A Working Paper Draft

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SOCIO-ENGINEERING PROBLEMS. NO. 9-A

A series of manuscripts on the social relations of engineering and related philosophical questions dealing with the interaction of science and society. Distribution is limited to reviewers and discussion groups for criticism prior to consideration for possible publication.

PARTIAL DERIVATIVES OF HISTORY

PART I *

1. Introduction - J. C. Maxwell on analysis vs. synthesis
   J. G. Crowther on the Royal Society, Series of
   "partial histories of different orders."
2. Fifth order partial history of the universe.
3. Fourth order partial history of the earth.

* Note: Continued in SEP No. 10-A.

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PARTIAL DERIVATIVES OF HISTORY

PART II

4. Third order partial history of man. **
5. Second order partial history of science.
6. First order history of physical science.

** Note: Rosenstock-Huessy "The paradoxical truth about progress, then, is that it wholly depends on the survival of massive institutions which prevent a relapse from a stage which has been reached. In general, this is the last thing a progressive is concerned about.

A Part of (A Proposal for a Book on)

"FRONTIER PROBLEMS OF ENGINEERING SOCIOLOGY"

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Preface

In a previous issue of, SEP No. 7, Problem 7. 1.2(c) Taylor's Series was stated as follows:

The Taylor's Series used in mathematics to represent a function in a limited region about a point suggests a series of partial histories of different orders for obtaining a suitable perspective to deal with the essential historical background of a problem dealing both with engineering and sociology. Taylor's series enables us to expand a function in terms of powers of x-a when the value of the function and its derivatives are known for x=a. The function is said to be expanded in the neighborhood of x=a, and the series can be used to compute the value of the function for values of x which are near a. For example, set

$$f(a+h) = f(a) + hf^{I}(a) + \frac{h^2}{2!} f''(a) + \frac{h^3}{3!} f'''(a) + \ldots + \frac{h^n}{n!} f^{(n)}(a) + \ldots\ldots$$

If we take the first derivative of f(a+h) with respect to h, we have

$$f^{I}(a+h) = f^{I}(a) + hf''(a) + \frac{h^2}{2!} f'''(a) + \frac{h^3}{3!} f^{IV}(a) + \frac{h^4}{4!} f^{V}(a)$$

Then the 2nd through 5th derivatives are:

$$f''(a+h) = f''(a) + hf'''(a) + \frac{h^2}{2!} f^{IV}(a) + \frac{h^3}{3!} f^{V}(a)$$

$$f'''(a+h) = f'''(a) + hf^{IV}(a) + \frac{h^2}{2!} f^{V}(a)$$

$$f^{IV}(a+h) = f^{IV}(a) + hf^{V}(a)$$

$$f^{V}(a+h) = f^{V}(a)$$

With the taking of each derivative less detail about the function is left. The objective of this note is to collect some reference material for the development of series of partial derivatives of history similar to the Taylor's Series of mathematics. Upon completion of this study, it may well be found that some other series representation is more applicable.

These notes were originally organized as a preliminary draft of a paper on "The History of Electromagnetic Theory" which is described in SEP No. 11-A. A graph illustrating the relative emphasis on these partial derivatives of history is included in SEP No. 34 as Fig. 1. To be more complete this note should have a graphical example of a Taylor's series expansion included.

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PARTIAL DERIVATIVES OF HISTORY PART I.

1. Introduction.

In the consideration of the history of electromagnetic theory from an engineering viewpoint it appears that different methods of attack may yield different types of concepts. James Clerk Maxwell stated that the relation of electricity and magnetism to several other important phenomena seem to indicate the special importance of electrical science as an aid to the interpretation of nature. Maxwell compared Faraday's methods with those of the mathematicians.

> When I had translated what I considered to be Faraday's ideas into a mathematical form, I found that in general the results of the two methods coincided so that the same phenomena were accounted for, and the same laws of action deduced by both methods, but that Faraday's methods resembled those in which we begin with the whole and arrive at the parts by analysis while the ordinary mathematical methods were founded on the principle of beginning with the parts and building up the whole by synthesis.(1)

> In a philosophical point of view, moreover, it is exceedingly important that two methods should be compared, both of which have succeeded in explaining the principal electromagnetic phenomena, and both of which have attempted to explain the propagation of light as an electromagnetic phenomenon and have actually calculated its velocity, while at the same time the fundamental conceptions of what actually takes place, as well as most of the secondary conception of the quantities concerned are radically different.(2)

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(1). Maxwell, James Clerk, A Treatise on Electricity and Magnetism, Preface to first edition (1873), p. ix. of 1892 edition.

