

High power lasers and ecology of atmosphere (I)

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ABSTRACT

There are many appearances in the literature of reliable observations of studying so-called “jets” and “sprites”—the discharges in the gigantic natural capacitor “Ionosphere-Earth” [1]. The volume of such a discharge is approximately 5 - 10 thousand cubic kilometers and usually it appears above the surface of ocean. There are the cases also of above mentioned discharges on the ground. The value of the energy transferred to the earth can comprise to several tera-joule. Events are accompanied by the emission of the waves of ultra-low frequency. Their study has the significant interest from many points of view. The essence of the observed irregular phenomena consists of the electromechanical conversion of the energy excesses of natural electricity into mechanical and thermal energy of cyclones, typhoons and other natural cataclysms. The ionosphere can retain only the specific quantity of energy. Otherwise, it discards the surpluses of electricity through the atmosphere or transforms them into the energy of storms, in that number and inside the Earth. By using the part of the natural electricity for useful purposes it is possible to govern the weather of planet. Causing the artificial breakdowns of the ionosphere it could be possible to arrange the discharge of the controlled aqueous sediments at the necessary points of the globe. It could be possible as well to attempt to regulate the climate of planet and to decrease the amplitudes of the magnetic storms, earthquakes and hurricanes.

Keywords: Jets; Sprites; Climate Change; High Power Lasers; Orbital Electrical Socket; Electrical Breakdown

1. POWER OF LIGHTNING

Lightning is the electrical spark discharge, which is manifested, usually, by the bright flash of light and by its

accompanying thunder. Electrical nature of lightning was opened in studies of the American physicist B. Franklin, according to idea of which was carried out the experience on the extraction of electricity from the thunderstorm cloud. With this problem also dealt famous Russian scientists: M. Lomonosov and G. Rikhman. Lightning had been fixed besides the Earth on the surface of other planets: Venus, Jupiter, Saturn and Uranium. The average length of lightning 2 - 5 km, some discharges stretch in the atmosphere up to the distance to 150 km. Let us pause more in detail at the process of the appearance of lightning. Most frequently the lightning appears in the rain clouds, due to that they are called thunderstorm. Sometimes lightning can be formed in the layered—rain clouds, and also with the volcanic eruptions, the tornado and the dust storms. Usually is observed the linear lightning, which relates to the so-called electrodeless discharges, since they begin and end in the accumulations of the charged particles. This determines them some, until now, to not so clearly explained properties, which distinguish lightning from the discharges between the electrodes. Thus, lightning does not occur shorter than several hundred meters; they appear in the electric fields considerably of weaker than field with the inter-electrode discharges; the collection of the charges, transferred by lightning, occurs for thousands of a second from huge number of small and well isolated from each other particles, located in the volume of several km³. The process of the development of lightning in the thunderstorm clouds is most studied, in this case the lightning can pass clouds themselves—intra-cloud lightning, and they can strike into the earth—ground-based lightning. For the appearance of lightning it is necessary that in the relatively small, but not less than the certain critical, the volume of cloud was formed the electric field with the tension, sufficient for the beginning of the electrical discharge ~ of 1 MV/m, and in the substantial part of the cloud there would be a field with the average tension, sufficient for maintaining the discharge ~ of 0.1 - 0.2 MV/m. In the lightning the electrical energy of cloud is converted into the thermal and the light. The process of the development of ground-based lightning consists of several stages. At the first stage in the zone, where elec-

