THE RULE OF PHASE APPLIED TO HISTORY

by Henry Adams

Edited by Prof. Eric Steinhart

0. Note on the Preparation of this Work

The original text is: Adams, H. (1909) The rule of phase applied to history. In H. Adams & B. Adams (1920) *The Degradation of the Democratic Dogma*. New York: Macmillan, 267-311. The text is copyright prior to 1923 and therefore is in the public domain. A PDF of the original publication can be obtained via Google Books.

The original text, written in the language and style of 1909, is almost completely unreadable in 2011. I have taken the liberty of editing it and paraphrasing it for the sake of readability; I have made every effort to preserve the author's original meaning. Section headings and tables have been added by Prof. Steinhart. Note that Figure 1 is by Adams.

All that follows is the edited and paraphrased version of the Henry Adams text:

1. The Phases of Material Substances

IN 1876-1878 Willard Gibbs, Professor of Mathematical Physics at Yale, published in the Transactions of the Connecticut Academy his famous memoir on the "Equilibrium of Heterogeneous Substances," containing the short chapter "On Existent Phases of Matter." Willard Gibbs helped to change the face of science, but his Phase was not the Phase of History. As he used it, the word *phase* meant *equilibrium*; but his concept of equilibrium [268] was limited. For example, ice, water, and steam were three phases of a single substance, under different conditions of temperature and pressure.

2. Phases From Solids to Mathematics

Solids [270] may be dissolved; liquids and gases may also be dissolved; and a change in composition must accompany a change of phase. Any gas might be likened to a body dissolved in the medium of the universal solvent, the ether. If every solid is soluble into a liquid, and every liquid into a gas, and every gas into corpuscles which vanish in an ocean of ether, if nothing remains of energy itself except potential motion in absolute space, where can science stop in the application of this fertile idea?

Where it can stop is its own affair; but where it must stop is a larger question that interests philosophy. There seems to [271] be no reason for insisting that it must necessarily stop anywhere within the region of experience. Certainly it cannot stop with static electricity, which is itself more obviously a mere phase of matter than water-vapor. The physicists cannot conceive it without conceiving something more universal behind or above it. It must be the case that electricity is soluble into ether.

The mind insists on asking what would happen if every substance is soluble in a more volatile substance, or under more volatile conditions. Supposing the mechanical theories of matter to be carried out as far as experience warrants, - supposing each centre of motion capable of solution in a less condensed motion, supposing every vortex-centre treated as a phase or stage of equilibrium which passes, more or less abruptly, into another phase, under changed conditions ; must all motion merge at last into ultimate static energy existing only as potential force in absolute space?

Yet the physicists here, too, were helpless to escape the step, for where they refused to go as experimenters, they had to go as mathematicians. Without the higher mathematics they could no longer move, but with the [273] higher mathematics, metaphysics began. There the restraints of physics did not exist. In the mathematical order, infinity became the invariable field of action, and not only did the mathematician deal habitually and directly with all sorts of infinities, but he also built up hyper-infinites, if he liked, or hyper-spaces, or infinite hierarchies of hyper-space. The true mathematician drew breath only in the hyper-space of Thought ; he could exist only by assuming that all phases of material motion merged in the last conceivable phase of immaterial motion pure mathematical thought.

No phase of hyper-substance more subtle than thought can ever be conceived, since it could exist only as his own thought returning into itself. Possibly, in the inconceivable domains of abstraction, the ultimate substance may show other aspects of itself, but to our present human minds it can be known only as hyper-thought, the region of pure mathematics and metaphysics, the last and universal solvent.

There even mathematics must stop. Motion itself [274] has ended; even thought became merely potential in this final solution. The hierarchy of phases is complete. Each phase, measured by its rapidity of vibration, arranges itself into a sequence.