(2). Ibid., p. x. of 1892 edition.

Pascual Jordan stated:

> The history of physics contains no more impressive example of the creative force of theoretical thought in physics than the history of the discovery of electro-magnetic waves.... They were formulated on paper educed from the mathematical formulae which Maxwell had begun to evolve as a quantitative description of Faraday's ideas. Only subsequently were they sought experimentally, and found by Hertz.(3)

However, with the passage of time what was at one time best interpretation of nature may become incomplete if one method is used to the exclusion of others. Stratton in 1941 commented on Maxwell's influence:

> The pattern set nearly 70 years ago by Maxwell's Treatise on Electricity and Magnetism has been a dominant influence on almost every subsequent English and American text, persisting to the present day.... from the single point of view of Faraday. Thus it contained little or no mention of the hypotheses put forward on the continent in earlier years by Riemann, Weber, Kirchhoff, Helmholtz, and others.... Only the original and solitary genius of Heaviside succeeded in breaking away from this course.
>
> For an exploration of the fundamental content of Maxwell's equations one must turn again to the Continent. There the work of Hertz, Poincaire, Lorentz, Abraham, and Sommerfeld, together with their associates and successors, has led to a vastly deeper understanding of physical phenomena and to industrial developments of tremendous proportions.(4)

In considering the history of electromagnetic theory we should watch out for possible factors which may be overlooked due to concentration upon what has been the

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(3). Pascual Jordan, Die physik des 20. jarhunderts (Braunschweig, 1936), trans. by Eleanor Oshry, Physics of the 20th Century (1944), p. 29.
(4). Electromagnetic Theory (1941), Introduction.

in the past. Maxwell appreciated the interrelationship of electromagnetic theory with other physico-chemical phenomena, but there may have been restrictions upon the scientific research of his time which prevented possible relationships with other phenomena to be carefully studied. A study of the history of the Royal Society reveals that political problems were avoided in the 17th Century because of the social conditions existing at that time. The prohibition of consideration of political problems may have delayed the discovery of important relationships between physical, chemical, biological, psychological, and social phenomena.

> The group tabooed theology and politics, and discussed medicine, anatomy, geometry, etc.... The group wished to be unnoticed by the theological and political contestants, and held its meetings in modest obscurity.... The Royal Society's relative lack of interest in the social relation of science since the end of that century (17th) until today is a reflection of an unchanging conception of the relation of science to society in the intervening period. (5)

One can understand why the Royal Society avoided the investigation of problems related to politics, by noting the fate of some of the individuals who dared to question the political and religious ideas of their time. Joseph Priestly (1733-1804), who is noted for his achievements in chemistry, published in 1767 a treatise on the History and Present State of Electricity which contained some

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(5). J. G. Crowther, The Social Relations of Science (1941), Ch. 62, The Royal Society, pp. 372, 373, 386.

original work. He was also a minister of religion. His inquiry into philosophical and theological problems was not appreciated by the church authorities, and in 1791 his chapel, house, and laboratory in Birmingham, England, were burned and wrecked by a mob. He and his family escaped, but all his books, notes, and laboratory equipment were destroyed.

From the above it is apparent that social conditions acted to direct scientists into study of less controversial phenomena. To study the history of electromagnetic theory from an engineering viewpoint as defined in Chapter I* of the manuscript, it is necessary to find a method of attack that will remove the retarding restrictions imposed by social conditions. It occurs to me that the first step in establishing such an approach might be to establish an historical perspective consistent with the engineering viewpoint previously defined.

The history of electromagnetic theory can be considered as a part of the history of physics, so that a perspective in respect to physics can be obtained by reference to an outline of the history of physics which I shall call a "first partial history of physics." Then the history of physics can be considered as a part of the history of science, so that its perspective in history may be sought

* The Chapter I of 1946 "Engineering Viewpoint" is lost.

in a "second partial history of science." The term "second partial history" is used to indicate that a greater number of events has been omitted in order to make a brief outline. To obtain a perspective of where the history of physics stands in respect to the history of science, a briefer outline is prepared, called a "Second Order Partial History of Science." Similarly higher order partial histories of man, the earth, and the universe are included to provide a base for an historical perspective of the history of electromagnetic theory.

