STRUCTURES IMPLICIT AND EXPLICIT

GRADUATE SCHOOL OF FINE ARTS UNIVERSITY OF PENNSYLVANIA

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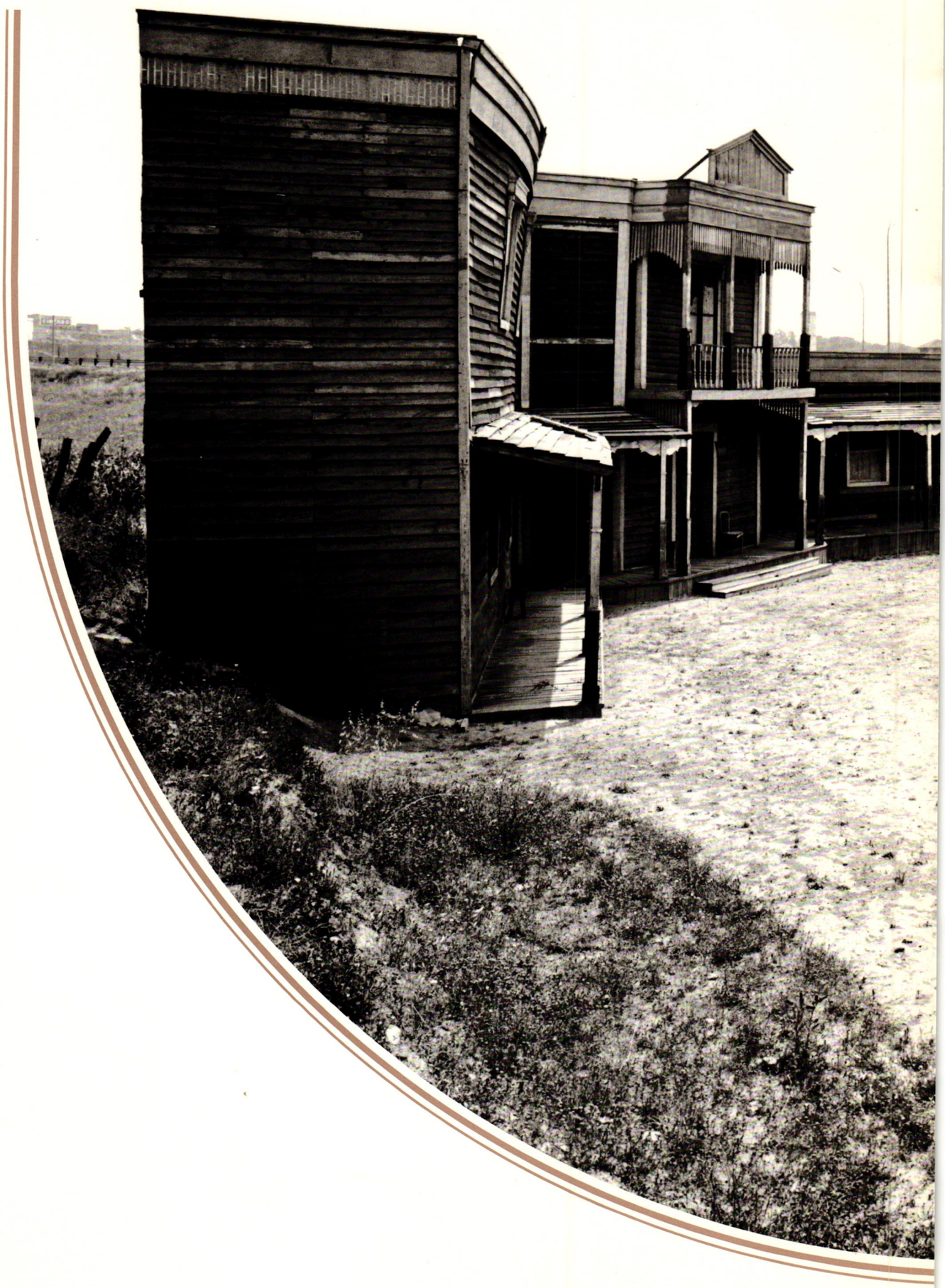
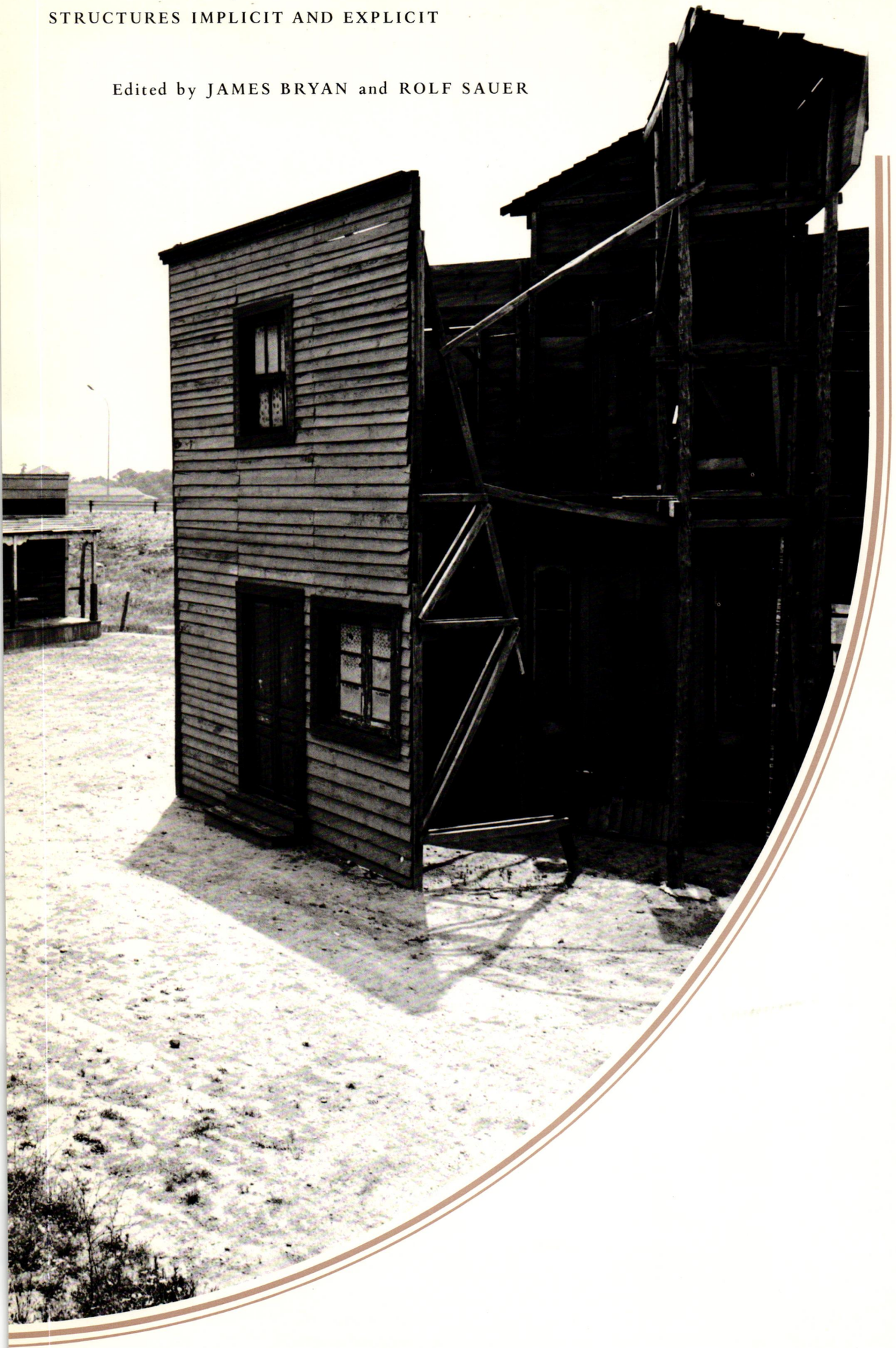


STRUCTURES IMPLICIT AND EXPLICIT

Edited by JAMES BRYAN and ROLF SAUER



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Contents 6 Maria Bottero · 'Dictionnaire philosophique': Architectural Entries 18 Antoni Gaudí Ornamentation 26 Robert Maillart · Arch Building 28 David P. Billington · Meaning in Maillart 40 Peter Caws · Significant Structures 46 Rowland J. Mainstone · Intuition and the Springs of Structural Invention 69 David Bohm · On Creativity 76 William S. Burroughs · Abstract 80 Interviews with Robert Le Ricolais · 'Things Themselves Are Lying, and So Are Their Images' 111 Robert Le Ricolais and Henriette Grindat · Matières 125 Claude Lévi-Strauss · Pioneer Zone / Markets 130 Umberto Eco Function and Sign: Semiotics of Architecture 155 Roland Barthes · Semiology and Urbanism 158 Interviews with Louis I. Kahn · Clearing 162 Roland Barthes · The Tour Eiffel 187 Notes, etc.


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'DICTIONNAIRE PHILOSOPHIQUE':

ARCHITECTURAL ENTRIES

MARIA BOTTERO



'The concept of the historical progress of mankind cannot be sundered from the concept of its progression through a homogeneous, empty time. A critique of the concept of such a progression must be the basis of any criticism of the concept of progress itself.' – Walter Benjamin

UTOPIA, HISTORY, PROGRESS. Exactly what is progress? If nothing else, it is the very substance of our Western society, and one can count on the optimists among us to accept that as the answer without further ado. The trouble is that those who are not happy about the present state of affairs might assume the answer to the question lies in a utopia – that is to say, in some sort of leap forward into a desirable and even possible, but still evasive, future. We could list, of course, many different types of utopia, from the socialist versions of the nineteenth century (culminating in the classic Marxian advocacy of a proletarian dictatorship) to utopias like Marcuse's, which anticipates, along with the end of class exploitation, the end of forced labor, thanks to automation, and the employment of free time in 'ludic' and creative pursuits. In the field of design, one cannot help mentioning Buckminster Fuller, not only for the real interest of his speculations but also for the considerable influence they are having.

It could be said, however, that utopias are essentially and by their very nature only *criticism* of some situation found unacceptable – class exploitation, deprivation, unbalanced forms of consumption, institutionalized waste, war, violence, etc. – with the remedy only hypothesized. More or less detailed and pointed strategies of 'intervention' may occasionally be prescribed, but one does not prescribe the moment at which that future will be with us. Between the present, critical situation and the ideal one of the future there is a gap, a leap that is qualitative as well as quantitative; in other words, there is discontinuity and opposition, inconsistency and incongruence. A no-man's-land of unpredictable dimensions stretches between the former and the latter. Moreover, the historical subjects entrusted with the strategy of intervention would be operating in a temporal dimension (their own) inevitably out of step with the temporal dimension of the strategy as planned. In the utopian perspective, the master

Illustrations from 'Mister Freedom', by William Klein
Here: Materializer in Freedom HQ – sends men pneumatically across Paris

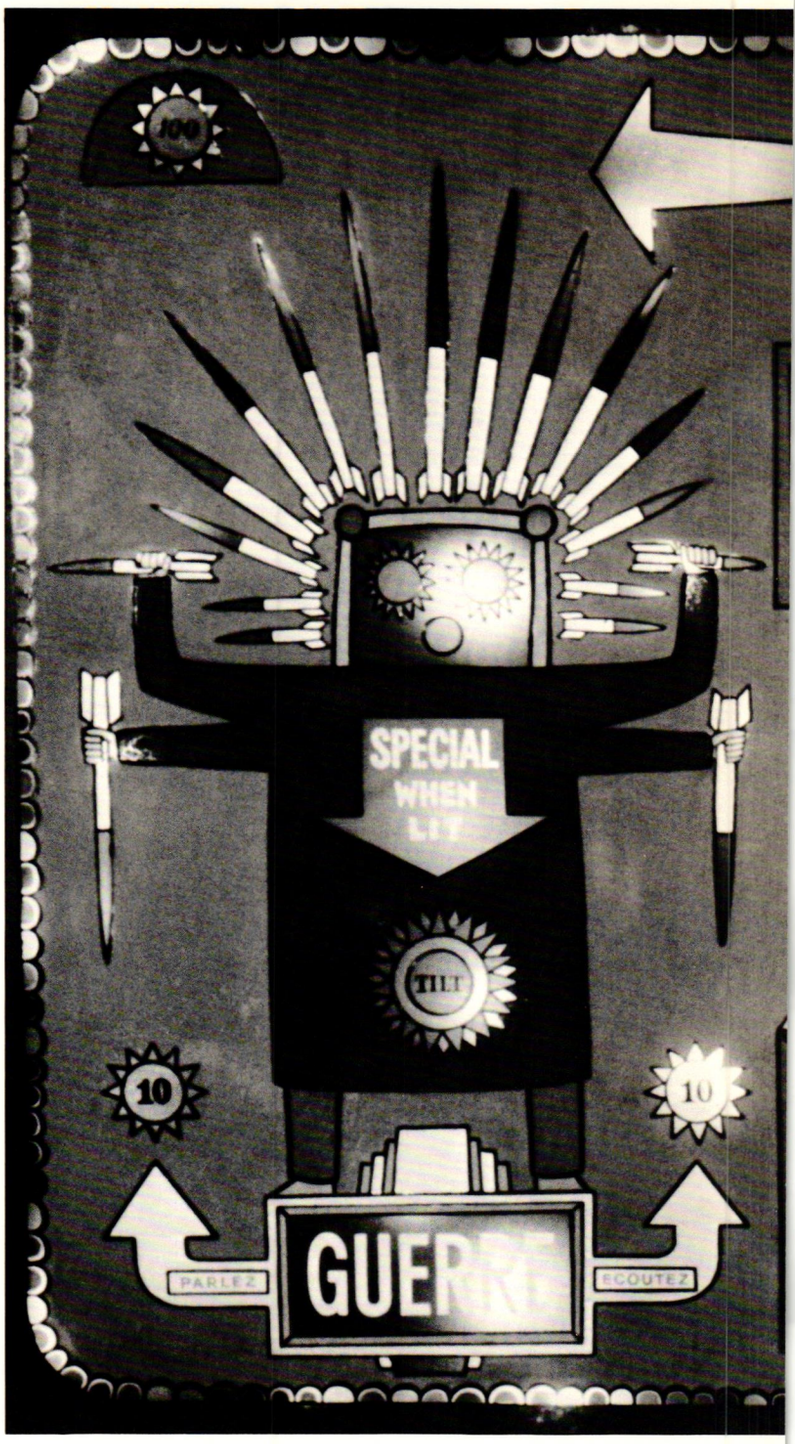
plan of strategic action transcends them, with its own time and rhythm of development, and so there is a further discrepancy; namely, in addition to the incongruence between the present and an alternative future, a discrepancy between the historical time of subjective action and that, which is collective, of the strategy's development.

This is clearly at odds with the old idea of history, history as a continuous and linear process, as a 'tide', powerful and unstoppable, sweeping men and things along in unison with it. But if that is the case – if the kind of history indicated by the utopia is, rather than a regular and uniform (and consequently transparent and legible) process, an indecipherable, opaque dimension – then how could one imagine that progress admits of any utopian definition? It would have to be ruled out.

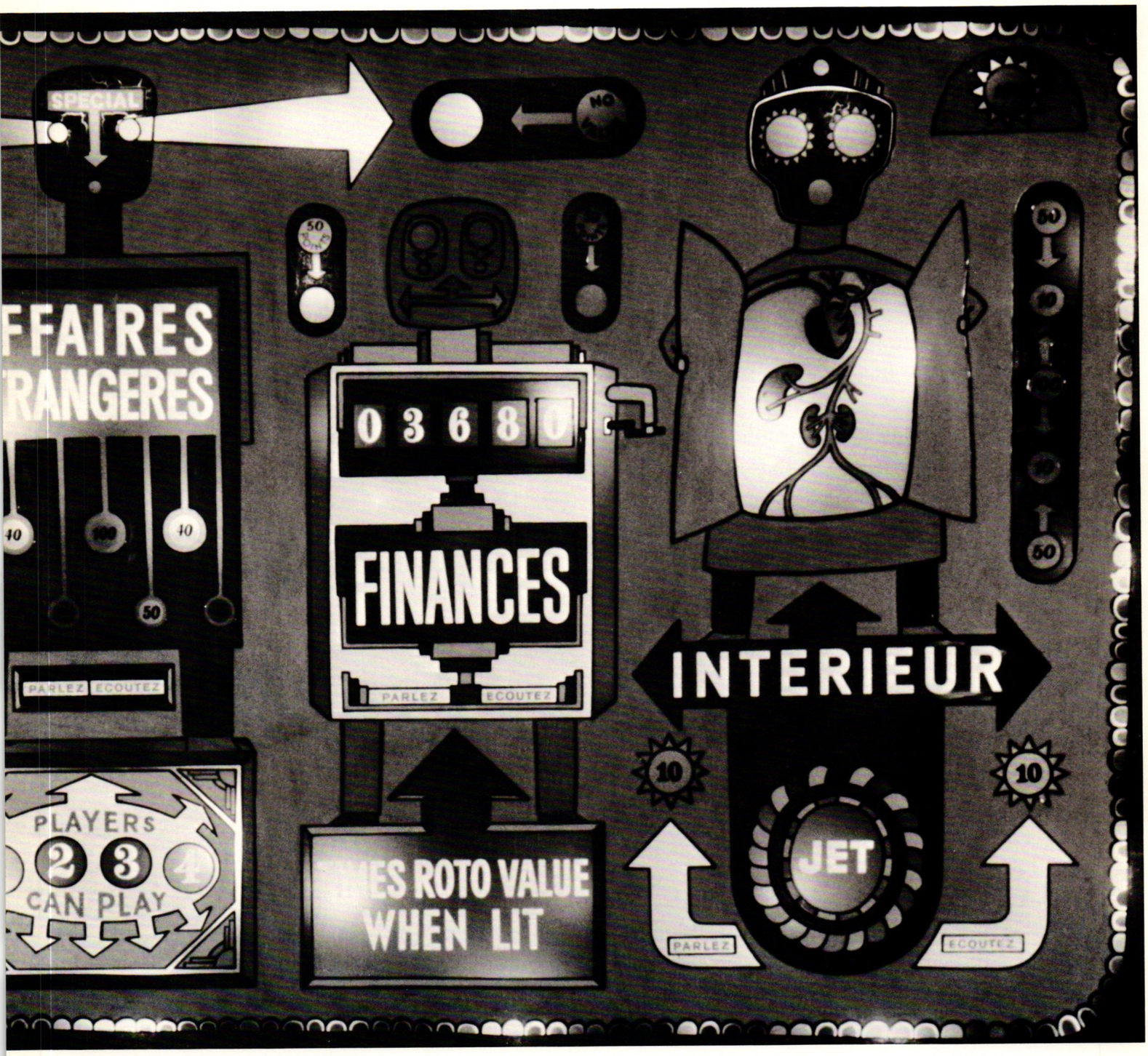
For progress, as we know it, implies at once the idea of a close-knit, continuous time-sequence, not stratified by any such diverse rhythms in coming about. It is a march to a regular and distinct beat, step by step toward an end, and indeed, unlike the utopia, would be inconceivable without linearity, historical continuity, regular growth, and thus predictability, possibilities of extrapolation, transparency, 'positive results'. So if asked what progress is, those who are not optimists about the present state of affairs would do well to keep quiet, ruminating meanwhile on the following.

MYTHOLOGY OF PROGRESS. This is at the root of our industrialized Western civilization: the many things we owe to the ingenuity and productivity of the nineteenth century, from the steam engine and its successors to the exploitation of the working classes, from colonization to the exploitation of the Third World, were all accomplished in the name of Progress. The conquest of the moon and the adventures in Indochina are among more recent manifestations of Progress, whose logic, simple and surefooted, is that of conveying the Word to those who are, or that which is, for one reason or another, still not abreast of it. (And who could doubt the sincerity of the message, who could fail to be convinced, when behind it there is an overwhelming accumulation of well-publicized technological powers?)

All along, of course, the ideology of Progress has been transforming the physical environment – the 'metropolis' and its culture may now be the structures within which



The ministers of Super-Frenchman – Defense, Foreign Affairs, Finance, Interior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we really lead our lives, but there is evidence of Progress even among specimens of modern architecture – and it is still at work. A brief look around is enough to catch Progress busy as a 'developer': implemented by governments, by powerful private parties, by philanthropic and charitable organizations, it builds feverishly, often setting records, and with no bias as to where (even in the most remote outlying area). It is a matter of providing housing and facilities for the masses being urbanized, a matter of dealing with the demographic explosion, of demolishing the old, if need be, in order to continue building something more efficient and bigger (and more profitable), of leveling roads for the automobiles multiplying, etc. And what matters in all its enterprises is efficiency, by which is meant a social organization geared to production and consumption. The industrial cycle of production and consumption pervades the whole metropolis, from the seemingly endless suburbs, into which the urbanized masses are in large part ultimately channeled, to the curtain-wall towers (the same the world over) of the office complexes, where those who manage power, and thus Progress itself, are seated. So the Word of Progress in metropolitan society, tirelessly voiced, repeated, and insisted upon in a war of persuasion waged by newspapers, billboards, illuminated signs, movies, radio, television, is, above all, 'Consume!' The level of civilization of a people may be seen in the amount it consumes, just as the meaning of the metropolis may be seen in industrialization.

FUNCTIONALISM. The functionalism of architects and urbanists has been a most helpful tool for Progress. The formulation of urban functions in the C.I.A.M. Athens Chart, for example – (1) habitation, (2) recreation, (3) work, or production, and (4) circulation – is happily accepted, in both private enterprise and public administration, since it in no way contradicts, but rather confirms, in terms of quantification and transparency, the ideology of Progress. (Transparency means that one is dealing with something that is as plain as the nose on your face, and implies, as in the notion that the process of history is transparent, that it can be predicted and kept under control.) So urban reality is transparent, and its functions numerable; they can be taken into consideration one by one, isolating the corresponding organs for study and, where they are not functioning, interceding with incisions, rehabilitative measures, amputations.

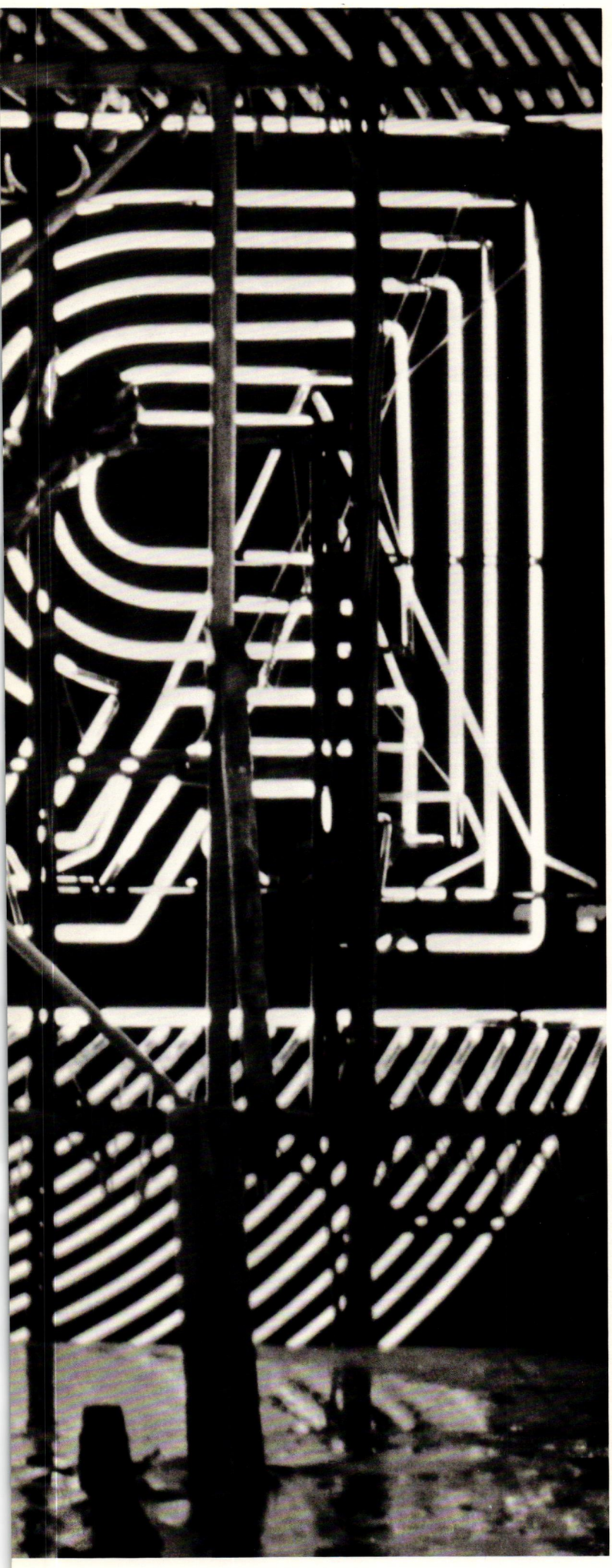
There will be no hesitation, therefore, in disemboweling historic centers in the cities in order to open up roads for the circulation of cars and trucks or carry on the celebrated 'urban renewal' operations with a view perhaps to habitation. If there is the appearance of a pause, that would be to keep on their feet the more interesting remains, or to save some remnant for the architect to incorporate in a new building. For as the Athens Chart reminds us, '. . . They [buildings and districts of historical interest, monuments bearing witness to our civilization] are part of man's patrimony, and those into whose possession or custody they have passed should, indeed must, do whatever they can to hand this noble heritage down intact to future ages.' It is certainly one of the concerns of Progress, indeed one of its principal concerns, to safeguard, defend, maintain, and hand down to posterity the riches of our civilization, and if there is any conflict, with certain riches in opposition to certain others, such as those from property sales and rentals, then the efficiency principle can be invoked and the matter settled.

In the interest of brevity, let us consider only one of the four functions – habitation. Market logic suggests the construction of housing on the outskirts of the cities, where land is cheaper, and that is where the vast residential tracts have been developed, also called dormitory suburbs or bedroom communities because the working population 'inhabits' them just at night (and over weekends and holidays). But never at a loss for what to do next, Progress does not stop there. For in the hearts of the great cities, half hidden among the remaining historic monuments and the factories, offices, apartments, deluxe residential districts, and prestigious quarters of important institutions, there are still to be found some pieces of urban tissue that are in decline (blight) or 'sick'; these are the slums or ghettos, inhabited by lumpen proletariat or ethnic minorities. Progress has here an embarrassment of reasons for stepping in: (*a*) the ghetto populations ought to be shown more decent accommodations and a higher standard of living; (*b*) in view of the elevated value in general of centrally located land, what ought to be done is to make the return from these sick pieces measure up to their potential value. How? By leveling the decrepit buildings, removing their occupants elsewhere (where they may be paying higher rents but while enjoying some of the benefits of the civilization of Progress), and constructing luxury housing, for example, or even setting the land aside for future use. This way a double goal is accomplished: recycling the metropolitan center, and conveying

Mr Freedom arrives to punish looters







the Word to a backward proletariat or even (where Negroes, Asians, etc., are the occupants) to pockets of those unfortunate peoples that history has left outside our Western civilization, that have remained, in a word, uncivilized. And in this way Progress, with its sharp eye for opportunity, can apply what it has perfected abroad (Third World, Vietnam) on two fronts at once, with colonization going on right in the heart of the metropolis.

HUMAN SCALE. Faced with the quantification resulting from industry (quantification of objects plus human quantification), the pioneers of modern design set about solving two pressing problems: quality and 'human scale', these *given* and *notwithstanding* the quantification. Their slogan becomes 'Quality in quantity', and as a means of reaching their objective, a kind of humanism through machines, they adopt the following twofold platform: (1) machines and industrial forms are 'beautiful' in themselves, exciting and suggestive, and as such may be taken as a source of inspiration for architectural aesthetics and for an architecture proper to an age of quantification; (2) there exists a human common denominator that should be considered, and it is on this common denominator (rather than on the 'cult of the ego') that the architect's work should be based. As Gropius puts it, 'This [the elimination of the cult of the ego] will presuppose a determined attitude of the new architect to direct his efforts toward finding the type, the best common denominator instead of toward the provocative stunt.' With this strategic maneuver, finding a source of beauty in the quantified production of industry and, vice versa, a good reason for quantification and standardization in the realm of architectural design, it is believed that the rampant industrialization might after all be kept within the bounds of 'human scale'.

What is human scale? Not unlike the linear idea of history, it is a comforting contrivance of our humanism, part of a frame of mind whereby reality becomes transparent and man, rather than being a social subject and obscure participant in complex and not easily decipherable events, becomes instead the universal subject: the subject that humanistic tradition depicts inscribed in the square and in a series of concentric circles, standing erect and with arms and legs outspread in an attitude of taking cognizance and possession of the surrounding world – the man in whose mouth Descartes put the famous words

Death of Red Maria – Mr Freedom crosses Paris via roofs

Cogito, ergo sum, and who appears again, hand raised, source of the universal scale of measurement, in Le Corbusier's Modulor. Man then imagines himself capable of constructing cities of human scale, and to this end generalizes, classifies, standardizes, zones the landscape, and comes up with building prototypes and urban models, all functioning perfectly, with machinelike precision (the *machine à habiter*).

It is a windfall for Progress. At perhaps the most precarious moment in its recent history – when with the industrial boom and indiscriminate quantification of men and things the loss of our historical and cultural patrimony might finally have become an issue, when there was the prospect of an irresolvable, disruptive conflict between the forces of beauty and humanism on the one hand and those of production or efficiency on the other – what should appear but some appropriate conceptual and organizational tools for heading off any crisis over the future growth of the metropolis and keeping things in perspective; a kind of *deus ex machina*, these building types promoting the new, industrial aesthetics and 'human scale', and the clearly rational principles of zoning, or division of the city into sectors corresponding to the different functions (if overly simplistic, the principles of zoning can be refined and complicated later). From here on, Progress has in hand everything it needs to go on building the metropolis; what is no longer of much use to it, which becomes clearer day by day, is the architect. With urban reality transparent, its functions quantifiable, and its structures capable of being standardized and extrapolated, one could save time and money and make the switch to computers.

THE ARCHITECT. A victim, in the last analysis, of his own inventions and stratagems, making his work lend itself to automation, the architect finds himself today on the fringe of productive reality. Meanwhile the metropolis assumes dimensions unimagined, and unimaginable given his notion of 'human scale'. It stretches before the eyes of the architect or planner as an impenetrable agglomeration, as some giant puzzle to solve. Formalization exercises for planners equipped with the modern principles of systems analysis, information theory, mapping, etc., are drawn from it, and in the midst of it the architect builds, if always less, proportionately, and always less in demand.



Cross section of public opinion comes over loudspeaker in Freedom HQ – 21% for F. 46% against 33% doesn't know



But the language the metropolis speaks eludes us: the syllables should be those of modern architecture, but are they? Who could say for sure? It is no longer clear even what architecture is, or what should be taught in the schools to students of architecture. And if in fact our culture is nothing but mystification and self-deception, how could one recognize the proper grounds for a fresh start? Leaving these questions unanswered, let us briefly take stock of the situation. Architects, meanwhile turned out by the universities somehow like hot cakes, would seem to face the following alternative: either adjust to the logic of production, in which case a place might still be found for them, perhaps as consultants to the big agencies and businesses that have entered the field, or become academics, backed by nonprofit organizations or by the government so long as their activities and contributions are kept at a respectable distance from what is in progress.

SYMPTOMATIC READING. In the end, the epistemological field of rationalism brought about a systematization of anthropological functions; having been classified, they could then be seen as isolated parameters, they could be measured, and, finally, their development over time could be predicted – which implied predicting the demographic and physical development of a community and mapping out its future history.

But this history, already fully contained in the premises and therefore transparent, is nothing but the negation of history, not only negation of collective history, but also negation of the history of the acting subjects, who were supposed to be theoretically identical (not differentiated, that is, by actual social status) and whose temporal dimensions were supposed to merge with collective historical time. A critique of this weakness in rationalist theory can be found in the architecture and ideas of Louis Kahn. It could be called, using a definition by Louis Althusser, a second, or 'symptomatic', reading of rationalism, 'insofar as it divulges the undivulged event in the text it reads, and in the same movement relates it to *a different text*, present as a necessary absence in the first [text]'.

Reading the rationalist functions as 'Institutions', as Kahn has done, has been enough to let the rumble of history into rationalist theory (in Althusser's language, what is undivulged in rationalism is the historical void, which could not be noticed from within the classification of the functions but which was nevertheless present there as a lapsus, as an intrinsic oversight, signaling what others, later on, would see; and the theory of Institutions is the different text). History here – the history of Institutions – is opaque, discontinuous, formed along diverse temporal dimensions, and with rhythms of development inevitably out of step with those of individual historical lives. In architecture, Kahn has said, only 'design' (the physical realization) is measurable and belongs to the designer; 'Form' (that which is institutional) transcends the designer and is immeasurable (or incommensurable with his subjective finiteness). Institutions, and among them that urban idiom of the metropolis, transcend us with systems, laws, and rhythms of their own. They tell us that men are finite, limited beings, and that what one does (when one speaks, works, etc.) takes shape autonomously outside the limits of the individual consciousness. In other words, they tell us that the meaning and direction of human existence always lie outside what has been called by Lévi-Strauss the 'supposed totalizing continuity of the self', the very image of which has been given back to us so consistently in humanistic tradition.

A critique of rationalism coincides at present with a critique of the ideology of Progress. The pretensions to totalization, along with the explicit decisions about what matters and the discriminations of good from bad, nonpathological from pathological, just from unjust, civilized from uncivilized, must presently face the challenge of another reality, whereby not only 'man', but also the whole ideology of humanism, will be put back in question. What we have rejected or discounted will come to show the dimensions of our ignorance. It would be no less than a revolution in consciousness, and that would be the grounds needed for any fresh start, for any remedy of the mistakes perpetuated in the name of Progress by Western civilization at home and abroad.

With such a revolution in consciousness, there would no doubt be a redefinition of architecture and of the architect's role. But formalizations, structural analyses, research into the behavior of materials and the gamut of alternative spatial arrangements, political engagement – these may all be regarded as worth pursuing as long as (and this is what matters) they help to put the old humanism in its place and to found a new epistemological field.

Hick Sheriff transforming into Mr Freedom, national and international vigilante





ORNAMENTATION

ANTONI GAUDI

August 10, 1878

Ornamentation

I intend to study Ornamentation seriously.

My goal is to make it interesting and intelligible.

Have spoken with Oliveras – seems to have no clear idea of where he is headed.

Visits to Cathedral during July to make casts of the *cimborio*, but annoying – without direct results.

Examination of Alhambra photographs, observing that the columns, being small in diameter, have been shortened by adding moldings to the shaft which extend the length of the capitals; I believe that the application of colors, especially to the base, aids in giving the effect of a shorter section of shaft. The same in the various halls where small columns are used to support the vaults, in order to increase the effect of the room or member, giving play to the imagination just as little Gothic canopies do. The same with the bands that are superimposed; their lines are of opposite directions; that is, if the interior follows the design or motif in a longitudinal direction, the exterior follows it latitudinally – this last occurring in the Arabic inscriptions.

To be interesting, ornamentation should represent objects that remind us of poetic ideas and that constitute motifs.

Such motifs are historical, legendary, representing deeds, emblems, fables – regarding man and his life, actions, and passions. Naturalistic motifs can represent the animal, plant, and topographic kingdoms.

They can also be geometric, in the forms of masses, surfaces, lines, and combinations of all of these, whose contrast can contribute to Proportion, which is one of the principal qualities of Beauty.

For an object to be very Beautiful, it is necessary that its form comprise nothing superfluous, but only the material conditions which make it useful; we must consider both the material available and the uses to which it will be put, and from this the general form will arise; concern for the preservation of the object and material will determine many elements of the form, and the others will be determined by contrast, that is, by giving them the form that, pleasing in itself, makes the neighboring ones all the more pleasing; and if, due to adverse dynamic or atmospheric conditions, satisfactory forms do not emerge from this process, then we can call to our aid purely ornamental motifs to elevate the form, perhaps concealing its structural and material parts and bringing out that form which is dictated by a satisfactory fulfillment of the needs. These are circumstances precisely determined by the 'Character' of the object.

It could be said that character is the criterion for ornamentation.

Nowadays, the character of an object depends on the nationality, the customs, and the splendor of its user; a public object must have a serious character which differs from that of an everyday object used by a family or individual. A Public object must correspond in character to its purpose; in embellishing it, the Gravity, grandeur of form, and simplicity must be tempered, not by means of more bland and easily decipherable ideas, but rather by geometric ideas, which preserve its distinctiveness; the former are preferable for private themes.

1. Workshop at Gaudí's Templo de la Sagrada Familia, Barcelona, c.1904

Geometry can play an important role in public and religious buildings; Greek temples and other buildings exhibit a rectangular plan, tapering, conical columns, square metopes, triangular pediments; in the ornamentation there are innumerable meanders decorating the members, palmettes that are no more than lines perpendicular to the horizontal line along which they are ranged, etc. Cathedrals – the semicircular ribs under their almost parabolic vaults, in the fretwork a combination of circles, the pyramidal pinnacles and other terminations, the geometric forms of the tracery.

When forms are dryly geometric and are frequently repeated, they have need of a good contrast: an object very free in form, one not adhering to any general shape. The Capital of the Temple of Apollo at Phigalia by Ictinus: the accentuated form of the abacus at the corners, square in a novel way, and the circular molding beneath, the meander of the abacus, and the collarino and the deep fluting of the shaft and the multiple base moldings – all this calls for palmettes resembling nature as closely as possible, and for *estiletes*, moreover, to dominate the whole of the moldings enumerated and have it give the effect of neutral surface. The Doric Capital, of simple, structural form, when a close-fitting collarino is put at the cusp of the fluting below it, needs no more than a completely conventional form from nature: the painted palmettes constitute the most daring element, in comparison with the meander of the abacus and with the neighboring lines (the fillet of the architrave, the triglyphs, and the guttae); and as principal ornamentation – not in formal richness, but in content – there are the themes of the metopes, and those of the tympanum and the corners and crest of the pediment. By way of contrast we have the case of the monument to Lysicrates, with exaggeratedly geometric forms: the square socle is stepped, constituting prisms and more prisms, above which there is a heavy cylinder, and the conical taper of the columns, which only serve to give it the appearance of being larger than it is – nothing could come after so much purely geometric form, which is so imposing as such, but the most precisely represented nature, as at the temple of Apollo, which could not be without its acanthus, with flowers and stems, and the roof had to be converted into a tapestry of leaves – leaves given to that Capital without rival, a model in size, in material, in line, in composition, in execution, and in lighting, that marvelously Greek creation, the Capital of the Erechtheum.

The Capital of the Erechtheum is particularly appropriate; the moldings are enriched with chiaroscuro, the palmette gorgerins with carved work of greater continuity, the fluting is more pronounced, and consequently the geometric and indispensable form becomes very rich throughout; there is the recollection of nature's most common forms to dominate so much movement and give it a culminating touch – something to crown the mass of ornaments and forms.

The Erechtheum, a temple whose interest lies mainly in the porch; its six columns, or four, constitute the principal element, since there is no major sculpture in the tympanum; its columns had to be as graceful as the human figure, and as rigid as those of the Parthenon, and their size, not great, had to be compensated for by a certain richness – not, however, the richness of damask work, but that of relief, of chiaroscuro, of silhouette, overall and in every single part; the smaller size had to be offset by the display of carved and elaborate form, and it is common sense that simple forms go with greatness and that abundant ornamentation is proper to small masses.

Great masses are always, in themselves, an element of elevated ornamentation. For example, the six-foot drums that make up the columns of the Parthenon – what ornamentation could possibly be wanted for them, or for the capital whose abacus was higher than the athlete's elbow and whose echinus would have dwarfed his footstep? – what better ornamentation than to have this grandeur shine forth in all its purity? And what could be more fitting than to bring this about, if possible, through subtle but energetic profiles which are delicate in

certain places to indicate the fineness and richness of the material and to emphasize the grandeur?

Ornamentation has been, is, and will be polychromatic. Nature does not present us with any object that is monotonously uniform, not in vegetation, geology, topography, nor in the animal kingdom; the contrast of color is always more or less vivid, and it follows that we must necessarily color, partially or wholly, an architectural member; this coloration may disappear, but then the hand of time will see to it that it is replaced by that proper and precious one of age. Who does not recall the golden tonality of the stones of the southern regions? Is there not perhaps a repellent coldness to a recently finished building? Who, for example, would dare to compare the brand-new façades of the University to the walls of the Lonja, or the exterior of the Diputación to that of the Ayuntamiento? Can cold monuments of white marble – in the Plaza de Palacio, for example – compare with what one finds in the Plaza del Duque or with the retrochoir of the Cathedral? Compare the Cathedral's tones with the vestibule of the University or the recently redressed stones of the Diputación, and you will be convinced that as long as the natural coloration of time is not present, painting is indispensable; this is equally the case with the rigidity and severity of great masses and in the luxuriant hollows of profuse ornamentation. This reminds me of something that proves to us the great importance of coloring, even in small masses: the Saint George sculpture on the Diputación is entirely monochrome, and of the coldest color, white; the balcony on which it is placed is of the same material, but in the ornamentation of the colonnettes of the balustrade, the red cross of the Diputación stands out; when the two objects are compared, the Saint George is cold, confused, deficient, and unsuitable as the principal focus of the façade.

Architectural painting in certain places has the great advantage of making the structural contours and planes seem more energetic, giving a clearer idea of the object.

The purpose of sculptural ornamentation is always to increase the importance of surfaces without weighing them down; the bossage, gargoyles, and moldings of the lateral, windowless façade of the Belén church are enough to make it one great decoration. From this it should be clear why smaller objects – and it should be understood that size is considered in relation to man and his special criterion – are the more ornamented, the more profusely sculpted (furniture is a good example): not because cost is an obstacle (proved by the use of marble), but because it is logical. Some French buildings depart from this: the Opéra, where one has attempted to give the façades great movement, as is commonly said, but where the result has been to diminish the general lines, which if defective to begin with were not improved by breaking them up, an amendment which does no more than call on overloading to obscure the defects.

Ornamentation is only a part; although essential in order to give character, it is, nevertheless, nothing more than the meter and rhythm in poetry. A concept may be expressed in many ways, but it becomes obscure and pale when one arbitrarily introduces extraneous accessories which do violence to the wisdom of the idea.

For an object to be considered beautiful, the first requisite is that it fulfill the purpose for which it is destined. This is not a matter of gathering together problems solved individually and assembling them to produce a heterogeneous result, but rather trying to reach a unified solution that attends to the material conditions, use, and character of the object, which are synthesized; and among valid solutions, it is a matter of taking the one that is most fitting to the object, meaning the one that attends to Use, Character, and Physical Conditions.

Use. It could be said that use is the reason for the creation of an object, character is the definition of its aesthetic-moral circumstances, and the physical conditions are those that concern the matters of durability, preservation, etc.

All of these bear on ornamentation, in the broadest sense, and also what we have said with respect to character and physical laws.

Consider Character, which when public can be Religious, Civil, or Military, and when private has to do with the family, its concerns, needs, and way of life, and the prestige of the family and its members.

Religious Character tends always toward the more grandiose, for it has to do with a mystery – a quality that is attained by an infinity of means. And that obliges us today to consider religion in relation to society. The time is past when faith and religious enthusiasm could erect an infinite number of Cathedrals, perhaps indicating that religious character is now a bit indecisive. Religious objects are slaves to a profane idea – art: those who make temples do not insist that they possess those characteristics proper to a terrible God who sacrifices Himself for that which He has created, that they be mansions for the omnipotence of the thousands of millions of solar systems; nor is their object to evoke in a very elevated manner that which is the Bloodless Sacrifice; rather they seek to imitate the forms of other ages, forms which however magnificent they may have been for that time – we can still perceive something of that sacred incense – do not belong to our language; and what we see in the reproduction of those forms is more the evocation of the sculpted forms, recollections of those men, than the idea that soars above them, revealing vaguely the Divinity to us. That is to say, what we are devoted to in the continuation of the Gothic styles is the Middle Ages, something with defects as well as qualities; its plastic forms remind us of the events, personages, and traditions of those peoples; it could be said that one's ideas are therewith more romantic than religious. This gives rise to a religious tutelage of the art of other ages – not an art that identifies with the religion in order to give it expression, as should be the case, but an art that imposes itself as a style. Thus modern conceptions are of a sort that could be called purely architectural. Neither painting nor sculpture are fashioned to give emphasis to the mysteries of the holy religion; nor are they occupied, as they should be, with the representation of the martyrs, as in the brilliant and sublime paintings of the Renaissance; not even the once so privileged symbol is given its proper importance. Rather all is given over, ridiculous as it seems, to the cabbage leaf, to the acanthus, to openwork, and to moldings – and all of these as purely plastic form. Perhaps such accessories, which as details do not conform to our way of life, are supposed to infuse religiousness? Where are those expressive reliefs that remind us here of martyrdom, there of mystery, charity, or contemplation? Now only some Saints are represented, and even these are simply an excuse to put up a pedestal or a little filigreed canopy; that is, one is seeking a pretext to introduce an irrelevant, purely plastic form. In addition, the means of execution have completely changed: at that time, all the idealized embellishment of those churches could be realized at a much less exaggerated price, whereas the tiniest sculpture today, the most insignificant capital, which will later be hidden in the shadows of the nave, costs a great deal. Because of the high cost of labor, it has become impossible to lavish moldings, openwork, etc. – even sculpture itself. Therefore we are obliged to be sparing and even stingy once the style has been adopted, and we necessarily produce incomplete buildings without meaning, because the elements at our disposal are completely different. Can, in spite of all that has been sacrificed, our modern buildings compare with the buildings of those times? Will the Sacré-Coeur in Paris bear comparison with the cathedral of the same city? And will it not be left even farther behind by the mere mention of those of Reims, Cologne, Strasbourg, Chartres, where stand the grandiose portals, the seven towers, the immense vaults? And note that while the latter are the result of the initiative of either a certain populace or a prince, the Sacré-Coeur is, or will be, the result of the effort of all Christendom; and all this to obtain an enormous monument that will not express to us what we desire or reach the level of those that it would imitate; and

all this because the elements of those days have disappeared and we are, at the same time, ignoring other elements which could give us great results, letting them wander hybrid and aimless, isolating them at present from these sublime manifestations. But it should not be said that no one has felt this genre: just recall, in the last exhibition in Madrid, the Burial of Saint Stephen, the latest drawings by Rosales for his Four Evangelists, etc., etc. This is decoration that in the best way suits the character of our sacrosanct religion in its spirituality; just as Paganism prevailed in sculpture – that is, in tangible forms, in the earthly perspective with its demigods and heroes – it suits Christianity perfectly, as a mold for its conceptions, to trace them spiritually in an impalpable atmosphere, on a body without relief, but entirely expression, entirely sensations of a moral nature. And note that this is perfectly realizable. That there exist highly qualified painters is undeniable; there are innumerable youths who would place themselves under their tutelage in order to learn the secrets of the art and one day become masters themselves. The cost of such a system of decoration could prove to be well within our means, and it would be most effective with the observances of the rite and the customs that could be called religious.

We know that in the age of Gothic architecture the custom of sermons was not general; it was only at the time of the Reformation that the preaching orders emerged and the custom began to be established; thus the church used to be only a place for prayer and the exercise of religious ceremonies: it was not, as today, a seat of learning, where one goes to be instructed and morally fortified by means of lectures. Before, the principal purpose was the rites, but now another has been added, that of discourses, indicating that there might well be, in this regard, a need to be satisfied. We must also consider the nighttime functions, which are now more frequent because of our daily occupations. It is unnecessary to recount the advantages of paintings under conditions of artificial light and the support graphic scenes give to the spoken word; that most easily distracted sense, hearing, is thereby made more attentive, guided by sight. This condition seems all the more worthy of consideration in light of the fact that not so many years ago – and even to this day in some places – the custom was observed of drawing all the curtains during the sermon, making the church almost completely dark, a darkness which would aid the imagination to see vaguely scenes related to the holy discourse. All of this is nothing more or less than the ideal of some of the churches of the Renaissance, but was later confused with some completely opposite ideas, that is, the application of forms and members so exaggeratedly presented that, as might be expected, the chiaroscuro of painting seemed phantasmagoric and as if seen through a veil; moreover the placement of this ornamentation obstructed the locations best suited to receive such paintings, which found themselves relegated to the most unsuitable places with respect to light and visual effect. Then let us pursue these ideas which are so vital, and instead of arguing among ourselves, solve the natural difficulties, which will be a considerable achievement.

Today, all that tends to elevate the cost of labor tends to lower the cost of materials. Everyone knows that since the beginning of this century the daily wage has doubled, tripled, or quadrupled in all branches of industry. Doubtless this is due to the employment of machines which produce great quantities in little time. Consider, however, the possibility of being able to employ machines so that labor costs would be reduced; as for materials, their price has indeed gone down a great deal, because of the ease with which they can now be extracted and transported. The Romans, who needed great buildings, did not hesitate to use the machines of their time in constructing their baths and circuses, that is, the slaves, as their military organization did not have a great abundance of craftsmen. They made use of construction in rubble and concrete. How much better we could make such works today, having, as we do, powerful machines with which to break up stones and make the concrete, powerful locomotives to cover great heights, and quarries all around producing the hydrated limes that are so well suited to the above construction. Let us be sparing with the carved-stone work, which can also be obtained by means of machinery, and economize with a system and cut back severely the sculpture; that is, let us not spend in vain for things that mean nothing, and let us address ourselves to the morally and materially indispensable. Molded products of glazed terra-cotta or majolica could be of great service in providing character and durability, and they could be obtained at a very reasonable price, one well within our means; then we would be in the position of freely possessing elements with which to give great character to religious buildings. And it should not be seen as an obstacle that secondary industries would have to be created, because it is unlikely that industries would be created if there were no market for the products.

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Every system of lines that accords with construction and the topographic, climatological, and meteorological conditions of the locale constitutes a Style, which will vary according to the physical conditions enumerated and others which are proper and peculiar to the locale.

It is perfectly clear that in a typical building one of the dimensions is dominant and the entire structure is subordinated to it.

The Egyptians developed horizontality; the men of the Middle Ages, verticality.

In the Orient, everything is based on the horizontal support and vertical uprights; the arch is simply a decorative motif inserted within the system of pillars and lintels; the vaults with simple spherical caps or stalactitic vaults, that is, flat ceilings from which stalactites hang to recall the coolness of a cave – but these apparent vaults amount to a roofing system that is a purely ornamental creation, that is, an exclusive luxury permitted only to certain special individuals at the expense of the community.

In today's society, where the tendency is not toward privileges but is rather toward the extension of benefits to everyone – not as with the Greek temples, where only the priests and oracles were allowed entrance to the holy places, or the Roman temples with their augurs – anyone can enter the Christian temple, even the wicked, without regard to age, sex, condition, or social position, a fact which indicates at once how great, how incommensurable, the temple must be, to contain everyone, great and small, rich and poor, absolutely everyone. The Greek temple was filled with gifts and donations, loot and trophies, placed there by all the citizens for the momentary enjoyment of a small number of privileged beings; these contribute a great deal to the monument's richness – not the richness of tinsel, or the appearance of great richness in the imitation of marbling and the gold of gilding, etc. Note the difference between the Greek monument – the Parthenon, built entirely of the marble today called statuary marble (that is, Pentelic), with its gods of ivory, gold, and precious stones, even the roof tiles, which if not of bronze were of marble, its tripods of bronze and even richer metals – and the recently built opera in Paris: although it has, it is true, marbles from all over the world, these are employed only in certain places, which then accentuates the poverty and lack of care in the lateral façades; the plaster sculpture imitating everything and satisfying nothing; seeing behind its bronze cresting miserable tiles of terracotta or slate. The difference is unquestionably great, and all the greater when we consider that the Opéra, a building dedicated solely to a leisure class of wealthy people, has ten or twelve times the area of the Parthenon, and two or three times the height, that there are places where it reaches more than four stories whereas the above temple has only one floor. It is clear that the services are all-important, that the modern need to shelter so many people necessarily means the fullest

use of resources. One has reached the extreme of completely neglecting certain parts in order to favor others, leaving one whole floor without light and poorly arranged solely for the pleasure of putting up a showy façade which serves no purpose and fulfills no aspiration other than that of the vanity of the Architect, who would feel impotent and resourceless if his façade did not overflow with sculpture, moldings, and countless exotic members, which follows the mania for agglomerating everything in one part of the building.

Is it not more logical, more natural, to satisfy material needs and moral aspirations than to concentrate all energies on something that is meaningless and that no one understands? Who, for example, in seeing the olive on a Composite capital does not confuse it with the acanthus, etc.? What is represented with the architrave, the frieze, and the costly cornice surmounted by an attic? Would it not be better to use what was spent on these things for the other façades and even the interior of the building, in order to give greater unity to the whole and more formal quality to the building?

