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Form–Finding, Form–Shaping, Designing Architecture

a cura di / edited by
Sonja Hildebrand, Elisabeth Bergmann

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Form-Finding, Form-Shaping, Designing Architecture

Experimental, Aesthetical, and Ethical Approaches to Form in Recent and Postwar Architecture
Approcci sperimentali, estetici ed etici alla forma in architettura, dal dopoguerra ad oggi

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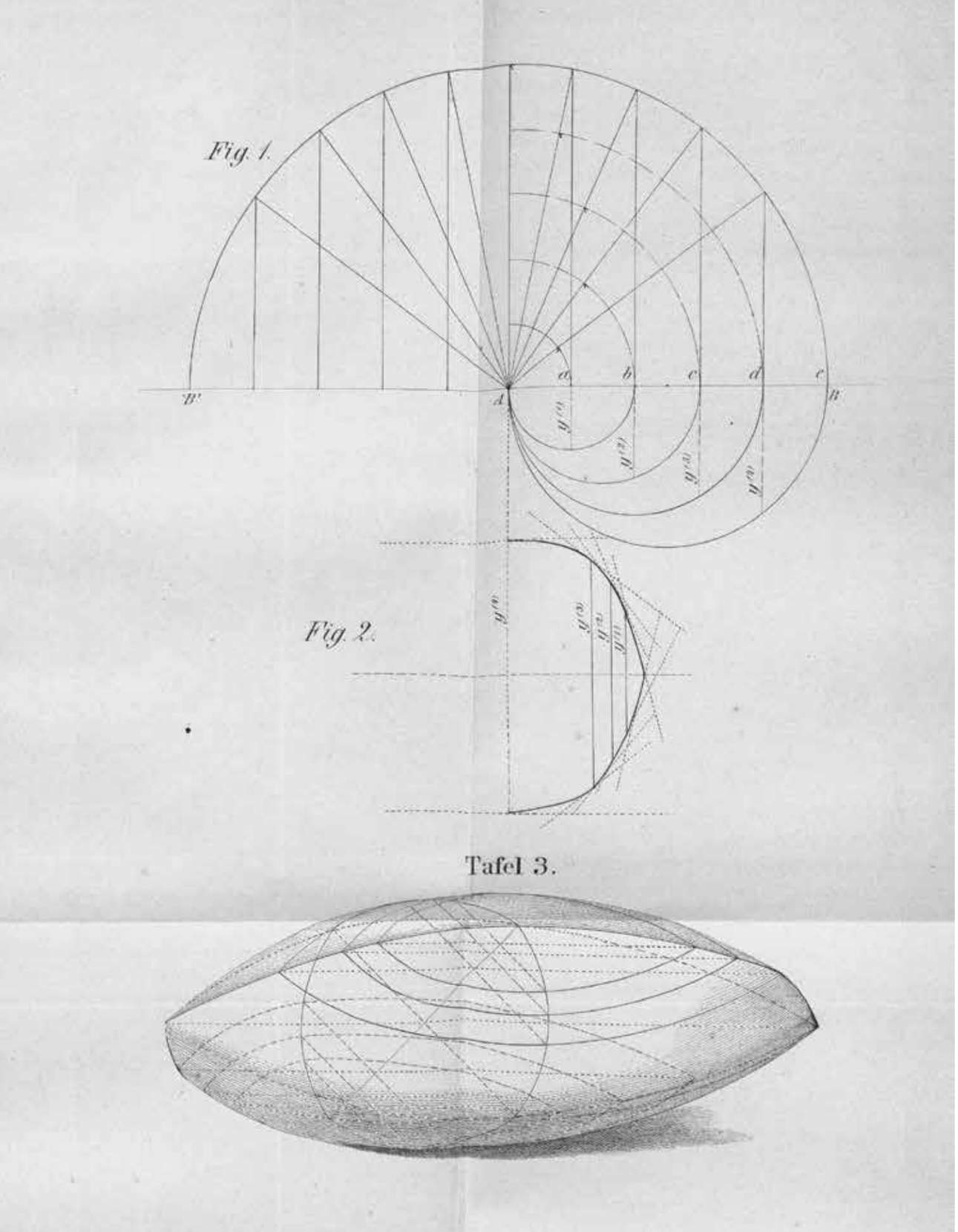


Sonja Hildebrand

Towards an Expanded Concept of Form

Gottfried Semper on Ancient Projectiles

_ Figure 1.
Gottfried Semper, *Ueber die bleiernen Schleudergeschosse der Alten…*, 1859, plates 2 and 3 showing the geometrical analysis of a Greek projectile (ETH-Bibliothek Zürich, Alte und Seltene Drucke).