Following this procedure it is proposed that the material be arranged as follows:

I. The Engineering Viewpoint

II. Historical Perspective *
   1. Introduction
   2. Fifth Order Partial History of the Universe
   3. Fourth Order Partial History of the Earth
   4. Third Order Partial History of Man
   5. Second Order Partial History of Science
   6. First Order Partial History of Physics

III. Basic History of Electromagnetic Theory

IV. General History of the Application of Electromagnetic Theory

V. History of Application of Electromagnetic Theory to Microwave Wave Guide Transmission

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* Note the portion of the outline enclosed in the box constitutes this issue of <u>Socio-Engineering Problems</u>.

To consider the possible value of using the above outline let us consider the relationship of "documented" history and "undocumented" history or pre-history. It is assumed that any history is really a history* of some type of phenomena. The complete history of a type of phenomena would include both the documented and undocumented history. To get a more complete picture we can make guesses concerning the portions of history for which we do not have documentary evidence, but we must keep in mind the extent to which our guesses are trustworthy. In the case of electromagnetic theory the documented history goes back to the 18th century. If we consider the phenomena[6] instead of the theory we can estimate that from the evidence available to date, electromagnetic phenomena must have been in existence from the time of the beginning of our universe. The relevance of this elementary consideration can be determined by inquiring as to whether there are other types of natural phenomena which may be considered to have different starting dates in history. Since biological phenomena are considered to have started later than the formation of the universe, this question of the starting dates of phenomena may have

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* Encyclopedia Britannica (1945 Edition), p 11-594. The concept of "history" is changing.

6 This raises the question as to whether this paper should be titled, "The History of Electromagnetic Phenomena" instead of "The History of Electromagnetic Theory." This and other questions of the nature of definition and usage of words, I am leaving for later consideration.

some significance. Similarly psychological and social phenomena may be considered to have respectively later starting dates in history.

2. Fifth Order Partial History of the Universe

Since the history of the universe is such a comprehensive subject, I shall only attempt to deal briefly with one aspect from the point of view of an engineering scientist as described in Chapter I.* Here I shall consider the basis upon which the age of the universe has been estimated.

From the relativistic gravitation constant, the mean mass density of the universe, and gravitation theory the diameter of the universe has been estimated to be ten billion light years. The velocity of spiral nebulae as measured by Doppler shift of spectral lines fit reasonably well with the hypothesis of an expanding universe in which the diameter of the universe is increasing with the velocity of light. From these two considerations and the assumption that the diameter of the universe started from a vanishingly small value, it would take ten billion years for the diameter to attain the value of ten billion light years. This means that the age of the universe can be estimated to be approximately ten billion years.[7]

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* This "Chapter I" is missing.

7 It should be remembered that the author is an expert in neither astrophysics nor cosmogony. The data used here is taken from secondary references in order to make an initial attempt at a partial synthesis as discussed in Chapter I of this paper; Sir James H. Jeans, "Cosmogony," Encyclopedia Britannica (1945), VI, 488-493; Pascual Jordan, op. cit., pp. 173-185. See also p 19-98b.

Next we should consider the age of our solar system.

From the assumption that the earth was once formed out of the material of the sun and from terrestrial radioactivity investigations of the type suggested by St. Meyer it has been shown that a part (perhaps half) of the life of the sun is 4.6 billion years.

3. <u>Fourth Order Partial History of the Earth</u>

From radioactivity investigations of how far the decay of radium has proceeded in different strata of rock, the age of the earth has been shown to be greater than 1.5 billion years. Pascual Jordan states that the age of the earth is probably not more than three times this value.[8] Others estimate the age of the earth to be from three to four billion years.[9] Harold Jeffreys gives an explanation of the radioactivity studies of Holmes, Lawson, and H. N. Russell which lead to the conclusion that the age of the earth is between 1,500 and 3,000 million years.[10]

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8 Jordan, *op. cit.*, Appendix II.

9 John Phelan "Anthropological Backgrounds," in Elmer Pendell (ed.), *Society under Analysis, An Introduction to Sociology* (1942), p. 9.

10 "The Age of the Earth," *Encyclopaedia Britannica* (1945), VII, 834a.

4. Third Order Partial History of Man

The development of man from his sub-human predecessors is briefly summarized in Table III, Sub-Divisions of the Pleistocene and Holocene Periods.