The problem is the budget. The latter building, in spite of the fact that there are no limits imposed on its budget, is carried out with meanness in judgment – discontinuing the bronze gutters, failing to use the marbles throughout, that is, failing to use them as a unifying system for both decorative and structural purposes – and the whole reeks of impracticability. It means nothing that all of Napoleon III's treasures were at the disposal of the Architect Garnier, from the moment that structure and decoration went their separate and even opposite ways; everything became a case of conscience as he tried to realize his excessive desires. The task is necessarily not only to create grandiose projects, but to make them realizable – and this is the main point, to make projects realizable, economically speaking, and consequently to attend to present-day conditions of production.

We have been making these comparisons in order to determine the true needs and criteria, in order to determine the whole, in order to establish the system of lines or dominant dimension.

Pyramidal lines.

Basically, some of the ideas expressed come from the *Entretiens sur l'Architecture*, but everything need not be subordinated to necessity. I believe the problem to be the following: in order to satisfy the artistic needs of our time, it is indispensable that we seek more economical means than those now in use, so that we will not be feeble in our conceptions but instead have the means to freely fulfill our aesthetic-moral objective.

Forms expressed with simplicity have more grandeur.

The multiplication of moldings necessarily leads to complication of the ornamental motifs.

Continuous moldings rob the different parts which make up an object of their special qualities, and therefore the structure appears confused; from this it follows that each object and each and every one of its members should have its own appropriate form, which will in itself constitute an ornamentation that can be more or less enriched depending on the character to be impressed on the object.

Forms derived from geometry give great order and clarity.

The more perfect the forms, the less ornamentation is necessary, excepting the ideas represented by statuary and relief sculpture which is a necessary member and not ornamentation. Egyptian and Greek forms and those of the Middle Ages do not require as much ornamentation as those derived from the Renaissance or the Byzantine itself. Or better, in the styles that are not original and that are, therefore, derived from others, ornamentation is of great importance: the Roman, loaded down with forms and sculptures, and the Baroque, which in this respect leaves the Roman far behind.



2. Templo de la Sagrada Familia in progress





The imitation of styles must necessarily lead to superfluous ornamentation; the simple styles are the ones of sound structure.

The aesthetic structure is one which reveals the construction with the various means employed and the numerous problems resolved, making the objects pleasing in themselves; that is, the object becomes an entity, whereas those covered by ornaments and without structure are admired only for their cost, the most loaded down being the best; by the other criteria it is the most proper and simple, in other words the most noble, object that is best.

Complication in ornamentation is but a poor and expensive solution, which succeeds only in making the object appear indifferent; the more little ideas it accumulates, the more tedious and diffuse the object.

Our furniture and buildings demand the fulfillment of an infinite number of conditions, which if clearly laid out in an adequate and organized manner already provide the basis of the ornamentation; but in the forms of the details or of the parts, it is even more complicated, because of the complication of the determinants involved, which become difficult to conceal, resolve, or modify with a view to achieving unity within variety and contrast within harmony.

Representational sculpture is either given some designated place or introduced at the least important parts of the structure, that is, at the passive parts.

Contrasting lines may arise from secondary, auxiliary ideas that work in – subordination to the principal object and to its character.

22 September

Ornamentation – Desk

On the panels, the large ones and the other, in the middle, long and narrow: the contrast between the ideas of that central one and the lateral ones; the material is iron appliqué polished and shaped, perhaps complemented with black enamel. The objects are without relief, and therefore the representations must be also. The leaves of the lower part suit the object perfectly, being flat and lending themselves to protective and decorative surfaces. The intention has been to represent a tapestry of creeping ivy. What could be more natural for completing the ornamental composition than to place on the panels themes which are somehow related? Let us see what that might be. In the first place: in the rustic field, scenes of the customs of animals and man; the quadrupeds of ornamental value have the drawback, in the present instance, of

suit the object, even showing some rare flower or prized fruit. Fruits

recognized to be of some advantage in this sense, the seeds of leguminous plants. But also a very rural character, and what is sought is that they be rustic – the wild cherry and the mulberry tree, the oak and the cork oak, the laurel and the olive. The mulberry is especially suited to the central panel, in which case the insects could be moved to the lateral ones, but these need a complementary idea that more than absorbs them and that would definitely suffice for all the panels. The luxuriant mulberry on the one hand, with the praying mantises or the bees for the large ones and the dragonflies for the center; but in that case I feel the large lateral panels would be lacking, being either repetitious or without a theme that extends the whole; however, equally useful as a complement might be the maidenhair (ruled lines), removing the praying mantises and placing them on the drawers if the pulls leave room for them. All of the preceding should be reduced to the most minimal expression, so that the result will be clear and intelligible.

Relief is definitely suitable for the panels, but in sheet metal, repoussé, lending itself to the representation of a fresh and luxuriant vegetation. The motif of the bird fascinated by the snake could also be used, on the small lateral panels and within the abundant vegetation.

It often happens that when ideas are put together they are diminished and obscured; simplicity gives them importance.

Between one geometric tracery and two naturalistic motifs, the latter are of better character, for the former distracts one from the symmetry arising from structural necessity and order, and makes the piece of furniture less notable and the motif alone what is important. But since there must be equilibrium between theme and mass for the contrast of the idea, perhaps a wading bird killing a water snake.

For the footrest, a scene with the reptiles man tends to trample underfoot and subjugate under his power.

It is clearly necessary to create an ornamentation based on our way of life and of equal interest to those who are knowledgeable and those who are not. This ornamentation has to be consistent with construction, with the materials, and with economy.

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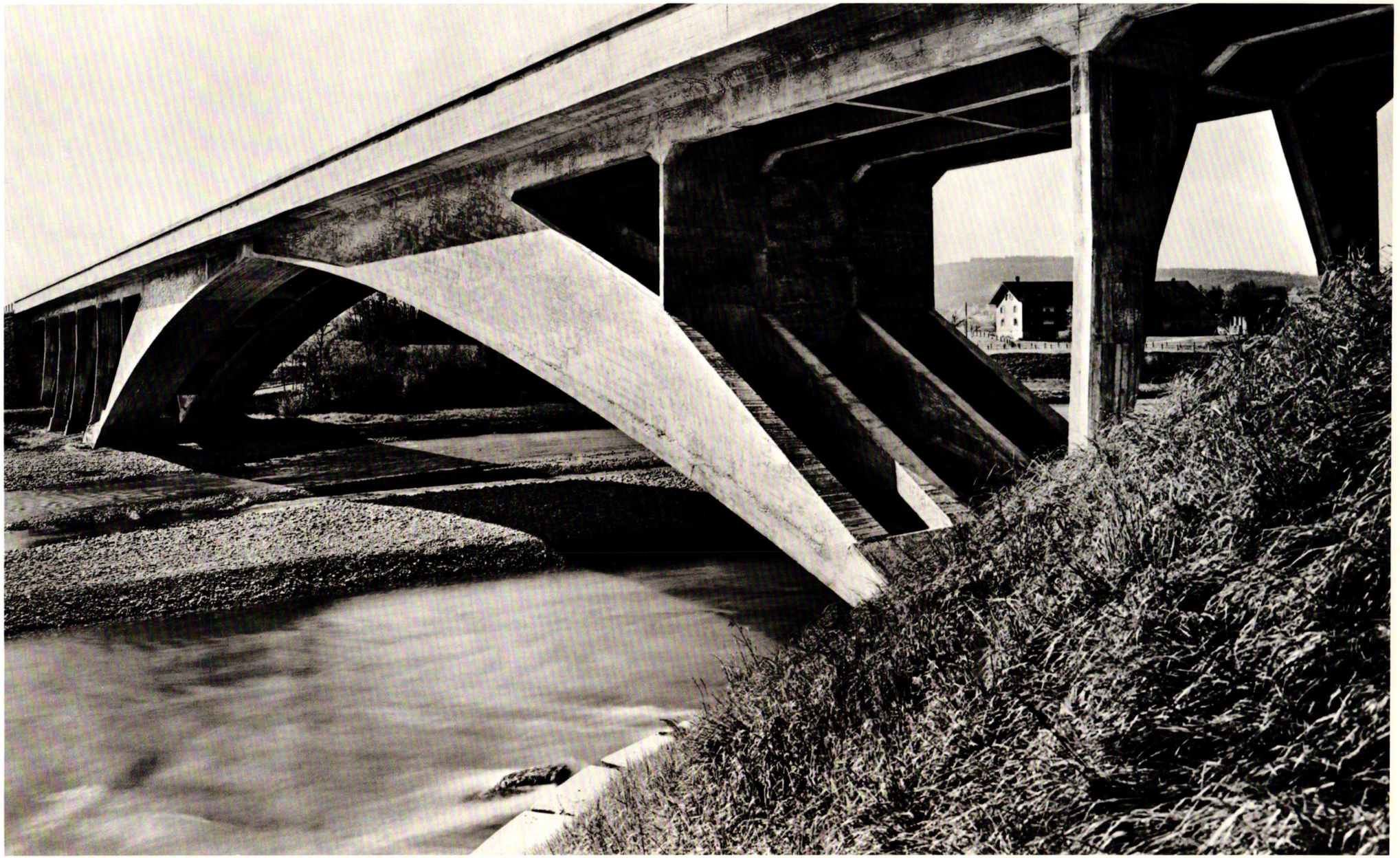
Once the idea is chosen, to translate it into a part of the construction, the following circumstances must obtain: that it not be in contradiction with the principal object; that the contrast with this object be appropriate or a clarifying part of the object represented; that it lend itself to reproduction, as to color, with the material to be used, and that this material be in harmony with the adjacent materials, in the ay that the object is in accord with the surrounding ones, and general forms of lines contrast with the surrounding ones.

central motif for my desk: it must be remembered that it is like the leaves of an album; one wants an object that has its own as regards theme and form. The panel is of cedar, and consea yellowish red; the ornamental material is beaten iron. The was formulated in the following way: I took up, as an idea that be compatible with the materials, the vegetation of the earth and of the animals which reside therein. Consider that in nature it is non and impressive thing to come upon a small pond where the grows; to pick a form, suppose that the water is represented by orizontal lines – the level of the water, that is – and that two attail stalks incline to the water, and then that lying on the ntals there are the leaves that grow at the surface of the water, n which a dragonfly hovers.

3. Gaudí's desk



ARCH BUILDING

ROBERT MAILLART

There are those who seem to think it is a madness – a form of megalomania – that drives engineers to make large arches. In a recent experts' report, put together by outstanding engineers and architects, one could read that some engineers have lately 'committed abuses' with bridge arches of great span. I know of no arch in Switzerland of which it could be said that a number of smaller arches should have been used instead. Certainly the ancients did not make their arches with spans as great as those we strive for today, but that was scarcely a matter of wise self-restraint; rather, the limits were drawn by their knowledge of statics, on the one hand, and by the quality of their construction materials on the other. If the Romans had been equipped as we are, they doubtless would have often built long-span arches in place of their viaducts, and people today would be accustomed to such structures and would not reject them as monstrous. We can, of course, learn much about bridge building from the Romans; the beautiful stone bridges of France were inspired by Roman examples, whereas utilitarian lines and modern decoration have in many places created the ugliest of structures. But this should not keep us from going ahead in arch building, just as the builders of the Middle Ages departed, with the use of the pointed arch, from the basic Roman viewpoint – according to which an arch without semicircular form would be unthinkable – and thus were able to achieve significantly greater spans. At that time, arches of over 160 feet came into being; for years people worked at building such structures, and generations made the greatest sacrifices to make them possible. They were seen not simply as functional structures but as noble tokens of the art of building and the pride of the country. In later centuries one was no longer capable of such efforts, however, and it was for Perronet to return arch building to honor. This master, as great an architect as an engineer, had already considered creating arches 530 feet in span a century and a half ago. The development of arches was then set back again, this time by iron construction, and thirty years ago we were still learning that a span of 160 feet was the maximum – in other words, that the dimensions attained five centuries before with the most primitive means (lime mortar was then in use!) were not to be exceeded.

It may be that everyone has his own thoughts about the aesthetic value of large arches. Certain large arches may give an impression of heaviness, but they are, to naïve perception, the absolute epitome of the sublime, with which other architectural forms can hardly compete. Much is being said about how the surroundings are spoiled by the introduction of a large arch. Granted that everything else moves into the background in relation to it, there is still nothing in this to find fault with *provided that the work itself is beautiful.* Aesthetes recently found that the old suspension bridge in Fribourg would not do at all in relation to the general aspect of the town. But the entire population of Fribourg, and all its visitors, attracted to the work, had endured the mistake with pleasure and would gladly have forgone the now completed 'correction', which is supposed to be a subordination of the bridge to the character of the town. While the famous old bridge drew the eyes of the world to itself, few are going to come to admire the 'new look' of the town, with this humdrum improvement, and among the inhabitants of the town the sight of the new bridge is sure to bring a sense of sadness over the one they lost.

I am aware that these heretical views do not meet with approval everywhere. Moreover, there is the objection that while a large and beautiful arch might, as I claim, give the onlooker the greatest pleasure, it would still not justify a financial sacrifice. But even in view of the difficult circumstances now prevailing, this objection is unfounded. Indeed the economic situation in which Switzerland finds itself demands no less than the highest kind of technical performance. The 'abuses' that have already been committed with large arches in Switzerland have carried the name of Swiss technology far, and in journals and manuals of all countries we learn with satisfaction of the eminence of Swiss arch-building technology. Switzerland cannot live without its exports; the exportation of our excellent cement, in contrast to that of other products, has enjoyed a considerable upswing, and to make this last, it is surely not without importance to show further what can be accomplished with these products. Also, a large number of engineers trained here are waiting to be 'exported', and the value of the Swiss engineer depends not only on what he has learned in the institutes, but also on the level of engineering technology that has been reached in Switzerland.

Yet does the execution of large arches lead in fact to greater costs, as is feared? In many cases these can be avoided, once we decide to give up certain deep-rooted views that do not agree with the circumstances. Let the engineer have the freedom to match the loading of his materials to their qualities, and we will see that a long-span arch is usually cheaper than a number of small ones on high piers. With the latter, of course, not much can be saved, even with the best-quality materials, because it is stability rather than compressive strength that governs. If, further, one considers that it is the severe loads from present-day traffic that are hardest on large structures, and that their influence decreases with arches of greater span, one sees clearly that it would only be dangerous to try to make the small arches of a viaduct lighter to the same extent that appears allowable with large arches.

Accordingly, in each case the possibility of employing large arches should be considered more seriously than it usually is here today. There will be, of course, many cases in which the viaduct proves suitable, especially when a flat valley with an insignificant watercourse does not have to be spanned with *one* arch or when the structure is to follow a curve. But where firm banks and moderate breadth of the valley make it possible, by the use of *one* span, to permit the water its free course and thus to bar its effects on the work during and after construction, a large arch is proper, and the viaduct only a frailty.

Maillart's bridge over the Thur at Henau, 236 feet in span, 1933


3034.
"THE BROOKLYN BRIDGE," N.Y. (FROM THE WORLD BUILDING)
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CASTORIA
ER'S 59

DAVID P. BILLINGTON

Like his three great predecessors in the nineteenth century – John Roebling, James Eads, and Gustave Eiffel – Robert Maillart achieved originality in design, in his use of reinforced concrete, through the search for uniquely rational form, the search the earlier designers had pursued in terms of the use of metal.[1]

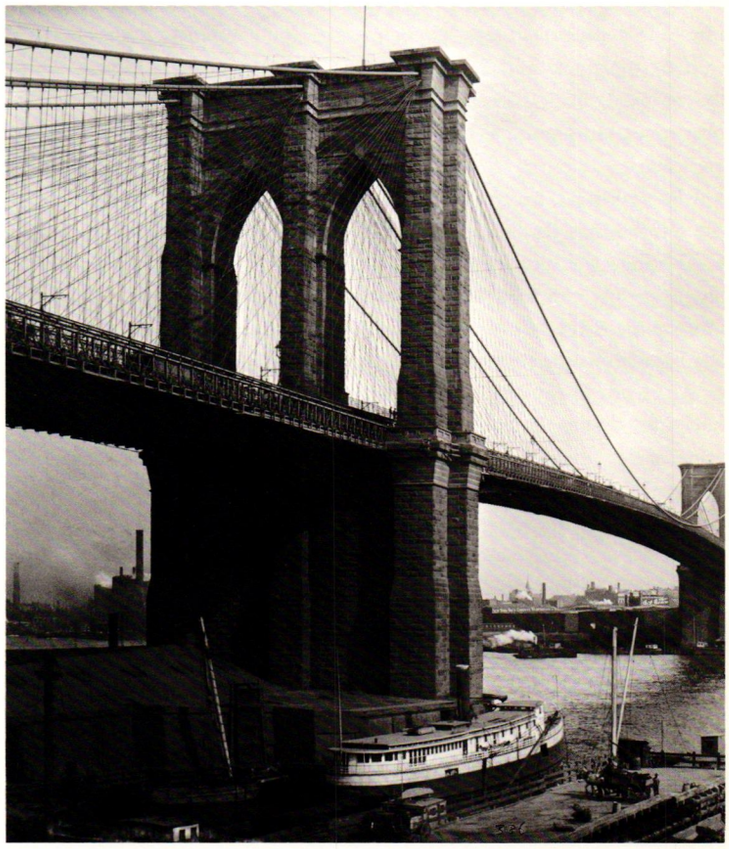
The paradox of structural design lies in this source of originality: the personal style evolving from a search for the impersonal form.

That their forms are never then repeated by other designers of the first rank continues to mystify laymen who see, in the practice of technology, only a gradual progression toward fixed intrinsic forms dictated solely by unchangeable extrinsic forces. This view of technology is expressed clearly by Lewis Mumford: 'Once we have achieved the right form for a type-object [a bridge, a chair, or a pitcher], it should keep that form for the next generation, or for the next thousand years. . . . the ideal goal for machine production is that of a static perfection, a world of immobile platonic forms, as it were, a world of crystalline fixity, rather than of continued change and flux.'[2] Now Mumford is arguing against the kind of 'superfluous' styling that puts tail fins on cars; unfortunately, by considering 'bridge' to belong in the same Platonic world with 'chair', he introduces a confusion between the design of mass-produced private objects, such as chairs, cars, and pitchers, and the design of individual public works, such as bridges or water towers. This confusion, which is common in our technological civilization, has even led water-tower builders to put fins on their tanks (see, for example, the facility in Brown Deer, Wisconsin, published in a *Water Storage Bulletin* of the American Iron and Steel Institute, where 'low bids received were $181,000 for an ordinary standpipe and only $213,000 for a more attractive design featuring a sloping, stepped roof and curved vertical fins welded to the standpipe cylinder').[3]

And this confusion has perhaps led the public to believe that public works would be monotonously alike unless, like many private tools, they are decorated. Here, the works of engineers like Maillart and Roebling stand as the most convincing refutation.

Roebling's designs for suspension bridges, from the Wheeling and Cincinnati spans to the Brooklyn Bridge, show a gradual refinement of form achieved by meeting dynamic forces resulting from wind loads with diagonal stays.[4] Although his last work, the Brooklyn Bridge [*1*, *2*], has become perhaps the most famous cultural symbol of nineteenth-century civil engineering,[5] its technical features were quickly outdated. No major twentieth-century suspension bridge has diagonal stays or stone towers, the key elements of his style; the stays are redundant for carrying vertical loads, as Roebling knew, but they are also less efficient for dealing with wind loads than horizontal-stiffening trusses, which he did not know. So in struggling against the wind to solve technical problems in his own way, Roebling fashioned a technique that worked well enough for its time and that produced distinct and impressive forms. But the style would not be repeated. One has only to compare his Brooklyn Bridge with the Verrazano-Narrows Bridge to see the difference.

Although this search of Roebling's for a rational form is clearly similar to that which Maillart would later make, we should expect to find two basic differences between his suspension solutions and the



1, 2. Brooklyn Bridge, over the East River, 1,596 feet in (main) span, by John and Washington Roebling, 1869–83

arch solutions by Maillart – one of scale, the other of material. For with minor exceptions, suspension bridges are reasonable only over very long spans, and are then necessarily of steel. On the other hand, the Saint Louis Bridge by Eads [*3, 4*] established the solution of multiple arches of steel as a major form for bridges of intermediate span; and it did so against the vigorous opposition of the engineering establishment in the middle of the nineteenth century.[6]

Again, as with Roebling's, the particular style of Eads did not carry into our century; at least two characteristic elements, the rectangular web of the deck-arch connection and the tubular arch-chords, are no longer used. Still, Eads's personal defense of his arches is perhaps the best nineteenth-century treatise for the layman on comparative form in civil works.[7] He had shown in one crossing that great river bridges need not be awkward, boxy trusses – indeed he called his superstructure for the Saint Louis Bridge 'far more graceful and elegant than any form of truss-bridge yet constructed' – but, curiously enough, Eads had to argue against the idea that a beautiful structure would necessarily be more expensive: 'We are too prone to associate our contemplation of the beautiful in architecture and engineering with an idea of costliness, which is not always just. It is easy to prove, beyond the possibility of a question, that in no other form could the material in those members of your Bridge which impart to it the chief feature of its gracefulness be used with such economy.'[8]

Though both Eads and Maillart gradually evolved a rational style, and felt that there could be economy as well as elegance in the final work, their arches are certainly very distinct in form. There were such extreme differences even within the nineteenth century, and even between metal bridges of similar span. Comparison of Eads's bridge with Eiffel's Garabit Viaduct [*5, 6*],[9] for example, raises the recurring question: What is the reason for such a difference in form?

Arches can be characterized by the form of their axes and the variation of their sections. The axial form is set by the permanent, or 'dead', load. The central design criterion is that all points of each cross section of the arch be stressed uniformly – without bending, that is, and so with a minimum of material needed to carry that dead load. For example, a dead load of uniform intensity along a horizontal line requires a parabolic arch in order to be carried with purely axial forces and no bending; when the dead load is uniform along the curved axis of the arch itself, then the required axial form is a catenary. In general, for any dead-load pattern, a single axial curve can easily be found from statics alone, and such a curve gives the primary form of an arch.

However, this primary form (corresponding to one loading pattern only) cannot carry the changeable, or 'live', loads with purely axial forces – bending moments will inevitably occur. So the designer then, in deciding how to stiffen the arch, must choose a profile. First he decides on the number of hinges, if any, and then he is able to draw, along the primary form, a second curved line, which graphs the maximum bending moment at each cross section for any possible live loading in a vertical direction (from gravity); he uses this as a criterion to judge how to stiffen the arch in the vertical plane. Somewhat similarly, moments from live loading in a horizontal direction (from wind) give the criterion for stiffening in the horizontal plane. Thus he chooses the secondary form of the arch.

Vertical live loads on two-hinged arches, such as the one by Eiffel for the Garabit Viaduct, cause the largest moments near the middle of the span; here the sections were made deepest, thus reducing chord stresses arising from the higher bending moments. Similarly, against wind the arch acts as a curved beam with fixed ends in the horizontal plane, and its width was made greatest at the supports, where the largest moments must be withstood.

So the primary form, dictated by dead loads, may be seen as a curved line whose subsequent variation in thickness is expressive of a secondary form, dictated by hinges and live loads, and the essential difference between the Eads arch and the one by Eiffel may be seen as a difference in secondary form, or in how vertical live loads are taken onto the arch: Eads could have used hinges and spaced the vertical columns between his arch and deck more widely apart and arrived at Eiffel's solution, but he chose otherwise. (Although the two primary forms are visually different because of the much higher rise of the Garabit arch, they are technically about the same – both are very nearly parabolas.) So far as I know, no one has ever attempted to judge these two designs in technical detail, but to me both appear convincing solutions. Maillart's mature bridges appear just as convincing, although as with those by Eads and Eiffel, no real precedent existed and no standard resulted.

If Maillart, too, did not set a pattern that was followed, what is his significance? Giedion, in *Space, Time, and Architecture*, connects him with abstract art in general,[10] and Bill, in *Robert Maillart*, makes him a source of constructivism in particular.[11] Both these critics firmly fix the bridges of their Swiss compatriot as works of art and cultural symbols of the early twentieth century. When Giedion first 'discovered' Maillart, however, he was really finding a modern example of an ancient idea – an idea embedded in the American consciousness and expressed, for example, by Ralph Waldo Emerson nearly one hundred years before. 'Readers of poetry', Emerson said, 'see the factory-village and the railway, and fancy that the poetry of the landscape is broken up by these; for these works of art are not yet consecrated in their reading; but the poet sees them fall within the great Order not less than the beehive or the spider's geometrical web'.[12] Emerson was encouraging his contemporaries to look into their own, present landscape rather than exclusively to the past glories of Europe, in the same way that Giedion (a century later in Emerson's home territory at Harvard) urged us to look beyond the masonry landscape of the Renaissance toward a concrete-and-metal vision of the twentieth century. Giedion's example for this vision in metal was Eiffel, and in concrete, Maillart.

Important as it was to proclaim the works of these engineers as cultural symbols, there have been few critics, if any, to go further than Max Bill in reading their meaning. This meaning undoubtedly lies in paradox – the personal search for impersonal form, the evolution of a unique style out of the standard materials of technology, in short the concrete remains of one man's struggle for abstract efficiency. But to begin to appreciate these works we could use three types of study: first, study of the engineer's works themselves (how efficient they are, how they were designed and built); second, study of the man himself and the context of his work (his ideas and struggles, his private thoughts as well as his public statements); and third, study of abstract efficiency in engineering (the deductive art of general analysis following from certain assumptions).

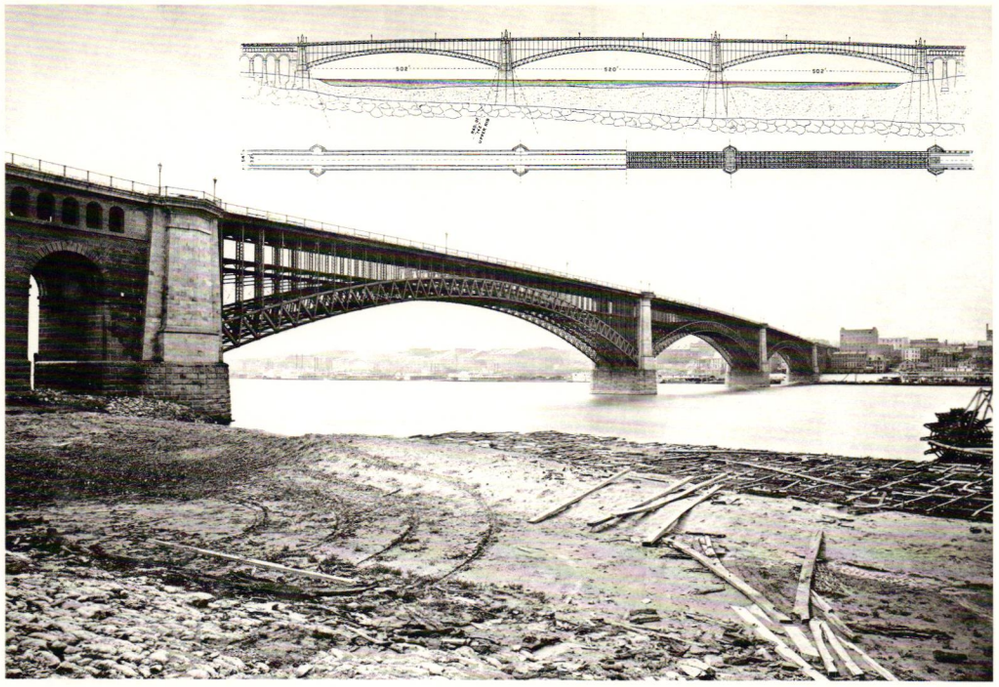
The first type might be likened to a complete case study, of the kind best exemplified by Woodward's book on the Saint Louis Bridge. For Maillart's work, as far as I know, only some test results on several of his completed structures have been published.[13]

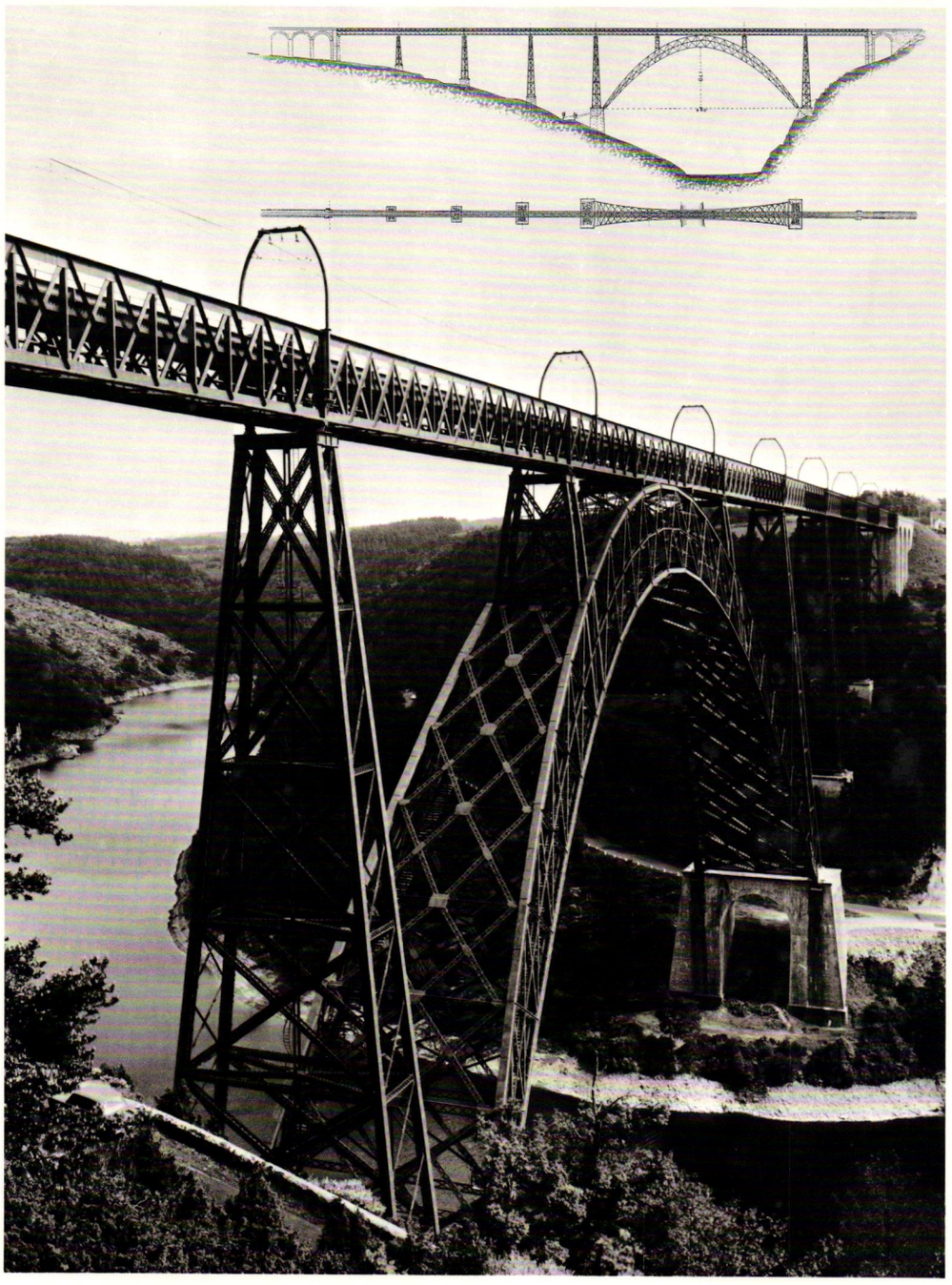
The second type often takes the form of biography. Although some have been written of noted engineers, only Trachtenberg's brief sketch of Roebling in *Brooklyn Bridge* attempts to get beyond mere narrative and into the specific context of, and personal thoughts behind, the work of a civil engineer; nothing like this has been written on Maillart.

The third kind of study needed to understand the work of an engineer like Maillart, to say nothing of far less distinctive work, involves

3, 4. Saint Louis Bridge, over the Mississippi River, three fixed arches, center arch 520 feet in span, by James B. Eads, 1868–74

5, 6. Garabit Viaduct, over the Truyère, one two-hinged arch 540 feet in span, by Gustave Eiffel, 1880–84







abstract theory of structural form. Even a cursory review of present research will reveal how scarce such analysis is, and how restricted it is in generality. If Maillart had waited for research of this kind, he would never have escaped the nineteenth century. The reason for this scarcity has to do with the quality of the assumptions: general ones often lead to complicated formulations useless for design, while more specific assumptions frequently produce trivial results.[14]

What is needed is not a theory on which to base future designs, but one with which to judge critically designs of the present. Montgomery Schuyler's fresh and vigorous judgments of designs at the turn of the century illustrate how powerful a theory of this latter kind (Schuyler made use of Viollet-le-Duc's rationalism) can be in the hands of a critic[15] – while for the act of creative design, the same theory can be a treacherous guide, as Viollet-le-Duc's own, dull designs clearly show. The difficulty arises because the personal choices made by the designer exert a primary control over his results, and theories can only correct, not provide, such choices. Maillart's works, notably his three-hinged mountain arches, provide some of the best twentieth-century illustrations of the effect of these choices. Taking one of these arches, we will sketch briefly what one might begin with in pursuing the three studies – of actual works, of the engineer's point of view and context, and of abstract theory of efficiency.

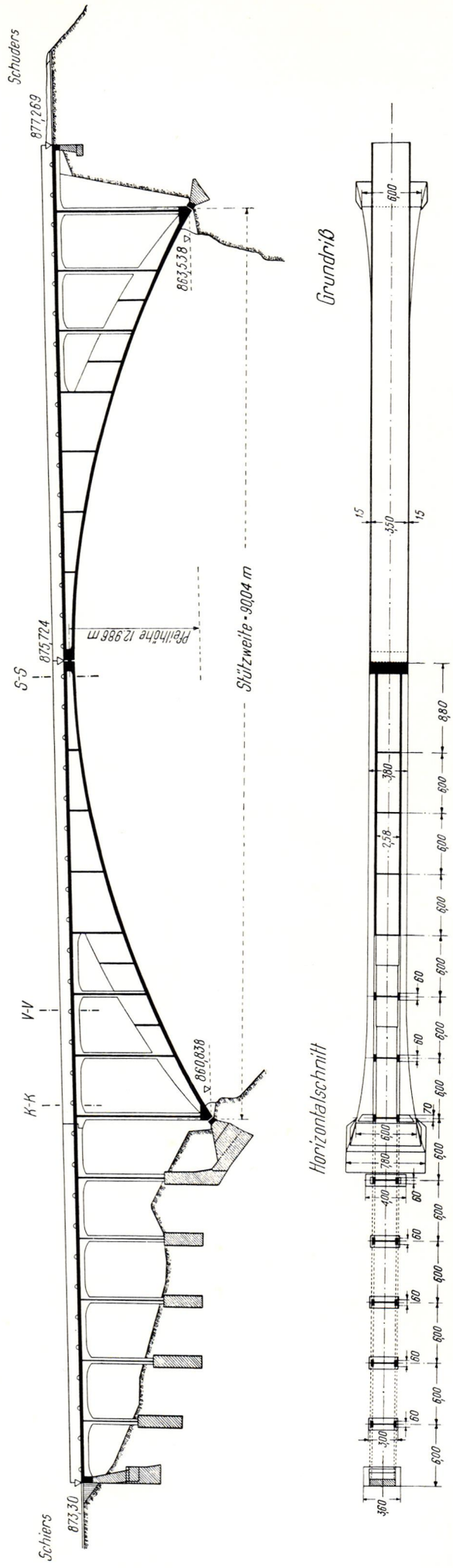
Maillart's works: The Salginatobel bridge

Perhaps the clearest expression of his mature style, the Salginatobel bridge [*7, 8*] also happens to be his longest arch, spanning 294 feet; it possesses that deceptive simplicity of appearance which can conceal an intrinsic complexity of structural behavior. In all probability, Maillart started off from three personal choices to arrive at the final form of this bridge.

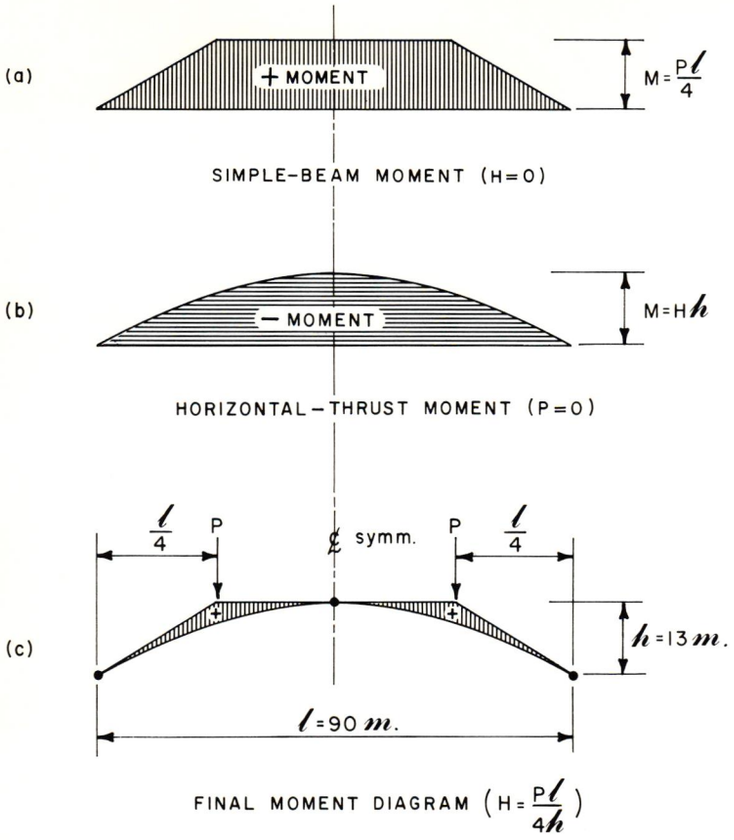
The first concerns the complex behavior of reinforced concrete, which includes such mysteries as creep, shrinkage, steel-concrete bond, microcracking, temperature effects, viscoelasticity, etc. Creep (a continued deformation over time, above and beyond the immediate strain caused by the initial application of load) was a major cause of misery for the early designers in reinforced concrete. Eugène Freyssinet tells how one of his arches nearly collapsed because of creep; his solution, to introduce jacks at the crown and push the arch back up, eventually led to his pioneering work in prestressing.[16] But Maillart took another tack, making his arch three-hinged (a hinge at the crown as well as at each abutment); he thus obtained a statically determinate structure, the nature of which is to undergo foundation movements and volume changes (from creep, shrinkage, and variations in temperature) without uncertain increases of stress in the concrete.

Once Maillart had settled on the three-hinged form, his second choice, a strong variation in the arch profile, followed from his consideration of the effect of live loading. With the axis of an arch chosen such that bending under a given dead load will be minimal, the stresses from live-load bending must also be minimized, through control of the profile, or secondary form, in order to achieve efficient use of material. In [*9*] we can see that live loads concentrated at the midpoints between the three hinges would define a composite bending-moment diagram that is, though idealized, closely analogous to the profile chosen by Maillart [*10*].

The third choice – a distinct connection between the arch and the horizontal deck of the structure – is suggested naturally by the shape of the arch profile. Moreover, although it prevents uncertain increases of stress from creep, the three-hinged form is more flexible than com-



7, 8. Salginatobel bridge, near Schiers, 294 feet in span, by Robert Maillart, 1929–30



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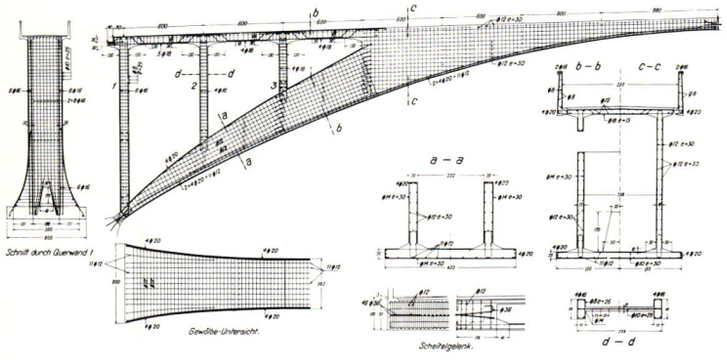

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9. Bending-moment diagrams for a three-hinged arch with live loads concentrated at midpoints between hinges

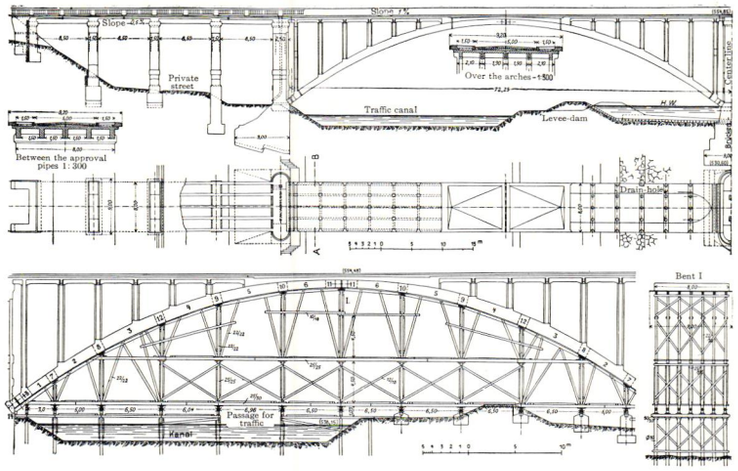
10. Details of Salginatobel bridge

11. Bridge over the Isar, near Grünwald, two three-hinged arches 203 feet in span, by Emil Mörsch, 1903–4

12. 'Floor with mesh and props', 11 and 1/2 feet in span, tested 1886

13. Bridge over the Rhine, at Tavanasa, 167 feet in span, by Robert Maillart, 1905–6

14. Diagram of the most appropriate secondary form for a three-hinged arch, by Josef Melan, 1908



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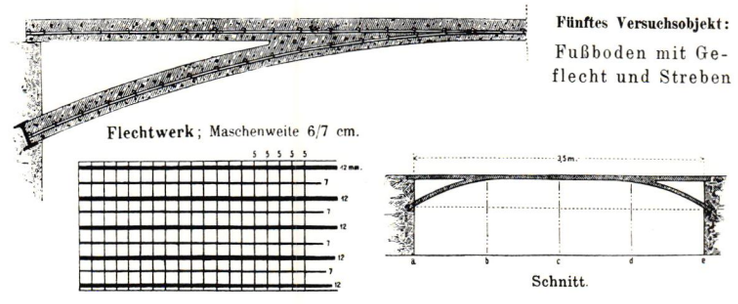

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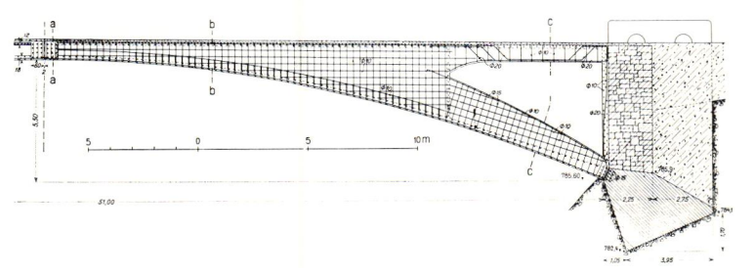

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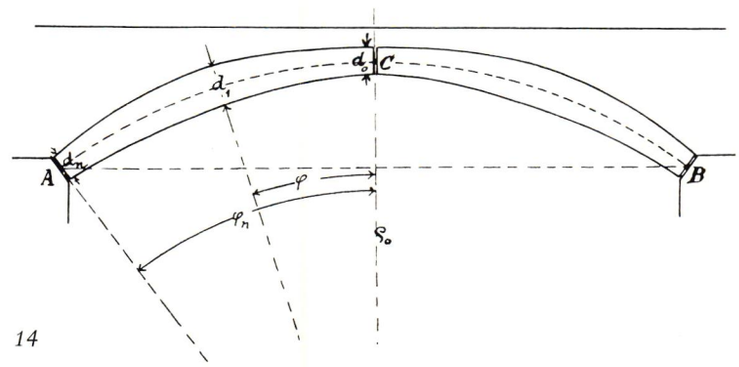

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parable two-hinged or hingeless arches; so the deck-arch connection helps in stiffening the structure, in allowing stresses to be more efficiently distributed, and therefore in reducing the total amount of material needed.[17] As taken together and developed by Maillart, then, these three choices resulted in a highly efficient structure. Tests of photoelastic and reinforced-microconcrete models of the Salginatobel bridge, carried out at Princeton University in 1969, have begun to indicate just how efficient it is – but a report fully interpreting results from tests of these models will require further study.[18]

The form of the Salginatobel bridge was not, in every respect, unprecedented. The tradition of making metal arches three-hinged was strong in the nineteenth century; the reasoning behind this was that one could thereby eliminate uncertain stresses and also avoid statically indeterminate analysis, considered at the time to be a very advanced problem. Three-hinged arches of reinforced concrete were not uncommon either, around the turn of the century – the largest (two spans of 230 feet with rises of 42 feet) being a highway bridge over the Isar River designed just before 1900 by Emil Mörsch, a professor at the polytechnic from which Maillart graduated in 1894.[19] That bridge [*11*] shows the beginning of the three-hinged form Maillart was to develop: the profile of the arch is deepest at the midpoints between hinges (47.2 inches) and tapers toward the hinges (35.4 inches at the springings, and 29.5 inches at the crown).

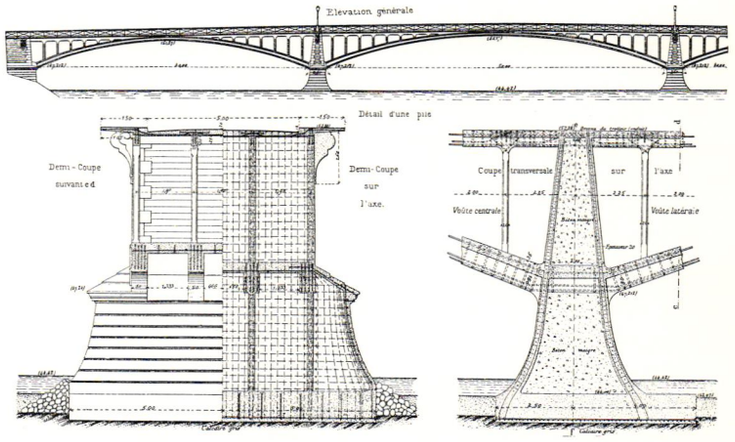
A yet earlier precursor to the form appeared in what was perhaps the first systematic set of arch tests, made in Berlin during February of 1886. The fifth of the six structures tested, 'floor with mesh and props' [*12*], resembles in a primitive, but significant, way Maillart's bridge at Tavanasa of 1905, the first in which he used the three-hinged form [*13*]. These Berlin tests were published in Fritz von Emperger's handbook on reinforced-concrete construction in 1908,[20] and with them appeared an essay by the engineer Josef Melan on the 'theory of arches and reinforced-concrete arches in particular'. Here Melan discusses the best primary forms, or *günstigsten Gewölbeform* ('most favorable arch form'), and secondary forms, or *Gewölbestärke* ('arch thickness'), with mathematical developments; a diagram of the most appropriate secondary form for a three-hinged arch [*14*] also shows clearly the kind of profile further developed by Maillart.[21]

François Hennebique, however, faced in 1899 with a problem nearly identical to the one Mörsch handled with the Isar bridge, built a bridge of three arches over the Vienne at Châtellerault [*15*]; the center span was about 170 feet with a rise of 12 feet, and his arches were fixed rather than hinged.[22] So the choice between hinged and hingeless configurations was – and appears to me to be still – a personal one. The final form may represent an efficiency that is rationally derived, sometimes better and sometimes worse, but the choices remain those of an individual designer.

Thus, while there were surely some partial precedents for Maillart's forms when he began his own firm in 1902, it took his work to bring out their potential in a distinctly coherent way. Other designs, such as the Isar bridge by Mörsch or a project of 1898 by David Molitor [*16*],[23] however thin their arches, lack the power of Maillart's mature works: the profile variation is too slight, the springing piers are unnecessarily bulky, and there is no clear connection between the horizontal deck and the curved arch.

Maillart's ideas and context: Constructor versus calculator

Before a detailed understanding of Maillart's work can be reached, substantial study of his life must be carried out. Without that, for the time being, we have to proceed with the few published papers in which he expressed some of his ideas and intentions. Perhaps the most significant of these, 'Aktuelle Fragen des Eisenbetonbaues', appeared two years before his death, and has been translated in Max Bill's book.[24]



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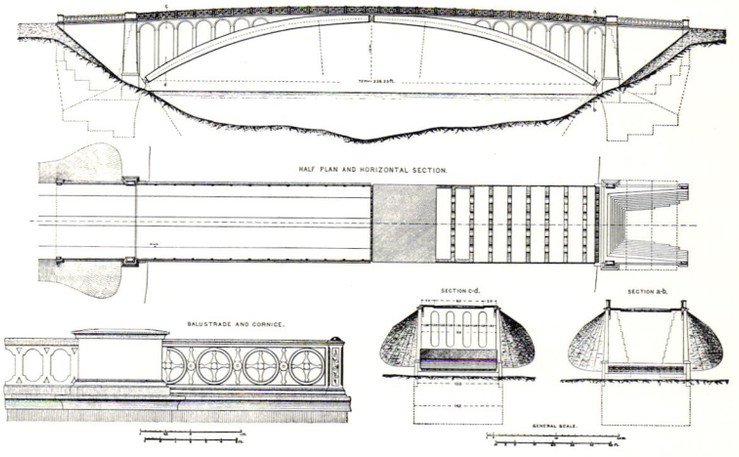

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15. Bridge over the Vienne, at Châtellerault, three arches, center arch 164 feet in span, by François Hennebique, 1899

16. Project for a three-hinged arch of reinforced concrete 236 feet in span, by David A. Molitor, 1898

The paper begins by identifying two origins of reinforced-concrete construction: Joseph Monier (1823–1906) and his tubs, slabs, and arches, relatively thin in section and reinforced with wire mesh; and François Hennebique (1842–1921) and his system of framing floors with reinforced-concrete T beams.[25]

Maillart states that the precedents set by Monier's work, and by a related series of arch experiments in Austria, had not received 'due consideration or development': official practice had adopted an unnecessarily small allowable stress in the extreme fiber for reinforced-concrete sections, based on an inappropriate theoretical assumption rather than on experimental data, and thus 'larger reinforced concrete arches designed on this assumption . . . lacked the slender form of their predecessors and hardly differed from plain concrete arches'. Furthermore, since allowable compressive stresses were so restricted, 'small or only quite trivial tensile stresses occurred so that the existence of the reinforcing no longer served any purpose. . . . The understanding that strong reinforcing allows for an increased stress in the opposite edge permeated very late and so slender elastic arches are relatively scarce.'

While praising Hennebique for having seen that, in the customary practice of constructing floors with steel I beams for support and with concrete as only infilling, 'the steel compression-flanges were no longer necessary when concrete was considered as a body capable of withstanding compressive stresses' – and thus for his innovation of the T beam – Maillart faults him for stopping short. 'For the most part his constructions consisted of main and secondary beams with slabs generally spanning only small distances and playing a minor role. And so this type of construction gives the impression of the earlier iron and wood constructions.'

In this first section of the paper, then, Maillart condemns two modern-design heresies – reliance on codified formulas, and uninspired dependence on 'forms stolen from the language of older materials' – and proposes his own alternatives: empirical testing, and conceiving a structure as a continuous whole so as to avoid rigid forms that might prove inappropriate. The testing, by which he meant the study of the behavior of reinforced concrete through scale models and instrumented constructions, would 'heighten the sensibility' of the engineer and, he claims, show the current method of allowable-stress calculation to be 'inadequate and in addition undesirable in education, because it mediates false ideas of the true behaviour of [for example] a rectangular section under bending stresses'. But even more important for Maillart, the engineer ought to 'free himself from the forms dictated by the tradition of the older building materials, so that in complete freedom and by conceiving the problem as a whole, it would be possible to use the material to its ultimate'. This approach would bring not only a true sense of beauty, but 'nearly always . . . economical advantage as well'.

Finally, once the engineer has attained the freedom that comes from direct experience with the material and seeing the elements of a structure in terms of 'fluid [and] beautiful continuity', and begins to use reinforced concrete in ways true to its ultimate capacities, he might well 'also arrive at a new style as in automobile and aircraft construction, as beautiful, and in the same way determined by the nature of the material. Then perhaps taste will begin to be rectified, so that the public judge the traditional form of reinforced concrete bridges in the same way as they judge the automobiles of the turn of the century whose prototype was still the horse-drawn carriage.'

Having established briefly his own approach to *Gestaltung* ('design' is a rough translation, but misses overtones of forming, molding, and styling conveyed by the German word), Maillart turns, in the second section of the paper, to a more detailed criticism of that first heresy of design, reliance on codified formulas. He illustrates the inadequacies of the methods of calculation prevailing at the time (1938) by discussing the problem of bending in a rectangular beam. His argument is essentially an appeal to abandon those methods (what we now call *working-stress* design), and to replace them with a more realistic procedure. The prevailing methods, according to Maillart, had three defects: first, they assumed a constant relation between stress and strain, from Hooke's law, which was valid only up to a point; second, they found structural dimensions by means of a codified allowable stress that was no longer appropriate; and third, they treated elements as radically different as wall-like beams and thin slabs as if they behaved the same under bending. Taken together, these defects implied rigid codes of practice, which 'mislead or compel the engineer to strict mechanical application. . . . Above all, these legal prescriptions should never be taught to students, because they can only be injurious to the freedom of their field of vision.'