tric field reaches critical value, begins the impact ionization, created by at first free electrons, always existing in a small quantity in air, which under the action of electric field acquire significant speeds in the direction to the earth and, colliding with the molecules, which compose air, they ionize them. Thus, appear the electron avalanches, which pass in the thread of electrical discharges—streamers, which are the well conducting channels, which, merging, give beginning to the bright thermo-ionized channel with the high conductivity—to stepped leader of lightning. The motion of leader to the earth's surface occurs by steps into several ten meters with a speed of ~50,000,000 meters in second, after which its motion stops by several ten microseconds, and glow strongly weakens; then in the subsequent stage leader again moves by several ten meters. Bright glow covers in this case all passed steps; then follow again stoppage and weakening of glow. These processes are repeated during the motion of leader to the earth's surface with an average speed of 200,000 meters per second. The field strength at this end is strengthened in proportion to the advance of leader to the earth also under its action from the objects protruding on the earth's surface the reciprocal streamer, which is connected with the leader, is ejected. This special feature of lightning is used for creating the lightning rod. In the final stage on ionized by leader channel follow reverse (from bottom to top), or main thing, discharge of lightning, which is characterized by currents from ten to hundreds of thousands of amperes, by the brightness, which noticeably exceeds the brightness of leader, and with the high speed of advance, which at first reaches to ~100,000 kilometers per second, while in the end of that being decreasing to ~10,000 kilometers per second. The temperature of channel with the main discharge can exceed 25,000°C. The length of the channel of lightning can be from 1 to 10 km, diameter—several centimeters. After pulse advancing of ionization current of channel and its glow is weakened. In the final stage the current of lightning can last the hundredth and even tenths it flogged, reaching hundred and thousands of amperes. Such lightning is called protracted, they most frequently cause fires. Main discharge discharges the part of the cloud frequently only. The charges, located on high altitudes, can give beginning to new arrow-shaped leader, who moves continuously with a speed of thousands of kilometers in second. The brightness of its glow is close to the brightness of stepped leader. When arrow-shaped leader reaches the earth's surface, follows the second main attack, similar to the first. Usually lightning includes several repeated discharges, but their number can reach also several ten. The duration of repeated lightning can exceed 1 s. The displacement of the channel of repeated lightning by wind creates the so-called strip lightning—luminous strip. With the entry

of lightning directly into the soil is possible the formation of the unique mineral of fulgurite, which is, in essence, the sintered quartz sand. Intra-cloud lightning includes usually only leader stages; their length varies from 1 to 150 km. The portion of intra-cloud lightning grows in proportion to displacement to the equator, changing from 0.5 in the temperate latitudes to 0.9 in the equatorial strip. The passage of lightning is accompanied by changes in the electrical and magnetic pour on and by the radio emission, by the so-called atmospheric disturbances. The kill probability by the lightning of ground-based object grows in proportion to an increase in its height and with an increase in the electrical conductivity of soil on the surface or at a certain depth. The action of lightning conductor is based on these factors. If in the cloud there is an electric field, sufficient for maintaining the discharge, but insufficient for its appearance, the role of the initiator of lightning can carry out long wire cable, products of the combustion of the engine of aircraft or rocket. Specifically, thus sometimes “provoke” lightning in the layered—rain and cumulus congestus clouds.

For the illustration of enormous power engineering of the lightning and the significant frequency of their repetition on the terrestrial globe let us give article from the British press about “Marakaibo's lighthouse” (Venezuela).

There are more than three million discharges of lightning *i.e.* more than thousand for each second occurs each day in the world. The greatest frequency of discharges occurs in the tropical and subtropical zones of the terrestrial globe, the enumeration of these record places following: Ale hook in Columbia (270 days in the year with the lightning); Tororo in Uganda (274 days); Bogor in Java in Indonesia (283 days). Completely extraordinary light storm occurs in Venezuela in the mouth of Katurumbo river, that falls into Marakaibo Lake. This spectacle can be seen at night during more than ten hours of one hundred eighty days of the year. Light show occurs exclusively in the complete silence because of the inter-cloud discharges nature at the high up to 10 km altitude. Sky is illuminated due to those bright flashes of approximately 300 times an hour, that comprises more than one million electrical discharges in the year with the current strengths from 100 to 400 thousand ampere each. These discharges are visible from the ocean for many tens of kilometers and during many centuries were used by seafarers as the natural lighthouse, which was called “The Lighthouse of Marakaibo”. Mixing cold wind from the Andes with the hot and humid air, which is risen from the swampy earth's surface in the environments, Marakaibo is the major factor, which creates this unique phenomenon. Air being risen from the surface of swamps in essence consists of methane, which appears due to rotting of plants. Each flash of lightning could illuminate all

lamps of South America. Now all depends on humanity which must find the method of the domestication of this enormous energy.

