be traced to the interaction of charged particles making up the device. This is an example that appeared many times but is not a valid approach. It is included here to avoid unnecessary detours by future investigators. The explanation hinges on the difference between energy and momentum and their relationships within a relativistic approach.

Although the effect was seen in many different guises it is best shown by a simple thought experiment. Suppose a point charge is outside an infinitely long solenoid with constant current at a distant d from the solenoid's axis. Since it is infinitely long there is no B field external to the solenoid in free space. Now if we change the current so that the flux through to coil changes then

the E field in the Ψ direction is given by $E_\Psi = -\left(\frac{\phi}{2\pi}\right)dc$. A force will act on the charge but there will not be a corresponding force on the solenoid. If we prepared a system of both the solenoid, charge and a method to vary the E field then the charge would be set in motion and the center of mass of the system could be set in motion without any external forces. It can be seen, however, from general relativistic theories that this is impossible and thus a paradox is produced.

Apart from the fact that an infinitely long solenoid is impossible and that end effects must be considered there are other resolutions to the general experiment. Here are two such resolutions. First, the thought experiment assumed that the charge exerts no force on the solenoid. This was tacitly assumed and is correct only if an infinitesimally small element of the current carrying wire was neutral. This neutrality at first seems most reasonable since a model of current is electrons of a given charge density flowing in a uniform background of positive charge of the same density. But relativity theory modifies this conclusion and predicts that the current density of the electrons in motion will be slightly different from the density when the electrons are at rest. This comes about because the charge density is defined as the quantity of charge per volume. The volume undergoes a Lorentz contraction but the charge is an invariant. In short, the relativistic theory predicts that the charge density of the flowing electrons will not exactly compensate for positive background charge density. In a local region the wire of the solenoid will appear charged even though the entire solenoid is uncharged as a whole. This local imbalance of charge density turns out to be proportional to $(v/c)^2$. Since the solenoid is locally charged an external point charge will exert forces on the wire of the solenoid and will generate a net force on the solenoid.

A second approach to the paradox is to make a more precise calculation of the force on each volume element of the wire. To accomplish this we must take the force on each electron and then average it over the volume. In relativistic mechanics the equations of motion for an electron involve both velocity terms and the rest mass. The time rate of change of momentum is

$$F = \frac{d}{dt} \frac{m_0}{\sqrt{1 - v^2/c^2}} .$$

(302)

This gives terms on the order of $(v/c)^2$ which can be shown to exactly correct the force to retain the center of mass of the system.

In general, many methods have been proposed to circumvent conservation of momentum by the center of mass but most fall prey to omission of relativistic effects. Clearly, unless some nonzero coupling between gravitational forces and other forces occurs then conservation of momentum must hold.

CHAPTER 4
CONCLUSIONS AND RECOMMENDATIONS

Five dimensional approaches to the unification of fields have a long and rich history. Unfortunately the theories have not been studied from an experimental viewpoint. Instead theorists have relied more on their physical intuition than experimental results to guide their developments. Attention to this area is long overdue and experimental study should be directed at establishing the creditability of various theories.

It is recommended that serious attention be paid to supporting experimental work that is directed at unification efforts. The subatomic particle studies have received a great deal of attention in recent years. However, very few, if any, experiments have been designed to study gravitational and inertial effects. This is regrettable since most results leading to practical engineering solutions will likely come from electromagnetism and gravitational effects instead of weak and strong nuclear effects.

It is recommended that policies and plans take into consideration long time studies in the area of gravity and inertia. These areas deserve more emphasis. This is likely to be more important than any single experimental program. Since chemical propulsion is reaching its theoretical limits and nuclear propulsion has political difficulties, it is more likely that gravitational and electromagnetic studies will lead to future breakthroughs than any nuclear force studies (with the possible exception of more recent low temperature fusion work).

Verification of the theoretical 5-D approach is best accomplished by re-examination and duplication of the Nichols-Hull experiment. This would be an important study for verification and for the study of classical effects. The costs are low for this type of approach. All of the required equipment is commonly found in optical laboratories. It is recommended that the program become part of existing research in the area of solar radiation studies or laser beam power studies. This is an important feature of the approach, since direct funding of a theoretical prediction is often difficult. The problem with the approach is that it will not directly produce a propulsion system.

The Biefield-Brown approach is best suited for experimental work which would lead directly to a propulsion system. This area is now being investigated by two independent groups. The study of a charging capacitor (by Woodward) rests on firmer theoretical support. This report specifically recommends that time varying (and not static) energy densities be studied. The fast switching times of capacitors achieve greater changes in energy densities than most other

processes. This should be the prime concern of any experimental design. The theoretical predictions indicate that the effect is proportional to the first or second derivative of the energy (or mass) density with respect to time. The most important development would be the verification of a nonzero second order term. This would alow for rapid and practical expansion of technology by the use of high frequency alternating currents.

Los Alamos and Lawrence Livermore labs are reportedly engaged in studies of high power density devices related to SDI research. Unfortunately this area appears classified and not accessible for this report. Any study involved in verifying 5-D work through the Biefield-Brown effect should seek to find the highest energy density changes available in capacitor systems. Woodward is using barium titanates from Sprague. This report has identified some specialized proprietary plastics by Pennwalt within which exceptionally high energy density capacitors could be made.

Specifically, this report recommends that the charging capacitor approach be taken and that it should be modified to provide:

1) a materials search for the highest energy density materials available for capacitor fabrication,
2) seismic isolation,
3) improved sensors, and
4) shortest switching time consistent with sensors.

Both the radiation pressure studies and the charging capacitor studies are extremely practical and feasible. The other approaches reviewed did not seem to warrant near-term support for the sole purpose of theory verification. Any AFAL support for such studies should wait until some new experimental evidence is produced by external researchers, likely in the form of scientific journal publications. The conductive submarine and spin aligned nuclei work are nearing the stage where there may be new evidence to consider. The noninductive coil approaches have a large following with independent inventors. As superconductive materials become readily available there could conceivably be some new work available. This is a long shot but it should be kept in mind as one searches for evidence of nonzero coupling.

The magnetic field propulsion device (by Engelberger) does not lead to verification of the 5-D theories. It does warrant reinvestigation in light of current superconductor advances. It is extremely practical and is suitable for shuttle "get-away-specials." Likewise, the Nuclear Resonant method of Paul Brown does not have the potential of 5-D verification but could become useful as a power source.

APPENDIX A
TENSOR SYMBOLS AND NOTATION

Coordinate base tensor symbolism was selected for this report. This seemed to be the best for understanding the role of any newly added dimension. The numbering system for the coordinate system is:

x^0	time
x^1, x^2, x^3	space, and
x^4	the added coordinate (mass density).

(Notice that for tensors the superscript denotes an index and not a power.) This report takes the view that five unit vectors (and derivatives) along these coordinates are all that is required to fully denote any physical event or object. For a physical law to exist throughout the universe then it must be possible to express it in general tensor form using these five coordinates.

In this appendix we will first briefly review the major points in tensor symbolism. For the best review of the notation and its operation the reader is referred to Dirac's General Theory of Relativity (26). His notation is entirely compatible with this 5-D theory. After reviewing the general notation, several points will be made which are specific to this report.

BRIEF REVIEW OF TENSOR NOTATION

1)   A contravariant vector is written as A^μ .

2)   A covariant vector is written as A_μ .

3) dx^μ is often written dx_μ but be careful to recall it is actually a contravariant vector. It appears to be the only time where a subscript is thought of as a contravariant instead of a covariant vector.

4)   The summation convention is: if a literal suffix is repeated in a term then that term is to be summed for values of that suffix (usually 0, 1, 2, 3, 4). For example:

$$ds^2 = g_{\mu\nu}dx_\mu dx_\nu \tag{A1}$$

means

$$ds^2 = \sum_{\mu=0}^{4} \sum_{\nu=0}^{4} g_{\mu\nu}dx_\mu dx_\nu \tag{A2}$$

or more specifically

$$ds^2 = \sum_{\mu=0}^{4} \sum_{\nu=0}^{4} g_{\mu\nu}dx^\mu dx^\nu \ . \tag{A3}$$

5) Any suffix that is repeated twice within a term is a "dummy suffix" and can be replaced freely. For example:

$$A_\alpha^{\alpha\mu} = A_\beta^{\beta\mu} \ . \tag{A4}$$

6) Coordinates are to be chosen as independent. For example:

$$\frac{dx_\mu}{dx_\nu} = 0 \text{ if } \mu \neq \nu$$

$$\frac{dx_\mu}{dx_\nu} = 1 \text{ if } \mu = \nu \ . \tag{A5}$$

7) Laws of Transformation are given by

$$A^\nu = g^{\mu\nu}A_\mu \qquad \text{(contravariants)}$$

and $\quad A_\mu = g_{\mu\nu}A^\nu \qquad$ (covariants).

8) The inner product (scalar product) is expressed as

$$A_\mu B^\mu \ . \tag{A6}$$

9) The outer product (vector product) is expressed as

$$A_\mu B^\nu .$$
(A7)

10)   Invariants are independent of the coordinate systems and are tensors of zero rank. For example:

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu .$$
(A8)

11)   Raising, lowering and substituting can be achieved by:

multiplication by $g^{\mu\nu}$ to give substitution with raising,

multiplication of g_μ^ν for substitution, or

multiplication of $g_{\mu\nu}$ for substitution with lowering.

12)   Vectors are perpendicular (orthogonal) if

$$A_\mu B^\mu = 0 .$$
(A9)

13)   Length, ℓ , of a vector is given by

$$\ell^2 = A_\mu A^\mu .$$
(A10)

14)   A vector can be perpendicular to itself if it is along a null path since $ds^2 = 0$ along such a path.

