Actual Time, Detached Time and Controlled Time:
Physical Paradigms and Energy Constructions

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OUTLINE

Introduction: actual life meets detached reason

- I. Actual Time, Detached Time and Mimed Time Paradigms of Conserved Energy
  - A. Mechanical perspective: Atwood's machine and Hooke's Law
  - B. Ideal gas and perfect gas
  - C. Carnot cycle
  - D. Ising model, critical point and critical opalescence
- II. Controlled Time Paradigms of Virtual Energy
  - A. Pulser devices
  - B. Timing devices
  - C. Force devices and bursting devices
  - D. Quad Net devices, critical moments and Shimmering Sensitivity
- III. Foundations of Energy Constructions
  - A. Diversity of constructions
    - 1. Rational constructions of physical paradigms
    - 2. Integrating constructions of psychology
    - 3. Polemical constructions that oppose the modern scientific view
  - B. Movements of and changes in animal bodies occur in actual time and make up the domain of actual life that establishes a foundation and goals for all constructions.
  - C. Constructions of images in rational domains initially arise in actual time but then repeat independently in detached time, co-existing with the domain of actual life and sometimes interacting with bodily movements and changes.
  - D. Movements of and changes in animal bodies that occur in actual time cannot be fully described or controlled by rational constructions that operate in detached time.
  - E. The modern scientific view presumes that there is full and automatic integration of rational domains with the domain of actual life.
  - F. To initiate and develop a new approach, three kinds of energy are constructed: actual, conserved and virtual.

Introduction: actual life meets detached reason

Scientific methods treat time as a numerical quantity that can be perfectly represented by a mathematical variable and precisely measured by standardized clocks. Such a narrow rigid treatment clashes with the rich flowing texture of temporal forms, tempi and rhythms that personal experience continuously weaves from memories of the past; from movements, feelings and perceptions of the present; and from anticipations of the future. "Reversibility" of the mathematical variable clashes with actual life where "the moving finger writes; and, having writ, moves on." (*Rubaiyat* of Omar Khayyam.)

In this project, three kinds of time are related to three energy concepts. Part I discusses standard Conserved Energy (CE) paradigms; Part II discusses new Virtual Energy (VE) paradigms. Part III discusses psychological and philosophical implications of multiple time and energy concepts.

First: ***actual time*** tracks movements of and changes in material bodies. Bodies that move and change in actual time include those with a simple constitution – a falling iron weight or a molten metal alloy in a crucible – and also living animal bodies with complex cells and organs. Moving and changing animal bodies make up the domain of ***actual life*** that is foundational in this project.

My approach begins with materialistic presumptions that are similar to presumptions of science, chiefly that movements of and changes in bodies depend only on their material constitutions, their histories and the histories of their interactions. I presume that there is universal agreement among persons about the order of such events in time and about periods of time between events.

Principles of freedom distinguish my materialism from scientific materialism. Science seems to be committed to a materialism where "theories of mechanics" (Newton's, Einstein's, statistical, quantum) and "mechanisms" (chemical, computational) are presumed to describe and control all movements of and changes in material bodies. Such commitments exclude freedom. I hold to contrary principles, like those stated by Truesdell (p. 424), that such commitments "reflect a failure to come to grips with the real complications of nature. Beyond the easiest and long-mastered special cases, nature is too intricate for any inclusive theory."

I suggest that movements and changes of actual life – e.g., itching and scratching – confound theories of mechanics. While seated, I bend down and my right hand precisely scratches an itch on my left ankle, which lifts to meet the hand. I suggest that itching and scratching are produced in the spine and that the whole spine participates in such productions. I suggest that itching is needed to guide scratching. In contrast, no thought or "will" is needed, although thought or will may block movements when socially mandated. Similarly, a visual goal guides walking movements of the body. I suggest that, while producing whole-body movements in their spines in actual time, animal bodies of birds, mammals and human beings exercise freedoms that are excluded from computational or mechanical theories of science.

Second: ***detached time*** operates in imagination, a domain that is occupied by ***images*** (feelings, perceptions, memories, forms, plans, etc.). Some images are connected to actual events. Others are generated during fantasies that have no connection to actual life. In imagination, events can be slowed down, speeded up or skipped over in ways that are contrary to events in actual time. In imagination, a clock can be reset to a start time and different alternatives can be constructed.

Detached time operates during rational processes such as adding numbers mentally. "Detached" means that processes are independent of muscular movements and actual time. Some people add numbers quickly in their minds and other people are slower. A person might add quickly at work and slowly when contemplating the bill after a family meal at a restaurant.

Detached time operates in thermodynamics paradigms of Conserved Energy. As discussed below, such paradigms are constructed from equipoise and equilibrium operations on stationary positions. Detached time also operates in computer algorithms. Rational processes operate in detached time – in imagination, in physics paradigms and in computers. Therein, movements can repeat incessantly without change. Such repetitions require ***time invariance***: an exact repetition of movements produces exactly the same results. If a variance is introduced in movements, any change in results is attributed to the variation. (Such an attribution maintains the ancient "principle of sufficient reason.") Time invariance requires a static environment and a fixed production system. Laboratories and consumer electronics devices aim to satisfy such requirements and to produce exact repetitions for prolonged periods. Animal bodies and movements of actual life have lesser capacities for such time invariance or for exact repetitions.

Movements that are produced in detached time can often be ***postponed*** or ***decomposed*** without changing results. Postponement means that timings between movements can be stretched out. Decomposition means that a big movement can be broken into a sequence of smaller movements, perhaps in various different ways. Decomposed movements can then be composed to recover the original movement. Novel compositions of decomposed fragments are sometimes possible.

In some repetitions in detached time, the ordering of movements – which of two movements is performed first and how movements are composed in sequences – can be varied without changing results; such capacities are represented by "commutative" and "associative" relations in mathematics. Other movements in detached time are ***reversals*** of original direct movements, also called "inverses" — subtracting where there was addition or returning to a prior position. A direct movement followed by a reversal movement adds up to a "null" or "zero" movement that is said to be the same as no movement at all. ***Mathematical groups*** are made of composed and ordered movements, reversal movements and null movements that operate in detached time.

Imaginary movements in detached time differ from those of animal bodies in actual time – e.g., romping on the floor with the kids – where trying to repeat movements, decompose movements, postpone movements or alter orderings of movements will usually change results. Actual movements are never reversible; two actual movements cannot add up to a null, even if an appearance of restoration is achieved. "You can't go home again" after home has changed.

Third: in ***controlled time***, operations in rational domains co-exist with bodily movements and changes in the domain of actual life. In other words, selections in rational domains trigger, inhibit or modify bodily movements in the actual domain; and perceptions and feelings that are rooted in the actual domain influence selections in rational domains. Practiced movements in a fixed environment are especially suitable for rational controls that select and vary details of repetitive cycles. Controlled actual movements can conform to rules of mathematical groups in limited ways in such an environment.

Many variants of controlled time occur in musical performances where movements of a musician are under the control of a conductor or ensemble or internal beat. Repetitive beats and cycling melodies provide gist for operational controls; but movements also require exercises of freedom in actual time on the part of each musician. Training programs of athletes provide long-range examples of controlled time, e.g., in records that track timings and laps in the swimming pool. Many electronics devices, e.g., computers, have internal clocks and operate in controlled time.

Particular controlled-time applications use rational methods to control actual movements but rational methods always have limited ranges of application. An application is specific to particular kinds of actual movement; attempts to apply the same rational methods to different kinds of movements can be risky. Riding a bicycle in traffic has greater risks than driving an automobile. Risky situations impose speed limits on actual movements that are controllable by reason. Rational methods must operate quickly enough to "keep up with" actual movements and to interact with bodies that manifest the ongoing physical principle of momentum. Otherwise, the bicycle rider loses control of the bicycle and of the rider's own body.

When a pianist first picks out a tune from a new piece of sheet music, it is clear that rational methods are controlling the movements of fingers. It may take many repetitions before the pianist is able to produce the different parts of the composition, to put parts together and to integrate them into a musical whole. After the pianist has fully learned the piece and skilled fingers are quickly "moving on their own" and "expressing feelings," rational methods are no longer in control. Movements of a whole person are being produced.

Another requirement of controlled movements is that movements themselves must be defined and constrained so as to be controllable by rational methods. The universal design of a piano keyboard with distinct white and black keys in a definite array defines limits to the pianist's movements so that they can be controlled by means of notes printed on sheet music. In contrast, movements of a downhill skier in a wilderness forest cannot always be so easily controlled. Skiers run risks of unforeseen hazards and loss of control that do not trouble pianists.

In ***mimed time***, a special kind of controlled time, an imaginary clock tracks imaginary events that take place in an imaginary domain, such as events in a physics paradigm. Important Conserved Energy (CE) paradigms operate with mimed time. Mimed time is intended to resemble actual time but imagination can manipulate mimed time in fantastic ways.

Part I of the project follows a course of progressive development of detached and mimed time paradigms that leads to a CE paradigm that is on the edge of freedom – the Ising Model. The Ising Model applies to a change or transformation in a magnetic body as temperature changes: at low temperatures, there is either a North polarity or a South polarity; but at high temperatures there is no polarity. When a hot un-polarized Ising Model cools below a "critical temperature," it goes through a whole-body change and acquires either a North polarity or a South polarity.

A whole-body change is called a ***phase change.*** An un-polarized body is in one form or phase and a polarized body is in another form or phase. The most familiar phase changes occur when a body of liquid water changes into ice — or into water vapor. During a phase change in the Ising Model, the body "chooses" between a North polarity or a South polarity. Sometimes, during repetitive phase changes in a fixed environment, a "tiny change in influence" changes the result. The physical principles set forth in the Ising Model paradigm have commercial applications in magneto-optical computer memory devices. A magnetic element in the device stores a bit of information: a North element denotes a "1" and a South element denotes a "0."

Virtual Energy (VE) paradigms of part II follow a similar course of progressive development but with new kinds of controlled time constructions. Critical point phase changes that are at the edge of CE constructions become central operating elements in VE constructions. Moreover, phase changes become ***activated***. In other words, VE paradigms operate with highly variable energy flows rather than with energy quantities that add up to a constant, as in CE. VE paradigms introduce flowing interactions and aim to operate in ways similar to those of animal bodies that speedily select from and combine rich repertoires of movements. In idealized paradigms, an organism – biological, engineered or personal – operates cyclically; and a whole-body selection occurs during each cycle. VE paradigms aim to apply to biological activity like the beating of a bird's wings to reach a certain perch; to personal psychological activity like chopping vegetables according to a recipe; and to technological activity of a Quad Net device assembly that models activities of an animal spine.

In Virtual Energy paradigms, there is a ready pool of "abundant" energy available; and controls operate by opening, squeezing and interrupting flows of energy and by adjusting competing dissipations ("wasted energy"). Such paradigms aim to apply to ordinary activities of muscle cells and nerve cells that drive muscles, where "more than enough" ATP energy packets are produced by mitochondria but where energy consumption and muscular force production involve friction, work loading and opposing muscles and where activations, energy consumption and resulting forces are controlled by combinations of signals originating from multiple locations and subject to multiple influences.

Competing dissipations and phase changes in VE devices are elements in models of sensory perceptions and image generation in addition to models of muscular movements. In Virtual Energy models, images are generated during underlying material processes that involve a new principle, the principle of Shimmering Sensitivity. Applying the principle to persons, operations that generate images also have independent repertoires and sensitivities and create continual innovations. Images that a person applies to actual life usually have originated in actual time in connection with events of actual life; they have since acquired an independent existence in memory and imagination and become subject to operations in detached time.

Device assemblies combine images and movements in ***sensory-motor modules***. In such a module, balance is first cyclically established and then lost during a phase change that involves Shimmering Sensitivity – and finally is again restored, ready for another round. During each phase change, a flicker of an image is generated and a movement is selected. In a model for itching and scratching, a locational image of an itch selects ongoing movements of spine and limbs in a series of momentary spaces constituted by possible movements.

In a more complex and layered model for "stop on red; go on green," each cycle of operations generates a perceived image that "matches" an image constructed from memory; a change in matchings in detached time triggers material processes that switch movements of the body in actual time. During repetitive activity in imagination, a delicate balance is shifted first one way and then the other way – with resulting consequences in movements of a person's body.

I. Actual Time, Detached Time and Mimed Time Paradigms of Conserved Energy

Overview of Part I. A number of standard physics paradigms are presented, analyzed and compared. Discussion aims at certain conclusions and bypasses mathematical details. Standard paradigms discussed in part I – based on Newtonian mechanics and Conserved Energy Thermodynamics (CET) – present features that are then reconstructed in new paradigms of Virtual Energy Thermodynamics (VET) discussed in part II. As a chief point of distinction, VET paradigms are continuously active while CET paradigms are grounded in periods of rest. Features of equipoise and equilibrium paradigms that are articulated in part I reappear in balancing paradigms set forth in part II.

In part I, a course of construction extracts features from: (1) mechanical paradigms (Atwood's machine, Hooke's Law, perfect gas), where dynamical movements that occur in actual time and mimed time contrast with equipoise and equilibrium movements that occur in detached time; (2) CET paradigms (ideal gas, Carnot cycle and critical point) where equipoise and equilibrium operations are performed in detached time and mimed time. Features are later reconstructed in part II VET paradigms in which controlled time cycling operations generate and lose balances.

In a corresponding psychological construction, dynamical movements that occur during a volley in a ping pong game (actual time) differ from those in chess, where players deliberate between moves (detached time) and also from those in videogames where movements of both machine and human player are controlled by computerized timings that may be variable. A conductor of an orchestra uses a different kind of controlled time.

CET paradigms have a central focus where multiple forces or influences meet and come to rest. In some CET paradigms, rest persists for indefinitely long periods of time; in others, movement starts from and returns to rest; and, in still others, rest is instantaneous and continually renewed. It is presumed in CET that paradigms based in rest comprehend all activities. In contrast, activated VET paradigms begin with streams of pulses and produce varieties of continuous, steady and jumpy movements that are controlled by rest, variable dissipations and competition.

Rest in CET paradigms starts with two equal weights in equipoise and adds an elastic body. The linear scale based on Hooke's Law relates stationary positions to weights. Paradigms lead to varied equipoise positions in ideal gases; to equal and opposing flows that produce equilibrium conditions in the perfect gas and that are developed to model perturbation and relaxation; to steady production in the Carnot cycle and steam turbines; and to stable and unstable bodies near the critical point of the Ising Model. A model with a "critical point" has two distinct ranges of activity that are based on distinct kinds of conditions; and they also have one unique form of activity that belongs to both ranges and that permits changing the range, a form of activity that serves, in other words, as a crossover point between ranges; and activities at such a "critical point" both mark a boundary and also have unique features that suggest potential applications.

Each paradigm, CE or VE, is constructed in an imaginary domain and consists of ***operations*** that are imaginary movements of imaginary bodies. An imaginary ***domain clock*** operates in the paradigmatic domain. In one kind of operation, the domain clock mimics an actual clock and ***mimed time*** so measured by the domain clock exactly resembles actual time for a certain period but is under the researcher's control. An imaginary domain clock can also operate in detached time in ways that are contrary to actual time, e.g., slowing time, stepping time, resetting time to 0 and even reversing time. As a prime example of mimed time paradigms, the Simple Harmonic Oscillator, said to operate dynamically, is built on top of detached time operations.

A. Mechanical perspective: Atwood's machine and Hooke's Law

Summary. Chief detached time and mimed time paradigms are thermodynamical. A broader context is provided by starting with mechanical paradigms. Atwood's original machine operates in actual time. The simple harmonic oscillator (SHO), based on Hooke's Law, produces cyclical movements in mimed time. "Equipoise operations" in new versions of Atwood's machine and Hooke's Law occur in detached time and foreshadow the Carnot cycle and the Ising Model.

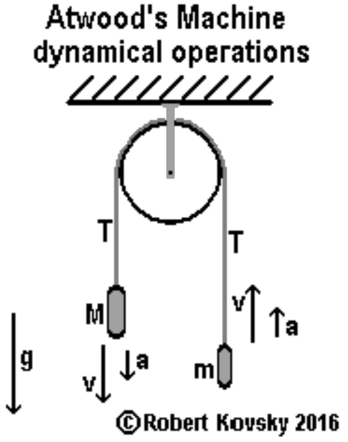
1. Atwood's machine

Important physics paradigms operate in actual time, including Newton's gravitational theory that describes actual movements of celestial bodies and Maxwell's theory of electromagnetism that is tethered to the actual speed of light. ***Atwood's machine*** exemplifies actual time applications of Newton's Laws; and then it is also adapted for equipoise operations in detached time.

a. original machine — dynamical operations in actual time.

Invented by George Atwood (1745-1807) to measure gravitational acceleration, the machine is a classic example of conserved-energy mechanics. (Marion, 261, n. 1; Goldstein, 18, 25-26.)

The adjacent figure shows an idealized and simplified design for Atwood's machine: a rope hangs over a pulley and connects two masses. Under the influence of gravity g, the heavier mass M falls, lifting up the lighter mass m. The rope has no mass in versions of the paradigms in this project.



One condition of operations is that the rope must be uniformly taut or tense; the tension is denoted by T. This ***taut rope condition*** binds movements of the rope and of the two masses into a single movement with a single velocity "v" and a single acceleration "a." In other words, both masses move with the same size v and a, but in opposite directions.

The taut-rope condition limits movements and operations that can be permitted. Permissible movements must be ***smooth***, with changes in time that can be described by mathematics functions that have continuous derivatives. ***Impulsive movements*** are prohibited: e.g., a brief interruption of a movement by grabbing, holding and then releasing one mass would send a jerk through the rope, contrary to the taut-rope condition.

In the paradigm, operations are strictly limited. Movement is in one direction only. The only effective force is gravitational. Idealized movements require a "perfect vacuum" with no air resistance. No friction can be permitted that might slow the pulley or heat the rope.

The chief aim of the paradigm is to state the acceleration of movement (previously defined as a) in terms of the sizes of the masses M and m and the value of g, the acceleration due to gravity.

Answer: assuming $M \geq m$, $a = [(M - m)/(M + m)] \times g$.

When m is close to M, a is much smaller than g; and a can be measured easily and precisely in a laboratory realization. At slow speeds, problems with friction and wear are reduced.

Suppose that a is greater than zero, that the machine is first held in a fixed position and that masses are released at time $t = t_0$. Velocity v increases uniformly with time; or $v = a \times (t - t_0)$. Assuming that nothing interrupts or modifies movements, velocity v increases without limit. The assumption lasts for only a short period of time while there is rope left to run through the pulley but it is good while it lasts. In this course of events, it is presumed that time is measured with an actual clock that is synchronized to a national standard.

