Active Matter

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Materials are regarded as passive, opaque, and refractory substances. As such, they form the base for an activity and an agency that is extrinsic to them, independent from them; that can be performed upon them and by means of them. This generic determination of a passive matter, which nowadays extends its decree over the multitude of materials, is what our contemporary culture and technology builds upon.[1] It describes ipso facto the necessity of an immaterial activity separated from matter, an activity whose position is occupied primarily by humans and their machines.

This determination has prevailed in so elementary a way over completely different technologies and media that it has long since ceased to be experienced as a historically emergent mode of creation and has instead become an unquestioned precondition for our culture's self-understanding. Today it is therefore a radical event when matter and materials are recognized in their own inner activity and creative potency. This reorientation of the material is tantamount to a return of the analog that will lead far beyond the digital age. A new vision of materials is becoming apparent, materials that are no longer passive, that can instead be understood as active and coded material.

Dead Matter

As merely passive carriers of forces and activities, materials constitute a necessary condition for cultural practices without which all human subjects, all tools, all machines, and all courses of action are rendered unthinkable. Activity is always directed toward a substrate set in motion by an external impetus, be it through thoughts as they steer the actions of the body and assume form as letters on paper, or through energies that must be exerted to activate devices in spite of their own inertia and material heaviness. This antagonism is ubiquitous as digital and material, mind and body, symbolic and physical, operative code and material carrier. The chain of action of implementation always leads from the agent to its embodiment, from the idea and the design to the work, its realization and materialization. The material itself is mere means and medium of embodiment and serves as passive carrier and neutral blank slate for symbolic and virtual operations. Nearly all our modern technologies and cultural techniques are based on this dichotomy, which has constituted, at least since the eighteenth century, a fundamental axis of our whole culture.

As early as 1766, Immanuel Kant formulated this principle in exemplary fashion as a physical as well as epistemological fact: "*Dead* matter, which fills the universe, is, according to its own proper nature, in a single self-same condition: it has solidity, extension and shape."[2] With the dimensions of "shape," "extension," and "solidity," Kant names three key determinations—form, space, and materiality. This passivity thereby appears absolutely uncircumventable; for, as Kant once again formulates in all clarity in *Critique of Judgment*, any active or living matter should prove entirely unthinkable: "And yet we cannot even think of living matter . . . as possible. (The [very] concept of it involves a contradiction, since the essential character of matter is lifelessness . . . *inertia*.)"[3]

Wood

Wolfgang Schäffner, "Active Matter," trans. William Locke Wheeler, *Conserving Active Matter* (2022),
Bard Graduate Center, https://exhibitions.bgc.bard.edu/cam/.

A glimpse into the history of materials and matter, however, reveals a rather mutable situation. In his text on technological and cultural notions that preceded the concept of "matter," Marcel Mauss describes the historical and cultural contingency of the term:

> The word matière [French for "matter"] comes from materia, a feminine noun in both Latin and French, while materies (derived, just as materiais, from mater, the feminine generative power) has yielded the word matériau [French for "material"]. In effect, materies used to be part of the vocabulary of the woodcutter and of the carpenter. It referred to the core of the tree; it was wood, the essence of all things, a solid expression connoting life. Also, it is the thread forming the woof of fabric, and it is equally the veined marble block out of which the sculptor, following the grain, will create his statue.[4]

These conceptions show that historically, entirely different roles were ascribed to material. Wood in particular, as *hyle*, is a quintessential material: one can understand it either as especially flexible and active or else as wholly passive and rigid. If a wood of the most rigid and passive constitution has been necessary for all classical objects and building elements, then so too has active wood been made useful in manifold ways, such as in shipbuilding, where wood, as it expands by becoming saturated with water, would join individual elements of the ship's hull into an impenetrable body (in a way similar to the production of wooden casks). Here the special moisture-activated agency of wood is not subjected to neutralization but rather constitutes an essential function as active material: "Wood swells anisotropically—largest size change in the direction of the annual growth rings (tangentially), less crosswise to the rings, and little in direction of the stem. In addition, different wood types swell differently."[5] This has long since been common woodworking knowledge: through a particular cutting of the wood, a corresponding responsiveness of the material was strengthened or weakened. However, the inner structure of wood was not analyzed more precisely until newer material research revealed its structural composition made of five different layers.[6]

This hierarchical construction of wood is a dynamic structure that reacts to temperature, moisture, and the application of force, and it can vary the wood's degree of stiffness or flexibility. As anything but a passive material, wood is thus a mechanism composed of intricately structured polymer elements. On all levels, wood is an active diagram of forces in the sense put forth by D'Arcy Wentworth Thompson.[7]

