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Feature Article

The Tribulations of the Inventor

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This is the translated transcription of a speech given in May 2005 in Florence.

My topic is innovation. The starting remark is that we are sick and tired of the innovation in the form of speeches, colloquia, prizes, etc. A great deal of people speak about it and, as usual, it does not result in anything concrete. However, we need innovation. If we look at the world as it is, we can say that we need innovation at two levels. There is, I would say, a selfish perspective, the perspective of a Western country's citizen who says: "we live in an incredible luxury in comparison to the Third World. If we want to keep this situation of comfort, we have to be constantly in lead, we must have more patents to sell, and industries to create that are not those of today because these will be much better ruled for example in Southeast Asia. We must do something else". There is this reducing point of view and then there is a more generous point of view which consists in saying: "Actually, we are in front of this Third World. If we want that this Earth remains in the long term, we have to discover its own way of evolution, and this implies a considerable technical innovation." Thus one way or the other, we cannot escape it.

But it is not so simple to do. I have to admit, contrary to what you just heard, that I am not at all an inventor. All that I can say is that I have been the advisor of a number of inventors at the industrial and academic level. And also I see some of the pupils of the École de Physique et Chimie coming up, at least we must try not to suffocate their enthusiasm, I would say. It is more or less the level of what we know to do. I should also tell you that there are heaps of Epinal prints on invention and innovation that are completely off the track. The first maybe is Bernard Palissy, a little bit crazy inventor who burns his last chair to cook its ceramics, to make something extraordinary. This picture is very dangerous. It often goes with the idea that this inventor is also misunderstood. This situation is dangerous. Being misunderstood does not mean to be a real creator.

I could quote the most famous newspaper in France, dedicated for a considerable time to people who made only stupid things, but that became heroes by their condition of being misunderstood. Thus, as for Bernard Palissy, this is distrust. There is another aspect that we still find in novels or things like that, which is the lightning revelation of the gentleman which suddenly has an idea that is going to submerge an entire domain.

It certainly occurs in some cases. There is a funny case, it is the story, that takes place more or less in 1900, of a young Hungarian who was walking in a park in Budapest and who suddenly decided with his friend that he knew the way to build an electric engine that could work.

At that time electric engines worked horribly badly. He drew with his cane (at that time, they still had sticks) in the sand of the park what will be the synchronous engine, the future engine, that will turn direct electricity used by Edison into the alternating electricity in which we live. It is an illumination, it is true. There is a very small number of cases of this kind. A lightning revelation is not at all what we expect from a pioneer.

And then, there is a third feature which concerns you more, a sort of creed of the current companies: in order to innovate, it is necessary and sufficient to follow the market, to know what your customers demand and to come out with the substantial answer to their request. This is absolutely insufficient. I can try to make two or three examples.

A first example is the story of the liquid crystals watches, the liquid crystal display in general, but in particular for the watches.

As this appeared, the industry of the watch was a Swiss factory that worked magnificently, used to listen very well to its market, and developed market oriented quartz watches. However at the time the company did not see the upheaval that this type of display and the associate microprocessors represented. Because of this error the Swiss industry knew 10 or 15 years of dramatic slump. It came out finally with a nice restoring as in the case of Swatch or things like that, but in any case it was a considerable strategic fault.

Thus, the market piloting in that case was completely dangerous. Another example that fortunately affects you at a minor extent, is the one of a sir named Hounsfield who worked in a disks company. The disks company used to make good bargains and had a certain investment policy in all-out research.

He was persuaded that X-rays pictures could be taken to look at objects. He did that with what was at hand, that is a target, a rotating arm which was pulled by the engine of a vacuum cleaner and an X-ray tube. Instead of taking one picture as we usually do to get an X-ray radiography as we say in medicine, he took hundred pictures by turning the arm.

Later, through a smart reconstruction, he got something that was much more informative. Then he went to the doctors. For a decade the customers and the market kept answering: "no interest". And then finally the device became a breakthrough and this object, that before was mounted on a vacuum cleaner, became what we call now a scanner, an object on which we are all dependent regrettably at one point or another during our life.

We gladly crow on the invention of the laser, a little bit dangerous pride because if we look at the old reports, we notice that the laser would have been invented much earlier, probably 20 years earlier. There were the practical and theoretical tools to make it. So probably, it was made unknowingly. In certain arc discharges or things like that, there are strange phenomena that people did not look deeper into, but probably they were producing lasers without knowing it.