This field of vision, which would include firsthand experience with the materials of construction and make the conception of a structure as a whole 'primary to that of the single elements', is clearly central to Maillart, and is characterized by the distinction he makes between *Konstrukteur* and *Rechner* ('constructor' and 'calculator'). The calculator, trained to facility in the direct application of codes and formulas, will produce timid and clumsy designs, while the constructor, with a deeper empirical understanding, can achieve bolder and more elegant structures, modifying the results of calculations and more closely approaching an ultimate use of the materials [*17, 18*]. Maillart concludes simply. 'A general [easing] of the prescribed laws in the sense of assigning greater responsibility to the constructing engineer would very much improve the quality of our buildings. . . . Only a simple method of calculation is therefore possible and adequate. The reasonable judging of its result anyway gives a construction of greater uniform safety than is possible with the strict but thoughtless application of a meticulous method of calculation to whatever degree of accuracy it is taken.'

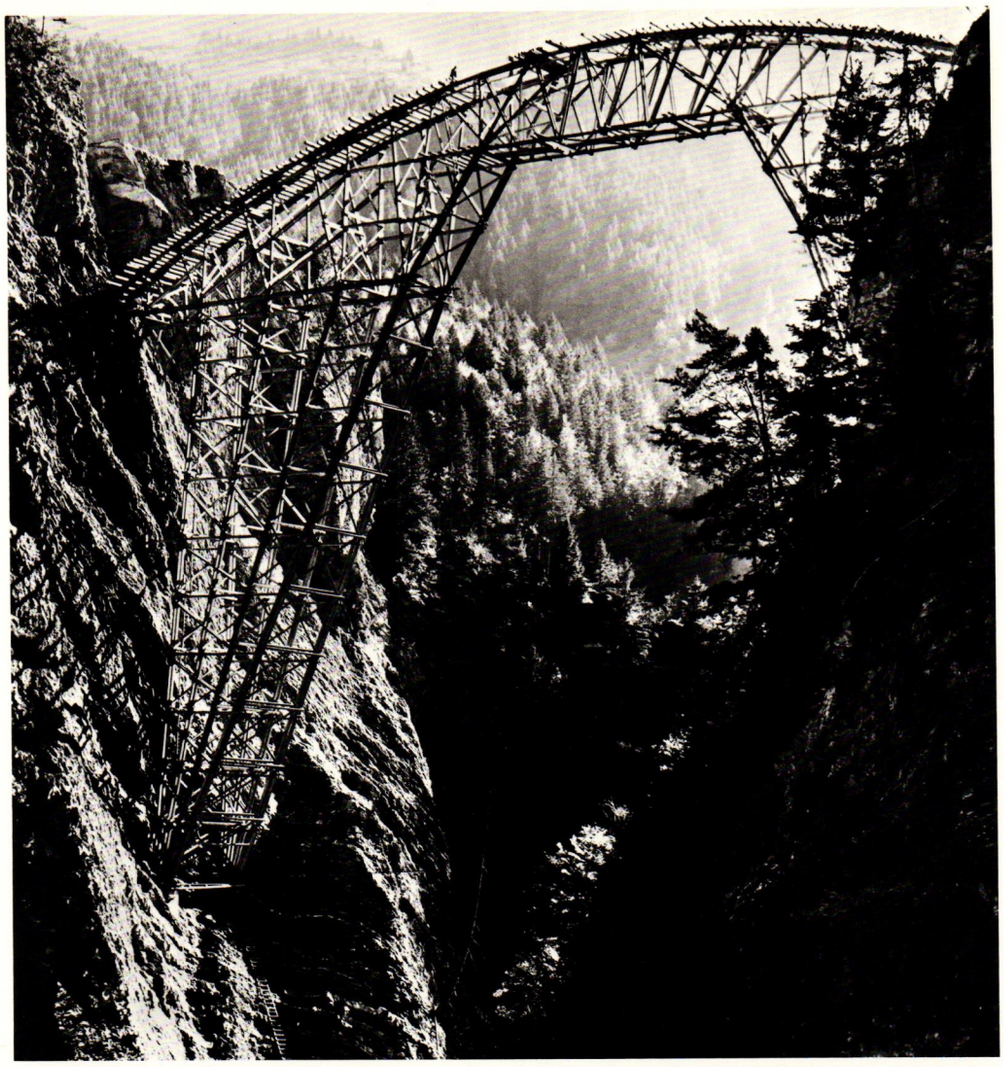
Abstract efficiency: Using material 'to its ultimate'

While it is easy to nod thoughtless agreement with Maillart, the real force and complexity of his ideas cannot be caught without some measure of analysis. Indeed, two of his points – that codes are obstacles to vision, and that efficiency implies both economy and beauty – might easily reduce, if not considered carefully, to clichés.

In the simple ending to his paper, Maillart expressed a concern that had grown critically important to him – overcoming the codes of his time. Now, in fact, procedures compatible with his idea of calculation (what we call *ultimate-strength* design) have become standard and preferred ones in the United States, with the publication of the 1963 A.C.I. building code; the limits of Hooke's law have been recognized, codified allowable stresses are no longer completely binding, and some distinctions are permitted in the treatment of structurally different members.[26] Still, I believe Maillart would have tended to condemn this code as well, simply because any code forces a compromise between safe, routine design and daring innovation. While inhibiting the pioneer, however, codes are usually the most practicable checks on irresponsible or inexperienced designers. The question of codes really involves the old and persistent conflict of safety versus efficiency, and these remain the two boundary conditions against which any theory of structure must be judged. To his credit as a pioneer, Maillart believed a worthy structure to be one that, conceived as a whole, led not only to 'minimum waste of material' but also to 'greater uniform safety'.

Then consider his implication that efficiency, 'to use the material to its ultimate', is synonymous with economy, 'nearly always brings economical advantage'. Such is not always the case, and indeed it is part of the mythology of American know-how that 'efficiency' usually means an inefficient use of materials, to achieve an overall economy in a

17, 18. Construction of Salginatobel bridge (falsework by R. Coray)









project through savings in the cost of labor. This verbal confusion tends, particularly in the United States, to limit the persuasiveness of Maillart's argument (as well as similar arguments by Nervi, Torroja, and Candela, all of whom come from cheap-labor economies). Nevertheless, this need not vitiate for us his principal ideas if we avoid the pitfall of debating whether or not economy results directly from efficiency.

But in trying to answer the more difficult question – whether efficiency, as defined by Maillart, would also have aesthetic meaning – we will not be struggling with the usual problem of art criticism, because here technical meaning is primary. In other words, the meaning of a work of engineering lies not so much in visual or iconographic relationships as in concrete technical performance. Certain aspects of the technical performance may, of course, be given visual emphasis in the final work [*19*], but that is not essential to its efficiency [*20*] and is not necessarily what Maillart meant by a 'style as in automobile and aircraft construction, as beautiful, and in the same way determined by the nature of the material'.[27]

Indeed, for many years engineers have depended upon a dichotomy between technical and aesthetic meaning to justify all manner of monstrosities. They have responded to often reasonable criticisms of their work by calling them merely aesthetic or, on the other hand, defended senseless decoration, structural 'expressionism', etc., on the grounds that the technical, by itself, was not sufficiently aesthetic. And the layman, led to believe that engineering involves only the technician's drive for efficiency, interprets any resulting beauty as chance, similar to the unconscious splendors of raw nature; Schuyler himself concluded that perhaps architects were needed to make the most out of engineering works.[28] Then how are we to understand the fact that works by such engineers as Maillart have been seen as works of art?

While there is a difference between objects designed for utility and ones destined to be contemplated aesthetically, it can be seen that works of art often have something to do with practical functions, and that perfectly functional objects can be experienced aesthetically.[29] At a certain level of consideration, we can even see a basic similarity between the activity of the artist and that of the engineer, for both of them are involved in questioning their means of expression rather than simply following precedent. Erwin Panofsky has suggested the source of this similarity in observing that other animals, unlike man, 'use signs and contrive structures, but they use signs without "perceiving the relation of signification," and they contrive structures without perceiving the relation of construction. To perceive the relation of signification is to separate the idea of the concept to be expressed from the means of expression. And to perceive the relation of construction is to separate the idea of the function to be fulfilled from the means of fulfilling it. . . . Beavers build dams. But they are unable, so far as we know, to separate the very complicated actions involved from a premeditated *plan* which might be laid down in a drawing instead of being materialized in logs and stones.'[30]

In this light, we can begin to see the implications of Max Bill's claim that 'Maillart had the creative power of an artist, who always conjures up something new through the means of expression of his time and by making use of all the possibilities at his disposal'.[31] Aesthetic meaning was not to be found in decoration or in collaboration with artists or architects. Rather, it would come from an individual power of originality, like the artist's, in conceiving the problem of bridging and the possibilities of achieving a coherent style with reinforced concrete.

19. Gatti wool mill, Rome, by Pier Luigi Nervi, 1953; floor slabs with ribs showing the isostatic lines of the principal bending-moments

20. Warehouse in Zurich, by Robert Maillart, 1910; the first beamless floor-system in Europe, incorporating two-way reinforcing

Indeed, in intimating how one might gain perspective on engineering structures such as those by Maillart, I have conscripted some tools from art history, in particular the kinds of study recognized by Panofsky as essential to man when he 'makes sense' of objects like paintings or cathedrals.[32] The counterpart of studies of individual monuments, related documents, and a general historical concept in art history could be found, I believe, in studying individual structures, the related ideas and practices of their engineers, and a general theory of form in engineering. Such study, when pursued with the same careful scholarship that is the rule in such fields as the humanities, will begin to reveal more specifically Maillart's vision and its significance in the first half of the twentieth century. And at the same time, we should be able to proceed to use Maillart, not as a model for imitation, but as a stimulus in our own approach to the continuously changing problem of appropriate forms for building. In short, his example could contribute to an abstract theory of structural form, one upon which to base a criticism of construction in our times.

Design in reinforced concrete is presently schizophrenic. On one side, the internal forces in monolithic structures are obtained from an analysis based on Hooke's law, while on the other, cross sections are dimensioned by comparing those forces to section strengths based on calculations that grossly (and correctly, as Maillart recognized) disregard Hooke's law. This psychosis produces the very defect he attacked – the splitting up of the design into pieces. So a theory appropriate to contemporary design would, in the spirit of Maillart, center on continuity in conception. Underlying his maxim about seeing structures whole, however, were the roots of his talent, and these must be considered basic to the theory.

First, Maillart gained direct experience in construction with his own building firm and could advance his work from observations of actual structures. Second, through these experiences, he saw the ground for innovation in scale-model testing, from which he developed his design procedures. Third, in conjunction with those procedures, he had a thorough training in that rigorous analysis of structures which has come to dominate academic research and teaching; indeed, he cleared up a complicated problem in three-dimensional elasticity by introducing the abstract concept of the *shear center*.[33] Having studied at one of the finest technical institutes in the world, Maillart was not afraid of mathematical rigor and rejected it only when, reduced to codified formulas, it limited the designer's full field of vision. Fourth, Maillart's vision was free enough to conceive new forms, rationally created, that could be both efficient and beautiful, and he was willing to persevere with 'the authorities' for chances to prove that his efficiency of form could be one form of economy as well.

Competitive construction, physical testing, mathematical rigor, and freedom of vision were the fundamentals behind his search for a coherent style. Designing a structure in terms of 'beautiful continuity' meant trying to keep them all contributing to its conception, forming all parts with equal reverence, and shaping and reinforcing to use the whole of the material closer to its ultimate capacity.

Although we can identify these central features, it is difficult to predict what might come once further study of Maillart's work and ideas has been brought to bear in a general theory of form in engineering. Here, I have just tried to suggest the possibilities, not only for engineers to search for equally powerful styles of efficiency in their designs, but also for the public to value such distinctive beauty in civil works. We should not, of course, expect to see future works in the style of Maillart. But I believe that as new studies and structures evolve, he will stand – with Roebling, Eads, and Eiffel – as one of those rare men, an archetypal civil engineer.



SIGNIFICANT STRUCTURES

PETER CAWS

As long as a structure, architectural or otherwise, serves its function, why should it matter that it is *structured* in one way rather than in another? Yet it clearly does matter; it is obvious (except to those who believe that form follows automatically from function) that a functional design can be wrong – that there are alternative ways of solving the functional problem and that some of them are better than others. One might argue the respective merits of functionally equivalent designs on aesthetic grounds. But the rules of that debate are far from agreed upon; and there remains the question, given some canon of aesthetic judgment, of why works judged better according to it should in fact be preferred by the observer.

The vocabulary of popular aesthetic criticism overlaps in interesting ways with other vocabularies. From what a man 'sees in' a work (a building) we move to what he 'gets out' of it, what it 'does' to him, eventually what it 'says' to him. We speak then of the designer's *expressing* something (himself, perhaps – and this in an unexpected way may come close to the truth if, as I believe, one of the principles of individuation among members of the same animal species, and the most important one in the case of men, is precisely their mental structure). His work becomes a *statement*, and its qualities become those of statements: it may be bold, assertive, enigmatic, lyrical. Its structure is not merely functional or even aesthetic, but also *significant*.

What makes an object into a sign? Most accounts invoke conscious intentions, and search for *meanings*. But we may be convinced of the significance of something even when, in any ordinary sense of the term, it doesn't *mean* anything at all. Meaning may indeed be only a special, utilitarian form of significance. A more general theory is required.

Structuralism, as a theory of significance, maintains (to simplify somewhat) that significance is a property of the *elements of systems*, of systems *having a structure* which it is the task of structural analysis to discover. Only *within* the system can the elements have significance; the system as a whole cannot have the kind of significance that its elements have, although it may have significance as an element of another system, which may or may not have a structure similar to its own. Once a structure proves to be significative, however – that is, to characterize a system whose elements are significant – *every* system having that structure will be seen to have significant elements, whether or not its primary function is to be a bearer of significance. If there were only one system with significant elements, its structure would give rise to a series of homologous structures, so that (to say the same thing) all systems of significance might be structurally equivalent transformations of one another. Or there might be two or more such sets of equivalent systems, corresponding to different structures.

The paradigm of a system whose function is primarily significative is language. So we have a tendency to speak of anything that appears significant as belonging to some language: hence the 'language of architecture', and so on. But it is a legitimate question to ask if the structure of the system of architecture is really equivalent to that of the system of language or whether architecture belongs to a different series. The structure of spoken or written language is ordinarily *syntagmatic* – linguistic utterances are ordered linear sequences in time, linguistic inscriptions are ordered linear sequences in space (which for this purpose can be regarded as one-dimensional). Another significative system which clearly shares this structure is music. The difference between them seems at first to lie in the fact that spoken or written language depends for its coherence on external reference (a *signified* to match the *signifier*), whereas the coherence of music is internal. Both are systems of *differences* – phonetic and grammatical on the one hand, tonal, harmonic, etc., on the other. But language alone appears to have the added dimension of *reference*, of the signifier to the signified.

Difference and reference may prove to be universal characteristics of significative structures. But the *external* reference of language may well be anomalous (and derivative, even in this case, from internal reference). The experience of poetry, not to mention on a less exalted level the use of language by children or in casual conversation, shows that the sense of the significant we get from language does not depend on its utility and is as much an internal matter as an external one, if not often more so. The elements of a significative system, in other words, need refer to nothing but each other: the system may be *closed*. (Note however that a closed system is not necessarily a finished one; the notion of closure is topological and is compatible with the admission of new elements.) It is not necessary, therefore, to look for the significance of architecture in some other realm, sociological or anthropological or psychological, any more than this is necessary for music.

To return to language: it was the analysis of the structure of its significance, initiated by Ferdinand de Saussure, that kindled the structuralist movement. Later structuralists have uncovered the significative structures implicit in a number of other human activities: totemism, kinship systems, psychoanalytic practice, political theory, history, above all literature. These structures, however, are not all syntagmatic. Even language has its nonlinear aspects – utterances accompanied by gestures or facial expressions, different typefaces and layouts – and the structures of these other activities occupy multidimensional and even abstract spaces.

Architecture is a special case: it is *both* syntagmatic *and* multidimensional, and furthermore syntagmatic in two senses. Buildings are three-dimensionally *there*, or two-dimensionally in plan, elevation, etc. In this they resemble the products of the plastic arts. But they are also places in which events happen, and the time-sequence of such events, which modifies, and is modified by, the architectural character of the place, constitutes one linear dimension. The other arises because buildings are also places to be *moved through* by persons, whose movements determine a sequence of perspectives: approaching a façade, passing through an archway, crossing a courtyard, climbing a stair – a literally linear sequence, since the observer follows an irregularly shaped but geometrically definite line through the space defined by the building.

The significance of architecture arises from the internal reference of its elements to one another, about which more will be said later. But it should be noted in passing that it *may* in fact have external significance also: a spire may point to heaven, the long low structure of a railroad station may point to distant destinations. Architectural symbolism (the church with its choir, nave, and transepts laid out in a cross, the mosque with its paradise garden) is one of the oldest and most obvious forms of this external significance. But the structures that convey this significance – and this is a general truth for significative systems – are often arrived at *unconsciously*. Conscious attempts at architectural symbolism, like those at the construction of languages, often fail.

This suggests that the architect cannot *set out* to do something 'significant'. It does not mean, however, that he is driven back to the pure functionalist extreme; he operates in a space bounded by the merely utilitarian and the wholly significative but not reducible to either. Nor is it a categorical warning; exceptional people may get away with it from time to time (as for example in the case – by now practically a cliché – of Saarinen's T.W.A. terminal). Similarly, in language, one *might* set out to write poetry, although most people are well advised not to.

1. Door in Kahn's Eleanor Donnelley Erdman Hall, Bryn Mawr College

Structuralist activity, in fact, is critical rather than creative; it has to do with the response to, and the analysis of, *products* of the human imagination. (To put it more accurately, what it creates is critical, constituting a new structure that parallels and illuminates the structure to which its critical attention is directed.) The domains of this activity are cultural domains, the elements in which are, directly or indirectly, creations of *mind*. It does not apply, and cannot be expected to apply, to natural domains, such as the physical or biological, except as *theories* of these domains, which are cultural products, come under review.

Mind is itself part of nature; one might therefore regard the cultural as a special subclass of the natural. But it is a subclass all of whose elements bear the stamp of mind; they are only to be reached, as it were, *through* mind. The reason for the significance of the elements of cultural systems is presumably to be found in the fact that mind itself has a certain structure which it communicates to its products and recognizes in them. Structuralism is therefore also a theory of mind; as such its main thesis is that the structure of mind is to be discovered through the analysis of the structures of its products.

It will be clear from all this that structuralism cannot provide *rules* for creative activity, in architecture or anywhere else. The characteristic of rules is that they can be built into programs whose execution can be independent of mind (they can, for example, be taught to machines). An understanding of structuralism may help to remove inhibitions on the free exercise of the creative powers of mind, or lead to the rejection, as a result of criticism, of products in which those powers have been inadequately exercised. But it will not make a sterile mind fertile or a flat mind brilliant. The only way to learn the creative use of a language (in the broad sense of the term) is to become immersed in its vocabulary and to give rein to the natural tendency to create structures out of the elements of that vocabulary. Chomsky's great contribution to the understanding of language in the narrow sense has been to show that every child, indeed every human being, employs language creatively almost every time an utterance is uttered.

The creative use of language, if language is to serve its function, must be constrained by its phonology and its grammar: only some among the possible combinations of sounds form linguistic units, only some among the possible combinations of words form sentences. But only some among the possible sentences are accepted as having more than a functional or utilitarian value. To sustain judgments of better or worse, applied to otherwise adequately formed linguistic products, phonology and grammar need to be supplemented by a theory of *style*.

The problem of style is dual: it involves on the one hand the design of the syntagma (or of a structure in several dimensions), on the other the choice of its elements. This choice introduces the notion of the 'paradigmatic axis'. Not only can we think of the sequential elements of a sentence as strung along the syntagmatic axis, but at each definite syntactic location we can think of possible elements that might occupy it as ranged along a paradigmatic axis. In the sentence *Mary Ann wore a brown coat* the word *brown* might be replaced by *blue* or *fur* or *new* and still yield an intelligible sentence; setting the paradigmatic axis at right angles to the syntagmatic axis we have:

warm
blue
Mary Ann wore a brown coat
fur
tweed
new
. . .

Now clearly not all paradigmatic substitutions are mutually exclusive; we can obviously expand the sentence into *Mary Ann wore a warm new brown tweed coat*, which then suggests a set of paradigmatic categories:

	thick	*blue*	*duffle*
	thin old	*green*	*fur*
Mary Ann wore a(n)	*warm new*	*brown*	*tweed coat*
	heavy	*red*	*rain-*
	. . .	. . .	. . .

Already however it is becoming possible to generate, from this limited sequence of paradigms, sentences which while syntactically well formed are semantically unexpected – for example, *Mary Ann wore a thin new green fur coat*. And further expansions are possible by placing paradigmatically related terms in syntagmatic conjunction: *Mary Ann wore a heavy thin new red-green fur raincoat*. Note that from *Mary Ann wore a brown coat* we have left the domain of description for the domain of the image; the paradigmatic complexity of the last long sentence approaches that of poetry, although its syntagmatic structure is still pedestrian. It strains the paradigmatic, but not to the breaking point; only if an outright contradiction (both members of a mutually exclusive pair – *thick thin* or *old new*) were introduced would we feel inclined to say that the sentence had become semantically problematic or had violated some syntactic rule, and even then it might still play a poetic role, the poetic function being defined by Jakobson as 'the projection along the syntagmatic axis of relations belonging to the paradigmatic axis'.

It is evident that in the architectural case an understanding of what constitutes architectural language, what is the grammar of architecture, is only the beginning. The question with which this essay opened cannot be answered by a theory of architectural language; it requires a theory of architectural style. And this will involve an understanding of paradigmatic as well as syntagmatic relations in architecture, a specification of which elements are, and which elements are not, mutually exclusive or otherwise incompatible. (Certain constraints operate in building physical structures that have no analogue in linguistic structures – a building can not only be elegant, incongruous, etc., it can also fall down.) But even where language in the narrow sense is concerned, structuralism is only beginning to have the elements of a theory of style. The best that can be done here is to point out some of the features of the structure of language that make style possible. A parallel exercise for architecture can then be sketched by reference to a couple of examples; its carrying out would have to be the work of people more at home in its proper vocabulary and grammar.

The analysis of significative systems in terms of the signifier/signified relation is probably, as indicated above, best reserved for the special case of language in the narrow sense, and language moreover as it serves one of its utilitarian or cognitive functions – communication, information storage and retrieval, or theory construction. Saussure's insistence on this relation was indispensable in order to put linguistics on a systematic footing, but its transference to other significative systems has a confusing rather than a clarifying effect. Serious structural linguistics owes more, perhaps, to one of Saussure's successors, N. S. Trubetzkoy, who with Jakobson and Karcevski was in fact responsible for introducing the technical notion of structure into linguistics.

Trubetzkoy's great contribution lay in his analysis of the notion of *opposition* in phonology. This work is to be found in his *Principles of Phonology*, and it, rather than Saussurean (or perhaps even Lévi-Straussian) models should probably be emulated if a developed structural theory of architecture is to emerge. 'An opposition presupposes not only characteristics which distinguish its terms from one another, but also characteristics which are common to the two terms. These characteristics may be called the "basis of comparison". Two things which have no basis of comparison, that is, no characteristic in common (for example, an inkpot and free will), do not form an opposition.' In architecture, for example, true oppositions would be inside/outside, plain/ornamented, wood/stone. It would be instructive

(although perhaps not easy) to determine the basis of comparison in these and similar cases.

Oppositions then are *bilateral* (when the basis of comparison is unique to the two terms in question) or *multilateral* (when the terms share this basis with other terms); they are *proportional* (when the relation between the terms is identical with the relation between the terms of some other opposition) or *isolated* (when the relation between them is unique). Trubetzkoy offers an empirical generalization as to the statistical distribution of these types in the phonology of natural languages: multilateral isolated are the most frequent, followed in descending order by multilateral proportional, bilateral proportional, and finally (as a rare exception) bilateral isolated.

Oppositions may then be *privative* (if one term is 'marked' as having a certain character, and the other can be anything at all as long as it does *not* have that character), *gradual* (if both terms have the same characteristic but in different degrees), or *equipollent* (if each has its own marked character and they are, as it were, of equal logical strength). And they may be *constant* (operative under all circumstances) or *neutralizable* (operative in 'positions of relevance', inoperative in 'positions of neutralization').

Now I give this (simplified) introduction to Trubetzkoy's scheme not so much in order to put it immediately to use as to point out that it is only with a sufficiently complex technical apparatus that one can hope to do anything serious or interesting with this kind of analysis. It is easy enough to see some of the types of opposition in the architectural case: plain/ornamented, for example, is clearly privative, rough/smooth is gradual, wood/stone is equipollent. The question of bilateral and multilateral oppositions is not quite so easy; Roman/Gothic (of arches) is clearly multilateral, and probably also isolated, since the contrast rounded/pointed does not spring to mind as significant in any other context (but this may be due to ignorance); bilateral cases, on the other hand, as Trubetzkoy's statistics would suggest, are harder to come by. Further cases are left as an exercise to the reader.

If a careful analysis along lines like these could be done for actual buildings recognized as masterpieces, some of the problems of a theory of style might solve themselves. A celebrated although controversial example of something like it for literature is the analysis of a sonnet by Baudelaire carried out jointly by Jakobson and Lévi-Strauss and published in *L'homme* in 1962. It is entirely a demonstration of structural elements at the levels of phonology, syntactics, semantics, and so on, and gives one the impression of *understanding* why Baudelaire enjoys the poetic reputation he does.

It may be said of an architect that he 'makes an imaginative use of materials' or 'manipulates forms skillfully', etc. As a critical judgment this is about as profound as saying of Baudelaire that he 'makes an imaginative use of words'. It needs to be shown in what the use consists; what oppositions, of what frequency in the architectural repertory, are exhibited, what internal (or external) references are called into play, and so on. And this cannot be done casually, but requires something analogous to a phonology, a syntactics, and where appropriate a semantics.

Corresponding to phonology would be a study of materials, textures, etc., with the types of opposition into which they enter; corresponding to syntactics, a study of structural elements and their oppositions and interrelations; corresponding to semantics, a study of the relations between structure and use, or in a few cases structure and significance on the signifier/signified model. But the analysis would have to follow that order: the syntactics cannot be fully understood without a developed phonology. And as suggested earlier, a slavish analogy to the linguistic case would be mistaken; architecture may belong to a different series from spoken or written language, although the structuralist theory of mind would suggest that if there are different series they must at least be intimately related to one another.

The fact that structurally interesting objects are all cultural (and this, given the structuralist theory of mind, almost by definition) means that they are the conscious or unconscious products of individual or collective human agency. The structural elements may be invented, or they may be inherited. Linguistic elements are nearly always inherited. Most modern languages, in fact, are constructed of the bits and pieces of ancient ones, and they thus illustrate what has become a central concept of structuralism, that of *bricolage*. There is no satisfactory translation for this in English; in colloquial French it means doing odd jobs, being handy around the house – the motto of the *bricoleur* is 'It may come in handy.' He is the man who keeps the old chair leg, the discarded molding, and who uses them to build heterogeneous structures which may or may not be functional but which often have unexpected aesthetic qualities. His opposite is the *ingénieur*, or engineer, who uses raw or processed material that has not been previously used, and who builds relatively homogeneous structures, whose heterogeneity, if any, is deliberate and controlled.

Bricolage is an important concept because it may amount (speaking loosely) to half the structuralist story. Structural analysis may turn up formal oppositions and overt references, and these may occur even in the most cleanly engineered structure. But it may also reveal references not easily accounted for in such formal terms, allusions to (or whole quotations from) an inherited tradition, juxtapositions of elements from diverse cultural streams in a newly significant combination. The theory of *bricolage* accommodates synchronic (that is, contemporary) heterogeneity because at the same time it preserves diachronic (that is, historical) continuity. What is significant to us may be so because of what it immediately is, but it may be so because it belongs to an inherited vocabulary of significance.

The architect is both engineer and *bricoleur* (not in the chair-leg-and-molding sense but in the sense that structuralism has extrapolated from it – and in this sense the practicing engineer, too, may well be part *bricoleur*). He may order his materials and calculate some components of his forms as an engineer, but he will almost certainly allow elements of *bricolage* into his design, perhaps without being aware of them. Also, what may be 'engineering' for one generation may become *bricolage* for the next: a design that must make its case in purely structural terms comes to be a model and a source of borrowings or quotations for subsequent designs. A form whose significance in one epoch lies in its contrast with other forms may in another epoch find a different sort of significance in its familiarity and frequency. (Consider, for example, the history of the skyscraper.)

In the last analysis the significance of any structure probably lies in its appropriateness to the condition of the observer, who alone can *confer* significance. The most satisfying structures will, I think, prove to be those whose complexity, in terms of their internal and external references and oppositions, most nearly matches the complexity of the mind that contemplates them. Highly undifferentiated structures (approaching the zero level, or nonstructure) arouse no interest; highly differentiated structures (fragmented, chaotic) overload the perceptual and intellectual mechanism. It may happen that within a particular domain the level of structural complexity changes apparently at random over time (from classical to baroque to rococo and back to classical; from Victorian gingerbread to functionalist streamlining), but it will almost certainly be found – although this is a thesis that cannot be argued here – that these variations are compensated for by reverse changes in other domains. One of the lessons of the structuralist movement is that the capacity of mind, from primitive times to our own, has remained more or less constant.

Structural analysis of the kind discussed in this article works best, as was suggested earlier, on human artifacts. It is easy to see why this should be so: humans are more likely to recognize themselves in their own products than in nonhuman ones, and it is this recognition of

ourselves that in the end constitutes the sense of significance. (That the natural world also should be intelligible to us, if not significant, is no doubt a consequence of the fact that we and it are products of the same forces.) But human artifacts may have different characteristics according as they have been produced by individual or collective action, consciously or unconsciously. There may be other ways of dividing them up as well, but these give us a two-by-two matrix in which various kinds of artifact can be located:

	Individual	*Collective*
Conscious	Works of art, literature, scientific theories, etc.	Public works, planned cities, law, etc.
Unconscious	Habits, gestures, taste, handwriting, etc.	Language, morals, kinship rules, cities, etc.

The functions of structural analysis will differ according to the location of its object in this matrix. Structuralism began in the bottom right-hand compartment, with the gross phenomena of culture (which I call unconscious not because of an adherence to a Jungian view of the 'collective unconscious' but because I take it that their overall structure is a result not of deliberation but of the unreflective interaction, over long periods, of many individuals, most of whom considered them indeed to have extrahuman origins). Structuralist inquiry in some of these domains has uncovered facts about them – their invariable elements, their systems of internal relatedness, etc. – that could not have been perceived by the casual observer, and to that extent it has had a scientific character. In the other three compartments its function is not so much scientific as philosophical, since it seeks less to explain what has happened than to understand what is happening.

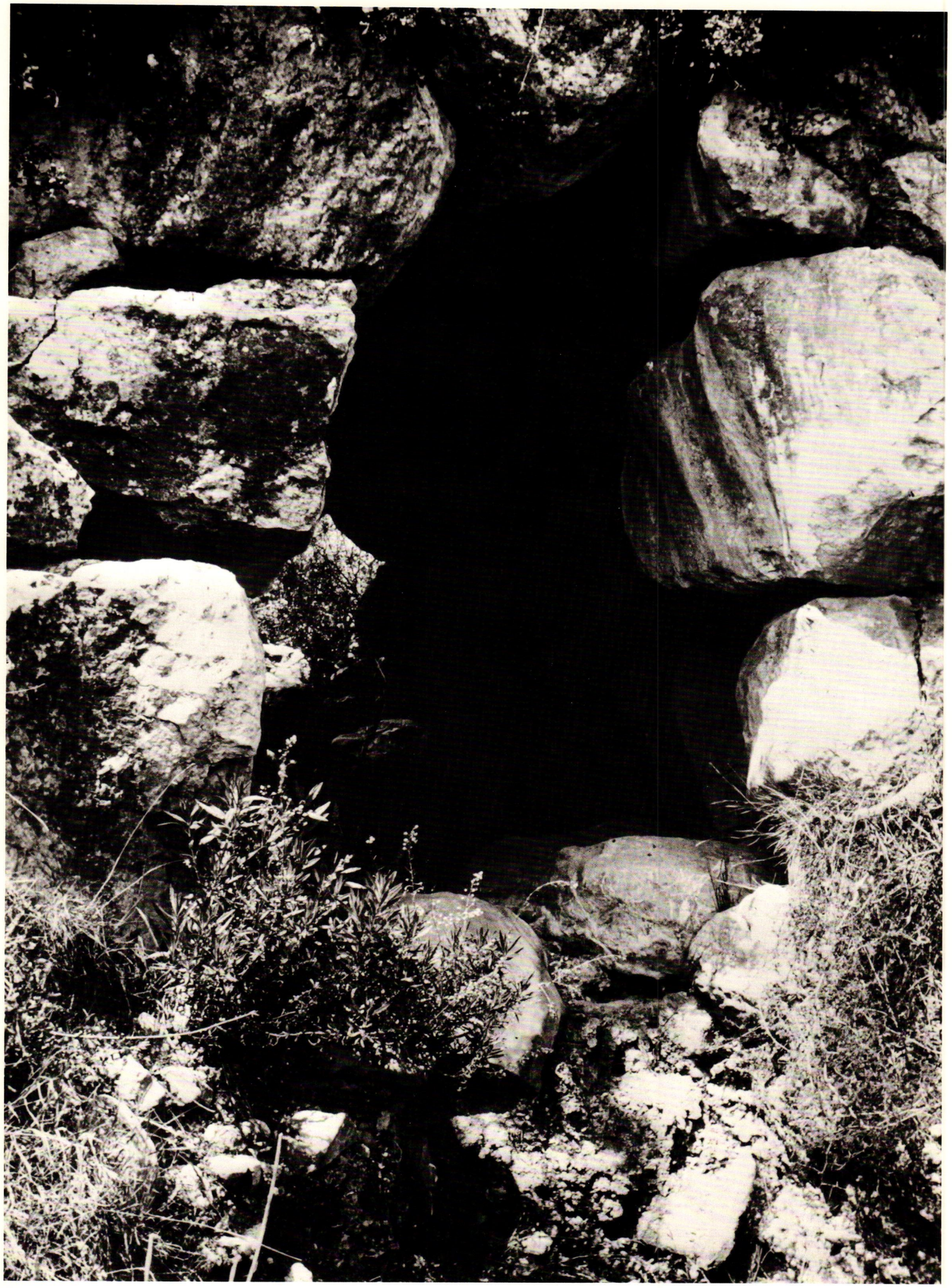
Architecture, to revert to the specific preoccupation of this essay, belongs in the top left-hand corner. In dealing with it structural analyses can play two major roles. They can help us to see more clearly the content of individual works, and they can identify classes of oppositions, paradigmatic sets, and the like, thus providing a kind of grammar of architecture and making it intelligible on the level of significance as well as on that of function. In conclusion I offer a tentative approach to these tasks in terms of a couple of examples. In [*1*] we see a fairly simple detail from Louis Kahn's Bryn Mawr dormitory building. Its simplicity is classical, in that it depends on a sparing and formal use of a small number of fundamental elements. The most obvious 'syntactic' relations involve the oppositions square/circle, vertical/horizontal, wood/bronze, wood/concrete, transparent/opaque. The first of these is the most striking, the semicircular window contrasting with the square doorplate and with the rectangularity of the door itself and of the corner. The surface of the door is made of vertical panels, the wall appears to be made of horizontal slabs; but the door functions as a single unit, and the wall was cast as a single piece in horizontal wooden forms. The wood has a built-in directionality because of the grain, the metal has no such directionality, the concrete acquires one because of the grain of the forms in which it was cast. The punctuation of the surfaces (the knotholes, the screws, the circular impressions in the concrete) constitutes an affinity that tends to neutralize the material contrast. The transparency of the window (obscured in the photograph by reflections and by the fact that, because the door is stopped open, only the wall can be seen through it) contrasts with one of the functions of the door itself, which is to be opaque, to separate one region of space from another; at the same time it emphasizes another function, which is precisely to connect the two spaces it separates. Such semantic ambiguity in a stable syntactic relation is of course a familiar feature of language. In this case window and door remain fixed relative to one another, but the window (and not the door) can be seen through and the door (and not the window) can be opened. In a more extended structural context the opposition fixed/mobile (between the walls and the door) comes into play primarily on the semantic level, since when closed the door functions syntactically as a wall. When open it is, as it were, syntactically disconnected from the neighboring elements, and might as well not be there at all (compare the type of sliding door that disappears entirely into the adjoining wall). The grain markings already drawn attention to in the concrete refer back semantically to a process of construction, just as the metal doorplate refers forward to the use of the door as it is pushed open. (The lower metal plate anticipates the same use in a less ceremonious mode.)

In [*2*] we see a detail of an interior in Antoni Gaudí's Casa Milá, the heterogeneity of which is in striking contrast to the classical simplicity seen in the detail of the Kahn door. Syntactically it appears somewhat confused, partly because of the interpolation of elements not intended by the architect – the two light-fixtures with their stark geometric lines, the ornate mirror that goes just as far in the opposite direction as compared to the fluidity of Gaudí's forms, the heavy furniture – partly because of the richness of the original structure, especially of the ceilings. Abstracting from the intrusions, one finds these oppositions: straight/curved (a weaker opposition than the square/circle in Kahn's design); plain/ornamented (in the window and doorway moldings as well as on the ceiling); transparent/opaque (although because of the way the leaves of the door are here arranged the glass panels contribute as much to the opaque as to the transparent, a point echoed in the panel of patterned glass to the right as well as in the apertures in the ceiling above the doorframe – even the window and the mirror give the impression of enclosing, rather than transmitting, light, as does the milk glass of the light fixture, while on the other hand the polished table seems transparent); and of course the material oppositions wood/plaster, wood/glass (the latter however in a muted form as compared to the definiteness of the corresponding opposition in the previous case), etc. All of these, however, as was true also in the case of the Kahn door, are exhibited within the given structure in both their terms; if I were to begin in either case to list other members of the paradigmatic sets from which elements of the structure are drawn, the exercise would exceed my time and capabilities. In the case of Gaudí, however, it seems required to comment at least on the ceiling in more detail, since it displays the characteristic mark of his style. Part of the impact of that style no doubt derives from the unexpected placing of the forms. If the photograph is turned upside down the flowing lines of the ceiling, and even the apertures in it that penetrate into the room, appear quite natural, like waves in some viscous fluid. We are used to seeing the heaviness and complexity of liquid surfaces at the bottom of our visual field, the lightness and simplicity of cloud or air at the top. Inverted, the wavelike forms become grotesque; the apertures suggest that the wall is really not a full partition and that the ceiling, lapping against it, has partially filled in the gap, in contrast to the usual plain (and plane) form of ceilings.

On the semantic level I draw attention to one feature only of the many possible, namely, the sociological reference implicit in the cracked paint on the doorframe and the careless painting of the door to the right, where the paint has been allowed to drip onto the glass. Others can easily be identified by the reader. These sketchy and no doubt amateur remarks are put forward in any case only for the sake of pointing a direction. They do not begin to exploit even the modest structuralist equipment described in this article. But refined and carried further by others they might lend a new emphasis to the study of architecture as a 'signiferous', or significance-bearing, system.

2. Doorway in Gaudí's Casa Milá, Barcelona





INTUITION AND THE SPRINGS OF STRUCTURAL INVENTION

ROWLAND J. MAINSTONE

'. . . all Arts were begot by Chance and Observation, and nursed by Use and Experience, and improved and perfected by Reason and Study.' – Leone Battista Alberti

'The Imagination . . . I consider either as primary, or secondary. The primary Imagination I hold to be the living power and prime agent of all human perception, and as a repetition in the finite mind of the eternal act of creation in the infinite I Am. The secondary Imagination I consider as an echo of the former, co-existing with the conscious will, yet still as identical with the primary in the kind *of its agency, and differing only in* degree, *and in the* mode *of its operation. It dissolves, diffuses, dissipates, in order to re-create: or where this process is rendered impossible, yet still at all events it struggles to idealize and to unify.' – Samuel Taylor Coleridge*

This paper poses and attempts to answer certain questions about the art of structural design or, more particularly, about the genesis of structural ideas within the wider context of architectural design. How do these ideas arise? What are the springs of structural invention? How are they related, for instance, to the theoretical bases of structural analysis? These questions will be approached from the standpoint of present practice; but earlier practice, where it can throw a useful light on this, will be considered in some detail.

First, though, in order that these questions may be precisely understood, it is necessary to state what is meant here by invention in general and by structural invention in particular.

Inventions may come about in different ways. Chance and the unpredictable never cease to play their part in human creative endeavor. But, as Alberti clearly saw, the process does change when the simple recognition of the usefulness of some accidental discovery gives way to more purposeful and thoughtful innovation.

Primitive man, when he built his first bridge or shelter, no doubt stumbled on the simple arch or beam with little deliberate design or forethought. And initially, we may assume, it was largely through further chance discovery and observation that he slowly learned to improve on this simple beginning.

At this level his own contribution was merely in perceiving the usefulness of that which he chanced upon, the superior merit of each improvement, and enough of its essential characteristics to enable him to reproduce it successfully.

Suppose, however, that the building of archlike structures had not progressed beyond the rudimentary form represented by the rough, cyclopean work of a bridge on the old road between Tiryns and Epidaurus [*1*] by the time that skill in dressing and fitting stones together had made possible walls of fine polygonal masonry. Occasionally, in such walls, the inclusion of a stone considerably larger than average [*2*] or the incorporation in the lower part of the wall of a humped outcrop of rock [*3*] gave rise, quite accidentally, to 'pseudo-arches'. If then – as is possible, though we might equally well suggest other origins – some builder discerned in one of these pseudo-arches the possibility of a true load-bearing arch of cut voussoirs and recognized, in this, a promise of superior strength and stability, he would, albeit still at a simple level, have conceived something as yet unrealized but potentially feasible and useful. For in the wall there was, structurally speaking, no such arch. Only if we removed the larger stone or outcrop, which in fact largely carries the stones above, and then allowed the stones of the pseudo-arch to settle enough to close the gaps between them would these latter stones become voussoirs of a true arch bridging the void.

Invention such as this would call not merely for perceptive observation but also for the prior recognition of a need and for some conception, based on the observation, of a possible way of fulfilling it.

In what follows, invention will be considered as a conceptual process similar to that here involved, though usually a more complex one that is quantitative as well as qualitative. This conceptual process, rather than any measure of possibly adventitious novelty, will be taken





2. Pseudo-arch at Segni

1. Bridge near Tiryns

3. Pseudo-arch at Cerveteri

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4. Rock-cut tomb at Cerveteri

5. Rock-cut church in Cappadocia

as its distinguishing characteristic. It has, therefore, a part in every design that is not mere pastiche.

However, since architectural design usually involves much more than the devising of simple structural elements or expedients, it is still necessary to ask ourselves what part structural invention plays in this larger context.

It is not to be expected that this part will always be the same. The architect's primary concern is usually to enclose space and provide shelter and, in so doing, to create appropriately expressive and perhaps also symbolic relationships of forms. At the same time he also creates structures in that these enclosures, these forms, must stand and endure. They must be so proportioned and so built that the natural tendency of most things to give way eventually under the constant action of gravity and the varying assaults of other disruptive agencies is forestalled. But this necessary end may be achieved in different ways. Contemporary practice exhibits many variations, and these can easily be paralleled, less invidiously, in architectural history.

If, for example, it is true that most basic architectural forms had a purely functional origin in which structural necessity played a large part, it appears also that, through long use, many came to be valued purely as forms and were, as such, often transposed to new materials and new kinds of construction. Initially form followed function. But in its new transpositions the form came first and the structural means were considered later, if at all. The most striking examples of this are the numerous rock-cut replicas (devoid of all structural logic) of hallowed forms originally constructed in timber, stone, or brick and detailed to exploit the capacities and respect the limitations of these materials [*4*, *5*]. Architecturally more important, and for the present purpose more relevant, are the transpositions of the domical form to different uses and methods of construction from the Roman period on.

Originally no more than the simplest form in which to construct a small shelter out of a wide range of naturally occurring materials [*6*], the roughly hemispherical dome or 'beehive' shape acquired over a long period, simply as a space-enclosing form, many layers of symbolic overtones – as ancestral home, mausoleum, martyrium, temple, and church [7].[1] So valued, more for the sake of its associations than for its structural merit, it became the central germinal idea of many architectural conceptions. In bringing this about, the architects of the Roman Empire from the time of Nero to that of Hadrian played a decisive, if somewhat fortuitous, role by demonstrating many new and exciting possibilities. Having chanced upon a concrete of unprecedented strength, they progressively exploited its ability to span wide spaces as a monolithic mass, proceeding tentatively at first, then with growing confidence in the Domus Aurea and the Domus Augustana, and finally with supreme assurance in the Pantheon [*8*] and the Villa Adriana [*9*]. Yet, apart from some constructional details, the domes of all these buildings appear to have been conceived wholly as forms and as interior spaces rather than as structures. It is as if the alternately projecting and receding surfaces of many of the domes had simply been carved out of the concrete mass: there is no sign of them externally. Where, indeed, something more than a simple modeling of the interior surface of a solidly based mass was attempted, as it may have been over the octagon at the south side of the Piazza d'Oro in the Villa Adriana, assurance possibly overreached itself.[2] Purely structural invention in these Roman domes is, therefore, to be seen less in their form or their scale than in constructional details like the selection and placing of the *caementa*, the incorporation of *amphorae* in the concrete to lighten it, and the use of brick ribs, revetments, and relieving arches.[3] When, however, these Roman achievements are transposed into Byzantine brick [*10*] or the brick and stone of medieval and Renaissance Italy or the more sparingly used concrete of today, the modeling of the whole form does again become a matter of structural concern and is often largely a structural invention.[4]