Although anthropological evidence is somewhat sketchy, it is considered probable that modern man developed through evolutionary processes in some favorable spot on the earth. Then groups of this more advanced species spread out over the earth to displace the earlier sub-human species who were less adapted to changing conditions. These separated groups of men were able to live and develop in comparative isolation so that different customs, habits and languages developed in each part of the world. Different skin pigments and minor characteristics developed to be better suited to the geographical and climatic conditions encountered.

As men developed some encountered more favorable circumstances which facilitated the development of inventions.

As man developed he began to need some understanding of the world in which he lived. Primitive religion developed to fulfil this need. Gradually man developed what we call conscience and formulated rules of ethics. Later philosophy and mathematics were developed.

TABLE III [21]

SUB-DIVISIONS OF THE PLEISTOCENE AND HOLOCENE PERIODS

Time span -- 2,000,000 years

Era	Period	Man and Manlike Primates	Glacial Stage (North American nomenclature in parenthesis)		Cultural Stage	Characteristics of Culture Stage
Quaternary, Age of Man, the Glacial Age	Pleistocene	Pithecanthropus erectus (Java man sub-human	Gunz glaciation (Nebraskan)	Eolithic	Pre-Chellean	Approximate date of appearance 1,000,000. Eolithic (dawn stones) rounded bones of twenty-seven extinct species found in drift with Java man.
		Sianthropus (China man) Eoanthropus (Dawson man)	Gunz-Mindel interglacial stage (Aftonian)	Paleolithic	Chellean	Primitive hand-axe, chipped stone, evidences of fire found with Sianthropus.
			Mindel glaciation (Kansan)		No culture	No sub-human form discovered for this period of time.
		Homo Heidelbergensis (Sub-human form found in Germany)	Mindel-Riis interglacial (Yarmouth)		Achulean	Paleolithic flints, hand axes, stone chipped on both sides.
					No culture	No data.
			Riis glaciation (Illineian)		Mousterian	Life in caves, evidences of fire, burial of dead. Paleolithic scrapers and borers.
		Neanderthal (Sub-human)	Riis Wurm interglacial (Sangamon)		Aurignacian	Drawings and paintings, awl, piercer.
					Solutrean	Bone needle and dart.
					Magdalenian	Needle with eye, harpoon.
		Cro-Magnon (Homo sapiens)	Wurm glaciation (Wisconsin)		Azilian	Transitional from the Paleolithic.

21 John Phelan, op. cit., p 17

Holocene	Modern man	Present interglacial	Neolithic	Ground stone	Polished stone; domestication of animals and plants; bow and arrow; spears. Period of beginning 25,000 to 18,000 years ago.
				Bronze	Tools and weapons of bronze; the plow, the wheel, writing; political organization. Period of beginning 3,500 years ago.
				Iron	Beginning of modern world of technological and social advance. Period of beginning 1,350 years ago.

The history of man is marked by a series of cases where one tribe or nation has become more powerful and conquers the surrounding nations. In each case the victor sooner or later becomes decadent and is replaced by some other group. The store of knowledge of the defeated nations in some cases were absorbed and used by the conquering nations. Where the conquerors were not appreciative of knowledge, the advancement of knowledge was maintained by peoples of other parts of the world.

The Greeks were noted for their great literature, philosophy, and mathematics. Roman civilization was noted for its organizational achievements. The Hebrew civilization under conditions of repeatedly being raided by great powers turned to searching examination of the basic meanings of life. They developed the concepts of "The Fatherhood of One God" and "The Brotherhood of Man" out of which developed Christianity. The Christian Church established an organization and body of doctrine during the dying days of the Roman Empire. During the middle ages a considerable degree of stability was maintained through the organization of European civilization around the Christian faith.

With the extension of trade and advancement in knowledge in Western Europe the institutional organizations of Christianity had difficult times adjusting to the new conditions. The Western Civilization which developed in Europe began to conquer the world after the explorations of the fifteenth and sixteenth centuries. This civilization which officially recognized Christianity as its basic religious faith, conquered most of the world. Since many of the peoples who were conquered had dark skins, the myth of "white supremacy" rose. This contradiction of claiming acceptance of "The Brotherhood of Man" while participating in practices based on contradictory principles appears to have caused a serious weakness in our Western Civilization.

Examination of other weakening contradictions in our civilization leads to consideration of the history of science. The development of modern communications have brought the various peoples of the world together so that the tribes which separated to live in comparative isolation in different parts of the world are now brought together again, but with inadequate preparation for cooperative living in one world.