At the *Anymore Conference* in Paris in 1999, Bernard Cache – an early leading thinker in the field of digital design and digital fabrication – suggested that a historical basis for digital design might be found in Gottfried Semper's architectural theory. There is a "clear affinity", he argued, between the digital procedures that he was exploring together with Patrick Beauce in their *Objectile* studio and Semper's theory – not only due to the latter's focus on materials and technology, but also in the "principle of dressing" that he defined. In particular, the affinity was also based on the way in which Cache's own "investigations into the generation of software to map key elements of modern topology, like knots and interlacing, consist of a contemporary transposition of Semper's … primitive pattern". The lecture was published in 2000 under the title *Digital Semper*.[1]

The roots of digitisation

The arguments developed in the essay are attractive. The basing of digital design on Semper's theory links the virtuality of digital procedures, which nevertheless lead to material results, with pre-digital procedures developed in concrete materials.[2] The products of digital design, which are often difficult or impossible to understand, thus in a sense acquire a genealogy in the material and factual sphere, which – as a kind of reading aid – connects the new types of form to a comprehensible and even everyday world of experience.

Cache starts with a systematic presentation of what he describes as Semper's correlation of materials (fabric, clay, wood, stone) with the technical arts associated with them (textiles, ceramics, tectonics/carpentry, stereotomy/masonry). This is based on the typology that Semper developed – first described in his *Die vier Elemente der Baukunst* (The Four Elements of Architecture) in 1851 – of pre-architectural craft techniques and basic architectural elements. On analogy with Semper, Cache regards

the technical arts as procedures. According to Semper, these procedures were originally developed with specific materials, but were later also applied to different ones. Ashlar blocks, for example, are assigned as an original material to the category of masonry and stereotomy. In the form of stone slabs, however, they can also be used for cladding or dressing, thereby acquiring the space-enclosing function of walls which were originally made of textile materials. Typical features deriving from the textile procedure – such as knots, seams and hems – are preserved here in the form of ornaments, the network of joints and dividing elements. On the basis of Semper's observations and interpretations, Cache presents a systematic table in which each of the four basic materials is linked to the four basic procedures, with a few exceptions.

The decisive aspect of Cache's argument is the continuation of this table that he then proposes. He considers that the way towards this continuation was opened up by Semper himself. In his principal theoretical work, *Der Stil* (*Style*), Semper introduces metal as the fifth basic material, but does not assign it to any specific technique. Metal can be processed equally with all four of the basic techniques.[3] The supplementation of the system with a technically and historically secondary material that this involves, along with Semper's occasional inclusion of other materials as well in various other passages, is used by Cache to justify supplementing the table with the modern materials of glass and concrete. But he does not leave it at this quantitative extension of the materials included. Following on from Semper's attempt to make the anatomic classification system developed by evolutionary biologist Georges Cuvier fruitful for his theoretical work, Cache also expands the system qualitatively and assigns the four classes of the animal kingdom defined by Cuvier to the four basic procedures: the mollusks to textiles, the radiates to ceramics, the vertebrates to tectonics and the articulates to stereotomy.[4]

Fig. 2

Fig. 3

Table 4 Historical and traditional materials (including metal)

Abstract Procedures	Textile	Ceramics	Tectonics	Stereotomy
Fabric	Carpets, rugs, flags, curtains	Animal skin flask, ex: Egyptian situla		Patchwork?
Clay	Mosaic, tiles, brickwork cladding	Vase-shape earthenware, ex: Greek hydria		Brickwork masonry
Wood	Decorative wooden panels	Barrels	Furniture, carpentry	Marquetry
Stone	Marble and other stone cladding	Cupola	Trabeated system	Massive stonework, isodomic's
Metal	Hollow metal cladded statuary; Olympian Jupiter reconstituted by Quatremère de Quincy; metal roofing; articulated metal structures; curtain wall	Metal vases or shells	Cast iron columns	Forge, ironworks

_ Figure 2.
Bernard Cache, *Digital Semper*, 2000, Table 4: *Historical and traditional materials*
(C.C. Davidson, ed., *Anymore*, Anymore Conference, Paris, 23-25 June 1999, MIT Press 2000, p. 195).

Cache continues a tendency that is inherent in Semper's theory – towards abstraction from the actual material to the way in which it is represented by ornamental residues – to the final and decision extension of the system, the introduction of information technology:

> ... it would be in the nature of these procedures to look relentlessly for more "immaterials" in order to find a new occasion for their progressive abstraction. Thus, information technologies would not simply be accidentally accounted for by Semper's theory: it would be in their very nature to fit into his system as the best vehicle to push the abstraction of the four technical procedures further.[5]

In accordance with this conception, Cache proposes that "ceramics could deal with revolving solids and operations in radial coordinates" and tectonics with "nonrotational transformations adequately described in Cartesian coordinates"; stereotomy would be connected with "the art of tiling and paving as it results from Boolean operations". The textile procedure, as a "procedure of going alternatively over and under" could be equated with the procedure of modulation. The basic procedure of sequencing in digital modulation, in the form of mere repetition, alternation or rhythmic repetition, Cache argues, is also implicit in Semper's concept of eurhythmia. Cache emphasizes this (not entirely accurately) as "the key concept of the Prolegomena" of *Style* and also connects it very closely with textiles.[6]

