2

SYSTEMS OF PROPORTION AND NATURAL SCIENCE

The famous dispute between Perrault and Blondel touched upon a fundamental issue, one that concerned the very meaning of architecture itself. The new theory, ultimately founded on the modern mechanistic world view, was haunted by an incipient subjectivism, which caused it to question its own ability to provide absolute and rational justifications of *praxis*. I have already pointed out that during the period between 1680 and 1735, the new epistemology ushered in by Galileo was felt with particular intensity. During the first decades of the eighteenth century, architects were generally very interested in technical problems and in their mathematical solutions.[1] This protopositivistic interest generally went hand in hand with criticism of traditional theory.

In 1702 Michel de Fremin published an astonishing little book entitled *Mémoires Critiques d'Architecture*, in which he defined architecture as "the art of building according to the object, the subject, and the place."[2] Taking to their logical conclusion some of the ideas expressed by Claude and Charles Perrault, Fremin questioned, for the first time in the history of Western architecture, the traditional primacy of the classical orders. He pointed out that a knowledge of the orders and their proportions constituted only a minimal part of what architecture truly was.

Fremin's book deals essentially with problems of construction but also emphasizes that the architect is not a mason; his role is to coordinate rationally all the operations of building.[3] Fremin believed that the architect had to control mentally the totality of the process of design and construction, making sure that all he imagined possessed absolute unity and coherence. He thought that good architecture had to be rational and used Gothic examples to illustrate what he had in mind. Fremin preferred Notre-Dame or the Sainte-Chapelle over the recent Baroque architecture, which he disliked and criticized, including the work of Blondel.

Fremin was also suspicious of seductive architectural drawings that were merely nicely rendered but lacked "architectural consistency."[4] This implied an understanding of drawing as a reductive technical tool, an understanding that would only become widespread in the nineteenth century.[5] While drawing had always expressed an architectural intention, the distance between its specific universe of discourse and that of "real building" had never been a problem.

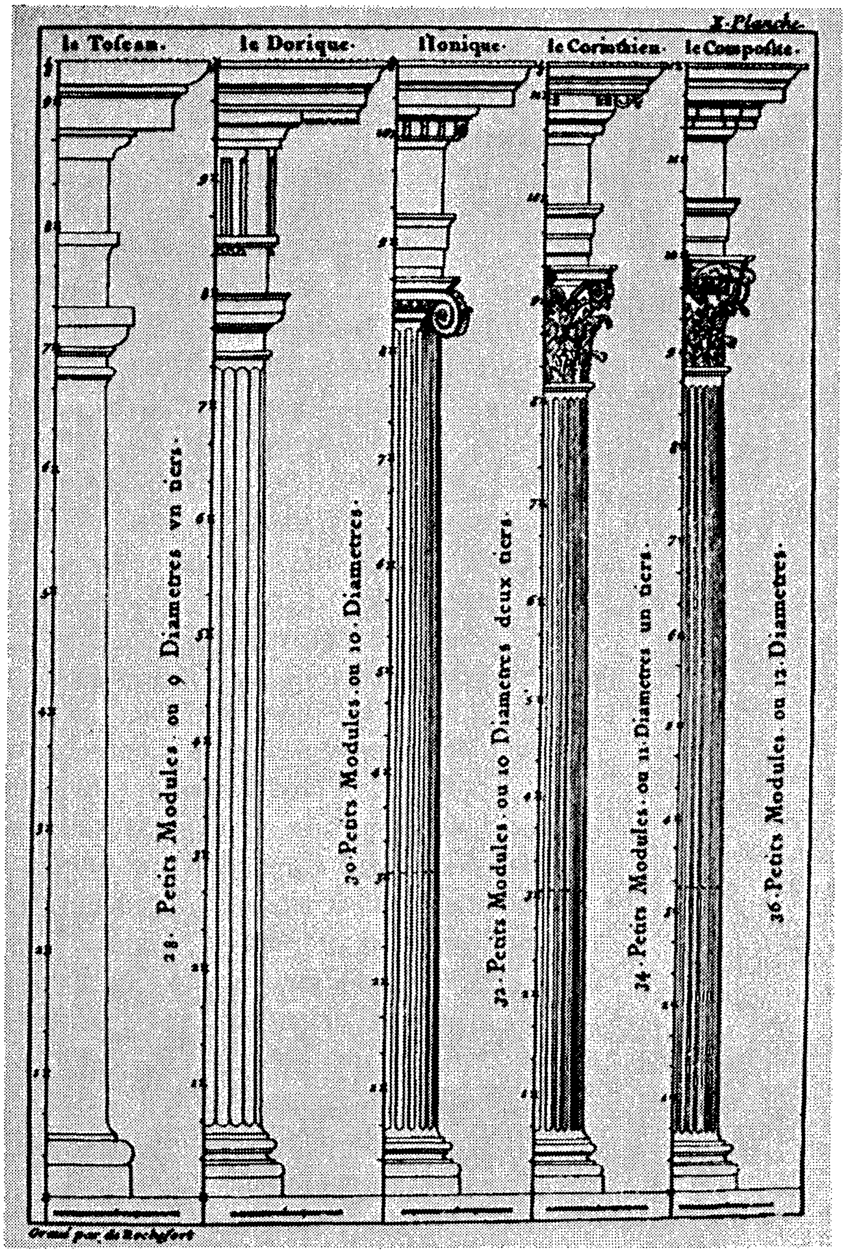
Fremin's understanding of theory, his perception "of that which constitutes true architecture," his attitude toward drawing, and his derogatory comments about "insignificant" architects who speak only about the classical orders, betray a truly protopositivistic attitude. He was totally oblivious to the metaphysical dimension of theory.

Perrault's influence appeared most explicitly in Abbé Cordemoy's *Nouveau Traité* (1706),[6] in which the defects and bad taste in most buildings are attributed to a lack of knowledge of the principles of architecture.[7] Believing that traditional treatises were useless because it was impossible to take from them the dimensions and proportions of the orders, Cordemoy praised Perrault's *Ordonnance*: "This book is the only one from which craftsmen can profit. [Perrault] provided a certain and comfortable rule for the dimensions and proportions of each order. He has even inspired the idea of beauty."[8]

Cordemoy invariably avoided any discussion of the critical questions concerning the relation between proportions and beauty. In this respect, he found Perrault "too verbose, confused, and rather obscure."[9] He never examined in his treatise the implications of proportion, except for a definition of the term that he included in the *Dictionary* added to the second edition.[10] After transcribing some opinions of Vitruvius, Cordemoy affirmed the importance of establishing a module that would allow the spectator to judge the dimensions of a building. This dimensional comparison permitted the beauty, majesty, and impact of the building to work upon the intellect. However, Cordemoy ignored the transcendental implications of proportion. He never seemed interested in establishing the actual numerical value of the module. Proportion and beauty seemed to have become problems of intellectual judgment, of relative scale rather than absolute value.

The lack of importance that Cordemoy attributed to the issue of proportion is in itself significant. He reproduced in the *Nouveau Traité* Perrault's simplified system based on the *petit module*, repeated the story about it being the most primitive, and blamed defective craftsmanship throughout history for its abandonment. Cordemoy also believed that mathematical precision was indispensable in theory. But the meaning of proportion was not even worth discussing. He seemed to be interested in the virtues of Perrault's system only as an *ars fabricandi* for craftsmen.

Perrault's immediate impact can also be discerned in the work of Sebastien Le Clerc, whose diverse interests ranged from the formulation of a cosmological system in which he tried to reconcile the Bible with Descartes's physics, to the invention of a curious theory of perception, in which only the right eye was capable of



Perrault's system of proportion, reproduced by Cordemoy in his *Nouveau Traité*.

clear vision.[11] In his *Traité d'Architecture* (1714), Le Clerc repeated Blondel's plea for all architects to learn mathematics and its related disciplines, including mechanics, leveling, hydraulics, perspective, and stonecutting.[12]

After comparing the proportions for the classical orders recommended by Vignola and Palladio, Le Clerc concluded that their rules were arbitrary, a product of their own taste and genius.[13] He also observed that it was possible to change the proportions of smaller elements such as triglyphs and metopes without offending even those most knowledgeable in architecture. Le Clerc insisted on the "absolute necessity of geometry" in architecture and described this science as the foundation of the principles that guide architectural practice.[14] Like Perrault, Le Clerc distinguished between a necessary "rational" geometry and the contingent proportions of the classical orders.[15]

Building upon these conclusions, Le Clerc decided to postulate his own system. Significantly, however, this is where the similarities with Perrault end. Le Clerc established his proportions through discussion and observation. Although there were often different proportions recommended for the same order, "it is unquestionable that among them some are more pleasing and receive universal approval."[16] He believed that his own personal taste could discern the better rules. Thus, instead of postulating an a priori mathematical system, Le Clerc thought that his rules had to be constituted a posteriori. His more humble attitude evinced no interest in controlling practice through a rational theory, and on the surface his discussion of proportions seemed merely traditional. In fact, however, his thought started to reveal a different set of epistemological presuppositions. In his theory, taste was already capable of stemming the menace of relativism while maintaining the possibility of reason—an early sign of the Neoclassical world.

