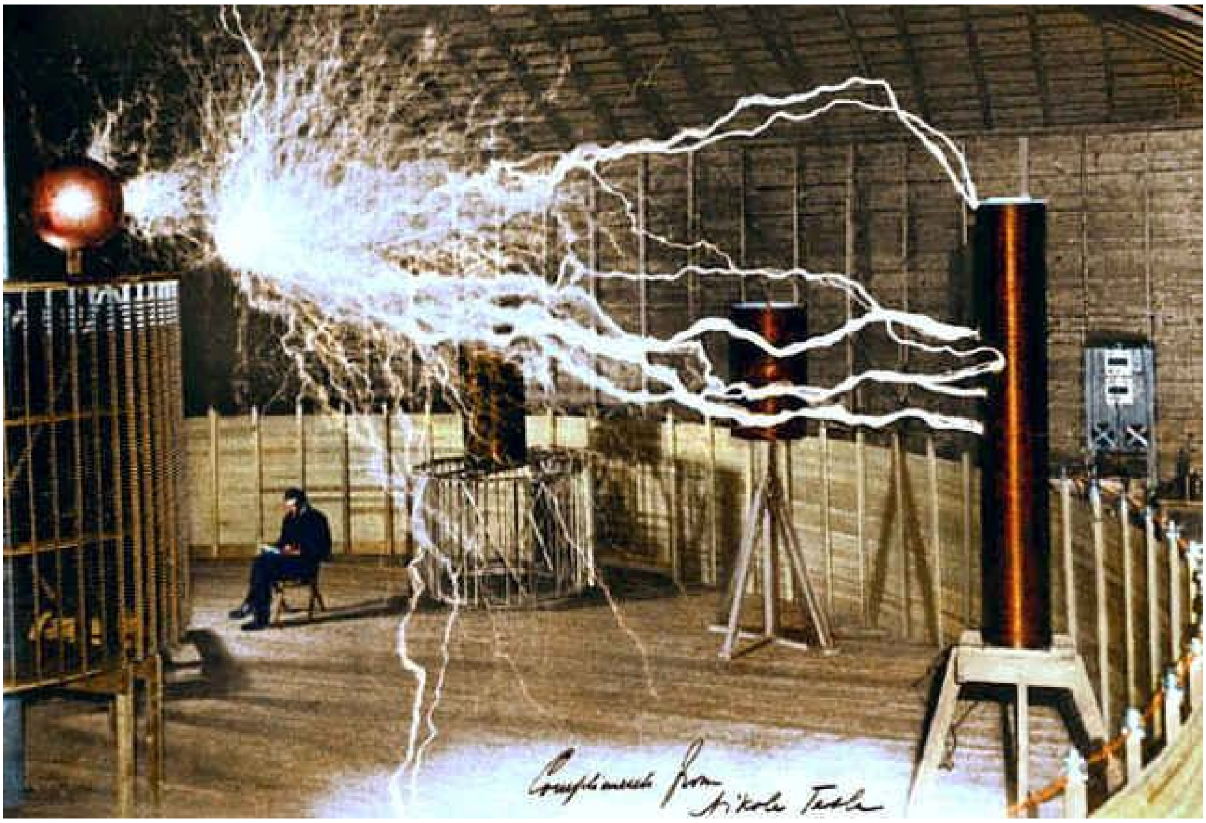
Ball lightnings in Tesla’s lab 1.



"When the action is very energetic, owing to the power of the streamer and other causes, the liminous portion of the same becomes a veritable ”fireball”. This observation wich, to my greatest astonishment, I have frequently observed in experiments with this apparatus, shows now clearly how ”fireballs” are produced in lightning discharges and their nature is now quite plain. I have heretofore always been inclined to belive this phenomenon to be merely a visual impression, similar to onen wich is experienced upon a violent blow on the eye, or some part of the head, or the spine, or wich follows upon a sudden and very intense manifestation of light most generally. Although the vision of a moving ball of great luminosity is experienced only in the rarest instances, the person as a rule seeing luminous spots, ”stars” or flaming tongues."
Nikola Tesla: Colorado Springs Notes, p.368. Nikola Tesla Museum, Beograd, 1978.
photo: Frank Germano