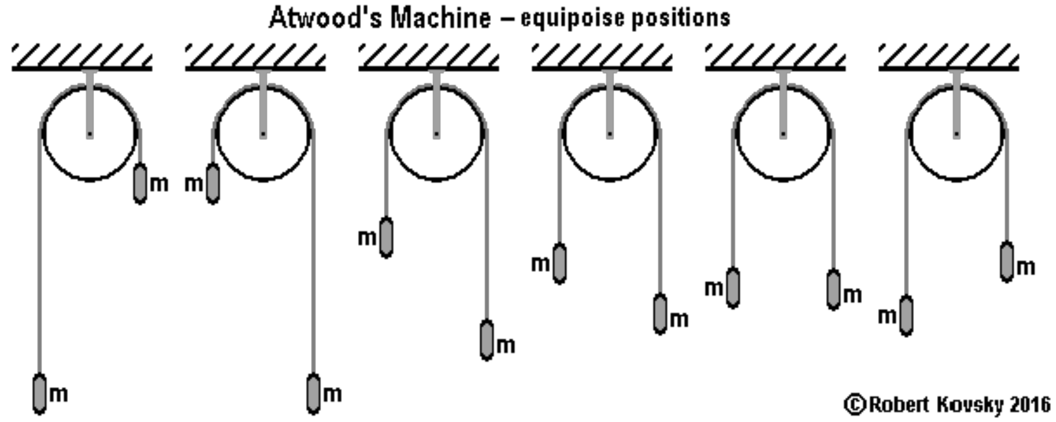
For purposes here, Atwood's machine provides a basis in mechanics for definitions and uses of words that are then developed to analyze thermodynamics paradigms, both CET and VET. A chief purpose of analysis is to distinguish actual dynamical operations in mechanics from detached equipoise and equilibrium operations in both mechanics and thermodynamics. During ***dynamical operations*** of the Atwood's machine paradigm, movements of bodies occur at rates determined by values of g, M and m. When the principle of Atwood's machine is realized in a laboratory, movements are measured by an actual clock and they occur in ***actual time***.

Also of importance is the fact that in Atwood's original machine, movements are the sole form of activity; a stationary state is, at most, part of preparation for a movement. Movements of the paradigm are realized in the laboratory and actual timings of movements are predicted from the paradigm. Movements in the laboratory domain are designed to conform to and coincide with movements in the paradigmatic domain, at least approximately – and any discrepancy is, at least at first, attributed to shortcomings in the laboratory domain. Movements in the two domains are indissolubly bound. In successful applications, operations of the rational paradigm predict or track or reproduce actual time movements of working models, such as working models built by Atwood.

As discussed in more detail below, actual time operations of Atwood's machine contrast with mimed time operations of the simple harmonic oscillator (SHO) that produce oscillatory movements. Operations of the SHO are grounded in Hooke's Law that is first defined for stationary states and then carried over uncritically to movements. Quantities involved in Atwood's machine – m, M and g – are referenced to actual bodies and movements; in the SHO, the chief property appears in the form of "k," a "spring constant" that exists only in imagination. An actual body may conform to a spring constant description but only for a limited range of movement and only in an approximate way. In practice, the value of k is adjusted to make actual measurements better fit the paradigm. The value of k so derived applies only to a specific piece of material over a specific range of movement. Specifying k requires a rational construction that forces a fit between limited phenomena and a mathematical form. In contrast, the specific value of g determined using Atwood's machine can be used anywhere on the surface of the Earth with a high level of precision.

b. adjustments and operations of an equipoise Atwood's machine occur in detached time.

A special version of Atwood's machine operates with ***equipoise positions*** if M = m and v = 0. As shown in the figure below, equal masses can be put into a large number of stationary or static or equipoise positions. An equipoise position never changes on its own; however, equipoise positions can be changed or adjusted by a researcher or other external cause. In other words, a researcher can adjust positions of masses to any stationary position within a range of positions. Operations in such an M=m machine are defined as movements that adjust masses between equipoise positions. More generally, ***equipoise operations*** are defined as movements between variable stationary positions that are established by equal and opposing forces.



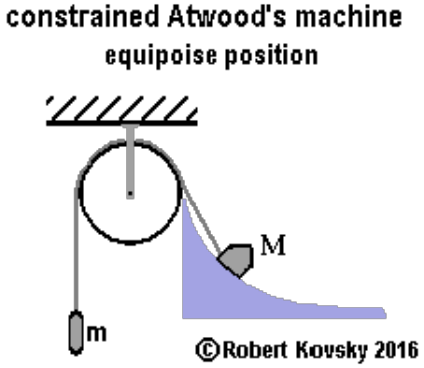
Additional restrictions and limitations are imposed on operations of the equipoise Atwood's machine. First: if set in motion, masses will continue to move until stopped. In equipoise operations, only stationary positions are recognized. Second: an adjustment of stationary positions violates strict conservation rules since energy must be used to set masses into motion at the start of an adjustment and to stop movements at the end. However, it is presumed that additional energy needed to start and stop movements can be disregarded in equipoise operations.

Operations of the equipoise Atwood's machine occur in detached time. Sizes of adjustments to stationary positions are easily varied, at least within limitations. A big adjustment can be broken up or decomposed into several small adjustments. A big adjustment can be composed from small adjustments. Details of decompositions and compositions can be varied. An adjustment to a stationary position can be postponed without changing the operation.

For any designated adjustment in the equipoise paradigm, there is another adjustment that reverses the designated adjustment and that restores the system to its condition prior to both adjustments. An adjustment followed by its reversal adjustment makes up a composed adjustment that is said to be a null adjustment. Adjustments, compositions, reversals and null adjustments make up a system of adjustments that can be modeled by a mathematical group.

Decomposition and reversal features of operations in detached time are absent from actual time operations of the original Atwood's machine. Actual dynamical movements are never reversible and reversed movements would resemble the "unreal" movements in a movie that is run backwards. In dynamical operations of Atwood's original machine, movements cannot be composed and attempts to break up or decompose movements would cause interruptions and violate the taut-rope condition of operations.

c. equipoise operations in a constrained Atwood’s machine.



A ***constrained version*** of Atwood’s machine is shown in the adjacent image. The left side of the device is the same as in the original machine, with a “loose” mass m. On the right side, the “constrained” and larger mass M rests on a curved slope that bears a fraction of the weight. Perhaps the slope is realized by means of a slot track, like a cable car but without friction; the larger mass moves freely on the slope and rests in a stationary position at the specific position on the slope that is determined by the ratio M/m. At that position, forces are in equipoise.

A ***continuity argument*** is used. The slope varies from nearly vertical close to the pulley to nearly horizontal far from the pulley. Where the slope is nearly vertical, an equipoise position occurs when the constrained mass M is just a little bit larger than the loose mass m. Where the slope is nearly horizontal, an equipoise position requires a constrained mass M that is much larger than the loose mass m. Assuming that the size of the loose mass m remains constant, the position on the slope where forces are in equipoise will vary with the size of the constrained mass M. A scale can be constructed on the curved slope where each position on the scale corresponds to a distinct ratio of the constrained mass to the loose mass.

An equipoise operation in the constrained Atwood’s machine builds on that of the equipoise machine but adds another component. It combines an adjustment to an equipoise position with a corresponding adjustment in the size of the constrained mass M. The change in mass and change in position occur together, with a relationship that is defined by the condition of equipoise and by the shape of the curved slope.

Suppose that the larger mass M has an iron frame with a mass equal to m and has ice as a filling material. As ice melts, the mass of M progressively diminishes and the equipoise position creeps up the slope. The rate of creep is controlled by controlling the rate at which the ice melts. In such equipoise operations, each position is stationary and could be frozen with a blast of cold air; but stationary positions appear to connect up into action, like an animated cartoon in a cinema. [See “The Cinematographical Mechanism of Thought and the Mechanistic Illusion” in H. Bergson, *Creative Evolution* (1911).]

Similar equipoise arrangements and operations are constructed below in paradigms of Hooke’s Law, the ideal gas and the Carnot cycle. All such paradigms operate in detached time. Movements, adjustments and changes can be decomposed, composed, reversed and postponed.

The principle shown in the constrained Atwood’s machine and generalized in later paradigms is that forces are in equipoise at each point along the curved slope. In imagination, on the curved slope, movements pass through a series of equipoise positions. There is ***continuous equipoise*** along the curved slope. As with the M=m equipoise machine, such imaginary movements along equipoise positions and such continuous equipoise operations occur in detached time.

d. oscillations of a constrained Atwood's machine occur in actual time around equipoise positions set in detached time.

Suppose that the two masses in the constrained machine are in static equipoise. Then suppose that a researcher displaces positions of the masses while maintaining a taut rope: one mass is moved up and the other mass is moved down. If the masses are held at the displaced positions and then released, the masses move back towards the equipoise positions. Their common velocity of movement is denoted by v; and they acquire kinetic energy denoted by [$\frac{1}{2}(M+m)v^2$]. They then pass through the static equipoise position at maximum speed, slowing afterwards until they reach an extreme position at the "far end" of the range-of-movement (ROM) on the other side, where they momentarily pause before beginning a reversed movement. Presuming an absence of friction or other loss of energy, the reversed movement proceeds until the masses return to the original displacement position that marks the "near end" of the ROM. There, movement pauses, before repeating the prior cycle.

Such movements, called ***oscillations***, occur in actual time, like movements of the original Atwood's machine. Extending the definition of actual time used for the original machine, movements occur at rates determined by values of g, M, m, the slope and the starting positions. If movements of the paradigm are calculated using Newton's Laws and the design is realized in the laboratory, actual timings of movements can be predicted from the calculations. Movements in the laboratory domain aim to conform to movements in the paradigm domain – and any discrepancy is attributed to shortcomings in realization in the laboratory. Movements in the two domains are indissolubly bound together.

e. adding dissipation to Atwood's machine paradigms.

Dissipation in an Atwood machine paradigm can be introduced, e.g., by imagining friction in the pulley or rope or by imagining immersion of a machine in a dense gas or a liquid. It is possible to imagine starting with very little added dissipation and then to increase dissipation.

First, suppose that equipoise versions of Atwood's machine are immersed in a liquid such as water. Equipoise operations remain much the same after dissipation is introduced in both equipoise versions of the paradigm. Two masses at rest in equipoise positions will remain at rest in a dissipative machine, the same as in a machine without dissipation. Equipoise positions do not change as dissipation is increased. Adjustments may require more energy under dissipative conditions but such energy costs are ignored in equipoise operations. Adjustments are slower under dissipative conditions but adjustments are never "instantaneous" and can be postponed. The same as prior to dissipation, an adjustment operation for a dissipative equipoise machine can be decomposed into a series of adjustments; intermediate adjustments can be postponed; and adjustments can be reversed – all without changing essential features of operations.

In contrast to the indifference of equipoise operations to dissipation, dynamical operations of Atwood's original machine are substantially changed if dissipation is introduced. In a model of frictional dissipation, a new force opposes the force of gravity so that acceleration a is reduced: $a_d = a_o - cv$, where a_d denotes the acceleration in the dissipative machine; a_o denotes the acceleration in the original machine; v denotes the velocity of movement; and constant c denotes a dissipative term that provides a rational or linear relation between v and a_d. As v increases, frictional forces increase and a_d diminishes. When v reaches the amount $v_t = (a_o - a_d)/c$, a_d has diminished to 0 and there is no more acceleration. Then v_t is called the "terminal velocity."

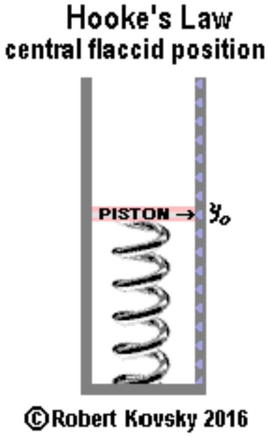
2. Hooke’s Law and the SHO paradigm.

a. The SHO paradigm begins with static positions, detached time and Hooke’s Law.

As introduced above, a physics paradigm begins with an empty imaginary domain and a domain clock. Hooke’s Law adds to such a domain an imaginary “spring” that is pictured as a metal coil. Unlike an actual spring, properties of a Hooke’s Law spring are completely described by a single number called the “spring constant,” along with a range of movement.

In the first construction, the only influence or force in the paradigm is embodied in the spring constant. Other potential influences are excluded from the imaginary domain. To start, there is no force of gravity in the imaginary domain. Movements in such a domain do not depend on the orientation of the spring in space. Movements do not slow because of friction in movements or heating of the spring.

In the Hooke’s Law paradigm shown in the figure below, a cylindrical container, vertically oriented, is closed at the bottom. One end of a Hooke’s Law spring is attached to the bottom of the cylinder and the other end of the spring is free to move up or down. A piston devoid of mass is attached to the free end of the spring; the piston slides easily inside the cylinder and steadies movements and positions. In a three-dimensional version constructed in imagination, the piston rotates easily inside the cylinder to accommodate twisting movements of the spring coil.



At the center of Hooke’s Law and SHO paradigms is a ***static*** position (y_0) where the spring is resting in a “flaccid” condition of loose immobility. In this position, it is easy to jiggle the free end of the spring up or down a little bit; but, to go beyond the little bit, a substantial force must be imposed. It is presumed that, when jiggling or force ceases, the spring returns immediately to the central static position.

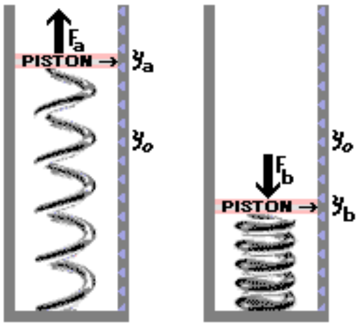
The central static position y_0 is called “y zero.” In the absence of gravity, it does not change if mass is added to the piston. The y_0 position serves purposes like those of zero in arithmetic. It is a central position with symmetrized operations up and down, within a range of motion. Nothing happens when the device is left at y_0 and no force is needed to hold it there.

A period of time at the y_0 position can be prolonged indefinitely. While the device remains at the y_0 position, the domain clock can slow, stop or go backwards without changing any results.

The central y_0 position is the only position that fully manifests all of the foregoing indifferences. Indifferences are shed in subsequent developments and the position of y_0 in the cylinder is moved; but the importance of y_0 is maintained.

Next, suppose that the piston is displaced from the y_0 position, as in the adjacent figure. To track displacements, introduce a variable y. Suppose that the piston begins at position $y = y_0$ and that the piston is moved to and held at a position $y = y_a$ that is different from $y = y_0$. In contrast to the loose immobile condition at $y = y_0$, it is necessary to impose a "holding force" F_a on the piston at $y = y_a$ or the piston will move. At a different position, e.g., $y = y_b$, a different holding force is needed, namely, F_b. In this case, F_b is different from F_a in both magnitude and direction. Displacement $(y_a - y_0)$ is greater than displacement $(y_b - y_0)$; the magnitude of F_a is greater than that of F_b.

Hooke's Law
displaced holding positions



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The holding force is defined in this paradigm as $F_h = k \times (y - y_0)$ where k, the spring constant, is a positive real number with appropriate dimensional units. The spring constant has the same value for all displacements $(y - y_0)$ where y is within the range of movement. The required holding force is in the same direction as that of the displacement from $(y = y_0)$.

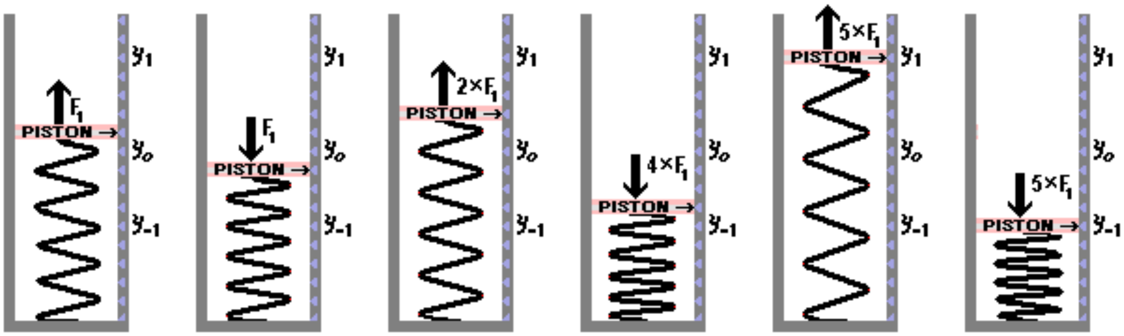
A stationary paradigm such as Hooke's Law qualifies for application of Newton's Third Law of Motion. ("For every action there is an equal and opposite reaction.") Therefore, a holding force that is defined as F_h is matched by an equal and opposing force F_s that is produced by the spring. This spring force, $F_s = - k \times (y - y_0)$, is said to come out of the elastic properties of the spring. In other words, each stationary position is maintained by a pair of equal and opposing forces, a holding force and a spring force. This approach is supported by the experience of a person exerting a force against a spring where the person feels a force coming from the spring.

$F_s = - k \times (y - y_0)$ is called "Hooke's Law" after its discoverer, Robert Hooke (1635-1703).

The figure below show operations of Hooke's Law for several piston positions. The range of movement (ROM) is the space between y_1 and y_{-1}. In the paradigm, the piston is moved to multiple positions within the ROM and the force required to hold it is measured at each position. If the displacement is doubled, a doubled holding force is required. The same principles applies in finer detail: a change in displacement of a specific percentage is matched by a change in holding force that has the same specific percentage. This is a ***linear relationship***.

As in the flaccid version, the holding force defined by Hooke's Law does not depend on the mass of the piston or spring. Hence, it is sufficient to show massless elements in the figure.

Hooke's Law -- a linear relation between force and space



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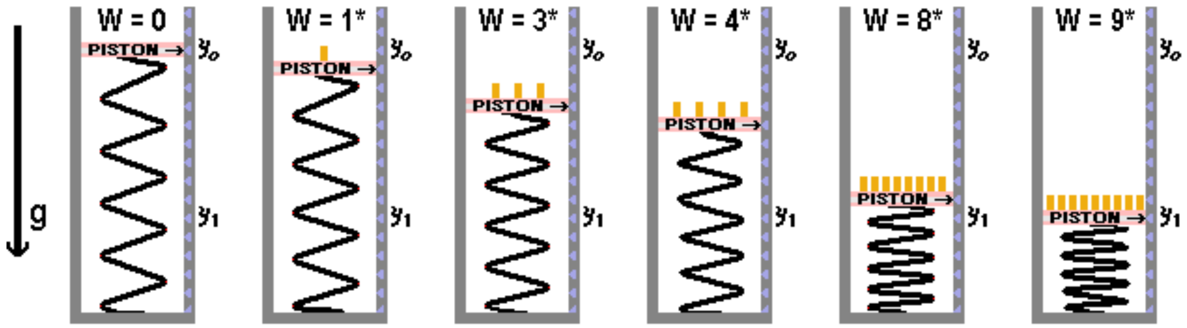
Static positioning and equipoise operations in the paradigm occur in detached time. In other words, in a system that conforms to Hooke's Law and Newton's Third Law, movements between equipoise positions and measurements of the holding force at various equipoise positions can be re-ordered, re-scheduled and reversed without changing results.

b. The Hooke's Law paradigm with gravitational force operates between equipoise positions in detached time.

