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Our Ref.: 187 507 v4/n15/kl
European Patent EP 2 368 252 (EP 09 806 118.7)
Proprietor & Appellant: Silvia Piantelli et al.
Opponent 1: Leonardo Corporation
Opponent 2: E.F.A. S.r.l.

Appeal File No.: T0134/16-3.4.01

In response to the written decision of the Opposition Division dated November 3, 2015 to revoke European Patent EP 2 368 252 B1 (the "patent") and supplementing the formal appeal lodged on December 30, 2015 against this decision, we herewith submit the

GROUND OF APPEAL

together with new requests as outlined in detail in the following:

1. Requests

We maintain as **Main Request** to set aside the appealed decision and to maintain the patent as granted. In addition, we file **Auxiliary Requests 1, 2, 3 and 4** as enclosed herewith, requesting to uphold the patent in the extent of these requests, should the Board of Appeal intend to reject the Main Request.

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Subordinately, we request Oral Proceedings pursuant to Art. 116 EPC.

1.1 Auxiliary Request 1

Claim 1 of the Auxiliary Request 1 is a combination of claims 1 and 8 as granted. We note that this combination has been limited to the subject-matter introduced in granted claim 8 by “in particular”. The remaining claims are deleted. Therefore, Auxiliary Request 1 satisfies the requirement of Arts. 123 (2) and (3) EPC.

1.2 Auxiliary Request 2

The subject-matter of claim 1 of Auxiliary Request 2 is a combination of claims 1 and 10 as granted. Again, also this combination has been limited to the subject-matter introduced in granted claim 10 by “in particular”. The remaining claims are deleted. Therefore, Auxiliary Request 2 also satisfies the requirements of Art. 123 (2) and (3) EPC.

1.3 Auxiliary Request 3

The subject-matter of claim 1 of Auxiliary Request 3 is a combination of claims 1 and 11 as granted. As before, this combination, too, has been limited to the subject-matter introduced in granted claim 11 by “in particular”. The remaining claims are deleted. Therefore, Auxiliary Request 3 also satisfies the requirements of Art. 123 (2) and (3) EPC.

1.4 Auxiliary Request 4

The subject-matter of claim 1 of Auxiliary Request 4 is a combination of claims 1 and 2 as granted. The remaining claims are deleted. Therefore, Auxiliary Request 4 also satisfies the requirements of Art. 123 (2) and (3) EPC.

1.5 Admissibility

In the oral proceedings of the first instance, the Opposition Division has rejected the Proprietor's argument that the late submission of the former Auxiliary Request 1 was occasioned by the flood that had occurred in Pisa on August 24 and 25, 2015. According

to the relevant reasoning, since a submission was filed on August 27, 2015, allegedly indicating that communications had been restored, there seemed to be no motivation to invoke a case of *force majeure* to justify the delay in filing the former Auxiliary Request 1.

However, the Opposition Division has not considered the circumstance that not only the representatives' offices were struck by the floods in Pisa, but devastating precipitations causing floods and landslides have also happened at the seat of the patent Proprietor in the province of Siena. This is documented by the enclosed document, a decree by the Italian Government calling a state of emergency:

E 1: Delibera della Presidenza del Consiglio dei Ministri del 6 novembre 2015, circa lo stato di emergenza per gli eventi meteorologici verificatisi a Siena il 24/25 agosto 2015

The state of emergency, as can be taken from page 3, no. 1 of E2, persisted for another 180 days. It is certainly understandable, and also mentioned in E2, that even though the actual flood water had mostly receded by August 26, 2015, severe disruptions to traffic, commerce, water & electricity supply and, importantly, accessibility of buildings persisted throughout the following weeks. Indeed, as put in evidence by E2, a state of emergency was called by the Italian government which is still ongoing.

These were the prime reasons why it has not been possible for the patentee to decide, and instruct his representative, about the Auxiliary Requests as fall-back positions within the date set in the summons. The fact that a submission was “nonetheless” filed on August 27, 2015, does not invalidate the fact that proper coordination with the patentee as regards the Auxiliary Request was impossible during several weeks after the flood.

Nonetheless, as indicated above, the former Auxiliary Request 1 filed in the first instance is not maintained in its old form. The patentee has used the available time to present the enclosed four auxiliary requests which are aimed to provide further inventive detail to the claimed method. All four Auxiliary Requests of today are based on combinations of claims as granted. Therefore, none of these requests puts the Opponents into disadvantage as their subject-matter was already known to them, and

attacked by them, at the beginning of the opposition proceedings. These requests are neither complex, nor do they risk delaying the appeal proceedings.

Therefore, we respectfully request to admit the auxiliary requests into the proceedings given that all requirements for their admissibility are fulfilled.

2. Lack of Inventive Step of the Main Request

In the opposed decision, in Section 2.2.4, the Opposition Division comes to the conclusion that the objective technical problem to be solved is how to facilitate or improve the absorption of hydrogen in the transition metal. It is further argued that, at the time of filing the application, the skilled man would have considered documents A2 to A12 and A14 which, allegedly, all disclose the advantage of downsizing a metal core by forming clusters of nanometre dimensions. Thus, these documents allegedly all solve the problem of how to improve absorption of hydrogen into the metal.

Short shrift is given to the fact that what is absorbed according to the patent is not "hydrogen" as such but rather the H^- ion, and the Opposition Division justifies this exclusion by stating that the patent itself teaches that absorption in the form of H^- is "given for free" as a consequence of the physical structure of the cluster and the subsequent steps.

This reasoning is, as we shall show in the following, fundamentally flawed. First of all, the Opposition Division has not properly determined the differing features with respect to the closest prior art document A1, and secondly it has not attempted a correct interpretation of the "cluster" features (1B) and (14H).