If you like, the laser, but it is not the case for making a trumpet blow, is a discovery guided by the theory. Good! That's very good. But in many other cases, it is not at all the theory that created the economic activity and finally did a service. An example that I came across this morning is the glass. You know how the glass came out: some Phoenician traders were transporting natron, that is sodium carbonate, and they arrived to a river in Palestine, they made a stop by the river and set a fire to cook their chow. It was necessary to build a sort of oven to make the fire and the only thing handy they had - there was no stone - was blocks of natron. They made it on a beach in flint, on a sandy beach.

And then suddenly they saw - while cooking - that something like a river of fire - this is what Pliny reports - spread and that later, this cooled river became a transparent extraordinary material. This is how the glass appeared, but the glass developed through a sequence of fabulous technological inventions. The melting pots to avoid dirt inside, the ovens to blow - it was necessary to let air in - and also the blowing in another sense, i.e. the idea to have a pipe and inflate in a glass pocket to make a bowl, all this dates from Syria-Phoenicia-Carthage, well before the Christian era. It was a fabulous technological innovation and after that there have been other remarkable developments. There has been something like that at the time of a technology transfer to the West, towards Cumae, at the end of the Roman Empire, and then towards Murano and Altare, in the middle of the Middle Ages. This technological transfer was not made without troubles because there was no more natron.

The natron is found in the Dead Sea or places like that, but not in the West. We had no sodium carbonate, it was necessary to find something else. People eventually noticed that the ash of ferns, was a good starting point. It is not the same carbonate, it is potassium carbonate. This allowed to restore the industry in the West. It was not made without difficulties because the practical properties, the melting points, all the miscibility properties of potassium are not the same as those of sodium salts. But people of the year 1000 AD more or less knew how to make it because they were pushed by the invasions - the invasions that cut the West from the East.

Then, here we are, the glass. Yet, this glass that nowadays is an extraordinary technological tool: in the 19^{th} century was used for lenses and optical instruments, in the 20^{th} century for what we call the ice flow (the glass made on a molten metal that allows to make it very smooth) and recently the glass of the optical fibers which allow to communicate stupidities at a large scale, it is still the technology of the glass. This magnificent technology - here is where I return to my original subject - is made up of a material that we do not understand. We do not have a serious description of what we call the glassy state.

Franklin, you know Franklin, great man, ambassador of the young republic of the United States in France, but also one of those who understood the electricity, he was curious about everything. Franklin had what we regrettably have no more: a robust Greek culture. He had read by the Greeks that if we put some oil which is a kind of cleaner on the sea, the waves are calmed down. But this observation had remained at the level where Greece was, that is, I would say in a pretty provocative way, at the level of the philosophers. We have a fact like that, but we do not learn anything real. Franklin had the idea to learn something out of that. At that time he used to live in London, and he went to Clapham Common, near London. There was a puddle - which some of you maybe saw if you are interested in cricket or things like that, there are still activities of this kind - and he chose one pretty windy day, with small ripples at the surface of the puddle, very easy to see. He brought a small bottle of a cleaner of his time, probably an oleate or something like that, a by-product of oil. He poured on the puddle a teaspoon of this cleaner and it calmed the waves on a surface probably a little bigger than this room.

There, he got a number. It was not simply a qualitative idea, he had a number. In fact, this number was extraordinarily precious as it represented one of the biggest stages, we can say, of the knowledge of matter. If he knew the volume - it was one teaspoon - and if he knew the surface over which this volume spread out - let's say the surface of this room -, dividing the volume by the surface he could find the height. In fact, he found the height of the molecules of surfactant, he found the size of molecules. Exactly, it was an immense progress compared to the Greek miracle. The Greeks had conceived an idea of atoms and molecules for a difficulty in reasoning, because they did not know how to go to the infinitely small, they badly knew how to manipulate atoms and molecules. But because of a lack of mathematical ease, they figured out: "it has to stop". By the way, small size objects, atoms, microlites and some others, but it is purely philosophical.

Since the experiment of Franklin, his finding becomes a scientific fact because we do not say that there must be something, but we say that there is something and that it has this size. From this moment, slowly things *are*. But you will notice the simplicity of the methods - one teaspoon, a small jar of oil and a puddle - and one of the biggest discoveries of the conceptual history of the matter follows.