As with plywood, whose most significant period of development was the nineteenth century, this activeness can now be neutralized, on the one hand, by alternately layering and gluing together individual sheets of wood at opposing grain directions in order to make the wood more stable and passive. On the other hand, as composite material, wood can also be layered as bilayer or multilayer to intensify its inner mobility so the wooden object bends extremely under the influence of moisture and heat. These are quite contemporary forms under the banner of "active matter," when the intention is to use wood as sensor and motor.[8]

Iron

The industrial and technical revolutions of the nineteenth and twentieth centuries as well as current digital technologies were all made possible by the triumph of the principle of passive material. With its passivity, hardware—as classical ironmongery—penetrated all areas of life and is also still implemented today to an unprecedented degree. The digital revolution fulfills the radical passivization of matter, even in the most current developments and visions of a digitally perfectly formable matter, and thereby achieves this classical engineering paradigm on a molecular level. For, if materials are to become so utterly programmable, like pixels on a screen,[9] then what we are dealing with is not active matter in the sense of a self-activity, but rather the inscription and implementation of an external active control in passive materials, all the way down to the level of their molecules. The operationalization and agentification of the digital technologies thus solidifies the principle of passive materials, which are supposed to constitute the passive carriers of the reliable implementation of the symbolic algorithms. In the context of the industrial revolution, the fact that matter is inert and passive also generated a sizable need for motors and agents to enable a widespread mechanization and technical activation of the per se purely passive material base. The clearer the separation between active motor and passive carrier material became, the more iron prevailed as hardware and technical base, transforming the nineteenth century into an epoch of iron. In the process, wood was increasingly replaced by the new forms of cast iron and steel, not least because of its inner activity. In his *Arcades Project*, Walter Benjamin demonstrates how Paris was changed from the ground up through the "technical absolutism" of the iron constructions, which also underlay the new arcades.[10] As a new construction material, iron becomes the basis for a new architecture:

> The systematic industrial process which converts raw material into immediately available building materials begins, with iron, at a much earlier stage than with previously existing building materials. Between matter and material, in this case, there is a relationship quite different from that between stone and ashlar, clay and tile, timber and beam: with iron, building material and structural form are, as it were, more homogenous.[11]

The iron structures of the 1889 Paris Exposition, especially the Eiffel Tower and the Galerie des Machines, are exemplary here in the sense that they fully expose the steel structure in its statics. Sigfried Giedion's description of the girders in the Galerie des Machines articulates the peculiar effect that could be achieved with them:

> The last hint of columns has disappeared, it is impossible to discern where support and load flow into one another. The arching begins quite low, bent as though in the act of leaping in order to receive the load. If you will: this is the symbol of our caryatids: they bear their load with neither the dignity of antiquity nor the buckling of the Baroque. They spring toward the load in order to unite with it. The ends of the downward-tapering girders are no longer rigidly connected with the ground but are left free to move. They transmit their weight, as well as a horizontal thrust of 120,000 kilograms, directly into the foundation by a hinged joint. With this supporting structure even foundation movements can take place without creating internal stresses. This was the only means of controlling the play of forces at all points.[12]

Compared with all classical structural forms, iron construction evinces a peculiar dynamic: a "play of forces" of this kind is only possible upon an absolutely reliable and passive material base that fulfills the static demands precisely. Hence, in Giedion's description this building seems less a static architecture than a machine which immobilizes its inner forces with great effort through rigid iron girders. The technology of the nineteenth century thus radicalized mechanical engineering on the basis of the combination of rigid materials and motors: large machines made of heavy metal and lacking in their own impulsion require all the more external energy input. For this reason, machines organize a "constrained motion," as the Berliner machine theorist Franz Reuleaux put it, which generates a directed movement excluding all other movements.[13] However, this machine principle based on rigid and hard materials, which materialized in veritably iconic fashion through the multi-ton railways, prevailed equally in architecture, which was able to realize its static character more distinctly through iron constructions. This immediate connection between architecture and machine can be seen in the transition of the train rail to the basic element of the building structure that Joseph Paxton utilized in 1851 in London's Crystal Palace. "The rail," writes Benjamin, "becomes the first prefabricated iron component, the precursor of the girder."[14]

Dynamic Structures

Architecture's twentieth-century spatial revolution goes one crucial step further here when material building structures realize their dynamics in the totally unmediated sense which R. Buckminster Fuller pursued starting in the 1920s. This becomes possible precisely when one understands material no longer as a passive surface for inscription and implementation or as inert matter, but as its own set of operative mechanisms wherein design and designed object coincide. Fuller divested architecture of precisely this sense of passive materiality:

> I often hear it said in our technical schools, and by the public, that architects build buildings out of materials. I point out to architectural students that they do not do that at all. That kind of definition dates back to the era of men's thinking of matter as solid. I tell architectural students that what they do is to organize the assemblage of visible modular structures out of subdivisible modular structures. Nature itself, at the chemical level, does the prime structuring. If the patterning attempted by the architect is not inherently associative within the local regenerative dynamics of chemical structure, his building will collapse.[15]