3. The Hierarchy of Phases

The hierarchy rose in an order more or less demonstrable, from :

1. The Solids, among which the Rule of Phases offers ice as a convenient example of its first phase, because under a familiar change of temperature it passes instantly into its next phase : -

2. The Fluid, or water, which by a further change of temperature transforms itself suddenly into the third phase :

3. Vapor, or gas, which has laws and habits of its own forming the chief subject of chemical study upon the molecule and the atom. Thus far, each phase falls within the range of human sense, but the gases, under new conditions, seem to resolve themselves into a fourth phase :

4. The Electron or Electricity, which is not within the range of any sense except when set in motion. Another form of the same phase is Magnetism ; and some psychologists have tried to bring animal consciousness or thought into relation with electro-magnetism, which [275] would be very convenient for scientific purposes. The most prolonged and painful effort of the greatest geniuses has not yet succeeded in uniting Electricity with Magnetism, much less with Mind, but all show the strongest signs of a common origin in the next phase of un-differentiated energy or energies called : -

5. The Ether, endowed with qualities which are not so much substantial or material as they are concepts of thought, self-contradictions in experience. Very slowly and unwillingly have the scientists yielded to the necessity of admitting that this form of potential energy - this undifferentiated substance supporting matter and mind alike exists, but it now forms the foundation of physics, and in it both mind and matter merge. Yet even this semi-sensual, semi-concrete, inconceivable complex of possibilities, the agent or home of infinite and instantaneous motion like gravitation, infinitely rigid and infinitely elastic at once, is solid and concrete com pared with its following phase : -

6. Space, knowable only as a concept of extension, a thought, a mathematical field of speculation, and yet almost the only concrete certainty of man's consciousness. Space can be conceived as a phase of potential strains or disturbances of equilibrium, but whether studied as static substance or substance in motion, it must be endowed with [276] an infinite possibility of strain. That which is infinitely formless must produce form. That which is only intelligible as a thought, must have a power of self-induction or disturbance that can generate motion.

7. Finally, the last phase conceivable is that which lies beyond motion altogether as Hyper-space, knowable only as Hyper-thought, or pure mathematics, which, whether a subjective idea or an objective theme, is the only phase that man can certainly know and about which he can be sure. Whether he can know it from more than one side, or otherwise than as his own self-consciousness, or whether he can ever reach higher phases by developing higher powers, is a matter for mathematicians to decide; but, even after reducing it to pure negation, it must still possess, in the abstractions of ultimate and infinite equilibrium, the capacity for self-disturbance; it cannot be absolutely dead.

4. The Rule of Phases

The Rule of Phases lends itself to mathematical treatment, and the rule of science which is best suited to mathematical treatment will always be favored by physicists, other merits being equal. Though the terms be as general as those of Willard Gibbs formulas, if they hold good for every canonical system they will be adopted. The Rule itself assumes the general fact, ascertained by experiment or arbitrarily taken as starting point, that [277] every equilibrium, or phase, begins and ends with what is called a critical point, at which, under a given change of temperature or pressure, a mutation occurs into another phase ; and that this passage from one to the other can always be expressed mathematically. The time required for establishing a new equilibrium varies with the

nature or conditions of the substance, and is sometimes very long in the case of solids, but the formula does not vary.

In chemistry the Rule of Phase applied only to material substances, but in physics no such restriction exists. Down to the moment of Hertz's experiments in 1887 and 1888, common-sense vigorously rejected the idea that material substance could be reduced to immaterial energy, but this resistance had to be abandoned with the acceptance of magneto-electricity and ether, both of which were as immaterial as thought itself ; and the surrender became final with the discovery of radium, which brought the mutation of matter under the closest direct observation. Thenceforward nothing prevented the mathematical physicist from assuming the existence of as many phases, and calculating the values of as many mutations, as he liked, up to the last thinkable stage of hyper-thought and hyperspace which he knew as pure mathematics, and in which all motion, all relation, and all form, were merged. [278]

The laws governing potential strains and stresses in an ideal equilibrium infinitely near perfection, or the volatility of an ideal substance infinitely near a perfect rest, or the possibilities of self-induction in an infinitely attenuated substance, may be left to mathematics for solution ; but the ether, with its equally contradictory qualities, is admitted to exist ; it is a real substance or series of substances, objective and undeniable as a granite rock. It is an equilibrium, a phase, with laws of its own which are not the laws of Newtonian mechanics ; it requires new methods, perhaps new mind ; but, as yet, the physicist has found no reason to exclude it from the sequence of substances. The dividing line between static electricity and ether is hardly so sharp as that between any of the earlier phases, solid, fluid, gaseous, or electric.

5. The Role of Mind in the Universe: Origins of Order & Direction

The physicist has been reluctantly coerced into this concession, and if he had been also a psychologist he would have been equally driven, under the old laws of association formerly known as logic, to admit that what he conceded to motion in its phase as matter, he must concede to motion in its form as *mind*. Whatever dogmatic confidence the mechanist had professed in his mechanical theory of the universe, his own mind had [279] always betrayed an uneasy protest against being omitted from its own mechanical creation.