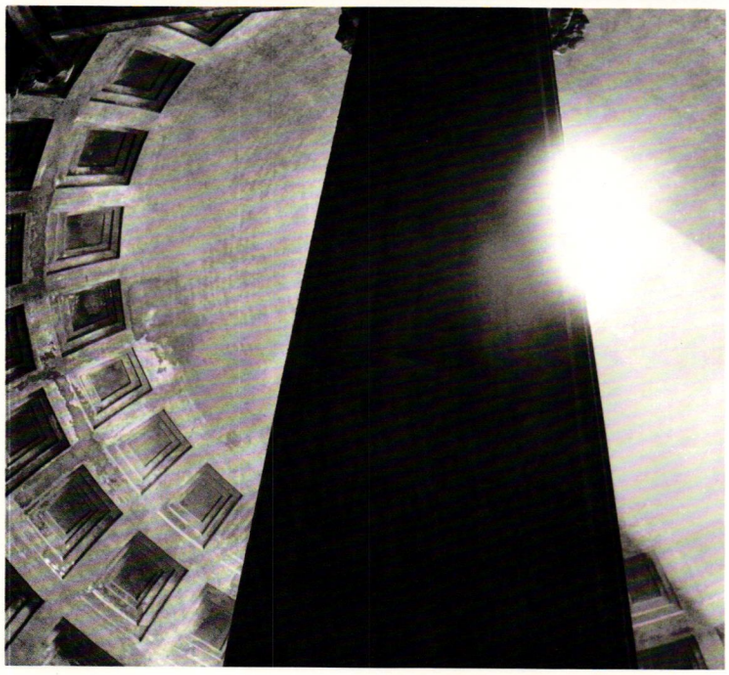
6. Stone beehive dome near Gordes

7. Monastery church at Daphne

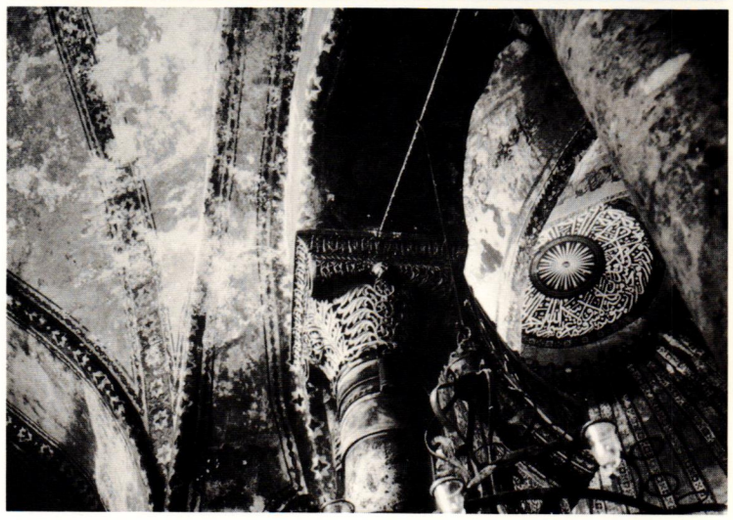
8. Pantheon, Rome





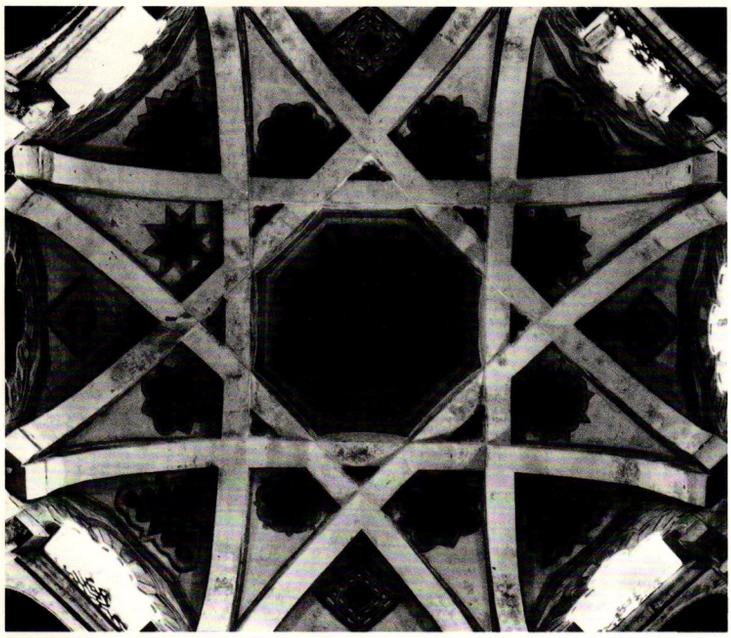


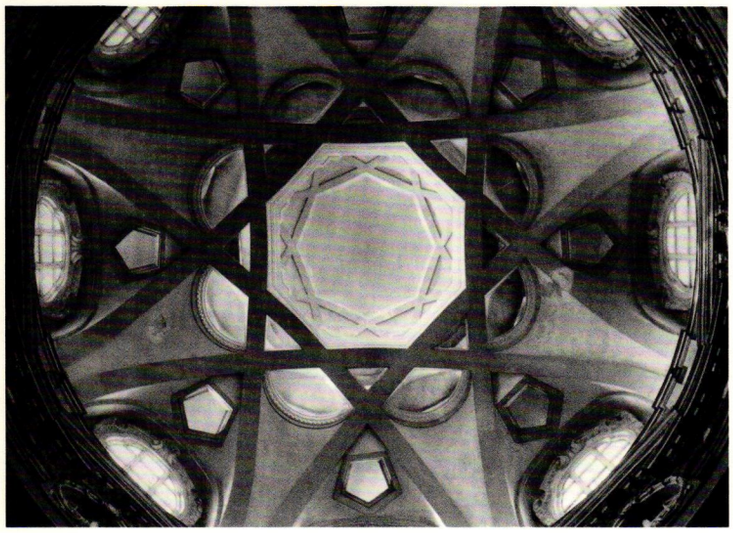




9. Serapeum, Villa Adriana, Tivoli

10. Hagia Sophia, Istanbul



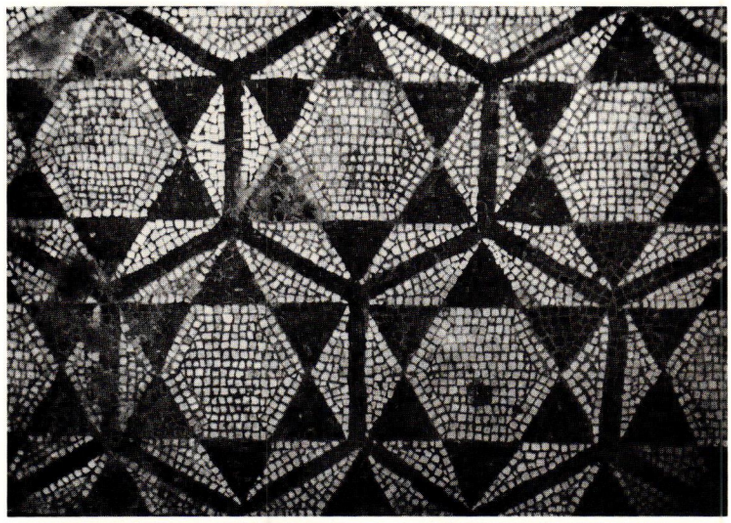


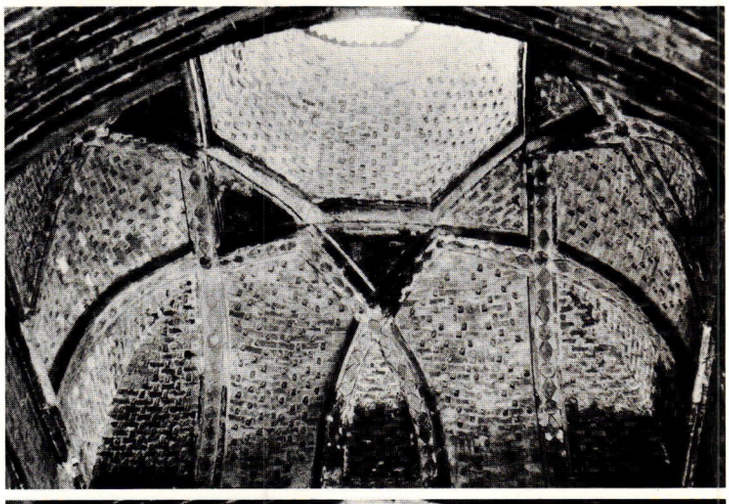
11. Mosque at Córdoba

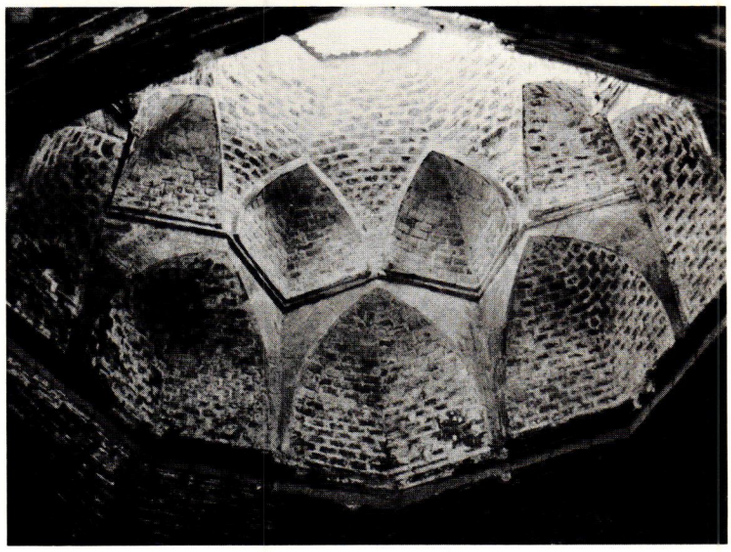
12. San Lorenzo, Turin

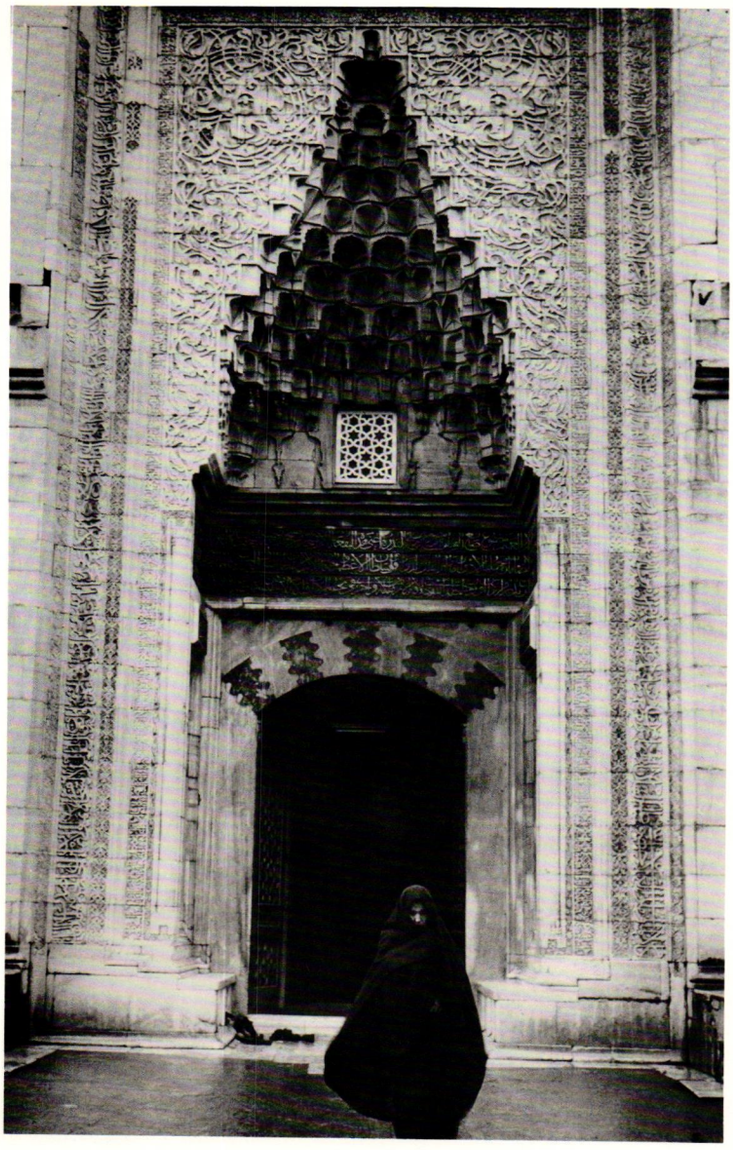
13. 'House of Livia', Rome

14, 15. Friday mosque in Isfahan



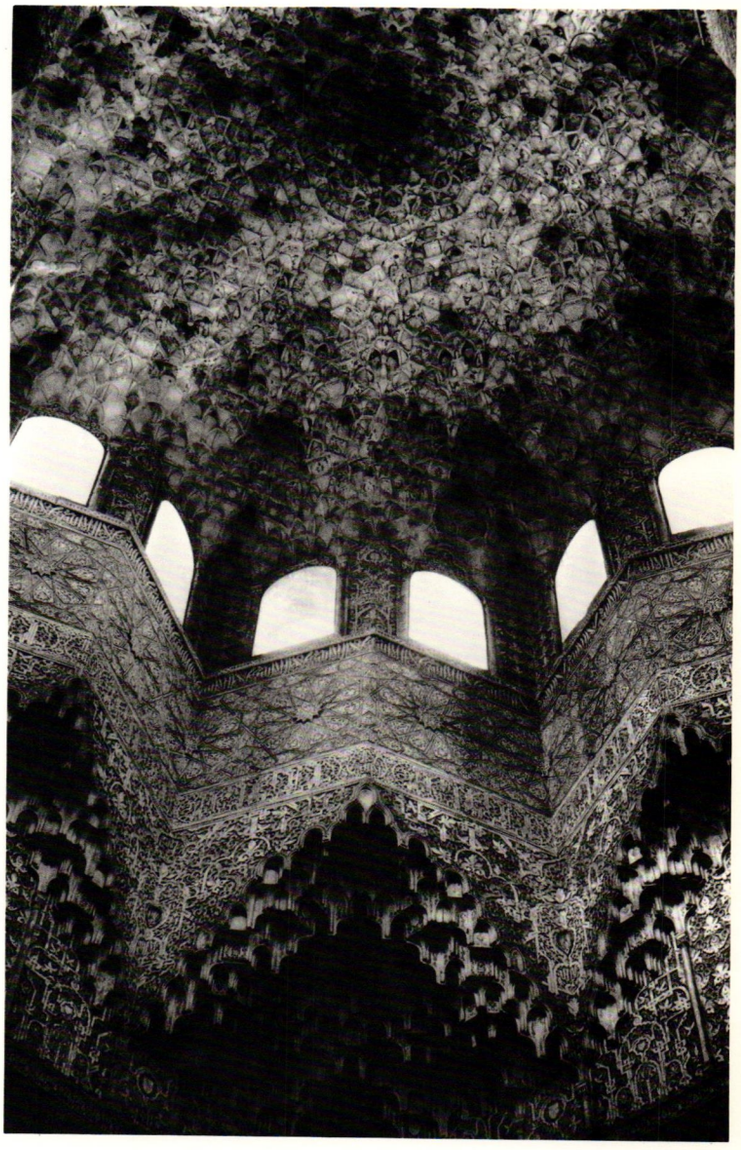






16. 'Green Mosque', Bursa

17. Alhambra, Granada



The development of the class of ribbed domes best known through the examples in the mosque at Córdoba [*11*] and in San Lorenzo in Turin [*12*] presents an interesting variant on this pattern of invention.[5] In Córdoba, and in the much smaller vaults of El Cristo de la Luz in Toledo, the ribs appear to be largely decorative and to have been conceived as little more than a surface pattern of a kind of which the Islamic world was particularly fond. This patterning originally had nothing to do with structure or architecture, having possibly a dual ancestry, both in the functional patterns produced in weaving and basketry and in the more playful superimposing or interlacing of simple geometric figures as in some Roman floor mosaics [*13*] and ceiling decorations. Yet it had a certain structural connotation when applied to a vault, and, at a later date, by analogy with load-bearing ribs of other kinds – or perhaps, if we may take a hint from the detailing of some early examples in the Friday mosque in Isfahan [*14*], by analogy with a family of intersecting squinches – a potential structural function was read into an existing form in much the same way as may have happened with the pseudo-arch; and similar ribs were conceived structurally. Finally, in the work of Guarini [*12*] and Vittone and, possibly, in a number of earlier exploratory sketches by Leonardo,[6] the ribs were given both an architectural and a structural autonomy and become the basis of new conceptions in which structure and form are indistinguishable. Conversely, in Islamic stalactite vaults, the basic forms of squinch and corbel, both originally purely structural elements, were elaborated for purely decorative ends [*15–17*].



18. Priory church in Vignory

In one case, however, structural preoccupations interacted continuously with others of a purely architectural kind in determining the total conception. This was the development of the Gothic cathedral, as seen at Chartres, Reims, and Amiens, from the timber-roofed, aisled basilica of early Christian Rome and its Romanesque successors like the church at Vignory [*18*]. The aim was both to give each building the durability of stone without sacrifice of light or stability, and to make of it a new and more glorious *domus ecclesiae* as that was conceived by men like Abbot Suger and the theologians of Chartres.[7]

In the course of its fulfillment many diverse attempts were made to balance and concentrate the thrusts of high masonry vaults. In the upper narthex at Tournus [*19*], for instance, and in the pilgrimage churches on the route to Santiago de Compostela and the Auvergnat churches around Clermont-Ferrand, the thrust of the main vault is taken by flanking quadrant vaults, usually in a gallery over the aisles. At Fontenay, ranges of slightly pointed transverse barrel vaults over the aisles perform the same function as these quadrant vaults [*20*]. And over the nave at Tournus a similar succession of transverse barrel vaults, here semicircular, largely obviates the need for peripheral buttressing [*21*]. Gradually these and other experiments converge toward the final solution. The buttressing quadrant vaults of the upper narthex at Tournus, the triforia of the pilgrimage and Auvergnat churches, and the transverse aisle vaults at Fontenay give way to the flying buttress; the largely decorative vault ribs of the ambulatory at Morienval and of Durham Cathedral become part of the main structural articulation; and a new unified structural system is evolved, which, through its very coherence and expressive clarity, becomes one of the most powerful and moving symbols that architecture has to show [*22*]. Here structural invention is to be seen both in the total concept and in nearly all its details. But in neither case is the invention solely structural.

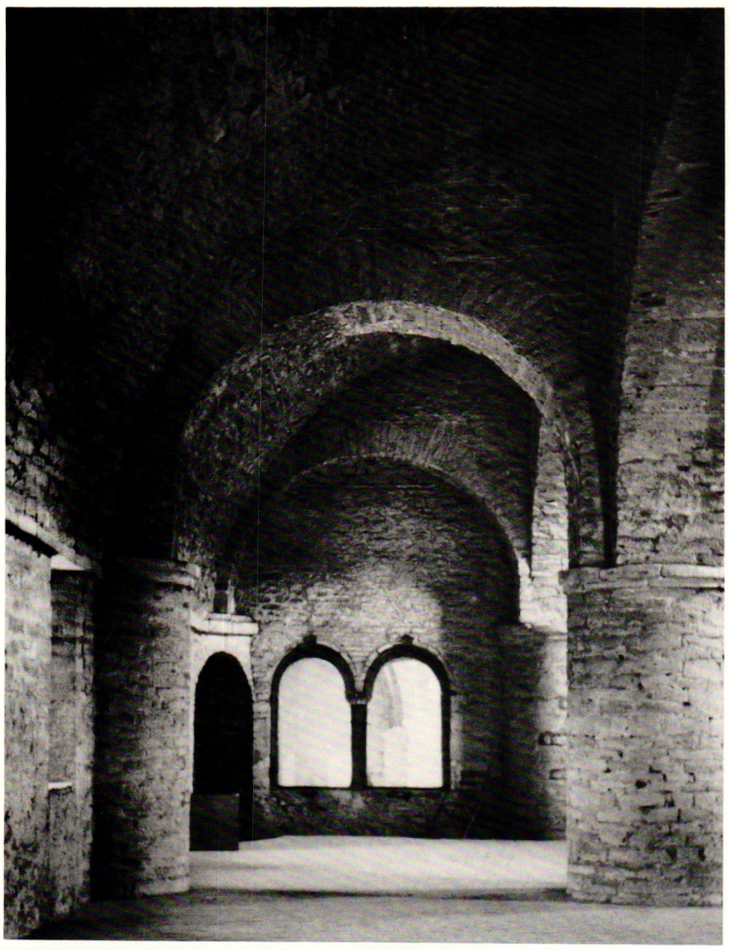
We might conclude that, where there is a deliberate concern with the structural integrity of a projected building, that concern may extend no further than the choice of materials and method of construction or than certain detailed modulations of the forms, or it may, at the other extreme, strongly influence the entire conception. But, in all cases, it will do so within the framework of other concerns and of inventions of other kinds, conditioning these and being conditioned by them and, ideally, stimulating them and being stimulated in return.

We will now distinguish structural invention as that part of the total conception marked by any such concern with structural integrity.

Creative knowledge: Intuition and insight

The process of conception is a complex one typically entailing much painstaking study of requirements and of potential ways of meeting them as well as repeated shifts of the focus of attention from the total concept of the evolving design to critical details and back again. Central to it though, at the levels of both the total concept and its details, must always be a sequence of imaginative apprehensions of possible solutions to the problems posed. These imaginative apprehensions must be refined, developed, and welded together by subsequent analysis and synthesis, but without them there could be no new conception, no invention.[8] And each of them implies, in turn, a prior awareness of the constellation of possibilities out of which it arises, just as Coleridge's creative 'secondary' imagination echoes the 'primary' one.

We will look, therefore, for the springs of structural invention in some kind of prior knowledge of the structural forms, materials, techniques, or modes of behavior that the new structure exploits. The emphasis will be on what might be called *structural* knowledge, but it should not be forgotten that, since every structural form is also a form or an enclosure of space which invites consideration from other points of view as well, knowledge of forms and spaces and patterns which is not strictly structural may also be expected to play an important role.





19. Saint-Philibert, Tournus

20. Abbey of Fontenay

21. Saint-Philibert, Tournus

22. Cathedral of Bourges









First we must consider what kind of knowledge is requisite. All our knowledge is born of experience, and it differs in its efficacy for each one of us according to the nature, for him, of that experience. If it is to serve as a springboard for imaginative creative thought, then at least part of the experience must be truly personal, like that through which we learn to speak our native tongue. Through listening to others use it and through using it ourselves, in imitation of them at first and then more independently, we gain a mastery which can make it a powerful vehicle for the formulation of ideas. In contrast, a study of the vocabulary, grammar, and syntax of a foreign language – the distilled experience of others – gives only a very different kind of knowledge, of which, by itself, we can make no such creative use. If we want the fuller and potentially more creative mastery, such study will, at best, help us to gain it more rapidly through direct experience. What distinguishes the kind of knowledge that is potentially creative is our ability to bring it effectively to bear without the effort of explicit formulation in the mind and indeed without any conscious concentration on it. The conscious mind must be free to focus on the creative end. For the structural designer this means turning over in his conscious mind the different aspects of the structural requirements and concentrating, through these, on finding an as yet unknown solution.

When creative knowledge stems, like that we have of the use of words in our native tongue, directly from personal experience, we may call it *intuitive*. When, like that which more commonly constitutes the mastery of a foreign language, it is guided by explicit codifications of the experience of others but deepened through personal experience, the word *intuitive* is less appropriate, and we may call it *insight*. Intuitive knowledge (or intuition) and insight, so defined, differ little, however, in terms of their potential usefulness for creative ends. Essentially, they differ only in that the former may remain tacit throughout whereas the latter, by definition, has involved some degree of explicit formulation. Since this distinction is not a sharp one – the insights with which we will here be concerned usually going beyond the initial explicit formulations and tending to acquire a more intuitive character – the word *intuition* will generally be used in the discussion that follows and should be read, where appropriate, as also denoting insight.

Experience

Structural intuitions stem both from experience related to building and from experience gained in a variety of other fields. Most obviously they stem from looking at buildings under construction, in use, or, most revealingly, after some failure, or from handling and working the constituent materials and elements and helping to put them together during the process of construction. They may similarly stem from looking at and handling certain types of natural structure or from experience of man-made structures other than buildings. But they also stem, in a very fundamental sense, from some of our most deep-rooted experiences of our own muscular actions and of the nature of the world around us as that is apparent to the senses of sight and touch. In addition they may draw upon a further range of what might be called contrived experience, of the kind that the scientist gains in his laboratory.

The range, depth, value, and relative importance of these different kinds of experience does, of course, change from one period, and even from one designer, to another. Even the consciousness of muscular actions is not the same for everyone. For the artist of the Mausoleum frieze [*23*] and for Michelangelo [*24*] it must have had a clarity that is perhaps given only to the sculptor of the human form and to the athlete. Moreover, when construction was largely a matter of manually placing stone on stone and of other similar manual operations, this direct muscular consciousness could play a much larger part than it usually can today. On the other hand, our previously unaided senses can now be assisted in many ways by modern instruments, and the range of experience that we can fruitfully contrive is vastly enlarged by modern testing equipment.

With these changes in experience the intuitions also change. Yet the intuitions are always distinct from the experience: they are something that our minds take from it and by means of which transcend it, usually by relating it to a wider frame of reference.

Even the simplest intuitions are mostly found, on analysis, to involve correlations between experiences of different kinds. Our intuition of our muscular actions is intimately linked not only with our awareness of muscular efforts and of external pushes and pulls which may call for them but also with our senses of balance and movement and our awareness of spatial relationships. And our awareness of spatial relationships is itself compounded of both visual and tactile experience, visual data being interpreted in what seems to be the most plausible way in terms of schemata derived from earlier tactile explorations.

Intuitions of pushes and pulls which we do not ourselves exert or directly feel involve a further association of experiences. Out in the wind we feel buffeted and we keep our balance by leaning against it. Then seeing the grass and the trees bending with the wind, we 'feel' similar forces acting on them and their development of a resistance that we would directly feel if we took the wind's place. Or, lifting and easing a stone into place on a building or straining a tie to correct a distortion or forestall a collapse, the builder feels the effort that this demands and subsequently 'feels' a corresponding effort on the part of the structure. Indeed our whole intuitive tendency to consider inanimate structures as being subjected, as we are, to external forces like gravity and the wind and as reacting to them, as we do, by developing internal resistances is a complex outcome of experiences of many different kinds.

We can, however, penetrate such complexities to some extent by distinguishing broadly between groups of intuitions stemming primarily from each of the kinds of experience mentioned above. Looking at buildings and other man-made or natural structures and observing that certain forms constructed in certain ways are adequate for some purposes and others for different purposes leads to what we will call *intuitions of structural adequacy*. The basic muscular and sensory experiences lead to the simplest *intuitions of structural behavior*. And deliberately contrived experience leads to, and is usually an essential foundation for, more abstract intuitions of behavior, or *intuitions of structural action*. The distinctions are not clear-cut, but they can help in understanding the intuitive springs of invention if it is remembered that the intuitions guiding designers in practice are generally composite ones.

Intuitions of structural behavior

The simplest intuitions of the orderly pattern which underlies all structural behavior – and which makes it all potentially determinate, if only we knew enough of the relevant parameters – are probably possessed to some degree by all men. We can even see them guide an intelligent child in his early efforts to build on the nursery floor. One aspect of the pattern may be described as *spatial*, the other as *physical* or *muscular*.

Our basic intuitions of spatial order in the sense here envisaged are such an integral part of our knowledge of the world around us that they usually pass unrecognized except in the incredulity with which we react to any apparent violation of the order. We see this world as composed of objects, each of which occupies a certain space to the exclusion of all others and seeks to occupy the lowest position available

23. Frieze from the Mausoleum, Halicarnassus

24. Michelangelo's Moses

to it insofar as this is consistent with other bodies' seeking to do the same. We expect a stone released in the air to fall to the ground unless something is interposed to arrest the fall. Equally we would expect each of the large roofing slabs of the shrine on Mount Cynthus [*25*] to swing downward and drop off the supporting ledge in the absence of the corresponding slab on the other side. With that slab also in place and undeformed, we recognize, however, that neither can fall without violating the presence and equal tendency to fall of the other. We thus arrive at one kind of understanding – complete in itself without necessarily invoking any concept of the nature of the physical interaction between the slabs – of this simple structural system; and, by a simple extension, we can arrive at a similar understanding of the arch of several voussoirs, including the recognition of the possibility of collapse here through simultaneous compatible movements of the voussoirs. Similarly, also, we can see how a buttress can prevent a threatened movement by being placed as an obstacle in its way.

The corresponding basic intuitions of physical actions within and between structural members stem from our direct awareness of our own muscular actions and reactions. Through this awareness we come to expect or 'feel' analogous pushes and pulls to be acting on and through, and resisted by, inanimate bodies. In the simple cases just considered, such 'feelings', though entirely different from the spatial intuitions, are, in practice, closely associated with them for most men. Likewise some intuition of the thrust in a column is usually almost inseparable from our concept of it as a simple obstacle to the fall of the architrave above [*26*], and we can hardly visualize a domical structure as a purely spatial configuration (in the structural sense just considered) without also having some analogous intuition of radial thrusts [*27*]. Conversely we can hardly conceive a tie as an obstacle of another kind to threatened movement without also 'feeling' the tension within it. Coupled also with our recognitions that, in standing up to and transmitting pushes and pulls and bending actions, some materials and some forms are strong and others are weak, some almost rigid and others much less rigid, these spatial and physical (or muscular) intuitions lie at the root of all our understanding of structural behavior.

The range of their usefulness is limited, though, by the lack of quantitative precision that is characteristic of the muscular component. We can directly perceive spatial magnitudes and directional relationships. Indeed these perceptions have long been given a precise theoretical statement in Euclidean geometry, and the spatial component has thereby become articulate in modern structural theory in the geometric conditions of compatibility of deformations and displacements. But we have no comparable sensory mechanism for perceiving quantitatively even the pushes and pulls we ourselves experience or exert. Still less can we perceive directly the magnitudes and directions of analogous physical actions in which we play no part. This means that, on the basis of the muscular kind of intuition alone, we can neither confidently assess the characteristic strengths and stiffnesses of the materials we use nor confidently predict the loads to which they will be subjected in particular structures. Since, moreover, the pattern of internal stresses is usually much more complex than in the simple cases just considered, it is often difficult even to be sure whether there will be primarily tension or compression in directions other than those in which the principal loads are applied or at appreciable distances from their points of application.

Intuitions of structural action

To overcome this limitation took many centuries. It was necessary to draw together many kinds of experience often, at first sight, not directly relevant to the behavior of static structures and, as has been said, deliberately contrived in the laboratory more frequently than gained in the course of everyday life or normal building operations. Clearly the highly imaginative synthesis that was called for was not reached on the nursery floor. It was very much the fruit of what Alberti called 'Reason and Study' on the part of men like Archimedes, Leonardo [*28*], Stevin, Galileo, Newton, and Hooke and their successors – assisted, since the pioneering work of Musschenbroek, by the development of accurate and versatile techniques for making structural actions (internal and external loads, stresses, strains, and small deformations) visibly manifest.[9]

The deeper understanding of structural actions which was thus progressively achieved was primarily the transformation of the basic muscular intuitions of pushes and pulls into a much more precise and powerful concept of forces and moments, coupled with a highly generalized understanding of the conditions for equilibrium. In turn, this new concept opened the door to a quantitative exploration and understanding of the response of different materials and structural elements to these actions.

The transformation became possible through learning to 'see' forces acting on material objects in the movements they induce and, conversely, to see the absence of movement as a state of equilibrium between the acting forces and between their moments. One of the forces most commonly manifest in this way is the force of gravity, and one of the simplest cases of equilibrium is that of two weights suspended from a balance arm. The Archimedean laws of the balance were largely empirical in origin, however, and could be extended to cover the equilibrium of forces acting in any direction only by a similar, almost ad hoc empiricism. The final clarification of the more Aristotelian concept of a force acting dynamically in any direction came only with Newton, and with it, as a simple corollary, an equally generalized statement of the conditions of equilibrium.

The subsequent quantitative understanding of responses was a much more straightforward extension of earlier recognitions of the different strengths and stiffnesses of different materials and different structural elements made from them. It was arrived at simply by applying known forces to specimens in the laboratory, measuring the response, and thereby building up a picture of the constancies underlying this response – of the ways in which distortions of different materials increase with increase in load and the ways in which different patterns of load lead to excessive distortion or complete disruption. Theories of elastic and plastic deformation, and related criteria of failure, are precise statements of simple idealizations of the pictures so obtained.

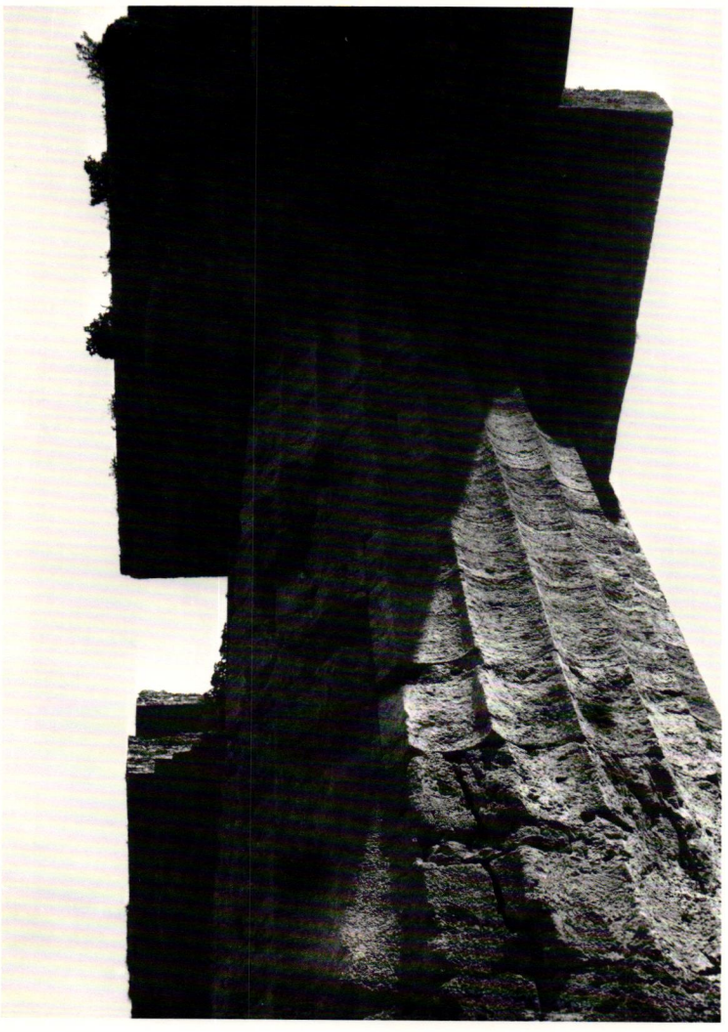
Today the structural engineer does not arrive at these fundamental insights unaided. Nor does he so arrive at much of the understanding derived from them, by his predecessors and contemporaries, of the more complex patterns of structural action associated with particular types of built form. He is guided to them by the theoretical statements and, so guided, draws from his own experience in both analysis and observation highly composite intuitions of the physical responses of the structures he is concerned with to imposed loads, imposed displacements, and other disturbances.

These responses can be considered in three ways. When considered in terms of strains and resultant deformations and displacements (akin to consideration in terms of the basic spatial intuitions), the picture obtained will be a purely geometric one, though it may be difficult to visualize as a whole because of its three-dimensional complexity and its emphasis on small changes in the simpler geometry of the unstrained structure. When considered in terms of stresses and internal reactions (akin to consideration in terms of the basic muscular intuitions), the picture will be a complementary one, but drawn from the rather different vector geometry of the main tensions, compressions, shears, bending moments, and torsions for a structure composed largely of linear members, or of the principal tensile and compressive stresses or the principal bending moments for a surface structure like a slab or a shell; the decorative rib patterns used by Nervi on the soffits of some of his slabs [*29*] give visible expression to such 'isostatic networks'. Consider-

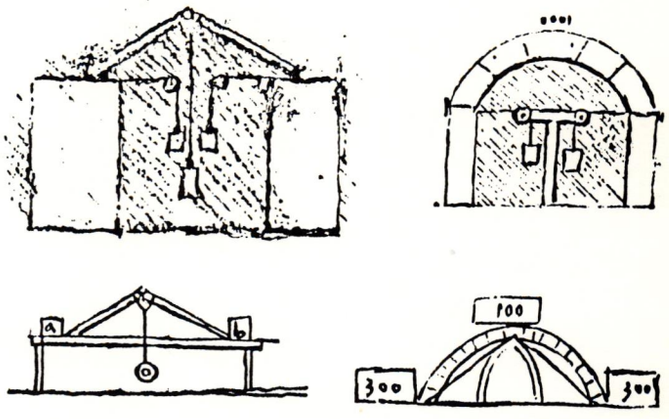
25. Shrine on Mount Cynthus, Delos

26. 'Temple of Poseidon', Paestum









27. Chapel of Santo Zenone, Santa Prassede, Rome

28. Studies of the statics of arches, by Leonardo da Vinci



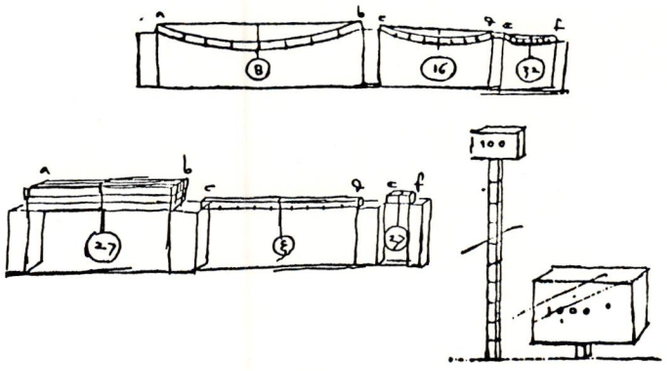


29. U.N.E.S.C.O. secretariat in Paris

30. Forum, Pompeii

31. Studies of the statics of beams and columns, by Leonardo da Vinci

32. Mykonos





ation of the stiffnesses and strengths of the structural elements and their interconnections will underlie both pictures and link both with the primary conception of any structure as something very real, to be built in a specific shape from specific materials used in a specific way.

These three aspects are always interrelated, but the extent to which they must be considered together varies with the type of structure and the importance of obtaining a full and accurate understanding of its action. When the deformations of each structural element can be accommodated by compatible deformations or displacements of other elements without inducing significant loads in these other elements, it is sufficient to consider each aspect in turn. However in most structures that are built today this is not so: all aspects must therefore be considered together if the action is to be seen correctly. If it is too difficult to do this from the start, a correct picture must be built up as far as possible, first by mentally breaking the structure down into simpler parts and visualizing the largely independent actions of these, and then by progressively correcting the pictures so obtained by allowing for the secondary actions necessary to reestablish the continuities that these simplified pictures ignore. For instance, in attempting to visualize the action of a shell structure with edge-stiffening ribs, we might first consider the shell and the ribs separately, taking into account the simple primary action in the shell itself and only the primary function of the ribs as collectors and transmitters of the primary stresses along the shell's boundaries. Considered in this way, the shell and the ribs would be seen to deform quite differently along their surfaces of contact because they would be subjected to different types of stress. We would then have to consider what changes would result from their actual monolithic interconnection. As in dealing with simpler structures, we would be helped in doing this by previous theoretical and experimental study but we would, ultimately, have to build up our own intuitive picture of the composite action.[10]

Intuitions of structural adequacy

These intuitions differ from those of behavior and action in focusing directly on the adequacy of a particular form for a particular structural purpose rather than on the precise manner in which this purpose is served. Some concept of the structural purpose is implicit, however, and, since it can be conceived in many different ways, these intuitions cover a wide spectrum. They range even more widely when they embrace, to a varying extent, some recognition of the effects of changes in scale and proportions.

The simplest of these intuitions remain largely at the level of perceiving the adequacy of an existing form for a purpose similar in nearly all respects to its present one. Perceptions such as this have already been shown to lie at the root of man's earliest and relatively unreflective acquisition of constructive skills, but they provide little guidance for innovative design. More developed intuitions both see more deeply into the essential character of the form and relate it to a more generalized (that is, less restrictive) concept of its purpose in terms of behavior or action.

As an example of the simplest type of intuition, the beehive dome in [*6*] may have been seen simply as a suitable form to use for other, almost identical huts. A more developed intuition would both embrace some understanding of the structural action of the domical form and see particular proportions as being suitable for particular types of construction and particular conditions of loading and support. Similarly, the adequacy of particular materials or structural elements may, at the simplest level, be recognized only in terms of specific uses; or it may, with much greater generality, be seen in terms of characteristic strengths and stiffnesses.

Where such intuitions extend to a recognition of the ways in which adequacy varies with shape and size, they merge with intuitions of behavior and action, and the distinctions that have been made become blurred. The rules Vitruvius gives, and later architectural theorists quote, for the desirable variations in proportion of superimposed columns [*30*] may be considered as formal statements of intuitions of adequacy. Though they are seen as necessary in order to match the strength to the variations in load, they are derived from direct observation of practice in a particular type of construction and from observation of an analogous variation in girth of growing trees. On the other hand, Leonardo's explorations of the strengths and stiffnesses of beams and columns of different proportions [*31*] and the more general observations of Galileo set out in the opening pages of *Dialogues concerning Two New Sciences* drew, to a much greater extent, on intuitions of behavior and action and led to intuitions which are themselves probably better considered as intuitions of structural action.[11]

It is more important, however, to remember that there is a continual interplay between the two classes of intuition – for intuitions of behavior and action also merge into intuitions of adequacy when a new structural form, sought initially in terms of the abstractions of behavior and action, is conceived in more concrete terms as adequate for the specified purpose.

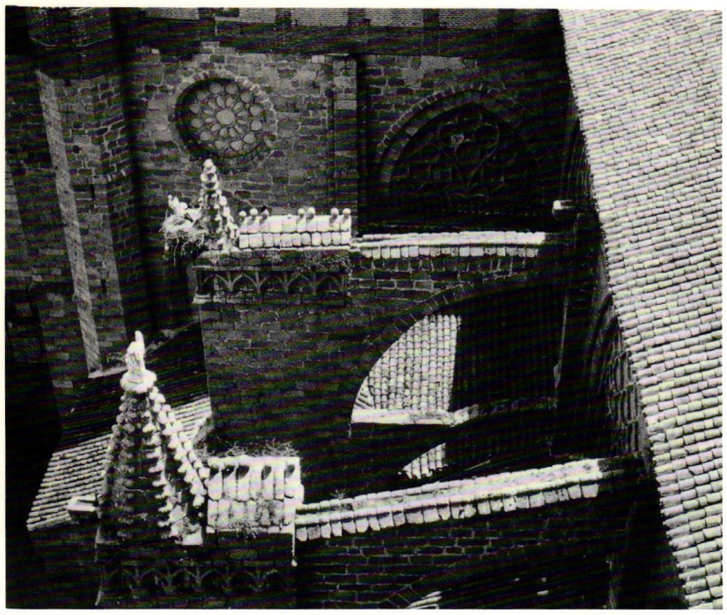
In focusing on concrete forms rather than abstractions, intuitions of adequacy, hybrid though they are, play an essential role in any conceptual process. Not only do they bring it to a conclusion: they also serve as the means whereby past experience in practical construction is most directly brought to bear as a starting point for fresh endeavor. None of us has enough imagination to think *ab origine* on more than a very limited front at any one time or to think far beyond what has been achieved already. Of this human limitation architectural history provides overwhelming evidence in the continuity and homogeneity of the pattern of development that it presents. This pattern is mostly one of slow evolution, to which, in the past, we have owed many of the subtlest refinements of style and most perfect marriages of form and function [*32*]. And even where it is punctuated by major innovations, familiarity with the milieus in which these arose often discloses a number of closely related antecedents. Rather than springing quite independently to life, the innovations bring together, or turn to a new purpose, existing possibilities.

Invention in the past

Most of the structural inventions described earlier may be seen as springing very largely from a combination of relatively simple intuitions of adequacy and simple intuitions of structural behavior.

These inventions were, as compared with much structural invention today, limited in scope. Most construction, other than the *opus caementicium* of imperial Rome, was essentially a piling up of units of masonry, balanced on one another so that they were able to resist the action of wind, subsidence, or earthquake. Timber or metal ties were introduced to assist in achieving and maintaining a state of balance by taking tensions where necessary within structural systems otherwise kept in equilibrium largely by the compressions resulting from dead weight of the masonry. But they did not modify its character radically, as do the reinforcing bars and cables of modern reinforced or prestressed concrete or the moment-resisting connections of modern steelwork. Also the range of materials used at any time and place was small. So there were fairly constant relationships between structural behavior and the simple geometry of structural form. Structure was, in this sense, an invariant of form.

Innovation was, moreover, more directly empirical than it is today, in that new structural forms and techniques of construction were mostly conceived to make good a shortcoming already observed in an existing structure or to overcome a difficulty already encountered in the course of construction. Either the innovation was a corrective





33. Cathedral of Avila

34. Saint-Philibert, Tournus

measure, applied to a structure that had been found wanting, or an attempt, in a new design, to forestall shortcomings or difficulties that had previously been encountered elsewhere. Potential structural weaknesses rarely seem to have been anticipated and provided for until they had made themselves felt somewhere in undesirable movements, local failures, or more extensive collapses.

Where cracking or buckling or other excessive deformation was met solely by increasing girth or using a stronger material, little more than trial and error was involved, calling for only the very simplest intuitions of the ways in which strength and stiffness varied with shape, size, and material. But where they were met more radically – by changing the form, introducing new members, or varying the method of construction – the simple spatial and muscular intuitions of behavior played a larger and more creative role. Usually the new conception was then primarily a geometric answer to the observed geometry of deformation or failure, whether it was arrived at during construction or subsequently. The spreading of the haunches of an arch or vault, encountered frequently when heights were increased and supports were made less massive, called for an obstacle to this movement in the form of a buttress or tie. The spatial intuition showed where it should be placed; the associated muscular intuition showed whether it would be subject to compression or tension and whether, therefore, it should be constructed of fairly heavy masonry [*33*] or could be a light section of timber [*34*] or metal. Open cracks, such as tended to appear around the bases of domes [*35*] or apsidal semidomes, always indicated excessive tensions either to be resisted by peripheral buttressing or encircling ties or to be reduced by a change of form. Usually the aim was to make a structure that was as rigid and immovable as possible. But the deliberately flexible structure of today, designed to remain strong and stable even when subjected to large settlements, also found its forerunner in the hinged masonry 'chain arch' of certain bridges built on shifting sands [*36*][12] and, to a more limited degree, in the relieving arch – an intentional pseudo-arch – of Augustan Rome.

During construction the stability of the incomplete structure had to be assured, and often, where timber for centering was scarce, the stability of each individual brick or stone as it was put in place was the main consideration determining both the bond of the masonry and the finished structural form. A preoccupation with the stability of the individual unit leads, through the simple spatial and muscular intuitions, to the characteristic profiles and the characteristic bonds of the soffits [*37*] of many arches and vaults, from those of ancient Mesopotamia to the brick domes built without centering in the Middle East today.[13] It leads, for instance, to the *a spinapesce* ('herringbone') brickwork [*38*] of Brunelleschi's dome for Santa Maria del Fiore (as well as, in all probability, to the pointed profile of this dome [*39*]) and to the slightly domical form of the webs of many ribbed masonry vaults.[14] A similar preoccupation with the practicalities of the process of construction, rather than a concern with the stability of the completed structure, is possibly the chief reason for the adoption of the pointed profile for arches and ribs in Gothic vaulting.

Some aspects of structural behavior and some of the choices that the designer would have had to make must, however, have remained puzzling on the basis of the simple intuitions of behavior alone.

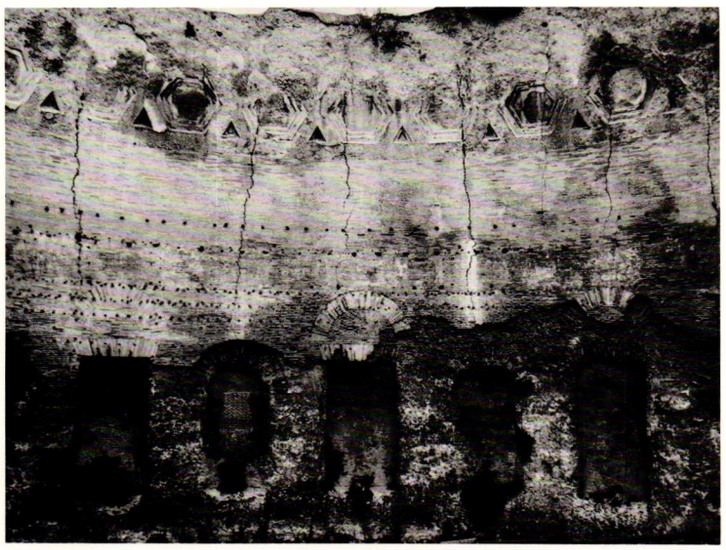
How, for instance, was he to visualize the structural role of the stone ribs of a Gothic vault or the brick ribs, relieving arches, and bond courses typical of Roman concrete construction? Did the ribs carry the rest of the vault in the Gothic structure? Did the ribs and relieving arches direct the thrusts in the Roman one – or did they not? And how was he to choose between many alternative profiles for an arch if he was aiming at maximum strength of the completed structure rather than at ease and economy of construction?

In all such cases the evidence furnished by existing structures was, in itself, confusing. Arches of many different profiles remained standing,

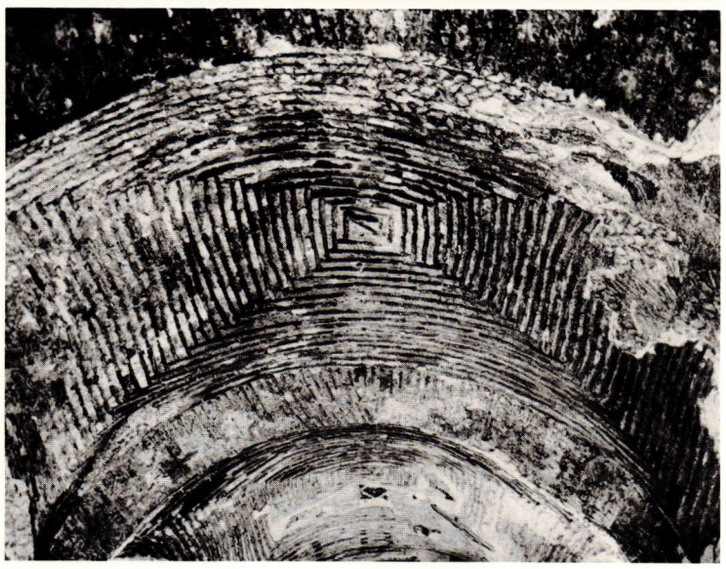
35. Baths of Trajan, Rome

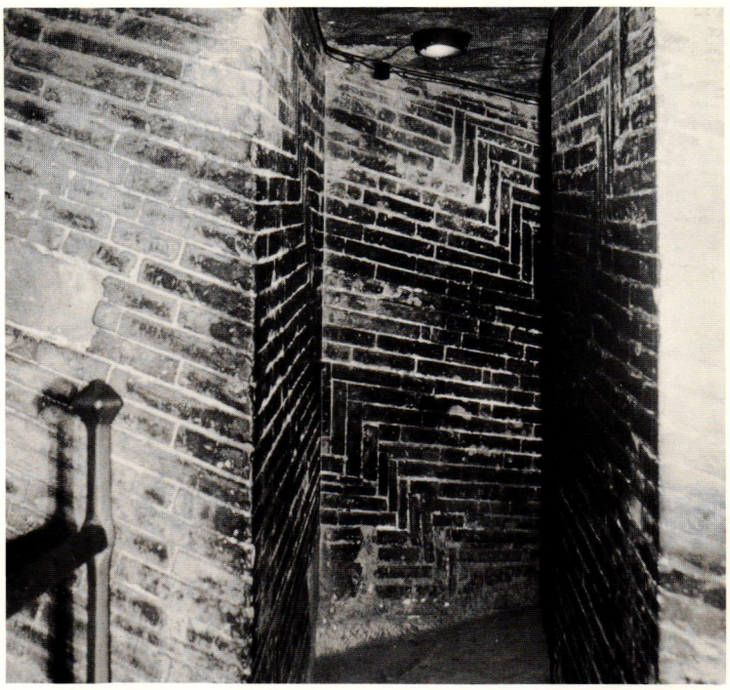
36. Bridge in Venice

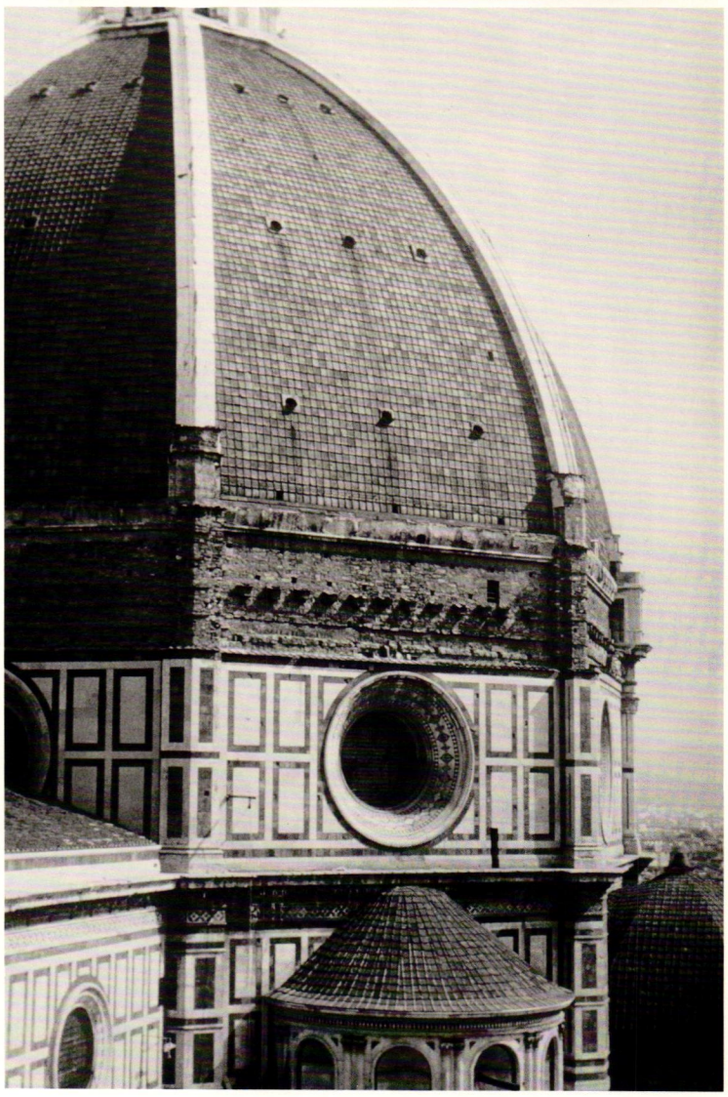
37. Hagia Sophia, Istanbul



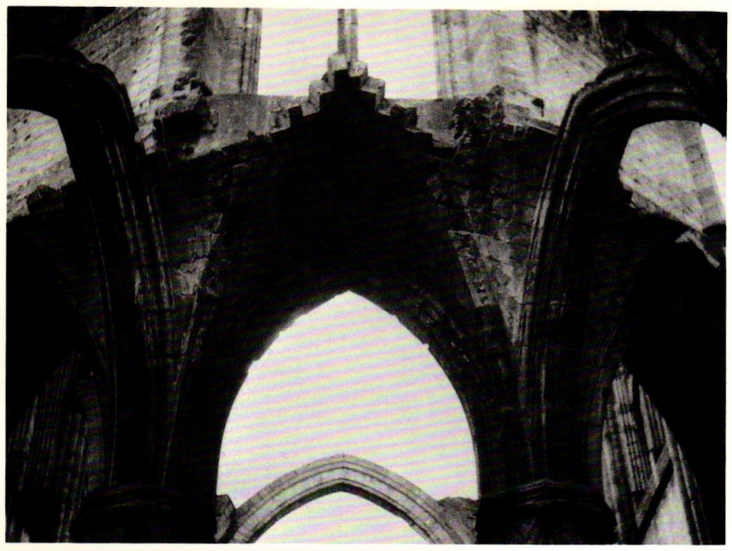








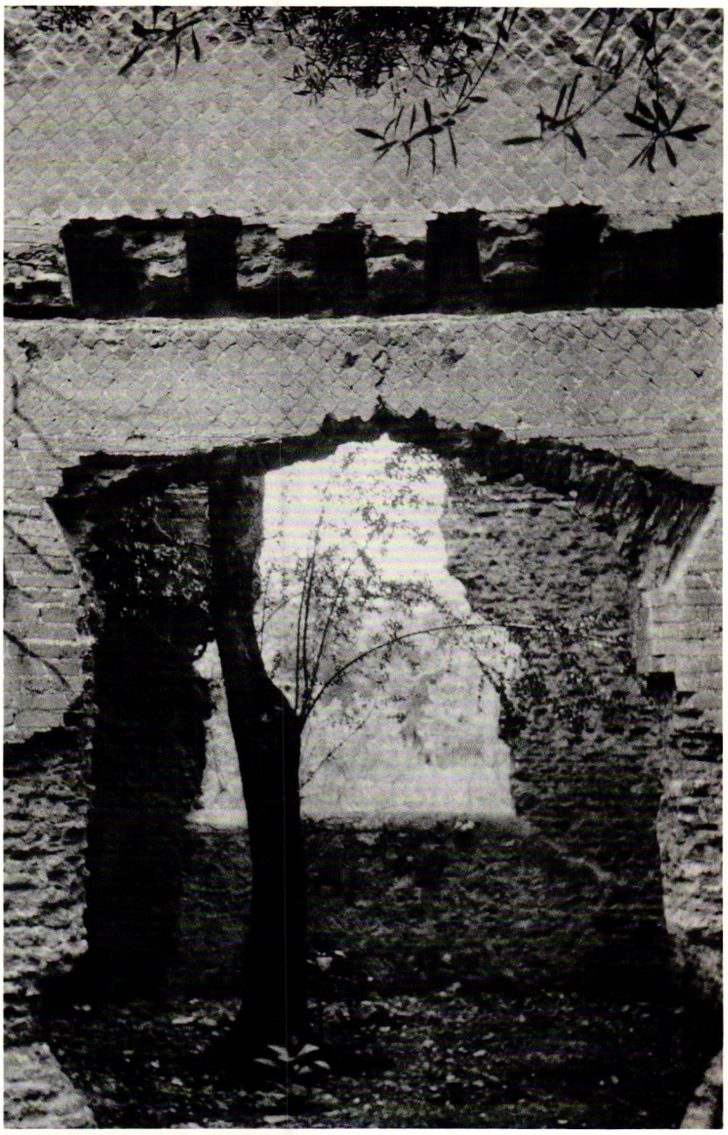
38, 39. Santa Maria del Fiore, Florence





42. Accademia, Villa Adriana, Tivoli

43. Saint-Urbain, Troyes





40, 41. Abbey of Ourscamp

and arches of as many different profiles no doubt fell. In Gothic ribbed vaults, the webs often cracked away from the wall arches and stood independently of these. Sometimes they remained standing, like simple groined vaults, when all the ribs had fallen away [*40*]. But elsewhere, occasionally even in the same building, cracks extended continuously through web and rib, or the web fell away leaving the rib behind [*41*].[15] Cracks and failures which can now be seen in Roman concrete structures have usually paid little respect to the embedded brick ribs and arches, often passing through them as if they were just like any other part of the concrete. Where these ribs and arches have fallen or been quarried out, the concrete usually seems well able to take over their role [*42*]. But this may not have been so when the concrete was much younger.

Yet we are faced with the historical fact that structures like Hagia Sophia and the cathedrals of Chartres, Reims, and Amiens were actually built, and that they sometimes came closer to the limits of what is possible with the means available than we would care to approach today without many exploratory tests. Were they, as structural inventions, merely the fortunate outcome of intelligent trial and error guided only by the simpler intuitions of structural behavior and adequacy? Or were they also guided by some of the more powerful and accurate intuitions of structural action, on which designers today draw?