As introduced in prior Hooke's Law paradigms, it is necessary to impose a "holding force" in order to maintain a position of equipoise that is different from $y = y_0$. The equivalent of a holding force can be imposed by the influence of gravity on a mass or weight w, as shown in the figure below. An equipoise position is maintained by a spring force that is equal to the gravitational force. In this version, the Hooke's Law paradigm operates as a "scale," both in the sense of a physical device to weigh objects and also as a rational device to connect variations in sizes of weights with marks on a line.

Hooke's Law -- spring force in equipoise with gravitational force



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An operation starts in one equipoise position with a certain weight and then adds or subtracts weights while controlling the movement to a second equipoise position. Control means that movements are smooth, not jerky, and are slow enough to ensure smoothness. Such movements and positions are similar to equipoise operations of Atwood's machine previously discussed. The Hooke's Law with gravitation paradigm is an advancement from the Atwood's machine paradigm in having two forces in equipoise instead of operating with the single force of gravity.

Additional restrictions are imposed on equipoise operations of this paradigm. Unless the system is in an equipoise position, masses will start to move and will continue to move until movement is stopped. In this paradigm, and unlike the original Atwood's machine, such movements are prohibited. Each mass size W will stand in equipoise at only a single position on the scale.

A range of movement (ROM) is specified and movements are confined within the ROM. Since mass must be positive, one end of the ROM is set at $y = y_0$. The other end of the ROM is set by limits of the system and is denoted as $y = y_1$. A mass of zero size is held at position $y = y_0$. The maximum mass W_M is held at $y = y_1$. A mass W can be any size between 0 and W_M. In the figure above, $W_M = 9^*$. The unit of weight, 1*, is denoted by an orange marker.

In physics paradigms, forces are combined by means of additions and subtractions. Easy paradigms use arithmetic additions and subtractions while other paradigms need vectors and tensors. The addition of a constant force of gravity to a linear SHO force produces a linear sum. In other words, the force of gravity is constant while Hooke's Law defines a linear relationship between space and force. Therefore, the "Hooke's Law spring with gravitational force" operates with a linear scale: in order to maintain equipoise, a percentage change in mass requires the same percentage in displacement from the flaccid $y = y_0$ position. Hence, the "linear" scale produced by Hooke's Law means that divisions between marks are equal and that divisions denote equal increments of weight. (In contrast, musical scales are not linear as to frequency.)

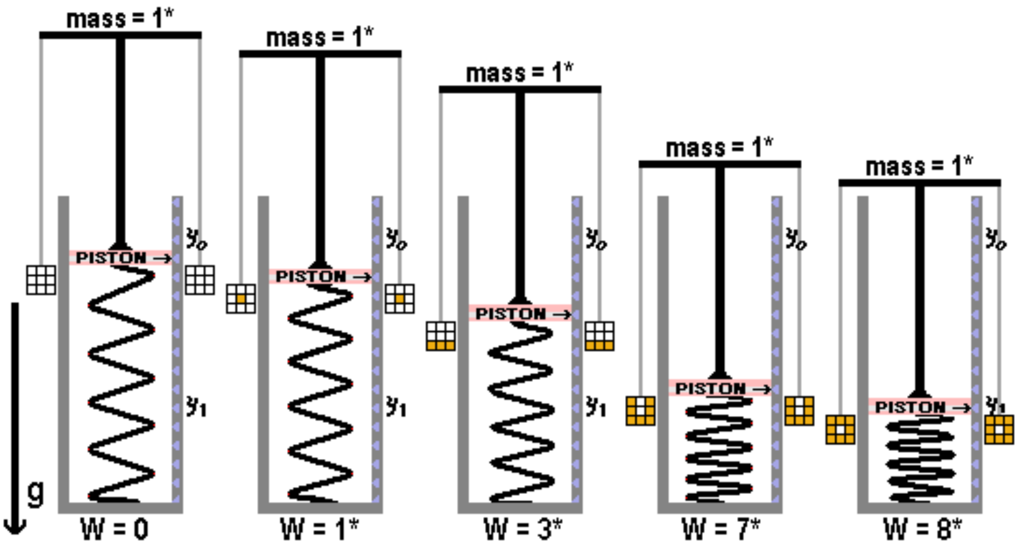
Equipoise operations of the new paradigm manifest detached time features. First, sizes of adjustments between static positions are easily varied without changing results. One big adjustment can be broken up or decomposed into several small adjustments and details of such a decomposition can be highly variable. Second, timings can also vary: a movement between equipoise positions can be postponed without changing the operation. Third, each adjustment has a reversal adjustment. Operations are independent of decompositions and postponements and operations can be attached to and detached from each other in various ways.

This paradigm illustrates special features of linear operations. If a movement is specified as a coordinated percentage change in mass and displacement from the $y = y_0$ position, the order of movements can be re-arranged without changing the result.

c. Equipoise operations of the Hooke's Law paradigm with added gravity can be controlled so as to model smoothly connected movements in detached time.

The figure below shows the Hooke's Law paradigm with added gravity in a revised version. Weights are relocated, with a pair of masses suspended by ropes. The apparatus and ropes have a total weight of 1*. Equipoise operations previously discussed are not modified by these developments: beginning from an equipoise position, a change in weight is coordinated with a smooth movement to a changed equipoise position. As before, everything operates without friction and ropes are always taut. As before, operations occur in detached time.

Equipoise positions produced by Hooke's Law spring and gravitation with a massive converter system and loose weights



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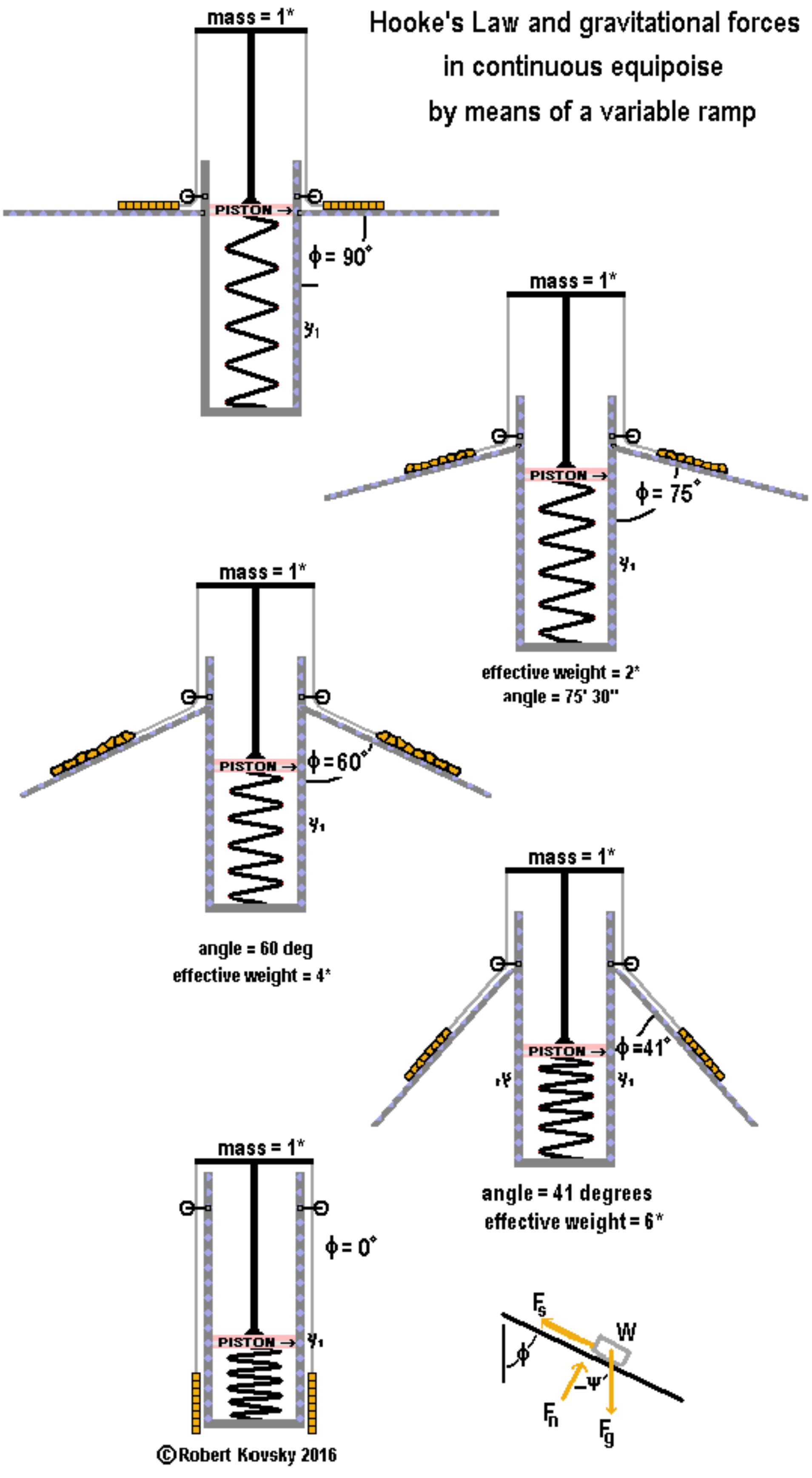
A ***ramped*** version of a Hooke's Law spring in equipoise with gravity, shown in the adjacent figure, introduces a new variable φ, which specifies the angle between the ramp and the vertical. Weights slide without friction on the ramp and angle φ ranges between 0 and 90°. When φ=90°, the whole weight is supported by the ramp and the spring force has only 1* to oppose it; the equipoise position of the weight is $y = y_0 + 1$ for any weight. When φ=0 the position is the same as in the loose weight version.

At an intermediate point, the position varies according to φ. It is possible to imagine that φ starts at 90° and then progressively shrinks to 0. As φ shrinks, the weight goes down on the scale. In the imaginary domain of the paradigm, such movements occur without friction and without any expenditure of energy. Spring force and gravitational force are in equipoise at each position.



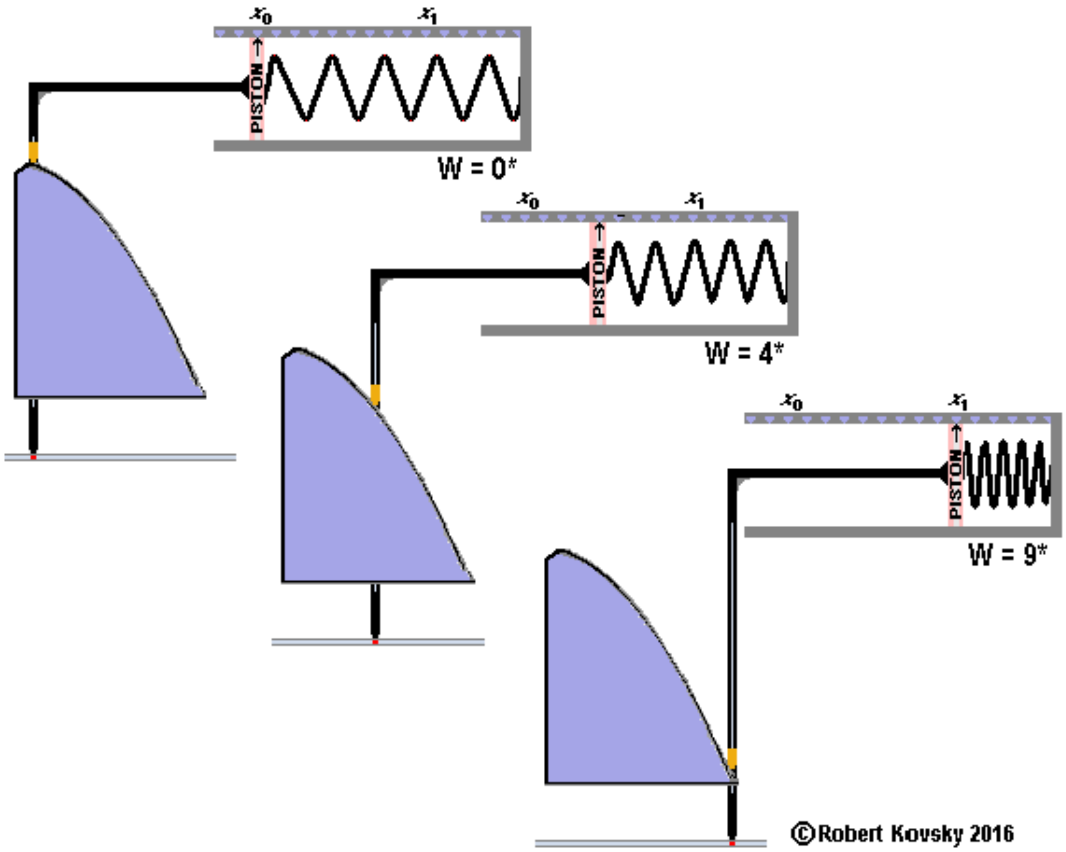
In this paradigm, the position z of the weight on the scale depends on g, k, W and φ. In that g and k are constant, a function G is defined such that G(W, φ, z) = 0. Such a function anticipates the equation of state for the ideal gas F(p, V, T) = 0, namely, PV = nRT.

The weight slides without friction on the ramp and is supported by the ramp; the ramp pushes with a supporting force against the weight in a direction perpendicular (or "normal") to the weight. The magnitude of the supporting force is equal to W × cosφ. The adjacent Figure shows relationships between forces on the weight in the ramped gravitational version of the Hooke's Law paradigm. The forces on the weight are in equipoise, namely the force of gravity imposed on the weight, the force of the spring imposed on the weight through the taut rope and the force of the ramp supporting the weight. Three different force directions are involved but the forces add to a null. Both the force of gravity and the normal force of the ramp against the weight are constant; therefore, for any added weight within the range 0* to 8*, there is a position on the scale where forces add up to 0. The desired position exists and it is unique.

Equipoise forces in the ramped paradigm illustrate another important feature that is developed below. Three different forces are involved in the paradigm: the spring force, the gravitational force and the supporting force of the ramp. Equipoise operations with three kinds of forces and with a ramp provide a mean to ***split forces in a variable way***. In this paradigm, the gravitational force is matched or balanced by the sum of spring force and supporting force and the relative proportion of spring and supporting forces changes as φ changes. These features reappear in ideal gas paradigms and Carnot cycle paradigms.

Next, forces and movements are re-constructed in further devewlopments. In the new version, the spring force operates in the horizontal x direction, the gravitational force operates in the vertical y direction and the supporting force operates in a variable intermediate position that carries out the requisite force split. Again, the result is a condition of continuous equipoise. (The revised force split anticipates thermodynamics transformations discussed below that lead to enthalpy and Gibbs free energy.)

The apparatus shown in the figure below weighs 1* and slides without friction both in the cylinder that holds the spring and also in the track at the bottom. The apparatus holds the fixed additional weight or “bolt” in a channel where it can move vertically under the influence of gravity. The channel presses on the bolt in the x direction with the force generated by the spring. The curved slope supports the bolt in a direction normal to the slope with a variable factor that depends on the position. In imagination, the three forces are “added” within the bolt, which achieves equipoise when the forces sum to zero. The requirement of equipoise at each position determines the shape of the curve. When the piston is at x_0, the slope is horizontal. As in the original Hooke’s Law paradigm, the piston can jiggle a little bit: the spring moves easily at that position and the weight glides easily on the flat surface. Moreover, the condition of easy glide continues at every position on the slope. Gravitational force and spring force are exactly equal all along the slope and adjustments with negligible energy move the weight between positions.



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d. Dynamical oscillatory operations of the SHO occur in mimed time.

Equipoise operations of the Hooke's Law paradigm are of first importance in this project. Most physics treatments focus on dynamical movements of the Hooke's Law paradigm, which then becomes the simple harmonic oscillator (SHO) paradigm.

During dynamical movements of the SHO, the paradigm domain clock operates in mimicry of actual time and events occur in mimed time. We prepare for such operations while in detached time by holding the mass m at position y_1 that is different from y_0. Then, we simultaneously start the domain clock and release the mass at mimed time $t = t_0$. In developing the paradigm to describe dynamical operations, it is presumed that Hooke's Law continues to apply, namely $F_s = -k \times (y - y_0)$. A sizable force is produced by the spring and there is no gravitation force or holding force; hence, the mass accelerates according to Newton's First Law of Motion: $a = F/m$. Equating the two F's leads to the familiar solution:

$y = (y_1 - y_0) \times \cos[\omega \times (t - t_0)]$ where $\omega^2 = k/m$.

ω has a dimension "per sec" and is called the "angular frequency." In the paradigm, movement of the mass occurs in a cycle with a period $\tau = 2\pi/\omega$. The period τ does not depend on the magnitude of the displacement $(y_1 - y_0)$ or on anything other than k and m.

Examination of the movements of the dynamical SHO shows that y_0 retains its central position even though it is not a position of rest. Rather it is the position of maximum speed of the mass. Positions of momentary rest occur at positions y_1 and y_{-1}.

The oscillatory SHO paradigm applies to certain actual phenomena. For example, transmissions of sounds in bodies of air, water and metals can be described by SHO principles operating at a molecular level. Math-like "harmonics" in music go back to Pythagoras in the 6th century B.C.E. Musical vibrations are oscillations; and vibrating musical instruments made of wood, metal and animal materials can be tuned exactly to frequencies that have a mathematical basis. For more examples of successful applications of the SHO, actual springs run clocks and watches with good precision and a similar paradigm applies to the pendulum clock, which can be even more precise.

Viewing SHO applications from a critical perspective, conformity of an actual material to the requirements of Hooke's law occurs, if at all, only approximately and only over limited ranges of motion. A wooden beam bears a substantial weight and bends a substantial amount; but it breaks if the weight is too heavy. Overdriven musical instruments produce buzzing noises. Unlike imaginary springs in the SHO, nearly all actual solids do change with use; and deformations leave traces that, after many repetitions, have a cumulative effect. A piece of metal that is repeatedly flexed and released may develop "fatigue," including cracks that lead to fracture. Violins sound different after having been played for many years.