2. LIGHTNING IN THE NATURAL CAPACITOR “EARTH-CLOUD”

Why does thunder and it does sparkle lightning? In the clouds are accumulated the electric charges, which lead to the breakdown of air, which are accompanied by the flash of light and by the formation of shock acoustic wave. By other words, thunder and lightning are the manifestation of atmospheric electricity existence. The fundamental connection of thunderstorm phenomena with the electricity for two and one-half of century was reliably confirmed by numerous studies of geophysicists, meteorologists, specialists on lightning protection. However, qualitative jump in the improvement of the methods of observations in the recent two decades led to the unexpected discoveries in the study of thunderstorm clouds, lightning, orbital scale of atmospheric electrical chain. It is similar, that the splash of interest in the problems of atmospheric electricity survived now will make it necessary to glance differently at the mechanisms of shaping of electric field and its role in the dynamics of atmosphere and ionosphere of the Earth. The heart of atmospheric electrical machine—thunderstorm cloud, is more precise, the totality of simultaneously “working” thousands of thunderstorms, distributed in the lower part of the atmosphere—to troposphere. Thunderstorm cloud lives not too for long—from the hour to several hours. But for the change to some thunderstorms come others, forming in the troposphere on the proximity. Contemporary satellite measurements, and also ground-based systems of the registration of lightning give to researchers the sufficiently reliable maps of the allocation of frequencies of lightning flashes over the Earth’s surface. Flash rate above the surface of ocean on the average to the order is lower than above the continents in the tropics. The reason for this asymmetry is the intensive convection in the continental regions, where the land effectively heated by solar radiation. The quick ascent of thoroughly heated saturated by moisture air contributes to the formation of powerful convective clouds of vertical development, in upper part of which the temperature lower than $\sim 40^{\circ}\text{C}$. In the result are formed the particles of ice, soft hail, hail, whose interaction against the background of the rapid ascending current leads to the separation of charges. Cloud height in case of big water surface in average lower than above the continents, and the processes of electrization is less effective above the ocean. In lately is discussed another factor—difference in the concentrations of the aerosols above the ocean and the continents. Since aerosols serve as the condensation nuclei, neces-

sary for forming the particles in the supercooled air, their abundance above the land increases the probability of the strong electrization of cloud. The quantitative analysis of this factor requires detailed experiments. Approximately 78% of all lightning are recorded between 30°S . and 30°N . The maximum value of the average density of the number of flashes per unit of the earth’s surface exceeds 80 1/km^2 is observed in Africa (Ruanda). Entire pond of Kongo river with area about 3 mln. km^2 it regularly demonstrates the greatest lightning activity, although other equatorial centers abound with thunderstorms. It seemed that the significant contribution to the global thunderstorm activity the centers of thunderstorm of subtropics and middle latitudes give. Some of them, for example in North Argentina and Paraguay, lead on the rate of lightning flashes. The study of the regional special features of statistics requires further improvement of the satellite and ground environment of mapping thunderstorms. These studies intensively are conducted in the connection with the realization of lightning activity as the important factor of the climate of planet, which sensitively reacts to changes in the temperature, humidity, radiation conditions and the composition of the atmosphere. The progress in studies of atmospheric electricity is connected, first of all, with the study of the mechanisms of generation and dissipation of electrical energy in the atmosphere. Main problem here—the so-called electrical dynamo: the generation of quasi-stationary electric field and space charge in the moving weakly conductive medium. Already in simplest formulation of the problem of dynamo is manifested its important special feature—very wide interval of time-spatial scales. So that on the scale in several kilometers would arise the electric field, compared in the value with the breakdown of $\sim 30 \text{ kV/cm}$ for dry air under the standard conditions, necessary that the random traffic of charges with the collisions of cloud solid or liquid particles would lead to the matched effect of the addition of micro-currents into the macroscopic current of the completely high value (several amperes), sufficient for the rapid (tens of seconds) process of the separation of charges. It is evident from the experience that in the ripe thunderstorm cell, the lightning and the discharges occur with the enviable regularity—each 15 - 20 s, *i.e.* the mechanism of charging acting in the cloud is very effective, although the average electric charge density rarely exceeds several nC/m^3 . As showed the measurements of electric field on the earth’s surface, and also inside the cloud medium (on the balloons, the aircraft and the rockets), in the typical thunderstorm cloud “main” negative charge—on the average several ten coulomb—occupy the interval of heights, which corresponds to temperatures from -10°C to -25°C . “Basic” positive charge composes also several ten coulomb, but it is located above basic negative;