Semper's abstraction

However, when we follow Cache's suggestion of carrying out a "close reading of Semper",[7] the potential genealogy that he proposes emerges much less clearly. Semper's theoretical exploration of "the regularity and order that become apparent in artistic phenomena during the creative process of becoming"[8] cannot be made consistent with Cache's interpretation without frictional losses. Semper's assignment of raw materials to the "four main artistic activities" – "1. textiles, 2. ceramics, 3. tectonics (carpentry), 4. stereotomy (masonry, and so on)" – is based on the specific properties of the materials, which suggest certain processing methods, "inasmuch as they require greater or lesser effort and technical procedures to make the raw material serve a definite purpose". Materials that are "pliable, tough, highly resistant to tearing, of great absolute strength" belong to the field of textiles. In ceramics, raw materials are used that are "soft, malleable (plastic), capable of being hardened". The field of tectonics includes "stick-shaped, elastic" materials that are "principally of relative strength, that is, resistant to forces working vertically along the length". By contrast, the materials in stereotomy are "strong, densely aggregated, resistant to crushing and compression" and "thus of significant reactive strength"; these properties mean that they are "suited to being worked into any required form by removing parts of the mass or by inserting regular pieces in strong systems".[9] This results in a much less clear definition of materials than Cache's tables suggest. Semper is concerned with the properties of materials, and only secondarily with materials that share these properties.

Table 5 Materials of Modern and Contemporary Architecture

Abstract Procedures	Textile	Ceramics	Tectonics	Stereotomy
Metal	Hollow metal cladded statuary; Olympian Jupiter reconstituted by Quatremère de Quincy; metal roofing articulated metal structures; curtain wall	Metal vases or shells	Cast iron columns	Forge, ironworks
Concrete	Prefabricated concrete screens; light warps; curtain wall	Ruled surfaces, like hyperbolic paraboloid	Slabs on stilts	
Glass	Thermoformed glass; curtain wall	Blown glass	System glued glass (Prouvé)	Glass bricks
Biology	Mollusks	Radiates, D'Arcy Surfaces de Plateau	Vertebrates, D'Arcy squelettons and bridge structures	Articulates, D'Arcy bees' cells
Information	Modulation interlacing (Eurythmy)	Revolving solid, polar coordinates	Translation, Cartesian coordinates	Boolean operation, tiling algorithms

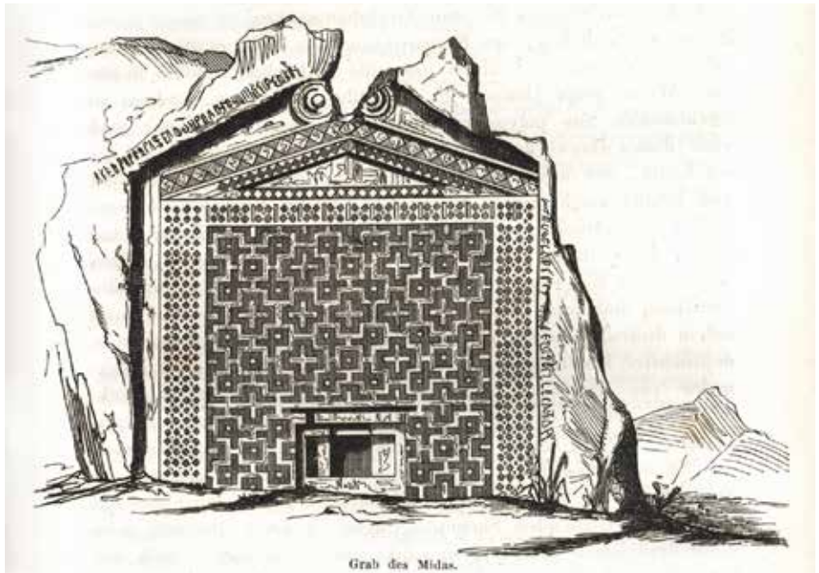
_ Figure 3.
Bernard Cache, *Digital Semper*, 2000, Table 5: *Materials of Modern and Contemporary Architecture*
(C.C. Davidson, ed., *Anymore*, Anymore Conference, Paris, 23-25 June 1999, MIT Press 2000, p. 195).

The four categories of raw materials that Semper defines in relation to their appropriate and originally craft-based processing are intended as a complete description. There is a biographical background for the fact that he devotes an entire section in *Style* to "Metallurgy (Metalwork)": Semper's work on the *Metals Catalogue* which he compiled in 1852 during his exile in London, at the request of Henry Cole. On the other hand – and at a more important level of content – Andreas

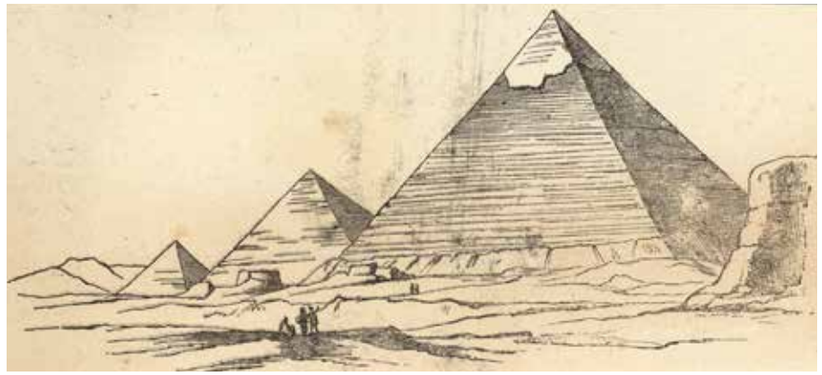
Hauser explains this section convincingly by arguing that metal acts as an eye-opener. Due to its absence of material-specific properties, metal is not predestined for any specific processing techniques. Accordingly, as Semper explains in the introduction, it does not represent a separate "formal field" in the way that "the topics of weaving, pottery, carpentry and masonry" do: "The flexibility of this material embraces all branches of technology".[10] However, since metal can be processed with any of the four basic techniques, it is able to clarify these techniques and the quality of the formal results all the better.[11]