Especially troublesome is the all-too-easy inflation of Hooke's Law defined for a static holding force into a dynamic principle. In other words, a movement in actual time is constructed from a succession of equipoise positions that are defined in detached time. As noted by Truesdell (79):

> First, in mechanics the concept of force originated in statics and was carried over bodily, if with much delay and discussion, to motions, If the restoring force exerted by a spring is proportional to the increase of its length in a static experiment, will it still be so when a ball is attached to the end and set into oscillations, especially if the experiment is performed in a spaceship in orbit around the moon? Indeed, does it make sense to talk about forces at all in a

> moving system? The forces, it seems, might be affected by the motions, yet we are supposed to know the forces first in order to determine what the motion will be. These questions, and far subtler ones of the same kind, were asked in the seventeenth century; today the freshman is trained specifically not to ask them.

Thus, a distinction between the Atwood's machine and SHO paradigms appears in the respective force relations. Newton's Laws of Motion are generally stated for moving bodies and apply to static bodies only as a special case that fits within the general case. Hooke's Law is defined for the static case and is then generalized without limit to apply to moving bodies.

Mimed time operations of the SHO manifest features different from those of actual time operations of Atwood's machine. Quantities involved in Atwood's machine – m, M and g – are referenced to actual bodies and movements. In the SHO, material properties appear in the form of "k," the spring constant that exists only in imagination. An actual body conforms to a "spring constant" description only for a limited range of movement and only in an approximate way. When laboratory measurements are made, the value of k is adjusted to make measurements better fit the paradigm.

The SHO paradigm would be useless if all materials had the same k, like all earth-bound bodies have the same g. For example, tuning a string on a violin or piano involves an adjustment of tension. Although there is nothing in the SHO paradigm that connects k to tension of a spring or of a string, we suppose that a suitable relationship can be constructed. However, the relationship that works for string instruments does not work for wind instruments, where tones are based on an air column in a pipe and the rate of vibrations can be adjusted by movements of the mouth of the performer (embouchure) or, in a larger way, by inserting an additional length of pipe, such as a brass horn "crook" that changes the key. In Atwood's machine, a single formula is precisely applied to a compact body of actual phenomena; in the SHO, a highly variable construction is manipulated for approximate conformity to various kinds and ranges of phenomena.

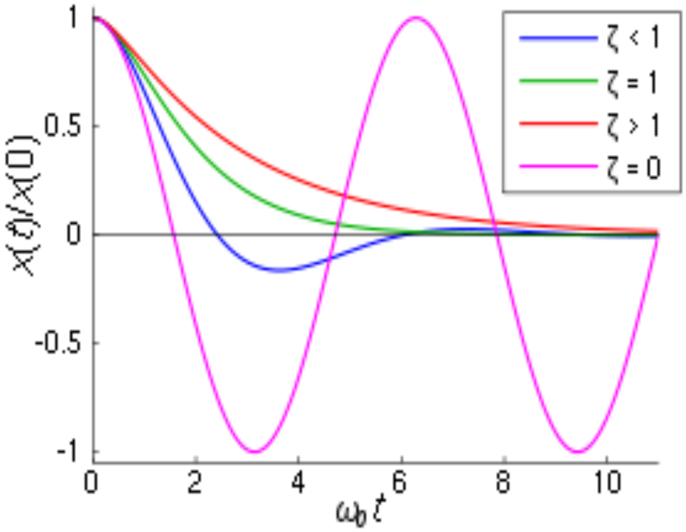
The distinction between actual time paradigms and controlled time paradigms is clearly shown by the ωt form of time that is used in the SHO. Actual time such as that used in operations of Atwood's machine cannot be stretched or compressed like an ωt form of time. Musical tempi also employ a stretchable ωt form of time, where ω appears in the form of metronome marks, e.g., ♩ = 80 or 80 beats per minute.

e. Dissipative operations of the SHO are movements in mimed time based on positions and movements defined in detached time.

A major development of the SHO is the introduction of an additional influence that is called ***damping*** (in mechanical paradigms) or ***dissipation*** (in broader classes of paradigms) and that is supposed to model friction and internal heating in actual bodies. Dissipation provides an additional means of control for the SHO and suggests further controlled time operations.

The image and caption below are copied from https://en.wikipedia.org/wiki/Damping and show aspects of dissipative operations. Each trace follows a separate movement of a dissipative SHO as measured by a domain clock that mimics actual time. Each movement starts from a position y=1 and a speed v=0 that is defined in detached time. Time is stretched or compressed to allow the traces to be directly compared.

The "damping ratio" ς tracks the amount of dissipation that affects such a movement. If $\varsigma = 0$, there is no dissipation; oscillatory movements continue indefinitely. If $\varsigma < 1$, there is small dissipation; oscillations die out — but, at least in the first return to the equipoise position, there is an "overshoot" or passing beyond the equipoise position, which occurs in the image below at about $\omega_0 t = 6$. If $\varsigma \geq 1$, larger dissipation prevents an overshoot. The value $\varsigma = 1$ identifies the least dissipation that will avoid an overshoot. It is a "critical" value. Critical value operations of the SHO provide the fastest return to static equipoise that avoids an overshoot.



Caption

Time dependence of the system behavior on the value of the damping ratio ζ, for

undamped (cyan),

under-damped (blue),

critically damped (green), and

over-damped (red) cases,

for zero-velocity initial condition.

As mentioned in Wikipedia, a mechanical door-closer may have a "damped spring" to return a door to the closed position after being opened. Critical damping provides the fastest closing that avoids having the door bang into the door-frame. Some door-closing devices have an adjustment to make it easier to achieve this standard of performance.

Critical damping operations introduce important features that re-appear in critical point operations of the Ising model and in critical moment operations of Quad Net devices. In such critical paradigms, there is a boundary between two kinds of operations; and operations at the "critical point" not only mark the boundary but also have special features of their own.

B. Ideal Gas and Perfect Gas.

1. **Summary**.

In this project, ***ideal gas*** is the name of a class of thermodynamics paradigms that date from Boyle's Law in the 17th century. Operations in ideal gas paradigms consist of movements between equipoise positions in detached time. So-called laws of energy conservation and entropy increase that were stated by Rudolf Clausius and others in the middle part of the 19th century are based on ideal gas paradigms and on detached time paradigms of the Carnot cycle.

In contrast, perfect gas paradigms and larger "kinetic theories" are mechanics constructions of the latter part of the 19th century. Perfect gas paradigms start in a domain of overlapping detached time and actual time called "equilibrium" and are then developed in ways that mimic movements in actual time. Perfect gas paradigms thus operate in mimed time.

This project employs the foregoing definitions but other investigators use terms differently. See J. S. Rowlinson, "James Joule, William Thomson and the concept of a perfect gas," http://rsnr.royalsocietypublishing.org/content/64/1/43.article-info (Notes and Records: the Royal Society journal of the history of science).

According to Rowlinson, such paradigms were not immediately accepted by all the founders of thermodynamics. William Thomson (1824–1907), developer of thermometric scales and later Baron Kelvin, declared that: "a mere quicksand has been given as a foundation of thermometry, by building from the beginning on an ideal substance called a perfect gas, with none of its properties realized rigorously by any real substance, and with some of them unknown, and utterly unassignable, even by guess…"

Results showed that "kineticists were justified in saying that a perfect gas is acceptable as the working substance of a Carnot engine. What may have aroused Thomson's apparently exaggerated fulminations may have been the behaviour of this gas when not at equilibrium. The application of the original form of the kinetic theory to a perfect gas leads, for example, to the prediction that such a gas has an infinite viscosity and infinite thermal conductivity."

Ideal gas paradigms and perfect gas paradigms converge in simple applications where equipoise operations of an ideal gas are equated with equilibrium operations of a perfect gas. In other words, "quasi-static" equilibrium operations in actual time would be indistinguishable from equipoise operations in detached time. When developed into paradigms of disequilibrium and irreversible processes, however, ideal gas paradigms and perfect gas paradigms have distinctly different characters.

(A third class of "statistical mechanics" paradigms also converges, in the simplest applications, with classes of ideal gas paradigms and kinetic theory paradigms. As discussed below, statistical mechanics constructions are tightly bound to equilibrium conditions and operate exclusively in detached time.)

2. the ideal gas paradigm operates in detached time

a. equipoise positions of the ideal gas paradigm

The adjacent image shows an ideal gas paradigm. A body of gaseous material at uniform temperature T is confined inside a cylinder of volume V. The cylinder is tightly enclosed but has a movable, massless piston – like the piston used in Hooke's Law and the SHO – which is maintained in a static position by equality of upward force from pressure of the gas inside the cylinder (p) and downward gravitational force from a weight on the piston (W) combined with atmospheric pressure (*).

As shown in the image below, equipoise positions can be changed. For example, a researcher can add a weight on the piston. Hot or cold liquid can be introduced into the base of the cylinder to heat or cool the gas. A new volume is typically required for equipoise to be re-established. The range of positions in the ideal gas paradigm resembles the scale of equipoise positions of the SHO plus gravity or in the constrained Atwood's machine. In ideal gas paradigms, mechanical forces and gas pressure forces add up to equipoise at each static position. Different static positions depend on different gas temperatures and different weights on the piston.

The ideal gas paradigm requires a perfect seal between the piston and the cylinder that provides frictionless sliding and that also prevents gas from leaving or entering the cylinder. Further requirements are that: the whole apparatus and all of its parts – including the piston, the cylinder and the base – are perfectly insulated and have no capacity to store heat – as a result, heat can neither enter nor leave the cylinder, except through the heat transfer element in the base of the cylinder. Heat is stored only in the body of the ideal gas. A "standard" operating environment is at sea level of the Earth, modeled by a fixed atmospheric pressure and a fixed gravitational force.

With a perfect seal and insulation and a fixed environment, "static" conditions can be maintained for an indefinite period of time. A static position is maintained by a balance or equality between the upward pressure of the gas within the cylinder and the sum of the downward forces on the piston. The downward force or "weight" provided by atmospheric pressure is denoted by "1*." Added forces are measured in units of 1*; various weights in the image are W=0, W=1*, W=2*, W=5*. The "standard" value of 1* is about 14.5 pounds per square inch (psi).

The temperature of the ideal gas is denoted by "T." Using standard parlance, T is measured by degrees Kelvin (°K), with the same spacing as degrees Celsius (°C) but with a different zero. Water freezes at the "standard temperature," 0 °C or about 273 °K. At T = 0 °K, "absolute zero," an ideal gas is inert. It is impossible to reach absolute zero: T must always be greater than 0 °K.

The changing volume of the cylinder occupied by the ideal gas is denoted by "V." Changes are also tracked by y, called ***the expansion***: $y \times A = V$ where A denotes the area of the cylinder.

To define gas pressure, apply Newton's Third Law of Motion. The upward forced exerted on the piston by the gas within the cylinder holds in equipoise the weight from atmospheric pressure * plus added weight W. Such force is expressed as pressure and denoted as $p = (1^* + W)/A$.

The definition of the character of an ideal gas – called its ***equation of state*** or ***constitutive relation*** – is based the foregoing rules and requirements for measuring values of variable quantities and is provided by the following formula:

$p \times V = n \times R \times T$, generally written $pV=nRT$. We have discussed variable quantities p, V and T.

Because T must always be greater than 0, both p and V must always be greater than 0.

Equivalently: $F \times y = nRT$, relating force $F = 1^* + W$, expansion y and temperature T in °K.

In the formulae, "R" denotes the "universal gas constant," a fixed number with a value that depends on the dimensional units used to define quantities in the laboratory where R is measured, e.g., depending on whether distance measurements are in inches or centimeters. R is the same fixed number for all gases that match up with the ideal gas paradigm.

The symbol "n" refers to the quantity of the gas; there is a "standard" where n = 1 denotes 1 mole of gas; a mole is standardized as a specific number of molecules or a specific volume. It is often convenient to ignore n and to assume a standard 1 mole.

The generality of the ideal gas law permits an arbitrary choice of dimensional units; and units can be chosen for pedagogical convenience. Suppose that we define ξ so that the expansion $y = 1\xi$ occurs when the only weight on the piston is atmospheric pressure ($F = 1^*$, $W=0$) and the temperature is 300 °K, just a bit above room temperature. Then: applying the ideal gas law, $1\xi \times 1^* = [nR] \times 300$ °K. The following table lists some of the equipoise positions that can be produced with such a system. Each position is defined by the ideal gas law and any two of: (a) temperature, (b) expansion, (c) force (weight) on the piston.

Temperature T =:				
1200 °K	F = 4* W = 3*	F = 2* W=1*	F = 1.33* W=0.33*	F = 1* W = 0
900 °K	F = 3* W = 2*	F = 1.5* W=0.5 *	F = 1* W = 0	
600 °K	F = 2* W = 1*	F = 1* W = 0		
300 °K	F = 1* W = 0			
expansion y =:	1ξ	2ξ	3ξ	4ξ

When corresponding properties of actual gases are investigated, experiments show that, within limited ranges of temperatures, the ideal gas law serves as a good approximation to a large class of actual gases but by no means all, The adjacent image is copied from Morse Figure 3-3 at page 26 and shows the ideal gas as a straight line at the center where the ratio pV/nRT is, by definition of the ideal gas, identically equal to "1.00" for all pressures. Morse states that: "Figure 3-3 shows curves displaying the departure from the ideal gas law of the equations of state of a few gases. We see that, except for gases near their temperature of condensation, such as CO_2 at 300° and H_2O at 600° the ideal gas law is correct to within a few per cent over a wide range of pressures and temperatures."

b. processes involving an ideal gas are operations that take place in detached time

The form $pV=nRT$ is subject to mathematical methods that imply a thread of connections or "analytic continuity" between nearby values of variables. It is possible to imagine a sequence of equipoise positions of the ideal gas paradigm that resembles mathematical continuity and to imagine movements between equipoise positions that follow the mathematics. Such imaginary movements between equipoise positions that follow mathematical forms are called ***processes***. Processes are: "Basic, explicit, and mathematically precise assumptions." (Truesdell, 83.)

Imaginary processes of the ideal gas paradigm resemble equipoise operations of the SHO. Both occur in detached time. An imaginary movement between static positions can be decomposed or postponed without changing the forces or temperatures that produce particular static positions.

The image below shows a series of equipoise positions that are part of an ideal gas paradigm with a single body of gas. In the first position, the temperature of the ideal gas $T = 300$ °K, y stands at 2ξ and $F = 1* + 5*$. In the second position, $T = 600$ °K, $y = 4\xi$ and $F = 1* + 5*$. In the third position, $T = 900$ °K, $y = 6\xi$ and $F = 1* + 5*$). Out of many equipoise positions that could have been chosen, these all have the same weights (and pressure).

In imagination, equipoise positions in the image constitute a succession of momentary states that occur during a single process in which a body of ideal gas is progressively heated so that it expands and lifts the piston. Suppose that, initially, the expansion $x = 2\xi$ and that the weight is maintained at $F = 1* + 5*$. Then imagine that the ideal gas is slowly heated from 300 °K and pushes the piston up. To start, a little bit of heat is put into the gas so it gets a little bit hotter. In symbols, T goes to $(T + \Delta T)$, where ΔT is small, perhaps 1 °K. Then, in the imaginary process, the added force from hotter gas will push the piston up an additional Δy where $\Delta y = [nR/(1* + W)] \times \Delta T$. Everything inside the brackets […] is fixed and there is a linear relationship between ΔT and Δy. Hence, little ΔT's can be added up to make a big ΔT.

The foregoing construction of a process becomes part of the ideal gas paradigm. It is called an "isobaric" process because the pressure remains the same. However, nothing is actually moving. The ideal gas paradigm does not include actual movements of the piston but only imaginary or constructive movements. In order to actually move, weights have to acquire momentum. Atmosphere weighing many pounds or kilograms would have to be pushed aside. Pushing aside such a weight requires energy in addition to the amount involved in a gravitational potential. Acquisitions of momenta and added energy requirements are ignored in the ideal gas paradigm.

Movements and operations in detached time are imaginary. In such operations, it is easy to imagine a series of "little bitty movements" and to combine them to construct a 'big" movement. Decomposition is equally simple. In such compositions and decompositions, energy costs of changes are disregarded. Jerky movements easily turn into smooth movements and smooth movements easily turn into jerky movements. Similarly, imaginary movements of ideal gas processes in detached time can be speeded up or slowed down without any costs.

3. perfect gas paradigms

   a. perfect gas paradigms that are restricted to equilibrium conditions can operate equivalently in detached time and mimed time.

Equipoise operations in detached time suffer in comparison to ***equilibrium operations*** that have a higher level of activation and multiple time forms. In equipoise operations, equal and opposing forces hold each other in fixed but variable positions. In equilibrium operations, equal and opposing flows in a steady environment produce a steady but variable condition.

Flows provide enlarged opportunities for control and innovation. Rational constructions using flows apply to many situations beyond the reach of static positions. Unlike static positions, flows can occur in actual time with rates that can be related to material properties.

In equilibrium paradigms, a body of material (gaseous, liquid or solid) can take on a variety of ***equilibrium conditions***. Seen from a large-scale perspective, a body in an equilibrium condition is devoid of movement or change. For example, distilled water sitting in a closed container at room temperature is in equilibrium – chemically, kinetically and thermally. The equilibrium condition, like conditions at equipoise positions, continues for an indefinite period of time. Changes can be decomposed into smaller changes and can be postponed. As with equipoise positions of the ideal gas, changes between equilibrium conditions are outside the equilibrium paradigm; but, unlike ideal gas paradigms, the perfect gas paradigm can be extended and varied so as to apply to some changes.

Equilibrium paradigms presume that a body in an equilibrium condition in a steady environment will remain in that condition unless moved or changed by an external influence. The simplest paradigms presume that any such movement or change is proportional to the external influence (a linear response). Further: it is presumed that if a body is isolated from all external influences, it will tend towards an equilibrium condition. A body left alone long enough in a steady environment will end up in equilibrium and stay there until moved by an external force.

Equilibrium requires conceptual isolation of the body. Perfect isolation is not possible in actual life. Any actual body radiates heat and receives heat radiated from other bodies. Some bodies conduct heat to other bodies. If a body remains in an equilibrium condition, and if no energy transfer occurs except by transfers of heat, the heat received must be equal to the heat radiated or conducted away. This requirement is troublesome to achieve in actual life but can be met by surrounding an inanimate body with walls at the same temperature as the body.