15)   Small displacements leave vectors unaltered to first order. To wit

$$(\ell + d\ell)^2 = \left(A_\mu + dA_\mu\right)\left(A^\mu + dA^\mu\right)$$
$$(\ell + d\ell)^2 = A_\mu A^\mu + A^\mu dA_\mu + A_\mu dA^\mu$$
$$(\ell + d\ell)^2 = \ell^2 + 2A_\mu dA^\mu$$
(A11)

and it may be represented by

$$dA_\mu = K - A .$$
(A12)

16) The direction cosine can be determined by the inner product where Θ is the angle between the vectors

$$\cos\Theta = \frac{A_\mu B^\mu}{\sqrt{\left(A_\alpha A^\alpha\right)\left(B_\beta B^\beta\right)}} .$$

(A13)

17) Simple derivatives are written with a comma as

$$\frac{\partial A}{\partial X^\mu} = A_{,\mu} .$$

(A14)

18) Christoffel symbols of the first kind are defined as

$$\Gamma_{\mu\nu\sigma} + \left[\mu\nu,\sigma\right] = \left(\tfrac{1}{2}\right)\left(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu}\right) .$$

(A15)

For example:

$$\Gamma_{\mu\nu\sigma} + \Gamma_{\nu\mu\sigma} = g_{\mu\nu,\sigma} ,$$

(A16)

or for an additional example (from #15)

$$dA_\nu = A^\mu \Gamma_{\mu\nu\sigma} dx^\sigma .$$

(A17)

19) Christoffel symbols of the second kind are defined as

$$\Gamma_{\nu\sigma}^\mu = \left\{\mu\nu,\sigma\right\} = \left(\tfrac{1}{2}\right)g^{\sigma\lambda}\left(g_{\mu\lambda,\nu} + g_{\nu\lambda,\mu} - g_{\mu\nu,\lambda}\right)$$

(A18)

$$\Gamma_{\nu\sigma}^\mu = \left\{\mu\nu,\sigma\right\} = g^{\sigma\lambda}\Gamma_{\mu\nu\sigma} .$$

20) Geodesics will be of fundamental importance to development of the theory. They have the properties which allow

$$\int ds \qquad\qquad \text{to be stationary.}$$

This means that the track given by $\int ds$ does not change drastically as the end points are changed only slightly,

$$ds^2 = g_{\mu\nu}dx^\mu dx^\nu .$$

(A19)

It can also be written as

$$\frac{d^2x^\alpha}{ds^2} = \Gamma_{\mu\nu}^\alpha \frac{dx^\mu}{ds}\frac{dx^\nu}{ds} = 0 .$$

(A20)

This is the equation of a geodesic and we can see that it is a natural result from requiring that $\delta\int ds = 0$. This will appear in many cases where we set the 5-D interval as stationary.

21)   Covariant differentiation is a somewhat special process in which care must be shown so as to retain tensor properties of the results. This is often a common cause of difficulties as it is sometimes easy to get into the habit of assuming the form of the results of the operations. We will write covariant differentiation by the use of a semicolon (;) before the suffix (notice we used a comma for an ordinary derivative).

The process can be seen by taking a vector A at a given point x and shifting it by a parallel displacement to point (x + dx). This results in a vector

$$A_\mu(x+dx) - A_\mu(x) = \Gamma_{\mu\nu}^\alpha A_\alpha\, dx^\nu$$

$$A_\mu(x+dx) - A_\mu(x) = \left(A_{\mu,\nu} - \Gamma_{\mu\nu}^\alpha A_\alpha\right)dx^\nu$$

(A21)

or

$$A_{\mu;\nu} = A_{\mu,\nu} - \Gamma_{\mu\nu}^\alpha A_\alpha$$

$$A_{;\nu}^\mu = A_{,\nu}^\mu + \Gamma_{\alpha\nu}^\mu A^\alpha .$$

(A22)

This is called the covariant derivative of A_μ. The covariant derivative of a product is then

$$\left(A_\mu B_v\right)_{;\sigma} = A_{\mu;\sigma}B_v + A_\mu B_{v;\sigma}$$

$$\left(A_\mu B_v\right)_{;\sigma} = \left(A_\mu B_v\right)_{,\sigma} + \Gamma^\alpha_{\mu\sigma}A_\alpha B_v - \Gamma^\alpha_{v\sigma}A_\mu B_v \ . \tag{A23}$$

Derivatives of higher order tensors can be given as

$$T_{\mu v;\sigma} = T_{\mu v,\sigma} - \Gamma^\alpha_{\mu\sigma}T_{\alpha v} - \Gamma^\alpha_{v\sigma}T_{\mu\alpha}$$

$$T^v_{\mu;\sigma} = T^v_{\mu;v} - \Gamma^\alpha_{\mu\sigma}T^v_\alpha + \Gamma^v_{\alpha\sigma}T^\alpha_\mu \ . \tag{A24}$$

In general we introduce a Christoffel symbol for each suffix with a + sign for each contravariant (superscript) part and a - sign for each covariant (subscript) part. Also in general the covariant derivative of a product of any tensor quantity is given like a "chain rule." In physical cases we are seeking tensor equations that will work in all coordinate systems. For the equations to remain tensor quantities, we must be careful to use covariant and not ordinary differentiation. In analogy with the d'Alenbert equation we must use the covariant form so

$$\Box \ V = 0 \tag{A25}$$

goes over to

$$g^{\mu v}V_{;\mu;v} = 0 \ . \tag{A26}$$

The confusion that most people run into with covariant differentiation is that covariant differentiation becomes the same as ordinary differentiation for the case of treating the $g_{\mu v}$ as constants. This leads to a tendency to treat the two the same. However, as soon as we move from flat space to varying curvature, we must be sure that all equations use covariant differentiation. In short, the two differentiations are only equivalent in space where the Christoffel symbols are everywhere zero.

22)   An antisymmetric tensor has the property

$$A_{\mu v} = -A_{v\mu} \tag{A27}$$

and since $A_{\mu\mu} = -A_{\mu\mu}$ $\tag{A28}$

then $\quad\quad A_{\mu\mu} = 0$ $\hfill$ (A29)

and the tensor must have a zero trace.

23) Order of covariant differentiation can be important in tensor quantities. If we differentiate a scalar twice then

$$
\begin{aligned}
S_{;\mu;\nu} &= S_{;\mu,\nu} - \Gamma^{\alpha}_{\mu\nu} S_{;\alpha} \\
S_{;\mu;\nu} &= S_{,\mu\nu} - \Gamma^{\alpha}_{\mu\nu} S_{,\alpha} \\
S_{;\mu;\nu} &= S_{,\nu\mu} - \Gamma^{\alpha}_{\nu\mu} S_{,\alpha} .
\end{aligned}
\tag{A31}
$$

This shows that for a scalar the order is not important. For a vector we must use

$$
V_{\nu;\rho;\sigma} = V_{\nu;\rho,\sigma} - \Gamma^{\alpha}_{\nu\sigma} V_{\alpha;\rho} - \Gamma^{\alpha}_{\rho\alpha} V_{\nu;\alpha} ,
\tag{A32}
$$

so by using the same process on $V_{\nu;\sigma;\rho}$ we have

$$
V_{\nu;\rho;\sigma} - V_{\nu;\sigma;\rho} = V_{\beta}\left(\Gamma^{\beta}_{\nu\sigma,\rho} - \Gamma^{\beta}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\beta}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\beta}_{\alpha\sigma} \right) .
\tag{A33}
$$

The second factor on the right side is called the Riemann-Christoffel curvature

$$
R^{\beta}_{\nu\rho\sigma} = \Gamma^{\beta}_{\nu\sigma,\rho} - \Gamma^{\beta}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma} \Gamma^{\beta}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho} \Gamma^{\beta}_{\alpha\sigma}
\tag{A34}
$$

and is antisymmetric in the last two of its suffixes or

$$
R^{\beta}_{\nu\rho\sigma} = -R^{\beta}_{\nu\sigma\rho} .
\tag{A35}
$$

Also we have

$$
R^{\beta}_{\nu\rho\sigma} + R^{\beta}_{\rho\sigma\nu} + R^{\beta}_{\sigma\nu\rho} = 0
\tag{A36}
$$

for cyclic substitutions of its subscripts. It is important to notice that only if the Riemann-Christoffel tensor ("curvature" tensor) vanishes can the order in covariant differentiation be treated

as permutable. Notice also that it can be expressed totally in terms of $g_{\mu\nu}$ and is, therefore, of fundamental importance. In fact $g_{\mu\nu}$ is the only tensor that can be constructed from the metric tensor and its first two derivatives that is linear in the second derivative. When it is contracted it is termed the Ricci tensor

$$R_{\mu\nu} \equiv R^{\alpha}_{\mu\alpha\nu} .\tag{A37}$$

When contracted twice it is called the curvature scalar or total curvature

$$R = g^{\mu\nu} R_{\mu\nu} .\tag{A38}$$

Also notice that

$$V_{\mu;\nu;\rho} - V_{\mu;\rho;\nu} = -V_{\alpha} R^{\alpha}_{\mu\nu\rho} \tag{A39}$$

and for tensors

$$T^{\lambda}_{\mu;\nu;\rho} - T^{\lambda}_{\mu;\rho;\nu} = T^{\alpha}_{\mu} R^{\lambda}_{\sigma\nu\rho} - T^{\lambda}_{\sigma} R^{\sigma}_{\mu\nu\rho} .\tag{A40}$$

Thus, the covariant derivatives commute if the curvature tensor vanishes. This feature is important to quantum mechanics.

DIMENSIONS

The Dynamic Theory specifies mass density as the added coordinate. This fifth coordinate has been chosen by various authors in many ways. The important thing to note is that it must be a function of mass to span the space of physical observable events. Some selections suit various needs and they will be better for specific applications. As long as there is a nonvanishing mass component of the variable, it should be possible to reduce the selection (Gram reduction) to a vector which can span the manifold of all physical reality. Mass density is convenient because it can be utilized readily to obtain thermodynamic relationships. Thermodynamics represents a large corpus of information that is often overlooked (except as an afterthought) by researchers working on unification. Williams has successfully started from thermodynamics and developed a basic relativistic principle. This is a major accomplishment.

COUPLING

Except for some tentative work by Woodward and Williams there is no estimate of the coupling coefficient. When examining the 5-D Poynting expression it appears that the $\mathbf{E} \cdot \dot{\mathbf{E}}$ term is the obvious place to begin experimental studies. Other processes are possible, but the complexity of the theory does not allow for easy calculations. Higher order terms may be possible but those cannot be clearly seen within the Dynamic Theory.

Several symbols have been used to indicate the coupling. The a_o is the notation by Williams and indicates the constant entering the line element. It places the same role as ic in the 4-D line element. The β which appears in Woodward's work is the coefficient to the first derivative term in the Taylor expansion of the gravitational field. Woodward uses both a beta and a beta prime. The difference is because the constant may be material dependent. This is similar to the role played by the dielectric constant and the magnetic susceptibility. This should be kept in mind when working with V which may have a counterpart similar to the pairs - B with H and E with D.

The other coupling factor is that of $\sqrt{\varepsilon_o G}$ and it is indicative of the relationship between the gravitational and electric forces. This is given the symbol β by Williams. Care must be used when speaking of beta since it is different for Williams and Woodward.

APPENDIX B
GRAVITATIONAL ROTOR

It has been suggested that the divergence in the electrical current can give rise to inertial effects. Williams has proposed an experiment (Section 3.5) which would develop torque by imposing a current through two cone-shaped copper conductors joined at the base. The torque developed would be monitored by a laser lever system. It has been calculated by others that the divergence will be offset in this geometry by a convergence elsewhere in the circuit. Although the concept is interesting, it is recommended that the Graneau "sub" type experiment (Section 3.4) would also test this concept and since the parts of the circuits can move, may be immune to some of the uncertainty in the convergence and geometry.

Williams has calculated that a gravitational rotor is possible using the torque developed from divergent current flows (Section 3.5). The charge conservation equation,

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \mathbf{J} + a_0 \frac{\partial J_4}{\partial \gamma} = 0 \tag{B1}$$

represents the prediction that it may be possible to violate one of the most sacred of the conservation principles. The force law is

$$\mathbf{F} = \dot{\rho}\mathbf{E} + J_4 \mathbf{V}/c \tag{B2}$$

so that it is possible to interpret J_4/c as the gravitational mass density. This would require that

$$mg = \int_{vol} J_4/c \quad d(vol) \tag{B3}$$

be the gravitational mass of the distribution of gravitational mass density through the volume. If the electromagnetic effects can create a gravitational mass density, then a new process to control gravitational forces is possible.