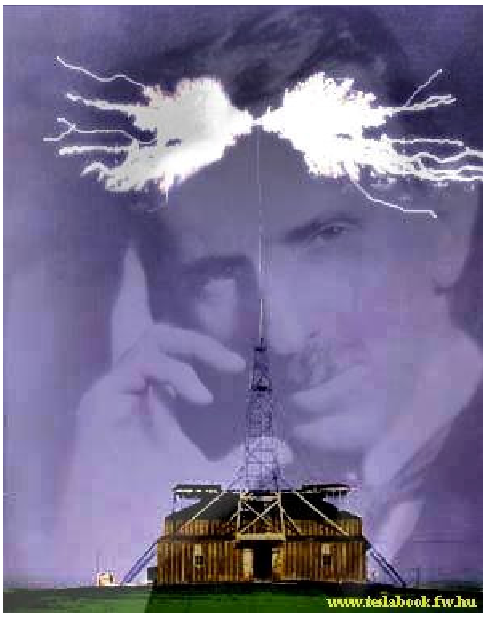
Ball lightnings in Tesla’s lab 2.

"With the present experiences I am satisfied that the phenomenon of the ”fireball” is produced by the sudden heating, to high incandescence, of a mass of air or other gas as the case may be, by the passage of a powerful discharge. There are many ways or less plausible in wich a mass of air might be thus affected by the spark discharge, but I hold the following explanation of the mode of production of the ”ball” as being, most likely of all others wich I have considered, the true one. When sudden and very powerful discharges pass through the air, the tremendous expansion of some portion of the latter and subsequent rapid cooling and condensation gives rise to the creation of partial vacua in the place of greatest development of heat. These vacuous spaces, owing to the properties of the gas , are most likely to assume the shape of hollow sphere when, upon cooling, the air from all around rushes in to fill the ”cavity” created by the explosive dilatation and subsequent contraction. Suppose now that this result would have been produced by one spark or streamer discharge and that now a second discharge, and possible many more, follows in the path of the first. What will happen? Befor answering the question we must remember that, contrary to existing popular notions, the currents passing through the air have the strength of many hundreds and even thousands of amperes.

It was a revelation to myself to find that, even with the apparatus used in these experiments, a single powerful streamer, breaking out from a well insulated terminal, may easily convey a current of several hundred amperes! The general impression, if I am not mistaken, is that the current in such a streamer is small but this belief is due to the comperative unfamiliarity of the electrician with such apparatus as I am now using. As a matter of fact it is quite easy to consume in such streamers, as are illustrated in these photographs, most of the energy developed by the apparatus and the currents conveyed through the air may be, by suitable provisions, made as strong as those circulating in the wire or coil itself wich produces them. No wonder then, that a small mass of air is ”exploded” with an effect similar to that of a bombshell, as noted in many lightning discharges.
But to return now to the axplanation of the ”fireball”, let us now assume that such a powerful streamer or spark dischare, in its passage through the air, happens to come upon a vacuous sphere or space formed in the manner described. This space, containing gas highly rarefied, may be just in the act of contracting, at any rate, the intense current, passing through the rarefied gas suddenly raises the same to an extremely high temperature, all the higher as the mass of the gas is very small. But altrough the gas may have been brought to vivid incandescence, yet its pressure may not be very great. If, upon the sudden passage of the discharge, the pressure of the heated air exceeds that of the air around, the lumious ball or space will expand, but most generally it may not do so. For assume, for instance, that the air in the ”vacuous” space was at one hundredth say, of its normal pressure, wich might well be the case, then, since the pressure in the space would be as the absolute tempreature of the gas within, it would require a temerature wich seems scarecely realizable, to raise the pressure of the rarefied gas to normal air pressure. It is therefore reasonable to expect that, despite the high incandescence of the rarefied air, the space filled with the same will continue to contract, and here an important consideration presents itself. When, as befor explained, the vacuous space was formed, the spark or streamer passed through the air disruptively, therefore the path