Amédée-François Frezier, author of a famous treatise on stonecutting, was a long-lived architect and military engineer.[17] Interested in science and construction, he was aware that geometry and mathematics were the basic disciplines providing the means for the implementation of technical operations. For Frezier, architecture was mainly a problem of rational building, and in several literary disputes with the most famous Neoclassical theoreticians, he argued that arches and piers were more suitable for stone construction than the column and lintel systems preferred by the architects and patrons of the Enlightenment.[18] It is particularly interesting, therefore, to observe the way in which he interpreted Perrault's ideas in his *Dissertation sur les Ordres d'Architecture* (1738).

Frezier recognized along with Perrault that there were no fixed rules in architecture. Ornament changed constantly, and therefore "it has no real beauty."[19] He admitted that "fashion reigns over the classical orders" and that it often determined our idea of beauty. But unlike Perrault, he never accepted custom as a positive force: "Fashion is not always a certain rule for judging what is beautiful or deformed."[20] Custom no longer determined a choice of proportions, which were then identified with "positive beauty" through association. Instead, it became a negative factor that prevented the appreciation of true natural beauty.

Frezier believed that the classical orders should be strictly subjected to rational laws, which could guide architecture toward "purely natural beauty."[21] And he believed it was possible to establish such rational principles, independent of the diversity of personal tastes and opinions: "Everyone would accept that the imitation of a natural thing is a cause of pleasure . . . and being perfect, a copied object derived from a beautiful nature is a cause of even greater pleasure than the original. . . . If it exists, the universal rule of the orders should be founded on the imitation of Natural architecture."[22] The point was, in Frezier's opinion, to establish the principles of this "great art . . . which has often even been called a science" and to obtain them from the most simple things. This, in turn, would lead architecture back to its origins. Natural architecture was simple, like Nature itself in eighteenth-century science.

After an evocation of primitive architecture taken from Vitruvius, Frezier discussed the appropriate number of architectural orders.[23] Inspired by the methods of natural philosophy, he declared his intention to reduce the number of principles to the least possible. Acknowledging only three ways to build: heavily, lightly, or in an intermediate manner, he concluded that there should also be only three orders: Doric, Ionic, and Corinthian. The Tuscan and Composite, normally accepted since the Renaissance, were rejected.

Frezier believed that man had a natural idea of the proportions between the dimensions of a column and the weight it carried. It was obvious that columns more squat than Doric or taller than Corinthian could be built. But the former lacked "grace," while the latter, although perhaps physically stable, would appear as dangerous and thus be unacceptable to the human intellect. Building should possess not only real stability but also "visible solidity."[24]

With this in mind, Frezier applied his natural common sense and experience to the determination of the maximum and minimum acceptable proportions and attributed them to the Doric and Corinthian orders. The proportions of the Ionic order were obviously the *juste milieu* between the two extremes and resulted from an arithmetical average of their dimensions. Frezier pointed out that in applying this system, it becomes possible to determine the proportions of the essential parts of each order: the column and the entablature. The greater weight should always be carried by the wider columns. But the adjustment of dimensions, he added, should be left to the good taste of the architect.[25]

Discussing the issue of proportion, Frezier recognized the great differences among traditional systems. Architects had chosen diverse modules, dividing their dimensions in extraordinarily complicated ways. However, Frezier questioned the "scientific" thoroughness of his predecessors, suggesting that perhaps their irrationality was intentional, "as if they had tried to complicate this frivolous issue and give an air of mystery to this art, which is almost totally arbitrary in that concerning the small subdivisions."[26] Frezier thus rejected the inveterate symbolic connotations of architectural proportion, maintaining that the dimensions recommended by architects and writers of the past were based only on their particular tastes. Numerical relations, then, did not constitute a mysterious guarantee of architectural beauty.

Like Perrault, Frezier believed that the "causes" of beauty should be visible and not merely speculative. But Perrault had postulated an a priori, mathematically perfect system of proportions, emphasizing its formal rather than its transcendental dimension. This, of course, was the only possible scientific solution to the problem in the epistemological context of the late seventeenth century. During the Enlightenment, however, the meaning of life itself would become visible in the operations of Nature, as revealed by the new empirical science. Frezier could therefore assert that the principles of architecture should be founded on the laws of nature and stem invariably from observation and not from a merely conceptual operation.

Thus Frezier established the essential proportions of his three orders, defining the relations among the heights of columns, their diameters, and the dimensions of their entablatures.[27] His proportions were simple, but they were never intended to become a mere tool of design. They were not arbitrary but natural and were therefore believed to be the most perfect, constituting a true source of pleasure. Even with regard to minor details, Frezier ended up admitting the existence of proportions, "which it is not possible to alter considerably."[28] The dimensions of doors and windows, for example, cannot be changed because their beauty "derives from a natural sentiment through which we relate everything to the dimensions of our body and to our needs, even before reason has determined their convenience."[29] To prove his point, Frezier stated that if humans had the proportions of sheep or birds, they would prefer square or circular openings. But because humans are approximately "three times as tall as . . . wide," these are the proportions that are considered beautiful. This phenomenological return to reality, with its emphasis on preconceptual perception as a fundamental source of meaning, would become normative in the natural philosophy of the Enlightenment.

Frezier provided an excellent summary of his own position when he declared himself "only partially (*de moitié*) in accord with Perrault on the insufficiency of proportions as a source of real beauty."[30] His theory of architecture, founded on the epistemological framework defined by eighteenth-century empirical science, sought to recover an explicit, traditional interest in absolute value (identified with mathematics) while accepting without contradiction the increasing power of reason.

A similar attitude was adopted by Père André in his influential and popular *Essai sur le Beau* (1741). André believed there were two types of rules in architecture: (1) rules that were necessarily equivocal and uncertain, resulting from the observations of diverse masters in different times; and (2) rules that were visible and conducive to positive beauty. André thought that the proportions of the classical orders were in the first group, but he also stressed the geometrical character of the second type of rules, which were "invariable like the science of architecture itself."[31] Essential geometrical principles, such as the perpendicularity of columns, parallelism of floors, symmetry, and perceptual unity, were always to be observed. In fact, André considered all regularity, order, and proportion to be attributes of essential beauty.

As the century grew older, Perrault's precocious distinction between technical necessity and contingent aesthetic considerations seemed to vanish from architectural theory. The dimensions of number and geometry as technical instruments or symbols began to be perceived as complementary in considering architectural value. Around 1750 preference for François Blondel's position in the famous dispute was practically universal, whereas Perrault's ideas often evoked criticism. The most explicit refutation of Perrault's theories appeared in Charles-Etienne Briseux's *Traité du Beau Essentiel* (1752), which sought to show the falsity of Perrault's ideas through the opinions of prestigious writers and evidence derived from "physical explanations and experience."

Briseux accepted that progress in art and science was prompted by a healthy expression of diverse opinions, but he believed extreme subjectivism was dangerous. An obstinate adherence to a certain position, "frequently motivated by the false honor of defending a singular system," often makes men lose sight of their own internal convictions.[32] Briseux speculated that Perrault's defense of a system of proportions "that had absolutely no relation to the beauty of buildings" might have been prompted by such human weakness. In Briseux's opinion, Perrault, perhaps offended by Blondel, had become insensitive to his own knowledge, the opinions of other authors, and the unquestionable evidence of experience. What caused him the most concern was the vast influence he thought the *Ordonnance* had exerted on other architects. Significantly, Briseux was aware that Perrault's system of proportion never became popular with eighteenth-century practicing architects. The issue was not simply one of immediate application. Briseux understood that the potential freedom from traditional principles, implicit in Perrault's theory, had made itself felt during the first half of the century. The ornamental exaggerations of Rococo, popular after 1715, were a clear manifestation of this influence.[33] Distinct from Baroque architecture (though certain formal similarities remain), Rococo eschewed theory. Only pattern books were used as sources of images. Taking their cue from Perrault, some architects felt themselves liberated from the authority of antiquity and resorted to a superficial, purely visible understanding of nature as a source of forms. By midcentury the nonmetaphysical nature of *rocaille* had been replaced by the Nature of Newtonianism, of which more will be said later. At this point, Rococo was universally condemned as decadent by the theoreticians of Neoclassical architecture.

