The monographic issue describes design as inventor through narratives, illustrations of approaches and experiments. It is a mapping of the design culture useful to decipher the complexity of design, explore the boundaries and draw the possible lines of evolution.
Thinking, inventing and producing: reality - the physical and psychological world - becomes material for continuous investigation and interpretation.
In order to arrive at innovative results the research of design "disrupts to reformulate", through the propensity to re-discuss established paradigms, methods and schemes.
The orientation towards experimentation and the tendency towards disciplinary contamination allow the design to be defined as a "privileged place" not only for engineering invention, but also for the search for new behaviours, new material and sensorial universes which are capable of reformulating in a new and radical way the relations between man and artifacts.

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Think

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Design, ingenuity, and imagination

Invention in design means putting into practice a technical/scientific idea that is the result of ingenuity. But it is also the pure capacity for imagination, capable of «altering the sensibility of the human race» (Kubler, 1962), acting as much upon the product's functions as upon the meaning. And indeed, invention in design is a process that is not in the least ingenuous or visionary, but the outcome of a highly sophisticated process, capable of selecting forms and technologies to obtain the maximum expressive result with the minimum exhibition of formal effort, and of stereotyping itself in formally essential objects. This is why innovation, for design, cannot be resolved only as a "muscular" display of innovative technologies, of use more for simplifying realization processes than for creating new functions or new languages. The designer's activity is in fact mainly that of serving as a mediator between art, technology, and society, interpreting not only functions, but also the meaning of discoveries in inventions of "sign mediations" and of new "social garments" (Zingale, 2012). Starting from these assumptions, the paper proposes a classification by categories, in which innovation in design is read as the result of a technological transfer process; as a spontaneous or even random activity; as the ability to apply "simplexity" by making the complex simple; or as a reaction to limitations and scant resources, by offering a vantage point that, without denying the potentials offered by recent innovations, aims to reaffirm the more humanistic and less technocratic dimension of our inventive capacity. This inventive capacity is not played out in the aesthetic dimension alone, but can join this imagination to define new uses, functions, and languages. Starting from here, the designer can and must set off again – while keeping his or her role well in mind – to configure a new humanism.

[invention, innovation, imagination, aesthetics, languages]

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Contrary to common belief, which sees the origin of an invention in the stroke of genius, the process of invention can be a very long activity, of which the "idea" represents only a very small part; in fact, according to one of history's greatest inventors, Thomas Alva Edison, «Genius is one percent inspiration, ninety-nine percent perspiration»[1] (1903).

Quite unlike discovery (often the result of serendipity[2] capable of bringing to light only what already exists), invention is in fact the creation of something that did not exist earlier – not only in culture, but in nature, too.

Once the invention has come to light, there is also the long phase thereafter, so it might be made available and usable, thus becoming innovation which, in turn, will generate progress and social change.

Innovation, which Schumpeter[3] sees as representing discovery in its applicative dimension and invention in its commercial one, may regard, among other things, a process or product[4] that, to become such, requires investment in terms of knowledge, capacity, information, and financial resources. Thus it is that while discovery takes place in a scientific setting (pure research), carried out by researchers and scientists, invention is born following long experimentation in an industrial setting, at research and development facilities.

Part of this framework is the activity of the designer who, by fulfilling a "social role" and a semiotic function, mediates between art, technology, and society, interpreting – as Italian philosopher Enzo Paci[5] maintained – not only the functions of the product, but also the "meaning" that the form he or she creates can potentially have for people. The designer's semiotic work often consists, then, of "inventing", but not only – at least not only – in the "engineering", sense, but also in terms of invention of "sign mediation", of new "social garments", also in order to respond to the needs of consumption. The designer's work is therefore one of interpretation, translation, looking forward, and projection. Indeed, all artefacts, before being designed, are absent and possible; if we can conceive them, it is only via logic and abduction[6] (Zingale, 2012) – that is, the inference capable of initiating every interpretative path, which is the instrument of the designer's work.

This deep thought, capable of being stereotyped in formally essential objects, is played out upon the dialectics between art and technique, between simplicity and complexity, and upon design's ability to exploit real or apparent contrasts to produce innovation, at times spilling over into utopia without letting itself be overwhelmed. This results in objects that may be likened to physical nexuses of social and cultural connections, which take shape through interactions on the digital plane, as well as on the more traditional one.