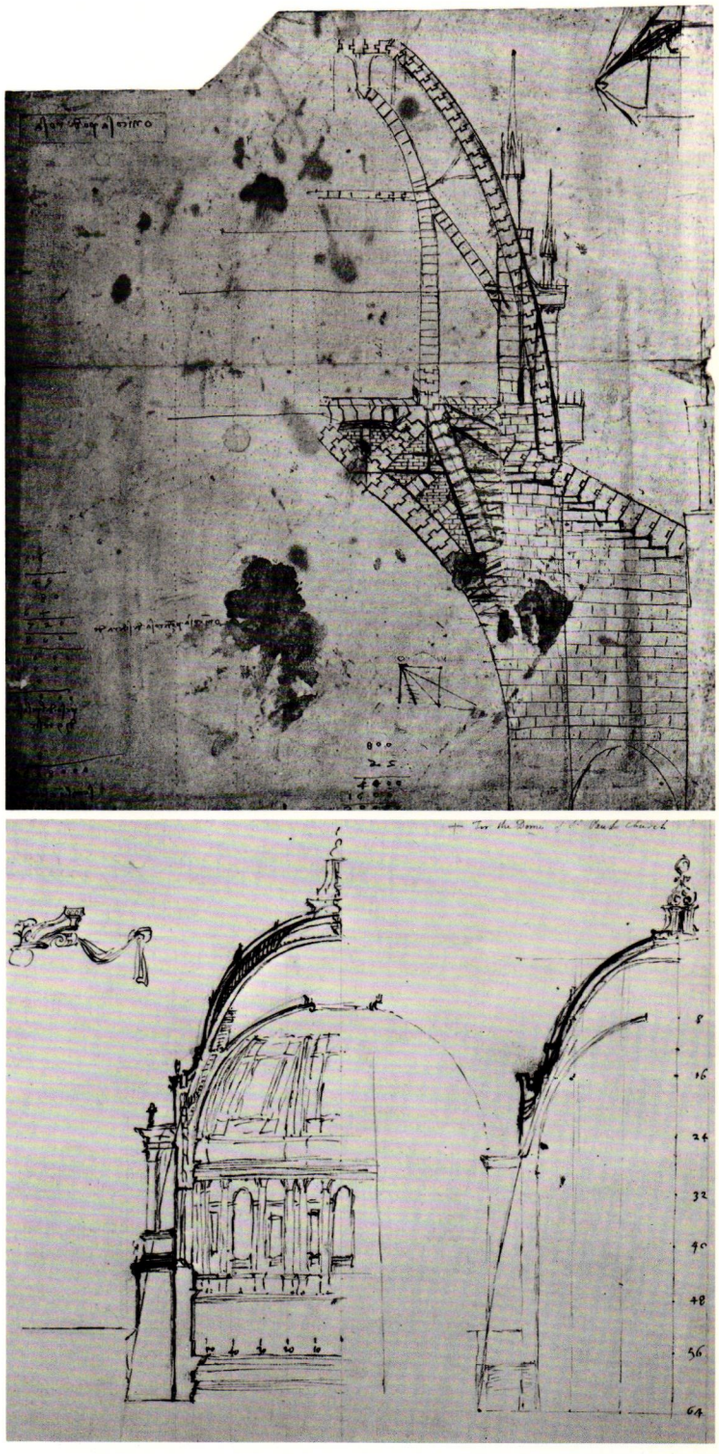
A definite answer to these questions would be of much more than merely historical interest. The theories which give articulate form to the essence of these latter intuitions are, with the sole exception of the laws of the balance codified in Archimedes' *On the Equilibrium of Planes*, all comparatively recent. Some are still being extended and perfected. So if these intuitions can be identified as having guided earlier work, they too must have been reached by designers independently of theory. An answer would, therefore, have an important bearing on the role of structural *theory*, as distinct from the intuitions behind it, in invention.

Unfortunately a definite answer is less easy to give than one would hope, and may well be unobtainable. It is always difficult, if not impossible, to relive the creative experiences of others – or at least to be certain that one is doing so. The effort of historical imagination here called for perhaps needs to be guided by more documentary evidence of past modes of thought and work than has yet come to light. Nevertheless a tentative answer is worth attempting.

Simple muscular intuitions of the forces acting in a column, arch, tie, or buttress are not now in question. They have already been discussed, and there is documentary evidence of them in the expressive terms used for such elements in some of the records of expert opinions called for, in the Gothic period, to resolve specific problems of design or construction.[16] Simple intuitions of the responses of different materials to load or deformation must also have been possessed by designers of all periods. The question to be investigated is whether these intuitions ever achieved the clarity and quantitative precision essential for an intelligent statical choice between alternative configurations of structural elements or for a proper understanding of the behavior of a composite structure like a ribbed vault.

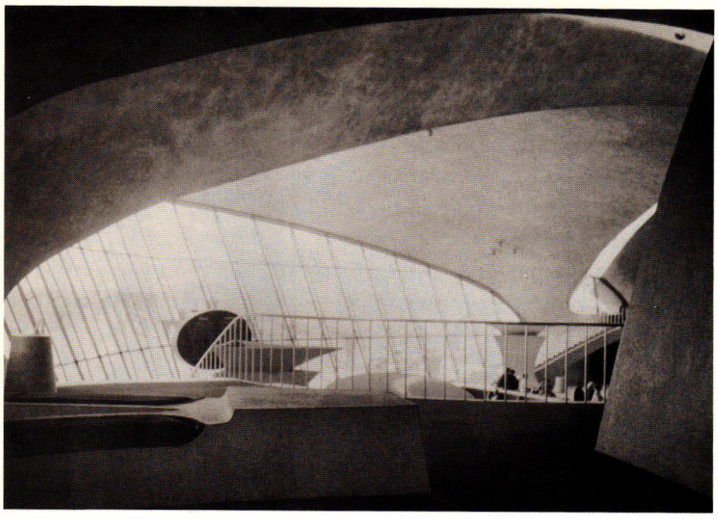
Occasionally a design does exhibit such structural virtuosity that we are tempted to say that the guiding intuitions did have this clarity and precision. In the church of Hagia Sophia, especially after the rebuilding of its dome by Isidorus the Younger [*10*], in the church of Saint-Urbain at Troyes [*43*], in the dome of Santa Maria del Fiore [*39*], in Leonardo's studies for the *tiburio* of the cathedral of Milan [*44*],[17] and in the domes of San Lorenzo in Turin [*12*] and Saint Paul's in London [*45*], a remarkably clear understanding of static equilibrium does seem to be manifest. Yet these designs are exceptional; much more often there is evidence of indecision or lack of understanding.

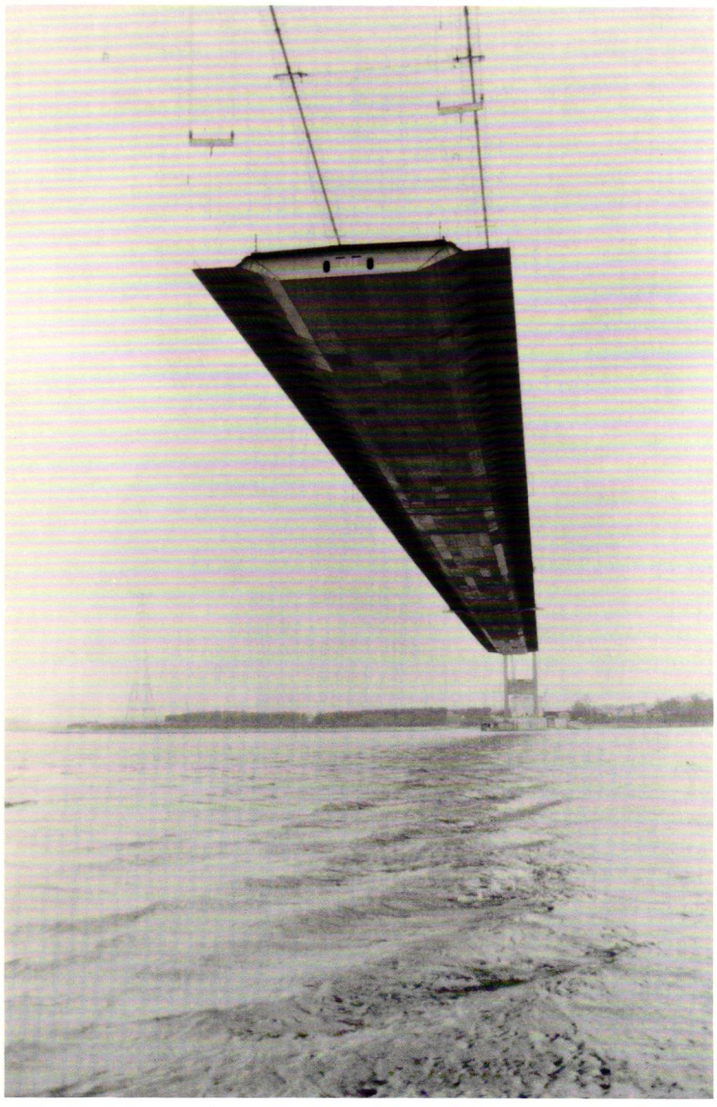
Where, for instance, a composite structure like a ribbed vault presented alternative paths for transmission of loads to the supports, this



44. Study for the cathedral of Milan, by Leonardo da Vinci

45. Study for Saint Paul's Cathedral, London, by Sir Christopher Wren





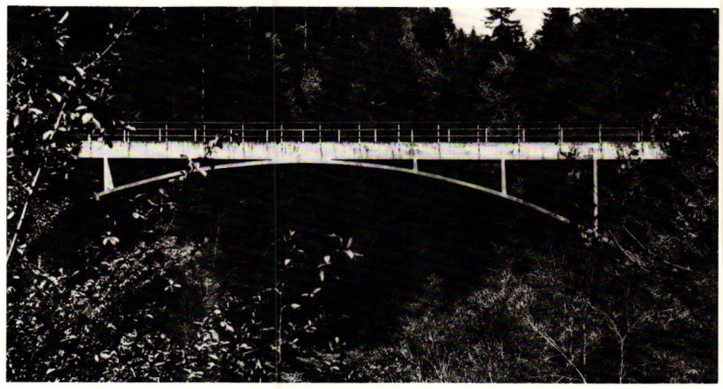
50. T.W.A. terminal at John F. Kennedy International Airport

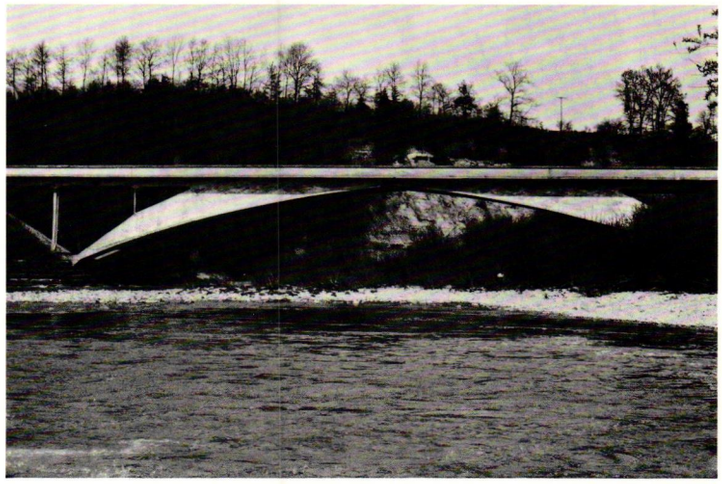
51. Severn Road Bridge, near Chepstow, under construction

52. Maillart's Schwandbach bridge, near Schwarzenburg

53. Maillart's bridge over the Thur at Henau

54. Failure of the Tacoma Narrows Bridge





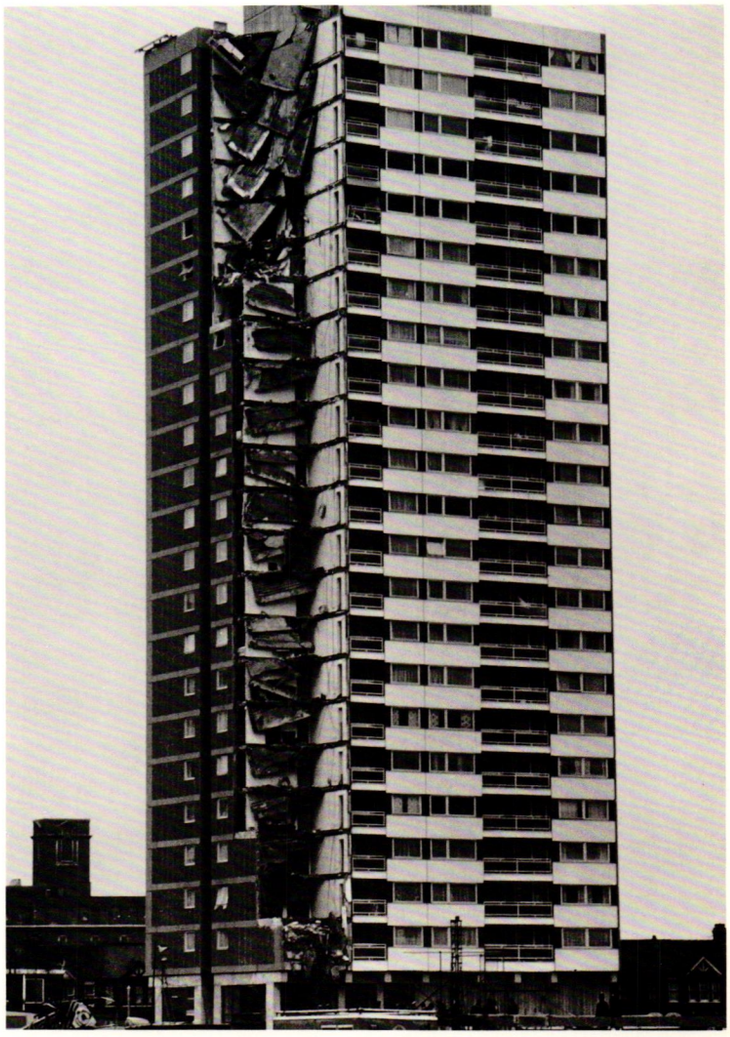


as a basis for formal analysis. For, in spite of continual development, the theory has never quite kept pace with the full complexities of the actions that have become critical for the safety or serviceability of new forms (or even of forms based on extrapolations from experience gained with structures already built). Indeed it would have been a severe brake on invention to have insisted that it should. Maillart, for example, made full use of the possibilities of the theoretical analysis then open to him in developing the forms with which his name is particularly associated – the mushroom slab with two-way reinforcement and smoothly flared column-heads, and two very elegant forms of bridge, each using the relatively thin slab as the basic element [*52*, *53*]. But he saw very clearly and correctly that they mostly implied idealizations – of the basic deformational characteristics of concrete and of the behavior of a continuous form like a slab – that were grossly at variance with the true characteristics and behavior, and he therefore undertook numerous tests to clarify his personal understanding of the true behavior.[22]

A further and more fundamental shortcoming of the theory, and even of the directly related personal insight, is that it can at best do no more than indicate how a structure may in certain respects probably act: by itself it can neither indicate whether it is in these respects that structural action will be critical nor give much guidance on what would be an acceptable level of performance – of stiffness under a given pattern of loading, for instance, or of ultimate strength under a given type of load or loads. Probably as many, if not more, collapses of recent structures that attempted some innovation in form or scale have been due to failures to ask a relevant question in the analysis, or to interpret correctly the results of the analysis, as to errors in the analysis itself. The collapse of the Tacoma Narrows Bridge [*54*] is a classic example, resulting from a failure to give proper attention to a mode of behavior that subsequently proved to be critical, and several serious collapses in tall buildings assembled from large precast-concrete elements – under circumstances which the usual alternative forms of construction would have survived with only local damage even without special provisions in design – are among more recent examples [*55*].[23] Only an imaginative intuitive visualization of the possible critical modes of action of a new structure can help to obviate this shortcoming.

Today, therefore, structural theory must be regarded as a necessary basis for structural invention, yet as a basis that is incomplete as well as essentially intermediary. If it is indeed to lead the designer to creative personal insights, its source in the kinds of experience from which it initially sprang must first be itself adequately perceived. Only thus will it come to life. Then it must be supplemented, through direct experience, with largely intuitive knowledge of some of the many differences between the idealized actions of which it necessarily treats and the more complex and variable actions of real structures and the real materials of which they are built. To this end, expectations must be continually checked against observation, making full use of the increasingly powerful new techniques of observation that have themselves been associated, to some extent, with advances in theory.

Modern structural theory thus serves the creative designer best as a guide, as a frame of reference and ready source of powerful interpretive schemata, rather than as a self-sufficient tool. Some practice in the discipline of 'exact' analysis gives him, moreover, a more quantitative feeling for structural behavior than he is likely otherwise to attain and discourages him from jumping to overly facile conclusions. Yet this discipline is perhaps best learned and then, temporarily at least, put aside. In the truly creative phase of invention, the precision of mathematics is more likely to be an impediment than an aid. For to create, one 'dissolves, diffuses, dissipates'; and the mathematical abstraction can, if dwelt in exclusively, 'shut out the real world and the sky'.[24]



55. Partial collapse of apartment building at Ronan Point, London

ON CREATIVITY

DAVID BOHM

Creativity is, in my view, something that cannot adequately be defined in words. How then can we talk about it? Words can indicate or point to something in the mind of the reader that may be similar to what is in the mind of the writer. I would like thus to indicate what creativity means to me. If you will take these remarks in that spirit, you can see whether, or to what extent, my notions make sense to you.

I am a scientist. So I will try to start from this field and extend out to others. The question that I would like to begin with is this: Why are scientists in many cases so deeply interested in their work?

Is it merely because it is useful? It is necessary only to listen to such scientists to discover that the utilitarian possibilities of their work are generally of secondary interest to them. Something else is primary.

Could it be that a scientist deeply wants to discover the laws of nature so that he can predict natural phenomena, and thus enable man to participate intelligently in nature's processes in order to produce desired results? Of course such prediction and intelligent participation can sometimes be very interesting, but that is within a context in which these activities are determined by something that is more deeply significant, such as a common goal of great importance. Generally speaking, however, there is hardly ever such a common goal. Moreover, in most cases what the research scientist actually predicts is in itself rather trivial (the precise paths of particles, the precise combination of instruments that will register a certain phenomenon, etc.). Unless there were something beyond this that could give it significance, his activity would be rather unsatisfying.

Is it, then, that the scientist likes to solve puzzles? Does he want to get a 'kick' out of 'being right' about a natural process, 'showing how it works'? A scientist may, of course, find this aspect of his work very enjoyable, but such enjoyment has properly to come as a by-product of something that goes much deeper. Indeed, if a scientist worked mainly in order to get hold of such pleasures and continue them as long as possible, his activity would be not only rather trivial but also contrary to what is needed for carrying out his research effectively. Recognizing that one's ideas are false or on the wrong track, which is often crucial for making real progress, generally gives rise to very unpleasant feelings of disappointment and failure, and to avoid these, the scientist whose first aim was pleasure of this kind would tend to overlook weak points in his work, as does unfortunately happen with surprising frequency.

The reason scientists are so deeply interested in their work is not to be found on such a superficial level. Scientists are seeking something that is much more significant to them, and one aspect of what this might be can be indicated by noting that the search is ultimately aimed at the discovery of something *new* and previously *unknown*. But of course it is not merely the experience of working on something novel and out of the ordinary that the scientist wants (this would be little more than another kind of 'kick'). Rather, what he is really seeking is to learn something new that has a certain fundamental kind of significance: a hitherto unknown lawfulness in the order of nature, showing *unity in a broad range of phenomena*. Thus he wishes to find in the reality in which he lives a certain oneness and totality, or wholeness, showing a kind of *harmony* felt to be beautiful.

In this respect the scientist is perhaps not basically different from the artist, who wants to *create* this sort of thing in his work. To be sure, the scientist emphasizes *discovering* oneness and totality, in nature, and for this reason the fact that his work too can be creative is often overlooked. But in order to discover oneness and totality, the scientist clearly has to create new overall structures of ideas, which are needed to express the harmony and beauty that can be found in nature. Likewise, he has to create sensitive instruments, which aid perception and thus make possible both the testing of new ideas for their truth or falsity and the disclosure of new and unexpected kinds of facts. So the artist, the composer, the architect, the scientist, etc., all feel a fundamental need to discover or create something new that is whole and total, harmonious and beautiful. And this is probably what very large numbers of people in all walks of life are seeking, when they ineffectually try to compensate for the unsatisfying narrowness and mechanicalness of their daily routines by engaging in every kind of entertainment, diversion, stimulation, change of occupation, etc.

If we can assume that the creative impulse is common to us all, then, why is it so often frustrated? Clearly there is something other than a lack of talent to blame, for there are many highly talented people whose work remains mediocre. Thus there may have been a considerable number of scientists who were better at mathematics and knew more physics than Einstein. The difference was that Einstein had a certain quality of *originality*. This is very hard to define or specify, but one clear prerequisite for originality is that a person not be inclined to impose his preconceptions on the fact he is seeing. Rather, he must be able to *learn something new*, even if this means that ideas and notions comfortable or dear to him may be overturned.

The ability to learn in this way is common to the whole of humanity. It is well known that a child learns to walk, to talk, and to know his way around just by 'trying something out' and 'seeing what happens', then modifying what he does (or thinks) in accordance with what has actually happened. He spends his first few years in a wonderfully creative way, discovering all sorts of things that are new to him, and this leads people to look back on childhood as a kind of lost paradise. As the child grows older, however, learning takes on a narrower meaning. In school he learns by repetition to accumulate knowledge so as to please teachers and pass examinations. At work he learns in a similar way, in order to make a living or for some other utilitarian purpose and not mainly for the love of the action of learning itself. His ability to see something new and original gradually atrophies.

It is impossible to overemphasize either the significance of the broader kind of learning in every phase of life or the importance of placing the action of learning itself above the specific content of what is to be learned. For the action of learning is the essence of real perception, in the sense that without it a person will not be seeing, in any new situation, what is a fact and what is not. Of course there is a routine and mechanical kind of perception that we can carry out, and habitually do, in dealing with what is familiar. Few people ever note, for example, more than a small number of salient features of their friends, of the places in which they live, etc., determined by habit. But real perception, capable of seeing something new and unfamiliar, requires that one be attentive, alert, aware, and sensitive. In this frame of mind one does something (perhaps only moving the body or handling an object) and then notes the difference between what actually happens and what is inferred from previous knowledge. From the difference, one is led to a new perception or new idea that accounts for it. This process can, moreover, go on indefinitely, without beginning or end, in any field. And when it does operate, there is an undivided and total interest in what one is doing, like the interest the young child is showing when learning to walk – you can see he is putting his whole being into it. Only this kind of wholehearted interest will give the mind the energy needed to see what is new and different, especially when what is familiar, secure, or otherwise dear to us seems threatened.

It is clear that all great scientists and artists have had such a feeling for their work. But no matter what his occupation may be, anyone can, in principle, approach life in this way. I am reminded of Anne Sullivan, the teacher of Helen Keller. When she undertook to help this child –

who was blind and deaf from an early age, and so also unable to speak – she knew she would have to treat her with complete love. On first meeting her pupil, however, she saw a 'little savage' who apparently could not be approached in any way at all. If she had believed this first impression, she would have given up immediately. But she worked with the child as best she could, with all the energies at her disposal, remaining extremely observant, 'feeling out' the unknown mind of the child, and eventually *learning* how to teach her.

The key step was to have the child form a concept of language, which she lacked because she had been unable to communicate with other people to any great extent. This was accomplished by having her come in contact with water in a variety of forms and contexts, each time finger-spelling *w-a-t-e-r* in her hand. At first the child did not grasp what it was all about. But suddenly she realized that these different experiences could all be referred to a single substance which was symbolized by the word spelled in her hand. This initiated a fantastic revolution in the whole of her mind, the depth and scope of which it is hard for us to appreciate without having experienced directly what it means to live without linguistic abstractions. As a result, where there had been a child without the ability to communicate, or even think, in terms of language, there was now a person who would become more and more articulate. In thus helping to transform this life, and later the lives of many other people in similar situations, the discoveries of Anne Sullivan were extraordinarily creative.

This example is especially worth considering because it shows by contrast how unperceptive and uncreative many parents and teachers are. Very few indeed have the kind of love for their children that would make them observant of how the children are, in reality, *different* from what they expect them to be, and few are aware of how an understanding of this difference might be the key to a transformation as remarkable as that initiated by Anne Sullivan in Helen Keller. They miss the opportunity to be creative and original. And such opportunities arise in many fields that might seem at first unlikely, perhaps especially in those that society (for the time being, at least) is not in the habit of recognizing as potentially creative. Indeed real originality and creativity implies, not working in fields that are so recognized, but being ready in each case to inquire for oneself whether there is some fundamentally significant difference between actual fact and preconceived notions that opens up the possibility for creative and original work.

But we must at this point begin to consider the act of creativity in greater detail. What would distinguish, for example, the discovery of something new and different that is truly creative from such things as isolated penetrating insights? In the former, let us say, there is the perception of a new basic order that is potentially significant in a broad and rich field, with this new order leading eventually to the creation of new structures of order having the quality of harmony in totality, and therefore to the feeling of beauty. To understand what this means, however, we must first go into what is signified by the terms *order*, *structure*, and *harmony*.

Order

Now it is commonly believed that terms like *order* refer to subjective judgments, dependent on our different tastes, prejudices, and opinions. I wish to suggest that order is not a purely subjective quality and that, on the contrary, judgments concerning it can have just as objective a basis as those concerning such things as distance, time, and mass. As I will try to explain, judgments of order are based on the perceptual discrimination of *similar differences* and *different similarities* and can be defined and communicated no less successfully than judgments of qualities commonly recognized as capable of objective description.

Consider, for example, a geometric curve, which is in a certain way an *ordered* array of points. This order is, of course, immediately noted by the eye, but our common language is generally too crude and impoverished to allow us to communicate exactly what it is that the eye has seen. Indeed it is because people find they cannot communicate their very often genuine perceptions regarding the quality of order that they are inclined to assume these perceptions are purely private and subjective – when all that is needed, to avoid this confusion, is to develop a way of describing the quality of order properly.

Then to express the order of a curve in a communicable and perceptually testable way, we might begin by regarding the curve as approximately a set of successive line-segments of equal length. The segments are thus similar in length but generally different in position and orientation, and the existence of a regular curve (rather than an arbitrary succession of points or line segments) clearly depends on certain similarities of the differences. The simplest curve is a straight line. Here the successive line-segments differ only in position, and these differences are similar in direction. Then comes a circle – the successive segments differ in direction as well as in position, but since the angles between successive pairs are the same, the differences are again similar. However, the *similar differences* defining the circle are *different similarities* from those defining the straight line. This, in fact, is the essential difference between the two curves. Next, take the three-dimensional curve that would occur if these successive pairs of segments differed in the planes defined by them; we can see that similarity of these differences would make the curve a regular helix.

We could go on to further differences, whose similarities would generate a series of ordered curves of ever greater complexity. We may note here that the *complexity* of a curve is in fact an objectively definable property of its order. Thus a straight line, determined by its first step, is a curve of first order, a circle is a curve of second order, determined by its first two steps, the helix is a curve of third order, determined by its first three steps, etc. One can imagine curves requiring more and more steps to define them. Eventually one would come to curves requiring an unlimited number of steps, which would be called curves of infinite order. The extremely complicated paths traced by atomic particles in 'chaotic' movement in a gas or by small smoke particles in Brownian motion would be curves of infinite order.

Now it is commonly stated that such particles are moving in a state of 'disorder'. In my view, there is no such thing as disorder, if by this is meant a total absence of order of any kind. For whenever something happens, it must be occurring in some kind of order, which can in principle be described in suitable terms. Thus, while the order of planetary motion is relatively easy to describe, determined in effect by a first step (and by the forces experienced by the planet in its motion), the order of Brownian motion is just more complex, in the sense that it too could be described, but only in terms of an unlimited set of similar differences. (The latter motion actually has certain statistical regularities or symmetries to it that do not depend significantly on the precise details of the paths. For example, on the long-run average each particle spends nearly the same amount of time in any unit volume of the space accessible to it. And if there are many such particles, they are almost always distributed nearly uniformly in the container. Clearly, these features of the order of Brownian motion are just as factual, communicable, and testable as the features of the orders in which an object falls to the ground and a planet moves through space.)

So *disorder* is merely an inappropriate term for complex kinds of order difficult to describe in full detail, and as such only a source of confusion. Our real task will never be to judge whether something is ordered or not, because we can assume that everything is ordered. Rather, we have to observe and describe the kind of order each thing actually has. And with expression in terms of similar differences and different similarities, we should be able, in principle, to describe the order of any thing, whatever it may be (just as we can express, in terms of units of length, the distance of one thing from another).

Structure

I would suggest that structure is, in essence, some kind of *hierarchy* of orders, on many levels. Consider, for example, a house. The basic similar elements may be bricks, which will differ at least in position. When these are then ordered in a certain array of similar differences, they make a wall. Now the wall becomes an element itself, and one of a *higher* order than that in which the bricks are arranged. For walls are arranged with suitable similar differences in position and orientation in rooms. Likewise, rooms are ordered at a higher level in a house, houses in a street, streets in a city, etc.

The principle of structure, or hierarchy of orders, is clearly universal. Thus electrons and nuclear particles ordered in certain ways make atoms, and these as elements are ordered to form matter at the microscopic level, whether liquid, solid, or gaseous, crystalline or noncrystalline, etc., and we can continue to observe this principle in operation up to the levels of stars and galaxies, as far as man has been able to probe with his scientific instruments. Similarly, protein molecules ordered in certain ways make living cells, and further ordering at higher levels of life produces organs, organisms, societies of organisms, etc.

It would seem that the evolutionary process of nature (which includes the development of man and his intelligent perceptions) is at least potentially of an infinite order, in the sense that it is never fully determined by any of its partial orders. In this respect it is similar to the random curve of Brownian motion. But it differs in that it does not tend to approach a state of statistical regularity or symmetry; rather, as we have seen, each order can become the basis of a new higher order, to form a continually evolving hierarchy, the new structures of which are generally able to order those of a simpler nature (as, for example, the nervous system orders the movements of the muscle cells). Thus nature is a *creative* process, in which not only new structures but also new *orders of structure* are always emerging (though by our standards the process is very slow).

Of course the basic principle in the development of all structure, whether natural or man-made – that each kind of order has only an approximate and limited symmetry and that the regular array of breaks or changes in the symmetry of one order are the basis of another level of order, and so on to higher levels – implies not only the possibility of the unending growth of a hierarchy of harmonious orders and the evolution of ever more encompassing and unified totalities. It implies also the possibility of conflict and clash between different orders, resulting, not in harmonious and unified totalities, but rather in destruction and decay of the partial orders.

Harmony

As with the notion of order, there is a widespread belief that the distinction between conflict and harmony is a private and subjective kind of judgment. But if we consider harmony to be a state in which partial orders are working together in a coherent way, such that each is compatible with all the others (and perhaps even necessary to them), we can see that this distinction need not be purely subjective.

For an elementary example of conflict, consider an intersection of roads. The function of the traffic signal is to help keep the orders of traffic on the different roads harmoniously coordinated, but if the signal is not operating properly, this coordination is gone and the cars may well collide at the intersection, destroying both themselves and their drivers. To take a more subtle example, consider the digestive organs of a sick person, which fail to follow the normal and proper order of operation needed for the health of the organism as a whole. Or else think of a cancer, whose order of growth is such as to clash eventually with all the orderly processes of the living body. In all these cases what we have to deal with is, not disorder (as an absence of order), but well-defined orders that are incompatible, in the sense that instead of forming a harmonious totality they come into conflict with one another, which may even result in their destruction.

Recognizing that the perception of harmony in a totality need not be a purely private kind of judgment, one can understand in a new light the fact that great scientists have, without exception, seen in the structural process of nature a vast harmony of order of indescribable beauty. It seems likely that perceptions of this kind were at least as important as those leading to precise theories and formulas by permitting the specification of individual details of the properties of matter. Indeed, every great scientific theory was founded on the perception of some very general and fundamental feature of the harmony of nature's order. Such perceptions, when expressed systematically and formally, are called laws of nature.

Perception of fundamental differences

To express some fundamental feature of the order of natural process in terms of a general law is always, however, to assert the basic *differences* relevant for the whole of the process, and the corresponding similarities in these differences. Thus, Newton assumed that in general the relevant differences were in the positions and velocities of material bodies at successive moments in time. The distances covered by such bodies in similar intervals of time in empty space were said to be similar in magnitude and direction, implying the order of motion in a straight line at a constant speed (the well-known law of inertia). It was further asserted that in the presence of matter the successive distances and directions were different, and that these differences, which define acceleration, were universally similar, in the sense that similar forces would always and everywhere produce similar accelerations. When expressed in precise mathematical terms, these assumptions led to Newton's laws of motion.

A part of Newton's thinking was the idea that the fundamental differences occurred in an absolute space and time. That is to say, he supposed that space and time differences were universally similar, so that different observers would all agree on what the same interval of time or the same distance in space was. Einstein's creative insight was to see that the facts available to him (which were such as to put physical theory into a state of considerable confusion) could be clearly understood if one supposed that observers going at different speeds are attributing the properties of simultaneity and equidistance to *different* sets of events. However, he also saw that observers having similar differences of velocity would have similar differences in their ways of choosing the sets of events to which to attribute these properties. When expressed in precise mathematical terms, this led to the well-known Lorentz transformation, which was fundamental to the mathematical theory of relativity.

Einstein's basic step was clearly to perceive a new set of essential differences, from which there arose a new relationship of similarity, and thus a new order of space and time. Since space and time are fundamental to all our conceptions, this new order was to have a broad and deep significance. It became natural, in terms of this new order, to ask new kinds of questions in the investigation of physical phenomena, and scientists were thus led to entirely new notions concerning the general properties of matter (including, for example, the revolutionary discovery of the equivalence of mass and energy).

Upon reflection, however, one will understand that Newton, too, perceived new basic differences, and thus creatively initiated new order in physics. To see this, let us go back to the ancient Greeks, who considered the key or essential difference to be one between the imperfection and corruption of Earthly matter and the perfection and purity of Heavenly matter (thus generalizing the moral notion of the difference between imperfection and perfection as relevant for the whole of

existence). The complicated movements of Earthly matter were taken as revealing its imperfect nature. Heavenly matter, on the other hand, was assumed to express the perfection of its nature by moving in a circle, which was considered the most perfect of geometric figures. If observation had disclosed that Heavenly bodies did in fact move in perfect circles, that would have been a tremendous discovery, tending strongly to confirm the notion that a key difference in the universe is between the perfection of Heavenly matter and the imperfection of Earthly matter. But when observations did not disclose this, astronomers began to accommodate the difference between fact and theory by fitting the fact to a set of circles within circles, or epicycles. If a few epicycles had proved to be enough, that too would have been a significant discovery. When the number of epicycles began to increase greatly, however, one should have begun to suspect that the distinction between Heavenly matter and Earthly matter was not a fundamental one – yet for various reasons (religious, political, psychological, etc.) the notion was not seriously questioned until much later. There arose instead a tendency to focus on utilitarian aspects of the theory of epicycles (its use for astrological and navigational purposes, for example).

Although it would be wrong to discount the value of such useful computations, one must nevertheless be struck by the contrast between the deep, fundamental, and all-embracing questions initially raised, by the ancient Greeks, and the subsequent emphasis on relatively narrow and limited concerns. Scientists lost much of the earlier impetus toward originality and creativity, and for a long time tended to strive mainly to accumulate potentially useful knowledge within an essentially fixed framework of concepts. (In fact, however, before the accumulation of such knowledge could begin to reveal even its potential utilitarian value, it was necessary to question the assumption of a fundamental difference between Heavenly and Earthly matter.)

It seems clear that the creative development of science, exemplified by Galileo, Newton, and Einstein, has depended quite generally on the perception of the irrelevance of an accepted set of fundamental differences and similarities. Psychologically this is the hardest step of all, but once taken it frees the mind to be attentive, alert, aware, and sensitive, so that one can discover new order and thus create new structures of ideas and concepts. The attitude of a scientist to the creative work of earlier scientists is of crucial significance here. He cannot be similar to Einstein in creativity if he merely applies what Einstein found to new problems, or even if he varies, extends, and develops it so that it reveals its full implications in synthetic combinations with other current theories. Nor, of course, would a scientist be creative in merely reacting against Einstein's work or ignoring it altogether. Creativity calls for his *learning* from the earlier scientist, in the sense that he must not only understand what Einstein did but also perceive the differences between Einstein's insights and those developing in his own mind as he works on the subject (these may differ from Einstein's not only because he has new knowledge, experimental and theoretical, but also for countless other reasons impossible to specify). It is the 'feeling out' of such differences that will indicate the new similarities appropriate to his own work. And these new similarities may eventually lead to a different set of laws of nature, which should nevertheless embrace, perhaps as special cases or approximations, what was correct in Einstein's laws.

Creative perception leads, one might say, to a new order in the hierarchy of our understanding of the laws of nature, which neither imitates older orders nor denies their partial validity. Indeed, it serves to help put our knowledge of the old laws, which cannot be expected to have an unlimited domain of validity, into a more appropriate order while at the same time extending the frontiers of knowledge in quite new ways. As these frontiers are extended, it is found that the sets of similar differences in terms of which the laws are expressed eventually cease to correspond to those actually occurring in nature. This leads to the perception of different differences and new similarities, and thus to the creation of new order and structure in our knowledge. So the order and structure of our laws of nature is always evolving by a principle similar in certain ways to that of the evolution of order and structure in nature itself – by similar differences giving way to different similarities in an ever growing hierarchy of order, which forms, as it were, a living body of natural law.

It is not just in science, however, that perception of relevant differences is the basic step. Actually all understanding begins with the perception of such differences. Consider what happens when one drops a coin on a highly patterned carpet. It all but disappears; but then one sees a glint of metal and the coin suddenly 'stands out', clearly visible. What one actually perceived was the difference between the appearance of the carpet without the glint and its appearance with the glint, and this caused one to recollect similar differences in past experiences, when metal objects caused glints to appear against nonmetallic backgrounds. One can easily pick out the coin now because the difference perceived fits into an already known pattern of similar differences. A great deal of our understanding is necessarily of this kind – that is, relatively mechanical, in the sense that what one understands of the order, pattern, and structure of what is perceived is simply drawn from the record of past experiences and thinking. The record may, to be sure, be adapted and adjusted so as to accommodate the presently perceived fact, but it is not basically transformed.

A somewhat higher level of understanding occurs when one thinks of a known order and structure that would not commonly be thought to be related to the observed set of differences; one may see that the differences observed in one field of phenomena are similar to those in a different and, at first sight, apparently unrelated field of phenomena. One of the most famous examples of this occurred when Archimedes had to devise a way of determining whether the king's new crown was made of pure gold or a fraudulent alloy of gold and silver. He suddenly understood, in the bath, that the order of volumes of water displaced by objects was similar to the order of volumes of the objects themselves. That is to say, a difference between the amounts of water that could be displaced with bodies of equal weight (the crown and an equal weight of pure gold) would disclose a similar difference between their volumes and thus a difference between them in composition. Determining the volume of a body whose complicated shape prohibited direct calculation of it through geometry was no longer a problem.

Such a penetrating insight may lead to important discoveries, and to inventions of considerable practical value. Yet it is not creation. For in creation one perceives a new fundamental set of similar differences – constituting a genuinely new order – and not merely a new relationship between two or more known orders. The new order leads hierarchically to a wide range of new structures, and an isolated penetrating insight connecting up one order with another generally falls far short of this.

Perhaps the original and revolutionary nature of a genuinely creative perception can be illustrated in considering again the experience of Helen Keller, when she suddenly understood the nature of linguistic abstractions. In the beginning she was aware of a complex and confusing series of differences – the differences in sensation that came from being exposed to various aspects of what we call water (drinking water, water rushing over her hand from a pump, water in a mug, etc.). She did not yet know anything about the word *water*. But her teacher's hint of some potential kind of similarity in the different sensations led her, at a certain point, to realize that the word being spelled in her hand on each occasion was the 'name' of such a set of similar differences. This understanding was not merely an application of something she had known before, nor even the perception of a new relationship between orders that she had already encountered. It was, in fact, the first perception of an entirely new order in the mind, the order of language. And when perceptions of this kind were, in turn, ordered in a hierarchy, it led to a new structure of the mind as a whole.

To sum up, we could say that in a creative act of perception one first becomes aware (generally in a nonverbal way) of a new set of relevant differences and then begins to 'feel out' or otherwise note a new set of similarities. This leads to new orders and structures, and the whole process tends to form harmonious totalities capable of profoundly moving those who understand them.

Mechanicalness

It would seem that creation of this kind has been fairly rare in the course of history. Though interlaced with flashes of insight and invention, which have helped to raise it above the level of mere routine, human action on the whole has been relatively mechanical and uncreative. One reason is that creative work requires above all a creative state of mind. And, generally speaking, what one has learned as a child (from parents, teachers, friends, and society) is to have a conforming, imitative, mechanical state of mind – one that does not lead one into 'making mistakes' or upsetting the 'applecart' on which our security, our happiness, and even our lives often seem to depend. Another reason is that one's interest in things is often limited by narrow aims, such as getting personal (or group) credit, advantages, profits, or 'kicks' out of the work one is doing in a particular field. Although such motives may permit occasional flashes of insight and invention, they tend to hold one a prisoner of old and limited orders of thought and action. Moreover, such aims are generally incompatible with the harmony in totality characteristic of real creation. For when each man in each field follows limited and independently determined orders, what can one expect but a general state of conflict among the orders?

Perhaps in the past it may have seemed reasonable to many to hope that the net result of the myriad conflicting orders men follow would lead in the long run to overall progress, with ever greater harmony and happiness. But more recently the actual course of events has been such as to make it very difficult to believe that anything but ultimate destruction, both physical and mental, is likely to emerge from this process if it goes on indefinitely. Clash and conflict is manifest not only in our daily lives and general social organization but also in the relationships between nations, and is now threatening all with annihilation. The disharmony of orders in society is not, however, a new concern, and from time to time, throughout the course of history, various individuals have tried to initiate a new and better order by means of the violent imposition of certain preconceived ideas as to what would produce a state of social harmony. Events have proved that this is no solution, for such preconceived ideas are in reality just as arbitrary and conflicting as the conflicting orders they aim to eliminate. This is, indeed, the basic defect of violence – it can only serve to replace earlier forms of clash and conflict with others, which may be even more dangerous and destructive.

Since any effort to impose order in this state of general disharmony is not likely to succeed, what then is to be done? Fundamentally, the origin of our difficulties lies in our tendency to be mechanical when what is called for is creativity. So I would suggest that the key is in the state of mind of the individual. To create genuine solutions to problems in any field whatsoever, the first prerequisite is a state of mind unceasingly observant of the actual order in the field. Without this, one's efforts are foredoomed to failure, because the order of what is done will not correspond to the actual nature of things, making conflict of some kind inevitable. Indeed, no really creative transformation can possibly be effected by human beings, either in nature or in society, unless they remain sensitive to the differences that will always exist between observed facts and *any* preconceived ideas, however noble, beautiful, or magnificent the latter may seem to be.

There is, to be sure, a place for mechanical adherence to given order. For example, we have a great many conventions (such as, in Great Britain, driving on the left side of the road) that do not admit of genuinely creative action. But when we try to hold to given order in the functioning of the mind as a whole, we are extending mechanicalness beyond its proper domain. The mind is not a mechanical thing and cannot actually hold to such limiting order. Recalling the notions of order discussed earlier, we could say that the processes of the mind, like those of nature, are basically of an infinite order – one that is always tending to evolve toward new orders, and thus to develop hierarchies constituting new kinds of structure. And since any given order is limited in certain ways, it will eventually stand in the way of adequate and creative responses to what is new.

If at all sensitive and observant, one can readily perceive it when the mind is mistakenly trying to follow an imposed pattern that is inappropriately limiting. One part of the mind thinks one should follow the imposed pattern while another part thinks one should not. In fact, both parts constitute mechanical, fragmentary orders of operation, and these conflict in the sense that they cannot be carried out together. One senses the conflict as a painful state of self-contradiction. To resolve this, the mind must be able to see the irrelevance of the mechanical patterns of thought or feeling. The disharmony that inevitably arises from trying to impose or follow them can come to an end only through creative responses of the mind, from moment to moment, for these alone can lead to a harmoniously ordered totality in the psyche in place of a structure of conflicting fragments. But because the conflict is generally very painful, the mind tends to try to 'escape' awareness of what is happening, avoiding the opportunity to respond in a creative way. It tries to escape by initiating a state of *confusion.*

We experience a simple kind of confusion, of course, whenever we are presented with a complex array of new facts and perceptions; it normally takes some time for all this to be 'sorted out', and during this time it is one's wholehearted intention to arrive at a clear perception of what is 'mixed up'. But when the mind is trying to escape the awareness of conflict, there is a very different kind of confusion, which is self-perpetuating, and in which one's intention is really to avoid sorting out the facts in clear perception. In this latter case, we tend to say that the mind is in a state of 'disorder'. It is actually following a well-defined order, but one that is as degenerative as, for example, the order of the digestive organs when they are not permitting food to be assimilated into the blood in proper form. The essence of this order is that every time the mind begins to focus on its contradictions it jumps to something else. It simply will not confront them. Continually it darts from one thing to another, or reacts with violent excitement that limits all attention to some triviality, or 'turns off', or projects fantasies that cover up the contradictions, or does something else to make one momentarily unaware of the painful state of conflict. This order of self-perpetuating confusion tends to spread in one's thinking, so that eventually the whole of the mind begins to degenerate.

When the process of degeneration in the order of operation of a person's mind reaches a certain point, the conflict is said to have made him neurotic. Everyone can then recognize that there is something deeply wrong with the way this person's mind works. Closer observation, however, would show that a basically similar state of conflict covered up by confusion prevails in what is called the normal state of mind. And it is this conflict and confusion in the mind of each of us that has brought us to the state in which we now find ourselves individually and socially (in other words, our external conflicts are mainly a result of our internal conflicts, though of course there are reciprocal effects). Unless we can begin to focus on the conflicts within us, and to respond in an original and creative way to the ever changing and developing nature of the overall fact with which we are confronted, it is futile to hope that the state of either the individual or society will ever develop into anything other than the clash of opposing forces set off by our confused and mechanical actions and reactions.

The ending of conditioning

The difference between creative and mechanical responses clearly transcends special fields, such as art or science, and is crucial in all areas of human activity. On it may depend even our survival. But given that we have been generally conditioned to mechanicalness, how are we to break out of this conditioning?

It seems that in some way each person has to discover again what it means to be original and creative. After all, the fresh, wholehearted interest of a child is not entirely dead in any of us. It comes in small bursts, and then it gets lost in confusion as all the old special interests, fears, desires, aims, securities, pleasures, pains, etc., come up from the past. The impulse toward originality and creation is deadened gradually, and eventually the subtle capacity for original and creative perception 'goes to sleep'.

I am reminded here of what happened when I first got on a horse many years ago. The man it was hired from told me, 'You must think faster than the horse, or else you will go where the horse wants to go.' This made a deep impression on me, and contained an important truth – that a given process can be further ordered only by the intervention of a faster, or finer and more subtle, order of process. An alert rider is able, by slight pulls on the reins, to change the overall order of movement of the horse. Likewise, original and creative action of the mind should be able to direct its more mechanical action, for one can perceive where the mechanism is going long before it has gained overwhelming momentum. But now imagine that the mechanical jogging of the horse has put the rider to sleep. Occasionally the rider wakes up and is horrified to see where the horse is taking him. So he corrects the direction of the horse, and the jogging soon sends him back to sleep again. Perhaps eventually the horse, too, begins to worry about the course of the journey and whether he will ever be able to find his way back to the stable. It occurs to him that he should wake up the rider, but first he wants to be sure that the rider will indeed take him back to the stable, where he knows he will have a good meal and a comfortable place to rest. Since his thinking is no match for the rider's, which may well direct him to an entirely different goal, he hesitates to awaken him. Similarly, mechanical reactions of the mind eventually lead to the thought 'I need a creative response to get me out of this mess.' But then there is further mechanical thinking: 'If I try an original idea, I might make a mistake. People won't understand. I could lose my comfortable position . . .'

Since mechanical responses never contribute to awakening the creative action of the mind, how can it be awakened? In my view, this can come about only through creative responses themselves. It is as if the rider, momentarily jolted out of his comfortable state of somnolence, began to be aware of the mechanical actions that were putting him back to sleep. Perhaps in this way he could really wake up. Likewise, to be original and creative one must first be original and creative about the thoughts and actions that are making him mechanical.

The varieties and details of these thoughts and actions are too complex to be discussed here. But certainly a basic impediment to being creative about the mechanical continuation of results of one's past conditioning lies in confusing this with what really constitutes one's 'very self'. For example, each of us can see that he is attributing, either tacitly or explicitly, great importance and value to certain comforts, pleasures, sources of a 'tingling' sense of excitement and euphoria, secure and satisfying routines of life, and various other things 'necessary' to his feeling of well-being. These often seem so basic to the psyche that one feels he cannot bear to have them seriously disturbed. Indeed, they may appear to be so inseparably part of one's very self that any creative potentiality of the mind would seem to depend first of all on seeing to it that they are maintained (just as one's physical action depends on maintaining an adequate supply of the right kind of food). We can see, however, that their maintenance – far from being necessary for creation, or for self-preservation and happiness – is in fact the principal barrier to creativity and a harmoniously ordered totality in the psyche. We must therefore pay careful and continual attention to how our habits and preconceptions are conditioning our thoughts and feelings and overall behavior and strictly limiting what we are doing individually and as a society. As we become sensitive to how this process is working in ourselves and in others, we are likely to discover that the mind is beginning to reach a more natural state, a state of creative freedom, in which all this conditioning is put in its proper place and in which the mind's operation is no longer mainly mechanical.

In emphasizing the need for each individual to realize the creative potentialities of the human mind, I do not wish to suggest that this is merely what I (or other people) happen to want or think would be useful. Rather, it seems to me that just as the health of the body requires that we breathe properly, so, whether we like it or not, the health of the mind requires that we be creative. That is to say, the mind is not something whose action is properly mechanical. The ultimate result of keeping it mechanical is always a painful state of dissatisfaction and conflict, covered up by confusion, in which the mind jumps continually between incompatible orders of operation, and this falls far short of even the limited kind of order displayed by a good machine. Awakening the creative action natural to the mind is not at all easy. But, for the reasons I have tried to indicate, I feel it is, for each of us individually and for society as a whole, essential. And the key will be to remain continually alert to the basically mechanical thoughts and actions that are causing us to 'fall asleep' again and again.

Originality and creativity will emerge, not as the final result of a planned and formulated program for achieving them, but as an inherent tendency of a mind that is developing its natural order of operation. And this is the only form in which originality and creativity can possibly arise, since any effort to reach them through some preconceived series of actions or exercises is a denial of their very nature. But after all, for thousands of years people have been led to believe that anything and everything can be obtained provided one has the right techniques and methods. We have to beware of the ease with which the mind slips comfortably back into this age-old pattern. Certain kinds of things can be achieved by means of techniques and formulas, but originality and creativity are not among them. The act of acknowledging this deeply – not merely verbally or intellectually – is also the act in which originality and creativity can be born.



ABSTRACT

WILLIAM S. BURROUGHS

(Marrakesh 1976 . . . Here in the middle of a film to find myself one of the actors. The Chief has asked me to his house for dinner.

'Around 8 Rogers.'

He received me in his patio mixing a green salad thick steaks laid out by the barbecue pit.

'Help yourself to a drink Rogers.' He gestured to the drink wagon. 'There's kief of course if you want it.'

I mixed myself a short drink and declined the kief. 'It gives me a headache.' I'd seen the Chief smoking with his Arab contacts but that didn't give me a license to smoke. Besides it does give me a headache.

The Chief's cover story is an eccentric old French comte who is translating the Koran into Provençal and sometimes he will pull cover and bore his guests catatonic. You see he really knows Provençal and Arabic you have to study for years on a real undercover job like this. The Chief wasn't pulling cover tonight. He was expansive and 'Watch your step Rogers', I told myself, sipping a weak Scotch.

' "I think you are the man for a highly important and I may add highly dangerous assignment, Rogers." You fell for that crap?'

'Well sir he is impressive.' I said cautiously.

'He's a cheap old ham', said the Chief. He sat down and filled his kief pipe with one hand. He smoked and blew the ash out absently caressing a gazelle that nuzzled his knee.

' "Gotta stay ahead of the Commies or everybody's kids will be learning Chinese." What a windbag. "Life is a game Rogers. You have to keep your eye on the ball." How would you define a game?'

'Well sir a game has goals and rules.'

'The game we play has no rules. I mean what is the common denominator of all games?'

'Players sir.'

'Yes and what else?'

'Winners sir, and losers.'