First consider only steady state situations such that $\partial \rho/\partial t$ is zero. Then

$$\nabla \cdot \mathbf{J} + a_0 \partial J_4/\partial \gamma = 0. \tag{B4}$$

Then equation B4 would become

$$\vec{J} = \frac{I}{2\pi yt} \quad \cos\Theta\hat{x}. \tag{B5}$$

Now the divergence is given by

$$\nabla \cdot J = \frac{\partial J_x}{\partial x} + \frac{\partial J_y}{\partial y} + \frac{\partial J_z}{\partial z} \tag{B6}$$

$$= \frac{\partial}{\partial v}\left\{\frac{I\cos\Theta}{2\pi gt}\right\} \tag{B7}$$

$$= \frac{-I\cos\Theta}{2\pi ty^2} \quad \frac{\partial y}{\partial x} \tag{B8}$$

but $\quad dy/dx = d/h$, so $\quad h = \cos\Theta\sqrt{d^2+h^2}$ $\qquad$ (B9)

$$\nabla \cdot J = \frac{-I\cos\Theta}{2\pi ty^2}\left(\frac{d}{h}\right) \tag{B10}$$

so $\qquad \partial J_4/\partial\gamma = \frac{-Id}{2\pi t\sqrt{d^2+h^2}a_o}\left(\frac{1}{y^2}\right)$ $\qquad$ (B11)

or $\qquad J_4 = \frac{-Id}{2\pi a_o t\sqrt{d^2+h^2}} \quad \frac{\gamma}{y^2} + (J_4)_o.$ $\qquad$ (B12)

This force is given by

$$F = \left(\frac{J_4}{c}\right)V. \tag{B13}$$

Then at x equal $-x'$ and x', the element of torque on two cones joined at their bases as shown below would be given by

$$d\tau = \left(\frac{J_4}{c} \right)_{at\ -x'} (-V)(-x)dx + \left(\frac{J_4}{c} \right)_{at\ x'} (-V)(x)dx .$$

(B14)

Equation B12 gives us an expression for J_4 at $-x$. Let's look at the expression for y for $x > 0$. Here

$$y = d - \left(\frac{d}{h} \right) x$$

(B15)

where $\qquad y = d$ at $x = 0$, $y = 0$ at $x = h$, and

$$\frac{\partial y}{\partial x} = \frac{-d}{h}$$

(B16)

Since the only difference in the expression for J_4 between $-x$ and x is the sign change in $\frac{\partial x}{\partial y}$, then $J_4(-x) = -J_4(x)$ and our expression for the element of torque at x becomes

$$d\tau = \frac{2J_4(x)}{c} \ |V| x\, dx$$

(B17)

$$= \frac{-2|V| I d\gamma}{2\pi a_o t c \sqrt{d^2 + h^2}} \left(\frac{x}{y^2} \right) dx$$

(B18)

$$= \frac{-|V| I d\gamma}{\pi a_o t c \sqrt{d^2 + h^2}} \ \frac{x\, dx}{\left(d - \left(\frac{d}{h} \right) x \right)^2}$$

(B19)

$$= \frac{-|V| I \gamma h}{\pi a_o t c \sqrt{d^2 + h^2}} \ \frac{x\, dx}{(h - x)^2} .$$

(B20)

Integrating the element of force we find

$$\tau = \int_{x=0}^{x=h-\delta} \left\{ \frac{-|V| I \gamma h}{\pi a_o t c \sqrt{d^2 + h^2}} \right\} \ \frac{x\, dx}{(h - x)^2}$$

(B21)

$$= \left\{\frac{-|V|I\gamma h}{\pi a_o t c\sqrt{d^2+h^2}}\right\}\left\{\log(h-x)+\frac{h}{(h-x)}\right\}_{x=0}^{x=h-\delta} . \tag{B22}$$

The expression for torque becomes

$$\tau = \left\{\frac{-|V|I\gamma h}{\pi a_o t c\sqrt{d^2+h^2}}\right\} \cdot \left\{\log\left(\frac{h-h-\delta}{h}\right)+\frac{h}{(h-h+\delta)}-\frac{h}{h}\right\} . \tag{B23}$$

The gravitational charge density is J_4/c. Thus, the force density is J_4V/c and the force is given by the density times the area, which is

$$area = \pi t(2y-t\cos\Theta). \tag{B24}$$

Since $\cos\Theta = 0$ at x, the element of torque would be given by

$$d\tau = \left(\frac{J_4}{c}\right)V\pi t(2y)(-x)dx - \left(\frac{J_4}{c}\right)V\pi t(2y)x\,dx \tag{B25}$$

$$= -\left(2\frac{J_4}{c}\right)V\pi t(2y)x\,dx . \tag{B26}$$

From equation B12, if $J_4 = 0$, then we may write

$$d\tau = -2\left\{\frac{-Id}{2\pi a_o t c\sqrt{d^2+h^2}}\left(\frac{\gamma}{y^2}\right)\right\} V\pi t(2y)x\,dx \tag{B27}$$

$$= \frac{4IdV\gamma x\,dx}{2a_o c\sqrt{d^2+h^2}y} \tag{B28}$$

$$= \frac{2IV\gamma d}{a_o c\sqrt{d^2+h^2}}\frac{hx\,dx}{d(h+x)} . \tag{B29}$$

Then the element of torque becomes

B-4

$$d\tau = \left\{ \frac{2IV\gamma\cos\Theta}{a_o c} \right\} \frac{x\,dx}{(h+x)}. \tag{B30}$$

Now we need to integrate the element of torque in equation B30 over the range $0 \le x \le h - Dh/d = h(1 - D/d)$. Thus,

$$\tau = \frac{2IV\gamma\cos\Theta}{a_o c} \int_o^{h(1-D/d)} \frac{x\,dx}{h+x} \tag{B31}$$

$$= \frac{2IV\gamma\cos\Theta}{a_o c} \left\{ h\left(1 - D/d\right) + h \quad \log\left(\frac{hd}{h(2d-D)} \right) \right\} \tag{B32}$$

$$= \frac{2hIV\gamma\cos\Theta}{a_o c} \left\{ \frac{d-D}{d} + \log\frac{d}{2d-D} \right\}. \tag{B33}$$

First, it should be noticed that the units of this expression for torque are a little strange if we envision V to be the earth's gravitational field and the torque expression includes the current I. Look back at the force law. In this force law the fields E and V have units of volt/m. If we look at the units of the earth's gravitational field and use the electrical units for joule we would write

$$G = -9.8\left(\frac{volt \cdot coulomb}{m \cdot kg} \right). \tag{B34}$$

From this expression, we see that the earth's gravitational field units are a factor of C/kg away from the desired units. Indeed, this unit problem crops up every time one wants to use predictions from the field equations which involve V. This is as it should be, since the V field is in a system of equations which have units of the electric and magnetic fields.

Using the equation $\beta = \sqrt{\varepsilon G}$ with the earth's known field strength, we find that

$$V = -9.8\left(\frac{volt \cdot coulomb}{m \cdot kg} \right) \frac{1}{\beta} \tag{B35}$$

$$V = \frac{-9.8 \; volt \cdot coulomb \cdot kg}{2.4 \times 10^{11} \quad coulomb \cdot kg \cdot m} \tag{B36}$$

$$V = -4.0 \times 10^{11} \quad volts \, / \, m \, . \tag{B37}$$

We now have the needed expression for determining the torque involved in some particular cones. Suppose we select

$$i = 10 \; ampere, \; h = d = 0.1 \; m, \; \text{and} \; t = 0.001 \; m \, .$$

Using the expression for torque, equation B33, we now have

$$\text{Torque} = \left\{ \frac{-2(10 \; amps)\left(4 \times 10^{11} volt/_m\right)\gamma\left(kg/_{m^3}\right)(0.1m)\cos 45^\circ}{\left(4 \times 10^7 kg/_{m^4}\right)\left(3 \times 10^8 m/_{sec}\right)} \right\}\left\{\frac{0.1 - D}{0.1} + \log\left(\frac{0.1}{0.2 - D}\right)\right\} \tag{B38}$$

$$\text{Torque} = \left\{ \frac{-6.7 \times 10^{-5} \; volt \cdot amp \; \gamma\left(kg/_{m^3}\right)\cos 45^\circ}{\left(kg/_{m^4}\right)\left(m/_{sec}\right)} \right\}\left\{\frac{0.1 - D}{0.1} + \log\left(\frac{0.1}{0.2 - D}\right)\right\} \, . \tag{B39}$$

For the particular device we had in mind, we would use a $D = 0.25$ inch or $D = 6.35 \times 10^{-3} m$. We also wished to use copper as the material so that $\gamma = 8.9 \times 10^3 kg/_{m^3}$. We then have

$$\text{Torque} \quad = \left\{ \frac{(-6.7 \times 10^{-5})(0.707)\left(8.9 \times 10^3 kg/_{m^3}\right)volt \cdot amp}{\left(kg/_{m^4}\right)\left(m/_{sec}\right)} \right\}$$
$$\left\{\frac{0.1 - 6.3 \times 10^{-3}}{0.1} + \log\left(\frac{0.1}{0.2 - 6.3 \times 10^{-3}}\right)\right\} \tag{B40}$$

Torque $\quad = -0.423 \, volt \cdot amp \cdot sec \{0.937 + \log(0.576)\}$ (B41)

$\quad = -0.423 \, volt \cdot coulomb \{0.276\}$. (B42)

Thus, we have

Torque $\quad = -0.117 \, N \cdot m = -0.086 \, ft \cdot lbf$ (B43)

$\quad = 1.03 \, in \cdot lbf$. (B44)

Williams constructed an experimental apparatus using the double cone geometry. Measurements were taken where $h = d = 0.1 \, m$, $t \approx 0.01 \, m$, $D \approx \frac{1}{2}\left(\frac{1}{4} in.\right) = 3.2 \times 10^{-3} \, m$. The cones were of brass with a density of 8.63×10^3 kg/m^3 (slightly less than copper).