was necessarily very thin, threadlike, and the minute quantity of the air wich served as a conductor for the current was expanded with explosive violence to many thousand times its original volume. Owing to the fact, however, that the quantity of matter through wich the current was conveyed was small, a great facility was offered for giving off the heat so that the highly expanded gas owing to its expansion and to radiation and convect of heat, cooled instantly.
But how is it when the second discharge and possibly many subsequent ones pass through the rarefied gas? These discharges find the gas already expanded and in a condition to take up much more energy consumption in any given part of the path of the streamer or spark discharge is, under otherwise the same conditions, proportionate to the resistance of that part of the path, and since, after the gas has once broken down, the resistance of other parts of the path of the discharge is much smaller than that including the vacuous space, a comperatively very great energy consumption must necessarily take place in this portion of the current path. Here, then, is a mass of gas heated to high incandescence suddenly but not, as befor, in a condition to give up heat rapidily. It can not cool down rapidly by expansion, as when the vacuous space was being formed, nor can it give off much heat by convection. To some extent even radiation is diminished. On the contrary, despite the high temperature, it is compelled to confinement in a limited space wich is continuously shrinking instead of expanding. All these causes cooperate in maintaining, for a comperatively long periode of time, the gas confined in this space at an elevated temperature, in a state of high incandescence, in the case under consideration. Thus, it is that the phenomenon of the ”ball” is produced and the same made to persist for a perceptible fraction or interval of time."
Nikola Tesla: Colorado Springs Notes, p.368. Nikola Tesla Museum, Beograd, 1978.

Ball lightnings in Tesla’s lab 3.