In order to correct these deficiencies and to provide a proper problem-solution-approach, it is useful to review the fundamental physical processes occurring during the claimed method steps, and to point out where and how the processes described in the prior art fundamentally differ, both in methods and in aims, leading to effects which are fundamentally different from the effects achieved by present invention.

2.1 Physical Principles

The patent in suit is directed to a method for producing energy by nuclear reactions between hydrogen and a metal. Thus, it is important to note that the primary difference with respect to the cited prior art already resides in the fact that the nuclear reaction does not occur between hydrogen atoms (such as hydrogen and deuterium fusing to give helium) but to a different process in which the reaction occurs between hydrogen and a metal, specified by claim 1 as a transition metal. To that end, the invention focusses on a process which is extremely difficult to achieve as it is normally inhibited by other processes of hydrogen interaction with the transition metal. The process upon which the patent focusses is the ***orbital capture of the H⁻ ion***, and will be explained in the following.

Formation of H⁻ ion (part 1) – avoiding chemisorption

The **H⁻ ion** is formed in several stages, which occur once the reaction pathway is available. In a first stage, the H₂ molecule is physically adsorbed onto the surface of the transition metal by Van-der-Waals forces, followed by dissociation and the subsequent acquisition, on part of the neutral H atoms, of a low energy electron belonging to the valence electron cloud present at the surface of the metal. These stages are explained in the following.

However, at all levels of surfaces (i.e. both in bulk and in clusters) this succession of stages is very easily disturbed by the process of chemical absorption, or chemisorption, by means of which the hydrogen molecules split on the surface of the metal into two neutral H atoms which each, instead of capturing from, share a valence electron with the metal. The chemisorbed hydrogen is covalently bound to the metal surface and no longer mobile, making the hydrogen atoms thus generated useless for the task of orbital capture. Chemisorption occurs once a particle bonded to the surface by weak forces such as Van-der-Waals forces diffuses along the surface and finds an appropriate chemisorption potential well in the surface potential of the metal seen by the particle. These potential wells, at which a favourable reaction pathway for the establishment of a covalent metal hydride bond is given, occur at defects and irregularities of the surface (potential) of the metal, favoured by a wide distribution of adsorption energies and adsorption sites. Thus, chemisorption is a process which is favoured by bulk surfaces, such as those in document A1, which show these defects and distributions.

Chemisorption is also a dominant physical effect in metal clusters, both on the surface and within. Chemisorption of hydrogen on and in the clusters is a means of binding and, thus, immobilizing hydrogen in certain amounts by chemical bonds, which alter the chemical properties of the clusters themselves, and therefore influence the catalytic properties of the metal clusters.

In the context of the present invention, however, chemisorption is the dominant *concern*. This is because, on the one hand, it favours reaction pathways that start with the generation of neutral H atoms, at the expense of the generation of H⁻ ions crucial for obtaining the effects of the invention, and on the other hand, chemically immobilizes the H atoms which therefore cannot participate in the desired reaction pathway of the invention.

Discrete energy levels – the giant metal cluster atom

In order to avoid chemisorption, i.e. render the probability of it occurring as low as possible, the present invention acts upon the structure of the transition metal surface, implementing it as **micro/nanometric crystalline clusters of a transition metal in a predetermined quantity** (this quantity of cluster “sites” is proportional to the later observed power output) and with a **number of atoms per cluster which is less than a predetermined critical number of atoms**. This latter teaching allows radically altering the potential seen by the hydrogen molecule which approaches the metal cluster.

At a macroscopic surface, i.e. a body in which more than several hundreds of thousands of atoms are present, the individual metal atoms combine to produce a band structure of electronic states which has the net effect of creating a nearly impenetrable barrier (due to the valence electron cloud) for negatively charged hydrogen ions (not neutral hydrogen molecules which may still approach rather easily the metal surface). This band structure is the result of the so-called Thomas-Fermi theory for systems of many atoms which determines the energy levels by treating the electrons as an electron gas of uniform distribution, in particular of uniform local charge density.

In contrast, the crystalline sub-micron transition metal clusters differ from the bulk in that their spectra do not present a Thomas-Fermi band structure but rather **discrete energy levels** much like a “giant atom”. This discrete energy level structure can be explained by the density functional theory of Kohn-Sham which treat the low number of

electrons of the transition metal as a fictitious system of non-interacting particles, wherein the exact energy levels, and therefore the depth of the respective potential wells created depends on the number of atoms in the cluster as well as the type of metal. In particular, these energy levels can assume values which are low enough (due to the non-compact distribution of metal atoms), leading to **a negative charge density low enough for the H⁻ ion to overcome with little additional energy**. In other words, the negative valence electron cloud associated with a bulk metal surface gets sufficiently "thinned out" for low barrier potential wells to occur.

Formation of H⁻ (part 2) – dissociation of the H₂ molecule

The physical process that the invention aims to exploit begins with a dissociation reaction, but rather than exploiting the chemisorption potential wells, it is mediated by the local field due to the "giant atom". When the hydrogen molecule approaches the metal cluster surface, the local field of the "giant atom" deforms the molecule asymmetrically, pulling a positive proton away from a negative H⁻ ion. Calculations based on such "giant atom" local fields have shown that this process is quite exothermic, and thus one would naively expect a spontaneous process.

Not so. Just as in the case of chemisorption, there is an activation barrier to the pathway $H_2 \rightarrow H^-$. But, without additional measures, the H₂ molecule will not overcome the activation barrier for this process, and no H⁻ ion will therefore be generated and approach the metal surface by itself. In other words it's not sufficient just to place hydrogen (H₂ molecules) next to a metal cluster and then expect H⁻ ion generation.