The impact of Perrault's incipient *ars fabricandi* was also felt in the Royal Academy of Architecture, where discussions during the first half of the century dealt mainly with technical questions. This obviously reflected the general interest of architects and caused Briseux to complain that the true "principles of architecture" were no longer taught by professors who followed the banner of Perrault.[34] Briseux considered the *Ordonnance* to be exceptionally obscure and full of contradictions. His refutation seems traditional at first glance. He asserted the analogy between the causes and effects of beauty in architecture and music and carefully justified his belief. In music, the harmonic relations, although not generally understood by the public, were nevertheless the source of pleasure. Equally, in architecture, the observer did not measure "geometrically" the building with his eyes before receiving the "sensation" of beauty. But "a sort of natural trigonometry" seemed to play a large role in the judgment of "the spectator who possesses a natural taste."[35] "The sensation of beauty" always depended on the observance of proportions, whose knowledge was the responsibility of the architect.

Briseux firmly stated that reason underlined all those products of "art and Nature" that were beautiful. This is an indication of Briseux's fundamental belief in a transcendental Nature and in the absolute character of its laws. His *Traité* attempted to prove the visibility of harmonic proportions in architecture and to show their origin in the mathematical laws that governed nature itself. Such proportions might then be said to be "analogous" to the human intellect, which perceives them with pleasure, and thus be posited as the unquestionable cause of essential beauty.

Briseux's text begins with a poetic glorification of Nature, "our fecund mother that leaves nothing to chance."[36] Nature is described as a projection of the human body, the ultimate model of just proportions, providing the true idea of harmony and symmetry. Harmonic proportion, moreover, had its origin in nature. The famous experiments of Pythagoras, who had subdivided a string into fractions producing harmonic consonances, clearly proved this point. Briseux then related how the ancients "inferred" from this observation a common principle of beauty, one that derived from the law of harmonic proportion, which was itself part of nature and did not depend on the visual or auditive character of our sensations. The human intellect, the judge of all "sensations," thus received from each of the senses uniformly pleasant or disagreeable "impressions".

But it was clear to Briseux that "the Creator established a natural sympathy between certain sounds and our emotions" that was not as explicit with regard to the inanimate objects of the visible world. The traditional justification of antiquity no longer seemed sufficient. Briseux was then forced to reformulate the question of this relation in a more rigorous and scientific manner. His conclusions reveal the most fundamental sources of his thought: "The rainbow provides an excellent example; its colors are clearly distinguishable, but everything is reduced to unity. According to the experiments of the renowned Newton, this marvelous effect originated from the correspondence between the proportions of the spaces occupied by the seven colors and that which regulates the intervals between the seven musical tones: a natural 'tableau' that the Creator offers to our eyes, in order to initiate us in the system of the arts."[37]

By invoking the name of Newton, Briseux hoped to give legitimacy to his "intuitions." It was evident that Nature always operated with the same wisdom and in a uniform manner. Therefore no one could question that both auditive and visual pleasure consisted "in the perception of harmonic relations analogous to our human constitution" and that this principle was true not only for music but for all the arts since "one same *cause* cannot have two different *effects*."[38]

Briseux also stressed his rejection of Perrault's distinction between the specific characteristics of visual and auditive sensations from the point of view of the subject: "The mind is touched in a uniform fashion by all commensurable objects."[39] This is significant because both Briseux and Perrault clearly shared the notion of perception *partes extra partes*, understood as an intellectual association of sensations transmitted by independent, specific senses. But Briseux, believing in the existence of a mathematical structure that linked the external world with the human intellect, could "recover" the primordial sense of preconceptual, embodied, and undifferentiated perception: "The mind judges all types of impressions in a similar and uniform way, this being an indispensable necessity, a sort of law that has been imposed by Nature."[40]

Briseux may not have fully appreciated the importance that proportions and arbitrary beauty had in Perrault's system.[41] However, his main criticism was perfectly valid in his own epistemological context. Perrault's proportions were not derived from the observation of nature, and so his system was despised by most architects precisely because it was totally intellectual and a priori. This explained, in Briseux's opinion, why Perrault's relatively small variations had "visibly altered the beauty" of the classical orders.

Briseux accepted the existence of a diversity of tastes, but he always reconciled any divergences with his belief in an absolute beauty that depended on "geometrical principles" and was derived from Nature. He thought that the rules of proportion, founded on "calculation" and "experience," constituted invariable principles that allowed the architect to "operate justly" and were indispensable for perfecting his innate talent: "In vain have the followers of Perrault pretended that there are no rules but those of taste."[42] On the other hand, Briseux emphasized that it was not sufficient to follow certain theoretical proportions literally in order to design a meaningful building. The architect's taste, perfected through experience, was ultimately responsible for the appropriate choice of dimensions. Taste was not synonymous here with pure, arbitrary subjectivity. It was perceived by Briseux as capable of correcting any conceptual system, including Perrault's. Resulting from experience and the observation of Nature, it had a transcendental and intersubjective character, and was thus incapable of distorting the true natural systems of proportion.

In sharp contrast with the intentions of Perrault's *ars fabricandi*, Briseux never pretended to reduce practice to theory. This is evident in the second volume of his *Traité*, where he illustrated his harmonic proportion applied to the classical orders without the use of numerical dimensions. Briseux merely drew graphic scales along buildings and elements of the orders demonstrating the existence of dimensional relations. He did not provide specific measurements or a module that might allow the translation of any illustration into a building. It is clear that his theory deliberately kept a distance from practice. Unquestionably, Briseux understood the values of the latter, which accounts for the apparent contradiction in his statements about taste. True taste was a warrant of architectural meaning at the level of practice, and Briseux's theory was an indispensable complement and guide, not a substitute. The role of theory as a justification of practice prevails here over its utility as a technical instrument.

Other architects and theoreticians during the second half of the eighteenth century adopted similar attitudes. Germain Boffrand, for example, believed that although acceptable buildings might be constructed without using the orders, proportions were absolutely indispensable.[43]

Boffrand, a member of the Royal Academy of Architecture and the successor of Jacques Gabriel in the leading post of the *Corps des Ponts et Chaussées*, published in 1745 his *Livre d'Architecture* along with an interesting technical study on how to cast in one piece a bronze equestrian statue of the king. Interested in a wide variety of technical and artistic subjects, including machinery, the centering of bridges, lock construction, methods of mensuration, and Gothic and Arab architecture, Boffrand, like François Blondel, attributed the beauty of some Gothic buildings to their just proportions. For him, the most important function of the architect was to choose appropriate rules of proportions. He thought that nature formed the germ of the arts, but that reflection and experience nurtured it and allowed it to develop. "Perfection derives from an excellent imitation of the *belle Nature*", which was also the origin of the principles of Greek and Roman architecture. Ancient models could, therefore, become once again a legitimate source of meaning.

Boffrand's small treatise examines certain relations between the classical orders and the different styles and genres described by Horace in his *Art Poetique*. His analogy was still clearly metaphoric. Architecture was a poetic activity in the sense of Aristotle's *poesis*, an action with transcendental objectives, determined by an implicit thrust to reconcile man with a cosmic order. Boffrand's primitive semiological study, however, stemmed from a belief that, once divorced from metaphysical concerns, would become the very source of modern structuralism. The fundamental point of departure for his work was the identity between the principles of the arts and those of the sciences, both of which are founded on mathematics and geometry. Geometry, he thought, could be applied to any science, so that "a study of one subject can bring new knowledge to another."[44]

The abbé and *homme des lettres* Marc-Antoine Laugier, the most influential theoretician of French Neoclassicism, also believed that architecture should have as sound principles as does science.[45] In the preface of *Essai sur l'Architecture* (1753), Laugier rejected the notion of a theory reduced to an *ars fabricandi*. He stated that in all those arts that are not purely mechanical like architecture, it is not sufficient to know how to proceed; the author should learn to think. An artist should be able to explain to himself why he does what he does: "For this reason, he needs fixed principles to determine his judgments and justify his choices."[46]

Laugier maintained that architecture had never been founded on true, rational principles. Vitruvius and all his modern followers, with the exception of Cordemoy, had only recounted the practices of their own times, but had never penetrated the mysteries of architecture. To Laugier, practice often misleads artists from their true objectives: "Every art or science has a definitive objective. There is only one way of doing things right."[47]

In order to establish "evident" principles that could be the basis of invariable precepts for practice, Laugier adopted an empirical method. He used "experiments" and observations to ascertain that the most beautiful buildings and objects produced the same positive or negative impressions on himself and others. After repeating these experiments a number of times, he became convinced that there were essential beauties in architecture, independent of custom and convention.[48]

Laugier was an eminent historian, so confident in his rational judgment that he could criticize the traditional political status quo.[49] He openly admitted his faith in the progress and evolution of architecture. But the abbé also believed that his *Essai* contained infallible and truly fixed rules, and that his efforts to discover "the causes of the effects" produced by certain famous and beautiful buildings were totally successful. Laugier's *logos* was certainly rigorous and inquisitive, thoroughly shaping his theory, but never betraying a superficial interest in formal or technical control. His fundamental concern was to disclose the possibilities of meaning in an activity that appeared increasingly in crisis because of its lack of principles but that was, according to him, crucial for the coherence of culture. Following from his premise that there was meaning in the world (*Nature*), Laugier aspired to understand the act of creation, and thus looked back to the origins of architecture. The final answer to his metaphysical question was necessarily a myth.