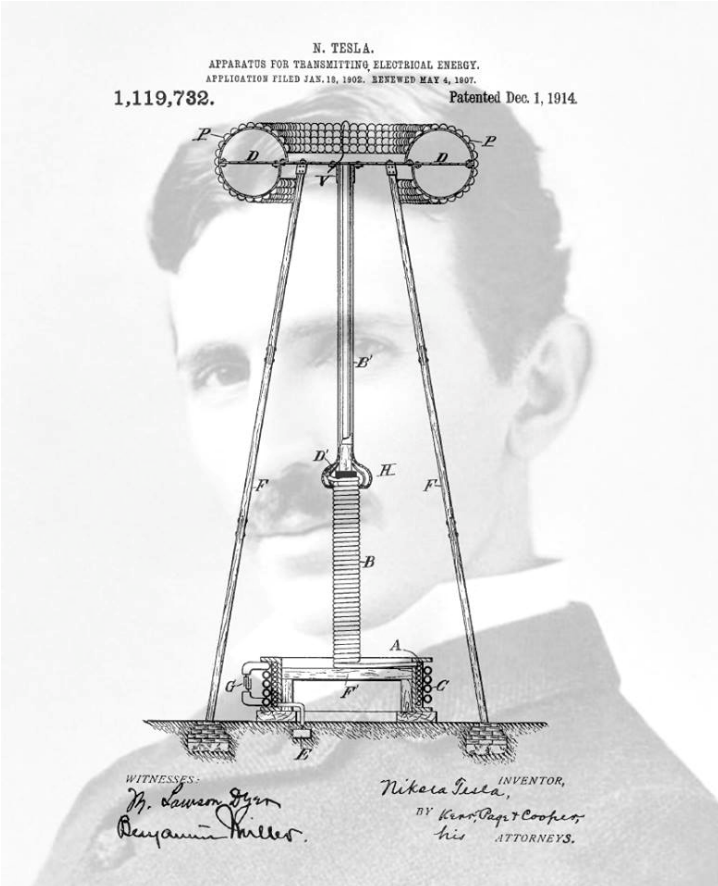


"In fact, all observers concur in the opinion that such a ”fireball” moves slowly. If we interpret the nature of this wonderful phenomenon in this manner, we shall find it quite natural that when such a ball encounters in its course an object, as a piece of organic matter for instance, it will raise the same to a high temperature, thus liberating suddenly a great quantity of gas by evaporating or volatilizing the substance with the result of being itself dissipated or ”exploded”. Obviously, also, it may be expected that the conducting mass of the ”ball” originated as described, and moving through a highly insulating medium (air), will be likely to be electrified, wich accords with many of the observation made. A better knowledge of this phenomenon will be obtained by following up experiments with still more powerful apparatus wich is in a large measure already settled upon and will be constructed as soon as time and means will permit. There may be a way, however, of intensifying in this respect, the action of the present machine. A very important matter is to use better means of photographing the streamers exhibiting these phenomena. Much more sensitive plates ought to be prepared and experimented with. The coloring of the films before suggested might also be helpful in leading up to some valuable observation. It being a fact that this phenomenon may now be artifically produced, it will not be difficult to learn more of its nature. Photography will be, of course, the best means to investigate it and the first efforts ought to be in this direction. With the present plates, although the ”balls” produced with the apparatus experimented with are probably up to 1 ½” diam. and possibly more, they leave only a small dark spot on the plate, only the nucleus or central portion impressing itself." Nikola Tesla: Colorado Springs Notes, p.370. Nikola Tesla Museum, Beograd, 1978.

Ball lightnings in Tesla’s lab 4.

"Colorado is a country famous for the natural displays of electric force. In that dry and rarefied atmosphere the sun's rays beat the objects with fierce intensity. I raised steam, to a dangerous pressure, in barrels filled with concentrated salt solution, and the tin-foil coatings of some of my elevated terminals shriveled up in the fiery blaze. An experimental high-tension transformer, carelessly exposed to the rays of the setting sun, had most of its insulating compound melted out and was rendered useless. Aided by the dryness and rarefaction of the air, the water evaporates as in a boiler, and static electricity is developed in abundance. Lightning discharges are, accordingly, very frequent and sometimes of inconceivable violence. On one occasion approximately twelve thousand discharges occurred in two hours, and all in a radius of certainly less than fifty kilometers from the laboratory. Many of them resembled gigantic trees of fire with the trunks up or down. I never saw fire balls, but as a compensation for my disappointment I succeeded later in determining the mode of their formation and producing them artificially."
Nikola Tesla: The Transmission of Electric Energy Without Wires, The Electrical World and Engineer, March 5, 1904.

Ball lightnings in Tesla's lab 5.



"The adjustments should be made with particular care when the transmitter is one of great power, not only on accout of economy, but also in order to avoid danger. I have shown that it is practicable to produce in a resonating circuit as E A B B' D immense electrical activities, measured by tens and even hundreds of thousands of horse-power, and in such case, if the points of maximum pressure should be shifted below the terminal D, along coil B, a ball of fire might break out and destroy the support F or anything else in the way. For the better appreciation of the nature of this danger it should be stated, that the destructive action may take place with inconceivable violence. This will cease to be surprising when it is born in mind, that the entire energy accumulated in the excited circuit, instead of requiring, as under normal working conditions, one quarter of the period or more for its transformation from static to kinetic form, may spend itself in an incomparably smaller interval of time, at a rate on many millions of horse power. The accident is apt to occur when, the transmitting circuit being strongly excited, the impressed oscillations upon it are caused, in any manner more or less sudden, to be more rapid than the free oscillations. It is therefore advisable to begin the adjustments with feeble and somewhat slower impressed oscillations, strengthening and quickening them gradually, until the apparatus has been brought under perfect control. To increase the safety, I provide on a convenient place, preferably on terminal D, one or more elments or plates either of somewhat smaller radius of curvature or protruding more or less beyond the others (in wich case they may be of larger radius of curvature) so that, should the pressure rise to a value, beyond wich it is not desired to go, the powerful discharge may dart out there and lose itself harmlessly in the air. Such a plate, performing a function similar to that of a safety valve on a high pressure reservoir, is indicated at V."
Nikola Tesla: US1,119,732. Apparatus for transmitting electrical energy, jan. 18, 1902.