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Background and beginning of the development of Electrical Engineering

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ABSTRACT

To date information about studies of magnetic and electrical phenomena at an early stage of development of electrical engineering seems do not coherent, are fragmentary and ambiguous. In this work a partially filled gap on the subject. The subject of this paper is to examine issues related to the major discoveries and research in the field of magnetism and electricity at the initial stage of development of electrical engineering.

Key words: Magnetism, electricity, electrostatics, sources of electrical energy, battery cells, electrical engineering.

1. INTRODUCTION

In the process of historical development the level of scientific and technical condition at a certain stage depends on the general development of society, the degree of cognition of laws of nature, from the ability to use them in practice.
Of particular interest is the emergence of knowledge on magnetism and electricity, based on observations of natural phenomena due to, primarily, natural magnetism and static electricity.

2. RESEARCH

According to the legends that have come down to modern times, about electrical phenomena spoke one of the first the founder of ancient philosophy and science, ancient Greek philosopher Thales of Miletus in Asia Minor (approximately 625–547 BC) [1]. In his message, the piece of amber, rubbed with fur or wool, at a distance of a few centimeters attracts downs, straws, linen threads etc. Thales argued that the magnet has soul because it moves iron [2].
According to available we information, references of magnetic phenomena found in the distant past. The Chinese and later the people of the Mediterranean, was known ore that had the ability to attract metal objects. A magnet (from Greek phrase magnetic (lithos) – magnetic (stone) [3] has found practical application in China and India BC, in particular, in the manufacture of magnetic compasses. In [4] states: apparently, in the VI century BC, the Chinese began to realize the phenomenon of attraction of iron and iron ore that has magnetized by means natural pieces of magnetite.
According to other sources the properties of magnetism were known to the Chinese in the XXVII century BC. According to the data given in [1], the property of the magnetic needle to Orient in a certain direction was known to the Chinese in 2700 BC.
According to the data presented in [5], the first references to magnetic phenomena are related, approximately, to the VII–VI centuries BC.
In [6] it is stated that on behalf of the city of Magnesia, which served as a point of trade of the Phoenicians with the peoples of the far North, the mineral is called magnet. Currently we call a natural magnet a pieces of iron ore magnetite.
Approximately in the IV century to BC major philosopher of the Ancient Greece Platon, a native of Athens (about 428 (or 427)–348 (or 347) BC) [7] noted that the divine power of the magnet is transferred from iron to iron just as the inspiration of the poet is transmitted through it the narrator to the listener [8]. Many writings of Platon were studied by many generations of people and are currently being studied. He created the Academy was the ancestor of higher educational institutions [9].
Student of Plato, ancient Greek philosopher and scientist Theophrastus, (real name Tirtam), (approximately 372–287 BC) [1] has shown that in the ancient world learned the ability electrify to not only of the amber-electron. Similar properties Theophrastus indicated for the "linkuriona" which representing, perhaps, one of the gems [10].
According to the information given in [4], the Chinese drew attention to the ability of natural magnets to navigate, mistakenly attributing it to the influence of the stars. From these observations grew the techniques of divination in a special device. It consisted of iron plate on which, thanks to its spherical surface, can freely slide to "spoon" from a natural magnet. On the plate are signs of the Zodiac. The handle of the "spoon" was oriented in a magnetic field. In I–III centuries this device has been used as a compass and got the name "pointer of South".
German orientalist Heinrich Julius Klaproth (1783–1835) [1] citing the Chinese annals, argued that about the polarity of the

magnet and the ability magnetized of the arrow to indicate the direction to the South was known in 120 BC [11].

In I century BC Roman poet and philosopher Titus Lucretius Carus [12] (approximately 95–55 BC) [1] in the poem of poetic form "On the nature of things" gave an essay on the theory of magnetic actions. Its concept was developed by such thinkers as the eminent French philosopher and mathematician Rene Descartes (1596–1650) and a great scientist, a native of Switzerland, Leonard von Euler (1707–1783) [13], the author of over 800 published scientific papers, including the book "Ship science or a treatise on the construction of ships and handling them" [14]. The basic idea Lucretius is that the magnet emits particles or currents. These currents their impulses split the air, forming voids in it. In these voids penetrate the iron atoms, and since they are extremely linked, and all the iron the body (ring) rushes to the magnet. This attraction is facilitated and impulses surrounding the iron air. The air rushing into the void, penetrates through the pores of the iron, and carries an iron ring [10].