The 1/4 inch diameter copper rods were immersed into the mercury for current carrying ability. The density difference between the mercury and copper was used as a balancing torque and as the reference torque for any measured rotation. The rotational torque required to overcome resistance offered by the mercury may be found from looking at the displacement of mercury on the side that the copper rod is forced down by

$$F_{up} = (Area \; of \; rod)(l\Theta)\left[\rho_{H_g} - \rho_{cu}\right].$$ (B45)

On the other side the force downward would be the same magnitude as the force up so that the reference torque is given by

$$\tau_{ref} = 2 \, Area \, l^2 \, \Theta \left[\rho_{H_g} - \rho_{cu}\right].$$ (B46)

However, l is not measured. The longer lever arm L is measured and the shorter lever arm l_2 is measured. Then, if there is a measured displacement in the light, L , the displacement of the rod in the mercury, may be determined since

$$l = \left(\frac{l_1}{l_2}\right) L$$ (B47)

and $\quad\quad \Theta \approx L/L_1$ $\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad$ (B48)

or $\quad\quad \tau_{ref} = 2\, Area \left(\rho_{Hg} - \rho_{Cu} \right) \left(\dfrac{L^2 L_1}{L_2} \right).$ $\quad\quad\quad\quad\quad\quad$ (B49)

$$Torque = \left\{ \frac{2\, I \left(-9.8 \dfrac{volt \cdot coulomb}{m \cdot kg} \right) (0.1 m)(0.707)\left(8.6 \times 10^3 \, kg/m^3 \right)}{a_o \left(3 \times 10^7 \, m/sec \right) \beta \left(coulomb/kg \right)} \right\} \quad\quad (B50)$$

$$\times \left\{ (1 - 0.314) + \log \left(\frac{3.18 \times 10^{-3}}{0.1} \right) \right\}.$$

$$Torque = 4.46 \times 10^6 \quad volt \cdot sec \cdot kg \cdot m^{-4} \left(I/a_o \right). \quad\quad (B51)$$

The current is unspecified because it is the parameter to carry in the experiment. The a_o has been left out because it is virtually an unknown. Indeed, perhaps the experiment would best be considered a measurement of a_o than anything.

If I is in amps and we set

$$a_o \left(kg/m^4 \right) = \alpha A_o = \alpha \left(4 \times 10^7 \, kg/m^4 \right) \quad\quad\quad\quad (B52)$$

then we may obtain the torque expression:

$$Torque = \frac{4.46 \times 10^6 \, volt \cdot amp \cdot sec \, I}{4 \times 10^7 \alpha} = \frac{0.112 \, I \, (in \, amps)(N \cdot m)}{\alpha}. \quad\quad (B53)$$

Now let us turn to the torque of the mercury device.

$$Torque\; ref. = 2\, (Area)\left(\rho_{Hg} - \rho_{Cu} \right) g \left(\frac{L^2 L_1}{L_2} \right). \quad\quad\quad (B54)$$

For our apparatus, area $= \pi\left(\frac{1}{8}in.\right)^2 = \pi\left(3.2 \times 10^{-3}\right)^2 m^2 = 3.17 \times 10^{-5} m^2$.

$$L_2 = 11 \, cm = 0.11 \, m \tag{B55}$$

$$\rho_{Hg} = 13.6 \times 10^3 \, kg/_{m^3} \tag{B56}$$

$$\rho_{Cu} = 8.9 \times 10^3 \, kg/_{m^3} \tag{B57}$$

therefore,

$$\text{Torque ref.} \quad = 241(N \cdot m)(L(m))^2(L_1(m)) . \tag{B58}$$

Now for a given experimental setup the L_1 is known. Let us suppose that $L_1 = 10 \, m$. Then if a_o (or α) were known, the current, I, would be related to the observed displacement of the laser spot, $L(m)$, since Torque = Torque ref, or

$$\frac{0.112 \, I(amps)}{\alpha} = 241(L(m))^2(10) \tag{B59}$$

then
$$\frac{I(amps)}{\alpha} = 2.15 \times 10^4 [L(m)]^2 . \tag{B60}$$

On the other hand the expected displacement, L, would be given by

$$[L(m)]^2 = \frac{4.64 \times 10^{-5} \, I(amps)}{\alpha} \tag{B61}$$

or
$$L(m) = 6.8 \times 10^{-3} \sqrt{\frac{I(amps)}{\alpha}} . \tag{B62}$$

From equation B62, we find that in our experiment with 10 amperes we would have expected a displacement of the laser spot of

$$L = \frac{2.15}{\sqrt{\alpha}}\, cm .\tag{B63}$$

If the estimate of a_o was off such that $\alpha = 100$, then the expected displacement would have been only 2 mm.

APPENDIX C
EM TRANSMISSION THROUGH CONDUCTIVE MEDIA

The 5-D Dynamic Theory predicts that certain frequencies can pass freely through conductive media without attenuation. This is not admitted by classical theories. Although it is doubtful if such an effect could lead to a propulsion system, it could be very useful for communications during nuclear blasts and reentry blackouts. This can be verified in a practical experiment. This development and discussion is taken directly from William's work (13, 14, 15).

Williams has found that the electric component will pass unattenuated (theoretically) if the 5-D analog to conductivity (σ) is zero. This is satisfied by two conditions. The first is that the 4-D σ is zero, the classical condition for a perfect dielectric. The second condition is that a constant appears as the additional component, h, of σ due to the 5-D nature of the wave. Williams has used this additional component to define a constant A by

$$h = \left(\frac{1}{2A}\right). \tag{C1}$$

The 5-D equations cannot be solved in general. However, approximations such as dielectric constants being linear to the fifth component can be made. Williams has calculated from the wave equations, equations 155 to 164, that an E-M wave would be unattenuated if

$$\left(\frac{\mu\varepsilon\omega^2}{A^2}\right)^3 - \left(\frac{\mu\varepsilon\omega^2}{A^2}\right)^2 - \frac{\mu\varepsilon\omega^2}{A^2} - 3 = 0, \tag{C2}$$

which has only one real solution:

$$\mu\varepsilon\omega_c^2 = 1.7971\, A. \tag{C3}$$

The complex solutions are:

$$\mu\varepsilon\omega^2 = (-0.8985 \pm i\, 1.0434)A. \tag{C4}$$

Considering the real solution and assuming A^2 to be real, we find that

$$\omega_c = \sqrt{\frac{1.7971}{\mu\varepsilon}} A \, . \tag{C5}$$

We do not yet know the dependence of A upon μ, ε, or ω. The assumption that A is linear in ω would mean that the relative strength of the gravitational component compared with the electric component, given by

$$V_y = -\left(\frac{A}{\omega}\right) E_y \, , \tag{C6}$$

does not depend upon frequency in free space. The classical assumption that

$$A = \eta\omega \tag{C7}$$

admits no frequencies at which the electric component of the wave is left unattenuated. By using the 5-D field equations and looking for cases of zero imaginary mass density, it is possible to obtain frequencies which do leave the wave unattenuated. These occur at

$$f = \frac{a_o c \, 4\pi\mu\omega h \left(\dfrac{\partial\sigma}{\partial\gamma}\right)}{A_{eo}^2 + (4\pi\mu\omega h)^2} \, , \tag{C8}$$

where h can also be expressed as

$$h = \frac{A_{eo}}{\mu\varepsilon\omega^2} + \frac{1}{2\left(A_{eo} + \sqrt{A_{eo}^2 + \mu\varepsilon\omega^2}\right)} \tag{C9}$$

and where A_{eo} is the real part of the initial electrical waveform given in equation 157. That is

$$k_4 = \frac{1}{a_o c}\left(A_{eo} + i4\pi\mu\omega\sigma h\right) \, . \tag{C10}$$

Substituting for the defined quantities in equation C8, assuming $\eta^2 << \mu\varepsilon$ and disregarding negative frequencies, we find two possible frequencies for which the imaginary part of the mass density vanishes:

$$\omega_c \cong \frac{1}{\eta}\left\{\frac{-16\pi\eta\, a_0\, c\frac{\partial\sigma}{\partial\gamma}}{2\mu\varepsilon^2} - \left(\frac{4\pi}{\varepsilon}\right)^2\right\}^{\frac{1}{2}} \tag{C11}$$

and

$$\omega_c \cong \frac{1}{\eta}\left\{\frac{4\pi\, a_0\, c\frac{\partial\sigma}{\partial\gamma}}{2\varepsilon\left(1-\frac{2\eta}{\mu\varepsilon}\right)}\left[2+\left(\frac{4\pi}{\mu\varepsilon}\right)\left(1-\frac{2\eta}{\mu\varepsilon}\right)\right] - \left(\frac{4\pi}{c}\right)^2\right\}^{\frac{1}{2}} . \tag{C12}$$

The condition specified by equation C12 represents a seventh order polynomial in ω, therefore the roots of this polynomial have not been sought. It may be noted, though, that there are up to seven possible frequencies for which the magnetic and electric components are unattenuated.

APPENDIX D
OTHER APPROACHES CONSIDERED

The following is a brief review of other methods that were considered during the effort. It is not recommended that much effort be spent on these areas unless and until they are more fully developed.

VARIATIONS IN e/m - Vladimirov (52) has a unified five dimensional field theory that predicts the time variations of the e/m ratios. It should be possible to plot the Josephson-frequency data as a function of the time of year (actually the distance to the sun and other gravitational forces).

CAPACITOR DETECTION OF GRAVITY - Gregory Hodowanec (53, 54) has made claims of experimentally detecting gravitational field with a capacitor. He has detected variations in his circuits during star eclipses, novas, and other events. He has recently claimed receiving extraterrestrial signals. The circuits are simple and would be easy to construct. However, the evidence is not very impressive at this time and there does not seem to be any simple way to make a propulsive system which involves the principle even if he is correct.

It may be interesting to use his device as a sensor in a Hooper v x B experiment. In some experimental designs Hooper would shield his motional electric field generator and would use capacitor as detectors. In Hodowanec's circuit he shields the capacitor and amplifier.

It is not recommended that this experiment be pursued for propulsive studies except as a possible circuit modification of any possibly existing Hooper experiments.

EM WAVES AND DIELECTRICS - In a number of developments (55, 56) it was found that there may be new and unusual effects imparted to an electromagnetic wave that strikes a rotating object. The most commonly predicted effect is that their would be an amplification of the intensity of the EM field. There is an interaction between the frequency of the EM wave and the angular velocity of the rotating dielectric. If this effect is real then it may furnish methods for frequency selection and amplification. Again there does not seem to be a direct link to propulsive system.

ROTATION OF MASSES - Wesson (57, 58) appears to be very active in the area of 5-D studies. Written correspondence with Wesson has shown that he is willing to work on experimental design but only as an paid consultant. He has proposed to detect possible departures

from the conventional law of gravitation by massive objects moving about a common axis in a circular path. His work is interesting and the form of many of his equations is similar to William's. He uses a variable rest mass as his fifth component. It is unclear if this will lead to a workable propulsion experimental system. His work bears a closer look.

GRAVITY WAVE EMITTER - There has been some Russian work in the area of inductive theories. Most of the work appeared during the mid- to late- 1970's. Specifically, Grischchuk (59) has proposed experiments involving gravitational- wave emitters. He proposed to excite a torus shaped coil with EM waves. Apparently this is similar to the Hooper experiment involving noninductive coils. Due to the translation and political difficulties the outcome of these experiments is not known. It may be profitable to do an indepth study of Grischchuk's work if the noninductive approach is taken.