By contrast, mechanized working processes are a different matter, leading to a weakening of the limiting and defining power of the original material qualities that Semper regarded as being essential. Observations of this type that he made at the 1851 Great Exhibition in London gave rise to his well-known critique of "abundance of means" in *Wissenschaft, Industrie und Kunst* (Science, Industry, and Art): "The hardest porphyry and granite are cut like chalk and polished like wax. Ivory is softened and pressed into forms. Rubber and gutta-percha are vulcanized and utilized in a thousand imitations of wood, metal, sandstone carvings, exceeding by far the natural limitations of the material they purport to represent".[12] In Semper's eyes, this does not represent an increase in available options, but primarily a loss of meaning and impact. Nothing could compare with the magical power with which "the granite und porphyry monuments of Egypt exert an incredible sway over our feelings ... because they are the neutral ground where the hard, resisting material engages the soft hand of man with his simple tools ... and they enter into a pact: "So far and no further, in this manner and no other!"".[13]

Semper thus regarded his classification of the properties of materials, and of the associated technical procedures, as being complete. New processing options



_ Figure 4.
"Dressing": *Tomb of Midas*, illustration in Semper's *Style*, vol. 1, 1860, p. 429.



_ Figure 5.
"Dressing": Pyramid with rest of plaster cover, press proof for illustration in Semper's *Style*, c. 1859 (gta Archive, ETH Zurich, Gottfried Semper estate, 20-0163-94B).

were to reflect the essential material qualities and conditions, in terms of both their content and form. Nothing else was valid for the categories of raw materials that he had defined, under which every new material ought in principle to be classified. For Semper, concrete would belong to the field of ceramics, to which he also assigned glass. The fields of biology and information that are introduced by Cache belong to a completely different class of categories. An information-technology procedure such as modulation, which is assigned by Cache to textiles, is a procedure that is applied to numerical "material" (information data) and not a product like a carpet, for example. And the theory-immanent abstraction that he introduces corresponds to a quite specific one in Semper's historical reconstruction: from the wattled wall via tapestry, wall relief and wooden or metal panels to the colourful painting of a Greek temple. During this process, however, the traces of textile modulation also disappear. Eurhythmia fits into Cache's extension of the system to the extent that Semper regarded textile art "as the primeval art, from which all other arts ... borrowed their types and symbols",[14] and in which consequently eurhythmic forms were achieved for the first time. But eurhythmia is also not a product, but rather a formal quality, which can be represented with the help of textile motifs such as the knot or seam.

Figg. 4-5

Architectural form

The above discussion should make it clear that it may well be problematic to appeal to Semper to construct a connecting line that runs all too smoothly from material-based craft work to digital procedures. Despite this, Cache's approach points in a direction that can be pursued further with regard to the degree of abstraction of digitally generated form and the associated problems. The starting-point is provided by the fact – also noted by Cache – that in Semper's theory, the potential for abstraction from the material is already implicit, and even fundamental. Exploiting this potential leads Semper to a very comprehensive interpretation of architectural form. It includes aspects of both form and also space, and anticipates both internal and external movement. It includes both a typology developed out of usage and also an aesthetics that argues on the basis of the material and technical conditions for formal design.

Through its anthropological linkage with the sphere of essential cultural practices and human production, form also acquires a fundamentally ethical dimension.

It is beyond the scope of the present discussion to go into detail on all of these aspects. Semper's far-reaching ideas – developed in his famous comparison of the Greek hydria with the Egyptian situla and elsewhere – on form as defined through specific usage, a form which at the same time encapsulates the entire character of a culture and reflects the nature of a people, cannot be pursued further here.[15] Nor can Semper's concept of successive abstraction from textile clothing to form-descriptive surface, developed in connection with the principle of dressing, be examined in any greater detail.[16] Instead, the aim here is to focus on a text that has a special position in Semper's work to the extent that it marks an intersection between his theory of art forms anchored in the material world and an abstract formal aesthetics: his essay *Ueber die bleiernen Schleudergeschosse der Alten und über zweckmässige Gestaltung der Wurfkörper im Allgemeinen* (On the Leaden Projectiles of the Ancients and the Purpose-driven Formation of Launched Bodies in General).[17] Starting from an explanatory approach to form via the analysis and description of physical laws, Semper moves in the essay towards a formal aesthetics that describes abstract rules, but nevertheless remains linked to the concrete variety of the material world.