In the first chapter of his *Essai,* he described the essential elements of architecture that can be derived from the primitive hut: the architecture of man in an idyllic, unprejudiced, and natural state. The columns, architraves, and pediments that constituted the hut were put forward as the *only* essential elements of architecture. During the earlier part of the century, architects and engineers had been more aware of the differences between the values of *firmitas* (physical stability, durability) and those of *venustas* (beauty). Before Perrault, this fragmentation of value had never played a role in architecture.[50] Striving to save meaning, Laugier emphatically identified the fundamental parts of the classical orders (ornament in Renaissance theory) with the very structure of the building. In spite of his differences of opinion with Frezier regarding what constituted the most rational form of construction, this attempt to reconcile the traditional values responded to the same concerns that the military engineer had first revealed in his *Dissertation.*

Frontispiece of Laugier's *Essai sur l'Architecture*, showing the primitive hut as a source of architectural principles.

The great impact of Laugier's *Essai* has been widely studied.[51] His "essential elements" became the favorite forms of Neoclassical architecture, and his ideal church was obviously the germ of Soufflot's project for Sainte-Geneviève, later to become the French Pantheon. But Laugier also published some twenty years later a second book, *Observations sur l'Architecture*. In this less popular text, he upholds the fundamental importance of proportions; this is so essential to architecture that, in his opinion, a well-proportioned building will always produce a positive effect, independent of the richness of its materials or ornamentation.

In the *Essai*, Laugier criticized Briseux for having invested so much effort only to prove a self-evident truth. No one with a minimum of knowledge about architecture would deny the necessity of proportions.[52] Furthermore, Laugier thought that Perrault had understood the absurdity of his own argument and defended it only out of stubborness, while Briseux, in his opinion, would have fared better if he had tried to discover and postulate rational rules of proportion.

This is precisely the task Laugier undertakes in his *Observations*. His objective is to establish the "science of proportions" on more solid grounds. A precise rational operation always has to be involved in the choice of dimensions; rules of proportion must be applied to not only the classical orders but many aspects and parts of a building. Laugier was critical of previous authors who had merely copied Vitruvius in their systems of proportion without pondering their importance. He himself wished to provide an adequate justification of proportions, "raising slightly the thick curtain that hides this science."[53]

His text is a rational tour de force that tries to establish a theory of proportion based exclusively on "visual" evidence. Three criteria of judgment are put forward: The first essential requirement for a correct proportion is the "commensurability" of the two compared dimensions, the exactness of their correspondence. The second requirement is "sensibility" and refers to the ease with which the relationship can be perceived, 3 : 5, for example, being better than 23 : 68. The third category is the "proximity" of the proportional relation to the perfect ratio (1 : 1); 10 : 30 is worse than 10 : 20. There is no further rational justification with regard to the choice of proportions. Numbers have to be simple and natural. Most important, however, was Laugier's belief in the essential character of dimensional relations generating meaning in architecture. Proportion, like the essential formal elements of his *Essai,* is ultimately derived from an ordered and harmonious nature whose *mathemata* could be evidently perceived by man.

After Laugier, the contradictions between taste and reason, which had been posited earlier in the century by Cordemoy, Briseux, and the abbé Dubos, were thoroughly reconciled.[54] They both, of course, were derived from Nature. Defending his position from the criticism of Frezier, who had brought up the issue of arbitrary beauty in a review of the *Essai,* Laugier categorically pointed out that there was an essential beauty in art, often difficult to define by reason, but absolutely evident to our hearts and perceptions.

The notion of simplicity as a source of beauty underlined architectural intentions during the second half of the eighteenth century and appeared in many theoretical works. In his *Traité des Ordres d'Architecture* (1767), one of the last manuals of this type ever published, Nicolas-Marie Potain declared his intention to elucidate the origin of the five orders, which are "derived from one common principle."[55] He adopted the prototype of the primitive hut and postulated it as a model for both the essential formal elements of architecture and his own system of proportions. Also, several scientists and philosophers of that period referred to architectural proportion in terms similar to Laugier's, for example, Christian Wolff, whose contribution will be examined in the following chapter, and Leonard Euler, the exceptional mathematician who determined the equations for the buckling of columns long before this phenomenon could be tested experimentally. In his *Letters to a German Princess,* Euler discussed musical harmony, rejecting its cosmological implications. However, he still thought that natural proportions, expressed in small numbers, were more clear to the intellect, thereby producing a feeling of satisfaction. He maintained this was the reason why architects always followed that norm, using the simplest possible proportions in their works.[56]

Compared to philosophers and *hommes des lettres* such as Wolff or Laugier, engineers and architects of this period obviously were more interested in technical problems. But the differences in interest should not hide the profound similarities of their theoretical assumptions. Jacques-François Blondel, the most important architectural teacher in France around midcentury, still conceived of architecture as something of a universal science. In 1739 he instituted a school of architecture, independent of the Royal Academy of Architecture, which taught that the architect should be knowledgeable in science, philosophy, literature, and the fine arts.[57] And while accepting the differences between naval, civil, and military architecture, Blondel praised the achievements of Frezier, François Blondel, and Vauban, all simultaneously architects and military engineers.

Jacques-François Blondel's ambition may have seemed unwarranted at a time when the first specialized schools of civil engineering (*ponts et chaussées*) and military engineering (*génie militaire*) had already been established in Paris and Mezières. What is significant, however, is the great number of similarities between the program of studies at Blondel's school and the curriculum of the two technical institutions.[58] Blondel's course actually became a requirement for admission to the *École des Ponts et Chaussées*.[59] It included, aside from the theory of architecture, the history of proportions, drawing, ornament, and sculpture, many technical subjects, such as mathematics, geometry, perspective, topography, mensuration, and the properties of the conic sections necessary for stereotomy. In his *Cours d'Architecture*, a vast work that summarized his pedagogical career, Blondel added other subjects to the list, such as mechanics, hydraulics, trigonometry, principles of fortification, and experimental physics "relative to the art of building."[60]

In the first volume of his *Cours*, Blondel emphasized architecture's usefulness, claiming it as the basis of all works that physically transformed the world of man. Not only temples and public buildings but also bridges, canals, and locks fell within its province. Throughout the eighteenth century, engineers and architects still shared a theoretical framework and a basic intentionality derived from common principles, so that their individual areas of action were not mutually exclusive. Many civil and military engineers such as Gauthey and Saint-Far frequently built churches and hospitals. Gauthey, the author of an important book on the structural analysis of bridges, also wrote about architecture and adopted Laugier's principles.[61] Perronet, a renowned civil engineer and founder of the *École des Ponts et Chaussées*, was also a member of the Royal Academy of Architecture. In a similar position was the mathematician Camus, who wrote his *Cours de Mathématiques* for the students at the academy and then saw his text adopted by the military schools.

Jacques-François Blondel's extensive *Cours* pretended to be the first truly universal encyclopaedic work on architecture. The similarity with the aims of the *philosophes* is, of course, not coincidental. Blondel admitted that except for the problem of distribution, all that could be considered as essential in architecture had been discussed previously. His text is basically a compilation and systematization of the most important and prestigious theories of the past.

In the second volume of his *Cours*, Blondel systematically studied the "distribution" in plan of different types of buildings (*genres d'édifices*), such as Greek cross, Latin cross, and centralized churches, cathedrals, markets, and convents. He was fascinated by room combinations and their relation to land use. An interest in typology led him to write the first consistent exposition on the subject in Western architecture. In contrast to nineteenth-century formulations, his types never referred exclusively to utilitarian or formal categories. His general eclecticism notwithstanding, Blondel never affirmed that the value of a building might result simply from the appropriate distribution or combination of its parts in plan.