In spite of serious difficulties in our civilization, there are aspects which are slowly improving. The necessity of maintaining existing institutions in order to insure progress is stated by Rosenstock-Huessy as follows:

> "The paradoxical truth about progress, then, is that it wholly depends on the survival of massive institutions which prevent a relapse from a stage which has once been reached. In general, this is the last thing a progressive is concerned about. He must make a real volte-face and learn to revere

5. Second Order Partial History of Science

The following table gives an approximate idea of the relationship of science to the history of man's mental development.

TABLE IV[23]

EVOLUTION OF MAN'S THINKING

I.	Period of subverbal thinking in which the conveyance of ideas is accomplished through elementary language supplemented with gestures, demonstration with tools or weapons, etc.	1,000,000 years = 3.16^{12}
II.	Period of verbal thinking in which languages are developed to convey all ordinary thoughts without need of demonstration.	10,000 years = 3.16^{8}
III.	Period of superverbal symbolic thinking in which mathematical symbols, philosophical concepts, etc., are used.	1,000 years = 3.16^{6}
IV.	Period of integrated collective thinking through organization of I, II, III into the scientific method.	316 years $\cong 3.16^{5}$

Although the above table does not appear to fit many historical facts without further clarification, it is useful in showing the relationship of the scientific method to the development of the human race. In a more thorough study of the history of science this table should be expanded to relate the early attempts to explain the mysteries of nature by theology followed

23 Adapted from Selden Smyser, "Logics: Subverbal and Superverbal," in "Papers from the First American Congress for General Semantics, March 1935," Arrow Editions, N.Y., 1940

our millennium of progress and invention as a whole. On the other hand, the list is an important lesson for the conservative as well...."

"The ladder of potentialities for progress and emancipation is shown in the following list.

CENTURY	LIBERTIES	PROTECTING PRINCIPLE	CORRESPONDING INSTITUTION
20TH	Freedom for growth, health	Public character of labour	(?Perhaps: adult education decentralization of industry?)
19TH	Freedom for talent, thought genius, speech creativeness to	Public character of private ideas	Copyright, patents, a written constitution
17TH	Freedom of endowment	Public character of wills	An independent judiciary
16TH	Free choice of profession, no vows for children	Public character of education	Public schools
13TH	Freedom of competition between teachers	Public character of the sciences	Universities
11TH	Freedom of movement for men in the professions	Public character of civil life (truce of God)	Judges of the peace public prosecution of crime."

Then these are the stakes of our present struggles.[22]

22 Eugen Rosenstock-Huessy, "Out of Revolution," pp 31-3 2, 1938

through various stages up to our present use of the scientific method. In preparing this material some sources have been used which are not generally accepted by both historians and scientists. Even though these sources may be in error in some respects, they are very useful in that they reveal the problems in our civilization that require investigation.

Rosenstock-Huessy gives an indication of his reaction toward science in the present crisis of our civilization.

> A pupil of the World War (I) sees a new future and a new past. He discovers a new political biology of the human race, filling in the gap between Planckism in physics, Darwinism in zoology, Marxism in economy, and liberalism in theology and political history.
>
> The year of Harvard's Tercentenary, 1936-1937, was also the tercentenary of a great intellectual event....the rational foundations of modern science were established....Descartes "Cogito ergo sum" opened the way to three hundred years of incredible scientific progress. 25
>
> Truth is divine and has been divinely revealed -- credo ut intelligam (Anslem) Truth is pure and can be scientifically stated -- cogito ergo sum (Descartes). Truth is vital and must be socially represented -- Respondeo etsi mutabor (Rosenstock-Huessy.)
>
> Our attack on Cartesianism is inevitable since "pure" thought encroaches everywhere on the field of social studies. Historians and economists and psychologists cannot stand the idea of not being "pure" thinkers, real scientists. What a frustration!
>
> I am an impure thinker. I am hurt, swayed, shaken, elated, disillusioned, shocked, comforted, and I have to transmit my mental experiences lest I die....