'Right. In any game somebody must lose. That is the condition for a game. All games are hostile. All games are war games and war is *the* game. The goal of war is to produce effects preferably lethal on the enemy and to prevent the enemy from producing such effects on you.

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Enemy has same goal. You act to destroy his goal and to create your own. That's the way it looks on the surface both sides all out to win. There are also hidden goals. The goal to lose for example. For someone engaged in war games the goal to lose poses such a threat that he cannot confront it. The presence of this negative goal makes the goal to win overwhelmingly compulsive which continually activates the goal to lose. Players with the hidden goal to lose will always lose in the end no matter how brilliantly they play. Hitler obviously had such a goal. So you see how the study of opposed goals is pertinent to our particular game?'

'I think so. You mean the enemy could be implanted with hidden goals of a disadvantageous nature.'

'Exactly. And what is all so-called black magic but techniques of varying effectiveness for implanting disadvantageous goals? To fall sick, to become impotent, to die. Now the boys who look into these witch doctor, ancient East, Mayan, Atlantean, Druid or whatever secrets are known as the Folk Lore Department or FLD. Well a Mexican shoeshine boy who was intimate with one of our agents . . .' The Chief got up and put the steaks on a grill over the barbecue pit. The boy was smiling from the other side of the patio like a shy young animal.

'Now that lad . . . he's a doll isn't he? . . . is a natural sensitive, one of the best deep trance mediums I've ever handled. In trance he turned into a young Mayan priest. Looking through his eyes I could see the pyramids and the sacred books. (As you may know most of these books were destroyed by Bishop Landa) In a series of sessions with the boy I was able to decipher the books. Deciphering anything is easy if you know what its purpose is and the purpose of the Mayan books can be summed up in one word CONTROL. The priests comprised about 1 percent of the population. They had no weapons that could not be readily duplicated by the other 99 percent. Therefore they had to maintain their power by thought control. The books consist of dates, the contradictory goals to be implanted on these dates, and the means by which contradictory commands were enforced . . . "To stay well to get sick" for plague. "To have plenty to eat to have nothing to eat" for famine. "To rebel to submit" when the workers showed signs of protest. The goals "to stay well to get sick" will always result in sickness. Once the negative goal is implanted the subject can only react against it and by so reacting defines and strengthens the negative goal. Similarly the goals "to rebel to submit" will always result in submission. The contradictory goals were written

in a symbol language that only the priests could read. To get some idea of this symbol language run through a series of contradictory commands: Stop. Go. Win. Lose. Love. Hate. Wait here. Go there. Rebel. Submit. Do it now. Do it later. Stay in. Stay out. Translate these commands into pictorial form. See yourself stop go win lose love hate ETC. You have pictorial representation for these commands?'

I nodded.

'Good. Now alternate' the Chief snapped his fingers 'Win. Lose. Win. Lose. Stop. Go. Love. Hate. faster faster faster. You feel anything?'

'Yes. A sort of tingle. Not pleasant.'

'Exactly. Alternating current. Not pleasant at all. Literally wires in the brain. Now here is a young apprentice priest. He sits naked on a leather cushion. The sacred books are open in front of him. He sits there rocking back and forth to the current humming like a dynamo. It is known as singing the pictures. He can feel the pictures hit and take. He can tingle right into the bodies and minds of the workers with his pictures.'

'And how are the negative goals implanted in the first place?'

'By fear of course. By a threat so horrible the subject cannot confront it. Death? Torture? Much worse. In the sacred books men are shown turning into crabs and centipedes. And the actual techniques for bringing about this metamorphosis are indicated in detail.

Contradictory commands run on alternating current. The purpose is to limit and confine. The step from alternating to direct current may explain why many of the Mayan cities were quite suddenly deserted. The control system broke down during a famine. As a last resort they called in the incomparable Yellow Serpent . . . The Serpent is carried in on his amber throne . . . blue snake eyes, skin like smooth yellow parchment, two long serpent fangs grafted into his upper jaw. He calls for the sacred books. "Live. Die. Life. Death" . . . As the current pulses through him he begins to rock back and forth. Suddenly he shifts from A.C. to D.C. A thin siren wail breaks from his lips now open to the yellow fangs.

DEATH DEATH DEATH

The pictures crash and leap from his eyes like white lightning blasting workers and priests alike to writhing smoldering fragments.

DEATH DEATH DEATH

A thin siren wail rising and falling over empty cities . . . this secret of the ancient Mayans which few are compe-

tent to practice. When comes such another singer as the Old Yellow Serpent?

The hidden goal of all war games is DEATH. DEATH for all players. No player is allowed to know this. For a player to know his real goals is a violation of game conditions.

"Bring us the ones that work", they say, "facts, figures, personnel. Put that joker DEATH on the line. Take care of Mao and his gang of cutthroats."

) I was privileged to assist in a manner of speaking at the Yellow Serpent's last broadcast in Washington D.C.

DEATH DEATH DEATH

The pictures lash and crackle from his eyes like a vast whip.

DEATH DEATH DEATH

And now the Serpent swings his whip in the sky.

Here lived stupid vulgar sons of bitches who thought they could hire DEATH as a company cop . . . empty streets, old newspapers in the wind, a rustle of darkness and wires.

(Soccer stadium in Lima. Referee calls a foul on the Peruvian team. Their goal is cancelled. The game is lost.

) Led by La Bomba the Peruvians vault into the stadium . . . tear gas . . . panic . . . a sound like falling mountains . . . the goal is torn down.

"And now if you will excuse me the soccer scores are coming in from the Capitol . . . One must pretend an interest . . ." 218 DEAD IN LIMA SOCCER RIOT . . . TOLL MOUNTS . . . 298 . . . 316 . . . MOST TRAGIC GOAL IN HISTORY . . .

(Mayor Daley calls for law and order, an end to anarchy and chaos

) Tear gas, screams, police whistles, crunch of nightsticks, breaking glass.


SOUS SECRETARIAT A L'AGRICULTURE - EAUX ET FORETS
COMMISSION DE PECHE ET PISCICULTURE - LABORATOIRE FLOTTANT



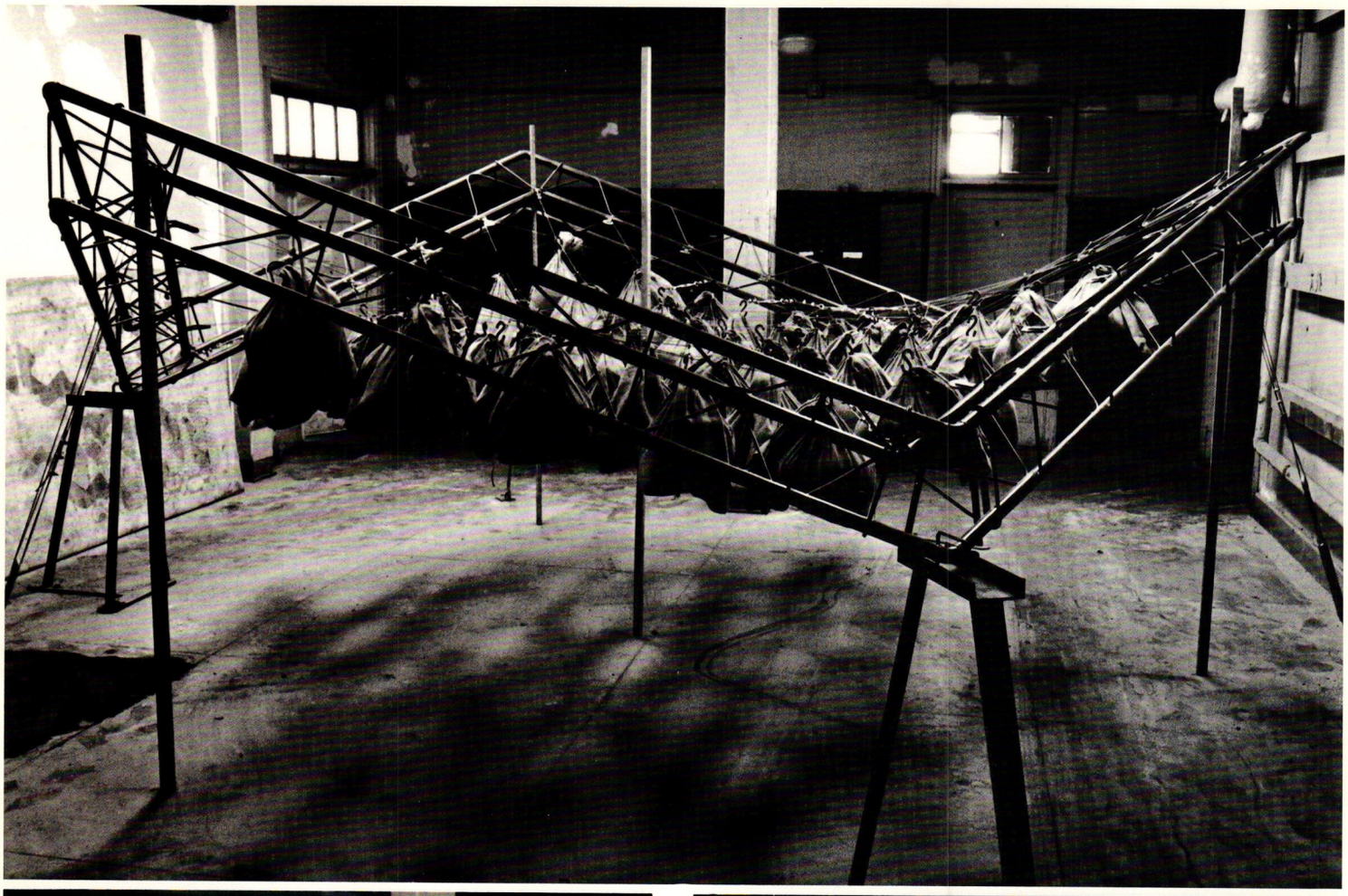
'THINGS THEMSELVES ARE LYING, AND SO ARE THEIR IMAGES'

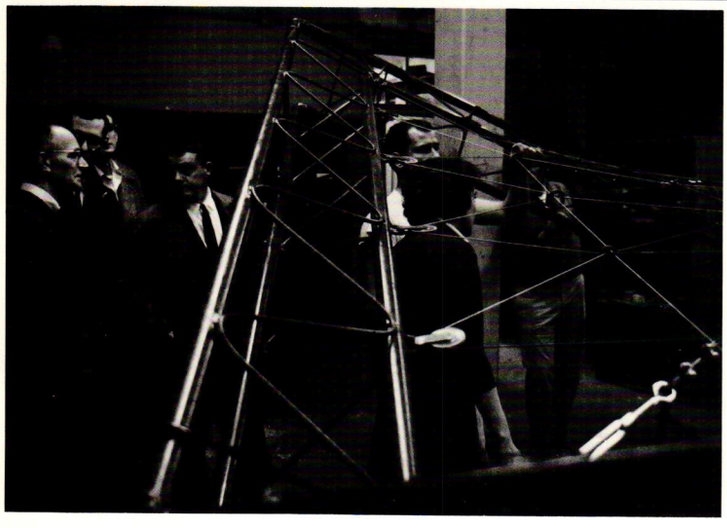
Things are moving so fast. You know, they have a tendency to become less pure. Before, it was much more restful and in some way, I think, wonderful, for we had not the feeling that we were only dealing with partial truths, which is the case today. I don't know why, time had not the same value as it has now. Maybe man wants to live this way, putting more events in his life, getting his life fuller. I wish it were an explanation, but I can't help thinking that it's a little like a dog running after his tail; you just go round and round. But somehow one has to move.

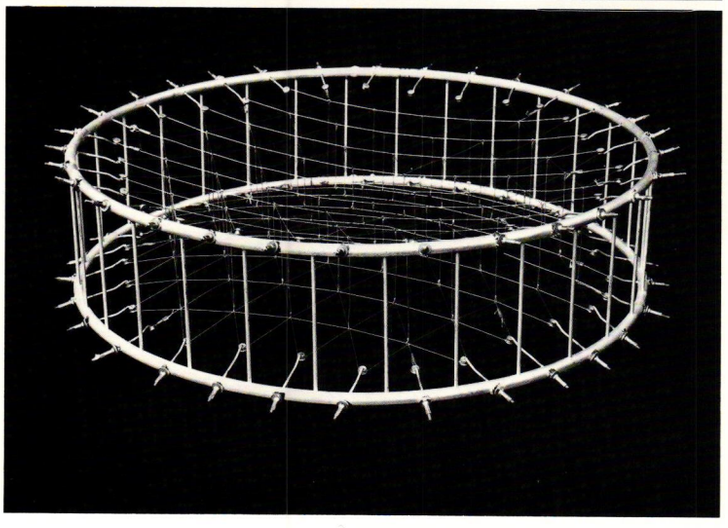
All sorts of new ideas have come on the market, and the spectrum is becoming very wide. Even the idea of research with experimental structures has taken on terrific proportions. Whereas fifteen years ago, in Paris, at the Beaux-Arts, they would have laughed at you for thinking that perhaps you could use a shop and some welding torches. They would look at you as if you were some guy trying to propose welding torches to Plato. He would have said no, these things don't belong with the straightedge and the compass, that's all. It's a very easy way of encircling knowledge, to certain facets: this you're allowed to do, this you're not. If a more juvenile approach could have been taken, much more would have been possible. But believe me – and this wasn't so long ago – I saw at a faculty meeting here that our idea of doing research was still absolutely misunderstood. I was advocating the creation of shops and a laboratory dealing with space frames, grids, tension structures, and so forth, and someone, whose name I've fortunately forgotten, said, 'To research what? Research of what?' It was kind of infuriating, this aggressive way of his, so I said, 'Well, that's simple: zero weight, infinite span.' I am not certain this was understood, but the years that followed showed that the joke had a pretty good point. You know it can't be done, but at least it's a limit that we could try to go to. It's, as I think Lou Kahn would say, a desire, a human desire to do. Why that is so, I don't know. Maybe man has a very stupid attitude, trying to do better than what has been done, but in a way, maybe it's a source of excellence, man never satisfied with himself – he wants to transcend himself, or to find some kind of thing that doesn't exist. He wants to go farther. Of course it's a way of devastating yourself, because there is just no end to it.

Really my vice, I should say, is curiosity. 'What about that?' 'How come we have not been careful to see what happens if we do this?' It's always this vicious curiosity. I mean the whole damn thing is to ask questions all the day. Sometimes you can't answer them, but sometimes you can produce the element. When you face some question you can't answer, you have to find some better tools. The point is that you're probably not prepared for this question. At this moment a book may be of some help, but I don't think there's any psychic to tell you the way to discover the nature of things. It's something that you come to feel or you don't. I think really the secret is to be curious. You see, we are our own first problem. What makes us different? Why should a guy be interested in some stupid things like leaves? – which are not stupid at all, but, you know, we are very mysterious. People have got a personality, and maybe they're not interested in leaves. Maybe they're interested in minerals. Minerals have a kind of unknown prestige for them. Why, we don't know. There are hundreds of other questions which are probably of the same importance. But to know what is really your interest is great: not to distribute your attention everywhere, to find your focus of interest, what is a big problem, what is a big question. So, for instance, you may be pursuing a peculiar study of nature

1. An early application of the Isoflex system, using sheets of corrugated plywood superimposed crosswise, 1937







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– it will probably not total into any kind of mathematical law, but for yourself you have discovered a lot of phenomena which you wouldn't have expected. My own conviction is that we can only appropriate and fully possess what we ourselves discover. A fascinating aspect of this is to see that what you find on the way is often more intriguing than what you first set out to do; the answers, you might say, formulated by nature to our queries are often more significant than the questions themselves. But that's the first step, I think, in finding the truth: to be interested. And the more curious you are, the more your chances are of finding an explanation, because it shows that you're puzzled, even unconsciously. Maybe you'll come around one day, and that's it, you get it now. But, to be sure, it's not immediate.

Fundamentally, my attitude – I shouldn't say this to a student – is that I'm fantastically hedonistic, and you know by hedonistic I mean the search for my own pleasure. It's not at all the desire to be sensational. You know what we are, we have limits. So therefore I think we have to be satisfied with little things – that's my religion now. Any day where you have something which marks the day, where you have done a certain thing which may not be that important but which gives you pleasure, you don't have a bad conscience. Sometimes it's absolutely silly, some little analogies which are really infantile are enough to keep me going for quite a while. These analogies may be pure fancy, maybe very stupid things, but sometimes they illustrate in an amusing way things which are very difficult to comprehend. And even if the analogy by itself isn't right, there is something there: it's the almighty power of an idea, as an incentive. I mean I'm obliged to admit that a fine work of engineering is okay, a standard of excellence which is visible, but the idea behind it may be more exciting. Because a building is a unique thing, and I have the feeling that the idea can give solutions for different sorts of things [*2, 3*]. You don't know what they will be. That's why if somebody said, 'Well, now we're going to give you a grant of fifty thousand dollars to go further', I would be bored to death. I'm not the organization man. Because I work on the kick, on the idea. It's not bad to have some guidelines, but to organize in a methodical way, in a really efficient way, I'm not the man for it.

We had some chances at one time, the story of our radar dish and the transmission towers [*4, 5*], which could have been a success but which could have been also a failure. The trouble is that in order to build you must find a victim. By that I mean a client who has some money. Then you're expected to draw up plans and specifications, figure out an estimate; you have to go through some red tape with officials and watch out for the contractors. It's just too much for my limited mental powers. It's a profession, to make a radar dish. It demands convincing power and technical certitude. And you must convince yourself, you have to make up your mind, because there's no room for these interminable reflections, these comparisons of opposed solutions to a project, which have always been my weakness. Besides, all these big companies would never support this kind of amateur research – they would lose too much time. In all this professional business it's fast, fast, fast. It has to go fast. The answer has to be given in a few months, and all this Penelope's tapestry of ours is incompatible with business, I suspect. There is also something else: in many instances when you go to these companies, you see that they are obliged to say they're not interested. How can you expect a man to go to the boss in his department to admit that some other guy has an idea which he has not? To protect himself he says, 'Yes, your new idea is wonderful, but it doesn't work.' Or else, 'We know about this. Our findings confirm yours.' Since he is the only one to make a recommendation, you have no chance unless you are protected by the president himself. But that is not always the case – you don't have people up your sleeve at every moment. You see, all these big companies, who really work for government agencies, want to keep their prestige, and the fact that they buy an idea from someone else only says that they are not competent to do



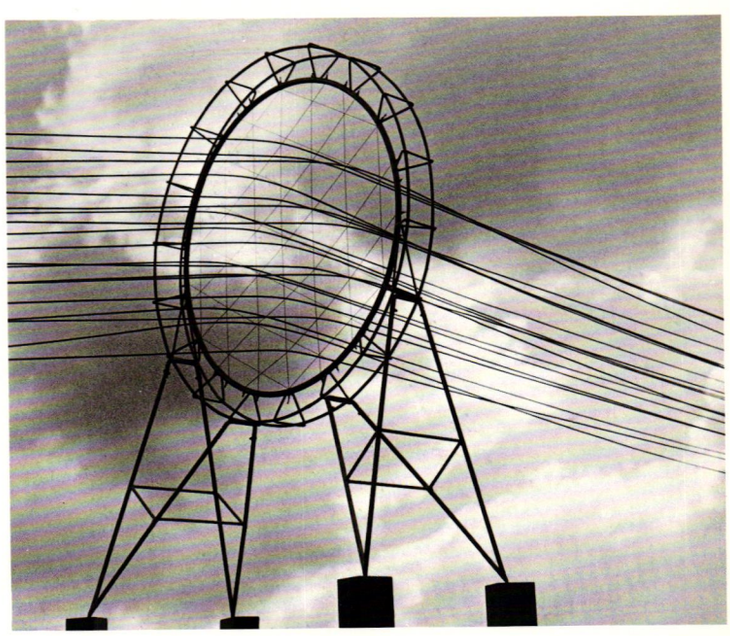
2, 3. A 'monkey saddle' structure, 180 inches between points of support, made of steel tubes of 1-and-5/8-inch diameter and rods of 3/8-inch diameter, welded, for the frame and aircraft cable of 3/16-inch diameter, strung on Bakelite aircraft-pulleys, for the tension network, 1959–60

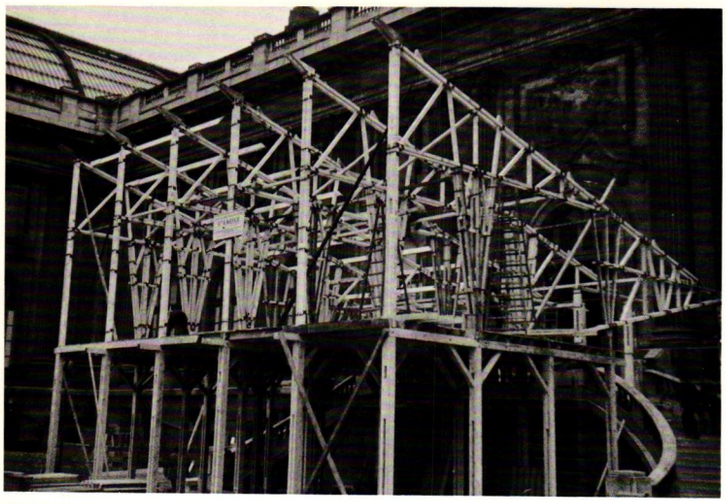
'This structure was based on some studies we made with soap film, where the principles of minimal surfaces, which are cumbersome to demonstrate in an abstract way, are clearly displayed; the students dipped several geometric frames made of wire into soap solution, and finally, by puncturing certain faces of the film occurring in a cubic frame [see diagrams above], they arrived at a 'monkey saddle' configuration. We chose to investigate this further in terms of a possible roofing system, because there seemed to be several advantages. The hexagonal boundary would give us a good ratio between the perimeter and the area covered, and the possibility of easily arranging a triaxial tension-network, which is more efficient than the biaxial or radial systems for distributing stresses. There would be a simple solution for support on the three low points of the boundary truss, and from the intrinsic properties of minimal surfaces of this kind, a very favorable homogeneity of tension throughout the network, effective even under reversals of external forces. . . . It may be very naïve, but I believe these elementary models should be built, so that they can be experienced and contemplated. They should speak to us, or help us in some way to see what might be done with them.'

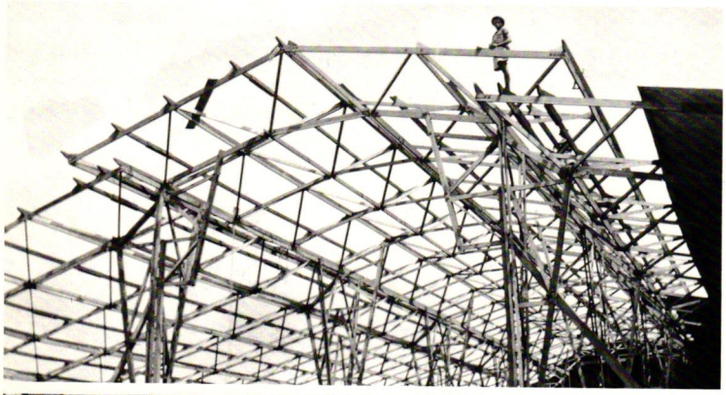
4. Model of a concave DNS (double-network system) frame for a radar dish, 21 inches in diameter with a maximum depth of 5 inches (scale, 1:35), made of steel tubes of 3/8-inch diameter, rods of 1/8-inch diameter, and aircraft cable of 1/64-inch diameter, 1959–60

'We thought this could have a thin reflective skin connected to the tension network, perhaps under vacuum, and an electronic system of jacks to maintain the required parabolic curvature.'

5. Model of an Omega tower for 19 power lines, 17 inches in diameter with a height of 24 inches (scale, 1:85), made of steel rods of 3/32-inch, 1/8-inch, 3/16-inch, and 1/4-inch diameters and aircraft cable of 1/64-inch and 1/16-inch diameters, 1967–68









6. An Aplex frame for a demountable exhibition-building, made of wood, Paris, 1948

7, 8. An Aplex space-frame for a hangar, 30,000 square feet, made of wood and corrugated metal, French Cameroons, 1947–48

9, 10. Model of a Trihex dome, 42 inches in diameter with a rise of 12 inches (scale, 1:200), made of steel rods of 3/32-inch and 1/8-inch diameters, 1967–68

11. Model of a Starhex dome, of same dimensions and scale as model in [9, 10], made of steel rods of 1/8-inch diameter, 1967–68
'The Trihex and Starhex networks are related topologically, and so we expected to find that these domes would have quite similar elastic behavior, which proved true in tests. The Starhex dome, however, was composed of a much less compact array of bars. Its weight was only 2.3 pounds, and the deflection in inches under a uniform load of 125 pounds was found to be 0.070 as compared with 0.025 for the Trihex, which is very nearly equivalent to the inverse ratio between the weights of the two models.'

it themselves. So there is always the tendency for them to say, 'No, of course, yes, your idea is very refreshing. It's very nice, very interesting.' That's it, it's interesting, but you don't see them again; you don't see their money.

It's easy to understand why I am so interested in research for the sake of research, and not in terms of making business and money. It's pretty sad, because I think that many things we have been doing here are certainly of commercial value. But maybe I've become fatalistic in some way. Let me tell you, if thirty years ago I had been successful in trying to promote the space-frame system, I wouldn't be here today. Which is some delight for me – it's not a terrific job, believe me, but I like it. If I'd been a success, I would have all their space-frame systems. Now I would be the current space-frame specialist, not doing anything else, all my time making connections, making joints, seeing people. Thirty years ago I would have been delighted, but well, I would have missed a lot of fun playing around with a lot of other things. No engineer would go the way of space frames then; now it's just the opposite. And now I don't believe at all in space frames. . . . There are phases of thinking. You see the eternity of life. Instead of becoming so enslaved by our results, which may be nothing at all, just delusions, we should be able to find some other way of fulfilling our desires. That's what I call the beauty of failure, the art of using failure. If it works, phut, we escape forward. That's what we're trying to do by not subscribing to a particular discipline, just turn our coat every now and then, 'turncoat'. That's life, not a predetermined idea. So I'm very sorry for the guy who is so imbued with his power of thought that he thinks what he says must always be the truth. Everything is kind of futile; we have only some partial results. You see, there would be no progress if you simply hit some wonderful idea. It would be so good to say, whatever it may be, a building, a theory, 'Well, this is it and it will always be beautiful', but that's not in the nature of things.

Look how wrong some thinking can be: it was a great mistake, which I realized a good many years later, to say that the art of building is to build with matchsticks [*6–8*], that if you want to build light structures you must use light members because if you use light members a group of light members will be light. It took me quite a long time to see that it was just the opposite; it's the art of making a light structure with big, heavy members. A paradox. But not when you take dimension into account. So for the project of a stadium for Philadelphia, instead of doing like the geodesic-dome people with small tubes, we took large tubes. And you know that the parabolic form is optimum for a uniformly loaded member, so when Mr Fuller says his dome could be a sphere, or part of a sphere, it's just not right; the difference is very slight, but in terms of accuracy a sphere has nothing to do with a dome or the laws of gravity. Therefore we followed the principle of projecting an optimum network for large members onto a paraboloid of revolution [*9–11*]. You know these members will not be equal in length after you do this kind of projection, but the thing as a whole is compatible. The idea of having all the members the same, the idea of prefabrication, is all right for making a house, but when you really want to go to high performances, as in bridges and domes, you have to change your criteria. That's why I wrote to a newspaper that the U.S. pavilion at Montreal gave me the impression of watching some kind of military parade, where the impressive thing is the number of soldiers, twenty thousand or so, not the way they are arranged. I think they are fooling themselves by playing with elements too small, because tubes of small diameter require short lengths and many more joints. Increasing the diameter from about three inches, which was the dimension used for the Montreal dome, to twenty inches, we should be able to use forty-foot, and even braced one-hundred-twenty-foot, tubes instead of the ten-foot ones. What is striking is the fact that a geodesic dome has about twenty times more joints, and eighty times more members, than our system, and ours is still lighter in relation to the area covered. Of

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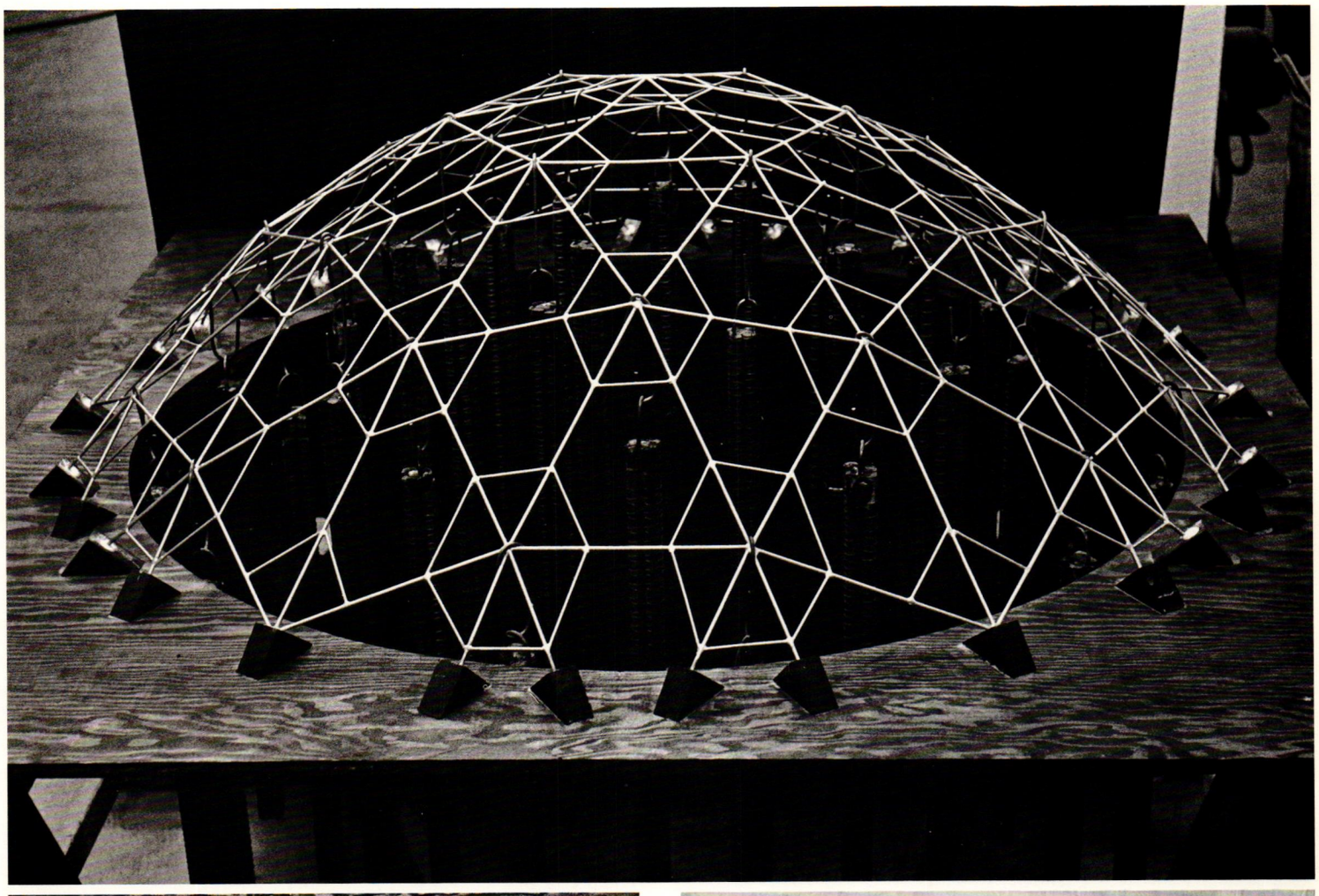

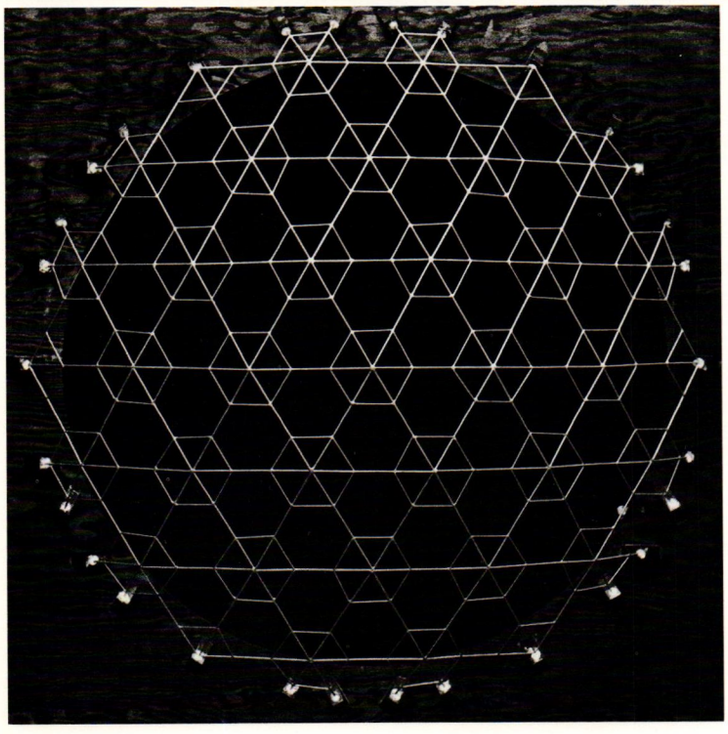

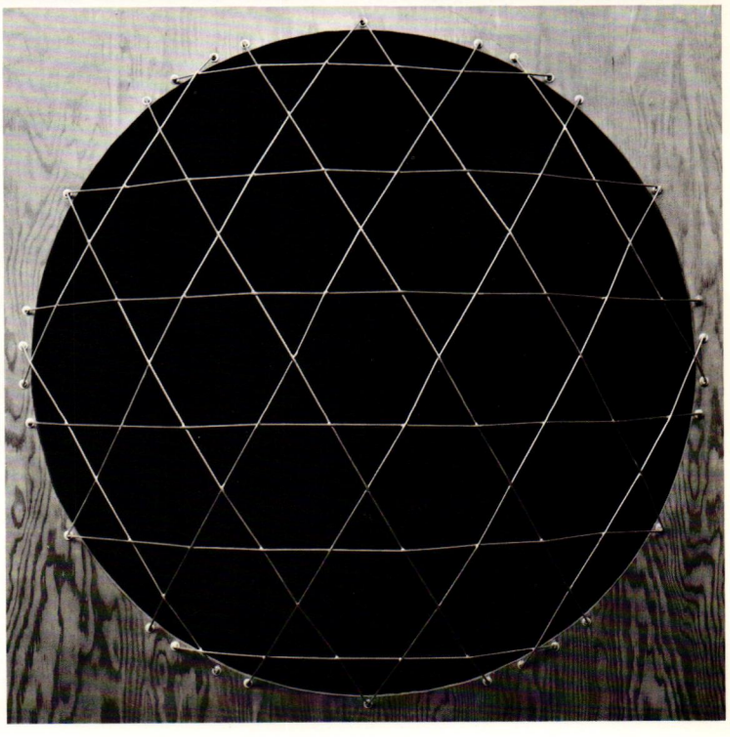

course with large tubes you dangerously increase the self-weight of each member, but this could possibly be nullified by introducing queen posts or gusset plates. Today everybody would be scared of making a joint for such large tubes. Why? It's bigger, that's all. This joint would be about six feet in diameter, an enormous piece of metal. Well, the thing is a little big, but finally when you see the area covered, it's not.

That doesn't mean I'm an advocate of just making things bigger and bigger, because as soon as you go outside certain limits, all sorts of problems are waiting for you. It's a law of nature, something which is quite natural. You can see this every time you put extreme loads on a beam or a truss. It's very curious, this truss is not going to perish the way you think it will; there will be some kind of devious way. You have computed it for bending, your '*I* over *c*', but boy, no-no-no – it's going to be torsion. The damn thing is going to warp. So this makes you wonder when you see that they are going to make these airplanes bigger and bigger. The way they do it, I think, cutting in two one of their 707s and putting in an intermediate body, it's just too simple to be true. There shouldn't be the 747, or it shouldn't be at all the same as the 707. I mean it may be bigger, but you're facing the same danger as if you started to make a house out of cardboard. Your little model in cardboard is going to be fine, just stiff enough, a wonderful little thing. Then you make the house of cardboard, and something is lacking there; it doesn't work. I don't want to be a Cassandra, a prophet, you know, always bringing some bad omen, but these planes are bound for some tragic bugs. Well, maybe they can do it; I'm not a specialist on the aircraft. But it's about the same everywhere: you reach such a scale that a new principle should be evolved. Any builder should have this present in his mind, things and their proportion. There are many scales, and each one seems to have some kind of adequate structure, which answers to its size and to the way it's made.

Architects should come to this feeling, that dimensions can fool us. Today it seems fashionable to speak about megastructure and making things big, but many times we don't really have an idea of that new principle which would answer a bigger scale. I'm always amused when I see planners making plans for some future city and they just don't realize how we are going to sit somewhere. I mean making a city for fifteen million – you don't do that; it's not going to work, or it will, but badly, with a lot of losses. It belongs to what I would call the curse of bigness. It's desperate. Of course I say that, but I'm proposing this crazy system to make a stadium seven hundred feet in diameter, and I have a student who is making what could be a very interesting model of some kind of parking garage for eight thousand cars. You see the folly has reached me. Really I hate it. I mean behind this there may be some unknown logic, but there's no sense.

This is serious. . . . We see the tragedy that this industrial landscape can be, which maybe has its beauty that we don't see. Maybe we are too nostalgic about forests and meadows and things like that. But I can tell you that I have always been fascinated by going from Philadelphia to New York, the approach to New York. It is very desperate and doubtless has great beauty. You know, all this sort of fight of man with nature is fantastic, and moreover you feel that this will be the place where a lot of things are going to happen, when we know technologically how to fill swamps and so forth. That's why I never agreed with my very wonderful neighbor here, the Danish architect. He was horrified in his way by the view from this street to the center of Philadelphia; these big columns of wood which you see, telephone poles, and everything messed up, a kind of no-man's-land that you know is going to be transformed – just unbelievable to him. He thought this is merely the work of an underdeveloped country. But then he showed me several of his own designs, and it was somehow disappointing. You see, some people have got a sense of order, a privative sense of things being symmetrical, which I have not. I think it's a pseudo-order, because neither in nature nor in art do you find this kind of total repetition that puts you to sleep; there are many more relations between things than their being simply contiguous, bing-bing-bing in a row, which is what you see in many planning projects – one would die of monotony living in such nice, clean arrangements. On the other hand, you know it's been made by a great architect when you see one of those Islamic walls where the symmetry is always broken with some kind of little detail. The patterns look fantastically well organized, but all of a sudden you see something surprising and out of context, which upsets the symmetry in a very discreet way. As you know, they avoided the presence of man, because representations of man were considered unholy, but in following these arabesques of geometric and naturalistic motifs you see that you can lose yourself in the delicate variation of details. This was not just to stun you. They wanted you to go into the play of the whole and the detail, which could become all-absorbing, a high without drugs. It's most impressive.

Perhaps what we call beauty is something that we are used to. Things which are new can be amusing, but certainly I don't think the adjective *beautiful* comes into play. We say at every moment that the shape of some new aircraft is really horrible because we are corrupted; we have seen aircraft going through so many transformations that we can't identify with the ultimate plane, which would be the plane of tomorrow, probably having nothing to do with the plane of today. It's very amusing, because one century ago they used to make the steam engine with boilers all of shining copper. That was beautiful – in New Orleans you find some of those boats, some remnant of this era of splendor and respect for mighty things, the big flywheel. And now you have a little thermal machine which does the same job as many once did, going twenty thousand r.p.m. instead of two hundred. The steam engine was overpowering, but you see our idea has changed and we know that the size doesn't determine the velocities. So I don't think one can find valid criteria in the sense of beauty by itself. It exists, no question about that, but everyone has his own coordinates; what may be beautiful to you may not be beautiful to me, unless perhaps you explain. I don't think it's innate. You see how your point of view is modified by a certain amount of culture.

But at least we know that the work of the engineer and the architect has to do with materials and matter, and when you want to devise some new structure, you have to have a clear enough idea of the orders of magnitude involved to know that the thing can exist. You really should know what you're proposing, because they're not going to use Scotch tape when you ask for two pieces of steel to be connected. Of course architects are people who automatically make a drawing, always making some abstraction, which is easy, because you do it in a void. Even if these are very simple, they can give you a completely imperfect notion of what the thing is. So in a way I kind of deplore the idea of image. I know a guy in Paris who can make fantastic dreams come true: taking the world for some kind of garden, you draw a whole future city in the sky; you reduce all the complex function of a city into a ready-made form. It may have some scenic value, but the danger of such an exhibit lies probably in its seductive power, the fascination with image for its own sake, based on some uncritical attitude or a desire for publicity. I mean all that kind of performance, drawing things like Eiffel Towers and this naïve idea of cities 'plugging in', belongs more to sport than reality, at least at this moment. It makes me suspect that we have to learn how to go from the concrete to the abstract. And yet I think it would be stupid to say that our abstractions have no use, because there are a lot of things we may be doing which appear to be totally impractical but which indeed have some light to shed on serious problems. So the other sequence would be quite good too: trying, from pure abstraction or a pure spatial concept, to find some correlation with things which exist, in which there could be an analogy. I won't say this should lead to application, because application has always some kind of sordid side – but analogy, I think that's right. It's a two-way system: we go

from the concrete to the abstract, going there, going back, back and forth, and that's perpetually what I think any man has to do. Getting lost in pure theoretical consideration isn't good. It starts you, but you get dry and just say, 'So what?'

There's a question of rapport, you see, this very fascinating thing between reality and symbols. Think of the mathematical models for moment, deflection, and so forth; even moment of inertia is a symbol, and quite a powerful one when you use it. But the question is whether we are playing with symbols – maybe symbols play some funny farce on us too. We become addicted to the symbol, even if many times we use it in the wrong way. Just think how long it would take to explain $ax^2 + bx + c$. It would be half a page: 'You have a coefficient multiplied by an unknown, which is the square, plus . . .' That's the elegance of symbolism. It's really the heroic work of mathematics to simplify, if just to escape the common language. You see four or five lines to an equation and you say the guy who did this is certainly great, but you don't know the time it took him to work that out. For me, the enjoyment is in trying to see some kind of rapport between things, which need not always be encompassed by a very dry formula. Of course when you have a dry formula that works, you're fantastically powerful and can do a lot of wonderful things. But there again, you have to be sure you're handling it in the right way.

It's an enormous reservoir of unexploited forms, mathematics and its symbols. These abstract concepts, which may be devised purely for the support of thought, enable our mind to escape the anthropomorphic attitude and confront an unknown universe. Probably magic and poetry in ancient times had the same power. But sometimes I wish we could have a physical model or apparatus that would show us the reality of, say, Euler's formula for polyhedra, $F - E + V = 2$, so that these things which are supremely abstract could be conveyed in a direct way. We can't live too well – at least I can't live too well – in such a rarefied atmosphere. Sometimes you need to see things, or experience them, where your eyes can help your mind. For example, I know that if I draw before you what we know is a rhombohedron, you would not be satisfied at all; it doesn't speak to your senses. Whereas as soon as you get the damn thing in your hand, you know what you're talking about. We are really maimed, you see. This need for representation, this need to make some kind of physical model as soon as a concept comes to us, proves how infantile our mind is. But it's a support. Our mind is not powerful enough to tell us what the angle is here when we have sixty degrees over there; it doesn't jump into your mind. So the contact with things is full of meaning: you know where you are, you have something that exists, that you can put your teeth into. You feel some ease. It should be important for any man to have some identity with phenomena, so that when he sees a resurgence, although there seems to be no connection, he knows that he is working in the same order.

Therefore I feel one has to start on the concrete and slowly converge with the abstract, but always keeping your eye on how the symbolism works with the fact. I would fight against too much symbolism – people relying too much on formulas and bookish things until they're just like ambulating textbooks, people eating symbols all the day, forgetting, you know, reality. That's my trouble: I may know very well what sort of symbolism should be applied, I know the rule, but going from the symbolism to some kind of particular solution is a difficult trick. I can do it for myself, but I can't always explain it to others. It's still an art, and anyone looking at the problem with a certain attention should be able to do at least as well as we do.

You see, it's interesting to travel in rather troubled waters, which are not science, and which are maybe a little more serious than the pure art of Corinthian columns. I can't help comparing this kind of work to some puzzle, very much like a crossword puzzle: you have to find six corners, twelve edges, and so forth [*12*, *13*]. You try, and most of the time it's hit-and-miss. That's no good for a mathematician; he'll just throw it away. I mean it's a long job, and it's a job some other guy could probably do much better. But since we're the only ones concerned, we're about to do it, even if we are doing it in an amazingly grotesque way. I don't think we should be blamed. I repeat it very often, my mathematics belongs to the sixteenth century. . . . Really I'm more interested in uncovering some privileged arrangements of things than in working for accuracy in our findings. In accuracy, which is the supreme quality of any mathematical thinking, you must define all your findings with a coefficient of error; you must limit this to one-tenth of one percent and so forth. I don't do this, because I rely too much on intuition. I mean I know that if I take a tube of a certain diameter it is going to buckle; it's an order of magnitude, not precision. My point is that if you dedicate time enough to this, you can come close to the accuracy needed. And you know it would be folly to go to many decimal places in the building trades. But this has a tendency to give some kind of lousy mind. You neglect – since pi means 3.1416, we'll take 3.14. That's good enough for us, but in pure terms of mathematics it's a lousy way to proceed.

The fact that we rely on a safety coefficient which varies from 2 to 3, sometimes more than that, tells you a great story about our inability to get high precision in the difficult art of building. This makes it very interesting to consider the problem of the beehive, the economy made by the bee with his trihedral lid. It was a great problem in the seventeenth century. I think it was an astronomer that started the damn thing – it's funny to see astronomers measuring the fantastic angle the bees use. Maraldi finally found it, something like one hundred nine degrees. And the saving in material is about two percent. Why should the bee do that, working on two percent while we work on two hundred percent? It tells you how far we have to go compared to the way of nature, the puzzling notion of the beehive. You know, at one time it was proposed to take the dimension of the bee's cell as the unit of length instead of the meter, because it has been observed that this is practically constant. It's very hard to find things which remain constant with evolution and time. Maybe with new mutation the bee will be shorter, and therefore . . . but it's good that they didn't take the cigarette as the unit of length.

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I must admit that everything dealing with mathematics was entirely confusing in my mind when I was your age; I was absolutely horrified by anything mathematical. I hated that attitude, and that's why I wasted so gloriously so many years of doing painting. You see the opposition? In painting you just do away with all this comparing, this fastidious way of mathematics. In mathematics, it's always precision; you have to know a few definitions, you have to compare, to measure, you have to deduct. When you do painting, you have this wonderful feeling of the unknown – especially since I really had no discipline. I came very late to this, so I didn't know how to paint; but I made the best out of ignoring how to paint. And as soon as I got to know a little more about it, I was not so amused. Really what was prodigiously amusing for me were my mistakes. Maybe some well-known operator would have just said, 'Well, this character, this guy doesn't know anything about the job of painting. There's a technique. There's a way of doing things.' This I would ignore fantastically, and many times that's probably the way I did my best painting. I was naturally very incompetent with my hands and could not draw – yet I had this eye for fairly exact definition of form. That's why I used the airbrush. I made some kind of stencil of cardboard, so you had a very wonderful definition of black and white. But why all this? It's because I was not sure of my hand to make the transition between black and gray and white. You see it comes to this notion of compensation: at some point you come to enjoy the thing you are lacking.

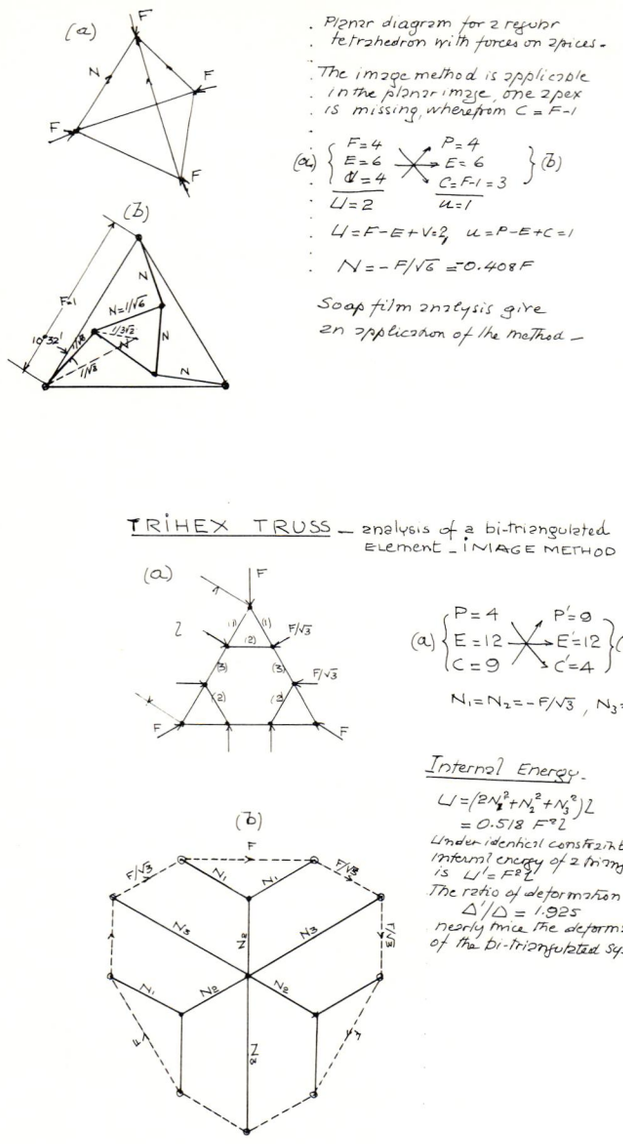
It looks like a cheap homily, what I'm saying, but honestly I believe that we do many things by compensation. We have some limitation, and well, all of a sudden you start to take it seriously, as a challenge to yourself. This plays very often – people who go through some kind of conversion, just reversing the trend. It's a challenge. Maybe it will take you a week more to understand something, but you go through it. Besides, things that come to be too easy are no fun. Things must be too difficult, you know. I'm sure you've seen some expert billiard players. It's dull, it's phut, you just see that they have no fun. They know they can make a hundred, bang-bang-bang; it's automatic, and really if you want to enjoy something you must have the feeling that sometimes you miss. I mean we have to be careful, even with the little models that we try to make, using soap films and things like this. We go very near phenomena many times that look complicated and are simple, but more often it's not as simple as it looks. At every moment one has to question himself. Indeed, you know the amusing story about bubbles is that they don't exist; we speak of a film, but really there's no film, only a phenomenon of attraction of molecules which are always moving. The fact is that we can't simulate this in any other physical or chemical way; you need the liquid, so the bubble is unstable and just dries up. There we are again, there is some kind of mirage in the image. One can be fooled so easily by the appearance of things and not see what is behind. Sure, I think it was Salvador Dali who wanted to make some bubbles for a big show, and he had prepared some frame which was about as big as they could carry. He dipped that into soap and nothing happened. Then he said, 'It's just what I wanted to show you!' Ha! You see, only Salvador Dali could do that – yesterday I was on the verge of proposing him as chairman for the school along with Jimmy Durante. It's wonderful that he could make money because the soap film didn't want to go that big.

Oriental wisdom has codified the problem in the proverb saying, 'Things themselves are lying, and so are their images.' So I think a certain self-analysis is needed, in order to determine our own coefficient of error. For instance, the frequency of a vibrating string to someone with well-trained ears is almost as precise as that given by computation; and you know there are engravers who can incise a steel plate to a measured accuracy of one-hundredth of a millimeter. This self-imposed discipline has some cathartic virtue in helping us to realize the discrepancy between what we really are and what we think we are, between the known and the unknown; it refines the meaning of experience. Because when you express yourself in this work, it's not a romance. When you're dealing with exact things, or things that are supposed to be pretty exact, you have to know what you're talking about – you can't misname things and make confusion. I don't take myself for a scientist, not in the least, but I know well that nothing in this domain of form is that arbitrary. It's not the arbitrariness of the historian, of the literary approach, of the art approach, although these have fascinated our imagination since the beginning of time. Deductions and propositions have to prove themselves, and not by seduction or good intentions; they have to come to facts.

I've found no better discipline in this unpredictable problem of form than to observe the prodigies created by nature. I mean you've got to have an eye, but the world is full of marvelous little things; their beauty and rigor is an amazing incentive. There was a good joke played by my students. They put a skeleton next to one of the models we had built, to illustrate how abstract and inhuman my structures were. It made me feel rather humble, but we took it to the lab and made some experiments. For example, we weighed it. Result: eleven pounds, a fairly light weight considering the man of one hundred fifty pounds that it had to carry plus many superimposed loads. Little weight, yet great structural solidity. At first sight this is an incomprehensible accomplishment of nature, since even with our special steels, very good materials compared to bone, we don't achieve comparable results. But the answer came with a photo of the bone texture [*14*]. The complexity of this structure was laughing at us. Not one element was the same. We read an astonishing three-dimensional network, whose geometry is practically impossible to resolve statistically, computing the average number of bars per joint and so forth. But if you think about the voids instead of working with the solid elements, the truth appears. The structure is composed of holes, all different in dimension and distribution, but with an unmistakable purpose in their occurrence. So we arrive at an apparently paradoxical conclusion, that the art of structure is how and where to put holes. It's a good concept for building, to build with holes, to use things which are hollow, things which have no weight, which have strength but no weight. The phenomenon of the eggshell is also a revelation, putting forward this kind of contradiction of a form which is extremely strong and yet locally very fragile. You can say that an egg is really very strong when you submit it to something like hydrostatic pressure, but when you exert a puncture load, when you squeeze it with two fingers, it's gone. It takes time to build up your mind for this. I was thirty when I came to ask myself about this notion of strength and fragility; before, the two were incompatible in my thinking.