ATMOSPHERIC DISCHARGES - Lasers are known to ionize the atmosphere. If a high altitude craft could direct an ionizing beam from above, it may be possible to direct the ever prevalent atmospheric electric potential to discharge to an object below. For a spacecraft positioned above the ionosphere no damage would be rendered to the beam origin. However, as a conductive channel is directed to the object a lighting-like discharge would be directed toward the object. For example, rockets in low boost stages are known to be susceptible to lighting due to the exhaust ionization of the plume. A beam may be useful against such targets or sensitive electrical installations.

Secondly, it is possible to cause thermal blooming of lasers in the atmosphere as IR lasers pass through regions of air (especially when seeded with materials such as SF_6). Pulsing such beams creates acoustic energy. Even small wattages of acoustical power can be very harassing demoralizing to ground troops.

ROTATION OF CLOCKS - Ziino of Italy (60) has proposed to test for the dimensionality of time by a clock experiment. It consists of two clocks, one at rest and one at the outer edge of a rotating system. The differences in time would yield information concerning the transverse time component and the validity of a three-dimensional time. The experiment would involve excessive rotational speeds or extended rotation times at precise angular speed. For this reason it is not recommended.

RECIPROCITY THEORY - Dewey Larson (61) has proposed a Reciprocity Theory which is 6-D in nature. The theory allows for interconversions between EM and gravity. The theory is

qualitative in nature. It proposes multiplicative instead of additive inverses between particles and antiparticles. The theory is difficult to understand since it is cloaked in specialized language and jargon. After about 40 years of development it still has failed to demonstrate any quantitative predictions outside of classical theory.

It is not recommended that this area be pursued until it demonstrates useful quantitative results to practical experiments not achievable by classical methods. Currently the few followers of the theory have not been willing to propose definitive tests of the theory. All of its present successes seem to be linked to its use of dimensional analysis (appears to be similar to general relativistic unit geometerization but with units of velocity).

GRAVITY STRESS - Sinichi Seike (62) has produced a device which is claimed to be a transistorized Gravity Power generator. According to one interpretation of his theory the gravitational stresses on a electrical system can be used to produce useful power. It is hard to see how a conservative field such as gravity can be used to do continuous work on a closed system. It would seem to be only possible if the fields had components that were not linear in terms of the velocities and currents.

This area may warrant watching for any future developments in light of the possible Ampere law modifications to current interactions that allow for nonlinear reactions in some cases.

ROTATION OF MAGNETS - There is a continuing debate in physics as o the reality of the magnetic field. The prime question is whether the axial magnetic field of a bar magnet rotates with the magnet or is stationary. The Faraday unipolar generator dates back to the 1830's. DePalma, Tewari and others (63, 64) have attempted to utilize the Faraday generator to produce more power than needed to run it. Most objective reviews of the work have, however, failed to see such effects. The work is a typical case of great claims (leviation claims, free energy, time warping, etc.) accompanied by claims of government suppression but without independent verification based on experimental numbers.

It is very doubtful that these claims will be independently validated and even more doubtful that they will lead directly to a propulsive system. However, the work on homopolar generators as high current devices is reasonable and may be useful for ground uses. The angular momentum complications seem to rule the system out for any practical space applications.

BASKET WOVEN COILS - Lester Hendershot (65) constructed an energy device in the 1920's which was claimed to extract "free energy." The devices were witnessed to work. The devices featured unusual "basket weave" coils and specially formed capacitors. Some circuit diagrams of his device still exist. Several possibilities do exist:

    1) the device worked via absorption of AM radio waves

    2) the device works via principles involving time varying inhomogeneous electric fields

    3) the device works by some unknown method

    4) the device worked by electrolytic action within the capacitors

    5) the device was a fake.

In the absence of any indepth analysis, it is not recommended that the experiment be duplicated.

SEARL EFFECT - The Searl Effect (66) is a separate issue from the homopolar generator above. Searl has claimed to produce disk levitation by rapidly rotating magnets. There have been claims of antigravity, high electric fields, perpetual motion, inertial loss, gas ionization. All these claims come from Searl or those supportive of his work and no outside witnesses are available. Searl has not supplied any technical data or specifics of the operation in any easily referenced source. It is not recommended that this work be experimentally followed by USAF. It is worth noting, however, that a rotating magnet does have some definite theoretical peculiarities.

PERMANENT MAGNETS - According to some reports, Hans Coler (67) was a German scientist during WWII who constructed a "free energy device." The device consisted of permanent magnets, coils, and condensers and output up to 6 kW were claimed. The device is vaguely reminiscent of Hendershot's. It may have been misinformation from the Germans due to war considerations.

VARIATION IN GRAVITATIONAL ACCELERATION - C. Brush (68, 69) formulated a unique theory of gravitation based on the ether or preferred frame concept. He conducted experiments to test his view using freely falling objects. The experiment involved measuring the acceleration of weights of different composition. He used timed sparks to photograph the fall. He

concluded that not all materials fell at the same rate. Barium aluminate and complex silicates fell at rates 0.02% less than the lead standard weight. Such experiments are done easily now with vacuum environments, photocell gates and mu-metal shields. It would make a good historical study for a well equipped undergraduate college physics lab.

DePalma (64) has also reported different gravitational acceleration in freely falling gyroscopes. This could be explained by general relativistic frame dragging and eddy currents induced by the earth's magnetic field. More recently E. Fischbach (70) reexamined the classic Eotvos experiment which is used as proof of the equivalence theory. He reexamined the exact data and found that there was a statistical bias dependent on the relative numbers of protons and neutrons within the test sample. He concluded that elements fall at different rates to one part in 10^8 dependent on their nuclear components. The effect was called the "Fifth Force." The hypercharge of the elements is thought to play a role in determining the magnitude of the force. It should be noted that the Eotvos experiment is primarily a static one. Gravitational interactions of falling objects may be different and involve terms of first order in derivatives of time.

PULSED FIELDS - R. Zinsser of W. Germany (71, 72, 73) has claimed the production of impulse by altering the local gravitational field. He uses pulses of electromagnetic waves of a specific shape and frequency (pulses of 2.5 ns at a 40 MHz repetition rate). He demonstrated a device at the 1981 meeting in Toronto. The claim was that a propulsive thrust developed due to localized gravitational anisotropy around the matter. We have not been able to verify the claims or gain detailed information on the process.

COUPLING IN BETA DECAY - In 1979 Dr. P.B. Eby with NASA-Marshall (74) proposed an experiment to test for possible coupling between gravitational and weak nuclear events. The proposal was to check the variation of Beta decay (or K capture) as a function of gravitational potential. Dr. Peter Parker (of Yale Univ.) was engaged to do preliminarily studies but the program was dropped. This was due to funding cuts and to questions as to the degree of accuracy obtainable.

Although it is doubtful that a separate experiment should be funded for such a check of coupling, it may be possible to search existing data for relevant information. Since beta batteries are being used on some space vehicles, it may be possible to obtain a power vs. gravitational potential plot. Since the power generated by a beta battery is dependent on the time rate of decay of nuclear particles, an upper limit on the coupling could be obtained. Such data was not obtained with coupling constants in mind. This means that variables effecting power may not be tightly

controlled. If a future power source was properly designed then a coupling value may be obtained without undo extra expense. There are no overwhelming reasons to believe that the coupling is nonzero but such a fundamental concept should be "nailed down" to rule out some theories. It is unlikely that even a positive result would lead to a propulsive system and the gamma ray spectrum experiment is much more practical (unless the data is already available).

APPENDIX E
POSSIBLE "ANTIGRAVITATIONAL EFFECTS"

Due to the added mass-related terms, there are eight field equations instead of the normal four of Maxwell. The terms also enter the continuity expression. The 5-D version of the expression is

$$\frac{\partial \rho}{\partial t} + \nabla \cdot J + a_o \frac{\partial J_4}{\partial \gamma} = 0 , \tag{E1}$$

which is a result of the antisymmetry of the electromagnetic field tensor. For the case where the coupling coefficient, a_o, is zero, the divergence of the current is classically restricted to zero by equation E1. But in 5-D the spatial divergence can be nonzero and proportional to the change in "mass-density current," J. Notice that the 5-D continuity equation is the same as Maxwell's as a_o tends to zero. If the coupling constant is nonzero then it would be possible to have a nonzero spatial divergence in the current J which would lead to mass-density effects. This means a mass flow may result from a divergence in the charge current flow.

In other words, it might be possible for a divergence in the special current flow to lead to "antigravitational" effects. This result is directly from the 5-D nature of the theory and the possible nonzero value for the coupling constant and not on the more uncertain assumptions of other portions of the theory. In fact, it seems to be unavoidable for amy multidimensional theory that uses a function of mass for one of its additional dimensions. The only question appears to be: What is the value for the coupling constant?

The other factor to consider is the Poynting vector expression. For the case of no divergence in J, the new effect can be expected where there is a nonzero $E \cdot \dot{E}$ term. In other words, where there is a changing electric field vector.

APPENDIX F
Access to Information

Much of the work in inductive theories goes unpublished in normal technical journals. This is due to: 1) their highly speculative nature, 2) the fact that due to the complexity of the topic good work is often too large to print, 3) some work is very poor, 4) there is a lack of experimental evidence and 5) experiments that would verify such inductive effects are not believed by the "establishment." Dr. Cravens will retain (for 5 years or longer from the date of this report) all reference materials used for this report. He will continue to accumulate reference material in this area. Interested individuals may contact him at:

Dr. Dennis Cravens   Dr. Dennis Cravens
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Vernon, TX 76384   Vernon, TX 76384

He will attempt to supply serious researchers reference and bibliographic materials for cost of duplicating and shipping. This will of course be subject to current U.S. copyright and export restrictions.

Dr. Cravens will also receive and archive new relevant materials that may be sent to him. It is hoped that an interested network of researchers may be developed and that new materials can be added to the archive.

APPENDIX G
OTHER THEORIES

There has been many approaches at unifying gravitation and electromagnetism. Many also attempt to combine other factors such as Dirac's Large Number Hypothesis which states the gravitational constant is changing with time or Mach's Principle which states inertia is dependent on distant matter. Some of the more debated theories are the scalar-tensor formalism.

SCALAR-TENSOR THEORY - This theory started from studies of 5-D unification attempts. In addition to the physical metric tensor, g, there is a scalar field φ. Many of the current approaches are now using four instead of five dimensions but retain the scalar field. Originally the g_{44} element of the metric tensor was found to require separate postulates within some 5-D theories and often appeared redundant. The scaler field is a coefficient in front of the stress tensor in the Einstein equation. The scalar is therfore related to the gravitational constant. This leads directly to the Dirac Hypothesis. Also the mass of a particle in the background reference frame becomes

$$m = m_o / \sqrt{\varphi} \ .$$

(G1)

Since the scalar field is related to the local gravitational field the mass becomes dependent on the distribution of matter in the universe. This leads to Mach's Principle. Thus, we have an approach for which matter moves gravitationally on geodesics and for which locally measured values of the gravitational constant depends on a scalar field. It is the distribution of the mass density in the universe that determines the scalar field.

The scalar gives rise to an additional wave equation. The added equation represents a scalar field that is mediated by a zero rest mass particle. From this one would expect an additional fundamental force that is yet to be discovered. This field would be connected to the gravitational field and influence inertial effects.