Kubler, in his 1962 "The Shape of Time: Remarks on the History of Things"[7], in defining "artistic" or aesthetic invention, says that this is invention capable of «altering the sensibility of the human race … [and by drawing] its entire origin from human perception … leads back to it", and is distinguished from "useful" invention, which is "linked to the physical and biological environment» (pp. 90-91).

According to Branzi (1988), this sort of intertwining between art and technology is to be seen as having an aptitude for disorientation, especially in Italian design. This leads to looking to the world of art for its technological possibilities and to the world of technology for it expressive capacities, thereby sealing the assumption that the road to innovation passes as much through invention as through imagination, at times even surreal, the result of a visionary capacity closer to utopia than to concreteness. This is a highly personal, Latin approach to design: visionary yet concrete, resistant to automatically adopting the demands of orthodox rationalism, and capable of conserving the genetic code of Italian design (Lucibello & La Rocca, 2014).

Baudrillard even says that "the modes of imagination follow the modes by which technology evolves, and future technical efficiency will create a new imagination" (1968), confirming the fact that the best inventions are fortunate intuitions, the synthesis between worlds and things that are apparently more than distant, placed creatively in a relationship with and in connection to one another.[8] The range of "imagination" in terms of invention is easy to understand when we consider, for example, the ability of many directors to conceive artefacts or technological instruments that then became reality, such as the interactive screen in Steven Spielberg's "Minority Report", or many of the objects used by James Bond or by the characters in Stanley Kubrick's "2001: A Space Odyssey".

This process, not in the least ingenuous or visionary, is in turn the outcome of a highly sophisticated process, capable of selecting forms and technologies to obtain the maximum expressive result with the minimum display of formal effort. But care should be taken with the current paradox, which offers us a glimpse of the new conditions characterizing contemporary production, and tends to favour an innovation aimed not only at the product, but also at the way of communicating its philosophy, also through a spread and at times "spectacularization" of the processes of design and production (diffuse creativity, makers, industry 4.0, etc.); this paradox exposes us to the danger that the changed cultural and technical conditions, which now promise new degrees of freedom for those doing design, may be resolved only in favour of «a new functionality [of objects], a new value of use, which is in fact called "symbolic"[…], "imaginary"» (Carmagnola, 2009, p. 34).

This, then, is invention as the fruit of ingenuity and the imagination, and not as a "muscular" display of innovative technologies, of use more for simplifying realization processes than for creating new languages. If it is in fact true that "anyone" can use a 3D printer and instantly see his or her own idea take material shape, it is also true that the consequent reduction of the time between the two phases to zero proposes an intuitive leap that tends to exclude the variety not only of materials and tools, but also of the established techniques and traditions, which gives us cause to reflect. A possible road to travel may therefore be to reaffirm a more humanistic and less technocratic dimension of our inventive capacity, and, without denying the potentials offered by innovations, to reconsider *humanitas* by reiterating, while conscious of our own level of knowledge, the historical moment we are experiencing, in the awareness that we can start again from here to configure a new humanism.

It therefore seemed interesting to us to reread and classify some of the most interesting cases in which design was resolved in invention, in order to better understand its various nuances and range in terms of produced innovation.

Invention as technology and design transfer

The concept of technology transfer is proposed as a strategy for innovation that "borrows" technologies and materials already known in other productive sectors through a shift of field, and gives them new currency by making them available in new applications. It follows that even a non-new material, for example, can be used to create innovation in a particularly creative way, by connecting professions and experiences and broadening the field of knowledge in a wholly cross-cutting fashion, on ground fertile for developing new design and production strategies.

Design history has many successful cases of technology transfer; one need merely consider the introduction of polyurethane foam in the furniture sector[9], which Busnelli (C&B Italia, Cassina&Busnelli) tells of having intuited by watching a rubber duck floating, and then using this material[10] in Gaetano Pesce's "Up" series. In implementing this particular technology transfer, the intrinsic qualities of the material and of the realization processes were exalted, such as, for example, the possibility of integral finish (self-skinning), and that of eliminating any support framework by using large volumes and thicknesses of polyurethane foam. The same holds true for the use of aerogel which, being 99% air and 1% silica, is considered one of the world's lightest materials: used initially in the aerospace industry where it was employed by NASA to capture space dust in orbit, it transitioned to high-performance use, first in the construction industry as the insulating core in double-wall or double-paned structures in the form of granules, and later in technical garments, providing the padding in thin and highly insulating windbreakers for Antarctic expeditions.