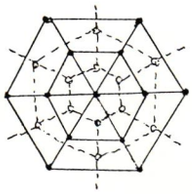
You see, it's always the convergence of certain ideas. There's some dilettantism in this attitude, but I think I would take it as a hobby which may be more than a hobby. I mean you may have a significant contribution to make here, because there's always some kind of no-man's-land between ideas, or between, say, strength of materials and biology. This is strange, but you can feel it very easily: there's some bridge to make between things. For instance, we speak of stressed-skin structures, which aircraft has developed a great deal, and of triangulated structures – here we are immediately facing two technologies, which belong to extremely different worlds. It's not the same guy; the guy who works with stressed-skin aircraft knows nothing about triangulation. That's the tragedy now, every branch of science getting into the hands of specialists. Being myself some kind of specialist, I can't blame them, but sometimes it's depressing, because you have nobody to talk to. We're just deluding ourselves, to think that the world should be separated between blonde and brunette or between stressed-skin and triangulation. Why should only a zoologist look at Radiolaria? That's a shame. I found in some magazine an interesting article about spiders and even communicated with one man about it. I don't think he understood exactly what I had in mind; I mean we were probably miles apart. You see, usually the spiders make indeterminate structures – there are always many connections – except one kind, with a funny name, who knows how to make strictly determinate structures. She has not gotten to the top class, remaining behind in the Maxwell diagrams. That's fun really, some kind of stimulation we need. And of course in terms of strength-to-weight, spiders are amazing, much better than we can do. The point is that the book of nature is so big that sometimes you find an answer to a question you have never formulated yourself. You correspond, but why should the zoologist know anything about $E = 2C - 3$, for determinacy in a planar system. It's not his job. He won't see a spider web and count the number of segments and the number of joints. Maybe, I don't know, he's interested in the society of spiders. I mean he's just as naïve as we are ourselves; we count the number of joints, but we don't know much about the spider.

So there is this rather exciting point between ideas, finding what is different, what is common, to what limit one system can go with another. Maybe you'll find some connection between the two which could lead you toward a solution. As you can see in some of the Radiolaria, there are forms that encompass the properties of both stressed-skin and triangulated structures [*15*]. They are just in-between: configurations with multiple holes, a perforated membrane in tension working together with a triangulated frame. And this may give an analogy, based on a few topological notions of the arrangement and



12, 13. Image Method diagrams

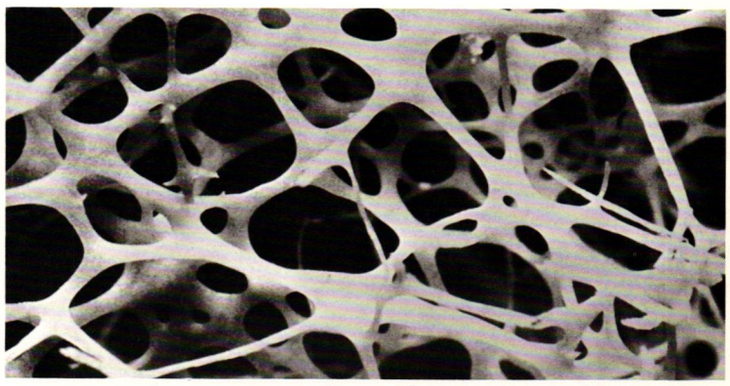
'The Image Method is based on the principle of duality and the definition of spatial invariance given in Euler's formula for simple polyhedra, F – E + V = 2, *with* F *being the number of faces,* E *the number of edges, and* V *the number of vertices. For a two-dimensional configuration, we use* P – E + C = 1, *with* P *being the number of regions,* E *the number of segments, and* C *the number of corners or intersections, and by means of a simple topological operation, in which the value of* P *becomes* C′ *and the value of* C *becomes* P′ *(the number of segments remaining the same), we obtain its 'image', or dual configuration; the planar image of a three-dimensional structure can be found by a similar operation. These images allow us to represent graphically the forces in members, once the reactions at boundaries have been determined, but the method leaves much to intuition. . . . It is also very amusing to consider the predictive power of these formulas; by simply manipulating the numbers involved and then trying to find the forms to satisfy the puzzle, you may discover things your mind isn't able to foresee.'*

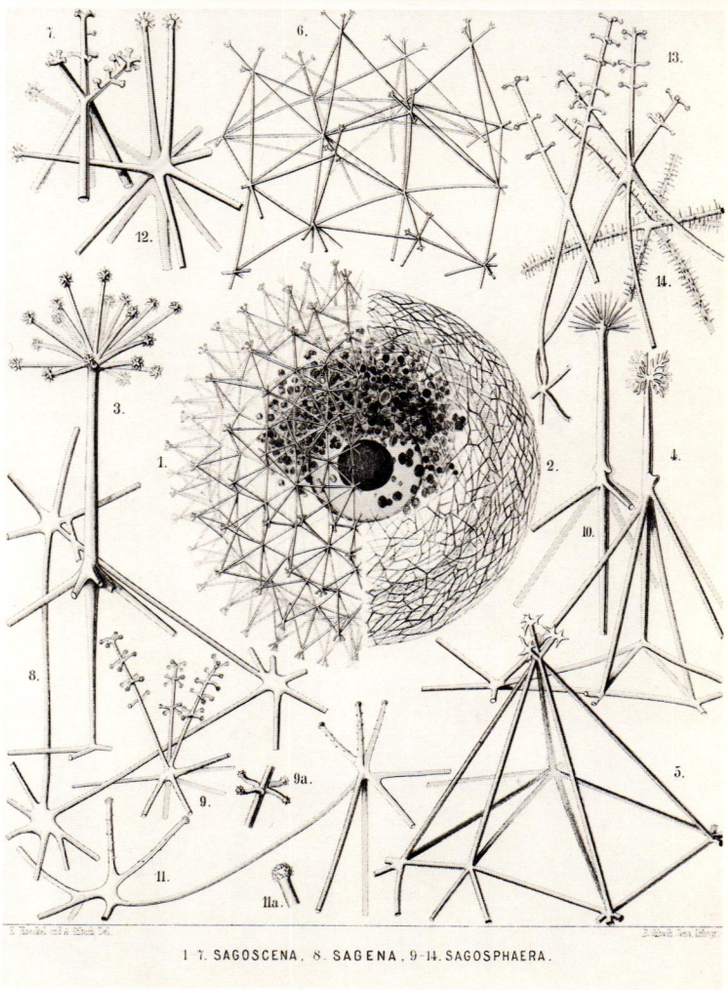


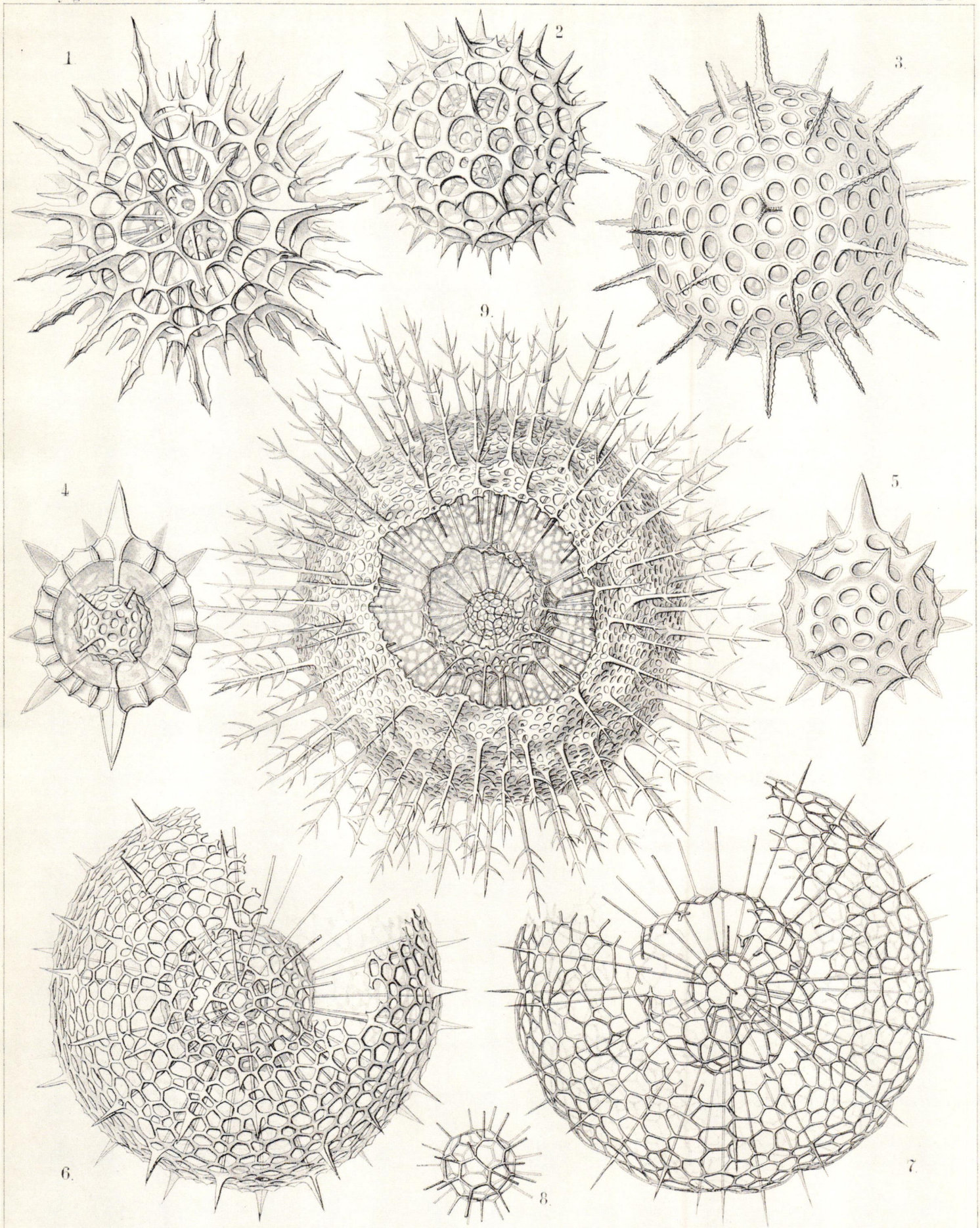
14. Photomicrograph of bone

15. Drawing of radiolarians, by Ernst Haeckel

'We can associate cyclic forms to cyclic patterns of re-formation, such as those found in structures submitted to vibrations, a self-adjustment of form tending toward an optimum equilibrium condition. The radiolarian Auloscena [*see diagram of diametral section below caption 13*] *shows this cyclic organization ruled by automorphism in a truly admirable way: the inner sphere radiates spicules which are reinforced by a peripheral wall reproducing the initial form, this being repeated a number of times. With the geometric differentiation between open configurations, typical of the growth of crystals and found in natural forms, and closed configurations, which are their duals, organized for stability and permanence, we are thus led to the notion of 'bimorphism', or the combination of a form with its dual. This is also a way of going from planar to spatial configurations; for instance, adding the values of* P, E, *and* C *of a triangle to those of its image, we obtain the values of* F, E, *and* V *for a tetrahedron.'*







E.Haeckel and A.Giltsch, Del. F.Giltsch, Jena, Lithogr.

1–8. ACTINOMMA. 9. PITYOMMA.

number of holes, that could bridge the gap between two kinds of structures and, possibly, the two technologies.

I don't think these Radiolaria should be ignored. They are more than mere curiosities, and we should study them carefully as highly elaborate pieces of work. The collection is of a fantastic vastitude. I think there are about four thousand different types, and you could spend days and days looking at the wonderful illustrations by Haeckel, dating from the eighteen seventies, when he sailed with the *Challenger* around the world. But one peculiar species [*16*], which was fascinating to me, is the one looking very much like the little Chinese ivory things you find in antique shops – where you have a ball inside a ball inside another ball. It's probably cheap labor involved here, because it must take some guy all his life to make one, unless they have a machine now. But it's kind of a prodigy, to see in a sphere another sphere and so forth. I mean there is something that really puzzles you. We are confronted with something full of meaning. Why should there be this kind of recurrence of form? It may be too obvious, but after all this may be the way standardization started, the importance of repeating something. And this principle is what in our jargon we call automorphism: some kind of geometric assemblage of forms which go into one another, repeating themselves. Of course nature does not simply repeat herself, and we have to be careful not to confuse the little object which we see and can touch or hold in our hands with form; as Eddington said, there can be no confusion between natural and man-made objects, because what man makes is usually single-purposed, whereas nature is capable of fulfilling many requirements, not always clear to our mind.

It was, you know, by chance that I came to be working with experimental structures. There was a long way to go, really, because I was not exactly young when I started that. I was in Nantes working for a liquid-air company, around nineteen thirty – fifteen years in an office, phut, just like a grocer, selling – and I saw some truck in the street unloading sheets of corrugated metal. This material had some unknown quality about it, like the fluting of ancient columns, and I got hold of some and even made a kind of furniture. Very humble stuff, this material, but I was absolutely fascinated with the corrugation. It took me quite a long time to understand why. Well now I can see it's this same repetition of form – this kind of sine curve which goes on endlessly, which repeats itself. It has some physical properties that are quite interesting, by the way. One of these is to deal in a fairly good way with rain water, and this is probably why it has been used for roofing material. But as you know, corrugation is a very wonderful way to increase moment of inertia; you can see that undulated cardboard is infinitely more stiff than plain cardboard. This could appear as a digression, but at least for me, the properties which arise from this configuration made of undulation have been related with the texture of all my life. I have no blackboard here, and even if I did I'm not sure I could express myself, but it is a certain form of symmetry, a property of certain imaginary configurations which we say are opposed. You have no better example than your two hands. They are really opposed; you can't superimpose one over the other. You see some kind of cycle.

Whatever it is, when you look at these things, it's very hard for me to explain, but you see some kind of coherence and a purity of design which is amazing, which is frightening. From the point of view of the radiolarian, the geodesic dome is three hundred million years old. We have been speaking about space frames for twenty-five or thirty years, and nature has been there for three hundred million. So what? Well, it's not by chance, and I'm glad that I saw the Radiolaria before I saw Mr Fuller's dome. So I started to play around with these things, during the years counting the number of bars, counting the angles, and so forth. There's delight in this. You learn something. Even if you learn that what you think is not true, even if you make the wrong conclusion, the landscape that has been before your eyes is great. Of course you can't just convert these things into building structures, but there is much to admire and understand. You know, there is something rather tragic and sordid in man – as soon as he puts his fingers on something, he wants to take it. We should fight against this kind of possessive behavior. Why should the Radiolaria help us to make money? They don't care. Hell, they are not our servants. Yet there's always this tendency for people to jump into some kind of trick, a quick way to success and reputation. No-no-no, you have to be patient to understand, infinite patience. And besides as soon as you use things, they cease to be art things. They become a little vulgar, tools.

But well, it's a little of both. You see, I'm not that pragmatic. I enjoy its mystery too. Maybe the radiolarian will give you some analogy to help you resolve some particular problem, but I think it's not so important to arrive at a particular solution as it is to get some general view of the whole damn thing, which leaves you guessing.

16. Drawing of radiolarians, by Ernst Haeckel

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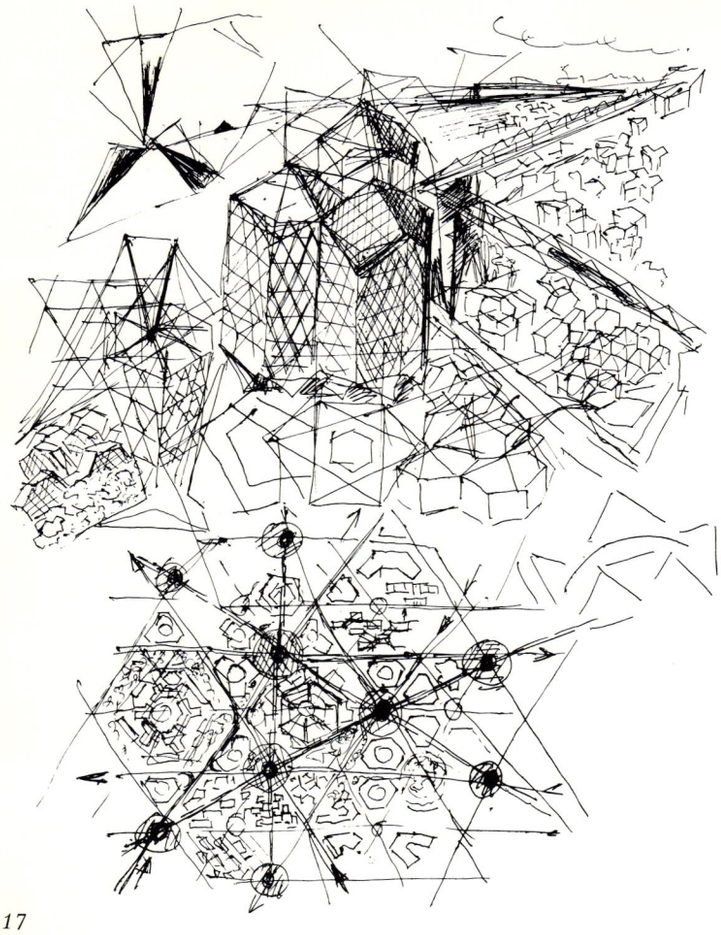
[*In the following, Mr Le Ricolais's comments on some of his works*]

17–24. Sketches of triaxial networks for urban circulation and Skyrail structures for aerial mass-transit, 1962–68

It is somehow surprising how much is known about the flow of gases, fluids, and electrons and how little about the circulation of human beings. We now have simply the increase in number of cars and streets, which are devastating our urban space and making the human condition a hazardous enterprise, but we are surely coming to some kind of limit. Because even if Detroit can supply every American family with two or three cars of rather immodest dimensions, you know that all the richness in the world cannot create an additional square inch of two-dimensional space, and it will be no joke to see what the future brings; any Metro strike in Paris gives a preview of an inhuman situation, when they are driving on the sidewalks and so forth. Of course on the other side, the automobile and road-building people look askance at any proposal to divert traffic from highways to mass transit, probably because they know very well that with railway systems you can handle 60,000 passengers per hour on a single line, which is equivalent to the maximum performance of a 20-lane highway.

I don't think we've ever faced this terrifying problem of number, although maybe we have learned to follow some schedule and do things in our lives by numbers – you can see that this has been a great principle in America. I believe it was here that I went to a cafeteria for the first time. You have been brought up with this, so you don't really notice a cafeteria, but the notion is diametrically opposed to the notion of a French restaurant, where you could remain for four hours, where you had plenty of personnel to bring you a flask of wine, and things like this. Nobody was waiting and there was always enough room for you. But you see how admirable this cafeteria business is in terms of circulation. Whir-whir, nobody stops. When somebody's off the line and stopped because the peas are not the same color as he likes them, at this moment thirty people are getting nervous. I'd like to think that what we lose in quality we gain somewhere else, but no doubt we are coming to an age where number and time will change all process.

It may take some time before we reach a general understanding of these new dimensions. Indeed, just to define the basic terms has become a real struggle, because we are everywhere finding doubt and uncertainty behind the appearance of common sense. For instance, there is the curious analogy made by some mathematicians, describing space as a moving flock of browsing sheep surrounded by alert dogs. Space is surely something more than what is put into it, and the richest



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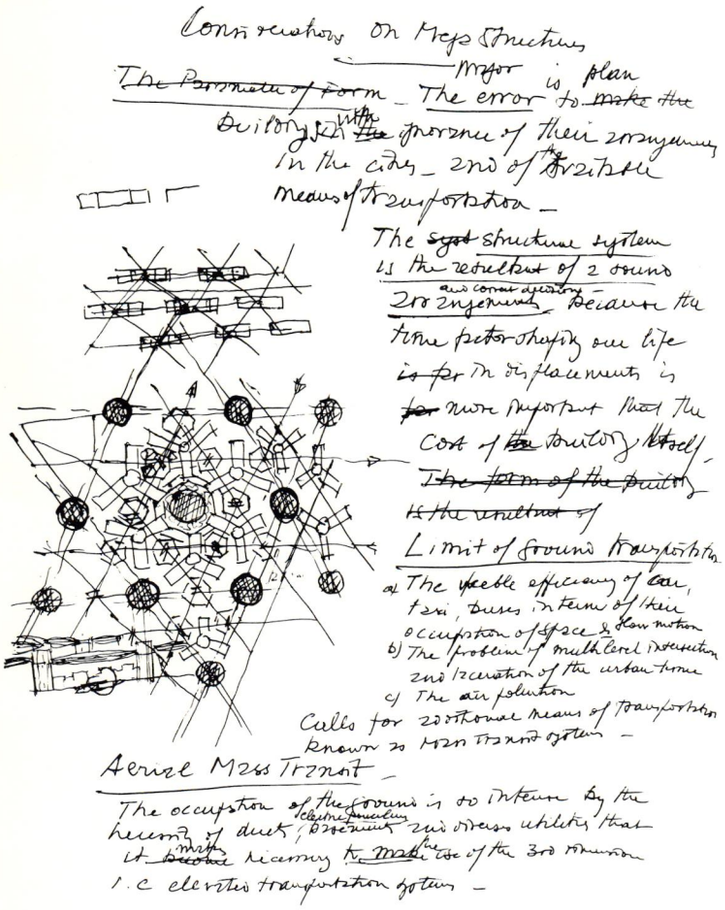
Consideration on Mega Structures
The Parameter of Form _ The error is plan to make the
building with the ignorance of their arrangements
in the cities _ and of the available
means of transportation _
The structural system
is the resultant of a sound
arrangement and correct decisions _ Because the
time factor shaping our life
in displacements is
more important that the
cost of building itself _
Limit of ground transportation
a) The feeble efficiency of car,
taxi, buses in terms of their
occupation of space & slow motion
b) The problem of multilevel intersection
and laceration of the urban home
c) The air pollution
Calls for additional means of transportation
known as mass transit systems _
Aerial Mass Transit _
The occupation of the ground is so intense by the
necessity of ducts, electric pencilings, basements and diverses utilities that
it makes necessary to make the use of the 3rd dimension
i.e elevated transportation systems _

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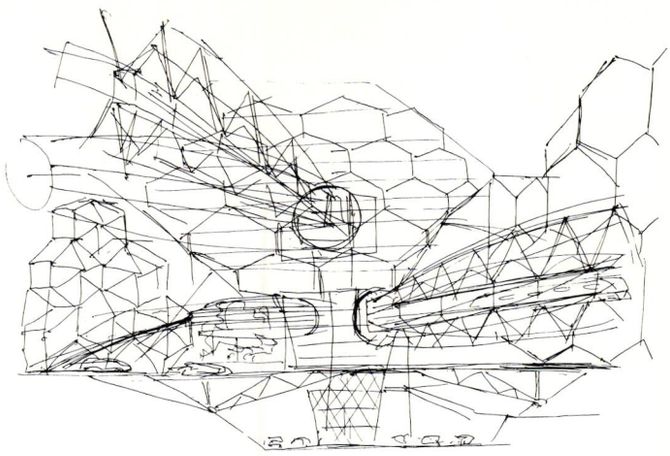

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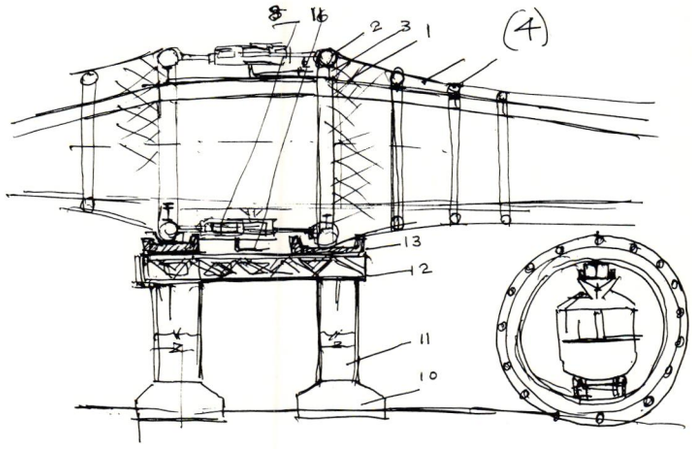
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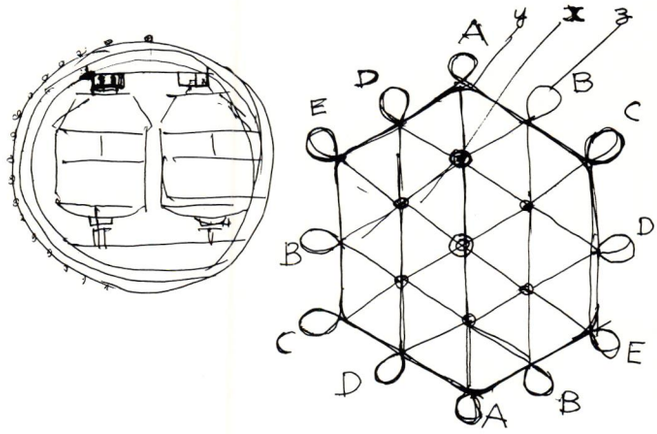
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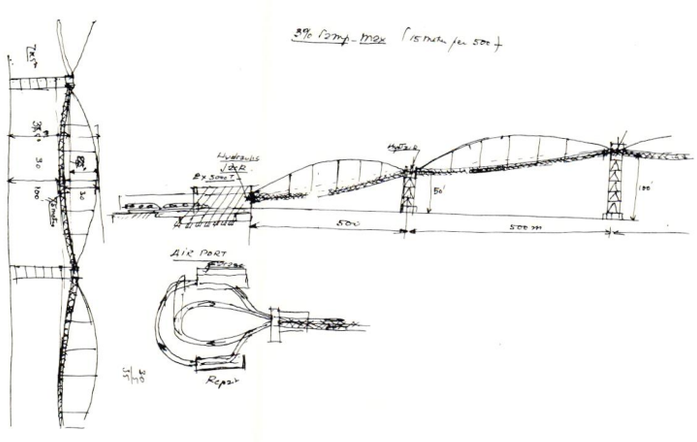
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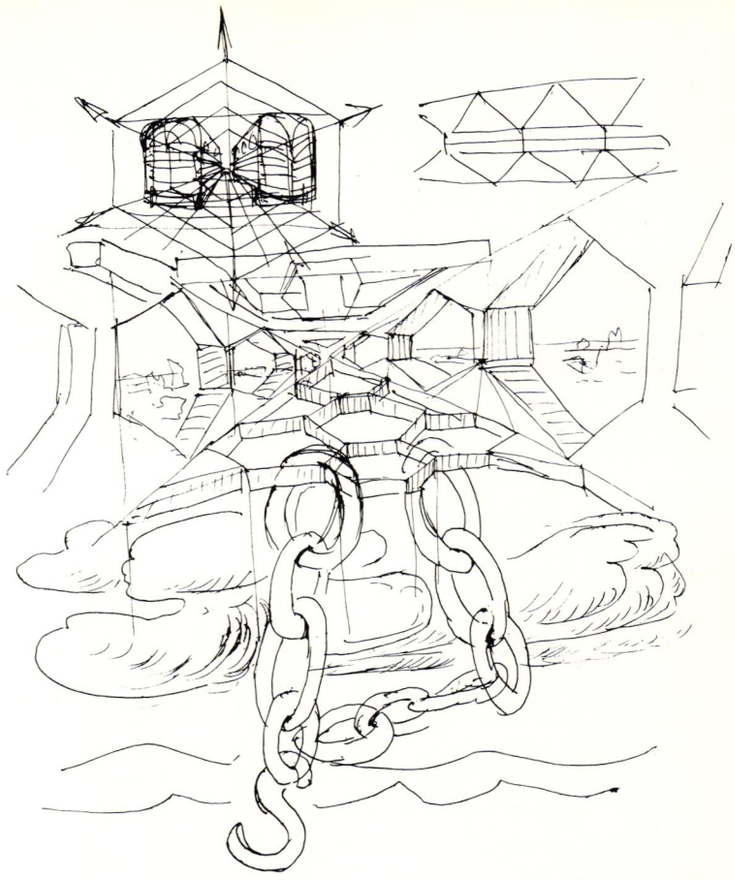
space is not necessarily the one into which you put the greatest number of things or beings, but a space in which something happens, where there will be the greatest number of possible relationships between them. Maybe, too, our notion of static, crystallized form is often an illusion given by our defective senses. I mean we no longer have the plaza of ancient Rome for our forum, but some kind of nervous system enabling people to come in contact with others and get to their business in the shortest and fastest way. And now that our movements are increasing even faster than the growth of population, probably due to the intensive specialization of functions, our future objective may not be at all how to structure buildings, but how to structure circulations – this flow of movements made by hundreds of thousands of inhabitants and vehicles.

We need more efficient systems for this intercommunication of urban space, and a prerequisite will be some better arrangement of potential routes, with a minimum number of intersections. That is why we thought the Starhex network [*17, 18*] would be a quite good theoretical pattern to consider: compared with an orthogonal grid over an equivalent area, the length of streets between intersections being equal, some simple calculation shows that the Starhex network has at least 13.5 percent fewer intersections, that the combined length of streets would be shorter by at least 13.5 percent, and that the average route would be about 12 percent shorter. (A network of all hexagons or all triangles may be even more efficient in some ways, but you would lose either straight-line movement or reasonably simple intersections.) The triaxial distribution of the Starhex network also gives a much richer combinatorial potentiality than orthogonal distribution. In fact it corresponds to the introduction of a new alphabet – not only producing new sounds but also allowing a given message to be conveyed in a much shorter time; this reflects a law of cybernetics, that the length of a message is inversely proportional to the logarithm of the number of signs in the code being used, resulting in the apparent paradox that the more ways there are, the less we have to use them.

Of course once you have all circulation taking place in the same plane, you see how complex it becomes, with the many possible points of impact at any intersection. We use the underpass and overpass and so on, we can move in a fairly efficient way, and yet think of the Paris Metro, without which life in that city would be impossible. It was thought through more than seventy years ago, but what a deep perception there of the problem, which is how to avoid intersection. And what a sense of order they had, because when you look at a map you see that all stations are practically the same distance from each other, about 1,600 feet. This is planning – believe me, when they did that they did not know the number of cars which we have today. It was a highly dubious enterprise, and now if you want to understand the Metro in Paris, you have to be there when there is a strike . . . your mind can hardly see the number of people who use it. Unfortunately, building a transit system in the bowels of the earth today, you would have insurmountable problems getting around the endless networks of pipes and wires and foundations. The ground surface also is totally occupied, by buildings and streets. So the alternative we have considered is an aerial system of mass transit, superimposed on the city. This is not to suggest a return to the elevated railways of the past, because those were really not too different from the surface systems: they followed the gridiron of streets, hardly leaving the ground, and operated on single lines, which takes no advantage of the value of interchanges. The Skyrail system we have proposed would consist of a Starhex network of aerial bridges spanning about 1,600 feet between interchange stations. These stations would be incorporated into buildings 30 to 40 stories high, and each one would connect two lines with banks of elevators and escalators leading to 300-foot platforms, where trains would arrive every 90 seconds. Undoubtedly, the station-towers would cost a great deal more than the bridges connecting them, but



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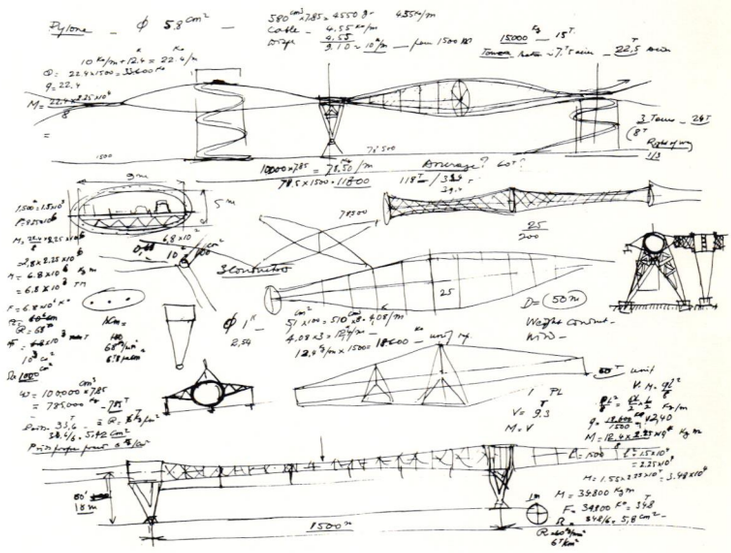

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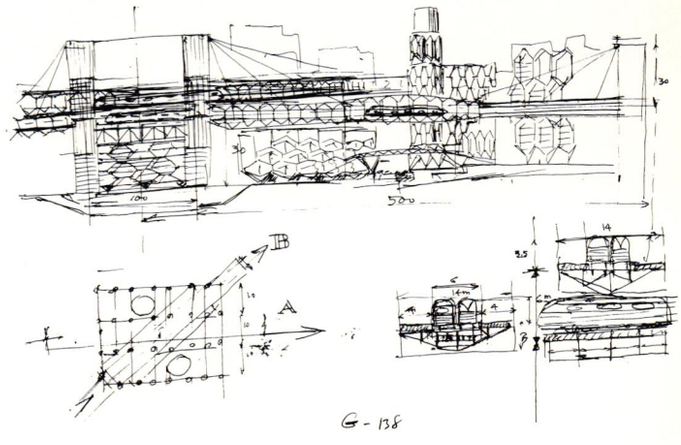

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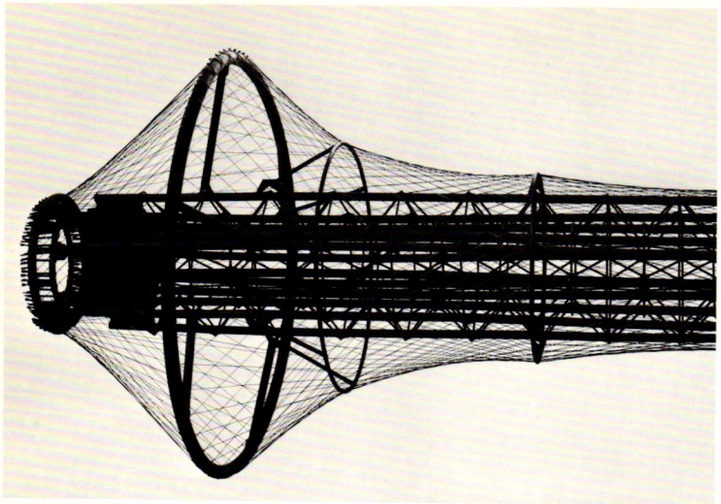

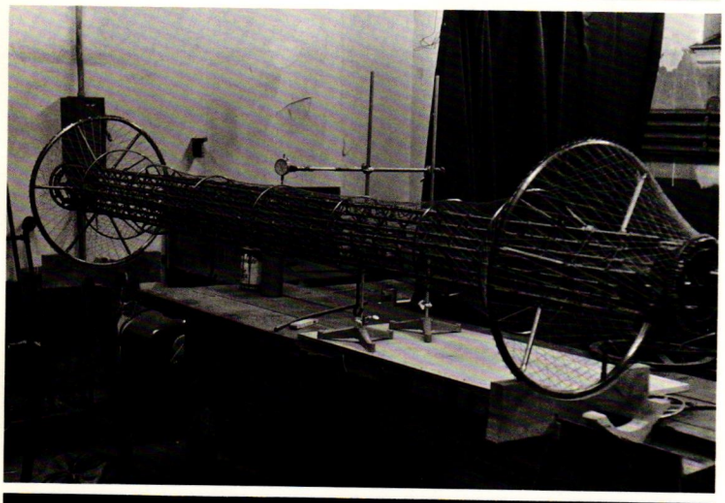

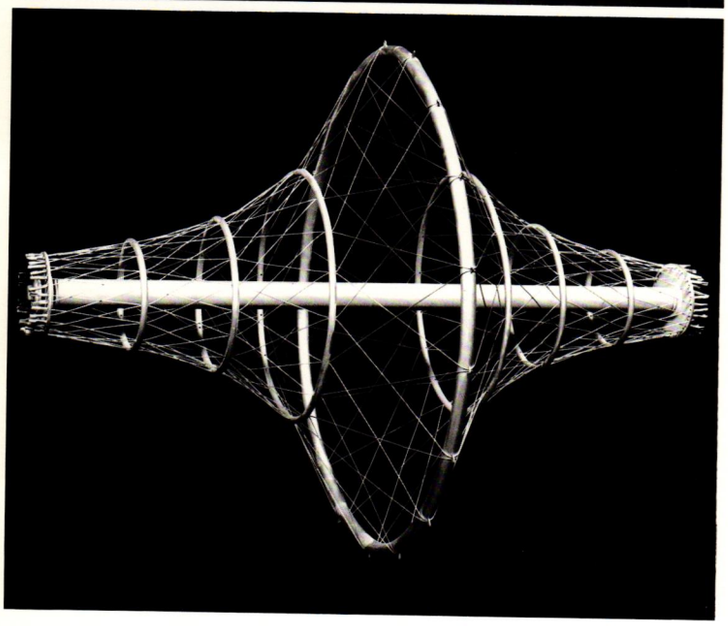

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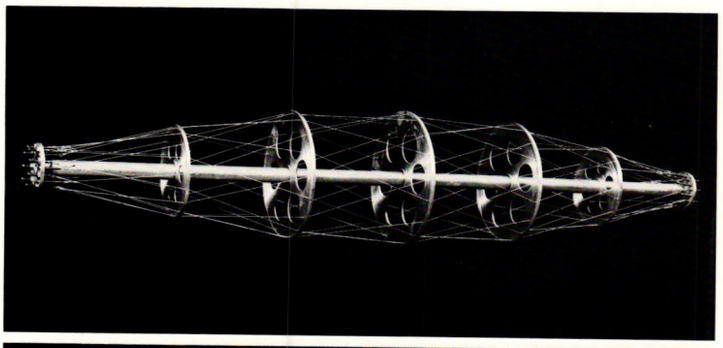
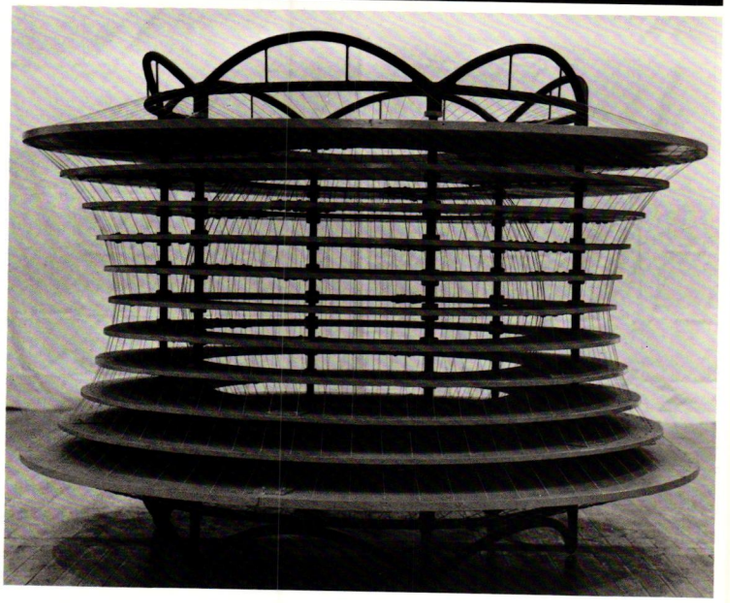






they could provide a lot of useful floor-space for the city, as some kind of focus for dense occupation, and the construction of such a system would not be taking miles of valuable urban land for just pavement.

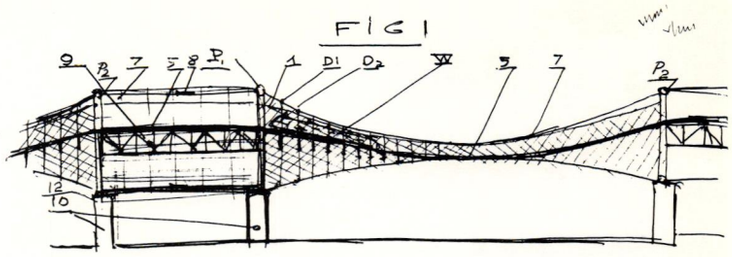
Like most theoretical proposals, this may appear to be verging on utopia. And really my interest is less directed toward an immediate application than toward some more imaginative solutions than those we are accustomed to see, whether in existing cities or 'new towns'. One can't take lightly the complex internal life of a city, which is why it would be foolish to propose a Skyrail three hundred feet in the air as any kind of exclusive system for urban transit. I mean I don't think it's rubbish, but it may be premature; we just don't know enough, and I wish a model could be made, because I'm sure it would help us detect what is wrong and what is going to take place, what combinations of different grids would work . . . However, if I am inclined to think about systems suspended in the air, it's not because they are in fashion today, but because I believe we already have the means to undertake such projects, without minimizing the considerable study and resources which would have to be invested. It seems also that there would be some extremely exciting value in superimposing on the rather confused tissue of an existing metropolis an order directed toward integration, to counter the kind of dislocation created by highways such as you see in Los Angeles. With a system of elevated transit, we could perhaps open up a new, or lost, dimension – the aerial view of the city, the city being seen as a whole without losing the feeling of orientation. The form of a city is too important to be lost in subterranean traffic or even seen from the limited vistas of corridor-streets.

25, 26. Model of an FPR (funicular polygon of revolution) bridge for the Skyrail, 132 inches in length with a diameter varying from 8 and 1/2 inches to 24 inches (scale, 1:100), made of steel tubes of 1/2-inch diameter and rods of 1/8-inch diameter for the axial compression member, tubes of 1/4-inch, 1/2-inch, and 3/4-inch diameters for the diaphragm rings, and aircraft cable of 1/32-inch diameter for the tension network, 1961–62

The idea of the FPR system was to see how we could weave cables and generate a tension network following a minimal surface, by rotating funicular strings around circular diaphragms and connecting the tension network to an axial compression member. From some topological considerations, we were interested in developing two basic notions: the high redundancy yielded by the degree of connectivity of the compression system, and the chain action of the cables, acting as bundles of fibers. At this moment, we had been working on the idea of an automorphic compression tube – what would be the ideal column – but we had no device to test it since the model was too long. So I thought it would be fun to kill two birds with one stone. Since the FPR network involved a force of several tons in the tensioning, we used this to put some pressure on our tube, to see what would happen. I was optimistic, saying we would get a much stiffer structure with the combination of tube and network. But no, the model didn't work – you see how everything you meet has its own contradictions; our hopes were just defeated. We were working at such a scale that the stiffness of the tube itself was too great and the network meant practically nothing to the structure. But if the model were ten times longer, the story would change; you'd begin to see that the cables have a contribution to make.

27–30. Various FPR models, 1960–62

31–33. Sketches of a Tension-Net bridge for the Skyrail, and a preliminary model, 158 inches in length with a diameter varying from 6 inches to 12 inches, made of steel tubes of 1/2-inch diameter for the diaphragm rings and aircraft cable of 1/16-inch diameter for the tension network, 1962–63



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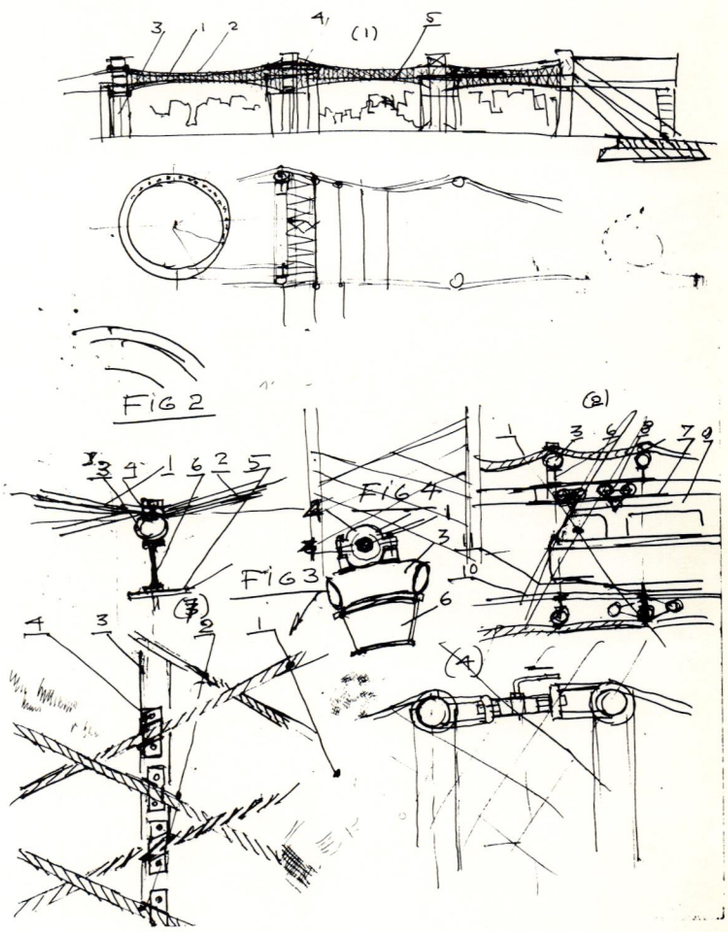

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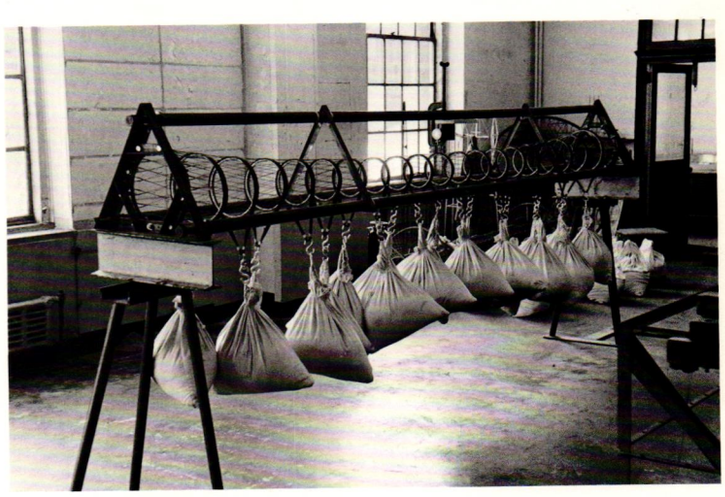

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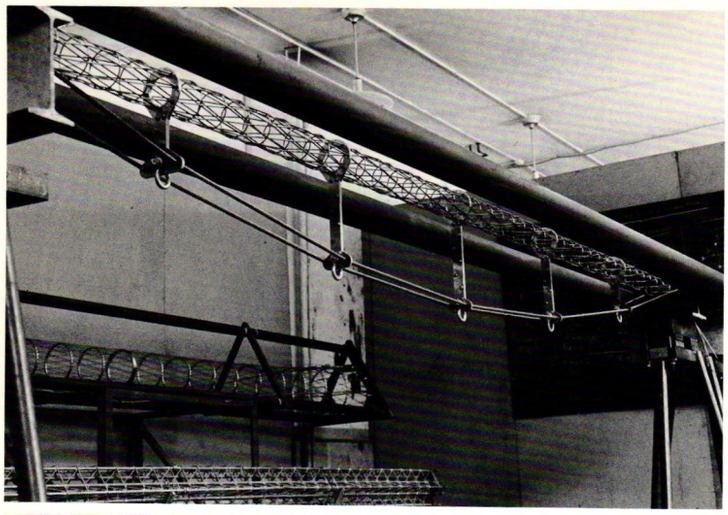

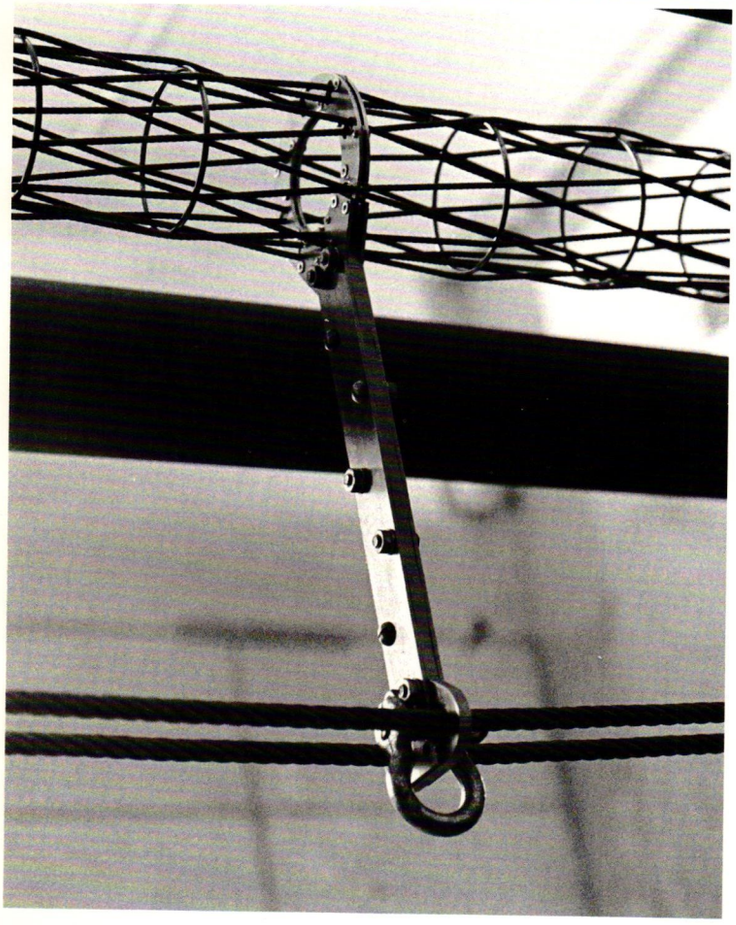

34, 35. Model of a parabolic Tension-Net bridge for the Skyrail, 186 inches in length with a tube diameter of 3 and 1/2 inches (scale, 1:100), made of steel plates of 3/32-inch and 1/4-inch thicknesses for the struts, rods of 3/16-inch diameter for the diaphragm rings, and aircraft cable of 1/8-inch diameter for the tension network and of 3/8-inch diameter for the bottom-chord cables, 1964–65

36. A Tension-Net tube, 47 inches in length with a maximum diameter of 7 inches, made of steel tubes of 3/8-inch diameter for the diaphragm rings and aircraft cable of 1/32-inch diameter for the tension network and coated with fiber glass and epoxy, 1964–65

The use of high-tensile steel cables suggested the potential capacity of plastics to take compressive forces balancing the cable tension – the object of this combination being not so much to improve plastics as to develop the full potential of steel cable with a lightweight material used in compression, generally in the form of stressed-skin structures. After the coating of fiber glass and epoxy had set, we removed the tube from the external compression-frame and tested it in bending; for such a light element, with a wall thickness of less than 3/32 of an inch, it showed remarkable stiffness, as did several tension-grid panels which we coated in a similar way.

37, 38. Model of a double-parabolic Tension-Net bridge for the Skyrail, 186 inches in length with a tube diameter of 2 and 7/8 inches (scale, 1:100), made of steel rods of 3/8-inch diameter for the struts, rods of 3/16-inch and 5/16-inch diameters for the diaphragm rings, and piano wire of 1/16-inch diameter for the tension network, 1965–66

As you can see [*34, 38*], the models represent only single spans of a transit line and were built and tested on an external compression-frame, with a tensile force of about 10 tons produced by a hydraulic jack mounted at one end. But except for the struts, introduced to increase stiffness, and the diaphragms to maintain the tensioned tubular section and support the suspended rails, this system of bridges would not require compression members, because the tensile forces of each span would be balanced by the tension in adjacent spans, the ultimate forces being absorbed at the ends of the line in suburbia.

With these Tension-Net tubes, we have been trying to find the way to make a hollow rope. Of course that is a figure of speech, but my mind is obsessed by the idea of going inside a rope. Who knows a better structure than a rope? – and if you can make a rope on a bigger scale with nothing inside, it works as if the material were in an extremely thin sheet. But it will be easier to manipulate than sheet metal, and it won't buckle, because it's tensioned. Experimentally it works; I mean in terms of a purely theoretical ideal, it's an answer for bridge design. That doesn't mean these bridges are going to exist tomorrow, because you can see that you have to really pull this long rope to keep it straight – the force you would have to sustain for a convoy of 250 tons is something like 15,000 tons. It would involve some fantastic forces at the anchorages, and since the structure is somewhat flexible, you may also have some severe dynamic actions.