First activation energy – first orbital capture by the giant atom

The potential wells of interest on the metal cluster surface are, in contrast to those present for chemisorption which are due to "true" (i.e. individual) surface atoms crating the chemisorption potential wells, eigenstates of the "giant atom". These can thus be compared to an electronic state in a normal atom and treated analogously. The inventors have realized that the reaction path starting from the H⁻ generation requires that the process exploiting the "giant atom" eigenstate potentials becomes likely enough to dominate over the process of chemisorption. And this likelihood, which physically corresponds to an appropriate overlap of the "giant atom" wave function with the H⁻ wave function, can be greatly increased by having a negative hydrogen ion

"fall" into such a potential well, since the freed energy is many times higher than when an electron falls into the well, given that the mass of the H^- is 1838 times larger than that of the electron. The H^- can thus get captured into the orbital of the giant atom, in a process we shall call "first orbital capture".

In order to provide the H^- with such a reaction path, it is necessary to provide sufficient energy (**first activation energy**) to it in order to overcome the electrostatic electron repulsion that constitutes the potential barrier for this process in the metal cluster. The process relies on two mechanisms: the first is the small size of the transition metal cluster, which confines the vibrational oscillations that travel within it; the second is the proper excitation of these vibrations. The *first mechanism, small cluster size* (due to the small number of metal atoms) ensures, as mentioned, that surface effects become predominant over bulk effects of the metal, and in the particular case at hand, that the vibrational states of the metal, the so-called phonons, can interact and transfer energy efficiently to the adsorbed species, here hydrogen, due to the large amount of metal surface available. The *second mechanism, excitation of as many high-energy phonons as possible*, is obtained by **heating** the metal cluster to a temperature superior to the Debye temperature T_D of the relevant metal species (see also [0026]).

In fact, heating a metal cluster to above the Debye temperature creates an effect specific both to the heating above such temperature and to the fact that what is heated is a metal cluster with a predetermined small number of atoms. The **Debye model**, from which the concept of Debye temperature is derived, has been created to estimate the phonon contribution to the specific heat in a solid, and uses the concept of "phonons in a box" in order to treat the vibrations of the atomic lattice. The Debye temperature which results from this treatment can be interpreted as that temperature at which the highest-frequency mode becomes excited. Below the Debye temperature, the vibrational modes are gradually "frozen out".

In the context of the metal cluster, which is heated to above the Debye-temperature, all phonon modes are excited and – in contrast to the bulk metal – they can strongly interact with the surface of the metal cluster enabling the **phonons to "sum up" at the cluster surface and transfer their vibrational energy to the H^- ion**, which thereby receives sufficient energy to overcome the first potential barrier and be captured into an orbital of the giant atom consisting of the metal cluster.

Orbital capture – H^- as fermion

Thus, the k vectors can sum up at the interface of the metal cluster with the H^- ion and transfer it the energy necessary to overcome the first potential barrier in order to be captured into the orbital of the metal cluster, which as we have observed behaves as a giant atom with discrete energy levels.

In orbital capture, in which an empty electronic state of the atom (here, the “giant atom”) is filled by a “captured” particle, the captured particle must be i) negatively charged and ii) obey Fermi-Dirac statistics, in particular the Pauli Exclusion Principle. Both conditions are true for the H^- ion, which comprises a proton and two electrons, and is therefore a **negatively charged fermion**, as opposed to deuterium, for example, which is a boson! It is easy to see already at this point that, since orbital capture requires fermions, processes focused on adsorbing deuterium or provoking their interactions with the metal are not relevant and cannot convey any useful information.

Second activation energy – second orbital capture by the individual metal atom

The replacement of an electron by a much larger and heavier negative ion in the energy level structure of the giant atom leads to an excited state of the giant atom since the above “first” orbital capture of the negative hydrogen ion by the giant metal atom is strongly exothermic, given that the mass of the H^- ion is 1838 times larger than that of the single electron instead of which it is captured. This large excess energy means that the captured hydrogen ion is now capable of coming close to the metal nucleus and occupying an inner orbital of individual transition metal atoms, at a distance of about three nuclear radii (about 3×4 fm for Ni). This “second” orbital capture, this time by the metal atom, also has its activation energy, and the H^- ion is provided with it by the strongly exothermic reaction of the “first orbital capture”.

Conditions for nuclear reaction of H^- and metal nucleus

At this distance of a few nuclear radii, nuclear interactions between the hydrogen ion and the metal core (consisting of protons) come into play. This strong interaction is observable as the force that binds nucleons together to form the nucleus of an atom, for example the 62 nucleons of Nickel-62, one of the exemplary transition metals of the present invention. At the distance of a few nuclear radii, the hydrogen ion becomes

susceptible to capture by the transition metal nucleus, similarly to electron capture as a decay mode for isotopes with a relative superabundance of protons. This energetically allowed process causes a structural reorganization within the metal core when incorporating the H^- ion, which leads to a mass defect, in other words energy is set free (see also [0028], [0029]). An alternative process to this nuclear capture is the so-called Coulomb Ejection, in which the proton that has been gained from the H^- ion is ejected from the metal nucleus.

Both phenomena, nuclear capture and Coulomb Ejection, have been experimentally observed, the first by detecting copper atoms in the spent fuel (what remains of the metal clusters) together with 0.511 MeV annihilation peaks due to β^+ decay, the second effect by revealing 6 MeV protons in a cloud chamber.

To that end, we file again the slides showing the experimental evidence, already presented in the first instance, as well as another enclosure which contains the corresponding discussion of experimental results,

E 1: Slides of the 10th International Workshop on Anomalies in Hydrogen Loaded Metals, April 10-14, 2012, Certosa di Pontignano (Siena, Italia), The International Society for Condensed Matter Nuclear Science

E1b: Discussion of results of E1 as presented in the 1st instance proceedings

These results show that the use of a transition metal core in the form of transition metal clusters permitted to adsorb hydrogen therein in the form of H^- ions after heating above a temperature threshold, and then to cause the capture of the H^- ions by the individual metal atoms of the clusters, leading to a nuclear reaction producing energy, as defined by claims 1 or 14 as granted.