The curvature of the Parthenon: ellipse versus hyperbola

According to Semper, what prompted the study was a lecture given by the British architect David Ramsey Hay at the Royal Institute of British Architects in February 1853 that he had attended.[18] Hay argued in the lecture in favour of as simple as possible a system of harmonic proportion, based on simple geometrical forms and arithmetical operations, which for him was the "fundamental element of the beautiful in architecture".[19] Starting from the observation that "a right line has only three directions – the horizontal, the vertical, and the oblique"[20] and that curved forms must be regarded as equivalent to angular basic shapes, he establishes a canon of six basic forms: "perfect square, oblong rectangle, isosceles triangle, circle, ellipse, and composite ellipse".[21] The reductionism of Hay's approach becomes clear not only from its strict two-dimensionality, but also in its limitation to forms that can be constructed geometrically and relationships that can be expressed arithmetically. Thus, the "composite ellipse" that he describes not only "closely resembles the parabolic and hyperbolic curves; but it has what these curves have not, viz. the essential quality of inscribing harmonically one of the rectilinear elements of architecture". By contrast, parabolas and hyperbolas were "merely curves of motion, which never can harmonically inscribe, nor resolve themselves into a figure of any kind".[22]

Geometric simplicity was a fundamental conviction (*Hintergrundüberzeugung*)[23] for Hay. It also determined his critical reaction to investigations by Francis Cranmer Penrose on the entasis of columns and curvature in the Parthenon:

> I cannot help demurring to the conclusions at which Mr. Penrose has arrived with respect to the aesthetic developments of the Parthenon; especially to his idea that the entases of the columns are hyperbolic curves, that the soffit of the corona of the pediment is a curve of the same kind, and that the echinus of the capital is composed of two different hyperbolic curves, and one circular curve. ... this mode of proof must at first sight seem conclusive; but it can only be so in the absence of a knowledge of the composite ellipse and of the various other modes in which ellipses may be combined. For an acquaintance with these will show that arcs of the composite, or mixed ellipse, resemble so closely those of the hyperbola and parabola, that the most careful investigator might be mistaken.[24]

Semper was also familiar with Penrose's work. He touched on it briefly in *The Four Elements of Architecture* in 1851, characterizing the optical correction produced by curvature as "a transposition of painterly effects into the field of architectural effects".[25] Following Hay's lecture he started to approach the topic of proportion in antiquity, including curvature and entasis, in a mathematical way, as Hay had done. However, his evidence points in the opposite direction from Hay's arguments. The principle that Hay had explicitly rejected – the form-generating laws of motion – Semper regarded as being fundamental to design. For Hay, motion was in itself an argument for rejecting parabolas and hyperbolas as "merely curves of motion".[26] By contrast, it was precisely these that Semper made the object of his investigation. His essay is therefore subtitled, *An attempt to demonstrate the dynamic origin of certain forms in nature and in art*.

The "dynamicist" Semper argues against the "staticist" Hay using examples that are sometimes quite strikingly reminiscent of the results of form-manipulating procedures in parametric design. This applies in particular to Semper's example of the Venus de' Medici: if the statue were to be placed in torchlight, according to Semper, the fine silhouette would cast a grotesquely distorted shadow. Again, when specific sectional planes are chosen, a building that is in principle beautiful may appear ugly in the sectional drawing. The graphic depiction (or shadow image) of a sculpture or a building does not represent the object directly, but refers to it "in a mediated fashion". Only those "who have previously recognized its true essence correctly and are practiced in reading from the musical score"[27] are able to infer the underlying beautiful form from the drawing or the shadow image. Semper even goes further: what is "physically beautiful" is "only truly beautiful and proportionate in specific conditions [of the light, location, and possible angle of view], while in others it is – even when the colour and shape are unchanged – indifferent or ugly ... These specific conditions are subject to infinite variations, however, so that generally valid numerical rules of proportion for beauty cannot be given".[28]

Form – or beautiful form, which is what Semper is always concerned with – is dependent on the conditions of perception. An analytical description of beautiful form aiming to define rules for producing it must take this relational aspect into account. In connection with the material indifference of metal relative to various processing techniques in Semper's theory, Andreas Hauser has compared the relational potential of metal with Wilhelm von Humboldt's category of form-describing words. In contrast to object-describing words, these do not refer to anything substantial, but rather to something relational – i.e., grammatical relations. According to Humboldt, purely form-describing words without any objective connotations only occur in more highly developed languages. They make the "'mysterious life

force' of human language perceptible" and "correspond to the animal's organs of sensation and movement" – i.e., the organs that distinguish animals (and human beings) from plants.[29]

The relational principle as a fundamental condition for form: Semper's projectiles

Despite the relational character of art forms, the way in which their perception and effect are dependent on external circumstances that are in principle infinite in number, it continued to be Semper's aim to provide rules for the form-generating architect to use. These rules or "formulas" were to be treated exclusively "as equations in which variable and constant values act in combination in the most multifarious ways".[30] One of these attempts is the style formula in the form of a mathematical equation that Semper presented as a model in a lecture at the Department of Science and Art in London in 1853. He explained the proposed mathematical equation by saying that "every work of art is a result, using a Mathematical Term, it is a Function of an indefinite number of quantities or powers, which are the variable coefficients of the embodiment of it".[31] The rules that the architect is to learn and follow include, for example, taking into account the specific properties of the materials in relation to their processing, and the complex requirement for form to be expedient.