Invention and spontaneous design

In the case of invention that may be attributed to the category we have named "spontaneous design", the design process can also be entirely instinctive – developed for successive phases and focusing on the physical realization of an artefact able to solve a specific problem (also by starting from already-given elements or, in a kind of ready-made process, by re-composing and using its parts to produce a new artefact); customarily, the process may be structured as a model and type.

Many of the "ingenious" objects we use every day, and that we commonly understand as the result of "anonymous design" belong to this group. These are artefacts about which we know neither the designer nor the company of reference, but that appear to us as the clear outcome of a design process, also spontaneous, that results in an invention without neglecting its formal quality.

In this case, too, we are dealing with objects that are useful and "simplex"[11] in form and function, which time often deposits into archetypes of design or aesthetic artefacts that are

the "result of a functional, technical, typological, formal, or other kind of idea – linked in different ways to a need, a clientele, or the market; it is a matter of preparing their characteristics in relation to possibilities and economies of production, distribution, and communication". (Bassi, 2011)

It is to these objects that Bruno Munari dedicates *Compasso d'Oro a Ignoti*, publishing in "Ottagono" no. 27 of 1972 and *Abitare* no. 545 of 1975 his search for well-designed[12] and well-sold objects, even if they are anonymous, including the spinning top, the mezzaluna, the artist's easel, the umbrella, the Neapolitan coffee pot, the soccer ball, and much else. All these inventions were born under the inspiration of spontaneous design.
Finessi, in the catalogue for the Triennale's Design Museum 2014 exhibition titled "Il Design italiano dopo la crisi", terms this "low-cost design", casting light on the interesting work done by Daniele Pario Perra, the result of "endless research between popular knowledge and extemporaneous solution, which yields a story of objects that are full-blown inventions, without necessarily aesthetic value, but always with a high degree of usefulness" (Finessi, 2014). Perra lists some interesting – and no fewer than seven thousand – examples in this category, including anti-scalding knobs made with corks; a rain protection system to collect fine dust, made with a funnel; chopsticks with hinge and spring; and a table salt and pepper set made using rolls of photo film.
The fishing net is certainly an emblematic example that fully belongs to this category. Created in prehistory (the Neolithic), it was initially made using "heaped-up" branches barring the passage of fish, and only later was made initially using tangles of branches or tree bark, and then mats of plant fibres, such as wicker, string, and nylon, and by trying out "weaves" that could be wide- or fine-mesh. Weights of various kinds (shards of broken amphorae, or scrap material of other kinds), shapes (lenticular pyramid, with one and two holes), and materials (stone, terracotta, lead) were attached to these matted structures. These were all elements that experience had shown as indispensable for keeping the net taut, thus allowing it to lie at the bottom and keep fish from getting away.
This invention, born from a need and from direct observation of what took place in nature (branches gradually trapping fish on river bottoms as the bottoms dried out during dry periods), evolved over the centuries to our own days, as it differentiated itself by type of catch (trawling, the *tonnarella*) and type of fishing (purse seining, trawl nets, special nets, gillnetting, drift netting). It then developed into knot-less industrial nets, made using materials like polyester or dyneema, respectively guaranteeing lesser water absorption (which makes the net lighter), as well as greater resistance, which is indispensable for withstanding very high breaking loads while reducing weight and volume. At any rate, Munari again, in his presentation to 1944's *Catalogo Illustrato dell'Umorismo*, dwelled on the bizarre and interesting waste that the sea leaves on the shore, concluding some years later that one could imagine "the sea as artisan" (Munari, *Il mare come artigiano*, 1995).
Another interesting example is the deckchair, consisting of an articulated frame whose structure is normally made of beechwood to which a fabric seat/backrest is anchored. The structure – which may be easily assembled and disassembled with no screws or joints – allows the deckchair to be easily folded for stowage in very restricted spaces (only 4 cm) when not in use.
The deckchair as we know it today appeared at the turn of the twentieth century, most likely inspired by the long chair – or *chaise longue* – that existed since the times of Ancient Greece, and saw a certain amount of attention and evolution over the centuries.
This version of the deckchair immediately found widespread use at beaches and resorts, becoming the symbol of summer life by the sea. The deckchair, whose patent was filed in 1957 with the name "Sedia Delizia", had a variety of accessories, like a backrest (reclinable in several positions), arms, footrest, and sunshade.
In the 1990s, wood – generally treated with impregnating resins to prevent the aging caused by sea brine, and held together with bicomponent glue – was joined, and then gradually nearly entirely replaced, by plastic and above all aluminium structures, thereby transforming this item of furniture into a high-performance, ultralight, and ultra-accessorized artefact. A prime example is the "deluxe Rimini" deckchair, designed in 2016 by Paola Navone for Baxter, made of acidified copper enriched with a cushioned headrest, and luxuriously trimmed with decorative leather tassels; another is the "J.J." – a small, interior armchair inspired by the deckchair, with a structure in steel rods supporting a highly refined wooden frame, offering us a cultured reinterpretation of this great classic by Antonio Citterio for B&B Italia.