This neglect of the role of mind in the universe involved not only a total indifference to the existence of mind as a material or immaterial vibration, although such mere kinetic movement was granted in theory to every other substance known ; but it ignored also the higher claim, which was implied in its own definition, that it existed as the sole source of Direction, or Form, without which all mechanical systems must remain forever as chaotic as they show themselves in a thousand nebulae.

The question of the origin of Direction was more vital to science than all kinematics together. The question how order could have got into the universe at all was the chief

object of human thought since thought existed. The sum of motion without direction is zero, as in the motion of a kinetic gas where only Clerk Maxwell's demon of Thought could create a value. Possibly, in the chances of infinite time and space, the law of probabilities might assert that, sooner or later, some volume of kinetic motion must end in the accident of Direction, but no such accident has yet affected the gases, or imposed a general law on the visible universe. Down to our day Vibration and Direction remain as different as Matter and Mind. Lines [280] of force go on vibrating, rotating, moving in waves, up and down, forward and back, indifferent to control and pure waste of energy, forms of repulsion, until their motion becomes guided by motive, as an electric current is induced by a dynamo.

6. History is the Flow of Thought-Stuff

History, so far as it recounts progress, deals only with such induction or direction, and therefore in history only the attractive or inductive mass, as Thought, helps to construct. Only attractive forces have a positive, permanent value for the advance of society on the path it has actually pursued. The processes of History being irreversible, the action of Pressure can be exerted only in one direction, and therefore the variable called Pressure in physics has its equivalent in the Attraction, which, in the historical rule of phase, gives to human society its forward movement. Thus in the historical formula, Attraction is equivalent to Pressure, and takes its place.

In physics, the second important variable is Temperature. Always a certain temperature must coincide with a certain pressure before the critical point of change in phase can be reached. In history, and possibly wherever the movement is one of translation in a medium, the Temperature is a result of acceleration, or its equivalent, and in the Rule of historical phase Acceleration takes its place. [281]

The third important variable in the physico-chemical phase is Volume, and it reappears in the historical phase unchanged. Under the Rule of Phase, therefore, man s Thought, considered as a single substance passing through a series of historical phases, is assumed to follow the analogy of water, and to pass from one phase to another through a series of critical points which are determined by the three factors Attraction, Acceleration, and Volume, for each change of equilibrium.

Among the many images that might be used to illustrate the idea, that of a current is perhaps the nearest ; but whether the current be conceived as a fluid, a gas, or as electricity, whether it is drawn on by gravitation or induction, whether it be governed by the laws of astronomical or electric mass, - it must always be conceived as a solvent, acting like heat or electricity, and increasing in volume by the law of squares.

This solvent, then, this ultimate motion which absorbs all other forms of motion is an ultimate equilibrium, this ethereal current of Thought, is conceived as existing, like ice on a mountain range, and trickling from every pore of rock, in innumerable rills, uniting always into larger channels, and always dissolving what ever it meets, until at last it

reaches equilibrium in the ocean of ultimate solution. Historically the current can [282] be watched for only a brief time, at most ten thousand years. Inferentially it can be divined for perhaps a hundred thousand. Geologically it can be followed back perhaps a hundred million years, but however long the time, the origin of consciousness is lost in the rocks before we can reach more than a fraction of its career.

7. Thought-Stuff Goes through Phases like Water

In this long and for our purposes infinite stretch of time, the substance called Thought has, like the substance called water or gas, passed through a variety of phases, or changes, or states of equilibrium, with which we are all, more or less, familiar. We live in a world of phases, so much more astonishing than the explosion of rockets, that we cannot, unless we are Gibbs or Watts, stop every moment to ask what becomes of the salt we put in our soup, or the water we boil in our teapot, and we are apt to remain stupidly stolid when a bulb bursts into a tulip, or a worm turns into a butterfly.

No phase compares in wonder with the mere fact of our own existence, and this wonder has so completely exhausted the powers of Thought that mankind, except in a few laboratories, has ceased to wonder, or even to think. The Egyptians had infinite reason to bow down before a beetle; we have as much reason as they, for we know no more about it ; but we have learned to accept our beetle Phase, and to recognize that everything, animate or inanimate, spiritual [283] or material, exists in Phase; that all is equilibrium more or less unstable, and that our whole vision is limited to the bare possibility of calculating in mathematical form the degree of a given instability.