Fuller shifts the perspective on passive material to active, dynamic structures, which become the actual structural forms of architecture. The Parisian iron buildings of 1889 already showed how these active structures eliminated the massiveness of structural components when columns became hollow bodies. Yet it isn't until the lightweight construction method as designed by Fuller, with his geodesic domes and their supporting frameworks and tensegrity structures, that this transition from passive material to dynamic structure becomes possible in architecture as well.[16]

These configurations reveal the extent to which classical building materials such as stone and iron are replaced by lightweight and dynamic structures. This structural and spatial revolution is an important line in the historical genealogy of active matter, which is nowadays manifesting as the New Structuralism in architecture and also in the field of materials sciences.[17] The latter are tied to the great iron eras insofar as they originated in metallurgy, through which people began to explain the special properties of the material by probing its microstructure.[18] In so doing, additional properties including structure and functional relationships were made visible. In contrast to the homogeneous structures of metal or stone, biological materials in particular display astoundingly active functions, which became models for innovative bioinspired technologies. Age-old knowledge of active wood was also profoundly renewed in that now the inner structure responsible for this activity could undergo analysis.

Image

With dynamic material and spatial structures, two components of the classical concept of dead and passive matter as formulated by Kant are agentified. Alongside "solidity" and "extension," however, Kant also named "shape" as matter's dimension of form. How, then, do image and shape transform under the banner of active matter as essential components of the material? What role does the image play here if it amounts to an active process rather than a static representation? The role of artifacts and the practices linked to them changes against this backdrop of materials that develop, on the basis of their inner reactive and adaptive structure, an activity of their own whose coding is intrinsic and does not require external input. Structures that react flexibly, such as tensegrity structures, or wood, which is formed in a way that enables it to act as sensor and motor, constitute coded base elements for a new infrastructure of active materials. This also means a change from the radical opposition between code and material as active symbolic order and passive carrier to a symbolic materiality. Consequently, material itself in its active structure becomes definable as symbolic structure. Whereas the discrete alphanumeric operations in the analog always require great effort to be realized and implemented, analog structures connect code, materialization, and implementation directly. It is no longer a question of an implementation of the symbolic in material; instead, material itself becomes active in its symbolic structure, on the basis of analog algorithms.

If the symbolic function can be described as material process, then there is a change in both the distance between words and things, which is elementary to the alphanumeric code, and the mere doubling of the physical world through the virtual. Active matter as a fusion of symbolic and material processes signifies material that itself contains code qualities. If spatial-material structures also have symbolic character, then not only do images as symbolic structures represent the world of things; they also act as symbols in the sphere of the material.

This is not possible on the level of the alphanumeric code. It is only possible through images that act as analog geometric operations and thereby embody their own hardware and that hardware's implementation: for images do what they show, while letters and numbers need additional external operators to execute and control their symbolic operations. Accordingly, images as material, spatial, and active structures illustrate the special symbolic dimension of a new analog code. In this respect, active matter as operative structure is also always image, and in this sense a special one, if not the pivotal epistemic implementation within a history of "intrinsic image acts."[19]

In contrast to numbers and letters, however, the symbolic operations of images require no more human actors, because they act on their own, both in artifacts and in natural objects. Biological materials, which to a special degree embody the active character of matter and thereby also an inherent symbolic dimension of form, therefore become special guiding principles for the formation of active materials. The postdigital age of an active matter and the return of the analog associated with it would hence also be an age in which images embody material-symbolic operations in a novel way.

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Notes

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[1] Bensaude-Vincent, “Concept of Materials.”
[2] Kant, “Dreams of a Spirit-Seer,” 316.
[3] Kant, *Critique of Judgment*, 2.2, § 73.
[4] Mauss, “Conceptions Which Have Preceded,” 142.
[5] Höhne and Tauer, “Studies on Swelling of Wood,” 245.
[6] Cf. Fratzl and Weinkamer, “Nature’s Hierarchical Materials,” 1268.
[7] Thompson, *On Growth and Form*.
[8] Burgert and Fratzl, “Actuation Systems in Plants.”
[9] Ishii et al., “Radical Atoms.”
[10] Benjamin, *Arcades Project*, 157.
[11] Meyer, *Eisenbauten*, 23, quoted in Benjamin, *Arcades Project*, 157–58.
[12] Giedion, *Building in France*, 139.
[13] Reuleaux, *Kinematics of Machinery*, 91.
[14] Benjamin, *Arcades Project*, 4.
[15] Fuller, “Conceptuality of Fundamental Structures,” 68.
[16] Fuller, *Synergetics*.
[17] Schäffner, “New Structuralism.”
[18] Bensaude-Vincent, “Concept of Materials,” 114–15.
[19] Bredekamp, *Image Acts*, 193–264.

