Transactions of the Materials Research Society of Japan 24 [3] 281-286 (1999)

Discovery and/or Invention of Useful New Materials and Limitations of Technology

KATSUKI Atsushi
Takachiho University, Omiya 2-19-1, 168-8508 Suginami, Tokyo, Japan
Fax: 81-3-3313-9034, e-mail: akatsuki@takachiho.ac.jp

After a short comment about the general process of discovery and/or invention of useful new materials, three cases of inventions: KS magnetic steel, Invar Alloy, and Super Invar and Stainless Invar, are discussed somewhat in detail. It is suggested that a useful new material to be one in which some antinomic properties coexsist. A transparent metal would be a "candidate" of such a material. Asking whether a person who is dreaming of inventing a transparent metal will be a pioneer or a swindler, we critically discuss the ideological situation, "Science, the Almighty", and show some case studies of techno-fraud whose deceptiveness is clearly debunked from the viewpoint of entropy. In conclusion it is suggested that the tempo of progress in technoscience should be harmonious with the tempo and rhythm of human life, of lives in the ecosystem and of biological evolution. It is also suggested that any materials with which so far Life has not been familiar in the long history of evolution should not be produced and producible materials should be limited to such ones as easily decomposable and harmlessly sucked into natural circulation of matter or as perfectly isolatable from ecosystem in a concreted solid form under keeping close watch.
Key words: KS magnetic steel, Invar alloys, Antinomy, Entropy, Techno-fraud

1. DISCOVERY AND/OR INVENTION OF USEFUL NEW MATERIALS

1.1 A general discussion

Discovery or invention of useful new materials has almost always called forth by a short supply of existing useful materials due to exhaustion of resources, stoppage of distribution, too expensive to produce and so on. Sometimes the discovery or invention of new materials accompanied some developments in technology which made the new materials more practical to use.

Examples are: substitution of coal for water in power source, i.e., that of the steam engine for the water mill, those of coal for wood and of oil for coal in fuel, that of coal for charcoal as carbon material indispensable to iron manufacture, that of transistors for vacuum tubes in electric circuits, and so on. Some of these substitutions have formed an epoch at each age in the history of the world. Kawamiya[1] has thoroughly discussed the above matter based on the thermodynamical and material analyses and has published his clear-sighted view and his definite conclusion, so I give no further general discussion here.

1.2 Actual cases of invention of useful new materials

Now I will discuss the processes of invention of some magnetic alloys and of useful alloys in which the useful property is deeply connected with their magnetic properties.

I take up here three cases: (1) Invention of KS Magnetic Steel by Honda and Takagi, (2) Invention of Invar Alloy by Guillaume, and (3) Invention of Super Invar and Stainless Invar by Masumoto.

I have noticed that what the three cases have in common is coexistence of antinomic phenomena within the very material.

1.2.1 Invention of KS magnetic steel by Honda and Takagi

Honda Kotaro was the man who opened the self-reliant period in materials science of Japan. Graduating in physics from the University of Tokyo in 1897, Honda started his academic life with research in magnetostriction of metals and alloys under Nagaoka Hantaro's guidance, then over the nine years thereafter, till 1907, he concerned with research in magnetic properties of ferromagnetic metals and alloys at the University of Tokyo as a graduate student and later (after 1901) as a lecturer. He energetically accumulated a lot of important data on ferromagnetic materials.

Before the appointment to Professorship of Physics at Tohoku Imperial University newly planned to be founded in 1910 (but in fact after one year delay, it was founded in 1911), Honda was ordered to Europe (England and Germany) for the study of physics. He left home in April 1907.

At Tamman's laboratory of Goettingen, learning fundamental techniques in metallurgy, e.g., for preparing alloys, he made many samples of alloys with various compositions and clearly showed the relation between composition and magnetic intensity. Then moving into Berlin, at Du Bois' laboratory he energetically measured the magnetic susceptibility of all elements available at that time, except gaseous and ferromagnetic ones, and showed in 1910 that there was a clear periodic relation between atomic number and magnetic properties of the elements.

He returned home in 1911. His main research before studying abroad was concerned with magnetism of ferromagnetic elements, i.e., he investigated the physical properties of Fe, Ni and Co and of special alloys among them. After returning home, he introduced the new technique, the "magnetic analysis" that he developed. In the field of metallurgy, he broke fresh ground -- physical metallurgy, a "frontier" at that time between physics and metallurgy. To determine the phase diagram for various alloy systems, Honda made full use of the new technique.