Equilibrium presumptions apply to some inanimate bodies that lack internal sources of energy; but the presumptions do not apply to living animal bodies. Such bodies never reach equilibrium. An animal will sleep for a while and then start moving on its own. Vegetable seeds also fail to fit the equilibrium model: they can remain inert for centuries and then spring into life.

Despite limitations, equilibrium has important uses. Branches of chemistry, e.g., biochemistry, are solidly rooted in equilibrium. Equilibrium operations in gases are explored in a branch of thermal physics called ***kinetic theory***. A kinetic theory is rational or axiomatic. The foundational construction of a perfect gas is stated in Morse at 14.

> Let us assume a very simplified model of a gas, one consisting of N similar atoms, each of mass m and of "negligible" dimensions with negligible interactions between them so that the sole energy of the *i*th atom is its kinetic energy of translation…

> The gas is confined in a container of internal volume V, the walls of which are perfect reflectors for incident gas atoms. By "negligible dimensions" we mean the atoms are very small compared to the mean distance of separation, so that collisions are very rare and most of the time each atom is in free motion. We shall call this simple model a *perfect gas of point atoms*.

It is also stated that "collisions are elastic." Of pivotal importance is the interplay between such elasticity, the restriction that "the sole energy … is … kinetic energy" and the restriction that "collisions are very rare." Suppose that two identical elastic atoms traveling at the same speed but in opposite directions collide directly head-on and then rebound in reversed directions. At the center-point of the collision, both atoms come momentarily to rest: applying Conserved Energy principles, the previous kinetic energies must be stored in elastic materials like that used in the SHO. But then, the sole energy is not kinetic. Because "collisions are very rare," energy stored in elastic materials might be ignored; but then changes occur very slowly. Similar problems beset the "perfect reflectors" in walls, which can be resolved by having the walls at the same temperature as the gas so that the walls and the gas are all at equilibrium together. This solution creates problems with changes because both walls and gas have heat capacities – but such problems are disregarded in kinetic theories.

A perfect gas, so defined, can be put into equilibrium conditions and also conditions where equilibrium is lacking. For an example of disequilibrium conditions, suppose that the container of the gas is divided into two equal regions by an insulated wall. On one side of the wall, a high density of atoms is maintained in equilibrium; on the other side of the wall a low density of gas atoms is also in equilibrium. At first, the two regions have no interaction. Next, suppose that tiny holes are opened in the insulated wall and that small flows of atoms pass through the wall. Flows will pass through in both directions but flows through the wall from the high density side will be heavier than flows from the low density side. As a result, the densities on both sides of the wall will change and conditions on both sides will depart from equilibrium. Eventually, the flows and changes will remove all difference in the densities and equilibrium will be restored.

To deal with such cases, James Clerk Maxwell (1831-1879) invented a concept that Truesdell (414-415) calls a "molecular density function *F*" and that Morse (162-63) calls it a "probability density *f*" or a "probability distribution." Morse states: "Probability distributions are the connecting link between atomic characteristics and thermodynamic processes." Truesdell concurs: "Thus the kinetic theory yields for equilibrium, duly defined, exactly the same gross differential equations as does … a corresponding ideal gas."

Truesdell provides an analytic definition. "MAXWELL regarded as being appropriate to equilibrium any molecular-density function *F* such as to be unaltered by collisions." Allowable flows under this definition would "include arbitrary expansions and rotations" and "represent something a little broader that what we think of in ordinary mechanics as equilibrium. WANG's definition of *local equilibrium* in the kinetic theory is $F(\mathbf{x}, \mathbf{v}, t) = F(\mathbf{x}, \mathbf{v}) = F(\mathbf{x}, -\mathbf{v})$. That is, *F* shall be steady and invariant under reversal of velocities."

In other words, there is a large class of *F* functions that apply to flows of atoms. If every flow of atoms were to be reversed, many *F* functions would change. For example, if flows in the disequilibrium situation described above were to be reversed, differences in densities would increase with time. Such events do not happen in actual life. Fortunately for perfect gas theories, equilibrium functions *F* as defined by WANG would be unchanged were such reversals to occur.

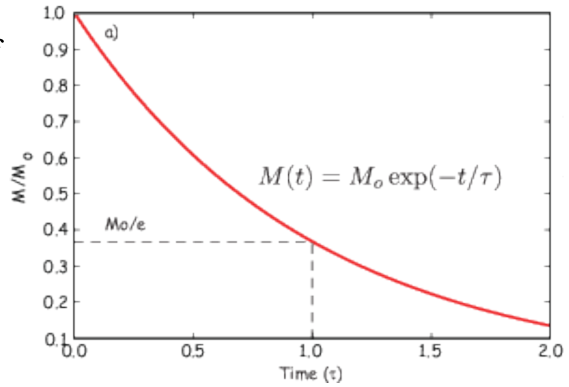
Alternatively, a definition of equilibrium is that *F* shall be steady and invariant under reversal of ***time***. If time reverses, velocities also reverse and the result would equivalent to that based on WANG's definition. As in the ideal gas paradigm, a body in equilibrium in the perfect gas paradigm would continue in equilibrium "the same" if time were to be reversed. Such changes are simple to perform in detached time.

Another resemblance between classes of equipoise operations – e.g., in Atwood's machine, in the SHO, in the ideal gas and in the class of equilibrium conditions in a perfect gas – is that they are special classes that contain only a small fraction of possible operations. Special features that facilitate mathematical development also suggest that such development has only a limited reach.

b. disequilibrium and relaxation

In the SHO, oscillatory movements in mimed time are based on equipoise positions set in detached time. Hooke's Law is defined for fixed positions and carried over into movements. Similarly, perfect gas paradigms of Maxwell and Ludwig Boltzmann (1844-1906) begin with equilibrium conditions maintained under steady conditions in detached time and investigate departures from equilibrium. Under steady conditions, a small departure of a from equilibrium leads to a return to equilibrium. In some cases, operations can be related to certain specific classes of actual phenomena.

In the paradigm, after a small departure from equilibrium, a perfect gas ***relaxes*** with a rate of relaxation that is, at each moment, proportional to the departure from equilibrium; the constant of proportionality is determined by material properties, like the spring constant in Hooke's Lw. Such relaxation is expressed by the "exponential decay form" $\exp(-t/\tau)$. Exponential decay forms also appear in the dissipative SHO when the damping ratio $\varsigma > 0$.



The period τ is called the "relaxation time." After one τ period, a departure from equilibrium has diminished more than 63%. After two τ periods, the departure has diminished more than 86%.

The exponential decay form is smooth and continuous through multiple derivatives. In the dissipative form of Hooke's Law, a change in rate resulting from friction is similarly defined as proportional to the rate. Simple proportional relations also appear in ideal gas paradigms.

Such simple proportional definitions are called ***linear***. Linear forms are smooth and continuous. On the other hand, linear methods often fail to apply to jumpy or discontinuous movements. As to some situations and tasks, ***non-linear*** methods work better. Virtual Energy Thermodynamics is designed to work with jumpy and discontinuous movements.

Morse (206-207) assimilates the relaxation time τ to the average time between collisions of the gas atoms. This is because "the distribution can return to equilibrium in one collision time." "Detailed calculations for the few cases which can be carried out, plus indirect experimental checks … indicate that it is not a bad approximation…"

Truesdell provides a more critical view of "molecular interactions." "In kinetic theory, these interactions are called 'collisions' and are visualized as motions of pairs of molecules subject to their mutual attraction or repulsion alone. On the one hand, the gas is regarded as a vast multitude of speeding molecules; on the other, to describe the details of a collision the entire universe is supposed empty except for two molecules."

"Physicists no longer regard the molecules of even helium or hydrogen as mathematical points or spheres following the laws of the Newtonian mechanics of conservative systems. Moreover , the kinetic theory contradicts those laws, for they obey the reversibility theorem, while the kinetic theory …represents the gas as a dissipative material…[and] rests upon a peculiar stochastic hypothesis of quasi-equilibrium: The pairs are statistically independent not only before but also after each encounter. … The interest of the kinetic theory is purely rational, not physical."

3. The Carnot Cycle.

a. **Summary**.

The Carnot cycle is a thermodynamics paradigm that has many uses, e.g., in designing electrical power plants that run on steam. It was introduced by Sadi Carnot (1796-1832), a military engineer, in *Reflections on the Motive Power of Fire* (1824).

In his rational thermodynamics, Truesdell defines the Carnot cycle as an axiomatic sequence of processes operating in an imaginary "heat engine," e.g., as an idealized steam engine. Truesdell derives or deduces the First and Second Laws of Thermodynamics from Carnot cycle processes. In other words, Conserved Energy, the content of the First Law, and Entropy, the content of the Second Law, are rooted in axiomatic presumptions. "Carnot cycles are ordinary, sound elements of mathematics, and reasoning based upon them can be good, sound geometry." (Truesdell, 32.)

The Carnot cycle operates in detached time but has an irreversible and productive character. In the Carnot cycle, costly heat turns into productive work. On the other hand, processes requires that some productive work turns into waste heat. Fortunately, processes can be arranged so that there is a net gain in productive work.

The components of Carnot cycles are ***adiabatic processes*** and ***isothermal processes***. As discussed above, such processes are imaginary movements of imaginary bodies and take place in detached time.

As shown below, an adiabatic process consists of imaginary movements between equipoise positions in detached time, similar to equipoise operations of Atwood's machine, the SHO and the ideal gas. An isothermal process employs equilibrium operations that occur either in detached time or mimicked actual time, in a form called ***quasi-static*** that is highly restrictive. In brief, Carnot cycles are rational constructions based on imaginary movements in detached time so as to approximate certain actual movements in actual time. If actual movements are smooth and limited to well-defined ranges, imaginary approximations can be valid and useful.

Paradigms based on the Carnot cycle help to identify areas of useful application for Conserved Energy principles. Conversely, the limited reach of axiomatic presumptions helps to identify phenomena, chiefly "the critical point," where Conserved Energy has diminished utility.

Two representation of the Carnot cycle are shown below, Morse's Figure 5-1 (p.49) and Truesdell's Figure 1A.1 (p. 90). The definition according to Morse states:

> A Carnot cycle operates between two temperatures, a hotter, T_h, that of the heat source, and a colder, T_c, that of the heat sink. Any sort of material can be used…And any pair of mechanical variables can be involved, P and V or J [stress] and L [strain] or $\mathscr{H}$ [magnetic field] and $\mathscr{M}$ [magnetization] (we shall use P and V just to make the discussion specific). The cycle consists of four quasi-static operations: an isothermal expansion from 1 to 2 (see Figure 5-1) at temperature T_h, withdrawing heat [] from the source and doing work []; an adiabatic expansion from 2 to 3, doing further work [] but with no change in heat, and ending up at temperature T_c; an isothermal compression at T_c,. from 3 to 4 requiring work [] to be done on the system and contributing heat [] to the heat sink at temperature T_c, ending up at state 4, so placed that process 4 to 1 can be an adiabatic compression, requiring work [] to be done on the system to bring it back to state 1, ready for another cycle (Figure 5-1). This is a specialized sort of cycle but it is a natural one to study.

Morse further states (p. 50): "We note that, since all the operations are quasistatic, the cycle is *reversible*; it can be run backwards…"

Truesdell's representation shows two Carnot cycles; his construction "serves to define a Carnot cycle $\mathscr{C}$ within $\mathscr{C}_0$." The set of all possible $\mathscr{C}$'s makes up "the *Carnot web* that corresponds to $\mathscr{C}_0$." Important functions in his construction "depend … upon the cycle $\mathscr{C}_0$ that engenders the web." Features of each $\mathscr{C}$ resemble corresponding features of $\mathscr{C}_0$ so that $\mathscr{C}_0$ governs the web and all possible $\mathscr{C}$'s within it.

In a fashion similar to Truesdell's web, Morse presents an "Arrangement of two Carnot cycles so their combined effect is equivalent to one cycle between the temperature extremes." (Figure 5-3 at 54.) He uses two engines where the lower temperature of the first engine is the higher temperature of the second engine and heat discharged from the first engine during its stroke 3 to 4 is absorbed by the second engine during its stroke 1to 2. Figure 5-4 (p. 57) similarly shows a "Reversible cycle [] simulated by a combination of several Carnot cycles." "In principle we can build up a combination of Carnot cycles to simulate any kind of reversible cycle…" (P. 58.)

a. a reversible adiabatic process is produced by continuous equipoise operations that occur in detached time.

Constructions in this stage combine and develop features from the curved-slope SHO paradigm and the ideal gas paradigm.

b. "quasi-static" operations in an isothermal process combine detached time features with actual time features in constructions suitable for steady flows.

(Morse, p. 39.) "Of course the process must be that slow, stepwise kind called quasistatic, if we are to use our thermodynamic formulas to calculate its change." "remove enough heat from the gas, keeping its volume constant meanwhile, to lower is temperature… we could do this relatively quickly (but not quasistatically) by placing the gas in thermal contact with a constant-temperature heat source at temperature ξ. Such a source, sometimes called a *heat reservoir*, is supposed to have such a large heat capacity that the amount of heat contributed by the gas will not change its temperature. In this case the gas would not be in thermal equilibrium until it settled down once more into equilibrium at t=tξ. To carry out a quasisstatic process, for which we could use our formulas to compute the heat added, we should have to place the gas first into contact with a heat reservoir at temperature $T_1 - dT$, allowing it to come to equilibrium, then place it in contact with a reservoir at $T_1 - 2dT$, and so on.

Morse, p. 40) "Thus, thermodynamic computations, using an appropriate quasistatic process, can predict the change in [state variables] for any process, fast or slow, which begins and ends in an equilibrium state. But those calculations cannot predict the amount of inteake of heat or the production of work during the process unless the process differs only slightly from the quasistatic one used in the calculations."

Morse 42, "perfect gas ,,, perfect isothermal energy transformers, changing work into heat or vice versa without holding any of it along the way. The transformation cannot continue indefinitely, however, for physical limits of volume or elastic breakdown or magnetic saturation of the like will intervene."

Truesdell at 37, quotes and criticizes Bridgman. "It has always been a reproach to thermodynamics that its handling of irreversible phenomena was inadequate or even impotent. We are now finding out how to deal with large and important groups of irreversible phenomena by methods in the spirit of thermodynamics. … It is possible, I believe, to go even further in the treatment of irreversible phenomena in the spirit of thermocynamics. Classical thermodynamics defines the entropy only of those states of the body which can be reached from a standard state. Such a definition rules out on principle most of the matter of daily life, because most states can be subject to no reversible displacement whatever – any plastically deformed metal is an example, or any biological system." (Truesdell's developments beyond "classical thermodynamics" do not extend to "biological systems.")

c. the Carnot cycle is used for detached time models of steady production processes.

d. detached time investigations of phase changes use constructions (Clausius-Clapeyron relations) that resemble Carnot cycles and lead to the critical point.

4. The critical point.

II. Controlled Time Paradigms of Virtual Energy Thermodynamics

Summary. Pulser devices were introduced in the original Quad Nets paper. Definitions of pulser devices, timing devices and Quad Net devices are outlined in the original paper, as organized and controlled by the Quad Nets functional, a math-like form. Timing devices were later developed in ways that did not depend on such forms. The most recent developments based on bursting devices and corresponding force devices introduce new and more general means of control. A “kit of parts” containing such devices is used for designs of engineered organisms that exercise freedom, e.g., anticipated designs that mimic movements of aquatic worms and eels.

A. Pulser devices

The Figure below shows a primal pulser device at three levels of depth. On the most superficial or operational level, the device discharges pulses with a uniform period τ_0 between pulses, like a clock or a metronome. Each pulse lasts an “instant,” which is the shortest period of time used in designs. Halving or doubling the length of time in an instant would not change any results. Discharged pulses travel away from the device on the “from projection” and resemble action potentials that travel on nerves or electrical impulses that travel on copper wires. Each pulse carries away 1 unit of Virtual Energy, called a “bang” and symbolized by “!.”

On the second deeper or VES level, the primal pulser device contains a Virtual Energy Store or VES. Virtual Energy (VE) flows into the VES at a rate R and is stored in the VES until one bang of VE is accumulated and then that bang is discharged via the from projection. The paradigmatic equation is $R \times \tau_0 = !$.

The third and lowest level shows the primal pulser in the context of its Virtual Energy environment. Electronics systems provide a partial analogy. Many electronics systems have a ***power supply*** that is independent of operational parts. The power supply connects to the standard commercial electrical power grid that provides an AC signal 110 volts and 60 Hz; and the power supply turns that signal into the particular forms needed for operations, such as 6 volts DC.

B. Timing devices

C. Force devices and bursting devices

Constructions of force devices are set forth in the *bursters* project discussed at www.quadnets.com/bursters.html The following materials are adapted from that project.

1. In a rigidly affixed and fully extended force fiber device, pulse bursts in Ψ-forms drive forceful twitches, operating with a linear variation.

A foundational movement is a ***twitch produced by a force fiber device***. As shown in Fig. 6, a force fiber device has two chief parts: (1) a signal ***detector*** which receives pulse burst signals; and (2) an ***effector***, which produces forceful contractile twitches and which can thus perform mechanical work, e.g., lifting a weight.