All of these considerations indicate that inertial effects can be altered in a local space. However is only in the positive direction. In other words, the inertia of an object can be increased (not decreased) by assembling mass close to the test body. To decrease the inertia of an object it must somehow be decoupled from the rest of the universe. This indicates that an object such as a spaceship could have its inertia increased but not decreased. Unfortunately, this is just opposite of

what is normally desired. On the other hand, it may still be possible to make the exhausted fuel appear to have greater inertia than normally expected by some still unknown mechanism.

FINSLER GEOMETRY - This area of research has attracted little work. The concept rests on Riemann's classic work - About the Hypothesis Lying at the Foundations of Geometry. In this work Riemann points out the possibility of more general metrics. This is based on a new method of length measurement. We take length to be derived from the square root of the quadratic in terms of distance,

$$ds = \sqrt{g_{\mu\nu} dx^\mu dx^\nu} \,.$$

(G2)

Riemann suggested that it might also be expressed as the fourth root of a quadratic form. This geometry is very complicated and leads to complex forms. This area of research has been almost ignored since the 1920's. During the work on this task it was found that 5-D theories using Finsler geometries may be similar to 10-D theories. The reasoning is that the fourth root opens the possibility of two separate states of 5-D each which are manifested together. They are represented as the real and imaginary components of similar expressions. This may be equivalent to the spontaneous compactification of 10-D string theories into two 5-D subspaces for the separation of Bose and Fermi particles. Comparison of the statistical nature of these particles with this interpretation remains unfinished.

THEORIES WITH TORSION - When Eddington developed his general geometry he assumed that the affine connection was symmetric, i.e.

$$\Gamma^\mu_{\alpha\beta} = \Gamma^\mu_{\beta\alpha} \,.$$

(G3)

If the relation is made nonsymmetric by the introduction of a constant coefficient on one side, we have a geometry with torsion. This is the last variation that Einstein investigated during his lifetime. This approach created a theory in which the connections coefficients were nonsymmetric and they contained a torsion tensor. The torsion component is often taken as the spin properties of the matter in question. Most modern theories of supergravity has a skew symmetric connection and hence torsion.

CLIFFORD ALGEBRA: Eddington developed a unified theory in his <u>Fundamental Theory</u> (76). Although not often recognized, the approach was five dimensional. On philosophical grounds he developed what is called E algebra. This is similar to complex algebra but instead of only i and l being impotent there is an array of numbers (E's) that also have absolute moduli of unity. In this algebra there are 16 elements that satisfy the anticommutation rules for Dirac matrices. This mathematics is consistent with what is now known as Clifford algebra. This math is at the base of supersymmetric gage field.

This algebra is five-dimensional over the set of real numbers. It possesses chirality and hence consistent with particle physics. The approach fell into disfavor during the 50's after Eddington's death. This was likely due to the fact of its complicated nature and lack of defenders. The algebra was later rediscovered by Majorana and is currently referred to as Majorana spinors.

REFERENCES

1.   Feynman, R.P. , A.R. Hibbs (1965). Quantum Mechanics and Path Integrals (McGraw-Hill Book Company, New York) also Feynman and Hibbs (1962).

This is a highly technical book that supplies the theoretical foundations of quantum electrodynamics. A popular view can be found in Feynman's QED. It is this area of work for which Feynman received his Nobel Prize. The basic view taken is that of examining the action integrals of interacting particles. In classical theoretical physics, the path taken by a particle is that which minimizes the $\delta \int ds$ integral. Feynman takes the approach that within quantum electrodynamics all possible paths must contribute to a real event. He sums over all paths using the phase factor of $e^{iS/\hbar}$ where S is the action. The quantity $\hbar$ is the least action (Plank's constant). Since $\hbar$ is very small, paths far removed from the path of the classical action oscillate rapidly (due to the phase factor). For large everyday items, only the classical path is noticed. For elementary particles the action, S , is of the same magnitude as $\hbar$ and many paths must be considered within the integral.

In this report, notice that the phase factor containing S must be integrated over the 5-D line element given by

$$ds^2 = g_{\mu\nu} dx^\nu dx^\mu ,$$

which can be identified with the 5-D generalized entropy.

The theoretical section of this report discusses the role of $\hbar$. The $\hbar$ is a measure of commutation properties of the quantum operators. This report finds that since it is related to the commutation of differential operators, it must also be related to the curvature term, R, in general relativity. This is an important point and has been overlooked by previous research. In a generalized space commutation of covariant differential operators occurs if and only if the curvature is nonzero.

Placing these two concepts together the $\hbar$ is found to be modified by approximately $g_{\mu\nu}$ which depends on the gravitational interactions. In other words, the time units of the least action constants must be altered due to the presence of a gravitational field. For QED calculations we now find that the phase which enters the path integrals begins to oscillate for cases of close

approach to the particle. Thus, only paths outside of (1-2m/r) contribute to the event in the same way that only paths near the classical action contribute. The theory is seen to approach QED for distances above (1-2m/r). This is a major accomplishment and it avoids most of the singularities encountered in traditional QED.

2.   Born, M. and Infield, L., "Foundations of the New Field Theory," Proceedings of the Royal Society of London, Vol. 144 (1934), p. 425.

        In this work the action integral is an invariant. The equations are not general and are devoid of any charge or current terms. The work tried to avoid the singularities in the self energy.

3.   Landé , Alfred, "Finite Self Energies in Radiation Theory - Part I," Physical Review, Vol. 60 (1941), p. 121.

        Landé's work involved the use of a finite size for the charge distribution. When the charge spreads over a volume terms similar to the Yakawa potential appear.

4.   Podolsky, Boris and Schwed, Philip, "Review of a Generalized Electrodynamics," Review of Modern Physics, Vol. 20 (1948), p. 40.

        Podolsky approaches the infinite self energy calculations by rewriting the Lagrangian. This is done by altering the field terms but not the particle terms. The field terms lead to zero mass particles which are assumed to be neutrinos. The potential is the same as in (3), above. What is happening here is that when the problem is thought of as residing in the particle (as in 3), the field is seen to be altered. When the problem is thought of as residing in the field then a new particle is required. This is indicative of a underlying problem.

5.   Corben, H. C., "Special Relativistic Field Theories in Five Dimensions," Physical Review, Vol. 70 (1946), p. 947.

        Corben uses a truly 5-D approach to the self energy problem. He views the added coordinate as a factor that relates mass to the electromagnetic fields. When derivatives of the fifth coordinates are dropped from his equations the potential function is equivalent to the Lienard-Wiechert potentials. In Corben's later work the fifth coordinate is taken as the rest charge density.

6. Corben, H. C., "Theory of Electromagnetism and Gravitation," Physical Review, Vol. 69 (1946), p. 225.

    See (5) above.

7. Pauli, W., "Relativistic Field Theories of Elementary Particles," Reviews of Modern Physics, Vol. 12 (1941), p. 203.

    Pauli's work is mostly a 4-D view. He derives laws from a modified Lagrangian. The work by Corben (4,5) uses Pauli's approach but extends it into 5-D.

8. Flint, H. T., "The Theory of the Electric Charge and the Quantum Theory - Part I," Philosophical Magazine, Vol. 29 (1940), p. 417.

    Flint assumes that the added coordinate is cyclical. That is, the components of a real world event are independent of the added coordinate. This is the same as saying that the added component of momentum is constant in the 5-space.

9. Flint, H. T., "The Theory of the Electric Charge and the Quantum Theory - Part II," Philosophical Magazine, Vol. 29 (1940), p. 417.

    See (8) above.

10. Flint, H. T., "A Study of the Nature of the Field Theories of the Electron and Positron and of the Meson," Proceedings of the Royal Society of London, Vol. 185 (1946), p. 14.

    See (8) above.

11. Ingraham, Richard, "Classical Maxwell Theory with Finite Particle Sources," Physical Review, Vol. 101 (1956), p. 1411.

    Ingraham's work is 5-D in nature. His work is concerned with conservation laws and charge distribution. Charge, in his theory, is spread out over a radius on the order of lambda and damps out quickly at larger distances.

12. Milne, E. A., Kinematic Relativity, Oxford Press (1948); also in Relativity, Gravitation and World Structure, Oxford Press (1935).

Milne's work is very interesting although much of it is lost in metaphysical arguments. Dirac often made reference to Milne's double time components (24). There are two points in Milne's work that should be reexamined today. One involves the role of the test particle within Maxwell's expressions. Current theories tacitly assume that a test particle can be introduced into the field without any undue effects. This cannot be done in a relativistic manner. Since charge is quantitized, it is physically unacceptable to postulate a test particle with infinitesimal charge so that no magnetic effects enter the field that is to be measured. The second point in Milne's work (which needs to be reexamined) is the concept of double time dimensions. This appears to be equivalent to the bi-metric theories. Instead of proposing a background metric, Milne proposes a background time.

13. Williams, P. E., "The Possible Unifying Effect of the Dynamic Theory," May 1983, LA-9623-MS.

This is part of a series of works by Pharis Williams. The novel aspect of the work is that Williams starts from thermodynamics instead of the usual general relativistic and Newtonian approach. He applies a generalization of the second law of thermodynamics (via Carathedory) to mechanical systems in addition to the usual thermodynamic ones. This leads directly to the constancy of the speed of light. For isolated systems the extremes of generalized entropy lead to the special relativity for zero $\partial \gamma / \partial t$. The existence of differential entropy within thermodynamics guarantees the existence of an integrating factor which couples the Reimannian space to a Weyl Space (via a gage function). This is an important point because there is often criticism of 5-D theories due to the lack of the integrating constants. In other developments, an "ad hoc" condition is imposed to guarantee an integrating constant. Here thermodynamics is used to prove its existence. The two spaces are similar to Rosen's bi-metric approach. The Reimannian space corresponds to a closed system with conservation of energy and severe boundary conditions. The Weyl space corresponds to differential entropy and a Machian world where only relative conditions enter.

Williams develops the 5-D field equations and the neo-coulombic potential. The equations allow for inductive coupling between the electric and gravitational fields. The fundamental constant, λ, in the potential may be material dependent and different for electrons and protons.

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Thus, for far fields, the difference between the two potentials may give rise to the gravitational potential. This concept is similar to that of O.F. Mossotti.

14.   "The Dynamic Theory: A New View of Space, Time and Matter," Los Alamos Sci. Lab. Report, Dec. 80, LA-8370-MS

       See (13) above.

15.   "The Dynamic Theory: Some Shock Wave and Energy Implications," Feb. 1981, LA-8402-MS

       See (13) above.

16.   Will, G. M., "Experimental Gravitation from Newton's Principle to Einstein's General Relativity," 300 Years of Gravitation, ed. by Hawing, Cambridge Univ. Press, p. 80-127 (1987).

G. Will has worked extensively in the area of experimental verification of general relativity and its variations. Most of the experiments are based on large scale cosmological events. Since they are far field events, it is doubtful that subtle deviations from $1/r^2$ potentials can be found by this method. His use of the PPN method is important. It is, however, based on 4-D theories with 10 independent parameters. In 5-D theories there are 15 parameters. A similar study for 5-D theories should be interesting. This is an area of recommended future studies.