The introduction of magnetic analysis into metallurgy was essential for the breakthrough. Metallurgy had been established as a discipline due to introducing thermal and microscopic analyses as fundamental methods, i.e., heating and observing changes in temperature, finding the arrest temperature in the heating process, and observing the structure just above and just under the arresting point with a microscope. The method had been powerful, but somewhat obtuse. In contrast to the traditional method above, the magnetic analysis method was much sharper and was able to detect and to identify some transition temperatures in a much narrower range. Honda's most brilliant academic achievement was to clarify the nature of A_2 transformation of iron, i.e., to settle the β-iron controversy in 1915. What led him to the correct answer was magnetic analysis and his unique idea about the shape of molecules of ferromagnetic substances. He was able to grasp the degree of internal freedom as the molecular shape changed. To grasp the degree of internal freedom was the key to understanding the second kind of phase transition, an example of which was the A_2 transformation of iron. Later, it was determined that the internal freedom was due to spin not due to molecular shape. Honda thought the internal freedom was due to molecular shape and succeeded in clarifying the nature of A_2 transformation. However because he did not relate it correctly as spin, his theory of ferromagnetism based on his idea of molecular shape ended in complete failure.

Honda and Takagi Hiromu, one of the research assistants in Honda's laboratory who graduated from the University of Tokyo in 1911, invented KS magnetic steel in 1917. The process of the invention was as follows:[2]

Due to the outbreak of World War I, the importation of magnetic tungsten steel from Germany was stopped. It was the best ferromagnetic material for permanent magnets at that time, of which the coercive force was 70 Oe and the remanent magnetization 450 CGSemu. Since there was a shortage of German magnetic tungsten steel, the Military Arsenal, offering a lot of domestic carbon steel materials to Honda, asked him to immediately produce domestic magnetic steel of high quality which was required for ignition of engines.

Repeating and repeating the tests to measure the highest remanent magnetization and the highest coercive force of each sample under a wide variety of quenching temperatures, Takagi could find no sample reaching 70 Oe in coercive force and concluded that it was hopeless to produce a ferromagnetic material of high quality from offered domestic carbon steel. Analyzing the relation between heat treatment and magnetic properties of carbon steels, Takagi found that annealed samples of low-carbon steel had high saturation and remanent magnetization and low coercive force. These samples easily lost their magnetic properties by getting a little shock. On the other hand, for samples of high-carbon steel, the annealing process lowered saturation and remanent magnetization while heightening the coercive force. Hardening process by quenching for high-carbon steel, though lowering remanent magnetization, heightened coercive force which led to a more stable ferromagnetic state. Generally speaking, there was an antinomic relationship between remanent magnetization and coercive force; if one of which was heightened under a certain condition, the other was lowered under the same condition.

Under this situation, Honda decided to prepare the starting material by adding more cobalt (dreadfully expensive in price) into carbon steel, because it had been known that an alloy of iron with 34-35% cobalt had shown high saturation magnetization -- 20% higher than that of pure iron. Honda and Takagi had known that for iron and cobalt to be well soluble in each other at high temperatures and for cobalt to form no carbide. They expected that with the addition of a small amount of tungsten (and/or chromium, manganese) carbide formation would intensify the hardening effect due to quenching.

The low quality of domestic carbon steel as a magnetic material helped them understand the necessity of finding some new material for permanent magnets, and gave them insight into the relationship between magnetization and coercive forces based on lots of tests on domestic carbon steel and with a clear consciousness of purpose let them to establish such a study plan.

Takagi began research under the new plan with tests for Fe-Co-W steels with 35% Co, 0.5-0.6% C, and less than 10% W added by means of ferrotungsten. In these tests, he found that high temperature quenching at 1100℃ was be needed for these Fe-Co-W steels to get the usual hardening result of quenching. Discovery of the need of very high temperature quenching for hardening, which was beyond Honda's presumption, was attributed to Takagi who actually performed the investigation. He stated in his thesis concerning KS magnetic steel that he found no specimens of high quality, the obtained highest coercive force being about 120 Oe. It seems to be somewhat funny, because the highest coercive force of best tungsten steel had been about 70 Oe and the value of 120 Oe far surpassed the previous best value. Takagi's above statement suggests that he had found some better magnetic materials with coercive forces over 120 Oe.