2.2 Interpretation of Features (1B), (1C) and (1D) of claim 1, and (14H) of claim 14

In the following, reference is made to the feature analysis as contained on pages 6 and 7 (Section 2.2) of the Decision under appeal. According to claim 1, the first essential step of the claimed method for producing energy by nuclear reactions between hydrogen and the metal consists in *prearranging a predetermined quantity of crystals of a transition metal as micro-nanometric clusters having a predetermined crystalline structure*. These clusters have, as is commonly understood in the physical sciences, a

small number of atoms, and it has been found that collective phenomena, which normally characterize bulk solids, such as its electrical conductivity, its ability to absorb or reflect light as well as magnetic phenomena, undergo noticeable changes for small cluster sizes (see paragraph [0093] of the patent). The physical explanation for this phenomenon, which he have explained in detail above, is that in micro-nanometric clusters the energy levels are no longer band-like structures as in bulk metals, but rather become discrete energy levels like in a giant atom (see paragraph [0016]).

Feature (1B), the first step of the claimed method, therefore requires that the transition metal is prepared on the one hand with a predetermined quantity of crystalline clusters, and on the other hand with a maximum number of atoms in each of these clusters. In other words, a strongly discontinuous distribution of the transition metal atoms in the reaction volume is required. The analogous structural limitations are required by **feature (14H)**.

As has been outlined above, the reason for requiring such specific discontinuous distribution of transition metal atoms is necessary in order to provide a discrete energy level structure for creating an exothermic reaction pathway to negatively charged hydrogen ions in order to bring them to the metal nucleus where it can react through a nuclear reaction with the metal (see feature (1A)).

In **feature (1C)**, the hydrogen is brought into contact with the clusters, and as we have outlined in Section 2.1, this step provides for the initial physisorption of the hydrogen to the metal clusters and sets up the system for the transfer of energy from the clusters to the H⁻ ion.

This transfer of energy, necessary to overcome the first activation barrier also mentioned above in Section 2, is provided by the step of **feature (1D)**, i.e. the heating of the clusters up to an adsorption temperature T_1 larger than a predetermined critical temperature T_D . This heating above the Debye-temperature is what renders possible the transfer of energy from the summed k vectors in the vibrationally fully excited metal cluster at the cluster surface to the H- ion, thus allowing it to overcome the potential barrier for the first orbital capture of the H⁻ ion in a discrete energy level of the giant metal cluster atom.

Thus, providing of an energetically favourable reaction pathway to the orbital capture on behalf of the giant atom allows for the dissociation of the physisorbed hydrogen molecule, its interaction with the valence electrons of the metal to form H⁻ ions and their adsorption into the metal clusters, see paragraph ([0026]). It is noted that by heating these specific transition metal clusters conditions are generated which fundamentally differ from other physical and chemical adsorption effects that may install themselves when bringing hydrogen molecules into the neighbourhood of a transition metal surface. In other words, the heating step of feature (1D) is not merely characterized by achieving a certain temperature larger than a predetermined critical temperature, but **it also comprises as essential elements the circumstance that what is heated is not merely any transition metal but a specific transition metal cluster as defined in step (1B).** In fact, in order to overcome the first activation energy threshold it is not only necessary to pre-arrange the crystalline transition metal clusters, but they also have to be specifically heated in order to provide a specific reaction pathway for a specific particle, i.e. the negatively charged hydrogen ion.

This is emphasized in the claim by the wording "active core" in feature (1D), which in the context of the patent defines the predetermined quantity of transition metal clusters into which hydrogen has been adsorbed as H⁻ (through the above-mentioned orbital capture by the giant cluster atom). This finds support in the explicit wording of paragraph [0095] which states

"the clusters 21 with the adsorbed hydrogen 37 in this form [i.e. as H⁻ ions, see [0094]] represent an active core that is available for nuclear reactions, which can be started by a triggering step ..."

Thus, it is quite clear that the term active core does not merely indicate any hydrogen loaded transition metal, even if such transition metal is present in powders or small size clusters, but that it needs to comprise a specific type of hydrogen, namely H⁻ ions. **This structural feature in claim 1 is essential and is a consequence of the combination of features (1B), (1C) and (1D).** By the same measure, the apparatus of the invention is essential defined by the structural feature (14H).

With the above precise interpretation of the claim features, we will now look at the prior art and show further differences not sufficiently considered by the Opposition

Division, and further deliberations the skilled person would have undertaken in view of the effects, and thus the objective technical problem, derivable by the differences.

2.3 Closest Prior Art – WO 95/20816 = A1

Document A1 is concerned with an energy generator that exploits anharmonic effects in a bulk transition metal in order to make stimulated fusion between hydrogen isotopes H and D possible. It is immediately clear to the skilled reader that there is a fundamental difference between the energy generation mechanisms of A1 and the patent, with the former fusing two hydrogen isotopes (^1H and ^2D to give ^3He), whereas the latter is causing a reaction between a specific hydrogen ion with a transition metal atom.

As is indicated on page 3, lines 5 to 7, the energy production of A1 relies on the excitation of hydrogen isotopes H and D adsorbed in a bulk transition metal through vibrational stress, leading to the fusion of a hydrogen nucleus and deuterium nucleus to form helium 3. In detail, the hydrogen is adsorbed in the crystal lattice of the transition metal by chemisorption (see page 6, line 28 page 7, line 7) with the consequence that (see page 7, lines 18 to 28)

"The chemical absorption of the hydrogen isotopes in the metal of the core causes the disassociation of the H_2 and D_2 molecules and the creation inside the crystalline structure of the core of covalent bonds (hydrides) between the H and D atoms with the metal. The electrostatic repulsion among the hydrogen atoms is screened by the excess of negative charge created by the free electrons of the metal. Therefore, the decrease of the electrostatic repulsion due to these bonds allows for the bonded atoms to approach one another more closely than is normally possible with free atoms in identical conditions."