17.   Will, G. M., "Theoretical Frameworks for Testing Relativistic Gravity," Astrophys. J. 169, 125-140 (1971).

       See (16) above.

18.   Anadan, J., Phys. Lett. 105A, 280 (1980).

This work discusses the possibility of detecting an electric potential that develops within a system in a gravitational field. No useful methods seem practical with the effect. The concept is based on a rearrangement of the conduction electron density due to the gravitational pull on the mass equivalence to the energy within the system. It is not an inductive effect between the fields.

19. Noether, E., "Invariante Variations Probleme," Goett. Nachr., p.235-257 (1918).

This is the theoretical foundation of the conservation laws. The idea is that conservation laws are illustrations of an underlying symmetry. A condition which will remain constant during some kind of transformation (physical event) indicates that some mathematical condition is the same before and after the event (symmetry). If our task is to find conditions for nonconservation, then we must find the underlying symmetry and strive to break it. Such "breaking" may not be possible in a global region but may be possible in a local area. To locally alter the conservation laws we must locally alter the underlying symmetry.

20. Wu, G. C., et al., "Experimental Test of Parity Conservation in Beta Decay," Phys. Rev. 105, p.1413 (1957).

The experiment showed that parity can be violated. Until then, parity was considered inviolable. Cobalt-60 was magnetized and the atoms were frozen in that state. The direction of escaping beta rays changed as the material thawed and allowed atomic rearrangement.

The important point here is that only tensors and not pseudotensors are required to be conserved in all physical events. General Relativity imposes the requirement that all physical laws be written in tensor equations so that they can be applied throughout the universe independent of the background reference frames.

21. Lee, T.D. and C. N. Yang, Elementary Particles and Weak Interactions, BNL 443, U.S. Dept. of Comm., Office of Tech.Serv., Washington (Oct. 1957).

See (20) above.

22. Sakharov, A. Sov. Phys. Doklady 12, 1040 (1968).

This is an alternative view of gravity. In it the gravitational force is seen as an extension of the Van der Waals forces within the vacuum. It has several interesting features and ties nicely to the Casimir force.

23. Puthoff, H. E., "Zero Point Fluctuations of the Vacuum as a Source of Atomic Stability and the Gravitational Interaction," Proceed. of the Brit. Soc. for the Phil. of Sci., Sept. 1988.

See (22) above.

24. Dirac, P. A. M., <u>Directions in Physics</u>, John Wiley and Sons, Inc. p. 36 (1978).

This is a collection of lectures by Dirac. He reviews some of the difficulties remaining in quantum theory. Most researches have grown complacent with the difficulties due to the great success of the theory. Dirac was one of the main founders of the theory and knows full well the weaknesses of the theory. He was quite bothered by the mathematical inconsistencies of the theory (i.e. self energies). The salient feature of the work is that real progress in physics is made by questioning the foundations not by complacency.

25. Casimir, H.B.G., Proc. Kon. Ned. Akad. Wetemscjap., 54, pp. 793 (1948).

This is a discussion of a very short range force. The force does not follow the $(1/r^2)$. The departures from the Coulombic potential at short ranges is difficult to study but may indicate departures from traditional explanations.

26. Dirac, P.A.M., <u>The Principles of Quantum Mechanics</u>, fourth ed. (Oxford at the Clarendon Press, Oxford), Chap. IV (1958).

This is the classic work that founded most of modern ideas about quantum mechanics. The interesting point is the use of the correspondence principle. It is the commutators that hold the primary role at the foundations of quantum mechanics. Yet few have tried to derive quantum mechanics from a correspondence to general relativity. Instead most researchers try to adjust general relativity by introducing quantum principles into it. One should not be surprised to find that approach incomparable.

27. Feynman, R.P., <u>Quantum Electrodynamics - A Lecture Note and Reprint Volume</u>. (W. A. Benjamin, Inc. New York).

This is a lecture series study of quantum electrodynamics. It develops rules for summing interactions between particles. Feynman introduces a function to supply a cutoff of terms at small r's. The problem is that when cutoffs and renormalization occur it is not general relativistic invariant while retaining the probability of one for a particle in space. This is the kind of problem that worried both Feynman (see 1) and Dirac (see 24).

Expressed in terms of 5-D theory, renormalization cannot be carried out without introducing new curvature turns to covariant differential expressions. There is room in the 5-D theory to renormalize by the modifications of the least action (change time units by g_{oo}). A cutoff function is better achieved in the 5-D theory by the maximum rate of energy (mass) conversion. Such a function gives a limit of $\dot{\gamma}_{max} = a_o c$ which plays the same role as $v_{max} = c$ which "cuts off" special relativity at high velocity.

28.   Fock, V., The Theory of Space. Time and Gravitation, trans. N. Kemmer, Pergamon Press, New York, Chap. III (1964).   See also Dirac, P.A.M., General Theory of Relativity, John Wiley & Sons, N.Y., p 17-31 (1975) and Eddington, A.S., The Mathematical Theory of Relativity, second ed., University Press, p. 60-73 and p. 82-85 (1924).

These books give a basis for general relativity. Eddington gives a very good development of the theory without undue clutter. However, it uses out of date symbols. Nevertheless, it is one of the best on the subject. Dirac's book uses current notation that is easy to use. It is extremely concise and is the symbolism used for this report. Fock's work is very indepth but often hard to follow. It is indicative to the approach taken by many Russian workers in the field.

29.   Schwartz, J. H., "Covariant Field Equations of Chiral N = 2, D = 10 Supergravity," Nucl. Phys. B226, p. 269-288 (1983).

The development uses 10 dimensions to describe space. The author points out that the equations most simply compactify into 5 and not 4 dimensions. It is interesting to note that the 10-D work with supergravity normally uses symmetry as its guide. Here the theory points to 5 dimensions. Unfortunately authors avoid compressing the space to 5-D. Instead, they attempt to compress it into 4-D.

In 10-D space, which is compactified into two 5-D manifolds there is a natural separation of the Bose and Fermi statistics. The change in sign on the exponents of these two statistics appears to be related to the sign of the metric signature (+---+ or +---).

30.   Newton, I. _Mathematical Principle_, University of California Press, page 10 (1960).

Newton describes his views on inertia. This is the classic reference to the rotating bucket experiment. His ideas of absolute position and time are no longer considered real. See Mach below (31).

31.   Mach, E. _The Science of Mechanics_ (1893) reprinted by Open Press (1960).

Mach reviews the historical and metaphysical foundations of mechanics. His primary principle is that the theory should be guided by physical observations and measurements and not abstract constructions. He disagreed with the concepts of absolute space and assigning properties to things that could not be physically examined. It is his work that influenced Einstein's development of relativity.

It is interesting to consider Milne's objection to the introduction of a impossibly small test charge to derive Maxwell's expression in light of Mach's views.

32.   Rosen, N. Phys. Rev. 57,147 (1940), Phys. Rev. 57,150 (1940), Ann. of Phys. 22,1 (1963).

Rosen has developed a theory in which there are two metrics governing space. One is the background space and one is the physical space. In this way there is a more natural way to discuss the role of gravitation. See (13) above.

33.   Halliday, David, Resnick, R., _Physics_, combined 3rd ed., John Wiley and Sons (1978).

This is a standard college physics textbook. It does contain some historical discussions of key experiments and developments.

34.   Woodward, J., personal communication with Jim Woodward, both by meetings and by phone 1988-1989.

Woodward is an experimentalist. His original investigation in the area of inductive coupling used rotating spheres and cylinders. He looked for electromagnetic effects during times of acceleration and deceleration. More recently he has examined the effects due to the changes of electric fields within dielectrics. He is studying the $E \cdot \dot{E}$ terms which appear in the flow of energy

within a region. This term can be expected from the $\nabla \cdot E$ expression derived in developing the 5-D Maxwell-like expressions.

36. Talley, R. "Twenty- First century Propulsion Concept", SBIR - AF-87-192 (1987).

This is an experimental program by Veritay Technology which is patterned after T. T. Brown's work. Veritay has placed an asymmetric capacitor on a vertical torsion fiber. They have detected a force on the order of a fraction of a dyne at applied voltages of several kilovolts. A pulsed asymmetric capacitor may be expected to produce an impulse.

37. Graneau, P. Ampere-Neumann Electrodynamics of Metals, Hadronic Press Nonantum, Mass. (1985).

In these works Peter Graneau has attempted to study modifications of the Lorentz-style forces. He starts from the historical perspective of Amperes Laws. Some modifications of Lorentz forces can be expected within 5-D theory. Specifically the 3-force would be

$$F = \left(\frac{1}{c}\right)(J \times B + J_4 V)$$

and the time component would be

$$F_o = \left(\frac{i}{c}\right)(E \cdot J + V_4 J_4)$$

and the mass density component would be

$$F_4 = \left(-\frac{1}{c}\right)(J \cdot V).$$

38. Graneau, P., "Electromagnetic Jet-Propulsion in the Direction of Current Flow," Nature 295, p. 311, June 18, 1982.

See (37) above.

39. Moray, T. H., The Sea of Energy, 5th ed, Cosray Research Inst., Inc., Salt Lake City, (1978).

Moray was an old style independent inventor. He may have found a way to directly convert energy released by radioactive decay into electrical energy. His work was the motivation for Paul Brown's Nuclear Resonance Battery.

40. Parker, Peter, personal communication via phone, also in "Development of a Direct Experimental Test for Any Violation of the Equivalence Principle by Weak Interactions," Final Report NASA-NAS-8-33572 (Dec. 1981).

Dr. Parker worked with NASA to test the coupling between gravitational and weak forces. The program was dropped. Most of the work involved viewing changes in decay counts of a very active source. The count rate was expected to change due to the gravitational red-shift. This was a GR view and did not require any inductive coupling of the fields.

41. Wallace, H.W., "Heat Pump," U.S. patent # 3,823,570 issued July 16, 1976.

These are a series of patents by Wallace which involve coupling between rotational systems and gravity. These are very curious claims and we have been unable to track down what became of them or of Wallace. It may be interesting to review his work in light of that of M. Trocheris and by examining $\nabla \times V$. The $\nabla \times V$ terms may be involved in rotation of nonzero masses.

42. Wallace, H. W., "Method and Apparatus for Generating a Gravitational Force," U.S. patent # 3,626,005 issued Dec. 14, 1971.

See (41) above.

43. Wallace, H. W., "Method and Apparatus for Generating a Dynamic Force Field," U.S. patent # 3,626,606.

See (41) above.

44. Hopper, W. J., "All Electric Motional Electric Field Generator," U.S. patent # 3,610,971 issued April 15, 1969.

Hooper's work involved separating the electromagnetic forces according to their method of production. He saw the $v \times B$ terms separate from $\dot{E}$ terms. He developed several experiments to check this assertion. He worked with copper conductors. Should anyone try to replicate the claimed effect, they should use superconductive materials. There is a gain of 10^6 in the drift velocity by using superconductors.