therefore the large part of the lightning discharges the cloud-earth returns to the earth negative charge. In the lower part of the cloud frequently is revealed smaller in the value the positive charge of ~ 10 Cl. For explaining the 3-layer structure of field and charge in thunderstorm cloud described above is examined the set of the mechanisms of the separation of charges. They depend on such factors as temperature, phase composition of medium, spectrum of the sizes of cloud particles. The dependence of the value of the charge from the electric field transferred for one collision is very important. From this parameter it is accepted to subdivide all mechanisms into the induction and the non-inductive. For the first class of mechanisms the charge q depends on value and direction of external electric field and is connected with the polarization of the interacting particles. Non-inductive of the charge exchanges between the being encountered particles in the explicit and does not depend on the field strength. In spite of the abundance of different micro-physical mechanisms of electrization, now many authors consider the main thing non-inductive of charge exchanges with the collisions of small with the sizes from ones to tens of micrometers of the crystals of ice and particles of soft hail with the dimensions of the order of several millimeters. In the experiments was established the presence of the characteristic value of a temperature, at which the sign of charge q reverses, points of reverse, which lies usually between -15°C and -20°C . Specifically, this special feature made this mechanism so popular, since taking into account the typical temperature profile in the cloud it explains the 3-layer structure of the distribution of the charge density. Recent experiments showed, however that many thunderstorm clouds possess an even more complex structure of space charge. Is especially interesting mesoscale, which means the horizontal scales from ten to hundreds of kilometers, the convective systems, which serve as the important source of thunderstorm activity. Their characteristic feature is the presence of the united electrical structure, which includes the region of intensive convection and extended, sometimes to several hundred kilometers the stratified region. In the region of stratification the ascending currents sufficiently weak, but the electric field has steady multilayer structure. Near the zero isotherm here are formed sufficiently narrow, with thickness into several hundred meters, and the stable layers of space charge, mainly critical for the high lightning activity of mesoscale convective systems. A question about mechanism and laws governing the formation of the layer of positive charge in the environment of the zero isotherm remains debatable. As other examples of the work of electrical dynamo serve electrization and discharge phenomena with the dust and snowy storms, with the volcanic eruptions, nuclear explosions in the atmosphere, in the technological processes, con-

nected with mixing of aerosol flows, for example in the flour-grinding and cement industry. The presence of powerful convective and turbulent flows in the thunderstorm clouds, and also the given above cases of electrization indicate that interaction of the large charged particles with the sizes of 0.1 - 10 mm with the particles of micrometer size in the moving conducting gas medium plays important role in the electrical dynamo. The poly-phase and multi-flow nature of medium brings in the final sum to the effective transformation of mechanical energy into the electrical. The problem of the initiation of lightning discharge remains one of sharp and unites entire complex of questions.