Arrival at the detector of the leading pulse of a burst starts the detector Ψ–form: the detector ***notices*** the burst for three ticks, denoted by "N" in its Ψ–form. During the next tick, joint ***processing*** in detector and effector, coded by "P," includes ***triggering*** of a forceful ***contraction*** of the effector, coded by "q" and "Q." The period of contraction starts at tick 2 (coded q) in the Ψ–form of the effector, with a force strength that starts at a minimum and that ramps up to the specified level as shown in the following Fig. 7. After a steady force for the next three ticks, marked Q, the strength level ramps down during effector tick 6, again marked q. On average, ramping q is half the force of steady Q. The tired effector ***recovers*** during its tick 7, activity coded by "R." Then it waits for a new contraction while in a ***ready*** condition coded by "r." When the effector is not contracting – during ticks P, R and r in the effector – the fiber has a minimal tautness. A tired detector recovers (R) after processing a burst but continues to be blocked (XXX) from receiving a new burst until expiration of the 8-tick detector Ψ–form.

twitching of force fiber device driven by pulse bursts

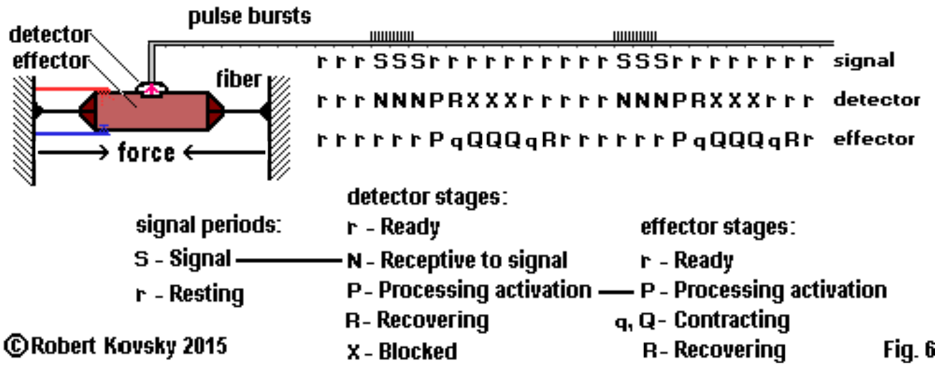


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Fig. 6

Repertoire of pulse-burst signals and forces of a twitching force fiber device

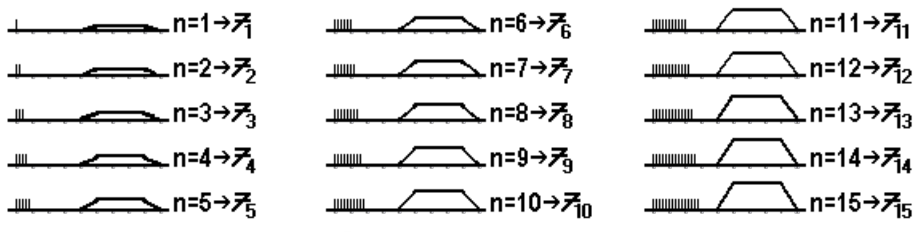

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Fig. 7

Fig. 6 shows an ***affixed fiber*** attached to rigid supports at maximum length. An affixed effector contracts isometrically even though actual movement is impossible. Initial definitions apply to a rigidly affixed and fully extended force fiber device. Then rigid constraints are relaxed for development of actual movements. A shortened fiber device generates a smaller force.

2. Two force fiber devices operating as a duet are driven by reciprocating and repeating bursting devices to produce steady forces that hold a weight.

Fig. 9 shows two force fiber devices, a and b, coupled together in a ***duet***, the first in a series of ***ensembles***. The two force fiber devices share physical connections that carry forces; they produce alternating forces that combine to hold a mobile weight W steady inside a supporting and constraining cylinder. The only possible movements of the weight are up and down; the only forces are provided by gravity and by the duet. In initial constructions, forces are in balance.

Fig. 9 also shows two ***repeating bursting devices***, A and B, that are connected reciprocally and that generate pulse bursts in a stiff Σ-form on reciprocating and output projections, similar to steady pulse trains shown in Fig. 2. Each repeating bursting device or "burster," denoted by "R," has a detector and a body that resemble the detector and the effector of a force fiber device.

The duet design aims to produce a steady but variable force **F**. Duet fibers share a variable length, denoted by ℓ_x. The quantity $\ell_1 - \ell_x$ ranges between $\ell_1 - \ell_x = 0$ at full extension and $\ell_1 - \ell_x = L$ at full contraction ($\ell_x = \ell_0$). L defines the range of motion (ROM). The strength of **F** is equal to that of $\mathcal{F}$, the central twitch strength. A steady **F** is "patched" together from alternating twitches; a successor twitch ramps up just as a predecessor twitch ramps down. As to momentary force, q+q = Q = $\mathcal{F}$ = **F**. In Fig. 9, gray ramps appear below the blue line that is tracing a steady **F**.

Steady force produced by a duet:
two joined force fiber devices driven by two reciprocating bursting devices

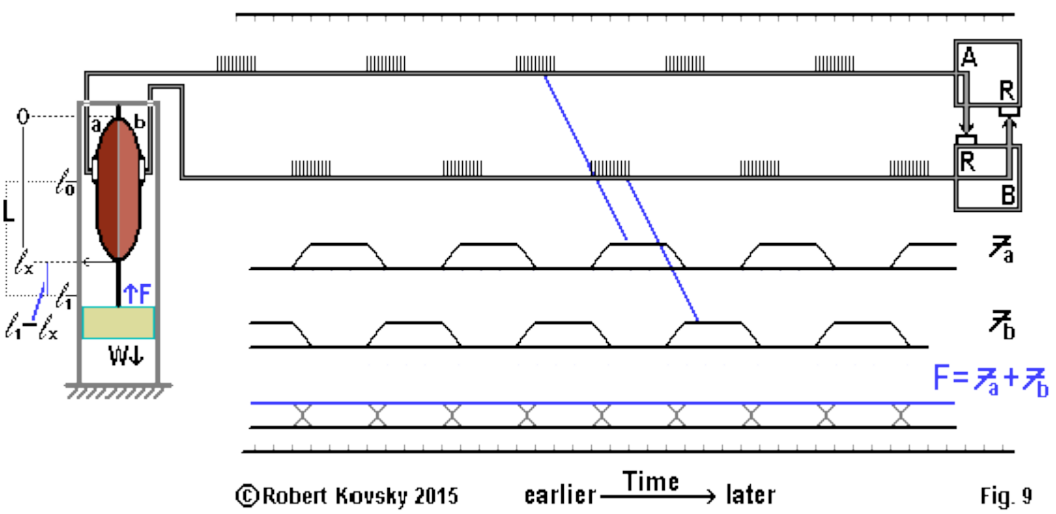


Fig. 9

3. Two opposing duets produce a spectrum of balancing positions.

Fig. 17 shows two equal and opposing duets, each affixed at one end and connected to the other duet at the other end. Outside the Figure, a pair of reciprocating bursters sends signals to the left duet with pulse number m; similarly, an independent pair of reciprocating bursters sends signals with pulse number n to the right duet. The design in Fig. 17 establishes relations between pulse numbers and spatial locations in a spectrum of balancing positions. The design is the first in a series of constructions aiming to mimic movements of eyes of animals.

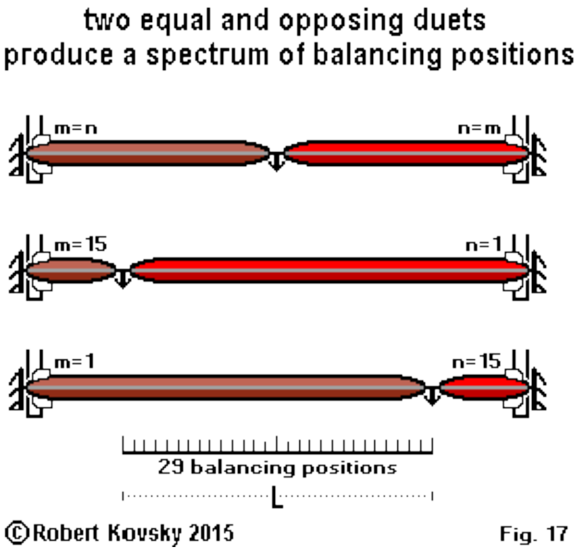


Fig. 17

The top image shows the duets in center-point balancing, where equal pulse bursts are sent to the two duets; that is, m=n. When signals are equal, the indicator arrow is centered and the location is called ***midline***. Equal forces and a centered indicator at midline can occur for pulse numbers of any size, from 1 to 15.

The range of motion in Fig. 17 is denoted by L, like L in Fig. 9. An end-of-range position occurs when one duet is driven by bursts with pulse number 1 and the other duet is driven by bursts with pulse number 15. At such limit positions, one duet is fully extended and the other duet is fully contracted.

In this design, fibers at full extension have a length that is 5 times the length of fibers at full contraction. That is, for each force fiber device, $\ell_1 = 5L/4$ and $\ell_0 = L/4$. $L+2\ell_0$ is the distance between points of affixation; and the distance from each such point to midline is 3L/4.

Let x be measured from midline, with positive values to the right. Balancing is expressed by: $F_m=F_n$, where $F_m=mF_1 - j(3L/4+x)$ and $F_n= nF_1 - j(3L/4-x)$. For duets to be in balance at extreme positions (e.g., $x=L/2$), $15F_1-5jL/4 = F_1-jL/4$; or $j=14F_1/L$.

In the $j=14F_1/L$ system, 29 equally spaced balancing positions are defined by $x/L=(n-m)/28$, where $-\frac{1}{2}L \leq x \leq \frac{1}{2}L$. When n>m, balancing points are to the right of midline. When m>n, balancing points are to the left. Except at limits points, multiple pairs of (m,n) hold the balance.

4. A tube for transport moves an object: encircling force devices tighten and relax in waves, with timings controlled by reverse triggering of an ensemble of bursters.

    a. A tube for transport is built from sections with a uniform design that combines a rigid tube, elastic materials and a Virtual Energy force device.

Movements in this design occur inside a rigid tube that is like a plumber's tube made of polyvinyl chloride (PVC). A toroidal form is symmetrical as to all portions (Fig. 28(a)); movements in a toroid are similar to movements at the central portion of a straight tube (Fig 28(b)). Straight tubes are simpler for figures and analysis.

Internally, a tube for transport is constructed from sections, each with two parts in an alternating sequence: active parts (red) are powered by Virtual Energy and passive parts (gray) have negligible energy values. (Fig. 28c, 28d.) Each part is a smaller toroid. Connected insides of parts/toroids form a central channel or ***lumen***. The lumen is internally bounded or covered by an elastic membrane that is attached to the insides of active and passive parts.

The closing force of an active part is opposed by elastic fibers that are attached to the inside of the rigid tube. A variable pulse-bust signal produces a variable contraction; an array of variable contractions can form a ***bulge*** that can move an object enclosed within, e.g., a ping pong ball.

A tube for transport: large-scale view

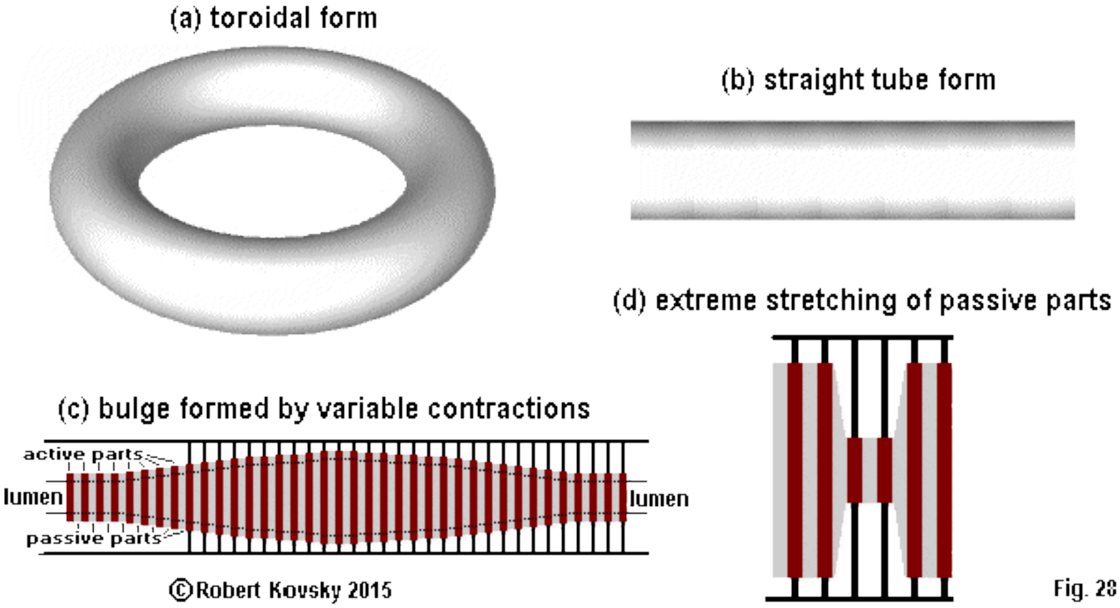


Fig. 28

A passive part stretches to accommodate movements of active parts on both sides. Extreme stretching results from the strongest contraction on one side and the weakest contraction on the other side. (Fig. 28.d.) To minimize stretching of passive parts in designs in this project, pulse numbers of burst signals differ by at most "one" between any active part and the next active part. Bulges are rather flat. Rounder bulges can be formed with greater stretching of passive parts.

b. Inside a tube for transport, the aperture opening of each section is set by a variable balance between elastic forces and forces from a Virtual Energy device.

As shown in Fig. 29(a), an active part in a tube for transport uses a duet force device (Fig. 9) modified into a circular force device with variable radius r. The duet produces centripetal contractile forces that are balanced by centrifugal forces produced by elastic fibers, each attached at one end to a sleeve around the duet and at the other end to the inside of the tube. Variable aperture openings form a linear series. (Fig. 29(b) views a bulge in 3-d from inside.) When an active part is in a fully relaxed condition, it has a pulse number of 0 and an aperture radius of r_1.

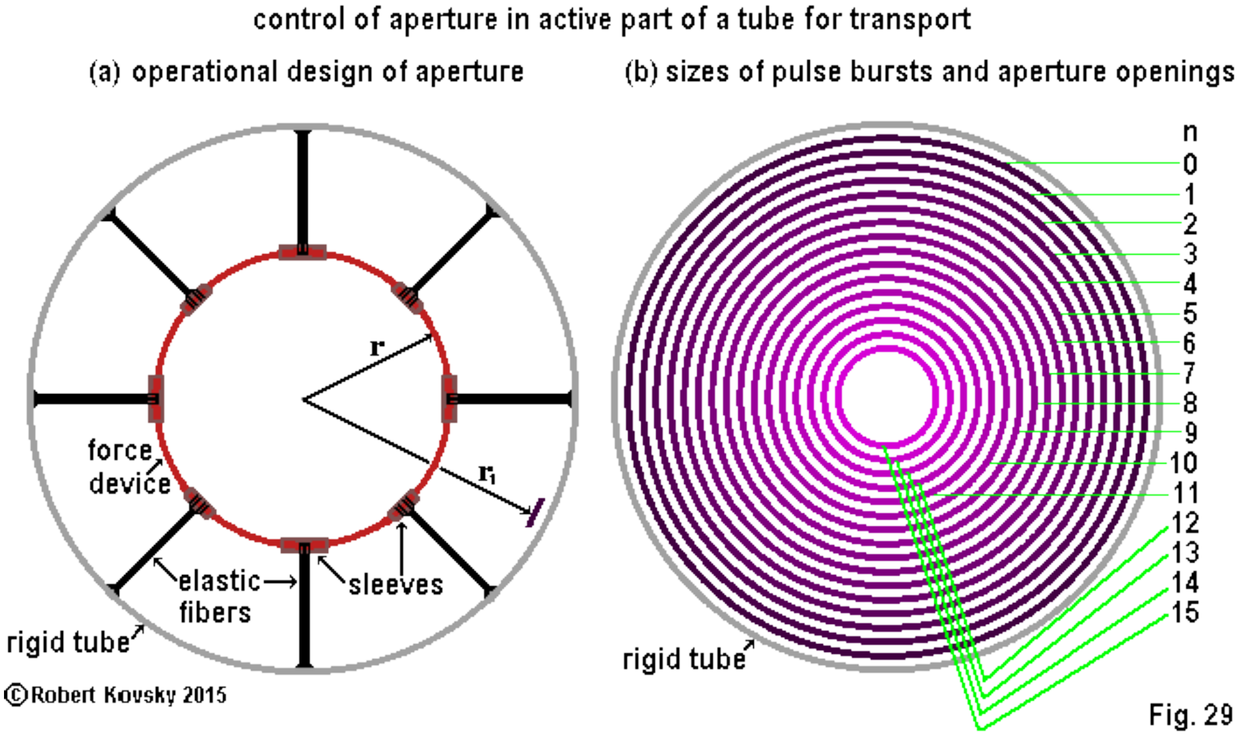


Fig. 29

Fig. 30 shows how a force produced by a force fiber duet opposes and balances a force produced by an elastic fiber, with a linear spectrum of balancing positions similar to that shown in Fig. 17. Note that there are 16 balancing positions in Figures 29 and 30 and 29 positions in Fig. 17.

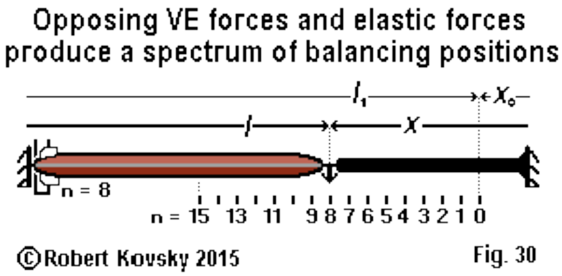


Fig. 30

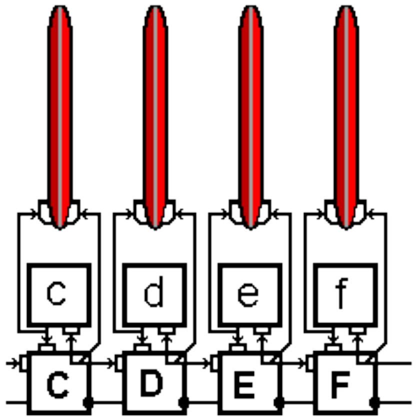
Balancing positions in Fig. 30 are defined by $nF_1 - j(l_1 - l) = k(x - x_0)$, where k is the "spring constant" of the fiber. Since $(l_1 - l) = (x - x_0)$, $l_1 - l = nF_1/(j+k)$. When n = 0, the elastic fiber is fully relaxed at $x = x_0$ and the force device is flaccid at $l = l_1$. Forces rise on both sides when n increases, but with a differential, and the balancing position shifts.

Application of the foregoing principles to the operational design of the aperture (Fig. 29(a)) leads to $r = r_1 - nF_1/(2\pi j + mK)$ where K is the "spring constant" for one elastic fiber and m is the number of elastic fibers, or m=8 in Fig. 29. It is convenient to hold mK fixed while the number of elastic fibers is increased. Conceptually, as the number of fibers increases, fibers become a membrane between sections with a continuous, elastic sleeve around the force device.

c. An ensemble of reverse-triggered bursters produces changes in aperture openings, moving objects (e.g., ping pong balls) through the lumen of a tube for transport.

A tube for transport moves an object enclosed in a bulge – e.g., a ping pong ball — by shifting a pattern of aperture openings. When a movement occurs, first, space opens in front of the object; next, the opening of space spreads back over the top; then, once over the top, opening becomes closing – and force devices near the back of the object push it forward into the open space. Reverse triggering is combined with forward projections to produce forward movements.