Roman statesman and scholar Pliny the Elder (Gaius Plinius Seconds) (approximately 23–79) is the author of "Natural history" ("Historia naturalis") in 37 books [1]. He wrote: by rubbing the hands amber receives warmth and life and attracts a pieces of straw and dry leaves of small weight, like a magnet attracts iron [10].

Presumably in the period up to 250 AD was created by the "Baghdad battery", which was found in the vicinity of Baghdad and consisting of a clay receptacle and iron core surrounded by a copper cylinder [1]. When we receptacle filled of wine sauce, battery capable of creating an electromotive force of about 1 V. The analysis of known data allows us to conclude that the "Baghdad battery" could be one of the earliest of galvanic cells.

Approximately in the second half of the XIII century traveler Mark Paul Venetian (Marco Polo) (about 1254–1324) brought a magnet from China to Europe, promoting the study of its properties in the European part [1].

In 1269 appeared handwritten treatise on magnetism of Peter Peregrinus (knight Pierre from Marikura) "The message of the magnet of Pierre de Marikur to knight Si geru de Fukokur". In this scientific essay is given, including description of methods for determining the polarity of the magnets, the interaction ("copulation") poles and magnetizing by touch, presented initial data about magnetic induction [1].

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The first theory of magnetic phenomena belongs to English physics and court physician of Queen Elizabeth William Gilbert (1544 (or 40)–1603). Carefully examining and critically evaluating the available information, W. Gilbert came to the conclusion about its limited nature and private character. Along with our own set of experiences, he reproduced and described to the main previous experiments for check their validity. In 1600 Gilbert published the first scientific treatise on magnetism "Of the magnet, magnetic bodies and the big magnet – the Earth" ("De magnete, magneticisque corporibus, et magno magnete tellure"), in which he argued that the Earth is a big magnet. He first summarized and systematized the totality of the available information and described a relatively coherent picture of the properties of magnets, opportunities to influence them and their conditions of use. In addition, using an electroscope ("versore") Gilbert found that many bodies (diamond, rock salt, sulfur, etc.) like amber, have the ability to attract after rubbing light objects (straws) [1]. Examining these properties, Gilbert called them the "electric" (from the Greek word ẽlektron – amber) [3]. Thus W. Gilbert first coined the term "electricity" when named as "electrical" body, able to electrify [1]. He has broadened and deepened the knowledge acquired in the distant past. On approval of Gilbert, the body was divided into "electroservice" by nature [15]. Comparing magnetic and electric phenomena, Gilbert came to the wrong conclusion about the different nature of these phenomena [16]. Gilbert thought magnetism there is some primordial force emanating from the bodies, while the electrization is caused by the squeezing from the pores of the body the special flows as a result of rubbing. In honor of William Gilbert named unit magneto motive force or the difference of magnetic potentials in Gaussian system and absolute system of electromagnetic units – Gb.

German scientist monk, the jesuit Athanasius Kircher (1602–1680) in the work "Magnetic art", published in 1634, described the results of studies of magnetic phenomena [15]. He noted that the magnet loves the red light and being wrapped in red cloth he becomes stronger and better maintains its ability to attract iron. Kircher explained this by the fact that the magnet is "the tsar of gemstones" and it is characterized by purple [16].

In 1639 appeared the work Nikollo Cabeo (Cabaeus) (1585–1650) "Magnetic philosophy" [10]. In this work he pointed out the existence of the electric interactions. Cabeo as and Gilbert expressed the idea about the "scope" of the magnet, which is limited to a certain space around the body. Such has been the idea of a magnetic field. This idea is more clearly expressed by Kepler, who came to the concept of "lines of action", forming the "sphere of action" around each of the poles. At this time a phenomena of electricity and magnetism were explained to the action of invisible subtle fluid – the ether [1].

Despite some progressive moments, according to Pavel Stepanovich Kudriavtsev (1904–1975) [17] the writings of "a dozen people" of the XVII century, like "Magnetic art" of Kircher (1634) and "Magnetic philosophy" of Cabeo (1639) represent a step back compared to the work of Gilbert [15].

One of the first known electrostatic sources of electric power was the machine that was invented in 1663 by the German scientist Otto von Guericke (1602–1686). The machine consisted of sulfur ball, which can rotate around an iron rod. When was mechanized the process of rubbing, he discovered that grated of ball actively attracts and then repels bird feather. Thus it was made one of the first discoveries in the field of electricity: an electric force as magnetic force can be not only attractive, but also repulsive. Guericke also observed the distribution of electric force in the conductor [1].