Thus results the plain assurance that the future of Thought, and therefore of History, lies in the hands of the physicists, and that the future historian must seek his education in the world of mathematical physics. Nothing can be expected from further study on the old lines. A new generation must be brought up to think by new methods, and if our historical department in the Universities cannot enter this next Phase, the physical department will have to assume the task alone.

8. History Studies the Phases of Social Evolution

Meanwhile, though quite without the necessary education, the historical inquirer or experimenter may be permitted to guess for a moment, merely for the amusement of guessing, what may perhaps turn out to be a possible term of the problem as the physicist will take it up. He may assume, as his starting-point, that Thought is a historical substance, analogous to an electric current, which has obeyed the laws of Phase.

The hypothesis is not extravagant. As a fact, we know only too well that our historical Thought has obeyed, and still obeys, some law of Inertia, since it has habitually and obstinately resisted deflection [284] by new forces or motives ; we know even that it acts as though it felt friction from resistance, since it is constantly stopped by all sorts of

obstacles; we can apply to it, letter for letter, one of the capital laws of physical chemistry, that, where an equilibrium is subjected to conditions which tend to change, it reacts internally in ways that tend to resist the external constraint, and to preserve its established balance ; often it is visibly set in motion by sympathetic forces which act upon it as a magnet acts on soft iron, by induction ; the commonest school- history takes for granted that it has shown periods of unquestioned acceleration.

If society has in so many ways obeyed the ordinary laws of attraction and inertia, then it must be asked whether society obeys them in all respects, and whether the rules that have been applied to fluids and gases in general, apply also to society as a current of Thought. Such a speculative inquiry is the source of almost all that is known of magnetism, electricity and ether, and all other possible immaterial substances, but in history the inquiry has the vast advantage that a Law of Phase has been long established for the stages of human thought.

9. Comte's Three Phases of History

No student of history is so ignorant as not to know that fully fifty years before the chemists took up the study of Phases, Auguste Comte laid down in sufficiently [285] precise terms a law of phase for history. Nearly a hundred and fifty years before Gibbs announced his mathematical formulas of phase to the physicists and chemists, Turgot stated the Rule of historical Phase as clearly as Franklin stated the law of electricity.

It was about 1830 that Comte began to teach the law that the human mind, as studied in the current of human thought, had passed through three stages or phases: religious, metaphysical, and what he called positive as developed in his own teaching; and that this was the first principle of social dynamics. His critics tacitly accepted in principle the possibility of some such division, but they fell to disputing Comte's succession of phases [286] as though this were essential to the law. Comte's idea of applying the rule had nothing to do with the validity of the rule itself.

Once it was admitted that human thought had passed through three known phases, - analogous to the chemical phases of solid, liquid, and gaseous, the standard of measurement which was to be applied might vary with every experimenter until the most convenient should be agreed upon. The commonest objection to Comte s rule, the objection that the three phases had always existed and still exist, together, had still less to do with the validity of the law. The residuum of every chemical distillate contains all the original elements in equilibrium with the whole series, if the process is not carried too far. The three phases always exist together in equilibrium; but their limits on either side are fixed by changes of temperature and pressure, manifesting themselves in changes of Direction or Form.

Discarding, then, as unessential, the divisions of history suggested by Comte, the physicist-historian would assume that a change of phase was to be recognized by a change of Form ; that is, by a change of Direction; and that it was caused by

Acceleration, and increase of Volume or Concentration. In this sense the experimenter is restricted rigidly to the search for changes of Direction or Form of thought, but has no concern in its acceleration [287] except as one of the three variables to which he has to assign mathematical values in order to fix the critical point of change. The first step in experiment is to decide upon some particular and unquestioned change of Direction or Form in human thought.

10. The Renaissance is a Critical Point: A Phase Change

By common consent, one period of history has always been regarded, even by itself, as a Renaissance, and has boasted of its singular triumph in breaking the continuity of Thought. The exact date of this revolution varies within a margin of two hundred years or more, according as the student fancies the chief factor to have been the introduction of printing, the discovery of America, the invention of the telescope, the writings of Galileo, Descartes, and Bacon, or the mechanical laws perfected by Newton, Huyghens, and the mathematicians as late as 1700 ; but no one has ever doubted the fact of a distinct change in direction and form of thought during that period ; which furnishes the necessary starting-point for any experimental study of historical Phase.