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25 Rosenstock-Huessy, op. cit., p 7

> Science, and history in its positivist stage, underrated the biological element in both nature and society....By beginning with abstract figures in physics, or general ideas in metaphysics, they never did justice to the central point in our existence. For neither physics nor metaphysics can offer us any practical base from which to enter the fields of biology or sociology. Neither from the laws of gravity nor from the ideas of logic or ethics is there any bridge to lead into the realms of life, be it the life of plants and animals or of human society. Dead things are forever divided from the living; figures and ideas belong to the limbo of unreality. 26

> ...However, finally *Credo ut intelligam* led to the Inquisition and *Cogito ergo sum* into an ammunition factory. 27

George Sarton in his two-thousand page book entitled "Introduction to the History of Science" which covers the period from Homer to Roger Bacon states some significant conclusions.

> The acquisition and systemization of positive knowledge is the only human activity which is truly cumulative and progressive. 28

> In the first place, we must consider not the history of one or of many sciences, but the history of every branch of positive science, the history of all sciences, or more correctly, the history of science....In the second place, it is not sufficient to consider the evolution of a single nation, because that evolution may have been handicapped, interrupted, or altogether halted by wars and other calamities, or even it would seem by sheer intellectual exhaustion....
>
> The main postulate of science is the unity of nature, a unity indirectly confirmed by the whole development of knowledge....*Nature is one*.
>
> The history of science establishes the unity of science in at least two different ways. First, the progress of each science is dependent upon the

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26 Ibid., p 741
27 Ibid., p 753
28 George Sarton, "Introduction to the History of Science," Vol. I, p 4, 1927.

progress of the others; this implies of course that the sciences are not independent, but interrelated in a number of ways, and that the interrelations are not accidental, but organic. Second, the simultaneity of scientific discoveries made in different places and sometimes by means of different methods implies also an internal congruency...Science is one.

Finally, the very fact that these simultaneous discoveries have been made by different nations, and that the chains begun by one people were harmoniously completed by another, proves that however different men may seem, they are all following the same purpose, they are all accomplishing the same task, the human task par excellence -- a task so great that only a few men are able to concieve it in its integrity, and that in most cases their collaboration is as blind as that of the bees of a hive. This confirms the view that in spite of many disparities and animosities, mankind is one. 29

The physicist, Karl Darrow has stated the same idea in different words:

"All that is perpetual is something of which they all are made, incarnating itself in all of them by turn, and passing unimpaired from form to form. For this immortal substance the least inadequate name, I presume, is "energy," the name is of little concern. To this have we come by applying the methods of physics to the rubbing of amber and to all that followed from it; how great a way, from so humble a beginning! The stone which so many builder rejected became the cornerstone of the temple; the little effect which seemed so trivial to so many of the wise became the key to wisdom, and supplied a physical meaning to two of the most ancient tenets of philosophy. Atomic theories existed long ago, but ours is the generation which, first of all in history, has seen the atom. The belief that all things are made of a single substance is old as thought itself; but ours is the generation which, first of all history, is able to receive the unity of Nature not as a baseless dogma or a hopeless aspiration, but a principle of science based on proof as sharp and clear as anything which is known. 30

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29 Ibid., pp 30-31

30 K.K. Darrow, "The Renaissance of physics," 1936, p. 301

6. First Order Partial History of Physical Science [31]

a. The Greeks attempted to coordinate knowledge.
Thales of Miletus (640-550 B.C.)
Socrates (469-399 B.C.), Plato (427-347 B.C.)
Aristotle (384-322 B.C.)

1) Attempted to find purpose

2) Speculations not checked experimentally

3) Successes in geometry, algebra, astronomy

b. Scholasticism in European universities (700-1100 A.D.)

1) Greek writings were rediscovered by contact with the Arabs

2) Aristotle was considered as final authority. This was a sad tragedy for the writings of a man who did so much to develop the scientific method to be used in a way to block further scientific inquiry.

c. Method of Controlled Quantitative Investigation

1) Galileo, Copernicus, and Kepler refuted the dogmatic use of Aristotle as the final authority.

2) Scientific inquiry accelerated through the development of ink, paper, and type.