Quite clearly, this text passage shows to the skilled reader the fundamental difference in physical mechanisms exploited by A1 as opposed to the principles used in the patent.

Moreover, A1 is explicit in that it wishes to obtain a sufficiently high proportion of adsorbed H and D isotopes ("crowding") so that one bound H atom and one bound D atom may approach one another sufficiently, i.e. to a distance at which nuclear forces come into play, so that the envisioned nuclear reaction between the hydrogen isotopes can take place (page 7, line 29 to page 8, line 2). This means that, in fact, the

performance of the device of A1 is improved if the number and, to that end, absorption of H and D isotopes in the bulk metal is increased.

The heating step of A1, although also going above the Debye temperature, is not directed to metal clusters with the aim of providing a pathway to orbital capture. Rather, the vibrational energy available due to the prevalence of anharmonic oscillations, which creates the possibility of summing K-vectors, is to be transferred to the bound hydrides of hydrogen and deuterium, a transfer which is mediated by the vibrational stress applied to the bulk metal (see page 8, lines 4 to 20 and line 27 to page 9, line 10). The result is H⁺ (proton) diffusion producing helium 3 and freeing 5.5 MeV dissipated through the metal lattice (without γ emission, see page 9, lines 11 to 24).

2.4 Differing Features

In view of the above, **the subject-matter of claim 1 differs from the disclosure of A1** by the circumstance that, instead of bulk metal, a predetermined quantity of crystals of a transition metal is prearranged, and each of these crystals are in the form of a micro-nanometric cluster with a predetermined crystalline structure and a number of atoms less than a critical number (**feature (1B) or (14H)**).

Moreover, the subject-matter of the main request differs from A1 also in the circumstance that the heating step is performed on clusters with the effect that a reaction pathway is provided *exclusively* to H⁻ ions, and the formation of an active core in which the clusters have adsorbed hydrogen in the form of H⁻ ions (**feature (1D)**).

Quite clearly, such a pathway is not present in A1 because rather than H⁻ ions, covalently bonded metal hydrides MeH and MeD are formed (page 7, lines 18 to 22), which then are made to approach by sufficient crowding (page 7, line 29 to page 8, line 2).

2.5 Technical Effect

The technical effect of these differing features is not, as has been assumed by the Opposition Division, to improve the absorption of hydrogen in the transition metal. To the contrary! A high level of absorption is deleterious to obtaining the object of the

invention, i.e. to provide a nuclear reaction between the hydrogen and the metal by exploiting orbital capture.

In fact, the creation of H^- is an extremely delicate issue and the population of H^- is in constant danger of being reduced by competing processes, the most important of which is certainly the so-called detachment, by which the H^- ion loses its electron again to the valence electron cloud of the metal. This process is strongly favoured by impacts between hydrogen atoms or molecules, and it is quite evident to the skilled reader that an increase in the proportion of adsorbed hydrogen in the metal lattice increases these impacts and thus the probability of detachment.

In fact, the chemisorption and crowding in A1 are necessary in order to create sufficient numbers of close hydrogen and deuterium hydrides for them to perform a nuclear reaction (between H and D).

Instead, the effect of the difference features is that hydrogen atoms are adsorbed as H^- with subsequent orbital capture, creating so-called excited giant atoms which are physically different from the formed hydrides of A1 and open up completely different reaction pathways.

Put differently, the effect of the combination of features (1B), (1C) and (1D) according to the patent is the **creation of an active core in which hydrogen is incorporated (adsorbed) as H^- ions in a form available for nuclear reactions**, precisely in the form of a metal cluster giant atom excited by orbital capture of the negative hydrogen ion.

2.6 The Objective Technical Problem

In view of this specific physical effect, which is very different from the effect achieved in A1, the **objective technical problem** is therefore how to create fermionic reaction pathway towards a nuclear reaction between hydrogen and a metal by orbital capture (as opposed to a reaction between hydrogen isotopes 1H and deuterium which uses the metal only as catalyst), and to avoid all mechanisms, in particular chemisorption, that bind the hydrogen in a form (such as covalently) that makes them unavailable for orbital capture. Thus, the inventions aim is to generate H^- ions, which are negatively charged fermions, the only species that “can do the trick”.

The Opposition Division, starting from the wrong problem of improving hydrogen absorption, has argued that the skilled reader would have considered – without inventive activity – the teachings of prior art documents A2 to A12 and A14, which all allegedly teach that the use of metal clusters allows increasing the absorption of hydrogen into the metal clusters.

As we have shown above, this technical problem is how to provide a fermionic reaction pathway towards a nuclear reaction of hydrogen with metal, and therefore how to avoid mechanisms such as chemisorption which suppress the creation fermions, and in view of this technical problem it becomes clear why none of A2 to A12 and A14 is capable of suggesting a solution. In order:

Document A2 is directed to cold fusion in which deuterium is fused with hydrogen, thus describing a reaction mechanism very different from the one presently claimed (see page 131 of A2). In detail, "hypercharging" of deuterium into palladium is proposed to store H and D atoms by chemisorption in the interstices of the palladium samples. In other words, as much H and D isotopes as possible should be absorbed in the palladium samples, and the pathway chosen in A2 is chemisorption. Quite clearly, both "hypercharging" by chemisorption and H-D fusion are incompatible with the objective technical problem of the patent. The skilled person looking at A2 at once realises that it relates to a different, and indeed unwanted, principle of interaction of a transition metal with hydrogen.