Semper made it his life's task to define these rules in the course of wide-ranging research and a critical analysis of historical artefacts. When his concept is examined in relation to the procedures of form-finding and form-shaping, it can be seen that he moves in an intricate balance between these poles: the architect needs to find pre-architectural forms, such as those generated by craft practices. These pre-architectural forms are the results of form-shaping processes, but the processes are determined by laws and properties that lie outside the sphere of human design. The same applies to usage as a form-defining parameter. It is determined by an interplay between an indefinite number of different factors, among which those that Semper discusses in the greatest detail are the handling of an object in a specific situation of activity and the social function of a building, and the interaction between this and political and religious convictions.

In his study of Greek projectiles, Semper now enters a field in which he is able to use dynamics to study a relational principle as a fundamental condition for form. The variability of external factors coincides here with the form-defining variability of the object in space. The underlying physical and mathematical laws, by contrast, are natural laws of gravitation, statics and dynamics that are fixed (or regarded as being fixed). Mathematical procedures from the infinitesimal calculus are available that describe the effect of (minimal) alterations in the input values on functions. The mathematically calculated results are optimized values that approximate "reality".

Fig. 1

The mathematical methods thus correspond to Semper's basic assumption that there are infinitely many variables of form, on the one hand, and on the other with his conviction that "certain generally valid general laws operate reliably through this immense variety of possibilities".[32] Semper defines his research field in distinction from Hay's rigid geometric formalism and against the background of Penrose's description of the curvature and entasis of the columns of the Parthenon. The context for Semper's discussion is provided by Greek temple architecture, which he describes as a unique example of "organic" architecture: only the Greeks had succeeded in "giving life to its tectonic shape in an almost organic way. The monuments and appliances of the Hellenes are not constructed, turned, or cast; they have grown".[33] However, it was not possible to approach this phenomenon in scientific terms using the means available. Although mechanics was able to explain the basic principles of movement and gravity, a "power" existed that had "so far escaped the acumen of our dynamicists – the life-force". The "most interesting creations", according to Semper, always arise when the life-force is placed "in conflict with the elementary forces". Accordingly, art forms were all the more perfect the more they conveyed the impression that they were "the results of a similar conflict between elementary forces and life-forces".[34]

On the basis of the effect of curvature and entasis Semper attempts to provide evidence that the Greeks, in the formal design of their buildings, did not merely follow the "inspiration of a vague artistic instinct". Instead, they had "a clear-sighted view of their task".[35] Semper is thus concerned with the rationalization of form-shaping processes. He describes these as being intellectual, although linked with nature. The Greeks' mathematical calculations, he argues, were based on a prior study of nature. But the decisive element is emancipation from nature through a scientific and mathematical explanation of it. Accordingly, Semper formulates the goal of his study as being:

> A desire to demonstrate, using an example that is as simple as possible, that the Greeks did not merely observe the laws of nature and strive to imitate the forms that had arisen from them, but rather had genuinely investigated these laws and derived from them – independently of any sort of imitation of nature – their own forms, which only coincided with nature in sharing its laws: this was what urged me to carry out the following study.[36]

Form-finding, the observation of natural forms, passes into form-shaping calculation.

Fig. 6

Semper applies an analogous procedure to Greek projectiles in his study. Their shape is similar to that of almonds or plum stones, which is why they were called *balanoi* by the Greeks and *glandes* by the Romans.[37] Projectiles, however, were not plum stones or almonds made of lead, but rather objects whose shape had been optimized and mathematically calculated and were made by human beings.

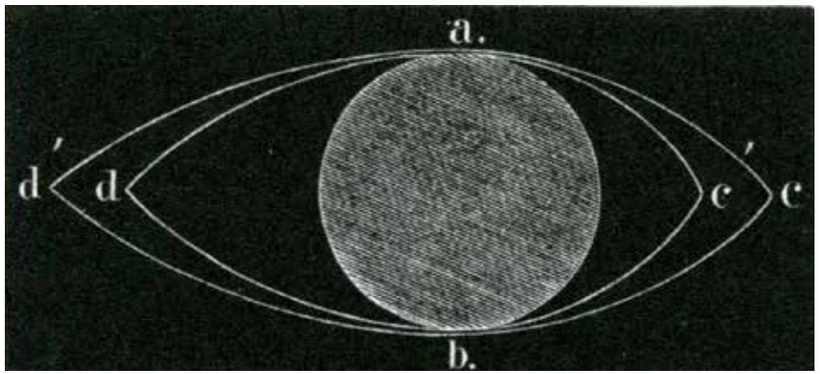
Almond-shaped projectiles represent such a conclusive example in the context of Semper's theory of form because their shape can be described in a certain sense as part action and part reaction. One half of them (the front part during movement) encounters air resistance actively with its sleek shape. The rear part during movement, although it has the same shape, is the result of a reaction: filling the space surrounded by the flow of air. Semper describes this as follows: "During the rapid movement of a system, there is a thinning of the air behind it that can be regarded as a result or function of the speed of the body. In its forms, nature fills out this relative vacuum ...".[38] In its material form, the projectile is thus a response to the course of the forces at work. At the same time, its curved shape corresponds to the curve

of its trajectory. In this sense, dynamics – to the laws of which the projectile's shape is a response – offers the best possible substitute for a life-force that cannot be described scientifically.