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45.   Hooper, W. J., "Apparatus for Generating Motional Electric Field," U.S. patent #3,656,013 issued April 11, 1972.

        See (44) above.

46.   Hopper, W. J., New Horizons in Electric, Magnetic and Gravitational Field Theory, Electrodynamic Gravity, Inc. (1969).

        See (44) above.

47.   Cullwick, E.G. Electro Magnetism and Relativity, Longmans, Green and Co., N.Y. (1957).

        This is a good reference book on EM effects. It is old but still one of the best. Cullwick mentions the fact that current analysis does not include the mass of the electrons within the EM calculations. He points out that such terms may appear sometime in the future as we go to higher current densities. If we ever succeed in developing a fluid superconductor many unusual effects should start appearing.

48.   Maxwell, J. C., A Treatise on Electricity and Magnetism, Vols. 1 and 2, Dover Pub., 3rd ed. (1954).

        This is the classic work in EM. It is old but this is an advantage. Maxwell lets all the basic assumptions (such as zero electron mass) be easily seen. Most current work assumes Maxwell is correct and no modifications are possible.

49.   Engelberger, J., "Space Propulsion System," U.S. patent # 3,504,868 issued April 7, 1970.

        This patent is of a magnetic loop to be carried on a spacecraft for the purpose of propulsion. This area has been reviewed several times in the past (AFRPL-TR-72-31). This patent appeared several times in computer searches using such key words as electromagnetism, gravity and propulsion. The newer superconductors are approaching the temperature range where simple solar shielding and proper re-irradiation can keep them in a conductive state. Unfortunately the new ceramic superconductors saturate at moderate magnetic field values. The interesting point

in Engelberger's patent is that a single large loop is used instead of small multi-turn loops. This keeps the magnetic fields low and would prevent saturation and hoop stresses.

50. Saxl, E. J., "An Electrically Charged Torque Pendulum," Nature 203, p.136, July 11, 1963. and "Device and Method for Measuring Gravitational and Other Forces," U.S. patent #3,357,253 issued Dec. 12, 1967.

Saxl claimed to see a change in the period of a torque pendulum when its electric potential was raised. The patent covers detail construction plans of his device.

51. Thyseen Bernenisza and Groten, "Testing Inertial Mass Variation," Transact. N.Y. Acad. of Sci., p. 687, Dec. 1972.

This is a proposed experiment to test the Mach effect. It looks for a change in the inertia of a mass connected to a torque pendulum. If Mach is correct, the inertia should be dependent on the coupling of the mass to all masses in the universe. This is an interesting experiment in light of the recent Greenland ice sheet experiment involving G.

52. Vhadimirov, Y.S., "The Unified Field Theory, Combining Kaluza's Five-Dimensional and Weyl's Conformal Theories," Gen. Rel. and Grav. 14, No. 12, p. 1165 (1982).

This work is indicative of the Russian work in 5-D theories. Most of the Russian work is based on Weyl's theories of differential geometry. In GRG vol. 14, no. 12, 1167 (1982) Vladimirov treats the added coordinate as a physically real variable instead of one of convenience to simplify projecting into a 4-D world. The Russian literature seems to be more open to nonzero inductive theories than does the free-world.

53. Hodowanec, Gregory, "All About Gravity Waves," Radio Electronics, p.53, April (1986).

Hodowanec is an independent inventor who is detecting anomalous readings from capacitors. His device is more-or-less a capacitor directly connected to the input of an op-amp. He claims to detect signals when masses are moved near the electrically shielded device. The effect may be simple "pink noise." Hodowanec has detected anomalous activities appearing from the device.

54.   Hodowanec, Gregory, letters, 34 Cleveland Ave. Newark, N.J. 07106.

      See (53) above.

55.   Schieber, D., "Some Remarks on Scattering by a Rotating Dielectric Cylinder," J. of EM
      Waves and Appl., Vol. 2, No. 2, p. 155 (1988).

      These articles are indicative of studies of EM waves and rotating bodies. It appears that
when EM waves pass through rotating dielectrics some unusual effects are predicted. This may
lead to some interesting future technology.

56.   Zeldovich, I. B. and Rozhavskii, L.V., "Rotating Bodies and Electrodynamics in a
      Rotating Reference Frame," Radiofizka, Vol. 29, No. 9, p. 1008 (1986).

      See (55) above.

57.   Wesson, P. S., "A New Approach to Scale - Invariant Gravity," Astron. Astrophy. 119,
      p. 145-152, (1983).

58.   Wesson, P. S., Gen. Rel. Grav. 16, p. 193 (1984).

      Paul Wesson has worked to produce a 5-D theory with the rest mass being the added
coordinates. This is compatible with the 5-D theory of this report. This report, however, prefers
mass density as the coordinate since it gives a better intuitive link to thermodynamic and field-like
(not point-like) properties.

59.   Braginskii, Grischchuk, L.P., et al., "Electromagnetic Detectors of Gravity Waves," Zh.
      Eksp. Teor. Fiz. 65, 1729-1737 (Nov. 1973).

      This is one of many Russian works that proposed to detect gravity waves with
electromagnetic detectors. During the 70's there seemed to be a lot of Russian activity in the area.
The work has now tapered off. There is no evidence that any of the methods were used.

60.   Ziino, G. "On a Straightforward Experimental Test for Three Dimensional Time," Nuovo
      Cimento, Letters Serie 2, Vol. 28, p. 551, Aug. 16, 1980.

Here Ziino has proposed a clock experiment to check for a 6-D space.

61.   Larson, D., communication at the Sept. meeting in Seattle, Washington.

Larson is an electrical engineer who has developed a 6-D alternative view of the world. The works of his followers appear in Reciprocity.

62.   Seike, S., The Principles of Ultra Relativity, 8th ed. G. Research Lab., Ehime, Japan (1986).

Seike has claimed to produce energy from the gravitational field. No working models are available for full examination.

63.   DePalma, B. E., "Electro-Mechanical Device for the Amplification of Electrical Power," Energy Unlimited: The New Age Science Magazine, no. 7 (1980).

Through the years there have been many interesting developments concerning the Faraday Homopolar generator. DePalma has claimed to get more energy out than is supplied to the generator. None of the claims seem to withstand careful examination and no machine has ever been made self driving. The underlying reason that such claims continue to resurface is that rotating magnetic fields are extremely difficult to handle within existing theories. This is because for a rotating frame there is a distance (removed from the axis) which is traveling at velocities greater than c. Although the distance is not within any real physical object, its existence within the mathematical development greatly complicates any calculations.

64.   Tewari, P., "Generation of Electrical Power from Absolute Vacuum by High Speed Rotation of Conducting Magnetic Cylinder," Tech. Rep. Dept. of Atomic Energy, Bombay, India (1985).

See (63) above.

65.   Skilling, E., "Hendershot's Fuelless Generator," Jr. of the Borderland Sci. Res. Found., (July 1962).

This is a claim of generating more energy than is supplied. The interesting point here is not the claim of perpetual motion but the method used. If there are previously unknown effects due to

the added coordinate then they may appear as annomolous effects. As described earlier, the effects should appear in cases of asymmetry of electric fields, at high frequencies, rotating magnetic fields and high currents. Perhaps some of the anomolous effects claimed by nonmainstream individuals may be a starting point to see the new terms. However, this does not seem to be one of those cases.

Some early accounts of Hendershot's device described it as a capacitor (wound from triangular sheets of foil) located within a "basket woven inductive coil."

66.   Searl, J.R.R., British provisional patent specification #57578 (Sept. 1970).

Searl claimed to produce a flying disc by using rapidly rotating magnets of special design. The rotating disc is claimed to produce extremely large potentials with negative polarity at the rim and vacuums in the surrounding air. His work appears to be targeted at gaining public funds for the project rather than at scientific inquiry.

67.   Hurst, R., "The Invention of Hans Coler Relating to an Alleged New Source of Power," Bios Trip no. 2394, British Intelligence Objectives Sub-Committee, London (undated, ca.1944).

Coler produce a device known as the Stromzeuger. It is a claim of greater than one efficiency. It used magnets in a circular arrangement. All claims and information related to the device are extremely doubtful.

68.   Brush, C., "Discussion of a Kinetic Theory of Gravitation," Proc. of Amer. Phil. Soc. 60,2 (1921).

Brush conducted a series of experiments testing the gravitational acceleration of various materials. He used bodies in free fall and calculated their acceleration from photographs (spark gaps).

69.   Brush, C., "Gravitation" Proc. of Amer. Phil. Soc. 68, 5 (1929).

See (68) above.

70.   Fischbach, E. et al., Reanalysis of the Eotvos Experiment, Phys. Rev. Let. 56,1 (1986)

       A reexamination of the data in the Eotvos experiment shows a statistical trend. The question
is whether materials of the same weight but various proton to neutron ratios have the save
gravitational interaction.

71.   Zinsser, R.G. "Mechanical Energy from Anisotropic Gravitational Fields," First Int'l
       Symp. on Non-Conventional Eenergy Technology, Toronto (1981).

       A claim of anomalous result due to pulsed power.

72.   Zinsser, R.G., U.S. Patent #4,085,384

       See (71) above.

73.   Zinsser, R.G., M.E.G.A. Mechanical Energy from a Novel Clean Regenerative Source,
       Idar-Oberstein (1983)

       See (71) above.

74.   Eby, P.B., "An Experiment to Verify that the Weak Interactions Satisfy the Strong
       Equivalence Principle," NASA-TM-78209, Nov. 1978.

       See (40) above.

75.   Weinberg, Steven, Gravitation and Cosmology: Principles and Applications of the General
       Theory of Relativity, John Wiley and Sons, Inc. New York, Pages 70-90 (1972).

       Weinberg takes a nongeometrical approach to relativity. He does not cover detailed
derivations nor classifications of exact solutions of the field equations. He concentrates on the
experimental results of gravity, more along the lines of applications of the theory than its
development.

76.	Eddington, A.S., Fundamental Theory, Cambridge Univ. Press, Cambridge (1946).

Eddington first wrote a very outstanding work on relativity (The Mathematical Theory of Relativity, 1924). This work is still one of the best works on relativity and shows a deep understanding of the physical ideas that support the theory. It was written at a time when the relativistic assumptions at the foundation of the theory were clear. Later works on relativity often develop the theory along chains of research with contradictory or incompatible assumptions.

Eddington, in his later works such as Fundamental Theory, attempted to expand his work to unify the basic concepts. Much of this later work has metaphysical foundations that have since been brought into question. However, his purely mathematical developments are still valid and point to areas that are fertile for the unification efforts. He saw a need to view the world in a 5-D approach and developed a separate 5-D algebraic system (E-algebra). This work seems to be the first to develop the concept of chirality based on the arbitrary sign before 1. It is also the first work that used the 4x4 and 16x16 matrices which have been important in understanding subatomic particle symmetry. All this was done before subatomic particle theory was developed. The important point is that the mathematics were based on a perceived need for a 5-dimensional space. This has been ignored by current research.