Document A3 is also directed to hydrogen chemisorption (page 271, first paragraph), i.e. a physical effect different from what is achieved by the transition metal cluster defined in claim 1 of the patent. In detail, A3 is concerned with the chemisorption of hydrogen on gas phase metal clusters with the intent to study deuterium uptake as a function of cluster size, both in cationic clusters of transition metals platinum, nickel and rhodium, as well as in neutral clusters of palladium (page 272, first full paragraph). The result obtained by A3 show how much hydrogen/deuterium can be taken up by such clusters, and conclude that such clusters are efficient hydrogenators (page 276, first full paragraph), thus employing the clusters quite conventionally as catalysers. A3 does not, however, make any attempt at identifying in detail reaction mechanisms. Those of A3, that much can be said by the skilled person, are certainly not due to fermionic orbital capture of negative hydrogen ions by the metal cluster lattice, but simply to covalent bonding by chemisorption, an effect that is unwanted – and indeed

harmful – for the aim of the patent. In other words, the skilled reader would quite clearly not have considered A3 when looking for the fermionic reaction pathways required to achieve the effect of the differing features of the patent.

Document A4 is concerned with the generation of an ultra-high pressure gas. Here, extremely pure deuterium with ultra-high pressure is used in a so-called "DS-reactor" (pages 3, 4), in which D₂ gas is heated to 140°C and passed under a pressure of 40 atmospheres through the walls of a sample-less Pd vessel, with the deuterium dissociating and entering the inside of the Pd vessel as a deuterium atoms (Experiment 1, page 7). The same experiment, but using H₂ gas and with a Pd sample, was done as Experiment 2. Experiments 3 and 4 described on page 9 then use again D₂ gas with both a bulk palladium sample as well as a so-called "nano Pd" sample. Nonetheless, the conclusions drawn on page 13 of A4 are unambiguous in stating that only in the case in which deuterium is used, excess energy can be obtained, and the explanation is advanced that such excess energy should come from deuterium nuclear fusion. Therefore, this document teaches the use of deuterium gas in a so-called "nano-Pd" in order to obtain a deuterium nuclear reaction, i.e. again using a physical reaction mechanism different from what is achieved by the differing features of claim 1 of the patent, and in fact mechanisms which would be deleterious for the object of the patent.

Document A5 also focusses on the difference between reaction energies generated in a D₂O cell and a H₂O cell in an experimental set-up using a "DS-cathode" equivalent to that of A4. Only the D₂O cell generates *"tremendously excess energy during a long period such as over several thousand hours, but any energy is never generated in H₂O cell when the chemical energy is subtracted in both cells"* (abstract). Although the metal is "Pd black" in the form of extremely fine powder of nanoscale, defined as "nano-particle" and/or "atom-cluster", the experiment with the incorporation of hydrogen does not lead to any reaction pathway that generates energy, so that the skilled reader would certainly not have investigated and combined the teaching of A5 with that of A1.

Documents A6, A7 and A8 are all concerned with energy generation by "spillover deuterium" generated in the same double-structure cathode on "Pd black" as in A4/A5. As an interesting aside, A6 on page 7, fourth full paragraph discloses that in the case of the use of "Ni powder", even with 20 nm sized Ni black, D₂ is not absorbed. Quite clearly, A6 would not be considered by the skilled person looking for a way to absorb H⁺ ions when looking to achieve a nuclear reaction between such ion and the metal core.

Document A9 uses palladium phases in a zirconia lattice as nanocomposite materials. Hydrogen gas at pressures of 1 MPa is led through the material, and its absorption or uptake is observed. A9 states quite clearly on page 1329, left column, last paragraph that the process of hydrogen absorption of hydrogen storage materials comprises the solution of hydrogen into the α phase (first stage) and the hydrogenation of the material itself to a β phase of Pd hydride (second stage). In other words, the proposed process involves chemisorption with the establishment of covalent hydrogen bonds at the surface of the metal. The fundamental physical processes are "merely" the effective hydrogenation of the Pd particles in the zirconia matrix, provided by the rather loose atomic configurations with high volume fractions of vacancies in the nanoscale palladium powders, favouring the chemisorption and chemical binding of the hydrogen, but again without providing the pathway to a nuclear reaction with the metal cores to H^- ions.

Document A10 is directed to deuterium electromigration in thin palladium wires coated with nanoparticles. Again, it is deuterium that is loaded and, supposedly, brought to nuclear reactions within (but not with) the palladium lattice. Thus, it is also here clear that no pathway for the adsorption of H^- ions is described.

The **review paper A11** is also concerned with gas loading of deuterium in palladium tubes, membranes, powders and wires. The chapter on the nickel-hydrogen system merely cites in a very generic manner that these systems are of great interest and have shown some results, but does not provide any explanation or hint to the specific process of H^- adsorption in metal clusters in the form of orbital capture.

The **textbook A12** only generically teaches that nanostructured materials possess very large surface areas and are, thus, useful in aiding hydrogen absorption. However, other than suggesting an abundance of acceptor sites on the metal surface, as well as unusual pore structures, no hints as to a specific pathway for H^- adsorption in the form of orbital capture, with the aim of a subsequent nuclear reaction between the H^- ion and the metal nucleus, is provided.

Finally, **document A14** describes a paper in which hydrogen gas-loading tests on solid nickel samples are performed, similar to what is done in A1, but the text passages at the end of the paper (page 3, starting in the left column "valutazioni e alcune prospettive"),

merely suggest that the focus is on H₂/D₂ absorption in the nickel with the evident aim of achieving hydrogen-deuterium fusion. Again, a complete lack of a suggested pathway to H⁻ absorption and the subsequent nuclear reaction of the H⁻ ion with the nucleus of the transition metal renders this document without any use to the skilled reader in view of the objective technical problem to be solved.