Bursters and force devices in a portion of a tube for transport



©Robert Kovsky 2015 Fig. 31

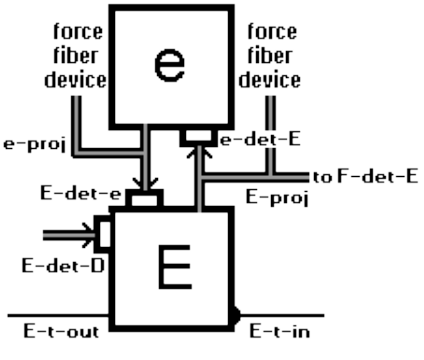
Fig. 31 shows an arrangement of VE force fiber devices and bursting devices in a portion of a tube for transport. Movements occur in four duets, which are pairs of force fibers that are driven by corresponding pairs of bursting devices C-c, D-d, E-e and F-f. The arrangement is continued to the left of C-c and to the right of F-f. Devices c, d, e and f are simple repeating bursters — R devices introduced in II.B.1 — while devices C, D, E and F are similar to R but modified to perform the shifting movements discussed herein. Operations of all bursters are tightly synchronized in the initial design but that constraint is relaxed in a later design. Each duet — e.g., E, e and the force fiber devices they drive — controls the aperture opening in an active part of a tube for transport.

Exemplary operations of bursters E and e are shown in Fig. 32 and in operational charts below. Signals arrive at e only through e's detector, labeled ***e-det-E***, that is reached by a projection from burster E that is labeled ***E-proj***.

In other words, pulse burst signals discharged by E and carried by E-proj arrive at e-det-E. In addition to carrying signals to e-det-E, E-proj sends signals to a force fiber device and to a detector on burster F, namely, ***F-det-E***. E may also receive a signal from D through detector ***E-det-D***.

Similarly, a pulse burst signal from e is carried on ***e-proj*** and arrives at a detector on E labeled ***E-det-e***. Such signal from e-proj also arrives at a force fiber device.

Burster pair and projections in a section of a tube for transport



©Robert Kovsky 2016 Fig. 32

E has two detectors, ***E-det-e*** and ***E-det-D***. During any cycle, one detector is receptive and the other detector is blocked. When E-det-e is receptive and E-det-D is blocked, aperture openings are kept steady. During such a steady cycle, E receives a pulse burst signal from e.

During a shifting cycle, the receptive detector is switched from E-det-e to E-det-D. E receives a pulse burst signal from D instead of from e. Such a shifting cycle in E begins with the arrival of a trigger pulse from F onto ***E-t-in*** and ends with the discharge of a trigger pulse onto D from ***E-t-out***. Two or more shifting operations can be performed in a sequence; in a sequence of shifts, E receives a pulse burst from D and passes it to F. Pulse bursts and trigger pulses travel in opposite directions.

The snippet of code below that is labeled “`shifts to`” represents a single shift step of movements in the cdef bank of bursters and force devices. Before the shift, signals are steady, with burst q in burster pair C-c, burst r in burster pair D-d, burst s in burster pair E-e and burst t in burster pair F-f. After a shift, signals are again steady, with burst q in burster pair D-d, burst r in pair E-e and burst s in pair F-f. A new burst signal p has shifted onto pair C-c from a burster B off the figure; and burst signal t has shifted off the Figure, onto G-g. That is, within the four focal pairs:

```
qrst shifts to
pqrs
```

In the operational chart for bursting device E below, the burster pair starts with reciprocal exchanges of signal NsN, detected as OsO. A trigger pulse arrives over the E-t-in line (~) and, eight ticks later, a trigger pulse is discharged over the E-t-out line (!). Between the trigger pulses, the receptive detector is switched from E-det-e to E-det-D for one cycle; and the new signal NrN, arriving through E-det-D, takes up occupancy in the E-e pair.

```
Operational chart for devices e and E (1 symbol, 1 tick)
e-det-E  NsNP    NsNP    NsNP    NsNP    NrNP   NrNP . . .
e-proj      POsOR   POsOR   POsOR   POrOR   POrOR    . . .
E-det-e      NsNP    NsNP    XXXX    NrNP   NrNP     . . .
E-proj   OsOR   POsOR   POsOR   POrOR   POrOR  POrOR . . .
E-det-D  XXXXXXXXXXXXXXXXXXXXNrNPXXXXXXXXXXXXXXXXXXX . . .
E-t-in                  ~
E-t-out                         !
```

The operational chart for e and E can be simplified through use of condensed code, The following chart is equivalent to the chart above. Prior to a shift, an s pulse burst is maintained in steady operations. Receipt of a trigger pulse (~) causes a switch in the receptive detector to E-det-e for one cycle, the detection through E-det-e of the r pulse burst and the establishment and maintenance of the r pulse burst in steady operations.

```
Operational chart for devices e and E (condensed code)
e-det-E  s s s s r r
e-proj    s s s r r
E-det-e   s s X r r
E-proj   s s s r r r
E-det-D  XXXXXr XXXX
E-t-in      ~
E-t-out       !
```

The movement of trigger pulses is in the direction that is opposite that of burst transmission and of actual movement of the object. Triggering is “reversed.” In other words, forward projection and reverse triggering both anticipate and control actual movement but in different ways. Forward projection controls the strength of the movement while reverse triggering controls the timing of the movement.

Condensed code is used in the operational chart below that tracks operations of sections C, D, E and F during a shifting operation. Note that the wave of trigger pulses moves in the reverse direction — from F to E to D to C — while the signal pattern p-q-r-s-t moves in the forward direction, from C to D to E to F. The actual movement of the object in the lumen defines the forward direction. Movement represented in the "`shifts to`" code snippet is thus produced.

```
qrst shifts to
pqrs
```

Operational chart for C-c, D-d, E-e and F-f (shift step)

```
C-t-out                    !
c-det-C  q q q q q q q q q p p p p p p p p p p p p p p p p p p p
c-proj    q q q q q q q q q p p p p p p p p p p p p p p p p p p
C-det-c   q q q q q q q q X p p p p p p p p p p p p p p p p p p
C-proj     q q q q q q q q p p p p p p p p p p p p p p p p p p p
C-det-B  XXXXXXXXXXXXXXXXXp XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
C-t-in                   ~

D-t-out                  !
d-det-D  r r r r r r r r r q q q q q q q q q q q q q q q q q q q
d-proj    r r r r r r r r q q q q q q q q q q q q q q q q q q q
D-det-d   r r r r r r r X q q q q q q q q q q q q q q q q q q q
D-proj     r r r r r r r q q q q q q q q q q q q q q q q q q q q
D-det-C  XXXXXXXXXXXXXXXq XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
D-t-in                 ~

E-t-out                !
e-det-E  s s s s s s s r r r r r r r r r r r r r r r r r r r r r
e-proj    s s s s s s s r r r r r r r r r r r r r r r r r r r r
E-det-e   s s s s s s X r r r r r r r r r r r r r r r r r r r r
E-proj     s s s s s s r r r r r r r r r r r r r r r r r r r r r
E-det-D  XXXXXXXXXXXXXr XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
E-t-in               ~

F-t-out              !
f-det-F  t t t t t t s s s s s s s s s s s s s s s s s s s s s s
f-proj    t t t t t t s s s s s s s s s s s s s s s s s s s s s
F-det-f   t t t t t X s s s s s s s s s s s s s s s s s s s s s
F-proj     t t t t t s s s s s s s s s s s s s s s s s s s s s s
F-det-E  XXXXXXXXXXXs XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
F-t-in             ~
```

Each shift step is produced through a distinct wave. Separate shift steps can follow each other in an arbitrary fashion so long as 8 ticks (or a multiple thereof) pass between any two trigger pulses. The ***shifting episode*** set forth below is produced by 5 trigger pulses with 8 ticks between successive trigger pulses. As a result of the shifting episode, the "`shifts to`" code is:

```
qrst shifts to
lmno
```

```
Operational chart for C-c, D-d, E-e and F-f (shifting episode)

C-t-out                    ! ! ! ! !
c-det-C  q q q q q q q q q p o n m l l l l l l l l l l l l l l
c-proj    q q q q q q q q q p o n m l l l l l l l l l l l l l l
C-det-c   q q q q q q q q X X X X X l l l l l l l l l l l l l l
C-proj     q q q q q q q q p o n m l l l l l l l l l l l l l l
C-det-B  XXXXXXXXXXXXXXXXXp o n m l XXXXXXXXXXXXXXXXXXXXXXXXXXX
C-t-in                   ~ ~ ~ ~ ~

D-t-out                  ! ! ! ! !
d-det-D  r r r r r r r r q p o n m m m m m m m m m m m m m m m
d-proj    r r r r r r r r q p o n m m m m m m m m m m m m m m m
D-det-d   r r r r r r r X X X X X m m m m m m m m m m m m m m m
D-proj     r r r r r r r q p o n m m m m m m m m m m m m m m m
D-det-C  XXXXXXXXXXXXXXXq p o n m XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
D-t-in                 ~ ~ ~ ~ ~

E-t-out                ! ! ! ! !
e-det-E  s s s s s s s r q p o n n n n n n n n n n n n n n n n
e-proj    s s s s s s s r q p o n n n n n n n n n n n n n n n n
E-det-e   s s s s s s X X X X X n n n n n n n n n n n n n n n n
E-proj     s s s s s s r q p o n n n n n n n n n n n n n n n n
E-det-D  XXXXXXXXXXXXXr q p o n XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
E-t-in               ~ ~ ~ ~ ~

F-t-out              ! ! ! ! !
f-det-F  t t t t t t s r q p o o o o o o o o o o o o o o o o o
f-proj    t t t t t t s r q p o o o o o o o o o o o o o o o o o
F-det-f   t t t t t X X X X X o o o o o o o o o o o o o o o o o
F-proj     t t t t t s r q p o o o o o o o o o o o o o o o o o
F-det-E  XXXXXXXXXXXs r q p o XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
F-t-in             ~ ~ ~ ~ ~
```

The shifting episode set forth above embodies the most forceful kind of action that the module is capable of producing, subject to constraints imposed for purposes of this project.

D. Quad Net devices, critical moments and Shimmering Sensitivity

III. Foundations of Energy Constructions

A. Diversity of constructions.

A variety of foundational principles are used in constructions. Different constructions have different foundational principles. Some constructions use only one kind of such principles. In other constructions, two or more kinds work together. The principle of *actual life* is implicit in new constructions and principles of freedom are their common aim.

Different sets of foundational principles implicitly limit each other. No single set of principles can be said to comprehend "everything." I hold to a general principle that human intelligence lacks capacities to comprehend, describe or control "everything." Of focal interest here is the incapacity of "modern science" to comprehend, describe or control bodily feelings and muscular movements of animals, e.g., feelings and movements of *itching and scratching*. I suggest that scientific models have only limited applications and introduce systemic errors. I suggest that alternative constructions can reach some important but neglected matters.

1. Rational constructions of physical paradigms

Physical paradigms in this project are examples of rational constructions in physics. Standard paradigms in part I employ Conserved Energy (CE) principles to construct Conserved Energy Thermodynamics (CET). New paradigms in part II employ Virtual Energy (VE) principles to construct Virtual Energy Thermodynamics (VET). All the paradigms, principles and constructions are set forth in a "rational style," similar to the "rational thermodynamics" of Josiah Willard Gibbs (1839-1903) and Clifford A. Truesdell III (1919-2000). Scientific systems of rational thermodynamics use rigid axioms and mathematical formalisms. Flexible principles of VET are different from rigid axioms of CET — but there are pervasive parallels. The VET paradigm of Shimmering Sensitivity in Quad Nets is based on the critical point paradigm in CET.

Other rational constructions in physics include Newton's corpuscular mechanics, Maxwell's electromagnetic fields, Dirac's quantum mechanics and vortices of Descartes and Rankine. Computers embody logical rationalism in operating devices. VET is foundationally different from such prior constructions but I follow a rational style in paradigmatic VET constructions.

A paradigmatic process of Shimmering Sensitivity begins by generating multiple fragments of device activity that potentially lead to multiple possible movements, each fragment leading to a different movement; initially, fragments co-exist in a "shimmering" condition that may include shifting combinations of fragments and competition between possibilities; next, the process passes through a critical moment and multiple possibilities change into a single actuality.

I suggest that processes of Shimmering Sensitivity are models for selections or choices in the lives of persons, such as choices made during ping pong games and in markets. During a critical moment in a selection, multiple possible next movements change into one actual next movement; and a change can depend on flowing influences, on material properties of body parts and on momentary sensitivities, as well as on happenstance events in the environment. When multiple devices with interactive processes of Shimmering Sensitivity are synchronized and pass through critical moments together, selections can be integrated and become one unified selection. In a supportive situation, a single movement is produced by a whole body made of many body parts. In anticipated models of aquatic worms and eels, the whole body of the engineered organism, and each and all of many sensory-motor modules, participate in selections of movements.

2. Integrating constructions of psychology

Psychological constructions model a personality as made up of multiple parts, where each part operates independently and where parts also interact. Freud's id-ego-superego model is similar and resembles a pelvic-manual-facial model in my approach. Interacting independent parts sometimes work together and sometimes not. Integration of activities of interacting parts is accomplished through various constructions, including models of Piaget's "sensory-motor coordination of actions" discussed below and processes that involve Shimmering Sensitivity.

Different psychological models target different situations and use different kinds and numbers of personality parts. In a simple model of purposeful action, a personality is made of (1) muscular movements of "the body" and (2) images in "the mind." Bodily movements occur in actual time. Movements of mental images occur in actual time, detached time or controlled time. Rational activities, e.g., operations of CET paradigms discussed in part I, occur in detached time.

In a body-mind model, integration of body and mind can sometimes be accomplished but not always. The two parts in the model have different characters and important distinctions between parts. Muscular movements are brief and easily varied in many situations. A basic repertoire of muscular movements is produced in the person's only body and is adapted to different tasks; some tasks require practice and training of skills. Through training, muscular movements match an external form (according to ancient Athenians) or (according to Piaget), an internal scheme with a source, e.g., innate, habit, parent, teacher, command, goal, book, principle, law.

Images in the mind that signal, guide, train or control actions have a character different from that of movements. Mental images occupy many different domains, sometimes with significant interactions with each other or with the body and also often with high degrees of independence. Images in domains such as "work," "family" and "play" compete for control of the body; the most powerful depend on permanent features and rigid demands. Often, a new task requires a new set of images, e.g., a new page of symbolic commands.

In a larger psychological construction, addition of a third part of the personality, "emotions of the heart," might be suitable to model social activities where groups of individuals are formed on the basis of shared and/or conflicting *attractions* and *aversions* (emotions or movements of the heart). Shifting patterns of attractions and aversions generate shifting groups of individuals that resemble blocs in the Ising Model and clusters of movement in Quad Nets.

In fish, flowing patterns of movement are produced by a spine made of an ordered series of modules. An ongoing movement in one module is influenced by activities in its neighbor. In birds and mammals, spinal modules maintain capacities of flow, as in flight and swimming. They also acquire distinct characters and particular additional capacities

In a two-tier model of different capacities of the human spine to produce movements, the "entire spine" extends up through the brain stem and includes cranial nerves. "The body" is based in the entire spine and has "pelvic parts," "manual parts," "cervical parts," "facial parts" and "optical parts." Personality parts have different levels of agility, slowest in the pelvis, progressively quicker with hands, neck, face, eyes and tongue, and quickest in the mind. Body parts interact with each other and with the mind. Often some parts of the personality are working together and other parts are inactive; e.g., while sitting at and playing an electronic piano keyboard, a person's manual parts and mind are working together while pelvic parts are inactive and facial parts are operating independently (perhaps expressing emotions that are not part of the body-mind model).

3. Polemical constructions opposing the modern scientific view

Polemical constructions use a principle of "type and anti-type" or "us vs. them," e.g., while comparing and contrasting VET and CET paradigms. Shimmering Sensitivity, the physical principle of freedom, is contrasted with determinism that is the presumption and goal of the modern scientific view. Flowing movements produced by flexible bodies of fish, birds, squirrels and children are contrasted with movements of rigid-body robots operated by computers.

As stated by computer intelligence advocate Marvin Minsky (*Society of Mind*, § 30.6):

> According to the modern scientific view, there is simply no room at all for 'freedom of the human will.' Everything that happens in our universe is either completely determined by what's already happened in the past or else depends, in part, on random chance. Everything, including that which happens in our brains, depends on these and only these:
>
> *A set of fixed, deterministic laws.*   *A purely random set of accidents*
>
> There is no room on either side for any third alternative. Whatever actions we may 'choose,' they cannot make the slightest change in what might otherwise have been – *because those rigid, natural laws already caused the states of mind that caused us to decide that way.* And if that choice was in part made by chance – it still leaves nothing for us to decide.

I suggest that Minsky's statements are refuted by the bodily feelings and muscular movements of household chores. Living alone, I choose when to clean, what to clean and how thoroughly; and accidents happen through haste or negligence. Virtual Energy and psychological constructions in this project provide further refutations. Such constructions are part of a "third alternative" for consideration of events in our universe that do not conform to the rigid laws and closed-minded classifications of the modern scientific view.

In the modern scientific view, "energy" is defined as a real number that attaches to every point in space in our universe and to every particle of matter in our universe. All the energy in our universe can be added up — and the sum is a ***constant*** with an existence that lasts as long as our universe. Hence, as asserted by the modern scientific view, conserved energy is universally and eternally real. The reality of conserved energy (CE) stands in the fore among the "rigid, natural laws" that is said to preclude freedom.

In contrast, virtual energy (VE) is a mental invention that has limited applications, chiefly to model rate-based processes in animal organisms where energy is supplied continually and to define similar processes in proposed electronics devices. VE can be conserved in storage bodies; but, in contrast to CE constructions, dissipations of VE participate in working operations during conversions and transformations. Continual dissipations are balanced by inflows of VE, leading to models with flowing integrated waves of transformational processes — instead of being bound to equipoise, quasi-static and equilibrium CE operations.

I suggest that VE has uses that reach beyond the modern scientific view, in which events are controlled by the "eternally constant universal sum" of conserved energy and its by-products "entropy" and "information." Instead, VE is generating multiple possible movements during transformational processes of Shimmering Sensitivity that lead to one actual movement; VE is dissipated in different ways that select and control actual movements; and such selections include production of flowing whole-body movements that require exercises of freedom.

B. Movements of and changes in animal bodies occur in actual time and make up the domain of actual life that establishes a foundation and goals for all constructions.

The ***domain of actual life*** serves as the foundation and standard for my constructions. The domain of actual life is prior to constructions and motivates constructions. For purposes here, the domain of actual life has a core made up of muscular movements and accompanying bodily feelings of persons. Core movements and bodily feelings exist prior to images of things, places or other persons. I presume first, that all healthy adult persons share a common foundation of muscular movements and related bodily feelings and that, more generally, birds and mammals have something similar. We all have personal bodily experience of itching and scratching. Dogs and cats stretch and scratch; and birds preen. Added to the common foundation, many persons, e.g., musicians and athletes, have additional movements specific to themselves.