Briefly let us pause at two of them. First, as measurements on the balloons, the rockets and the aircraft showed, the maximum tension of electric field in the thunderstorm clouds does not exceed usually 2 kV/cm, which is substantially lower than the threshold of the breakdown of dry air at the heights in question, the composing value order 10 kV/cm. In the thunderstorm cloud, however, the discharge is developed in the humid air, which contains the particles of different size. Natural to assume that the threshold the field is reached in the compact spatial domain, for example, on the scale less than 10 m or generally on the microscale because of field strengthening on the particles, and to the sufficiently short period, so that the usual sensors of field do not ensure that required three-dimensional—time resolution with the registration. The development of the avalanche of the fast, so-called running away electrons with energy on the order of 1 MeV can serve as the alternative explanation to initiation of spark in the sufficiently weak field. Such electrons can be accelerated in the field of cloud because of a drop in brake power with an increase in the energy of particle. The threshold of the development of avalanche almost is by an order lower than the usual threshold of the breakdown of dry air; therefore when the seeding particles of the high energy are present, which are supplied by cosmic rays, the development of avalanche in the cloud can give birth to the localized region of high conductivity, capable of initiating spark. In the second place, the classical theory of gas discharge does not make it possible to explain the rapid passage of cloud medium into the conducting state at the preliminary stage of lightning. Recently the new scenario of this stage had been proposed and investigated, it is connected with the reaching by the cloud of the regime of the self-organized criticality. In the model of electrical cells with the significant dimension of $\sim 1 - 30$ m and with that randomly growing in the space and the time by potential the separate small-scale breakdown between the pair of cells is capable to cause “chain reaction” of intra-cloud micro-discharges—is developed the stochastic process “of the metallization” of intra-cloud medium. This model

describes well the experimentally observed special features of the preliminary stage of the lightning discharge, in that number dynamics of micro-discharges and characteristic of radio emission. The study of thunderstorm phenomena includes experiments on the artificial initiation of lightning—trigger lightning. In order to cause the discharge in the atmosphere under the thunderstorm cloud, the rocket, which leaves after itself in the regime of a deficiency in the oxidizer a significant quantity of soot conducting electricity is used. As it proved to be, initiation occurs with the sufficiently high tension of field on the earth's surface under the cloud—not less than 5 - 10 kV/m. The for the first time classical diagram of the initiation of discharges with the wire pulling after the rocket was realized in 1960 from onboard of research vessel. From those times about thousands of successful experiments are carried out; physics of the ascending and arrow-shaped leaders, the return shock, mechanism of the sudden strengthening of the luminosity of lightning channel because of the sharp current amplification was in detail investigated because of them. Today are opened new possibilities for control of lightning discharges, in that number with the aid of lasers. Thus, powerful lasers are capable of organizing the extensive plasma cylinders in air, which could initiate and direct the lightning discharges similar to metallic wire in the trigger lightning and conducting channels from the products of the combustion of special geodetic rockets. Ch. Wilson has indicated in 1925 to the possibility of accelerating the electrons to the relativistic energies in the field of thunderstorm cloud. This hypothesis was confirmed during our days: on the generation of relativistic particles and quanta of high-frequency emission in the atmosphere, which correlate with the thunderstorm activity, a whole series of experiments testifies. Thus, measurements on the balloons revealed an anomalous increase in the intensity of X-ray and gamma-radiation more than two or three orders in the course approximately of minute with the maximum of spectrum in the region 50 - 60 keV. Ground observations also revealed the intensive flashes of X-radiation with the energy of quanta into several hundred keV, whose appearance coincided with molding of the leader of lightning flash and the arrow-shaped leader of trigger lightning. Finally, for the latter several years were published the results of observations from the satellites of the splashes of the gamma—quanta MeV-foot level, X-ray and ultraviolet radiation of atmospheric origin. For explaining these phenomena in a number of works are drawn the phenomena mentioned above new for the atmospheric electrodynamics, and precisely: the generation of the running away electrons and breakdown on the running away electrons. Energetic quanta can arise from of the bremsstrahlung of the fast electrons, which interacts with the molecules of air. Models describe different situations,