Agency

For Semper, the inability to penetrate to the "real matter" using rational means continued to be an insuperable challenge during his subsequent theoretical work as well. But he succeeded in making his awareness of this deficiency productive in a way that led, at the level of theoretical reflection, to the greatest possible activation of architectural form. The key passage for this is the final paragraph of the *Prolegomena* in *Style*.

In the context of his reflections on "formal beauty", which begin with his study in Greek projectiles, Semper defined three "axes of formation" that correspond to the three extensions of space and from which the "three spatial characteristic qualities of beauty" emerge: symmetry, proportionality and direction.[39] In the projectile, for example, the symmetrical axis runs along the longitudinal axis; the vertically structuring proportion in the human figure or in trees, by contrast, coincides in the projectile with the axis of directionality. These aspects of formal arrangement and beauty, which Semper mainly presents using decorative objects, form the elements of a higher order that Semper describes as "unity of purpose or unity of content". The highest level of development is reached when the three "axes of formation", as in human beings, do not coincide wholly (as in a crystal) or partly (as in the projectile), but each develops further along their own axes. In architecture, this stage is reached for Semper in the Greek temple: "Yet in the Greek temple, in its most perfect splendor and great freedom, unity and purpose stand out much as it does in humans – in its purest harmony! Athena's crowning pediment embodies, like the visage of its goddess, the dominance of proportion, the quintessence of symmetry, and the reflection of the approaching sacrificial procession".[40] However, since the sculptures in the pediment reflect the sacrificial procession and at the same time represent its goal in terms of content and location, they become agents of its movement. In their movement, human beings implement a spatial potential that is inherent in form.



_ Figure 6.
Gottfried Semper, *Ueber die bleiernen Schleudergeschosse der Alten* ..., 1859, p. 14, schematic drawing of flying projectile with thick air in front of it and thin air behind (ETH-Bibliothek Zürich, Alte und Seltene Drucke).

Fig. 7

_ Figure 7.
Gottfried Semper, Reconstruction of the Acropolis of Athens, 1832-1833 (gta Archive, ETH Zurich, Gottfried Semper estate, 20-0215-2).

What makes Semper's theoretical reflections relevant in connection with the question of the relationship between form-shaping and form-finding is his awareness of the boundaries between nature and art, between existing natural forms and created art forms, as well as the intersection between these two areas that can at least be theoretically postulated: the laws of natural form that can be defined in rational operations, which can be applied to artistic form. By demonstrating these laws mathematically using the example of projectiles, Semper demonstrates at least in principle the possibility of transferring ratio and beauty in existing natural form through a form-shaping, rational process of mathematical calculation into a form produced by human beings. In this way, Semper does achieve one of the potentials that Bernard Cache associates with the tools of digital design: "The most important thing enabled by the digital is not the design of beautiful curved surfaces, but rather the construction of a long chain of relations between the initial hypotheses of a project and its formal result – and this applies as much to an orthogonal architecture in the Hilberseimer mould as it does to 'curvy broken-style' architecture".[41]

(Translation by Michael Robertson).

Abstract

Verso un concetto espanso di forma.
Gottfried Semper sui proiettili antichi

Il contributo prende spunto dal saggio di Bernhard Cache *Digital Semper* del 2000 per elaborare una riflessione sul concetto relazionale di forma, sviluppato da Semper nel suo testo del 1859 *Ueber die bleiernen Schleudergeschosse der Alten und über zweckmässige Gestaltung der Wurfkörper im Allgemeinen*. Viene affrontato criticamente il tentativo da parte di Cache di ampliare il sistema categorie-materiale in Semper e le rispettive tecniche originarie di artigianato verso un processo di tecnologie dell'informazione. Anziché utilizzare questo sistema di Semper come fondamento teorico per le tecnologie dell'informazione progettuale coadiuvata dal computer, viene proposta una correlazione tra la creazione formale sulla base di fattori variabili, analizzati da Semper nel suo lavoro sui proiettili greci, e il processo di disegno digitale.