There is a second example on the same line, due to a lady (I might be wrong, but maybe she was the first woman scientist in the Western world). Maybe I am wrong, but it is the first that I know personally, she was called Agnes Pockels. She lived in Germany in the middle of the 19^{th} century, fascinated by sciences, wanting to go to the university, but it was impossible for a woman. Her brother went to the university and did nothing. But she tackled a problem that fascinated people at that time, which is what we call the surface tension of water. Water does not like to lay bare, there is an energy associated with the surface. This energy by square centimeter is what we call the surface tension that we measure by pulling a drop of water by very fine devices and by seeing which strength is necessary to engage in order to convince the water to undress.

But the measures that were made at that time gave totally conflicting results. Sir X in Naples and Sir Y in Göttingen, etc., found absolutely different results. Of course the good scientists used to say: "you did not clean your water, it must be dirty". They said: "we did everything that current chemistry allows us to do, that is we distill, we crystallize the water and then we melt it again, etc.". We eliminate the maximum of impurities, but no go, nothing. Agnes understood that it was not the usual impurities that are in the water such as the common salt or things like that that made the tragedy, but that they were some very rare molecules of these cleaners that I just mentioned. How to get rid of these cleaners? Certainly not by the classic methods because they are so few that those methods are useless, there is a much simpler method. She took her water, shook it strongly – this produces foam where there was a cleaner, an impurity - and she skimmed this foam with a paddle about twenty times.

Once she made it in her kitchen, she obtained a perfectly reproducible water.

She was the first to measure the surface tension of the water. Very happily, it came out. Lord Rayleigh who was the big guru at that time in this field of science gave her a considerable publicity and she came out well. I will show this story to you. Do not expect someone line Marilyn Monroe, she was an austere lady of the 19^{th} century, but she was someone infinitely respectable in her working.

There is another aspect, it is the tenacity. Innovation is not exactly a job where you find something close by. The Concours Lépine that started in France in the 19th century is very dangerous, is not at all like that. Innovation requires a long time, it is a long investment. It is important to underline this point because it is also an opinion that often escapes to the big companies' shareholders. I am going to make an example which is a little bit older.

We go back to 1891. At that time, ladies carried corsets and ankle boots. A very difficult problem is to manage how to tie all the sequential units of the corset or even more in certain hot occasions to untie the same stuff.

Judson in the United States is convinced that it would be necessary to find something better. His attitude at the beginning is to try to find a sort of key which opens all the locks at the same time. There was an absolutely horrible mechanical device with stalks in brass meant to open the corset along the lady's back. Obviously, this device did not work, but Judson worked hard. In 1905 - look at the timescale -, he found a partner called Sundback. In two, it works better. Finally, they came very gradually with this idea to have, instead of a stalk, a flexible join and they created, just before the Great War, what we call nowadays the zipper, which is a very beautiful discovery.

Look at the timescale from 1891 till 1910 that was necessary for this thing. Thus, the tenacity of these people is something extraordinarily respectable and we still need it. I often say that if an extraterrestrial came with the idea to observe a little what is going on on this small planet, he will note maybe with interest that we found as I said the transistor, the laser, etc., but I believe that he will also note that we found the zipper and maybe that we did not find a number of things which are under our nose. Let us be humble.

This experiment that requires a rather complex material that I am going to collect here, is about what we call the dewetting. I take here some water, H_2O, that I am going to place on a sheet of polyethylene. Polyethylene hates water. First I put a small drop, you will not see it very well, I try to add two or three. When it is quite small, it tries to minimize its surface to be exposed. The shape that has the smallest surface for a given volume is the sphere. Thus, it is a spherical cap, it is a portion of sphere. If I force a little the nature, I put some more there, I face a difficulty which is due to the slope of my system. You see, what is made here is an object that is an interesting compromise. It is an object in which the capillarity and the surface forces want to retract this drop, to make it expose less surface, but there is its weight that goes the other way and that forces the drop to flatten. There is a compromise weight-capillarity analyzed by Laplace in 1805 which leads to a thickness very well defined of the order of the millimeter. The object which is there, and that we usually call a puddle, is a very precise object of interface science.

It is all good, but it is not enough to look at the nature in this way.

We try to tease it a little more, that is we force the sheet of plastic to be wetter than what it likes. I will make it by means of this experimental device.