According to Takagi, because he had been able to find no notable results in Fe-Co-W steels, he tried to add into Fe-Co steel a very hard material which he had heard from a worker in a metal processing shop of the laboratory. The metal processing shop had a very hard cutting tool highly prized for cutting due to its extreme hardness (though its composition had been unknown). Obtaining and adding it into Fe-Co steel, Takagi found a magnet with coercive force of 180 Oe. Honda was very surprised by the result and ordered him to do chemical analysis soon. It was clarified that the increase in coercive force was due to chromium. Then, adding Cr by means of ferrochromium and testing samples, Takagi obtained a new magnetic steel with coercive force Hc=180-200 Oe and remanent magnetization Ir=500-600 CGSemu. This invention corresponds to the second patent[3] related to KS magnetic steel. At the beginning of the study, they wished to get new magnetic steel of Hc=100 Oe and Ir=1000 CGSemu; the newly found material excelled the expected one in coercive force. Effectiveness of a permanent magnet is judged by the product of remanent magnetization and coercive force, the latter of which is more important from the view of stability of the magnet. Desired value of Ir=1000 CGSemu would be expected from the fact that the saturation moment of iron is $2.2\mu_B$/atom, i.e., 1.73×10^3 CGSemu and the expectation for 35% Co-Fe alloy to have 25% or so higher than that of pure iron, 2000 CGSemu and for the half or so of the value 2000 CGSemu to be realized as remanent magnetization, the desired value of Hc=100 Oe would be aimed at 40% or so higher than 70 Oe of existing tungsten magnetic steel. The key to the discovery of the new material at this stage was the finding of the positive effect of adding chromium into 35% Co-Fe alloy. It had been known at that time that the adding of chromium into tungsten magnetic steel would not improve the magnetic quality. Honda used to say "Study beginning with no presumption should result in no success." and he correctly presumed that adding a lot of cobalt into iron could lead them to success. On the other hand, the finding of the positive effect of adding chromium, being beyond Honda's presumption, was due to Takagi who actually carried out the tests under Honda's guidance.

After clarifying the positive effect of adding chromium, it was natural to add it into Co-Fe-W steel. Very large amount of cobalt were needed in preparing samples and Honda permitted Takagi to use expensive high purity cobalt originally for use as the chemical element in chemistry. Magnetic measurement for Co-Fe-W-Cr steels gave better results than that for Co-Fe-Cr steels. To find the composition range with the best results, he prepared a lot of samples and repeated the measurements. He determined the composition range as follows:
Co:30-40%, W:5-7%, Cr:1.5-3.5%, C:0.45-0.7%, of which the coercive force was 200-250 Oe, and the remanent magnetic flux density 9000-10500 Gauss corresponding Ir=716-836 CGSemu. A typical composition, Co:35%, W:6%, Cr:2.5%, C:0.6%, so Fe: 55.9%, corresponds to an atomic formula, $Fe_{58}Co_{31}W_2Cr_3C_3$. The composition of the final material, the KS magnetic steel, was included in the region which the first patent[4] had covered.

An antinomic requirement (a high intensity of magnetization requiring the material to be soft and high coercive forces requiring it to be hard) was simultaneously satisfied in one material, KS magnetic steel. The addition of lots of cobalt made the former realized and the very high temperature quenching and the addition of a suitable amount of chromium and tungsten to make carbide for hardening made the latter realized.

1.2.2 Invention of Invar alloy by Guillaume

Invention of Invar alloy was tightly connected with the metric system. In 1875, the Convention of Metre was adopted and the International Bureau of Weights and Measures was established. In 1889, the First International General Meeting was held and the metre standards were distributed among signatories. The metre standards were composed of highly expensive alloy with 90% Pt and 10% Ir. Guillaume, who had been attached to the International Bureau, intended to find an alloy with a performance as good as the metre standard in measuring, but much cheaper in price[5]. In the last decade of the 19th century, Guillaume began research for finding new alloys free from thermal expansion. In advance of Guillaume's investigation, Hopkinson[6] had found in 1890 that the magnetic transformation of some irreversible Ni steel accompanied a change in volume (rapid cooling of non-magnetic soft 24% Ni steel by immersion into dry ice had made it hard and magnetic and its volume larger by 2%). Guillaume was highly interested in the phenomenon. To confirm whether such a phenomenon could take place in reversible Ni steel, he studied the relationship between magnetic transformation and dilatation of reversible various Ni steels and found that 34.6% Ni steel was magnetic and its thermal expansivity was 4.570×10^{-6}/℃, about two-thirds of Pt's. As the thermal expansivity of Fe and Ni were, respectively, 11.7× and 12.7×10^{-6}/℃, the found thermal expansivity of the above alloy was much lower than those of the component metals[7]. Guillaume first discovered the exception to the rule of mixing in the above alloy. At that time, it had been supposed that an alloy would have the weighted mean values of component metals in any physical quantities. Guillaume named the alloy "Invar", implying no variation in length under change in temperature.