Notes

_1. B. Cache, *Digital Semper*, in C.C. Davidson (ed.), *Anymore* (*Anymore Conference*, Paris, 23-25 June 1999), MIT Press, Cambridge MA-London 2000, pp. 190-197, p. 191.
_2. Elsewhere, Cache traces the "roots of the digitisation of architecture" back to Vitruvius; B. Cache, *Projectiles*, AA Publications, London 2011, p. 18.
_3. G. Semper, *Style in the Technical and Tectonic Arts, or, Practical Aesthetics*, 2 vols. (1860-1863), trans. H.F. Mallgrave and M. Robinson, Getty Research Institute, Los Angeles 2004, chapter 11: "Metallurgy (Metalwork)", pp. 823-900, p. 824.
_4. In the table concerned, Cache also supplements the biological classes with D'Arcy Thompson's classification of construction principles in nature: *surfaces de plateau* – ceramics; skeletons and bridge structures – tectonics; bees' cells – stereotomy; Cache 2000 (see footnote 1), p. 195. Cf. D'Arcy Wentworth Thompson, *On Growth and Form*, Cambridge University Press, Cambridge 1961.
_5. Cache 2000 (see footnote 1), pp. 195-196.
_6. *Ibidem*, p. 196.
_7. *Ibidem*.
_8. Semper (1860-1863) 2004 (see footnote 3), p. 71.
_9. *Ibidem*, p. 109.
_10. *Ibidem*, p. 824.
_11. A. Hauser, *Der 'Cuvier der Kunstwissenschaft'. Klassifizierungsprobleme in Gottfried Sempers 'Vergleichender Baulehre'*, in Th. Bolt (ed.), *Grenzbereiche der Architektur*, Birkhäuser, Basel-Boston-Berlin 1985, pp. 97-114, pp. 104-105.
_12. G. Semper, *Science, Industry, and Art: Proposals for the Development of a National Taste in Art at the Closing of the London Industrial Exhibition* (1852), in G. Semper, *The Four Elements of Architecture and Other Writings*, trans. H.F. Mallgrave and W. Herrmann, Cambridge University Press, Cambridge 2010, pp. 130-167, p. 134-135.
_13. *Ibidem*, p. 138.
_14. *Ibidem*, p. 113.
_15. Cf. G. Semper, *London lecture of November 11, 1853*, ed. with a commentary by H.F. Mallgrave, "Res. Anthropology and Aesthetics", 1983, n. 6, pp. 5-31, esp. pp. 9-10.
_16. See the famous passage in Semper's *Style* (1860-1863), 2004 (see footnote 3), p. 243: "Among these ancient and traditional formal elements of Hellenic art, none is of such profound importance as the principle of dressing and incrustation. It dominated pre-Hellenic art and by no means lessened or languished as a part of the Greek style but survived in highly spiritualized fashion, serving beauty and form alone, in a sense more structural-symbolic than structural-technical".
_17. G. Semper, *Ueber die bleiernen Schleudergeschosse der Alten und über zweckmässige Gestaltung der Wurfkörper im Allgemeinen. Ein Versuch die dynamische Entstehung gewisser Formen in der Natur und in der Kunst nachzuweisen*, Verlag für Kunst und Wissenschaft, Frankfurt am Main 1859.
_18. Semper does not mention Hay's name, and erroneously dates the lecture to 1854; *ibidem*, p. 1. However, the occasion can be clearly identified on the basis of the content Semper reports. Cf. the published extracts of the lecture in D.R. Hay, *An Attempt to Develop the Principle which Governs the Proportions and Curves of the Parthenon of Athens*, "The Builder", 11, 1853, n. 527, pp. 162-164; with a more detailed report from the ensuing discussion in "RIBA Transactions", 3, 1850-1853 (no continuous page numbering).
_19. Hay 1953 (see footnote 18), p. 162.
_20. *Ibidem*.
_21. *Ibidem*, p. 163.
_22. *Ibidem*.
_23. Cf. W. Detel, *Wissenskulturen und universelle Rationalität*, in J. Fried, M. Stolleis (eds.), *Wissenskulturen. Über die Erzeugung und Weitergabe von Wissen*, Campus, Frankfurt am Main 2009, pp. 181-214.
_24. Hay 1853 (see footnote 18), p. 164. Penrose started to publish the results of his research in 1847; cf. the review of his major work, *An Investigation of the Principles of Athenian Architecture; or the Results of a Recent Survey, Conducted Chiefly with Reference to the Optical Refinements Exhibited in the Construction of the Ancient Buildings in Athens* (Society of Dilettanti, London 1852 [recte: 1851]), "The Edinburgh Review", 95, 1852, n. 194, pp. 395-405, esp. p. 395.
_25. G. Semper, *The Four Elements of Architecture* (1851), in Semper 2010 (see footnote 12), pp. 74-129, p. 80.

_26. Hay 1853 (see footnote 18), p. 163.
_27. Semper 1859 (see footnote 17), p. 2.
_28. *Ibidem*, p. 3.
_29. Hauser 1985 (see footnote 11), p. 104.
_30. Semper 1859 (see footnote 17), p. 3.
_31. Semper (1853) 1983 (see footnote 15), p. 11; cf. U. Poerschke, *Architecture as a Mathematical Function: Reflections on Gottfried Semper*, "Nexus Network Journal", 14, 2012, n. 1, pp. 119-134.
_32. Semper 1859 (see footnote 17), p. 3.
_33. *Ibidem*, p. 4.
_34. *Ibidem*, pp. 4-5.
_35. *Ibidem*, p. 5.
_36. *Ibidem*, p. 6.
_37. *Ibidem*.
_38. *Ibidem*, p. 11.
_39. G. Semper, *On the Formal Principles of Adornment and its Meaning as a Symbol in Art (second section)* (1856), trans. by K. Schoefert, S. Papapetros, "Res. Anthropology and Aesthetics" 2010, n. 57-58, pp. 299-308, p. 303.
_40. Semper (1860-1863) 2004 (see footnote 3), p. 96.
_41. Cache 2011 (see footnote 2), p. 16.