3) Newton published Principia in 1687. Newton's three laws of motion formed basis of science.

d. Physical Science based on Newtonian mechanics

1) Conservation of matter, atomic theory

2) Conservation of energy

a) Mayer attempted to determine mechanical equivalent of heat, 1842

b) Helmholtz proposed principle of conservation of energy, 1847

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31 Adopted from outline of L.B.Loeb.

c) Second Law of Thermodynamics established by Clausius and Lord Kelvin, 1850-1851. Attributed by some to Carnot.

d) Maxwell established electro-dynamics in 1865

e. Development of discrepancies with Newtonian mechanics

1) Roentgen discovered X-rays, 1895

2) Planck developed quantum theory, 1900

3) Einstein proposed special theory of relativity, 1905

4) Einstein's general theory of relativity verified, 1919

5) Wave mechanics developed by de Broglie, Heisenberg, Pauli, Schroedinger, 1926-27. Experimentally confirmed by Thomson, O. Stern, Davisson, and Fermer

f. Development of Nuclear Physics

1) Curie-Joliots produced artificial radioactivity, 1934

2) Frish and Meitner predicted nuclear "fission," 1939

3) Atomic bomb developed, 1945

11/25/46

POSTSCRIPT:

There are, of course, many other social problems related in some way to electromagnetic theory, but they cannot be all mentioned here. An electrical engineer cannot go into detail regarding all related problems, but he must take the responsibility of seeing that the appropriate specialists are examining the phases of his problem which lie in their respective fields of specialization.

TABLE I*

	Geological Eras, Rock Formations, Main Events and Approximate Dates of Beginning[11]			Age in Millions of Years of Different Rock Strata Within Each Geological Time Period (From Radioactivity Studies)[12]
	Geological Era	Main Events and Forms of Life	Approximate Date of Beginning; Millions of Years Ago (Date Merely an Estimate)	
	AZOIC (No life)	Formation of the earth from the sun	3,200	1,525 1,336 1,273
Precambrian	ARCHEOZOIC (Primitive life)	Development of mountain ranges which were eroded before the Proterozoic era; primitive one-celled plants and animals but record insufficient	2,000	1,212 1,150 1,089 1,029 961 897
Precambrian	PROTEROZOIC (First known life)	Earliest known glaciation; great iron-making age due to presence of bacteria; evolution of invertebrates, molluscs, worms, sponges	1,200	831 767 700 635
Primary	PALEOZOIC (Age of Fishes and Amphibions)	Seas sweep over large portions of the earth as continents sink; first forests; widespread glaciation; great coal forming era; world wide continental uplift toward close; invertebrates present; vertebrates appear; amphibians and armoured fishes; extinction toward close of the period of most of the Paleozoic forms; primitive reptiles, sharks	550	567 498 430 360 289

* For publication, this table should be checked against up to date primary sources.

11 John Phelan, op. cit., p. 15.

12 P. Jordan, op. cit., p 176 (from a compilation by O. Halm).

(MESOZOIC ((Age of (Rep- (Tiles)	Continents emerging; extensive chalk deposits, sandstones, marl, clay and limestones; reptiles dominant; primitive mammals; large amphibians, early crocodiles and dinosaurs; toothed birds and flying reptiles; extinction of Mesozoic forms toward close of era.	200	218
CENOZOIC (Recent Life) (Neoroic) (Age of Mammals and Man)		60	58.7 36.9 ....

TABLE II *

SUBDIVISIONS OF THE CENOZOIC ERA INTO PERIODS
Time span—60,000,000 years

	Geological Period	Main Events and Forms of Life	Approximate Date of Beginning Years Age	Duration
Tertiary (Age of Mammals)	EOCENE (Dawn of the recent)	Beginning mammalian dominance; earliest lemuroids; marsupials abundant; reptiles few.	60,000,000	20,000,000
	OLIGOCENE (Few of the recent)	First small and primitive anthropoid apes; ancestors of Old World monkeys; early ancestral elephants; forerunners of camels; carnivores; insectivores; Parapithecus, Propliepithecus.	40,000,000	10,000,000
	MIOCENE (Minority of the recent)	Cordilleras, Alps and Himalayas formed; Uplift results in cooler climatic condition; generalized anthropoid ancestors of great apes; possibly ancestors of man; marsupials disappear fossil monkeys; notable advance in horse and elephant families; Dryopithecus.	30,000,000	18,000,000
	PLIOCENE (Majerity of the recent)	World-wide elevation continues; horses and elephants almost modern; humanoid types; ancestors of apes; Australepithecus; Pliepithecus.	12,000,000	10,000,000

* John Phelan "Anthropological Backgrounds" in"Society Under Analysis", Jaques Cattell Press, p. 16, 1942.

PLEISTOCENE (Most of the recent)	Four great ice advances separated by inter-glacial epochs with warmer climate; early forms of modern man; extinct ape-like primates; early stone implements.	2,000,000	To Holocene