In actual life, movements usually involve ***images*** of external things, places and other persons — and also memories of such images. At a traffic light, we stop on red and go on green. In actual life, images are significant when they are involved in movements; such images are included in the domain of actual life as needed. However, images detached from muscular movements and having a separate existence– e.g., arithmetic, TV, laws – are not included in initial constructions.

Persons share domains of actual life with other higher vertebrates such as dogs, cats, birds and squirrels. Of course, persons have movements of actual life that are additional to movements of such animals, such as movements used in card games and cooking. In all vertebrates, including fish, phenomena of actual life include possibilities of multiple different movements and relations between possible movements of choice, exclusion, triggering, emphasis, sequencing and/or causation. Human beings have further developed such relations using technology.

Psychological constructions seek to organize imagery. Psychologies based on the domain of actual life include both a general psychology and a restricted psychology.

The restricted psychology aims to work with technical VE device constructions and VE concepts. In other words, specific constructions target specific activities of persons where psychological models fit VE device designs. Such activities are made up of repetitive movements and practiced repertoires of movements and courses of movement. By selecting and modifying repetitive and familiar courses of action in actual life, a person reaches goals, follows mental forms and exercises freedom. Targeted activities include sports competitions, musical performances, driving automobiles, parlor games, technologies and institutional decisions.

A general psychology of actual life is founded on actual muscular movements of persons in ordinary activities of life, e.g., eating, cooking, chores, hygiene, sleep, travel, markets, exercise, consumer technology. Of special importance are whole-body movements and large-scale movements involving multiple spinal regions, e.g., scratching the left ankle with the right hand. Quick, impulsive and precise whole-body movements of birds and squirrels resemble those of children and provide exemplars of exercises of freedom in actual life.

Overall psychological guidance is provided by Jean Piaget (1896-1980), who described a practical intelligence, "an intelligence before language," that arises from and then controls ***sensory-motor coordination of actions***.

> Essentially practical – that is, aimed at getting results rather than at stating truths – this intelligence nevertheless succeeds in eventually solving numerous problems of action (such as reaching distant or hidden objects) by constructing a complex

> system of action-schemes and organizing reality in terms of spatio-temporal and causal structures. In the absence of language or symbolic function, however, these constructions are made with the sole support of perceptions and movements and thus by means of sensory-motor coordination of actions, without the intervention of representation or thought.
>
> [Piaget & Inhelder, The Psychology of the Child (1969) at 4. "A scheme is the structure or organization of actions as they are transferred or generalized by repetition in similar or analogous circumstances."]

C. Constructions of images in rational domains initially arise in actual time but then repeat independently in detached time, co-existing with the domain of actual life and sometimes interacting with bodily movements and changes.

For purposes here, constructions in ***rational domains*** include numbers, mathematics, maps, expository language, theories, device designs and other symbolic functions based in the mind. Persons initially encounter elements of such constructions through engagements with their environments, e.g., by reading a book. Such engagements occur in actual time, requiring eye movements for acquisition of images. Multiple engagements with permanent elements lead to a network of constructions in the mind that can be explored and elaborated in detached time.

Regardless of roots in the domain of actual life, rational domains are reconstructed in ways that are separate from and independent of muscular movements of actual life. For example, there is a domain in the imagination of each adult person of ordinary intelligence that is occupied by the counting numbers "1, 2, 3, 4" and so forth — and this domain is independent of bodily experience — although it was created during infancy in connection with bodily movements and may be used in connection with similar movements. Many rational domains are independent of each other and of bodily movements and are shared by adults, e.g., domains of arithmetic, money, family relations, alphabets, names, logic and, recently, computers. Such rational domains have independent and interactive existences in the imaginations of persons or in memories of computers — existences that may be represented by symbols on paper or on computer screens.

The division between the domain of actual life and rational domains corresponds to the division between body and mind. In a crude model, practical intelligence that controls muscular movements is located in the body and spine while rational intelligence operates in the mind.

In actual life, bodily movements are often integrated with mental images. A simple example occurs during a weight-lifting session at the gym. Movements in the two domains are performed together. Each exercise ***set*** consists of an integral number of repeated cyclical movements; each cycle is called a ***repetition*** or ***rep***. Suppose that there are 12 reps to a set of bench press exercises, performed by lying on the back on a bench and raising dumbbells up from the chest, then lowering them under control. The person counts successive repetitive cycles as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, thus applying the rational construction of counting to the bodily movements. In addition, there is a ***form*** of the exercise that prescribes details of movement, e.g., that the dumbbells should move smoothly, in parallel and in a vertical direction. The same methods of integration (counting reps and following forms) are applied to arm biceps curl exercises and to squats. Records of exercises, weights, sets and reps are used by an athlete to track and control progress. Similar rational methods are applied to activities of cooking and card games.

D. Movements of and changes in animal bodies that occur in actual time cannot be fully described or controlled by rational constructions that operate in detached time.

Successes of civilization are based on applying constructions in rational domains to the domain of actual life. For example, one ancient rational system, plane geometry and land surveying, successfully resolves boundary disputes. Other successes range from following a cake recipe to building a sewage plant or, in a legal case, enforcing the Uniform Commercial Code. Activities of actual life that are based on rational constructions are said to be ***rationalized***. Questions are presented: Can all matters in actual life be rationalized? If not, which matters in actual life can be rationalized? Which matters should be rationalized?

I suggest that there are clear limits to rationalizations. Rational forms are sited in specific mental domains, such as computation or commercial law, and depend on specific principles. Forms do not generate novel forms; rather, new forms are developed through exercises of human imagination or as a response to actual need. Human beings continually invent novel kinds of rational imagery in many activities of actual life, e.g., in internet culture, arts, international relations, clothing fashions and financial markets. In these activities, past rationalizations have had least success in predicting future events or future rationalizations.

Viewed more generally, activities of actual life often do not match or fit constructions in rational domains. Sometimes a better fit can achieved through practice, but, even then, only in limited ways. Muscular movements are of brief duration and easily varied, with a transient existence that is often difficult to repeat or to define exactly. Some practiced movements can be repeated and defined exactly, e.g., those used in 19th century ballet academies and performances; but such movements are in special categories and lack the spontaneous and flexible character of movements in ordinary activities of actual life. Spontaneous movements depend on momentary feelings more than on forms of practice. During spontaneous movements, changes occur in response to environmental interactions. Spontaneous movements occur in integrated flows.

In contrast to flowing movements in actual time, detached operations of computers use programmed forms that are subject to “interrupts.” Generally, computer operations through the 1960’s were not interrupted at all and jobs were run with “batch processing.” Personal computers appeared in the 1970’s; an historical course of PC languages begins with BASIC and develops to c to C++ to java to mobile app; such development required progressively greater use of interrupts. In all computers, interrupts operate as part of programmed forms. Interrupted programs of computers and spontaneous flows of actual life do not fit together easily.

In contrast to transient movements of actual life, mental images such as numbers have a permanent, even an “eternal” character. A single name attaches to a person who grows and changes while developing from infancy to old age. Many mental images occur in definite, fixed structures, spaces and forms and are governed by rules that prohibit changes or deviations.

Attempts to apply detached operations and fixed mental images to transient, variable muscular movements are often frustrated by such systemic misfits. Frustration may be compounded when a person is presented with a new challenge or a new environment. Fortunately, human beings are sometimes able to invent means to overcome such frustrations.

E. The modern scientific view presumes full integration of rational domains with the domain of actual life.

In the modern scientific view, “Everything that happens in our universe” can be rationalized by means of “fixed deterministic laws” and “random chance.” It is presumed that numerical values are attached to each point in space and to each particle of matter and that sums of values over the universe determine actual movements according to differential equations, e.g., equations based on Newton’s Laws of Motion, Laws of Thermodynamics or Einstein’s Field Equations.

A view similar to the modern scientific view was declared by Georg Wilhelm Friedrich Hegel (1770-1831), who wrote: “What is rational, is actual; and what is actual is rational.” (Hegel, *Philosophy of Right*, Preface, Kaufmann trans. in *Discovering the Mind*, vol. I at 222.)

Hegel set forth a doctrine that ideas are real (*Philosophy of Right*, S. W. Dyde trans.):

> Against the doctrine that the idea is a mere idea, figment or opinion, philosophy preserves the more profound view that nothing is real except the idea. Hence arises the effort to recognize in the temporal and transient the substance, which is immanent, and the eternal, which is present. The rational is synonymous with the idea, because in realizing itself it passes into external existence. It thus appears in an endless wealth of forms, figures and phenomena. It wraps its kernel round with a robe of many colours, in which consciousness finds itself at home.

Hegel’s constructions were popular during the 19th and early 20th centuries but have also been cited as a source of totalitarian ideologies. According to Karl R. Popper in *The Open Society and Its Enemies* (1950 rev. ed.), Hegel constructed a philosophy of “might is right” to ingratiate himself with the Prussian King. Hegel’s construction conflated Plato’s Forms or Ideas where “the Ideas alone are real” with “ideas in our minds” — “and this allows Hegel to maintain that everything that is reasonable must be real, and everything that is real must be reasonable, and that the development of reality is the same as that of reason.”

Hegel wrote:

> Was vernünftig ist, das ist wirklich.
> Was ist wirklich, das ist vernünftig.

Translations differ on the English equivalent for “wirklich,” choosing in some cases the word “actual” and in other cases the word “real.” Similarly, “vernünftig” is alternatively translated as “rational” and “reasonable.” Distinctions between actual and real or between rational and reasonable appear to be obscure in Hegel’s philosophy. In a model of everything, where “vernünftig = wirklich,” it seems hard to avoid real = rational = actual = reasonable.

Minsky’s modern scientific view likewise declares that mathematical constructions, rational propositions and eternal certainties control “Everything that happens in our universe … including that which happens in our brains.”

My alternative approach avoids such unlimited universals but rather suggests that “reality” may change when “rational” constructions in the mind fit and combine with “actual” movements of the body to make up an integrated, purposeful course of action. (Similarly, under the common law of England, in order to establish a criminal offense, a prohibited *actus reus* of the body must unite with a specific *mens rea* of the mind.) When mind and body are working together, something real is going on. I decline, however, to grant a metaphysical status to “reality.”

F. To develop a new approach, three kinds of energy are constructed: actual, conserved and virtual.

Prior to its apotheosis as an eternal universal principle, “energy” had origins in Newtonian mechanics and mechanical paradigms such as Atwood’s machine and the SHO. In mechanics, energy is a capacity to generate forces and to produce certain movements of inanimate bodies. Forms of mechanical energy (kinetic, gravitational, elastic) are converted into each other according to general principles — in contrast to particular properties of material bodies and to particular phase changes that are investigated in thermodynamics.

In mechanics, changes in movements of bodies are easily rationalized as changes in energy. In thermodynamics, changes in properties of bodies are similarly rationalized and difficulties are glossed over. As shown in Part I of this project, thermodynamics rationalizations can match mechanics rationalizations when movements and changes are restricted to equipoise positions or equilibrium conditions operating in detached time. In such cases, matching elements make up a structure that covers both mechanics and thermodynamics. Certain restricted applications and constructions in actual time can be appended thereto, e.g., through invention of “enthalpy” used in conversions of flows of heat energy into flows of electrical energy. Such rationalizations have been developed into the system of Conserved Energy that is said to control the Universe.

Theories of Conserved Energy have had solid successes, such as rationalizing movements of celestial bodies, subatomic particles in *vacua* and movements of aeronautic and astronautic projectiles and vehicles. Conserved Energy principles provide important guidance in designs of power plants and automobile engines. Extensions of principles of Conserved Energy to chemical reactions have also had solid successes; but such successes are clearly limited to simple cases.

When attempts are made to apply principles of Conserved Energy to movements and changes of living animal bodies, however, the empirical results show major shortfalls and defects. Animal bodies ingest energy foods, expend energy through movements and discharge energy in the form of heat and bodily wastes. These activities cease only on death. Animal bodies are continually undergoing internal changes. While inanimate bodies are chiefly moved by external causes, internal stores of energy enable an animal body to move on its own regardless of external causes. In contrast to robot bodies made of rigid elements, animal bodies have flexible elements and multiple uses for friction, viscosity and dissipation. Unlike chemical processes of Conserved Energy that are clearly defined only in equilibrium situations, chemical processes of living bodies occur in situations where equilibrium is not maintained and where the degree of disequilibrium is of major importance. In stating biochemical cycles — e.g., the citric acid cycle — scientists can articulate and quantify steps of energy change but not rates of change. As discussed in part I, CET operates in detached time regimes that are disconnected from actual movements that are based on such rates of change.

Chief styles of science include the empirical style and the rational style. Empirical scientists classify natural phenomena and organize regularities that are observed. Empirical investigations of Linnaeus led to organized biological groupings, those of Mendel led to organized hereditary traits of plants and those of Mendele’ev led to the Periodic Table of elements.

The domain of actual life can be approached by an empirical style. Investigations show the presence of regularities in diverse movements of diverse kinds of animals. It is possible to classify movements according to a temporal form (stationary, steady, saccadic, shimmering) or, in higher vertebrates, according to body area or areas (pelvic, manual, cervical, facial, ocular).

Empirical evidence suggests that there is something fundamental — I call it ***actual energy*** — that is a source of feelings in animal bodies and that produces, controls and unifies the various movements of a person or animal. In my approach, human beings lack a capacity to comprehend actual energy and actual energy is not denumerable; but it has various useful approximations, e.g., conserved energy and virtual energy. On the largest scale, the empirical nature of actual energy in animal bodies might be described no better than by Hegel, as quoted above: that such energy appears in "an endless wealth of forms, figures and phenomena. It wraps its kernel round with a robe of many colours, in which consciousness finds itself at home." Other empirical descriptions are provided by yogic *prana* and by *qi* in Chinese practices of bodily discipline.

Further suggestions appropriate for a rational approach to actual energy were stated by Teilhard de Chardin in *The Phenomenon of Man* (1955, 1959 English transl.). In the following extracts, I would substitute "body" for his "atom" and omit "from the real evolutionary standpoint."

> …Energy is the measure of that which passes from one atom to another in the course of their transformations. A unifying power, then, but also, because the atom appears to become enriched or exhausted in the course of the exchange, the expression of structure.
>
> …Though never found in a state of purity, but always more or less corpuscular (even in light), energy nowadays represents for science the most primitive form of universal stuff. Hence we find our minds instinctively tending to represent energy as a kind of homogeneous, primordial flux in which all that has shape in the world is but a series of fleeting 'vortices.' From this point of view, the universe would find its stability and final unity *at the end of its decomposition….*
>
> Let us keep the proofs and indisputable measurements of physics. But let us not become bound to the perspective of the final equilibrium that they seem to suggest. …(pp. 42-43.)
>
> *First Principle*. During changes of a physico-chemical type, we do not detect any measurable appearance of new energy. …
>
> *Second Principle.* In every physico-chemical change, adds thermodynamics, a fraction of the available energy is irrevocably 'entropised,' lost, that is to say, in the form of heat. Doubtless it is possible to retain this degraded fraction symbolically in equations so as to express that in the operations of matter nothing is lost more than anything is created, but that is merely a mathematical trick. As a matter of fact, from the real evolutionary standpoint, something is finally burned in the course of every synthesis to pay for that synthesis. (pp. 50-51.)

A rational style of science based on axioms or on de Chardin's principles is more adventurous than the empirical style. In the rational style, mental constructions are invented for purposes of trying to apply them to actual events. Such attempted applications may or may not succeed, with results that may be variously judged e.g., solid, limited, speculative, trivial or trumped up.

Truesdell's style of rational thermodynamics invokes mathematical rigor and is highly focused and restrictive, expressly avoiding universal presumptions like those of Hegel. According to Truesdell, a construction has only a limited and specific range of applications.

Truesdell's investigations, like those of other rational scientists, presume ***Conserved Energy*** as an axiom. Foundational paradigms start with the Ideal Gas. Another presumptive axiom leads to the definition of Entropy that is derived from Conserved Energy.

The modern scientific view presumes that there is a universal equivalence between rational constructions and actual events and calls this presumption "reality." In alternative constructions, I avoid the "reality" of Conserved Energy and, instead, construct ***Virtual Energy***.

The distinction between a "real" construction and a "virtual" construction is based on optics, the physics of light, where a "real optical image" is contrasted with a "virtual optical image." In rational constructions of geometrical optics, both kinds of images are made up of many light rays. To form a real image, rays actually come together in space that is external to any person. Often, a real image is formed on a movie screen or inside a camera. In a virtual image, on the other hand, light rays do not actually come together in external space; rather, they come together inside the eyeball of a person, where lenses modify rays for that purpose. Unlike a real image, a virtual image depends on the presence and orientation of the person who sees the image.

Conserved Energy constructions presume identity between rational structures and actual movements. Like a real image, Conserved Energy is said to be independent of the observer. Virtual Energy avoids such presumptions. In actual development, however, VE constructions have achieved progress by conforming to CE principles, e.g., by following the "quasi-static" path in burster development. VE constructions start in an overlap region shared with CE principles. VE constructions are more conducive to modifications and develop into variant forms in different contexts, activations and domains. VE constructions sometimes contain ambiguous components in anticipation of future modifications and other potential changes. Any definition of VE is provisional, whether in the form of principles or in the form of device designs.

In modeling biological organisms by devices, general VE presumptions are that: "more than enough" energy is available for multiple kinds of operations but subject to principles of economy and efficiency; energy passes between and through changing forms; dissipations are common and useful. VE operations generate internal conflicts that are overridden through movement. Overriding requires continual selections. A whole-body selection may depend on fixed purposes, on multiple influences that are based in an environment, on competing dissipations that are based in memories and on momentary energetic interactions, activations and entrainments. I suggest that such a selection cannot be rationalized in terms of permanent images or numbers.

General VE presumption are based on biological evidence. Mitochondria in cells produce plenty of "energy packets" (ATP). Movement proteins (actin and myosin) are present in all cells and structures of animal bodies, including not only large muscles but all bodily organs and connective tissues, even acting through tiny fibers between adjacent cells in an organ or extending in webs of tissue around organs. I suggest that during a highly activated whole-body movement of actual life – e.g., movements that occur during dancing – every muscle, every organ and billions of cells located throughout the body participate energetically in the movement. Additionally, I presume that each animal body is unique in its material properties and processes and that descriptions and controls of movements of animal bodies are beyond full comprehension by models. In the technological domain, on the other hand, it appears likely that devices based on VE principles can be manufactured that closely conform to paradigms.

Work in progress, draft 5/24/2016