including the development of the avalanche of fast electrons when the extensive air shower of cosmic rays is present, and breakdown on the running away electrons in the strong field of the stepped leader of lightning. One should note that an increase in the number of fast electrons in the field of thunderstorm cloud with the presence of extensive air shower is accompanied by the generation of a large quantity of second particles, and this leads to the generation of the current pulses and radio emission. If energy of primary particle is sufficiently great (10^{17} - 10^{19} eV), the short (several microseconds) pulse of radio emission can have the enormous energy (to 1 MeV), which explains the appearance of the so-called narrow bipolar pulses, observed sometimes during ground-based and satellite measurements and correlating with the thunderstorm activity. The formation of such intensive current pulses is of interest both for understanding of the mechanism of the generation of lightning and for studying the cosmic rays of super high energies. It is interesting that the presence of the cellular structure of electric field in the thunderstorm cloud with the amplitude, which exceeds the threshold “of running away”, proves to be essential for the process of accelerating the electrons to the relativistic energies. The randomly oriented electrical cells together with the acceleration sharply increase the time of life of relativistic electrons in the cloud because of the diffusion nature of their trajectories. This makes it possible to explain the significant duration of the splashes of X-ray and gamma-radiation and the nature of their interrelation with the lightning flashes. The role of cosmic rays for the atmospheric electricity they must explain experiments on a study of their correlation with the studied thunderstorm phenomena.

3. LIGHTNING IN THE NATURAL CAPACITOR “CLOUD-IONOSPHERE”

The powerful pulse to the study of atmospheric electricity at the very end XX of century gave observations of the discharge phenomena in the middle atmosphere – Sprites and Jets (**Figures 1 and 2**), which correlate with the thunderstorm activity, each day where the region of glow stretches to 85 - 90 km above the earth, and flash duration comprises from ones to tens of milliseconds, elves, who stretch to the heights—70 - 90 km with the duration less than 100 s and jet-discharges, which start from the upper part of the cloud and which are extended at times to the mesospheric heights with a speed of about 100 km/s. Registration of high-altitude discharges and diagnostics of their characteristics are complicated because of the short time of life and sporadic nature of the lightning discharges. Partly therefore, until now the physical models of Sprites, Elves and Jets remain the object of intensive discussions. Perhaps, the greatest

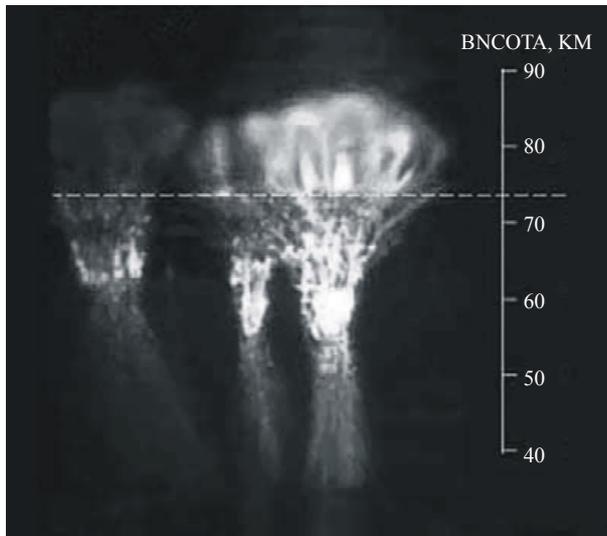


Figure 1. Photo of “Sprite”.



Figure 2. Photo of “Jet”.

information to the present time is accumulated about Sprite. Jet and its physical examination is the most interesting stage of the work for the future.