Any one who reads half a dozen pages of Descartes or Bacon sees that these great reformers expressly aimed at changing the Form of thought ; that they had no idea but to give it new direction, as Columbus and Galileo had expressly intended to affect direction in space ; and even had they all been unconscious of intent, the Church [288]would have pointed it out to them, as it did with so much emphasis to Galileo in 1633. On this point there was no difference of opinion ; the change of direction in Thought was not a mere acceleration ; it was an angle or tangent so considerable that the Church in vain tried to ignore it. Galileo proved it, and the Church agreed with him on that point if on no other. Nothing could be more unanimously admitted than the change of direction between the thought of St. Augustine and that of Lord Bacon.

Since the Rule of historical Phase has got to rest on this admission, theory cannot venture on the next step unless this one is abundantly proved; but, in fact, no one as yet has ever doubted it. The moment was altogether the most vital that history ever recorded, and left the deepest impression on men s memory, but this popular impression hardly expresses its scientific value. As a change of phase it offered singular interest, because, in this case alone, the process could be followed as though it were electrolytic, and the path of each separate molecule were visible under the microscope.

Any school-boy could plot on a sheet of paper in abscissae and ordinates the points through which the curve of thought passed, as fixed by the values of the men and their inventions or discoveries. History offers no other demonstration to [289] compare with it, and the more because the curve shows plainly that the new lines of Force or Thought were induced lines, obeying the laws of mass, and not those of self-induction.

On this obedience Lord Bacon dwelt with tireless persistence; "the true and legitimate object of science is only to endow human life with new inventions and forces"; but he defined the attractive power of this magnet as equal to the sum of nature s forces, so far as they could serve man s needs or wishes; and he followed that attraction precisely as Columbus followed the attraction of a new world, or as Newton suffered the law of gravitation on his mind as he did on his body.

As each newly appropriated force increased the attraction between the sum of nature's forces and the volume of human mind, by the usual law of squares, the acceleration hurried society towards the critical point that marked the passage into a now phase as though it were heat impelling water to explode as steam.

Only the electrolytic process permits us to watch such movements in physics and chemistry, and the change of phase in 1500-1700 is marvellously electrolytic, but the more curious because we can even give names to the atoms or molecules that passed over to the positive or negative electrode, and can watch the accumulation of force which ended at last by deflecting the whole current [290] of Thought. The maximum movement possible in the old channel was exceeded ; the acceleration and concentration, or volume, reached the point of sudden expansion, and the new phase began. The history of the new phase has no direct relation with that which preceded it.

11. The Law of the Acceleration of Thought

The acceleration of the seventeenth century, as compared with that of any previous age, was rapid, and that of the eighteenth was startling. The acceleration became even measurable, [291] for it took the form of utilizing heat as force, through the steam-engine, and this addition of power was measurable in the coal output. Society followed the same lines of attraction with little change, down to 1840, when the new chemical energy of electricity began to deflect the thought of society again, and Faraday rivalled Newton in the vigor with which he marked out the path of changed attractions, but the purely mechanical theory of the universe typified by Newton and Dalton held its own, and reached its highest authority towards 1870, or about the time when the dynamo came into use.

Throughout these three hundred years, and especially in the nineteenth century, the acceleration suggests at once the old, familiar law of squares. The curve resembles that of the vaporization of water. The resemblance is too close to be disregarded, for nature loves the logarithm, and perpetually recurs to her inverse square.

For convenience, if only as a momentary refuge, the physicist-historian will probably have to try the experiment of taking the law of inverse squares as his standard of social acceleration for the nineteenth century, and consequently for the whole phase, which obliges him to accept it experimentally as a general law of history. Nature is rarely so simple as to act rigorously on the square, but History, like Mathematics, is obliged to assume [292] some rule, which may be left as general and undetermined as the formulas

of our greatest master, Willard Gibbs, but which gives a hypothetical movement for an ideal substance that can be used for [293] relation. Some experimental starting-point must always be assumed, and the mathematical historian will be at liberty to assume the most convenient, which is likely to be the rule of geometrical progression.

12. The Evolution of Thought Before 1600

Thus the first step towards a Rule of Phase for history may be conceived as possible. In fact the Phase may be taken as admitted by all society and every authority since the condemnation of Galileo in 1633; it is only the law, or rule, that the mathematician and physicist would aim at establishing. Supposing, then, that he were to begin by the Phase of 1600-1900, which he might call the Mechanical Phase, and supposing that he assumes for the whole of it the observed acceleration of the nineteenth century, the law of squares, his next step would lead him backward to the fur more difficult problem of fixing the limits of the Religious Phase that preceded 1600.