2.7 Could-Would-Approach

Therefore, from the above it is clear that in looking for a solution to the technical problem of providing a pathway for the H⁻ ion to be available for a nuclear reaction with the metal nucleus, the skilled reader probably *could have* considered prior art documents A2 to A12 and A14, as they are all in the widest sense directed to "cold fusion". However, all of these documents focus on cold fusion as a reaction of hydrogen and deuterium atoms, and in as far as they disclose metal clusters, none of these metal clusters is described as a possible pathway for the generation of H⁻ ions and their orbital capture by first the giant transition metal cluster atom, and then the individual transition metal atoms themselves.

Consequently, since the skilled reader, which is a physicist or a nuclear engineer with several years' experience in the research and development of low energy nuclear reactor devices, and is therefore aware even of subtle differences in physical reaction mechanisms and their effects, ***would not have considered*** any of the mentioned documents when looking for a solution to the technical problem defined vis-à-vis A1.

From the above, it follows that, contrary to the opinion of the Opposition Division, the **subject-matter of claim 1 as granted is based upon an inventive step.**

3. Auxiliary Requests

3.1 Auxiliary Request 1

Claim 1 of Auxiliary Request further specifies the method for producing energy by nuclear reactions between hydrogen and a metal of claim 1 as granted by requiring that

during said step (120) of bringing hydrogen (31) into contact with said clusters (21) said hydrogen (31) satisfies at least one of the following conditions:

- it has a partial pressure set between 1 mbar and 2 bar;
- it flows with a speed (32) less than 3 m/s according to a direction substantially parallel to said surface (23) of said clusters (21).

None of the prior art documents **D1**, and **A1** to **A14** disclose such a method step or the necessity of taking corresponding provisions. In fact, the limit on the relative pressure of the hydrogen feed ensures that an optimal number of hydrogen molecules 31 will hit the surface 23 of the metal cluster, significantly lowering surface desorption and other undesired phenomena which are caused by excessive pressure. As to the limit on speed and parallelism to the surface, the hydrogen molecules 31 will in such case have small angles of impact and small kinetic energies which strongly favour the adsorption by physical means and the consequent dissociation of the hydrogen molecule into H^+ and H^- rather than the chemisorption route where dissociation leads to neutral hydrogen atoms which then covalently bond with the surface metal atoms.

Indeed, research has shown that chemisorption efficiency is strongly angle-dependent with the probability of chemisorption being highest for molecules striking the surface at high polar angles (i.e. essentially near normal incidents). As an example of this research, we provide in the enclosure an authoritative paper from the American Chemical Society's *Journal of Chemical Physics* illustrating this point precisely for the interaction of H_2 molecules with a transition metal surface, here made of Ni. This document is

E 3: Chyuan-Yih Lee and Andrew E. DePristo, *Dissociative chemisorption of H_2 on Ni surfaces: Dependence on incident angles and rovibrational states*, The Journal of Chemical Physics **87**, 1401 (1987); doi: 10.1063/1.453269

This paper (and numerous further research indicated on the cover sheet of E2 as well as in the references cited therein) illustrates that S_0 , the dissociative chemisorption probability for H_2 on a Ni surface, is highest for polar incidence angles of 0° , i.e. normal incidence, while it significantly decreases for angles above 60° (see Figs. 4 and 5 of E2, reproduced below).

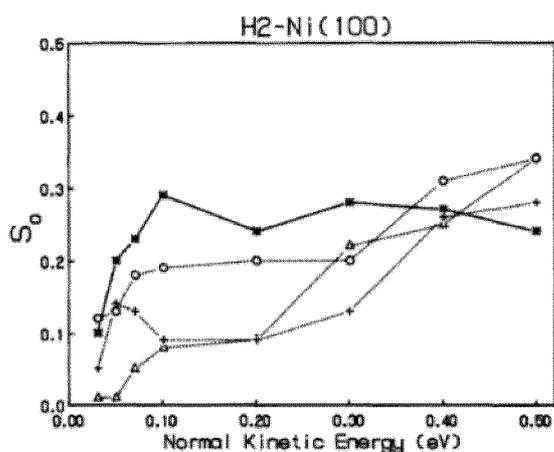


FIG. 4. Dependence of the dissociative chemisorption probability on the incident polar angle θ of H_2 on the Ni(100) surface. *: $\theta = 0^\circ$; O: $\theta = 30^\circ$; + : $\theta = 45^\circ$; Δ : $\theta = 60^\circ$.

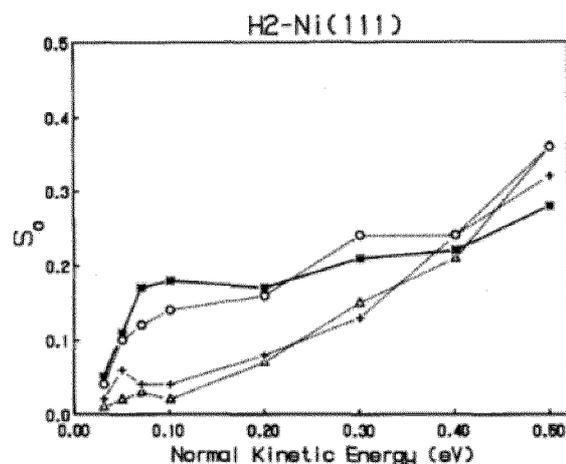


FIG. 5. As in Fig. 4 except the H_2 is on the Ni(111) surface.

In particular, at low kinetic energies below 0,1 eV and angles above 60° (triangular data points), S_0 virtually vanishes. It is to be noted that a speed of below 3m/s as presently claimed corresponds to energies of less than 10^{-7} eV.