Blondel recounted in a traditional way the story about the mythical origin of the classical orders and reproduced the proportional systems of Vignola, Palladio, and Scamozzi. His understanding of fashion was very confused, but in the end, he also considered taste as a positive criterion for the appreciation of beauty. Natural taste, although innate, could be perfected through the comparison of great master works, "becoming a banner to guide artists in all their productions."[62]

Blondel often stated that the problem of proportion was the most interesting part of architecture.[63] In his *Cours*, he tried to prove that architectural proportions were derived from nature, citing the opinions of great masters. Although he could understand the differences between visual and auditive sensations, he still believed in the analogy between architectural proportion and musical harmony. Without mentioning Perrault by name, Blondel criticized "those authors that have considered proportions as useless, or at least arbitrary." Basing their theories on independent systems, these authors rejected fundamental laws and traditional principles, pretending that there were no convincing demonstrations in favor of architectural proportions and that a lack of innovation was synonymous with timidity. After measuring many beautiful buildings, Jacques-François Blondel repeated in almost identical words the original refutation of François Blondel, concluding that the source of true beauty in architecture consisted essentially in proportional relations, "even though it might not be possible to prove [this] with the scrupulous exactness of advanced mathematics."[64]

In his *Architecture Françoise* (1752), Jacques-François Blondel tried to show how the most pleasant proportions could be determined from a comparison of the best existing buildings. In attempting to rationalize the problem, he established three different types of proportion. The first was derived directly from human dimensions, such as the measurements of a step; the second referred to the structural stability of a building, prescribing, for example, the thickness of walls; and the third was concerned with beauty, being applied particularly to the classical orders.[65] J. F. Blondel's types of proportion correspond to each of the traditional Vitruvian categories: *commoditas*, *firmitas*, and *venustas*. His lucid distinction contrasts sharply with the confusion between the aesthetic and technical attributes of proportion in François Blondel's Baroque theory.

Nevertheless, J. F. Blondel always maintained that architecture had access to the sphere of absolute values. He thought beauty immutable and felt that architects, through their open spirit and sense of observation, were capable of extrapolating it "from the productions of the fine arts and the infinite variety of Nature."[66] He believed that excellent buildings possessed "a mute poetry, a sweet, interesting, firm or vigorous style, in a word, a certain *melody* that could be tender, moving, strong, or terrible."[67] Just as a symphony communicated its character through harmony, evoking diverse states of nature and conveying sweet and vivid passions, so proportion acted as the vehicle for architectural expression. Properly used, it presented the spectator with "terrifying or seductive" buildings, allowing for a clear recognition of their essence, be it "the Temple of Vengeance or that of Love."[68]

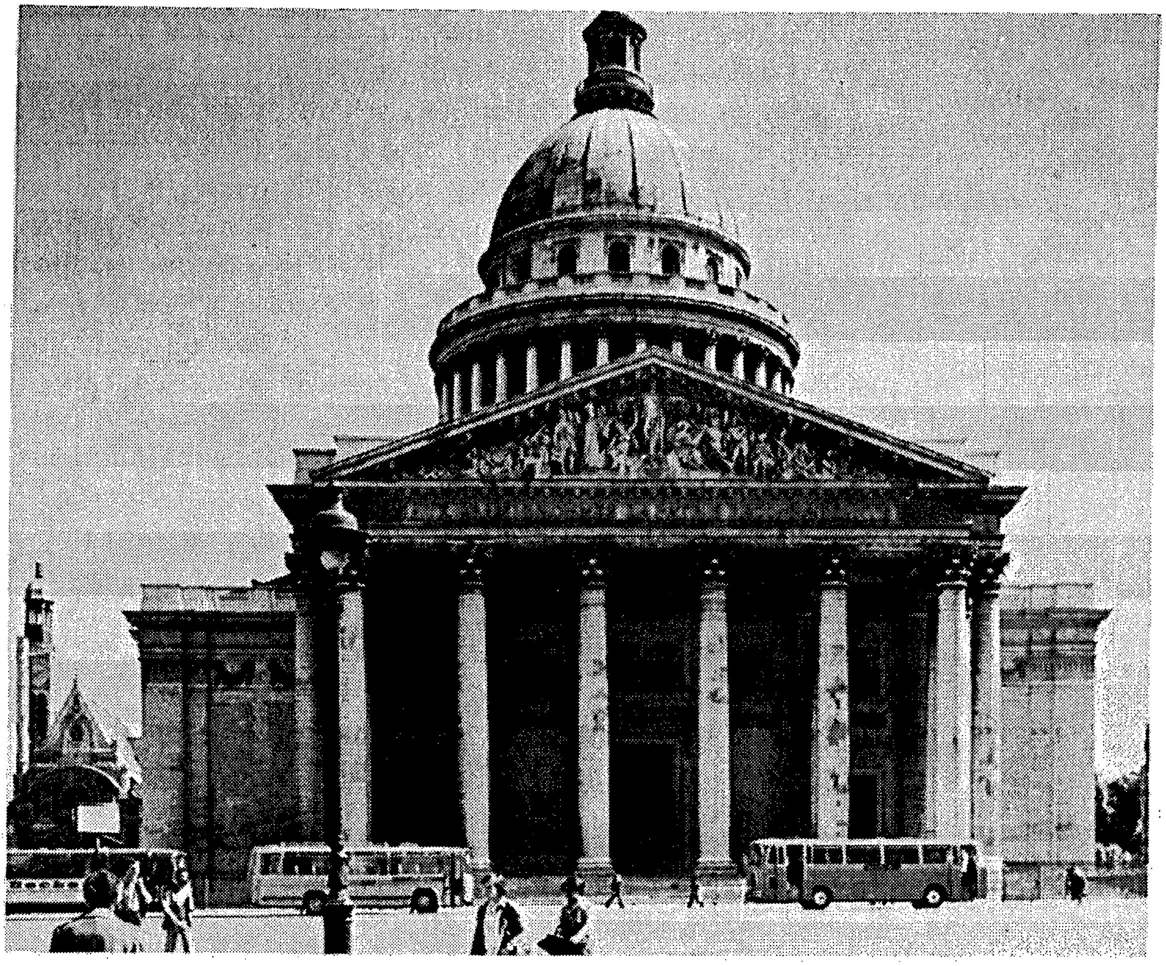
In an age when enlightened reason was capable of questioning the absolute validity of the forms of classical architecture, the problem of meaning appeared more clearly at the level of theory. For Blondel however, it was never reduced to the issue of evidence of style or type; it was primarily a problem of reference. Blondel believed that "it was ultimately unimportant whether our buildings resembled those of classical antiquity, the Gothic period, or more modern times," as long as the result was happy and the buildings were endowed with appropriate character.[69] Naturally, the expressive and poetic character of architecture was guaranteed by proportion.

The crucial reconciliation between aesthetic and technical interests to which I have previously alluded is particularly evident in the work of Jacques-Germain Soufflot,[70] whose most significant creation, the church of Ste.-Geneviève, represents the culmination of French Neoclassicism, embodying that taste that admired the lightness of Gothic structures and the purity and grace of Greek architecture. In this building, it is impossible to establish where aesthetic motivations end or at what point design decisions were prompted by an intention to rationalize the structural system. In his constant participation in academic deliberations, Soufflot displayed an interest in geometry, mechanics, geology, physics, and chemistry.[71] His best friends were famous engineers like Perronet and Rondelet. Soufflot also designed a machine to test the quantitative strength of stone. His scientific observations were instrumental in determining the proportions of Ste.-Geneviève, particularly the dimensions of the structurally critical central piers under the dome.[72] He defended the daring dimensions of his structure, claiming that they had been established through observation and experimentation. In 1775 he proposed to the Royal Academy of Architecture the construction of other machines to determine the strength of metals and wood. These machines, he thought, should be made easily accessible to architects and engineers.

All this notwithstanding, Soufflot wrote two formal papers on the problems of taste and proportions. His work on the identity of taste and rules in architecture was initially presented to the academy at Lyons in 1744, and read at least twice in the Royal Academy in Paris during 1775 and 1778.[73] According to Soufflot, there existed a reciprocity between taste and rules in architecture; taste had been the original source of rules, which, in turn, modified taste. Rules have always existed; the Greeks simply discovered them. Taste and rules were found in Nature, but they could also be taken from excellent authors. "A force whose cause I ignore," writes Soufflot, "always leads me to the choice of proportions. I build accordingly; my work pleases and becomes a rule for those that come after me." If greater assurance was required, Soufflot recommended precise measurements of beautiful buildings and a careful consideration of the effects produced by their proportions.