[Given our present ignorance about the details of the past, it seems safe to say that the Religious Phase runs from the beginning of history to the condemnation of Galileo (in about 1600). Perhaps it runs backwards to about 100,000 years ago. Before the Religious Phase, there is only the biological Phase of Instinct.]

13. The Law of Thought is Gravitational

Thus the physicist-historian seems likely to be forced into admitting that an attractive force, like gravitation, drew these trickling rivulets of energy into new phases by an external influence which tended to concentrate and accelerate their motion by a law with which their supposed wishes or appetites had no conscious relation.

At a certain point the electric corpuscle was obliged to become a gas, the gas a liquid, the liquid a solid. For material mass, only one law was known to hold good. Ice, water, and gas, all have weight ; they obey the law of astronomical mass; they are guided by the attraction of matter. If the current of Thought has shown obedience to the law of gravitation it is material, and its phases should be easily calculated. [300]

The physicist will, therefore, have to begin by trying the figure of the old Newtonian or Cartesian vortices, or gravitating group of heterogeneous substances moving in space as though in a closed receptacle. Any nebula or vortex-group would answer his purpose, say the great nebula of Orion, which he would conceive as containing potentially every possible phase of substance. Here the various local centres of attraction would tend to arrange the diffused elements like iron-filings round a magnet in a phase of motion which, if the entire equilibrium were perfect, would last forever ; but if, at any point, the equilibrium were disturbed, the whole volume would be set in new motion, until, under the rise in pressure and temperature, one phase after another must mechanically, and more and more suddenly, occur with the in creasing velocity of movement.

That such sudden changes of phase do in fact occur is one of the articles of astronomical faith, but the reality of the fact has little to do with the convenience of the figure. The nebula is beyond human measurements. A simple figure is needed, and our solar system offers none. The nearest analogy would be that of a comet, not so much because it betrays marked phases, as because it resembles Thought in certain respects, since, in the first place, no one knows what it is, which is also true of [301] Thought, and it seems in some cases to be immaterial, passing in a few hours from the cold of space to actual contact with the sun at a temperature some two thousand times that of incandescent iron, and so back to the cold of space, without apparent harm, while its tail sweeps round an inconceivable circle with almost the speed of thought, certainly the speed of light, and its body may show no nucleus at all. If not a Thought, the comet is a sort of brother of Thought, an early condensation of the ether itself, as the human mind may be another, traversing the infinite without origin or end, and attracted by a sudden object of curiosity that lies by chance near its path. If such elements are subject to the so-called law of gravitation, no good reason can exist for denying gravitation to the mind.

14. Laws of Thought – Gravity and Electro-Magnetic Laws

Comets show direction and purpose more clearly than any other heavenly bodies. Comets furnish the only astronomical parallel for the calculated acceleration of the last Phase of Thought. No other heavenly body shows the same sharp curve or excessive speed. [303]

But there are some problems with using the movement of a comet as an analogy for the movement of Thought. The acceleration of the comet is much slower than that of society. The world did not double or triple its movement between 1800 and 1900, but, measured by any standard known to science (by horse-power, calories, volts, mass in any shape), the tension and vibration and volume and so-called progression of society was one thousand times greater in 1900 than in 1800; the force had doubled ten times over, and the speed, when measured by electrical standards as in telegraphy, approached infinity, and had annihilated both space and time. No law of material movement applied to it.

Some such result was to be expected. Nature is not so simple as to obey only one law, or to apply necessarily a law of material mass (like gravity) to an immaterial substance (like Thought). The result proves only that the comet is material, and that thought is less material than the comet. The analogy between the comet and Thought is useful only as an introduction to the physical study of history. If [304]the laws of material mass do not help him, the physicist-historian will look for a law of immaterial mass, and here he has, as yet, but one analogy to follow: electricity. If the comet offers an analogy for studying the laws of the current of human society, electricity offers one so much stronger that psychologists are apt instinctively to study the mind as a phase of electro-magnetism.

By watching the movement of Thought on the enormous scale of historical and geological or biological time, we can see that the current of Thought has been constant as

measured by its force and volume in the absorption of nature's resources, and that, within the last century, its acceleration has been far more rapid than before, more rapid than can be accounted for by the laws of material mass. But only highly trained physicists will be able to invent exact models to represent such motion. At present we can merely guess what the skilled historian-physicists of the future will say. [305] We can only imagine simple analogies, like the analogy between electricity and Thought.