The new alloy, Invar, was immediately put into practical use for land surveying. Accurate geodetic survey was an important scientific problem in the last quarter of the 19th century. Before the use of Invar wire, wires were used that had considerable thermal expansivity, so for an accurate measurement of length, an accurate determination of temperature had to be made. Furthermore, there was difficulty in getting accurate temperature readings of the wires because of their exposure to air and various clever devices were needed for correction. Two wires made of different metals, for example, were used to determine the accurate temperature from the difference between the apparent length of the wires. Use of the Invar wire in land surveying not only made accuracy of measurement much higher, but also made the measuring tools much simpler, the work much easier, the time much shorter and the cost much lower.

In 1899, the Sweden-Russia Joint Expeditionary Party for Geodetic Survey of Spitzbergen used Invar wires offered by Guillaume. It was the first practical use of Invar. The land surveying at Spitzbergen was a great success and a report on the survey was given at the 13th General Meeting of the International Association of Geodesy held at Paris in 1900. Attending the meeting, Guillaume explained about the measuring Invar alloys in detail. Nagaoka Hantaro, who had attended the first General Meeting of International Association of Physics held at Paris just before the Meeting of Geodesy and had reported there about magnetostriction of Fe and Ni, also attended the meeting of Geodesy and gave a report on magnetostriction. Guillaume offered various Ni steel wires to Nagaoka to test the effect on the length of the magnetic field due to the Earth and due to the electric current in power-transmission lines. The test by Nagaoka and Honda confirmed that the magnetic field had no effect on the length of the wires. A paper on the test was presented to Seance de la Societe Francais de Physique as a joint work by Nagaoka, Honda and Guillaume in 1902[8].

Invar wire was used also as a non-expansive transmitter. In 1912, the vertical expansion of the Eiffel Tower was very easily measured by using Invar wire. Until then no measurement of vertical expansion of the Tower had been performed because of the lack of suitable means. The observed data showed a close correspondence between expansion or contraction of the Tower and the rise or fall in temperature. For example, the Tower rapidly contracted during a shower when the temperature fell sharply. The Eiffel Tower was a very sensitive giant thermometer.

Later, Guillaume also invented Elinvar alloy, which had little thermal change in elasticity. The accuracy of a watch was made much higher by use of a hair spring of Elinvar and balance wheel of Invar. The superiority of Swiss-made watches was not due to the scenic beauty of Switzerland, but due to such a material base for accuracy.

Guillaume won a Nobel prize in Physics in 1920 for the discovery of Invar alloy and his contribution to precision measurement through it.

In Invar alloy there coexisted with each other two antinomic phenomena: expansion with rise of temperature (usual thermal expansion) and contraction with rise of temperature, i.e., the contraction due to loss of magnetization accompanied by the rise of temperature. Consequently changes in temperature caused very little change in length. Usually, an appearance of magnetization was accompanied by an expansion.

As seen from the fact that Guillaume's first paper on Invar alloy[7] began with the phrase "Transformations magnetiques et dilatation", he was well aware that there was a relationship between magnetic transformation and thermal expansion. He pointed out clearly that the temperature coefficient of thermal expansion is larger above the magnetic transformation temperature than below.

1.2.3. Invention of Super Invar and Stainless Invar by Masumoto

Based on their precise investigation of A_3-transformation, Honda and Miura[9] concluded that the abnormal property of Invar (very small thermal expansion) had no connection with A_3-transformation and suggested that it was characteristic of the ferromagnetic alloy in the γ-phase.