Invention and design "by accident" or "by error"

Soichiro Honda, founder of the eponymous Japanese corporate giant, said that "success is 99% failure"; if this is indeed the case, one may rightly wonder where that 99% ends up, and what design can draw from "non-success".
Unforeseen, uncontrolled variables have in fact always been an integral part of innovative processes, suggesting that intent and "risk" coexist (Pizzocaro, 2004, p. 83). Precisely for this reason, failure may be understood as the key for investigating the normally hidden paths of design, and for highlighting all those course corrections or errors that we normally tend to censor, but that generate innovation all the same. In fact, many inventions are born from errors or random events that are transformed into discoveries that have changed our daily life. The circumstances in which the "Post-it®" was invented in 1968 provide a well-known example. Silver Spencer, a researcher at the historic United States company 3M, was actually looking for a new super-powerful adhesive when he accidentally invented a no-tack, reusable, and perfectly transparent one instead. This adhesive component could stick to any surface. In spite of this, Spencer, finding no use for this glue, considered it a failure and set the invention aside; it was a colleague, Arthur Fry, in 1974, who, while looking at a hymnal used in his church chorus, came up with the idea of using this adhesive for bookmarks. Originally conceived as yellow and square, with sides measuring 7.6 cm, the "Post-it®" is now made in no fewer than 8 sizes, 25 shapes, and 62 colours – a striking example of how, born by error, it has become a highly widespread item.

The same may be said for Velcro (the name being a combination of *velour* and *crochet*), invented by pure accident by Swiss engineer Georges de Mestral who, in 1941, noted the burrs of plant material adhering to his clothing and to his dog's fur. This was the reproductive method for certain plants, whose seeds hooked onto animal fur to be carried and spread; Mestral had the idea of replicating this form artificially. At the start, the idea of making it into a fabric that could come apart and reattach, again and again, nearly ad infinitum, was unsuccessful. But in 1960, NASA chose it as the solution for anchoring objects in zero gravity, and since then we have never stopped using it.
Other examples of flops and uncompleted efforts by great designers, showed in the exhibition curated by Raumplan and ACCC titled "Failures. Process beyond Success" in 2016, celebrate error[13] as a source of innovation, reaffirming that it is in the process that designers and producers quite often create true added value and innovation. It is a way of saying that doing is making. So we have the chairs by Marco Zanuso and Richard Sapper, whose success was determined by their stackability, a quality that designers had considered as implicit and a bit taken for granted; or the failures of Aldo Rossi, Sottsass, and Mendini with Alessi: respectively a chair, goblets for hotels, and a vase, which remained prototypes but whose value lies precisely in experimentation and in the innovative process. And, from certain standpoints, there is also the case of the Philippe Starck lemon squeezer – an utter failure in functional terms but, unexpectedly perhaps even for its creator, immeasurable from the semiotic perspective.

Invention and "plus-functional" design

The invention that generates forms without paradigm, and thus with no typology or model of reference, has been recounted here as the "plus-functional" category. This is to be understood as establishing an equivalent of what in language we call "syntactic neologism", to identify those inventions – and those phenomena, discoveries, and developments – that incorporate several functions into one, giving rise to objects often original and neutral in form, that interpret contemporary life in the possible relationship between expressed and unexpressed needs, and between evident and latent utility, in the same way as occurs when a new word expresses two or more meanings. This takes place in the invention of artefacts that lend themselves to carrying out several functions resolved until then by several objects, such as for example the case of the Swiss Army Knife, a multi-function tool par excellence, conceived in 1891 by Victorinox founder Karl Elsener to meet the needs of soldiers in the Swiss Army. In "sharing" several functions, the artefact takes on new formal, material, and semantic configurations, which have no references to types or models, but respond in a tangible way to new needs that, over time, will become "type-needs, passing through type-functions, then becoming type-objects" (Cristallo, 2015). A striking example of this paradigm-less "assembly" of functions is, for example, the smartphone, which now allows us, among other things, to make phone calls and take pictures, while no longer resembling any of its predecessors (no telephone receiver, and no camera).