In 1705 the Englishman Francis Hauksbee (1666–1793) created more a stronger electrostatic source of electric power – "influence machine". Instead sulfur ball, which was used in the machine of Guericke, Hauksbee used a glass bowl. He pumped the air from the ball and, brought the ball in rapid rotation, and rubbed his to arms. Significant results of the experiments of Hauksbee is the reconstruction of the electric machine, obtaining a relatively powerful electrical sparks and glow in the discharged space [15]. Have to some variants of electrostatic machines (sources of electrically energies) that time is given for example in [18]. Some variants of electrostatic machines (of electricity sources) submitted by the authors, for example, in [18].

In 1729 English chemist Stephen Gray (1666–1736) empirically established that electricity can be transmitted from one body to another by wet string and opened it the phenomenon of electrical conductivity [19].

The French naturalist Charles-François Du Fay (1698–1739) in 1733, repeating gray's experiments, created the first theory of electrical phenomena. Du Fay divided the electricity by "glass" and "resin", which feature were to push away bodies which electrified homogeneous electricity and to attract bodies electrified heterogeneous electricity [19].

French physicist Jean Antoine Nollet (1700–1770) and the Czech physicist and priest Prokop Divish (Diviš) (1696 (or 98 [15])–1765) researched a number of electrostatic phenomena with the help of improved electrical machines [20].

Further improvement of these machines is connected, primarily, with the name of the German physicist Johann Heinrich Winkler (1703–1770 years), who in 1744 built the electric machine [20]. Instead of manual friction balls he used pillows, which pressed against to the balls or cylinders of screws, and later springs [15].

Also in 1744 L. Euler called scientists-contemporaries to investigate the cause of electricity [8].

In 40-ies of the XVIII century the attention of scientists was attracted by three things: 1) new designs of electrical machines; 2) new ways of producing electricity in large quantities; 3) the research of atmospheric electricity [15].

One of the founders of works on electricity, a domestic researcher and a German by birth Georg Wilhelm Richman (1711–1753) [16] by the beginning of 1745 produced an improved electrostatic machine that allowed making the electrical experiments at Saint-Petersburg Kunstkamera. "Generated" electricity was measured on the electrical measurements installation, which was created by Richman. Part of the install was a device resembling apothecary scales [8]. This device with a scale, called the "electric pointer" or "electrometer" [17], in fact, was the first electrical measuring instrument of direct assessment, transition design from the electroscope to the electrometer [21]. G. W. Richman considered of the first electrician of Russia.

In 1745 a German prelate Ewald Georg von Kleist [22] (Dean E. J. von Kleist) [18] was found "a strong electric effect", described in [15]: if in a medical flask with a small amount of mercury to put the iron nail and to electrify it, then, if you hold the bottle in one hand and touch to the nail of the other hand, was generated a strong spark and painful blow in his hand.

In 1746 (according to other sources in 1745 [22]) Dutch physicist and mathematician Pieter van Musschenbroek (1692–1761 [13] regardless of Kleist conducted similar experiments and invented the first electrical capacitor ("Leyden jar"), which was a glass jar, partially filled with water. Metal pin with attached wire was immersed in water. Wire through the tube output to the outside. When the wire was connected to a device that produces static electricity, the bank maintained this electricity so that it can be used in the future [18].

The main works that marked the beginning of the study of electrical phenomena are included results research of the American scientist and enlightener Benjamin Franklin (1706–1790), which he was doing in the period from 1747 to 1753. In 1750 B. Franklin invented the lightning rod [20], who tried out in 1752 [23]. He established the identity between atmospheric electricity and electricity generated through friction, and also proved the electrical nature of lightning. Franklin created the "electric wheel" that rotates under the action of electrostatic forces [24]. He introduced a conventional designation electrically charged States "plus" and "minus", developed a common "unitary" theory of electrical phenomena, proceeding from the assumption of the existence of a single electrical substance or matter, lack or excess of which determines the sign of the charge of the body. According to Franklin, this particular substance, later called the "fluid of Franklin" that has a positive charge, and when there is the electrification of the body or gain or lose positive charges [18]. Proceeding from modern representations, in most cases of the contact electrifying there is an exchange of negative charges – electrons. Thus, thanks largely to the theory of Franklin, was later it is a mistake to be considered for to direction of the current in metal conductors the movement of positive charge.