Masumoto[10] developed the above suggestion and connected it with ferromagnetism of γ-phase Fe-Ni alloys. At first, Masumoto presumed the more ferromagnetic a material was the less expansive it would be and tried to add Co to Fe-Ni alloys because he expected the addition of Co to make the Curie temperature higher implying it was more ferromagnetic. Addition of 5% Co to Invar composition gave a thermal expansivity of less than 10^{-7}/℃, one order less than that of Invar. This alloy was named Super Invar. In the process of the work, analyzing the curves of thermal expansion vs. temperature of various alloys in reversible Fe-Ni system, and after magnetic consideration of the typical curve, Masumoto concluded that alloys with high saturation magnetization and low Curie temperature could have very small, or even negative, thermal expansion. This is Masumoto's empirical rule for Invar, which he discovered in the investigation of Super Invar[10] and led him to the invention of Stainless Invar[11]. This rule remains valid.

The first presumption that the addition of Co would lower thermal expansivity due to a rise of Curie temperature, conflicted with his later found rule; rise of magnetization due to adding Co was more rapid than that of the Curie temperature.

In the invention of Stainless Invar, Masumoto's rule functioned well as the guiding principle. It was well known in Honda's laboratory for Fe-Co alloys generally to have high magnetization, and for Cr, as an additional third element, to have a drastic effect of lowering Curie temperature. After an enormous systematic investigation of Co-Fe-Cr system, Masumoto found an alloy of composition 54.0% Co, 36.5% Fe, 9.5% Cr, with thermal expansivity less than 10^{-7}/℃. In a corrosion test immersing it in 0.25N NaCl solution, the alloy did not suffer corrosion at all; Masumoto named the alloy Stainless Invar.

Antinomic phenomena, higher magnetization implying more ferromagnetic and lower Curie temperature implying less ferromagnetic, coexist in this alloy.

1.2.4. A suggestion about useful new materials

The above discussion suggests that a useful new material be something in which some antinomic phenomena would be able to coexist; for example, a transparent metallic material would be a "candidate".

Is a person who dreams of inventing a transparent metal and getting people's credit for the dream, a pioneer or a swindler?

Now, we must go into such a serious problem.

2. LIMITATIONS OF TECHNOLOGY

2.1 A general discussion on the ideological situation, "Science, the Almighty"

Today we are frequently confronted with deceptive arguments put forward by pseudo-scientists to the effect that advancement in science should be directed toward fulfilling any and every desire of the human race. An important function of science, however, is to declare what is impossible to fulfill. In thermodynamics, for example, the establishment of the first and second laws destroyed any illusions about the possibility of perpetual motion and so enabled genuine scientists to avoid wasting their time and put swindlers out of business.

Nowadays, something corresponding to the two laws of thermodynamics is needed and this may well be the unificative view of Nature based on the entropical viewpoint.

In the following, I would like to criticize the idea, "Science, the Almighty", by showing that a drastic progress in technoscience might result in a great waste, provided it is tightly linked with the Establishment ruling the society. Also, I would like to show that a thinking based on entropy and natural circulation of matter can make clear judgments about certain arguments whose deceptiveness is not always easy to recognize.[12]

2.2 Case study of techno-fraud

2.2.1 Social monumental extravagance, Military expenditures

When I was a student, a knowledgeable person taught me that loss of warplanes or the sinking of warships on our own side in a battle should be a happy event for the war industry and arms merchants, because when arms have been consumed, new demands are created and their business will be more prosperous.

Since the end of World War II, or after the Revival of the Japanese Army, we have not experienced any mass consumption of weapons due to war. Nevertheless, the Government continues to demand a heavy expenditure for military purpose. Why?

Steady progress in technoscience has brought a progress in military technology, which produces new weapons of high technology day by day, and makes the yesterday's high-tech weapons obsolete today. At the present time, technoscientific progress functions as big battles in war.

2.2.2 Crops fruitful even in the desert

Is it possible to make crops fruitful even in the desert by biotechnology ?

There are regions which, because of long-standing exploitation as colonies by imperialistic powers, have not yet succeeded in creating conditions of economic independence and are suffering from a bad economic situation -- the Third World.

To justify experiments with recombinant DNA in genetic engineering, the bad food situations of some countries in those regions are sometimes mentioned. It is said that if we created crops that will grow even in the desert, it would be a great contribution towards solving the food problem in those regions. But such arguments are not valid.