Autarchic invention and design

The choice has been made to dedicate this category to "autarchic design", by virtue of that particular condition that is manifested in certain historical periods where absence becomes a resource; this spurs creative opportunities, as well recounted by the 2014 exhibition curated by Beppe Finessi for the Design Museum at Triennale di Milano. In the interpretation given by the exhibition curator, it appeared clear that "Italian design, right from the beginning, knew how to make lemons out of lemonade: in 1935, when the materials and techniques of our tradition were rediscovered – and new "fanciful" ones actually created – as a consequence of the economic sanctions imposed on Italy by the United Nations; when, during the oil crisis of the 1970s, new languages were tried out to respond to the dearth of resources; and today, when, in a setting of crisis of the productive model pursued in decades past, the impetus runs towards rediscovering not only self-production, but also specific features and local traditions as well.
These inventions are unique or reproducible, like Renato Vengoni's "bisiluro", and Bruno Munari's sunglasses; but they are also new and interesting applications of local, available materials, from white metals to linoleum and safety glass (Bernardini & Dal Falco, 1992), «tempered and layered, which used river sand and clay sand, and reconstituted wooden scraps originating from the sawmills of the Alpine valleys», (Dal Falco, 2014), bearing witness to an aesthetics of transparency.

[1] "Genius is one percent inspiration, ninety-nine percent perspiration", oral declaration from about 1903, reported in Harper's Magazine in September 1932.

[2] This is randomness, or the luck of making fortunate discoveries by pure chance, and also the finding of something unexpected and unsought when seeking another.

[3] The Austrian Joseph Alois Schumpeter (1883–1950) was one of the twentieth-century's greatest economists. As early as 1911, Schumpeter introduced the fundamental difference between invention, which does not necessarily involve bringing a new product or process onto the market, and innovation.

[4] The OECD (Organisation for Economic Co-operation and Development) and the European Commission in the Oslo Manual, containing guidelines for collecting and interpreting technological innovation data, provide the following definition of innovation: "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations". See Oslo Manual, *Guidelines for collecting and interpreting innovation data*, Third Edition, 2005.

[5] The phenomenologist Enzo Paci (1911-1976) introduced, for the first time in Italy, semiotic themes with reference to design at Congresso Internazionale dell'Industrial Design, 1954 Triennale di Milano, whose Executive Committee he chaired.

[6] Unlike induction and deduction, abduction is an inference that always arrives at a possible but not certain conclusion: it arrives at a "maybe".

[7] In *The Shape of Time: Remarks on the History of Things*, Kubler recounts – as an "anthropology of techniques" – the "process that continually transforms human sensorial capacities and knowledge through ongoing discovery".

[8] Similarly, (1936) Benjamin already assigned to art a role of sensitive prefiguration of the future and, vice versa, to technology the ability to make utopian aspiration operative once innovation has introduced new conditions.

[9] Created in Germany in the early 1940s, the first polyester-based polyurethane foam found immediate use in the construction industry where, thanks to its fluidity when put in place, was well suited for plugging the natural cavities caused by traditional materials, thus helping to insulate the structures.

[10] In collaboration with Bayer.

[11] Simplexity, a neologism formed by fusing Simple and Complexity. Proposed for the first time in the 1950s and relaunched in the scientific community in 1990 by Alain Berthoz, professor of physiology of perception and action at Collège de France, it describes the ability to see a complex system in a simple way. See also Lucibello, S. (2014). *Semplessità nel design*. In Smart design, *diid* n°58. Roma: Rdesignpress.

[12] Jasper Morrison and Naoto Fukasawa identify the objects in their Super Normal exhibition in which, alongside some clean and essential designs, belonging to them or to colleagues, selected the Bic pen, the paperclip, and paper lamps.

[13] In scientific research, one proceeds by trial and error.

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