Soufflot believed architecture should be simple and guided by the "beautiful correspondence among the parts of the human body." Like Père André a few years before him, he affirmed the existence of an essential geometry, which could be perceived empirically in nature and that was the origin of true beauty. Architecture was bound to respect these universal rules, such as the observation of horizontal and perpendicular lines and the disposition of weaker over stronger elements.

The church of Sainte-Geneviève in Paris, transformed after the Revolution of 1789 into the French Pantheon.



Soufflot's theory again reflects the fundamental paradox of eighteenth-century epistemology: Architectural rules can be determined empirically through taste only after one has accepted the premise of a universal, immutable architectural value to which natural observation has access. Ignoring the relation between cultural or historical context and architectural expression, particularly explicit after the publication of Johann Bernhard Fischer von Erlach's universal history of architecture (1721), Soufflot rejected formal invention: "What was beautiful two thousand years ago is still beautiful." True beauty, in his opinion, was not "an extravagant composition of ornament." Consequently, he disapproved of rococo, baroque, and medieval complexities. Beauty consisted "in a perfect disposition of the most common parts" whose forms and proportions were perfectly known already. The role of the architect was to combine and establish dimensional relations between these absolutely valid classical elements, which would constitute the specificity of each work, its true source of meaning.

In his *Mémoire sur les Proportions d'Architecture* Soufflot discussed the dispute between Perrault and François Blondel.[74] Like Laugier, he questioned the authenticity of Perrault's conviction; both architects, in spite of their differences, had obviously created beautiful buildings. But Soufflot, while admiring Perrault's facade for the Louvre, unhesitatingly sided with Blondel. He thought natural proportions did exist, differences among specific examples notwithstanding. Discrepancies, after all, were the product of optical correction and adjustments. After measuring many famous churches, including some Gothic structures, Soufflot concluded that their general proportions were approximately the same, a product of nature, not custom, and, as in music, constituted a true cause of pleasure.

Soufflot was well aware of the works of Galileo and was capable of using mathematics as a formal instrument in his speculations about statics and structures. His predilection for quantitative experimental results in problems of strength of materials and his ability to disregard the experience embodied in prestigious buildings of the past and the authority of famous architects seems to betray the attitude of a positivistic engineer. The truth, however, is that Soufflot's positions in relation to both aesthetics and mechanics were derived from a belief in a mathematically ordered nature. Scientific observation and experimentation yielded quantitative results that led to the establishment of absolute laws. In a similar way, a transcendental taste had access to the rules of proportion implicit in the same elemental Nature; architecture, a metaphor of divine creation, should therefore be simple and thoroughly ruled by number. And the truth and beauty of any building were endorsed by the presence of number.

Soufflot's most severe critic was Pierre Patte, also an architect and prolific writer, who was mainly interested in the technical problems of building.[75] In the introduction of his most important work, *Mémoires sur les Objets les Plus Importans de l'Architecture* (1769), Patte emphasized that except for the problem of proportion, on which there was no universal consent, the remainder of architecture still needed to be expounded. In his opinion, the most essential, useful, and necessary part of architecture was construction, which still lacked principles. This aspect, Patte conceded, had been traditionally understood by masons. But it was imperative to study its principles in a more profound way "from a philosophical point of view."

Among the many chapters devoted to clarifying technical problems of architecture and urbanism, there is one that addresses the proportions of the classical orders. Patte does not question the fact that "proportions constitute the essential beauty of architecture," and in an earlier work he had drawn a connection between proportion, character, and morality.[76] He thought that beautiful buildings ruled by proportions would inspire noble and even religious feelings. The problem was to determine what these proportions actually were. Patte was convinced that if this became possible, architecture would achieve perfection.

He rejected outright the ancient metaphoric identification of columns with the human body, relating the former to the "disposition" of trees. Repeating Frezier's argument, he replaced the Vitruvian myth of the genesis of the classical orders with a theory based on the intuitive mechanics of primitive building. According to Patte, the Egyptians had used very heavy columns; it was the Greeks who gave columns a thickness relative to their heights and to the loads they had to bear. Thus, he thought, were established the natural proportions of the orders. But here begin the problems. Like Perrault, Patte worried about the discrepancies between theoretical systems of proportion and the dimensions of real buildings. Even during Vitruvius's lifetime these problems existed, and all subsequent attempts to reconcile the differences had failed. Patte attributed this failure to the lack of absolute rules of proportion, which architects had never been able to establish. Two great difficulties existed: finding principles leading to self-evident or at least probable truths, capable of satisfying both taste and reason, and the impossibility of subjugating the human intellect to determinations whose principles were not derived from nature.

Patte thought that the architect faced problems similar to those of an artist trying to determine geometrically exact relations between the features of a beautiful face. The mathematical law existed; the problem was to discover it from the observation of nature.

From this point of view, Patte devised a devastating criticism of Perrault's *Ordonnance.* Acknowledging Perrault's intention to "reconcile the differences between theory and practice, " Patte maintained that Perrault had failed. He attributed this failure to his predecessor's belief that neither reason or good sense nor the imitation of nature constituted the foundation of beauty. Patte's interpretation of Perrault's ideas is peculiar and significant. Perrault's understanding of proportion as arbitrary, dependent solely on custom, amounted in Patte's opinion to an absolute negation of the existence of positive beauty in architecture.[77]

Perrault had tried to justify his new rational system by identifying it with a mythical, perfect, ancient system that had been ruined by the carelessness of craftsmen throughout history. Patte never took this claim seriously. He thought Perrault's theory was only an extreme example of what had always happened in architecture, perpetuating the discrepancies between theory and practice. But Patte agreed with Perrault in his assessment of optical corrections. It was absurd to pretend, like Blondel had, that true beauty might be derived from those adjustments. Thus Patte emphasized the modern intention to establish a fixed and immutable system of proportions capable of controlling practice.

Both Patte and Perrault shared a concern to solve the problem of architectural proportion through scientific method. The great differences between them corresponded precisely to their divergent beliefs regarding the origin of knowledge in science and its accessibility. Patte declared that instead of trying to establish new, ideal systems, inevitably condemned to fail, it was preferable to define methods for the determination of optimal proportions through practice. Only then would it be possible to postulate a truly rigorous system, capable of reconciling different opinions in one rational whole. Patte believed that Perrault's system was erroneous and had never been used because "it was false that a proportional mean could produce in any case the most agreeable effects, coinciding with true perfection."[78]

Patte distinguished, as did Perrault, between observed phenomena and speculative causes. Nevertheless, he rejected the possibility of inventing a priori systems, choosing instead the empirical method of natural philosophy. While both authors wished to define the mathematical principles of architecture, Patte was the more patient. He repudiated the Platonism of Perrault and insisted that proportions should be derived from nature. Numerical relations were assumed to be visible. For Patte, then, numbers recovered their transcendental dimension and could be postulated as the fundamental means for the imitation of nature, still architecture's task.

The system that Patte finally put forward after his rigorous scientific disquisition was, perhaps not suprisingly, eclectic, confused, and rather disappointing. He established six orders: "rich," or ornamented, and "simple" versions of the three main classical orders. Evidently, Patte had greater faith in his method than in the result. Empirical science progressed to the degree to which observations were accumulated and systematized. He believed that any system based on his method was assured of becoming truly objective, producing real satisfaction.

The last architect whose work I examine in this chapter is Nicolas Le Camus de Mezières. Between 1780 and 1782 he published three books, two concerning technical problems and the other dealing with harmonic proportion. In the introduction to his *Traité de la Force de Bois,* after mentioning several buildings that had suffered structural failures, Le Camus pointed to the existence of mathematical laws derived from the science of mechanics. These laws, in his opinion, should always be respected. In his book, he commented upon the results of many experiments made by Buffon on the strength of wooden beams. Although he did not provide analytical methods for structural design, his intention was technical: the systematization of experimental results with the purpose of designing wooden structures scientifically.

In apparent contrast to this attitude, Le Camus emphatically defended the value of harmonic proportion in *Le Génie de l'Architecture*. Architecture, in his opinion, should have "character," indicative not only of its type but also of its internal composition. Each room in a building is meant to have particular qualities, so that our desire for other rooms may be stimulated: "This agitation occupies the intellect and keeps it in suspense."[79] According to Le Camus, the objective of architecture is to move our souls and excite our sensations. And this could only be achieved through the use of harmonic proportion.