An entropical analysis of photosynthesis has clarified that for the reaction of photosynthesis to proceed, not only sunlight but also a lot of water carrying away entropy is needed. Where water is lacking, however hot the sunlight that may beat down upon the ground, no vigorous photosynthesis can proceed and crops can not be fruitful. One might create crops fruitful in fertile land, but these crops would be fruitless in the desert. There may be plants that will grow with a small supply of water, but they will be of slow growth. A lot of water is necessary for plants to grow rapidly and to be fruitful.

In order to solve the food problem, what science and technology have to do is not to try to create new crops fruitful even in the desert (the very effort would be in vain), but to protect fertile land from devastation and to reclaim the desert and turn it into fertile land.

2.2.3 Construction of space colony

Is it possible to construct a space colony existing independently of the Earth ?

When the Space Shuttle Program was proceeding successfully, people declared that the successes would open up a new age, "the era of space colony". They made a plan to set up a space colony -- where the colony would be constructed, from where the construction materials would come, how they would be transported, what scale and what form the colony would have, how many people would live there, what the interior of the colony would be like, and so on.

But these "space colonialists" did not recognize the importance of entropy elimination or the important role of water circulation. To them, water is a familiar material, which merely enlivens a rural landscape as a stream running through fields and is needed only for paddy fields and breeding ponds in a space farm attached to the colony. Because of their biased view of almighty energy, they are interested in obtaining energy alone, and are unconcerned with the elimination of entropy. They are under the illusion that if we could just succeed in harnessing the Sun's light sufficiently for the colony to continue to live by solar cells then all will go well in the colony.

But this is not the case. No space colony can satisfy the conditions necessary for a celestial body to be a "living" one. Water will not circulate in a space colony because the colony will be too light to keep in water without walls and ceilings; therefore, water can not function as a "fundamental substance" for entropy elimination.

A space colony can not be self-sustaining and self-sufficient; it could only work as a "parasite" on the Earth, i.e., with a good supply of low-entropy materials (water, food and so on) from the Earth; it would not be a colony, just merely a space station.

2.2.4 Construction of subterranean urban community

About ten years ago, the price of land was skyrocketing in Japan. To raise the efficiency of the utilization of land, development projects deep underground were proposed by companies of the construction industry and the Government supported them. They claimed the construction of big subterranean urban community was possible technologically and would be realized within 20 years. But it is clear from the viewpoint of entropy that the plan must not be realizable. Urban activities inevitably generate extraordinarily vast amount of heat as the result of the law of increasing entropy. The higher the activity is the more the generated heat is. To continue the urban activities, it is necessary to expel the generated heat. If we do it by air cooling, then the city on the ground just above the subterranean urban community dries into desert by the warm wind blowing up from underground.

The Japanese Government has not given up the project, yet.

2.2.5 Economic development based on technoscience

The present national policy of Japan is enriching the State due to economical development based on technoscience, which seems better than the old one which was based on wealth and military strength. Under the present policy, Japan imports great quantities (in mass) of raw materials (7.3×10^8t in 1994) in exchange for a little yen or dollars (¥2.1×10^{13}), and makes them valuable by technoscientific manufacturing, and exports a rather little (in mass) high-valued manufactured goods (0.95×10^8t) in exchange for a lot of yen or dollars (¥3.1×10^{13}). Consequently, Japanese business is in the black and due to the law in economy a lot of dollars accumulates in Japan. But due to the law of mass conservation in physics, many fields in Japan have been filled up with the waste materials, and in time all grounds in Japan may be filled up with the waste materials. We must do something to prevent this before it is too late.

2.3 A suggestion

Due to the rapid acceleration of technoscientific progress massive amounts of outdated goods (which are still serviceable) have been accumulating in our dumping grounds.

The technoscientific progress should be harmonious with the tempo and rhythm of human life, of lives in ecosystem and of biological evolution.

Every organisms living on the Earth has two common periods in time, Day and Year, which makes it possible for their rhythms to be synchronized harmoniously with each other. The synchronization or the harmony is one of the most fundamental necessary conditions for realization of a balanced ecosystem. For example, suppose in a field, a plant A blooms at a season in its own life cycle and on the other hand an insect B emerges at that season; A feeds B on nectar and pollen and B helps A with pollination; the synchronization of the emergence season of B with the blossom season of A produces an ecosystem of A+B in the field. Quasi-stationary ecosystems are formed in such a way.