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In 1751 the Italian scientist Giambattista Beccaria (Baptista Beccaria) (1716–1781) by repeating a number experiments of B. Franklin hypothesized about the existence of a close connection between the "circulation" of electric fluids and magnetism [18].

In the summer of 1752 G. W. Richman created the first installation for the study of atmospheric electricity, comprising a metal rod rising above the roof of one of houses of the Fifth line of Vasilievsky island St. Petersburg, and connected with it the pointer of electricity, which were isolated from the ground.

French physician Louis-Guillaume Lemonnier (1717–1800) [22] in 1752 opened the electrification of the atmosphere even when weather is clear [18].

The following spring G. Richman conducted a series of successful experiments, the results of which confirmed the assumption about the dependence of electric field intensity on the distance from its source. At the end of July 1753, when Rihman watch at the pointer of electricity, he was killed by an electric lightning discharge [8].

In the mid-eighteenth century studies on electricity was engaged extraordinary (supernumerary) professor of medicine Gallic University (Germany) Johann Gottlieb Krueger) (1715–1759). From experiments made by rubbing glass tubes, he moved on to a qualitatively new stage – the use of electric machines. This machine was built in the image and likeness of machines F. Hauksbee, but with minor design changes [18].

In 1753 in Turin came the work of D. Beccaria "About artificial and natural electricity". In this work he said about "natural electricity" (atmospheric) and "artificial electricity" (static). He first showed that electric charge is distributed over the surface [20]. Beccaria introduced the concept of "electrical resistance" and marked the beginning of his study [18].

English experimental physicist John Canton (1718–1772) in 1754 [17] described the phenomenon of electrical induction or influence as follows: elderberry balls divergence in different directions before contact with of the electrified body. This fact gave rise to the creation of a hypothesis of action at a distance, which developed Russian physicist, an ethnic German, by Franz Ulrich Theodor Aepinus (1724–1802) [15].

A special place is occupied by the results of observations of atmospheric electricity produced by Russian scientist Mikhail Vasilyevich Lomonosov (1711–1765) [25] independently from the research of B. Franklin. In his report on Petersburg the Academy of Sciences he outlined his theory of atmospheric electricity, which based on convection of air masses. This work is highly appreciated by L. Euler. Regardless Lemonnier Lomonosov made a very important discovery, consisting in the fact that his "thunder machine" (the ancestor of lightning rods) can show the presence of electricity in the atmosphere at a time when no lightning phenomena [10]. M. Lomonosov in his report on behalf of the Russian Academy of Sciences formulated the theme of the competition task for scientists around the world to the end of 1755: find the real cause of the electric force and to draw up an exact her theory [26].

During 1755 to the competition, which announced by M. V. Lomonosov, there have been 13 works of domestic and foreign scientists. The winner of the contest was announced the work, presented under the motto "Happy is he who could discover the reasons for things", the official author of which was Johann Albrecht Euler (1734–1800) [26], eldest son of L. Euler, later a prominent Russian scientist [13]. Co-author of this work was L. Euler. On this occasion he wrote: since I didn't know if I have the right to write a work for the award, I gave it to my son and instructed him literary to processing work, which sent to you. In this work was given the criticism of the theory, which rejected mechanistic explanations of the fields, and the theory based on the assumption of flow a hypothetical of electrical matter: the first erroneous theory makes it impossible for any knowledge of nature and the

second one replaces the truth on delusional fantasies of the mind. He claimed the essence of electricity need to see in removal or reduction number of ether, which usually in a natural state filled the pores of the body. All phenomena of electricity without exception the happen as a result of imbalance in the ether [26]. The theory of Euler for the first time explained the electricity phenomenon of hypothesis the vacuum and compression of ether. Its feature was the absence of mathematical calculations, which is not typical for the works of the great mathematician L. Euler. This drawback did not allow checking the ideas, underlying his theory.

To 1756, contrary to popular opinion that electric force is a liquid, M. V. Lomonosov argued that electric force is action. He attempted to assume the ether theory of electricity, said about the link of electricity and light, and also about the electrical nature of the northern lights [15].

In 1757 a Swedish physicist Johan Carl Wilcke (1732–1796) [18] also described the phenomenon of electric induction. According to the data given in [17], the phenomenon of electrical induction was already known to G. W. Richmann.