These results are not at all isolated, and have indeed become common general knowledge as illustrated by, for example,

E 4: *Chemistry and Physics of Solid Surfaces VII*, Vanselow, R., Howe, R.F. (Eds.); Springer Series in Surface Sciences (1988); ISBN-13: 978-3-642-73904-0

of which only the relevant pages 1-21 are filed at this time. A more complete excerpt covering the entire chapter on chemisorption will be filed as soon as possible. E4 discloses on page 19 that, in model calculations with a one-dimensional activation barrier for chemisorption, the angular distribution of a molecular flux with a translational energy sufficient to overcome the barrier and be chemisorbed is notably peaked in the direction of normal incidence, as shown in the polar plot taken from this reference:

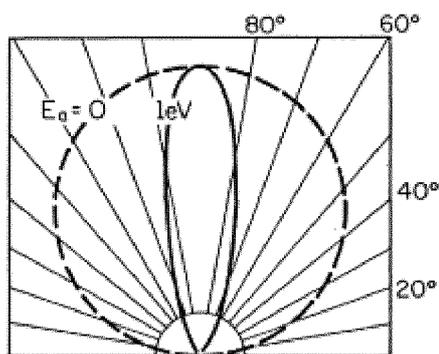


Fig.1.16. Angular distribution of molecular flux striking surface with translational energy perpendicular to the surface larger than the barrier height E_a [1.52]. Curves are arbitrarily normalized

Thus, from a theoretical and experimental point of view, one can draw the corroborated conclusion that chemisorption is favoured by normal incidence.

It follows therefrom that the skilled reader, even in the case that he should consider any of the prior art documents A2 to A14, which deal with chemisorption, he would chose nearly normal incidence angles and much higher kinetic energies appropriate for chemisorption and, thus, work in the exactly opposite direction of what is required by Auxiliary Request 1, i.e. much, much lower energies and angles of incidence of close to 90°.

In view of the above, the **subject-matter of Auxiliary Request 1 is based upon an inventive step.**

3.2 *Auxiliary Request 2*

According to the subject-matter of Auxiliary Request 2, the method of granted claim 1 is further specified in that

after said heating step (130) of said determined quantity of clusters (21) a step is provided of cooling said active core (1) down to room temperature (T_a), and said step of triggering (140) said nuclear reactions provides a quick rise of said temperature of said active core (1) from said room temperature to said adsorption temperature, said quick rise is carried out in a time (t^) that is shorter than 5 minutes.*

Again, no prior art document suggests at all to cool the active core down to room temperature, let alone to provide a quick rise of the temperature on a time scale shorter than 5 minutes when triggering the nuclear reactions.

The technical effect afforded by the cooling and rapid heating is that the structure of the clusters, obtained at the high temperature above the Debye temperature T_D , is "frozen", as it were, and is not substantially altered by the rapid heating. Both measures contribute to limiting desorption phenomena, which would otherwise reduce the H- population, before the nuclear reactions are triggered.

Since there is neither a corresponding disclosure nor a corresponding indication in the prior art, the **subject-matter of Auxiliary Request 2 is based upon an inventive step.**

3.3 *Auxiliary Request 3*

According to the subject-matter of Auxiliary Request 3, the method of granted claim 1 is further specified in that

said step of triggering (140) said nuclear reactions is associated with a step of creating a gradient (ΔT), i.e. a temperature difference, between two points of said active core (1), said gradient (ΔT) being set between 100 and 300°C, in order to enhance the anharmonicity of the reticular oscillations and to assist the production of the H⁻ ions (35).

As before, none of the cited prior art documents discloses the generation of a temperature gradient between two points of the active core. In all examined prior art documents the entire metal material is heated as a whole, so that nowhere measures are taken to create a temperature gradient.

The effect of this inventive provision is that, along the active core, the lattice vibrations at given positions will differ quite substantially due to the temperature difference, thus causing further increase in the anharmonicity of the vibrations generated in the crystal lattices of the clusters, and therefore contributing to an even more effective energy transfer from the phonons to the H⁻ ions, with a consequential increase in the efficiency of H⁻ orbital capture.

These effects are not contemplated by any of the prior art documents, and no solution is accordingly proposed therein. It follows that **the subject-matter of Auxiliary Request 3 is also based on an inventive step.**

3.4 *Auxiliary Request 4*

According to the subject-matter of Auxiliary Request 4, the method of granted claim 1 is further specified in that

said step of prearranging (110) is carried out in such a way that said determined quantity of crystals of said transition metal (19) in the form of micro/nanometric clusters is proportional to said power.

As defined here, and explained in paragraph [0016], the number of clusters is the variable through which the predetermined power can be obtained from an active core that comprises a predetermined amount of metal. This is particularly important since the power output cannot simply be increased by adding more hydrogen. In fact, doing this would destroy the fragile reaction pathway towards H⁺ capture by increasing the likelihood of chemisorption, on the one hand, and desorption or detachment processes (in which hydrogen ions leave the metal surface and, in general, recombine again to molecular hydrogen). It builds on the circumstance that each cluster is a reaction site rather than a catalyst, thus allowing to increase the power generated without having to increase the number of negative hydrogen ions when generating the active core.

None of the available prior art documents discloses acting on the number of clusters in order to control the reaction power output, and indeed none of them even hints at any power control mechanism. The patent according to Auxiliary Request 4 however provides just such a mechanism, i.e. simply setting the power output by prearranging a number of clusters that is proportional thereto. Therefore, **the subject-matter of Auxiliary Request 4 is inventive.**

4. Conclusions

In view of the above, the request to set aside the decision of the Opposition Division and maintain the patent as granted is justified.

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Enclosures:

Auxiliary requests 1, 2, 3 and 4

- E 1 Slides of the 10th International Workshop on Anomalies in Hydrogen Loaded Metals
- E 1b Discussion of results from the 1st instance
- E 2 Decree by the Italian Government of November 6, 2015
- E 3 Lee and DePristo, The Journal of Chemical Physics **87**, 1401 (1987)
- E 4 Chemistry and Physics of Solid Surfaces VII, Vanselow & Howe (Eds.); Springer (1988), pp. 1-21