The phase of a life or of an ecosystem varies quite slowly; the variation is characterized by a time much longer than the common period, a Year. Roughly speaking, the time characteristic of a change of phase of human life is to be 10 years or so, of historical phase of human society 10^2 years, of evolutional phase in a species (branching into subspecies) in nature 10^3, of evolutional phase in a suborder (appearance of new species) 10^4 or 10^5, and of geological change in the lithosphere 10^6 or 10^7 years, and so on.

It should be noticed that these characterizing times are very much longer than a Year, which help the ecosystem keep its stability. If a change in an external condition occurs slowly, living beings can adapt themselves to the external condition by making the externality inherent, that is, by making some proper change in their organic system not only in genes but also, perhaps, in their whole system. For example, breeding by mating and selection needs time -- 10 years or more -- much longer than a Year. Within the rather longer time the improved breed gets an inner new system as a whole, adapting to the new conditions, or without any loss of adaptability to the existing conditions. On the contrary, breeding by gene recombination seems to be much more effective in time; it operates upon the gene, directly by means of chemical reaction and what is changed is only genetic, nothing else. The characteristic time of the operation, essentially being an hour or a day, is much shorter than a Year. It should be said that the operation is act of violence for the concerned plant or animal. We must throw away the misguiding ideological slogan "the faster, the better" as the techno-swindler's banner.

In the long process of evolution, living beings have got the ability to live in their environment and to adapt themselves to it. In the long history of evolution till now, organic substances have been produced only by organisms, and the kinds of organic compounds with which a living being is familiar have been limited to a specified ones. Living beings have lived in the environment where only closely limited kinds of organic substances are existing and the nuclei of cells and those of atoms are fairly stable.

"Stability of nuclei and existence of only limited kinds of organic compounds" is one of most important conditions of the ecosystem. We conclude that any materials with which so far Life has not been familiar in the long period of evolutional process (that is, new organic substances, cells with artificially produced nuclei and artificial radioactive substances) should not be produced and producible materials should be limited to such ones as those easily decomposable and harmlessly sucked into the natural circulation of matter or as perfectly isolatable from the ecosystem in a concreted solid form with close watch being kept.

References

1) N.Kawamiya, "Hitsuzen no Sentaku (Inevitable Choice — Global Environment and Industrial Society)", Kaimeisha, Tokyo (1995), in Japanese.
2) H.Takagi, Ph.D. Thesis "Study of KS Magnetic Steel" submitted to Tohoku University in 1958, in Japanese;
K.Honda, "The Days of Invention of KS Magnetic Steel - Academic Researches and Invention" Kagaku-Asahi, Aug.1942, 122-126 (1942), in Japanese;
A.Katsuki "Process of The Invention of KS Magnetic Steel" Kagakushi-Kenkyu (Journal of History of Science, Japan), 23, 96-109, 150-161 (1984), in Japanese.
3) Patent No.32422 (addition to the patent No.32234) for special alloy steel, application: 10 July 1917, registration: 26 Mar. 1918, inventor: Honda Kotaro, patentee: Sumitomo Chukosho (Steel casting company).
4) Patent No.32234 for special alloy steel, application: 15 June 1917, registration: 22 Feb. 1918, inventor: Honda Kotaro, patentee: Sumitomo Chukosho (Steel casting company).
5) C.E.Guillaume, Proc.Phys.Soc.,32, 374- (1920); Lecture to the 5th Guthrie Lecture held at 23 Apr. 1920.
6) J.Hopkinson, Proc.Phys.Soc., 47, 23- (1889), 48, 1- (1890).
7) C.E.Guillaume, Compt.Rend.,125, 235- (1897)
8) K.Itakura, T.Kimura and E.Yagi, "Nagaoka Hantaro Den (Biography of H.Nagaoka)", Asahi Shinbun-sha, Tokyo (1973), in Japanese, pp.234-235.
9) K.Honda and S.Miura, Sci.Rep.Tohoku Imp. Univ.,16, 745- (1927).
10) H.Masumoto, Sci.Rep.Tohoku Imp.Univ.,20, 101- (1931).
11) H.Masumoto, Sci.Rep.Tohoku Imp.Univ.,23, 265- (1934).
12) More detailed discussion, see
A.Katsuki, "Kankyo no Riron (Theory of Environment)", Kaimeisha, Tokyo (1999, in press), in Japanese.

(Received January 11, 1999; accepted April 12, 1999)