The optical flash of Sprite in the mesosphere appears through several milliseconds after discharge cloud (+)-the earth, sometimes at the removal several ten kilometers along horizontal from the channel of lightning. Discharge ignites at a sufficiently high altitude, since the threshold of the breakdown of air falls with the height exponentially, whereas the amplitude of the disturbances of electric field, which appears at the moment of the powerful lightning flashes of capacitor “cloud-the earth”, decreases with the height much slower—according to the power law, and at the heights approximately 75 km in the atmosphere exceeds the threshold of breakdown. In the last decade the study of the high-altitude discharges in the atmosphere became the extensive, intensively developing direction of geophysical electrodynamics. And

although the stage of the accumulation of data, that characterize the morphology of these phenomena, is by no means completed, already it is possible to switch over to a study of the thinner special features of structure and dynamics of the high-altitude discharges and their role in the orbital electrical chain and the balance of low components of the atmosphere. Experiments and theoretical calculations show that these discharges must be considered as the part of the dynamic process, which includes the formation of the structure of field and charge in the cloud and lightning discharge to the earth. Widely are discussed different approaches to the simulation, including with the attraction of the mechanism of the running away electrons. In the detail, was developed the model of the generation of electric field in the middle atmosphere, which considers the special features of the charge distribution and its dynamics in orbital scale the convective systems, which serve as the basic sources of positive discharges to the earth. The physical model had been developed, which makes it possible to describe fine structure and dynamics of Sprite. Sprite is represented as the network of micro-discharges—streamers, and as the self-sustaining process in the external field. Together with metallizing process of thunderstorm cloud mentioned above, we have here one additional example to self-organizing, when the dynamics of high-altitude discharge is caused by reaching the threshold of the so-called directed flow, which characterizes the formation of the branched conducting channels, which overlap entire length of Sprite. Immediate prospects in the study of the high-altitude discharges in the atmosphere are connected with conducting of the coordinated ground-based and space experiments, and also with the development of the new methods of diagnostics of the parameters of high-altitude discharges, in that number with the use of possibilities of radio-wave and laser diagnostics. Electrical field of the atmosphere is very variable. The tension of the vertical component of field, which is usually much more than horizontal, reaches several kV/m with the saggings, the ground-winds and the thunderstorm cloudiness. Therefore is introduced the concept of conditions grow prettier weather, that corresponds to wind speed not more than 6 m/s into the absence of any kind of sediments, hoarfrost, fog, lower cloudiness. But even under these conditions near the earth’s surface there is an electric field by tension approximately 150 V/m, along which in the weakly conducting air flows the electric current with the density several pa/m^2 . This field changes in the time and the space, the fluctuations relative to average value can comprise from ones to tens of percent. The measurements of electric field, current and conductivity under the conditions grow prettier weather they serve as the powerful means of the study of the electrical state of the atmosphere. However, to use it is possible, having

only learned to divide global *i.e.* planetary scale, orbital—with the scale of the order of the height of neutral atmosphere 100 km and the local disturbances of the electrical parameters. The latter, in their turn, is directly connected both with the changes in the ionic- aerosol composition and with the dynamics of medium. In studies it was established that the boundary layer of the atmosphere is characterized by the presence of the aero-electrical structures, which are manifested in the pulsations of electric field with the power-law spectra short-term with the periods from ones to several hundred seconds. The electrodynamics of fog is of special interest. Full-scale observations showed that under the conditions of fog in the frequency band 10^{-2} - 1 Hz also realize the power-law spectra of the pulsations of field, but the intensity of pulsations increases more than by the order in the comparison with the conditions grow prettier weather, which is explained by the diffusion charging of drops in the lowest layer of the atmosphere. The results that it is structural—temporary analysis made it possible to isolate two forms of the electrical state of fog, the first of which is characterized by the formation of intensive aero-electrical structures, and the second—by chaotic structural-temporary variations in the field and current.