Le Camus was convinced that "there was only one beauty," which could be found in the purity and harmony of proportions. But he never provided a system of dimensions that could be applicable to practice, only some traditional advice and the suggestion to avoid irrational or excessively small proportions, which might be confusing. In a more radical way than his predecessors, Le Camus rejected the possibility of an *ars fabricandi* concerning the fundamental problem of proportions. The immutable *mathesis* was indispensable in architecture, but it could not be made synonymous with a set of rules. Harmony, wrote Le Camus, is only accessible to the genius: "It is a spark of Divinity whose smallest reflection carries the imprint of a dazzling source."[80]

Le Camus tried to provide general prescriptions for the design of buildings with true character, something he perceived as lacking in the work of his contemporaries. Because natural phenomena could produce sensations such as happiness, sadness, sublimity, and voluptuousness, he exorted architects to capture these effects in their forms. Meaning in architecture had to be attained through a careful study of Nature. Proportion was understood as the essence of beauty because number constituted the most explicit form of a natural harmony pregnant with poetry, the ultimate source of architectural expression. Proportion alone could "cast that spell that overwhelmed our souls."[81]

Le Camus was aware of the critical importance of his theory and defended it, not without anguish, from the menace of relativism. He wrote, "Architecture is truly harmonic. . . . Our principles about the analogy of architectural proportions with our sensations are derived from those of the majority of philosophers. . . ."[82] These principles constituted, in the words of Le Camus, "the metaphysics of architecture," upon which followed its progress. The ultimate meaning of architecture depended on the existence of these absolute, natural principles.

After such an emphatic declaration, it is not surprising to encounter a violent criticism of Perrault's theory. Indeed, Le Camus thought Perrault was mistaken in his belief that "immutable proportions should not exist, that taste alone should decide," that too many strict rules restricted and sterilized the genius of the architect.[83] Le Camus identified Perrault's theory with relativism and contested it by establishing a circular argument that was noncontradictory only in the context of eighteenth-century epistemology: It was imperative to establish "immutable points of departure," laws that might set limits to our imagination, which in itself was licentious and incapable of self-restraint. Le Camus was obviously referring to the fundamental philosophical principles of architecture, not to an invariable, merely prescriptive, theory.

Among the traditional works admired by Le Camus were Ouvrand's treatise on harmonic proportion and the commentary on the Book of the Prophet Ezekiel by the Jesuits Prado and Villalpando, who illustrated how the Corinthian order and classical proportions were derived from the Temple of Solomon in Jerusalem.[84] But he also praised the more recent work of another Jesuit, Père Castel, who had been fascinated by Newton's discovery of the mathematical laws of optics and had composed a treatise to prove the analogy between the harmony of color and music.[85] Castel built an organ, or *clavecin oculaire,* in which a special mechanism produced colors relative to the notes played. The instrument was admired by the composer Telemann and also by Le Camus, who saw in it a proof of his own theories. The colors appeared in harmonic succession, he wrote, charming the sight of a well-educated man with the same magic of the well-combined musical sounds that enchanted his hearing.[86]

Number in Natural Philosophy

The major architects and theoreticians of the French Age of Reason ultimately accepted the mythical belief in proportion as the source of beauty and values. Looking back, what can we say about this reactionary attitude that always rejected the protopositivism of Perrault and adopted François Blondel's traditional position? First, this preference cannot be interpreted as a mere revival or survival of Renaissance theories. Modern historians of architecture have felt the need either to ignore or to isolate this attitude, perceived as curious and extraneous to the dominant characteristics of the period, which was marked by an ever increasing rationalism and interest in technology.

But Neoclassical architecture is not merely a dogmatic and rationalist precedent of contemporary practice. The theory behind this architecture was still prepared to accept an implicit but fundamental mythical dimension, one that allowed reason to elucidate the basic metaphysical questions of architecture while still avoiding contradictions.[87] The increasing rationalization evident in architectural intentions during the second half of the century was only the most conspicuous sign of architecture's adoption of the methods and principles of natural philosophy. The full meaning and implications of this assimilation have never been seriously considered by historians of art, architecture, and engineering since they assumed that their respective disciplines evolved as autonomous entities. Architects, engineers, and philosophers of the Enlightenment explicitly identified the principles of architecture with those of science, presuming a fundamental analogy in the methods and sources that led all human disciplines to the attainment of truth.

The science of the Enlightenment was the natural philosophy of Newton. After 1735, when his methods and premises were generally accepted in Europe, Newton appeared as a hero of superhuman dimensions, having solved once and for all the enigma of the universe. Many popular versions of his philosophy appeared in different languages, and he became a venerated figure among philosophers, scientists, poets, engineers, architects, and even priests. His scheme of the universe became a model for all disciplines, including aesthetics and architectural theory.

It might be said that during the Enlightenment, the science of Newton took the place of philosophy. Rejecting as fictitious the great deductive metaphysical systems of the seventeenth century, Newton declared that science should not make hypotheses or substitute reality as it presents itself to our senses with false or fantastic representations. Natural philosophy, for Newton, constituted a compendium of laws that attempted to explain the behavior of the physical world in mathematical terms and was deduced from phenomena through induction and experimentation. His principles were presented as a discovery of mathematical relations in the observed phenomena. And it was precisely his great success in establishing a connection between mathematical theory and the experience of everyday life that allowed his natural philosophy to be perceived as the final refutation of traditional metaphysics.[88]

Newton always tried to explain with the smallest number of principles the diversity of phenomena in the real world, reducing them whenever possible to one universal law. His model of the cosmos became the only acceptable system for eighteenth-century epistemology: a systematization of knowledge through the observation of nature, rejecting a priori hypotheses while searching for and finding general principles and often a universal *mathesis*.

Newton seemed quite capable of distinguishing between final causes and the mathematical laws derived from quantitative observation and understood as simple formulations of the empirical world. Alluding to the essence of gravity, he declared his interest in establishing the phenomenon's mathematical law, not in discussing "the cause of its properties." Consciously eschewing metaphysical or transcendental questions, he often disclosed the autonomous formal character of scientific discourse.[89] Consequently, he rejected all symbolic connotations of mathematics and seemed prepared to use it as an instrument for resolving problems in physics. His discovery of infinitesimal calculus derived from this specific practical consideration, which contrasts markedly with the symbolic and universal implications that Leibniz, its almost simultaneous codiscoverer, saw in it. For Newton, the origin of geometry was not intellectual but practical; geometry was only a part of universal mechanics, whose objective was "to postulate and demonstrate with precision the art of measurement."[90]

Around 1750 many scientists and philosophers could criticize the mathematical exterior, or geometrical form of thought, that purportedly had guaranteed absolute truth in the philosophy of the previous century. D'Alembert, for example, disapproved of the work of Euler, Spinoza, and Wolff precisely because their ideas were structured *more geometrico*. Mathematics apparently could be conceived as a mere formal system of relations, with no inherent meaning.

Having proved experimentally the imaginative intuitions of Galileo, Newtonian physics presented a definitive formulation of modern epistemology, becoming a model for all future knowledge. Newton seemed able to recognize truth from illusion, objective science from subjective speculative philosophy. He made available a relation between theory and practice in which the former aspired to be no more than a mere description of the technical means of the latter and not a discussion about its meaning. This opened the way for positivism, or the possibility of acquiring the truth about things without a concomitant theory concerning their natures. Or, more simply, the Newtonian schema encouraged the belief that it was possible to know a part (meaningfully) without knowing the whole.[91]

Although correct from the point of view of its consequences, this interpretation of Newton's thought is totally inadequate in its own terms. The great British scientist devoted much of his life to alchemy and theology, concerning himself with the Rosicrucian texts and the archetypal Temple of Jerusalem.[92] His theological writings were criticized even during the eighteenth century, but the fundamental metaphysical presuppositions of his natural philosophy were implicitly and thoroughly assimilated into all the scientific endeavors of the Enlightenment.

Particularly after Einstein, it became abundantly clear that Newton's "empirical science" worked precisely because it started from hypothetical and absolute premises. The existence of independent, geometrical, and absolute space and time was, indeed, an a priori postulate, indispensable for the success of his physics. In Newton's most important work, *The Mathematical Principles of Natural Philosophy*, observed phenomena from the world of everyday life were explained as relations of geometrical bodies in an abstract, empty, and truly infinite space. Newton was aware that the concept of absolute space was obviously not the space of human experience, and so there seems to be an unavoidable contradiction emerging from the simultaneous adoption of an empirical method and the hypothesis of absolute time and space. In Newton's philosophy, however, absolute time and space were not merely formal mathematical entities implicit in the experimental method. They were unquestionable premises precisely because he perceived them as transcendental manifestations, as symbols of the omnipresence and eternity of almighty God. "God," wrote Newton, "endures forever and is everywhere present; and by existing always and everywhere, He constitutes duration and space. . . . In Him are all things contained and moved; yet neither affects the other."[93] This "primary existing being," whose "emanative effect" is space-time, was consequently responsible for the order, regularity, and harmony of the structure of things.[94] Newton believed His intervention was required constantly, but most particularly, of course, when man was confronted by irregular phenomena that could not be easily explained within the framework of his universal law.