15. Efforts to Assign Dates to the Phases

This ideal case would offer to his imagination the image of nature's power as an infinitely powerful dynamo, attracting or inducing a current of human thought according to the usual electric law of squares, that is to say,- that the average motion of one phase is the square of that which precedes it. The curve is shown in Figure 1.

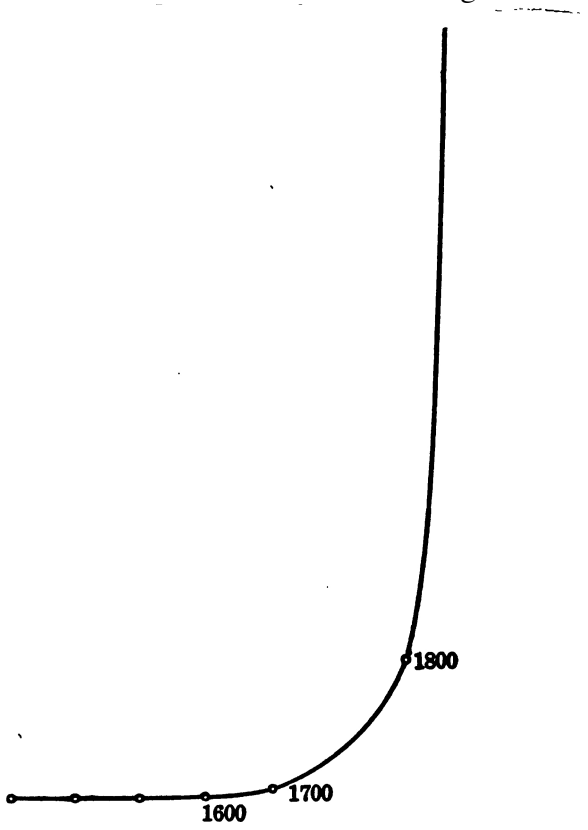

Figure 1. The curve of history. By Henry Adams.

Assuming that the change of phase began in 1500, and that the new Mechanical Phase dates in its finished form from Galileo, Bacon, and Descartes, with a certain lag in its announcement by them, say from 1600, the law of squares gives a curve like that of ice, water, and steam, running off to the infinite in almost straight lines at either end, like the comet, but at right angles.

Supposing a value in numbers of any sort, say 6, 36, 1296, - and assigning 1296 to the period 1600-1900, the preceding religious phase would have a value of only 36 as the average of many thousand years, representing therefore nearly a straight line, while the twentieth century would be represented by the square of 1296 or what is equivalent to a straight line to infinity.

Phase	Length in Years	Quantity of Energy
[Instinctual Phase]	[8 billion years]	6
Religious Phase	90,000	36
Mechanical Phase	300	1296
Electrical Phase	17.5	1679616
Ethereal Phase	4	2.8 trillion

Table 1 [Added by Steinhart]. Lengths of phases and their energies.

Reversing the curve to try the time-sequence by the same rule, the Mechanical Phase being represented by 300 years, the Religious Phase would require not less than 90,000. Perhaps this result might not exactly suit a physicist's views, but if he accepts the sequence [306] 90,000 and 300 for these two phases in time, he arrives at some curious results for the future, and in calculating the period of the fourth, or Electric Phase, he must be prepared for extreme figures.

16. The Electrical Phase

No question in the series is so vital as that of fixing the limits of the Mechanical Phase. Assuming, as has been done, the year 1600 for its beginning, the question remains to decide the probable date of its close. Perhaps the physicist might regard it as already closed. He might say that the highest authority of the mechanical universe was reached about 1870, and that, just then, the invention of the dynamo turned society sharply into a new channel of electric thought as different from the mechanical as electric mass is different from astronomical mass. He might assert that Faraday, Clerk Maxwell, Hertz, Helmholz, and the whole electro-magnetic school, thought in terms quite unintelligible to the old chemists and mechanists. The average man, in 1850, could understand what Davy or Darwin had to say; he could not understand what Clerk Maxwell meant. The later terms were not translatable into the earlier; even the mathematics became hyper-mathematical.