4. ORBITAL ELECTRICAL SOCKET

Electricity grow prettier weather is inseparably connected with the thunderstorm electricity, it composes the part of the distributed current outline—the orbital electrical socket (OES) of the atmosphere. As the physical cause for formation OES in the atmosphere serves a sharp increase in the conductivity of air with the height. Near the earth's surface the conductivity of air is very small and comprises $(2 - 3) \times 10^{-14}$ S/m, which corresponds to the concentration of light ions of approximately 10^3 cm⁻³. With an increase in the height because of an increase in the ionization level, determined to 40 km by galactic cosmic rays, and it is above—by the ultraviolet and X-radiation of the sun, conductivity grows almost exponentially with the characteristic scale of 6 km. Already at the height of lower boundary of the ionosphere (about 80 km) it increases to more than 10 orders in the comparison with the troposphere. The conductivity of the earth in the surface layer, and all the more water in the ocean also exceeds the conductivity of the boundary layer of the atmosphere to 10 - 12 orders. Thus, the constantly functioning thunderstorm generators prove to be concentrated in the sufficiently narrow weakly conducting layer between the earth's surface and the ionosphere. Frequently with the simplified description OES the earth's surface and lower boundary the ionosphere (70 - 80 km) they are considered as the facings one additional gigantic spherical capacitor of the orbital

scale, which is discharged in the regions grow prettier weather it is charged in the regions of thunderstorm activity. In this case the quasi-stationary currents of charging are not locked completely to the earth near the thunderstorm clouds, but partially “they are involved” into the superincumbent region of high conductivity and spread on the ionosphere. It is considered that the precisely quasi-stationary currents in the first turn “bear responsibility” for the maintenance of a potential difference of ~350 kV between the Ionosphere and the Earth. Since the upper part of the majority of thunderstorm clouds has positive charge, the potential of the ionosphere also proves to be positive, and in the regions grow prettier weather electric field directed downward, causing thus the conduction currents, which close OES. If the action of generators ceased, a potential difference between the earth's surface and the ionosphere would disappear in the time not more than 10 min. The orbital electric generator, caused by the nonmonolithic nature of the rotation of the plasma sheath of planet, can serve together with the thunderstorm generators, the potentially important source of atmospheric electricity. In order to understand in the components the mechanism of work OES and its role in the system solarly—terrestrial connections, to be dismantled at is three-dimensional—to temporary dynamics, are necessary the complex experiments, which include the high-precision measurements of electric field and current on the orbital scales and the measurements of the integral activity of thunderstorm generators. For understanding of work OES are necessary the adequate models of thunderstorm generators, which give the possibility to calculate quasi-stationary and pulse currents, and also the contribution of generators to complete power engineering OES. The results of calculations show that the contribution of mesoscale convective systems in OES can substantially exceed the contribution of single thunderstorms. In spite of the significant disturbance of electric potential in the region of convection, which reaches hundred megavolts, the basic contribution to the complete vertical current and structure pour on and currents in the environment of meso-scale convective systems are determined by region stratifications. Taking into account last experimental data and based on them theoretical estimations was created new description OES as the open dissipation system, supported in the state of dynamic equilibrium by the entering it energy flow, in the first turn of radiant energy of the sun. It is established that electrical energy is generated predominantly in the regions of the reduced atmospheric pressure and in the zones of cold fronts and comprises in average 5×10^{13} George, that two orders higher than energy, concentrated in the orbital spherical capacitor the earth-ionosphere. The average speed of the dissipation of electrical energy 4×10^{11} W exceeds the speed of the dissipation of energy

in the tectonic and magmatic processes and is characterized OES as completely dynamic system with the very short time of the renovation of electrical energy. The process of the transformation of energy in the atmosphere is accompanied by the generation of the dissipative structures of different scales, in the detail of convective systems and aereoelectrical structures, that clearly it is possible to visualize in the form the global processes of the accumulation of electrical energy and its dissipation in the atmosphere. On the basis of higher than aforesaid, in the near time the study of power engineering of the atmosphere, structure and dynamics OES will remain one of the vital problems of atmospheric electricity.

5. CONCLUSION

In conclusion it is necessary to say several words about the interrelation of atmospheric electricity with the formation of the composition of atmosphere and climate

of planet. Many years were undertaken attempts at the creation of the conducting channels of large length for studying the upper air and solution of special problems. In this connection is of great interest the program "Impulsar" [2,3], which in the combination with the high-voltage high-frequency Tesla's source can be useful in the solution of the enumerated above problems.

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