During the eighteenth century, God was still required in the universe of theoretical discourse, and Newton's natural philosophy simply took the place of the traditional metaphysical systems as a foundation of religion. In fact, Newton believed that science would necessarily lead to a true knowledge of the "first cause." This belief became commonplace among writers, scientists, and artists; it was interpreted literally in Craig's *Mathematical Principles of Christian Theology* and in Derham's *Astrotheology*, and in a more sophisticated and rational fashion by Voltaire and Buffon. The religious principles of natural philosophy were also practically identical to those of Freemasonry, the most popular "religion" of the Enlightenment after 1725,[95] and scholars have pointed to the great interest and often clear affiliation of eighteenth-century architects with this society.[96]

The law of universal gravitation summarized the quantitative essence of the cosmos. One principle explained the motions of the heavenly bodies and those of any object in the sublunar world. The order of Newton's universe depended upon the existence of gravity, yet there existed only a relatively small amount of matter in motion within an infinite and homogeneous space. How then could gravity account scientifically for the essential order? Attraction had been a common enough concept in the astrobiological cosmos of antiquity and the Middle Ages, which explained it as a projection of human affection. Animism and inexplicable forces, however, had been rejected by seventeenth-century scientists, who attempted to explain motion mechanically, that is, as the result of immediate and direct physical actions. Newton was unable to explain the nature of gravitational force, but he appeared willing to accept action at a distance through a vacuum. He conceived of gravity as substance, not merely as a mathematical formulation. Gravity could only occur in the absolute space that is God; its universal mathematical law was postulated as a consummate symbol of divine existence.

Deep within Newton's empiricism was a Platonic cosmology. He believed that after having created the great masses composing the universe, God put them in motion within Himself. The creation of matter from pure space is a notion that appeared in Plato's *Timaeus*. This is also Newton's ultimate source for his understanding of the corpuscular structure of matter and the properties of its particles, a conception he shared with other Neoplatonic philosophers, in particular, Henry More. Newton allotted occult properties to particles in his *Opticks* in order to justify the ultimately successful hypothesis of the structural similarity between electricity and gravity. Inspired by Newtonian empiricism, Condillac wrote that physical science consisted in "explaining facts by means of facts." Paradoxically, nothing could be further from this than Newton's own natural philosophy.

Newton's philosophy was based on the proposition that number and geometry were the essence of external reality, their only true form. But having rejected seventeenth-century metaphysical systems, and recognizing the limitations of formal thinking, he opted for inductive methods and asserted that knowledge should always derive from the observation of reality. This created the belief in the possibility of demonstrating the mathematical and geometrical essence of reality through the observation of nature. The metaphysical preoccupations implicit in Newton's traditional cosmology retained, often surreptitiously, but always forcefully, their essential role in the realm of theoretical discourse. The order manifested by the mathematical regularity evident in nature became an immediate symbol of divine presence in the world of man. Physical reality, although excluding all supernatural phenomena, was still capable of revealing the ultimate meaning of human existence.

Newtonian physics was evidently successful in the experimental field. This was instrumental in the arts and sciences of the Enlightenment adopting both its methods and its implicit beliefs. During the eighteenth century, most thinkers rejected the traditional link between human and divine reason, generally renouncing all hypotheses and the authority of ancient texts and envisioning truth as the goal of experience. In this sense, enlightened reason was more humble than Baroque philosophy, believing that truth belonged in the world and was part of empirical reality. The task of theory was to disclose the rationality evident in the natural order. This meant that such operations were never merely motivated by a technological interest, but were grounded in metaphysical necessity. In short, the ancient myth of preestablished harmony was now revealed to man through experimentation and technical action.

The use of inductive methods began to be seen in all disciplines as a guarantee of absolute certainty and meaning. Newton had shown that such methods could reveal the mathematical wisdom of Creation. This was a not gratuitous hypothesis, but a fact accessible to immediate perception. Man could now presuppose the integral rationality of reality and assume its validity in any branch of theory. The new empirical method and the systematization of knowledge became an indispensable stage in the process by which theory was transformed into an effective instrument of technological domination in the nineteenth century. The same empiricism, however, gave renewed priority to practice (rather than theory) and permitted the symbolic perception of nature. All those immutable principles that reason "discovered" through the observation of nature were seen as a manifestation of divine will. The reason of the Enlightenment could come to terms with radical problems of meaning only because it had deep roots in the mythical realm.

The method of natural philosophy put a new emphasis on the embodied perception of the physical world. Knowledge about life became inseparable from sentiment, differentiated but consciously integrated in artistic manifestations. The perception of the universe was truly symbolic, capable of apprehending meaning behind the presence of reality, and thus avoiding the menace of subjectivism. Nature was the place where all human values were to be found, a transcendental reality full of life and movement, where God, man, and things were subject to mathematical harmony. This fundamental belief prevented theory from becoming an instrument of technological domination; man always felt the need to reconcile himself with Nature.

During the eighteenth century, man thought he was capable of discerning the hand of God in His work through the discovery of mathematical and geometrical laws that betrayed His presence. God no longer inhabited a supernatural sphere from which He communicated with the human mind; the Creator of the Enlightenment was a force that endorsed the perpetual miracle of everyday life. Corresponding to this transformation of divinity, geometry and mathematics, which had lost their symbolic power with the end of traditional metaphysics after Leibniz, recovered it from a Divine Nature. Paradoxically, this recovery was precipitated by the growing interest in technical problems that revealed the presence of a symbolic mathematical harmony through quantitative experimentation.

Architecture had traditionally depended upon geometry and number to vouchsafe its role as an immediate form of reconciliation between man and the world, between microcosm and macrocosm. During the second half of the eighteenth century, architectural theory, sharing the basic premises, intentions, and ideals of Newtonian philosophy, adopted an implicit metaphysical dimension. The results appeared as a passionate defense of traditional positions, strengthened by a consciousness of the power of reason to control practical operations. Deriving its fundamental principles from Nature, architectural theory was capable of maintaining its customary role as a metaphysical justification of practice. Thus while respectfully modifying Nature, building *praxis* remained *poesis*, the character of which was determined primarily by its reconciliatory aims.

During the eighteenth century, rationality in architectural theory was capable of disclosing differences of taste and opinion, questioning the absolute value of the classical orders, the authority of ancient and Renaissance texts, and even the specific myths that explained the genesis of forms. In the end, however, architects and theoreticians did not accept subjectivism and relativism. In the last decades of the century, theory became a set of *grands* *principes,* often impossible to describe, but postulated emphatically as a necessary source of architectural meaning. Apparently subjective notions like taste, once it was established that they originated in Nature and experience, could be invoked as absolutely objective reasons in favor of theoretical arguments.

Perhaps the most explicit work on "Newtonian aesthetics" was Abbé Batteux's *Les Beaux Arts Réduits à un même Principe* (1746). He believed that taste was the foremost principle of the fine arts and that these disciplines were therefore never subject to chance. Batteux stated that "taste is for the arts what intelligence is for the sciences."[97] He thought that the intellect had been created in order to know truth and to love goodness and that we should simply let our hearts choose freely. Each aspect of human consciousness had, in his opinion, a legitimate objective in nature. Even symmetry and proportion were determined by the laws of taste.

Once the transcendental dimension of mathematical reason is established, it becomes evident that there were no contradictions between the technological and the traditional interests of eighteenth-century architecture. In fact, the true meaning of Neoclassical architecture can only be understood after accepting the radical coherence of its technical and aesthetic dimensions. In a similar way, taste reconciled the lightness of Gothic with the purity and grace of classical architecture. It is therefore futile to attempt an elucidation of Neoclassical architecture as a juxtaposition of formal styles, systems, or the specialized interests of architects and engineers.[98]

After 1750 numerical proportions recovered their traditional role in architectural theory. An ever increasing empiricism brought architecture constantly closer to nature. Architects strived to imitate the *belle Nature,* finding it increasingly more simple. This process, which I shall try to clarify from diverse perspectives in the following chapters, already shows the great impact that the Galilean revolution had upon architectural intentions during the seventeenth century and the basically traditional framework of eighteenth-century theory and practice. It should already be clear that modern architecture did not appear around 1750 and that it was not simply generated by the Industrial Revolution. The process of transformation of theory into an instrument of technological domination started with modern science itself. Nevertheless, after adopting the humility of natural philosophy, the architecture of the Age of Reason became motivated primarily by a symbolic intention.

BLANK PAGE

II

GEOMETRY AND ARCHITECTURAL MEANING IN THE SEVENTEENTH AND EIGHTEENTH CENTURIES