Based on the ideas of B. Franklin and I. Newton, F. U. T. Aepinus developed the theory of magnetic and electric phenomena, emphasizing their similarity [27]. In 1759, Aepinus in the fundamental work on the Latin language "The experience of the theory of electricity and magnetism" ("Tentamen theoriae electricitatis et magnetismi") first explained the phenomena of electrostatic induction and polarization [15]. According to many scientists this work ushered in a new epoch in the history of theoretical studies of electricity and magnetism [26]. In the same year was published an article of Aepinus "A brief news about of the newly invented way to multiply the power in natural magnets" [10].

It should be noted that at this time the subject of further discussion was the theory of B. Franklin.

English physicist Robert Symmer (1707–1763) in 1759 proposed a two fluid version of this theory – the "dualist theory", or rather were recovering forgotten ideas of Du Fay [15].

The researchers of electricity over the next long period of time don't have divided on the question whether the electricity a single fluid or two fluids. As a result they concluded, there can be no such experiment that could distinguish between two variants of the theory, and therefore they are equivalent [18].

The sample electrostatic sources of electric energy of that time can serve as machine with leather cushions and insulating rod for collecting electric charges, described in 1761 by L. Euler in "Letters about different physical and philosophical matters, written to a German princess" [28].

We can assume that the evolution of electrostatic sources of electricity ("friction machines") ended with the produced in the XVIII century devices with flat discs.

In 1775 Italian physiologist and physicist Alessandro Volta (Alessandro Giuseppe Antonio Anastasio Volta) (1745–1827) produced a source of electrical energy, based on the idea of Aepinus – resin electrophor ("electrophoro perpetuo" – permanent carrier of electricity), which differed from the previously created of sources. The principle of operation electrophor machine of a Volta was based on the phenomenon of electrification by induction (electrostatic induction), in contrast to electrostatic machines, in which the electricity was produced by friction. It consisted of two metal discs, one of which was covered with a layer of resin. Volta said: my machine gives the ability to get electricity in all weather, and produces a more better effect than best of disk and ball machines [18]. On the basis of this machine A. Volta has created a series of electrophor (induction) machines. Such machines were created of the electric charges about (10^{-6}...10^{-4}) C [29].

From 1780 were machine used in his experiments as a source of electrical energy Italian scientist Luigi (Aloysius) Galvani (1737–1798) [18].

In addition to electrostatic and electrophor sources of electric energy, which can be considered as electromechanical generators, in the XVIII century was work carried out on the development of other sources of electrical energy, in particular electrochemical.

According to A. Volta at the contact of two different metals occurs "electrical excitation force", under the influence of which electricity of one sign is concentrated on one of the metals, and the electricity of opposite sign on the other.

For the summation to the actions of individual couples, must contact one of the zinc plate with one a copper or one a silver, to prevent metal contact. This is done using circles of wet tissue. These circles share a pair of metals and at the same time not preclude with the movement of electricity.

In 1799 Alessandro Volta, not understanding the true causes to origin electrical current, has created an electrochemical source of direct electric current (galvanic battery). The device he initially called "artificial electric organ", then "electromotive column". The principle of operation a source of A. Volta was based on the conversion of chemical energy into electrical energy [5]. Later the French gave the name to the source "galvanic column", or "Volta column". Presumably the voltage of the "Volta column" was (40...50) V, and the current is less than 1 A [18]. The invention A. Volta source of electrochemical of energy in the form of a "Volta column" created the preconditions for the application of a new form of energy for various purposes, gave a powerful impetus to the creation and further development of various branches of science and technology.

3. CONCLUSION

1. On a historical stage, which investigated in the paper, the phenomena of nature were incomprehensible even most advanced thinkers of that time and was explained ambiguously and sometimes contradictory. Natural

phenomena were used, as a rule, spontaneously. Ancient science and technology, including in the area of electrical engineering, despite the presence of some brilliant discoveries, was speculative, fragmentary and contradictory and intertwined with fantastic views.

2. At this time, advanced thinkers have developed the basic views on the relationship of natural phenomena. There was the first understanding of magnetic and electric phenomena. The historical period may be considered the first stage of discoveries and researches in the field of electrical engineering.

3. Many scientific achievements and discoveries of that time had been the property of a limited circle of scientists and inventors in a number of reasons, including different languages, the presentation of the material in the primary sources. As a result of insufficient mutual awareness of the authors independently from each other, repeated investigations in different degree of their similarity, the opening is sometimes re-opened, sometimes after a long period of time.

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