I have some troubles with this story of the slope, but in any case you can see that the sheet gets by quite well. It retracts, there are dry regions which grow either from a small hole inside, or from edges or from defects. If you have a good eye and some faith, you will see that as long as it moves forward, it does it at a constant rate. This process, it is what we call dewetting. It is something that we meet in our everyday life, but that is also important in many industrial applications. These things were made at the Institut Curie by Françoise Brochard's team. They sensed that it was going to be important, they did not very well figure out how, but they established the fundamental laws.

Obviously, it is not as simple as in the air. To prepare clean surfaces with no defect that may hamper the movement, etc., we need the chemical synthesis on surfaces, it means three years of work, or something like that.

Then, there is some hydrodynamics. It is very interdisciplinary, it is necessary to understand how it moves, etc. But finally, everything has been clarified and they had the very clear impression that it was going to serve, but they did not know so much where. It turned out to serve in several domains that have an interesting industrial impact. Since it is late, I am only going to quote one that is described by what I call the British experiment.

In the British experiment, these British wanted the rain. On the road there is more or less 1 mm - maybe less, some micrometers - of water. Under the water there is the asphalt and there comes a car that drives at a British speed of the order of 50 km/h. If this car was really on a film of water like that, you would immediately lose control. It is absolutely necessary to recover a contact between the rubber of the tire and the asphalt. The rubber of the tire turns like this. It keeps the contact with the asphalt during the short moment that corresponds to the flattened part of the tire of your car, which is not very large. At this speed, it means that the tire remains only some milliseconds in contact with the asphalt.

During these few milliseconds, the film of water has to strip out.

This problem is not so that far from what I showed you in my superb experiment. In my magnificent experiment, there was some polyethylene, there was some plastic, some water and air. In this experiment, there is some asphalt that behaves precisely as the plastic, which hates the water, some water and the rubber. It is not the same problem, as rubber is very different from air, but it is a cousin of this problem. These people at the Institut Curie dedicated three generations of theses to understand these phenomena.

Now, we can say that they are relatively well understood and that we have an idea of what a car aquaplaning is. The industrial impact is not so much on the industry of the tire because many of the countermeasures that you can think of to facilitate this process would consist in carving the surface of the tire, like a lace on the surface of the tire. Unfortunately, as you know, a tire wears out very fast and this lace would be very quickly removed. Thus, many of the countermeasures designed for the tire are not good.

On the other hand, the countermeasures about the road, some effective dewetting initiators on the road, are the most interesting for the future.

Thus in that respect, there are interesting hopes. I mention this to show you that this kind of very simple experiment remains valid even in the 21st century and that it is not of the past that I am talking about. If I come on the big perspectives - it is necessary a little bit in a way - I would say that what strikes me, is the fact that the inventors had several following cycles. There was an extraordinary time in the 19th century with people working alone such as Edison, who really changed our world. And then, there was also another extraordinary time, that of the heavy industries. In the domains that I know - it is very restrictive -, it is for example General Eletric. General Electric had a big pilot, Langmuir, who was, let us say, the author of the flashlight as we know it today. The Edison' flashlight was made with a roasted fern had no mechanical stability and did not resist in time. Whom shall I quote still? Dupont. And Carothers for the nylon, or Bell Labs and Schockley for the transistor.

Thus, there was this superb time of the heavy industries that was an admirable superposition. But you should be aware that this time is about to go and that these heavy industries do not play anymore the same piloting role in the future as they did in the 20th century for a simple reason that your professors will explain to you better than I, what is the grip of the power by the shareholders of the big companies. At present, the shareholders have the power and these shareholders are not you and me, they are rather the pension funds of California or things like that, they are very demanding on the profitability in the short term, that is in three years. In other words, they accept to support all the projects of innovation that are very fast, within three years. They do not support anymore whatever is in a 10-year frame. A big part of what was made in all these examples that I mentioned there was exactly a research that lasted at least 10 years. Thus under this point of view, the heavy industries are in a very difficult situation. You see in France the bosses of companies who are in troubles and try to defend a long-term corporate development plan, but who do not always succeed. Some are kicked out, others are threatened, let us say. Thus, there is a hole there.

Thank you for your attention.

* Pierre-Gilles De Gennes (1932 - 2007) was awarded the Nobel Prize for Physics in 1991.

Translation by Pierandrea Lo Nostro