Possibly a physicist might go so far as to hold that the most arduous intellectual effort ever made by man with a distinct consciousness of needing new mental powers, was made [307] after 1870 in the general effort to acquire habits of electro-magnetic thought . The physicist knows best his own difficulties, and perhaps to him the process of evolution may seem easy, but to the mere by-stander the gap between electric and astronomic mass seems greater than that between Descartes and St. Augustine, or Lord

Bacon and Thomas Aquinas. The older ideas were intelligible; the idea of electro-magnetic-ether is not.

Thus it seems possible that another generation, trained after 1900 in the ideas and terms of electro-magnetism and radiant matter, may regard that date as marking the sharpest change of direction, taken at the highest rate of speed, ever effected by the human mind ; a change from the material to the immaterial, from the law of gravitation to the law of squares. The Phases were real : the change of direction was measured by the consternation of physicists and chemists at the discovery of radium which was quite as notorious as the consternation of the Church at the discovery of Galileo.

17. The Ethereal Phase

Should the physicist reject the division, and insist on the experience of another fifty or a hundred years, the [308] consequence would still be trifling for the fourth term of the series. Supposing the Mechanical Phase to have lasted 300 years, from 1600 to 1900, the next or Electric Phase would have a life equal to the square root of 300, or about seventeen years and a half, when that is, in 1917 it would pass into another or Ethereal Phase, which, for half a century, science has been promising, and which would last only about as long as the square root of 17.5, or about four years, and bring Thought to the limit of its possibilities in the year 1921. It may well be !

Phase	Length in Years	Start	End
[Instinctual Phase]	[8.1 billion]		
Religious Phase	90,000	(Long ago)	1600
Mechanical Phase	300	1600	1900
Electrical Phase	17.5	1900	1917
Ethereal Phase	4	1917	1921

Table 2 [Added by Steinhart]. Historical periods of phases.

Nothing whatever is beyond the range of possibility; but even if the life of the previous phase, 1600-1900, were extended another hundred years, the difference to the last term of the series would be negligible. In that case, the Ethereal Phase would last till about 2025.

Phase	Length in Years	Start	End
[Instinctual Phase]	[25.6 billion]		
Religious Phase	160,000	(Long ago)	1600
Mechanical Phase	400	1600	2000
Electrical Phase	20	2000	2020
Ethereal Phase	5	2020	2025

Table 3 [Added by Steinhart]. Alternative calculation for historical phases.

The mere fact that society should think in terms of Ether or the higher mathematics might mean little or much. According to the Phase Rule, it lived from remote ages in terms of fetish force, and passed from that into terms of mechanical force, which again led to terms of electric force, without fairly realizing what had happened except in slow social and political revolutions. Thought in terms of Ether means only Thought in terms of itself, or, in other words, pure Mathematics and Meta physics, a stage often reached by individuals. At the utmost it could mean only the subsidence of the current [309] into an ocean of potential thought, or mere consciousness, which is also possible, like static electricity. The only consequence might be an indefinitely long stationary period, such as John Stuart Mill foresaw. In that case, the current would merely cease to flow.

But if, in the prodigiously rapid vibration of its last phases, Thought should continue to act as the universal solvent which it is, and should reduce the forces of the molecule, the atom, and the electron to that costless servitude to which it has reduced the old elements of earth and air, fire and water ; if man should continue to set free the infinite forces of nature, and attain the control of cosmic forces on a cosmic scale, the consequences may be as surprising as the change of water to vapor, of the worm to the butterfly, of radium to electrons.

18. Conclusion

Such seem to be, more or less probably, the lines on which any physical theory of the universe would affect the study of history, according to the latest direction of physics. Comte s Phases adapt themselves easily to some such treatment, and nothing in philosophy or meta physics forbids it. The figure used for illustration is immaterial except so far as it limits the nature of the attractive force. In any case the theory will have to [310] assume that the mind has always figured its motives as reflections of itself, and that this is as true in its conception of electricity as in its instinctive imitation of a God.

Always and everywhere the mind creates its own universe, and pursues its own phantoms ; but the force behind the image is always a reality, the attractions of occult power. If values can be given to these attractions, a physical theory of history is a mere matter of physical formula, no more complicated than the formulas of Willard Gibbs or Clerk Maxwell ; but the task of framing the formula and assigning the values be longs to the physicist, not to the historian ; and if one such arrangement fails to accord with the facts, it is for him to try another, to assign new values to his variables, and to verify the results.

WASHINGTON, January 1, 1909.