The notion of fiber, or a linear succession of strongly connected grains of matter, has played an important role in the science of strength of materials, and the technology of ropes and cables and their structural configurations in itself represents an enormous accumulation of ingenuity. Perhaps conveniently, under the pressure of requirements for new types of building, we have seen in our century the tendency to extrapolate a given quantity of matter into two dimensions, or in other words to have materials and structures working in more than one way. Yet crisscrossing materials was certainly among the first rewarding enterprises of primitive man – as in basketry and clothing – and far-reaching through its mental assimilation, since such experience showed

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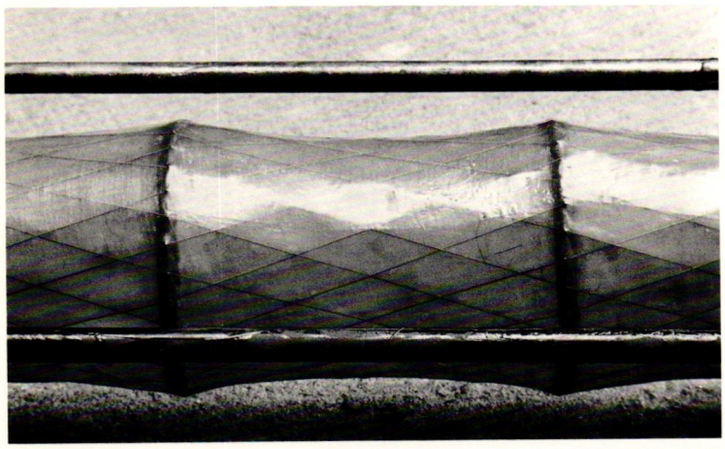
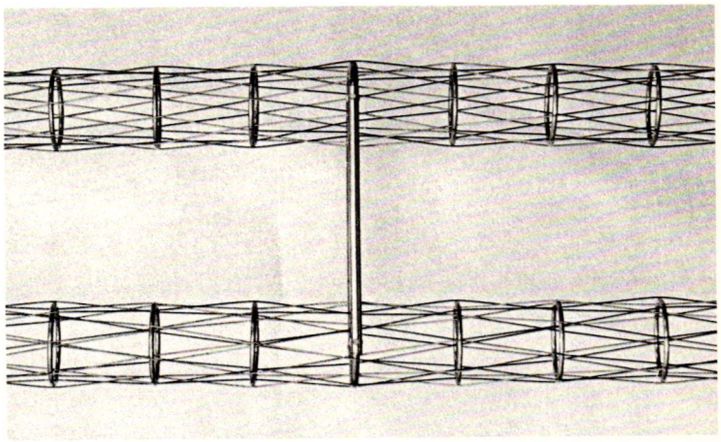
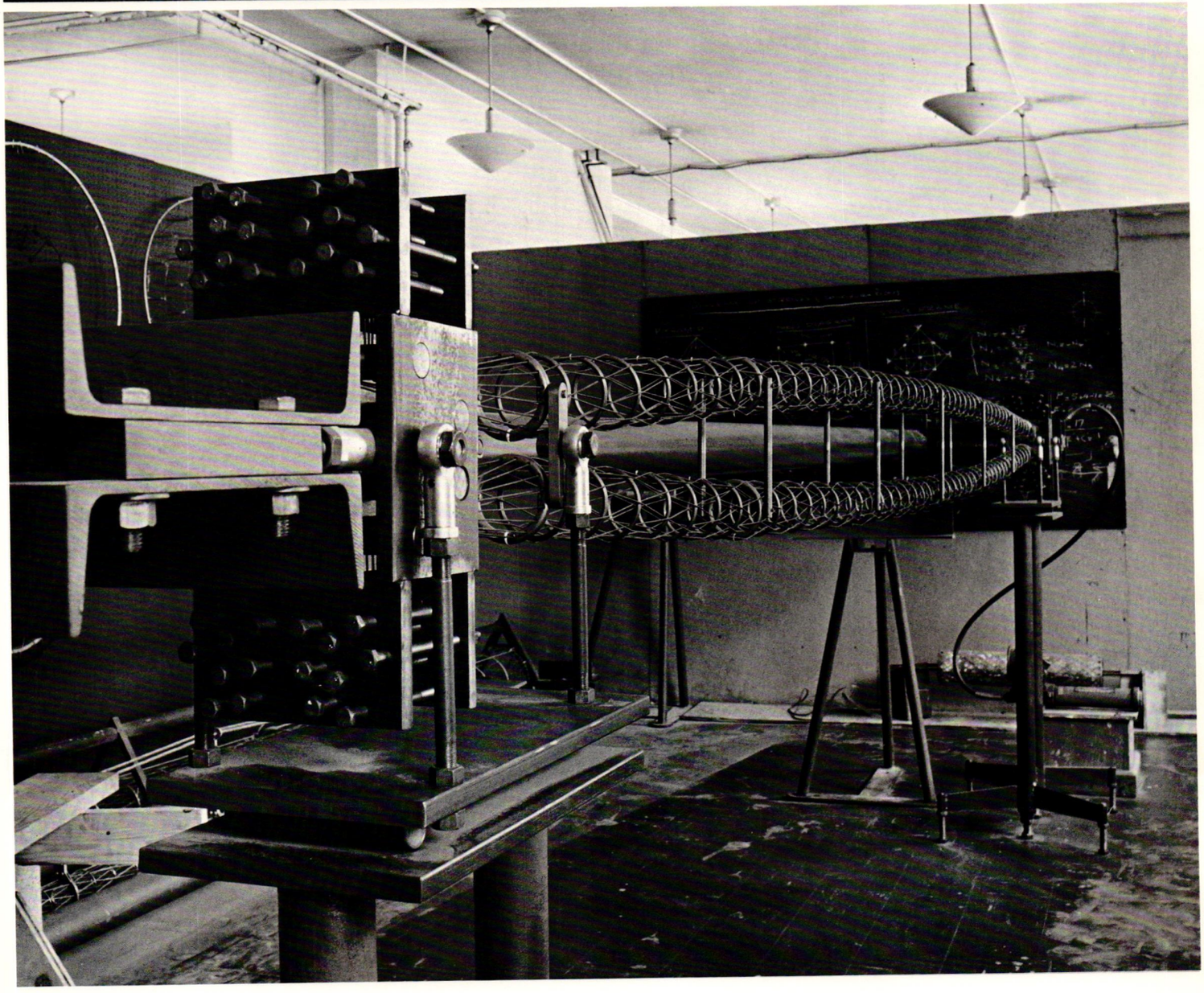


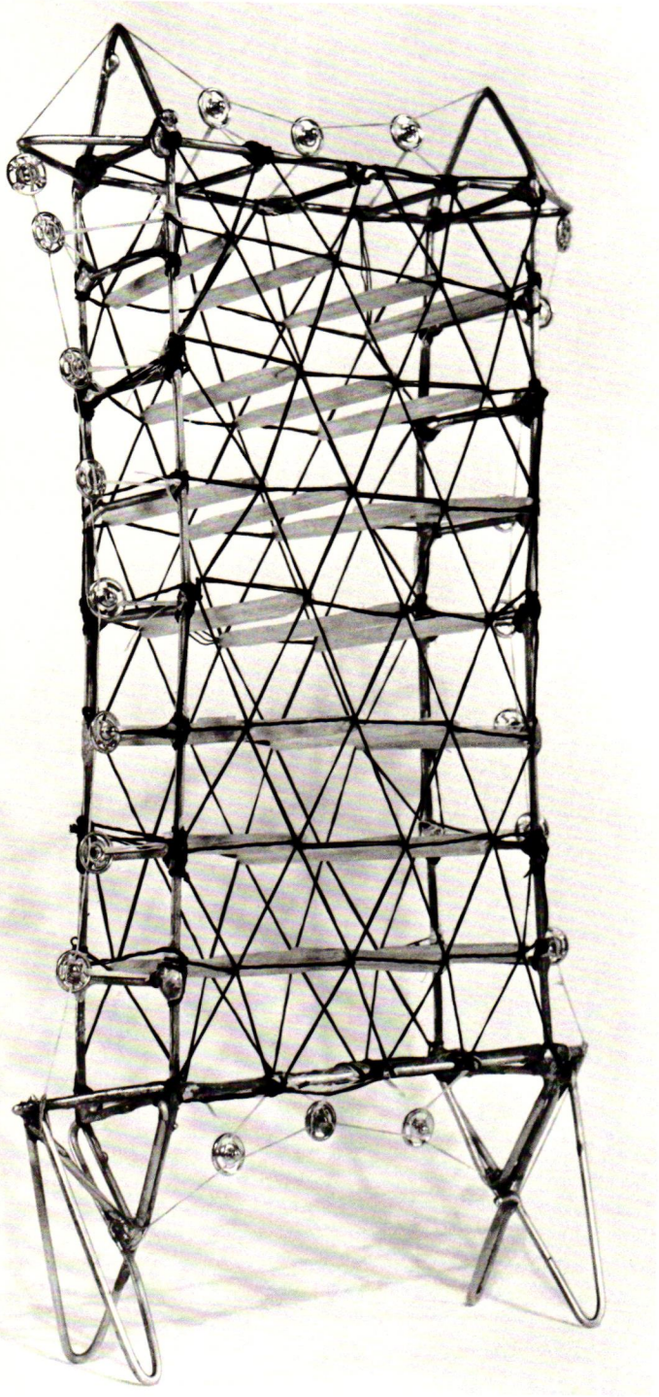




how to establish connections between the first and the second dimension; a particularity of this kind is enough to introduce a hairline between two degrees of civilization. . . . Speaking very generally, we could say that a great age has begun. And among our predecessors Freyssinet should be remembered, for he proved, around 1928, I think, that the introduction of forces into systems can increase the strength of materials. To increase strength is to reduce weight, the worst enemy of the engineer. To me, even greater than the practical results is the beautiful and pure notion that forces of an abstract nature could be a substitute for concrete and ponderous materials.

39. A student's Tension-Net construction ('a little outrageous, perhaps, but it's better than Brasília'), 9 inches in height, made of bronze welding-rod, matchsticks, thread, and clothing snaps, 1961–62

40, 41. Model of a double-parabolic Trihex bridge for the Skyrail, 80 inches in length with a maximum depth of 14 inches and width of 4 inches (scale, 1:200), made of steel rods of 1/8-inch diameter and aircraft cable of 3/32-inch diameter, 1967–68

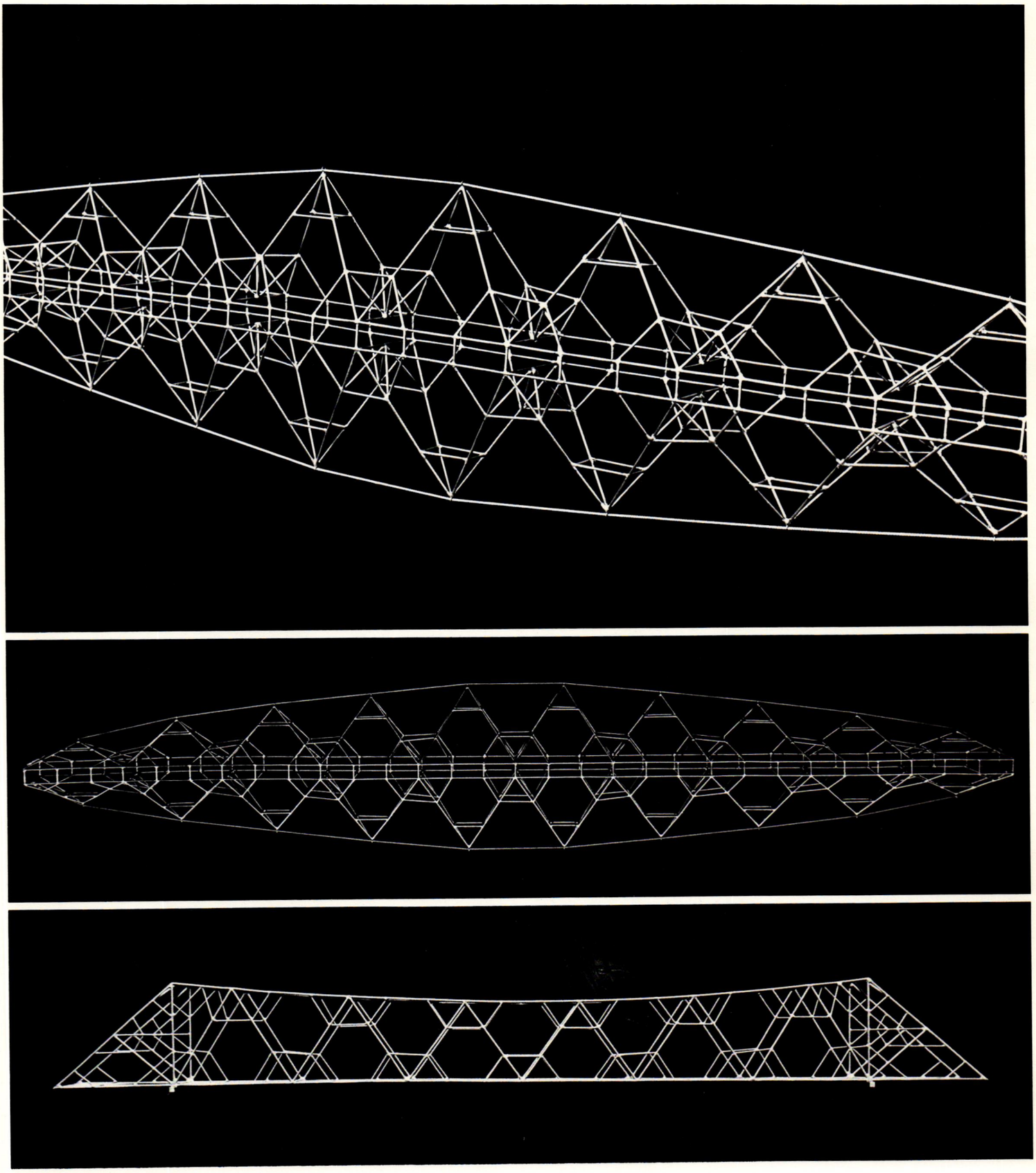


The tragedy of pure tension structures is elongation – as soon as you get to big dimensions, you have something that can expand and distort. Moreover, a Skyrail system based on a continuity of tension between spans has the drawback of being restricted to absolutely straight lines. It may be more convenient to locate stations on a more flexible path. So we went back to a less efficient structure in terms of weight, but a system easier to construct and of a more classical character; the bridge becomes a self-contained body, with no structural connection between adjacent spans required, and yet of an efficient nature due to the generalized use of high-tensile steel for the top and bottom chords. With the application of Trihex partitioning, reducing the buckling length of the compression members by two-thirds, this results in a very light space-lattice structure, capable of resisting large bending moments.

At full scale, the distance between apices would be about 80 feet, or a total of 20 bays of opposed pyramids over the 1,600-foot span. Under maximum loading – two convoys of 250 tons each at midspan – the cable elongation would be about 16 inches, yielding a deflection of 20 feet. Such deflection would be incompatible with more rigid systems, where strength is equated with stiffness, because it would create high secondary stresses in the compression members. But here, the top and bottom cables sliding on rollers at each apex would allow the lattice to work under nearly constant conditions. The controlled deflection could even provide trains with a certain amount of acceleration on leaving one station and deceleration on entering the next; a sag of 20 feet would give a rolling train a velocity of 25 miles per hour at midspan, and this convenience should result in an economical power system, both in terms of weight and kilowatts.

42. Model of a Trihex bridge, 47 inches in length with a maximum depth of 5 inches and a width of 5 inches (scale, 1:100), made of steel rods of 3/32-inch and 1/8-inch diameters, 1967–68

In this case we were concerned with obtaining stiffness, to see what contribution could be made by the redundancy of Trihex partitioning. The basic Trihex truss is a Warren truss where we have substituted bitriangulated elements for the regular triangles. In several tests comparing a classical Warren truss with Trihex trusses of identical span, we found that under the same loading conditions the deflection of the Warren truss was about twice as great, which followed closely the theoretical result from the Image Method [*13*]. Taking the increase in weight from the bitriangulation into account – about 33 percent for a 5-panel truss – a Trihex truss of identical weight would still be about 30 percent stiffer.



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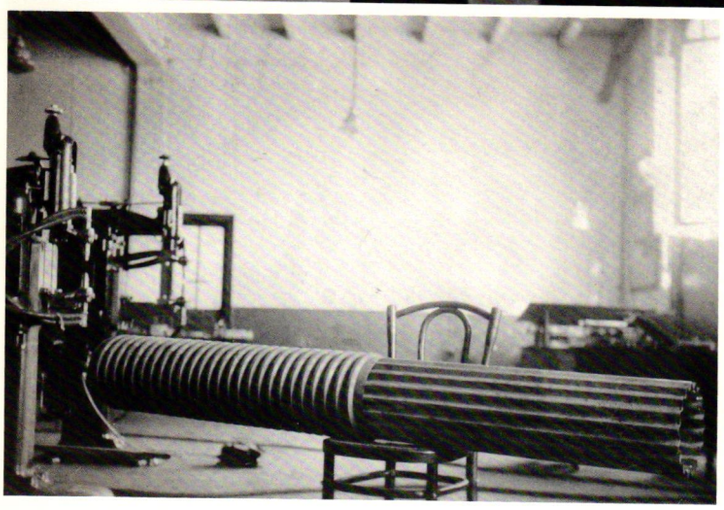

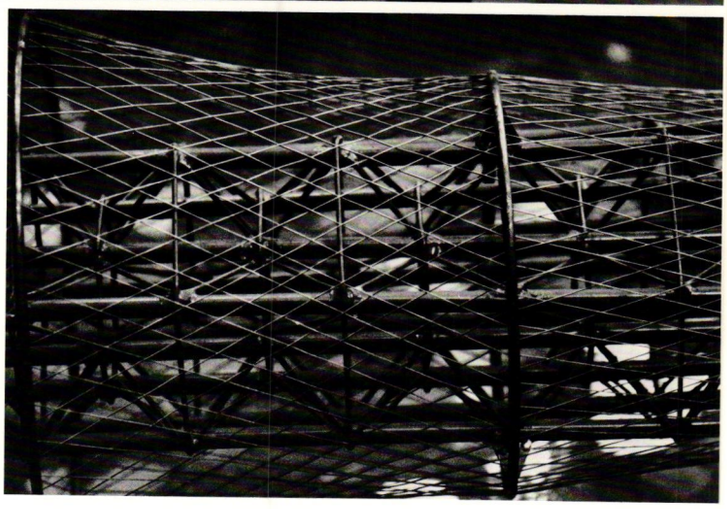

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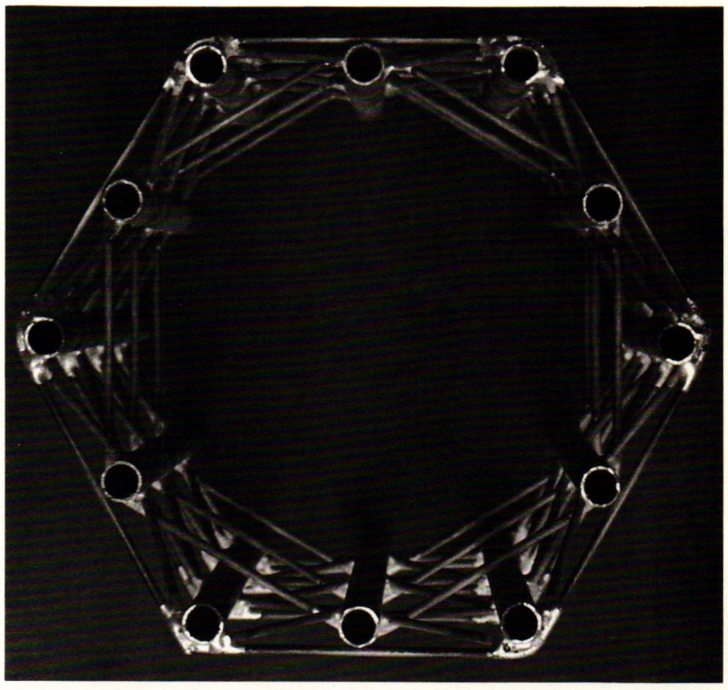
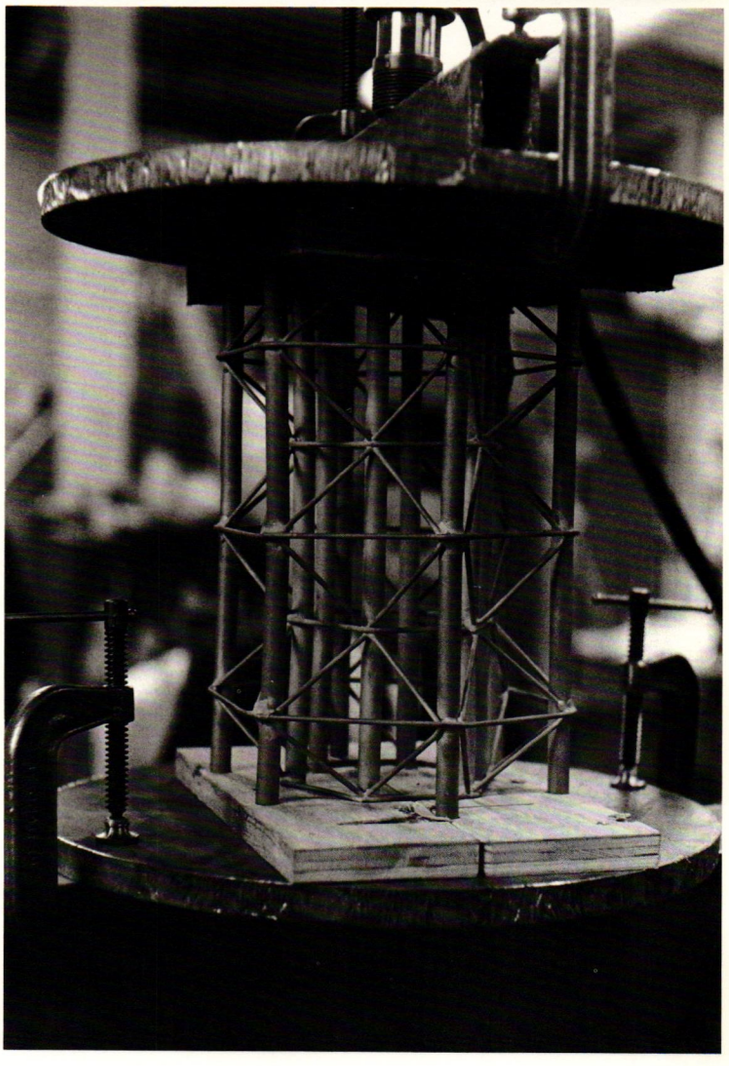
43, 44. Prototype Isoflex tubes, made of two corrugated steel cylinders of 1/50-inch wall thickness spot-welded at points of contact, 1937 46 47

45. Automorphic tube of FPR model shown in [25, 26]

46–48. T-12 Automorphic tubes, 9 inches in diameter, made of steel tubes of 1/2-inch diameter and 1/32-inch wall thickness and rods of 1/8-inch diameter, 1961–62

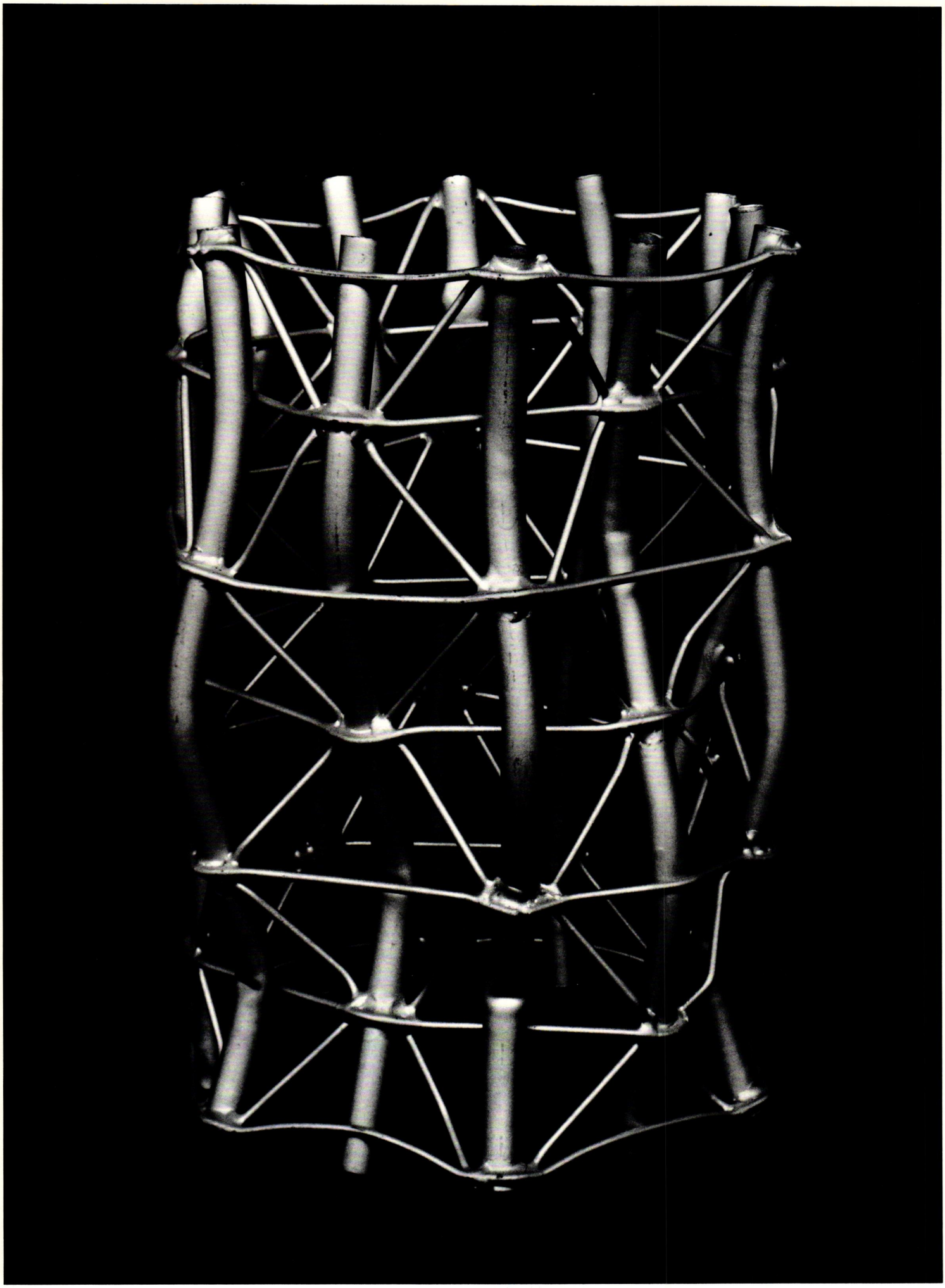




It seems that in the search for structures two opposed attitudes are possible: to start with a 'block' and work by means of excisions or, on the contrary, to start with a germinal cell in order to arrive at the definitive form by means of addition, as in some arrangement of repetitive elements. We took the first approach in the FPR system; we treated the structural dissymmetry between tension and compression not by following the conventional differentiation of alternating members, common in trusses, but by decomposing the whole structure into two groups acting massively and brought into equilibrium by tensioning. For the tension part of the structure, a network was substituted for separate cables, yielding a uniform distribution of material in space, distinguished from a continuous membrane only by holes: by virtue of the weaving, the forces in the individual cables would approach a statistical average and the fundamental vibrations would be replaced by their harmonics, a very favorable condition considering the problem of flutter in single-cable systems. For the diaphragm compression members, whose function was to maintain the undeformability of the network, the closed configuration of the torus gave the best use of material. But except when the great tensile forces can be annulled by anchorages, a straight internal tube would be the most economical solution for the main compression part of the structure.

So the inevitable counterpart of our work with tension networks was to investigate what might be the optimum form to give to an axial compression member of minimum weight. This problem was not without analogy to one we had about thirty-five years ago from the French navy – how to make some very rigid tubes for their optical telemetry devices; we had already done some work on the Isoflex system for various structural elements, based on superimposing sheets of corrugated metal crosswise, or even corrugated plywood [*1*], and thought this product would be equally advantageous in a tubular form. When finally compared with the plain tubes of 1/2-inch wall thickness used previously, the Isoflex tube [*43*] was not only lighter, but also considerably reduced vibrations, which were disastrous for the precision of their range finder. Then with the Automorphic tube, we tried to extend the notions of connectivity and repetitive form inherent in the Isoflex system to a triangulated structure, or in other words to find some kind of hybrid system between stressed-skin and triangulation.

From topology one can see that holes are a determinant for the classification of structures and that the number of holes in a structure, p, is related to its degree of connectivity, which is often indicated by the symbol h. The expression '$h - 1$', following Hilbert's definition, is the number of chains of edges that can be found on a given body that do not cut the surface in two, on the condition that the first chain is closed and that every subsequent chain connects two points lying on the preceding chains. Since all simple polyhedra are continuously deformable into spheres, they are simply-connected and thus have a connectivity number, or h, of 1. However with triangulated structures, we are no longer dealing with just polyhedra bounded by surfaces, because the faces become holes, giving an F of 0 in Euler's formula for simple polyhedra [*12*]. So we have to use a modified form of the equation, which works for polyhedra of any degree of connectivity, $F - E + V = 2 - 2p = 3 - h$. For example, by substituting for the solid tetrahedron a tetrahedral element made of 6 bars, we have 2 holes through the 2 pairs of faces and obtain an '$h - 1$' of 4 chains of edges.

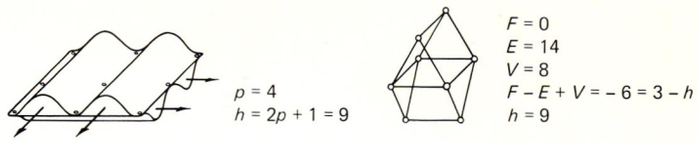


In terms of connectivity, then, it appears that the Isoflex system could be isomorphic with some kind of triangulated structure [*49*]; and we have some reason to suspect that the more chains you introduce into a structure, the greater will be its strength and rigidity. That is to say, the art of making an efficient structure lies in adequately distributing a maximum number of holes, connecting as rigidly as possible the chains surrounding the holes. I don't mean to suggest that the triangulated element is stronger than the solid, but that through higher degrees of connectivity it could lead to a lighter and more efficient structure.

Among the possible motifs for such a partition of space, it was natural that some automorphic system like those we had seen many times in the graphic analysis of three-dimensional structures would come to mind. I'm sure you've seen this kind of thing before, when during the course of a telephone conversation, for example, your hand mechanically draws triangles inscribed in triangles. These elementary diagrams are intriguing in that they express very well a phenomenon of discontinuous growth related to a continuous curve, that is, the logarithmic spiral. More precisely, a configuration is said to be automorphic when it reproduces itself by a permutation of its lines and points in such a way that no incidence is lost and no new incidence gained; we should also note that, for unbounded configurations, to an automorphism of structure will correspond an automorphic diagram of forces.

In a three-dimensional structure composed of bars, automorphism would mean repetitive joints of identical incidence, or reproducing the same number of branches per joint. But as simple as the principle might appear, its application requires a certain amount of judgment because of the multiplicity of possible combinations with any given number of branches per joint. Really what we've been trying to do with many of these Automorphic structures is to work with determinate systems and then find where you can use more bars, working up to indeterminate systems which are still economical. Redundancy has great power – by a somewhat curious paradox, it is often the indeterminate structure which is the more easily conceived and sometimes the more easily built. But you have to learn how to do it; we don't want to add weight unless we can get at least an equivalent increase in strength.

After a time we had a big collection of Automorphic tubes, having varied the number and position of the bars and tubes, and we wanted to test these in bending, in order to get some idea of their moment of inertia, and also to see the pattern of failure under axial compressive forces. For the latter, a hydraulic jack was used to apply a force of about 18 tons; many of the tubes showed erratic buckling, but one combination of tetrahedra and square-based pyramids gave a rather interesting performance [*48, opposite*]. It's quite a good belly dance. You see, the buckling length was broken into its harmonics, with a wavelength of 9 inches, or twice the distance between nodes. The inner bundle of tubes tended toward a convex curvature while the outer one took a concave curvature of greater radius, showing that for an even distribution of stresses between the two layers their neutral axis should be slightly displaced toward the periphery. But this harmonic buckling allows the maximum area of the section to work in compression, with failure occurring at the elastic limit of the material, and compared with a plain tube of similar weight and diameter, the T-12 tube could withstand about 25 percent greater axial forces. A conclusion of perhaps purely epistemological value would be that the order of destruction of a system should follow the order of its construction.



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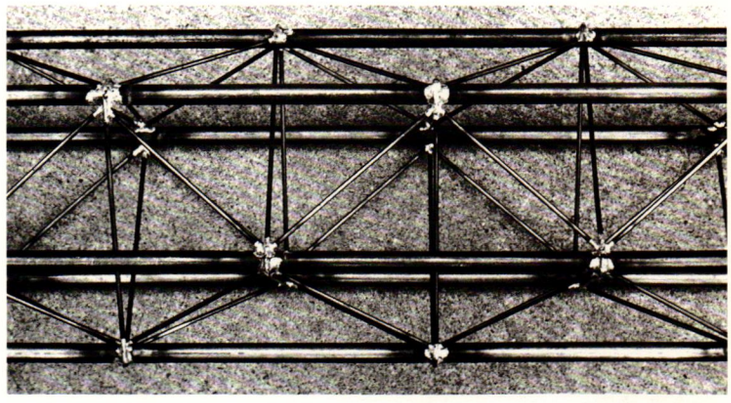

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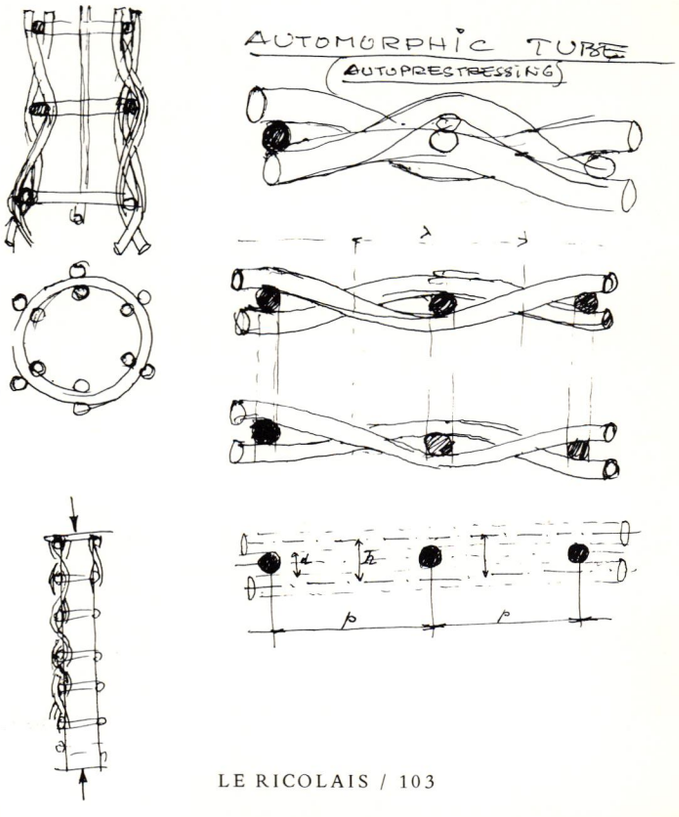

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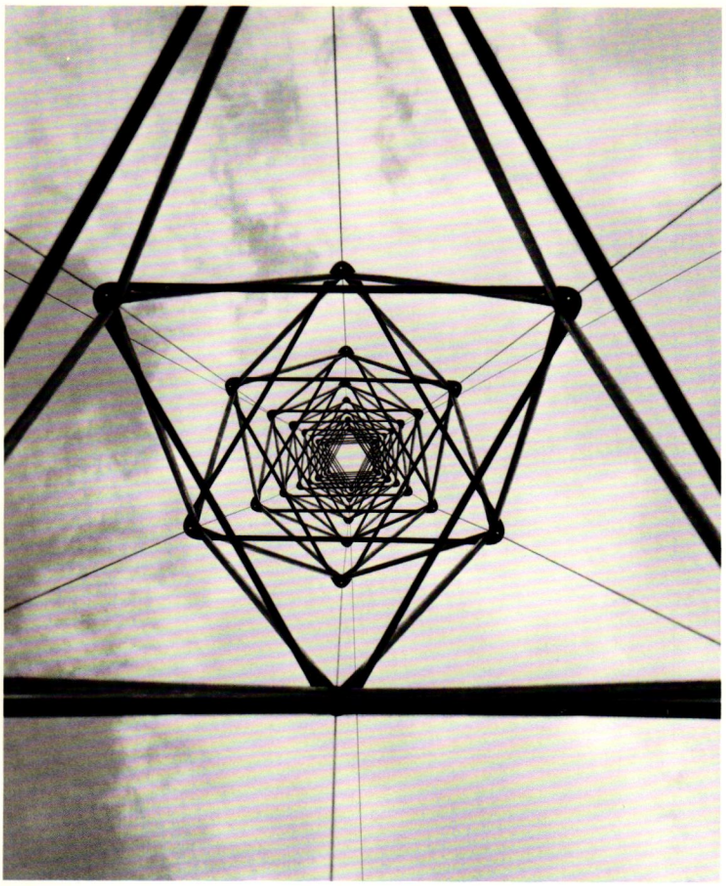
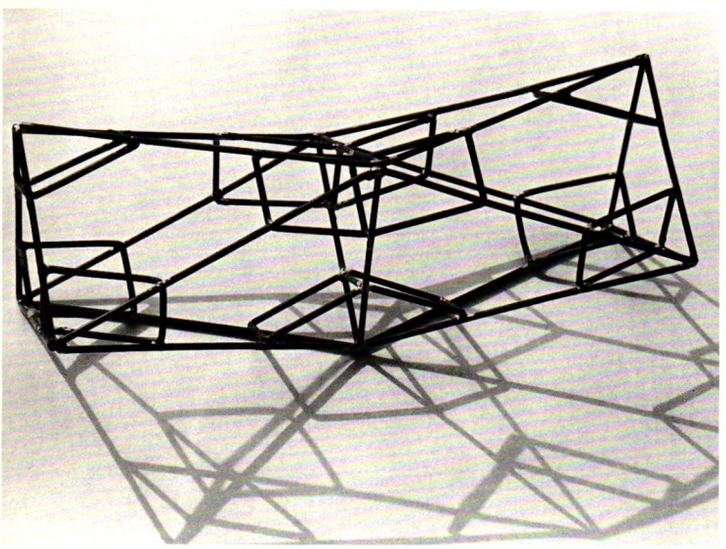
49. Diagram relating Isoflex and triangulated configurations

50. A prestressed T-12 Automorphic tube with queen posts, 1961–62

51. A T-6 Automorphic tube, 1962–63

52. Sketch of an Automorphic tube, 1966





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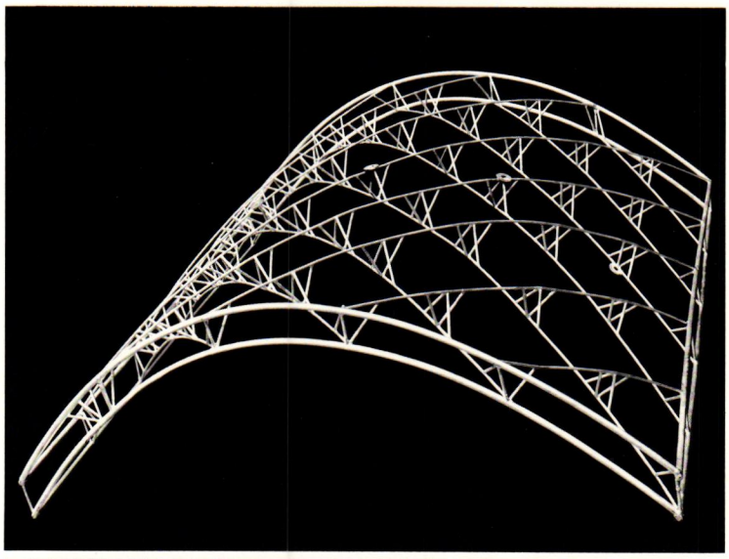
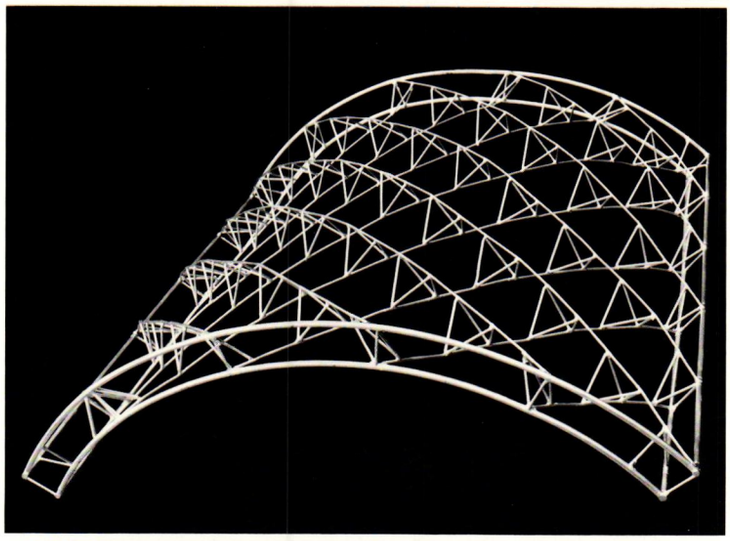
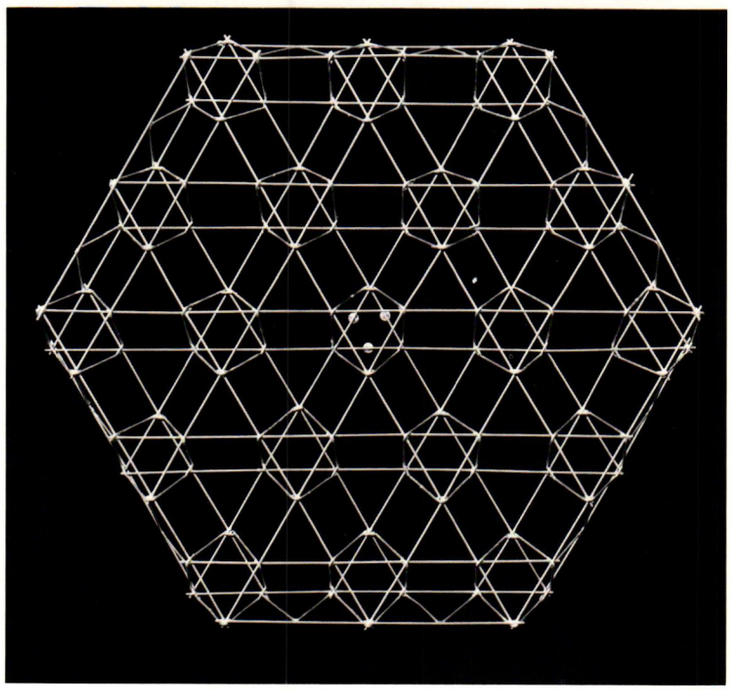






53. An Octen tower (axial view), 65 feet in height with a diameter of 23 inches, made of steel rods of 3/8-inch diameter, welded, and aircraft cable of 1/4-inch diameter for the six axial cables and three stays, 1965–66

It's the 6-pointed star again, really Solomon's seal, but in this case tensioned cables replace the axial tubes of the Automorphic tube, following our principle of differentiation, and we arrive at a result which is basically similar to that obtained in prestressed concrete. The choice of an octahedral element for the part of the structure under compression was based on its very favorable ratio of volume to perimeter and on the intuitively simple idea that, as with a spring, the potential energy of a system will be related to the volume developed by its bars, provided that the rules of buckling are respected.

In the search for the optimum structural unit, the conditions of compatibility are multiple and varied – stability in space, maximum volume for a given perimeter, partition of the plane or space – and the difficulty of the problem is particularly evident in the design of transmission towers and antennas, which are subject to complex forces of bending, tension, and compression and in which the reduction of dead weight is imperative. This exercise built on the university campus was only a first step: we thought that a tower of this size would reveal what modifications should be made, since tests on small-scale models are insufficient to simulate the apparently simple, though in fact relatively complicated, conditions prevailing in structures of this sort. Considering alternatives for a 130-foot Octen tower, we later elongated the octahedral element, without a serious loss of efficiency, applied Trihex partitioning to the faces, and progressively increased the size of the elements toward the base of the tower.

54. Elongated and bitriangulated octahedral elements, 1966–67

55. Model of a parabolic Tetragrid for a hangar roof, 28 inches square in plan with a rise of 8 inches (scale, 1:100), made of steel rods of 1/8-inch and 1/4-inch diameters, 1968–69

56. Model of a cylindrical Tetragrid for a hangar roof, of same dimensions, scale, and materials as model in [55], 1969–70

Recently in a magazine there was a photo of a lamentable failure – a big hangar, about 300 feet in span, completely collapsed. I think it was because their space frame was made by the simple addition of planar trusses; they had limited their attention to computing these for bending stresses, but they forgot the composition in space and never suspected that in some cases the stability of the system would suffer from some kind of parasitic torsion, for which there were no members. The thing wasn't balanced enough, so its failure was not at all graceful. This is a good example of wanting to build in space while your mind remains in the plane. Although the Tetragrid involves the projection of an orthogonal grid, we started with a three-dimensional element: the joint is replaced by a kind of key which is definitely stable and which reduces the buckling length of the grid members – in this model, we have substituted a tetrahedral element for the V connections used in the first model – and this really changes your attitude, because it introduces a thickness, an added dimension to the structure. A test of the first model [*55*] showed that it could support 33 times its own weight with a deflection of 1/240 the span. Although you may have local deformations, it could resist much more torsion than a system made of planar elements; but since a student had been working three months to build the model, we weren't sadistic enough to perform a failure test.

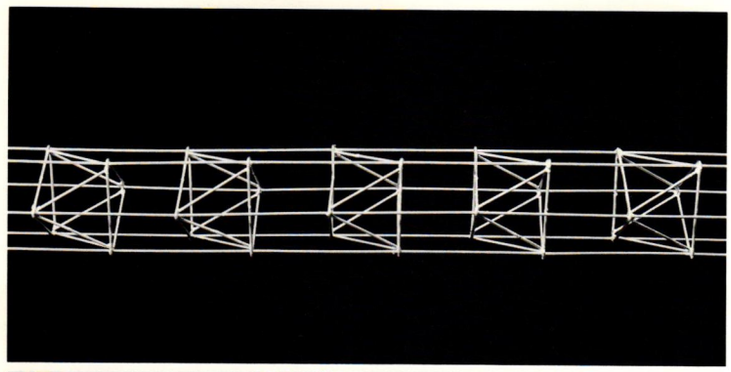
57. An Octagrid, 45 inches in diameter, made of steel rods of 3/16-inch diameter, 1970–71

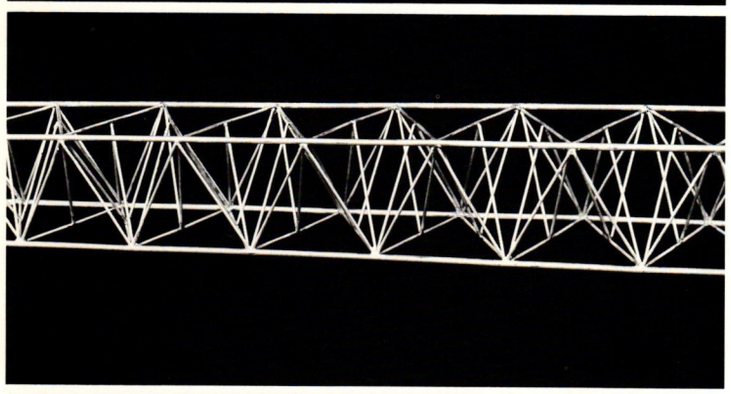
The top and bottom layers of the Octagrid are both made of a Starhex arrangement of bars, and the key element connecting them is in the form of a warped hexagon, resulting in a middle layer of isolated octahedra. Ideally, disregarding the boundary conditions, where you may have to add some bars, there would be 342 segments of equal length in this panel – 114 in each of the Starhex networks and 114 for the 19 connecting elements. This would seem to be a very good distribution of material, with repetitive bars and joints, but we have to make a number of tests to be sure, because we are dealing with some kind of paradoxical structure: with an E of 342 and a V of 114, $E = 3V$, suggesting that we have 6 missing segments, since for a space frame which is determinate, $E = 3V - 6$. Although the technical analysis is complex, really something for distinguished experts, my belief is that redundancy is a powerful way to control deformations and retard failure; however, you keep in mind the fact that some arrangements with redundant bars will give you no advantage for the increased weight or even have adverse effects on the structure. Sometimes it's better to take material away; you don't know until you test it and compare. . . . It's tentative, this kind of research, and we have to be satisfied with some results that tend to justify our attitude, because for us to make the formal proof would leave little time for anything else.

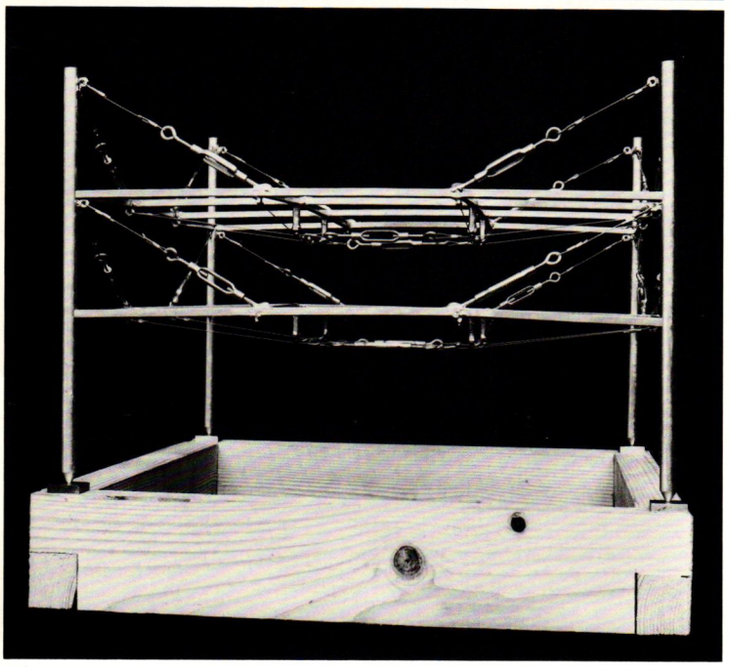
It may be of some interest to note that the motivation of our work on the Octagrid was less concerned with a new space-frame configuration than with investigating the practicality of a nearly jointless system. As you know, we can get industrially produced profiles of material in infinite lengths, provided they can be shipped; so the practice of cutting them into many little pieces and then putting them back together by means of heavy and costly joints seems a highly dubious endeavor in terms of our technology. Here, we have reduced the joint to a simple ring at each vertex of the connecting elements, which allows us to use continuous, superimposed members for each of the Starhex networks; even without clamping devices, the friction would be sufficient to secure stability, at least within certain limits. Using this system, you could very easily erect a demountable structure, or convert it into a permanent and stiffer one by welding the intersecting bars.

Compared with space frames based on closest packing of tetrahedra and square-based pyramids or of tetrahedra and octahedra, the Octagrid is significantly less dense and stiff, having fewer bars; its deflection would be much greater than that of a grid of equal weight composed of tetrahedra and octahedra. However, to rely exclusively on this as a criterion of marketability would be a mistake. You may have to increase the section of bars in order to obtain the required stiffness, but more important than the cost of metal is the cost of joints, which are the main items in any space-frame program. Looking into the problem more closely, you can see that this decisive cost-factor depends not only on the number of joints, but also on the number of branches at each joint – 6 for the Octagrid compared with 8 and 9 for the other grids. So the cost reduction from fewer bars, fewer joints, and fewer bars per joint would largely pay for the increased section of these members, and with the added advantage of a greater safety-coefficient for buckling.

For quite a long time we have advocated the hexagonal plan as an architectural solution for floors, based on its obvious economy over the orthogonal plan in terms of the columns and peripheral walls required for a certain floor-area. (Besides being efficient for circulation, the triaxial partition of urban space [*17, 18*] could result in lots which would lend themselves to the economies of such building systems.) A combination of the Octagrid with queen posts, along the lines of the SSS models [*60*], could easily be made and would lead, I suspect, to a structure of maximum area and minimum weight for large spans between columns. Finally, application of the Octagrid system to towers, domes, and vaults seems promising – further experimental models and tests should confirm or infirm our deductions.







58. An Octagrid tube, 6 and 3/8 inches in diameter, made of steel rods of 3/16-inch diameter, 1970–71

59. An 'antitorsion' beam, 4 and 3/4 inches square in section, made of steel rods of 1/8-inch and 1/4-inch diameters, 1968–69

We started without all the triangulation, as a point of reference. The geometry of the primary system was perfectly simple: you've got the Warren truss and the section is a square. In the partitioning, however, we departed from our notions of symmetry and obtained this monster – to make a computation of stresses and so forth would be equivalent to hard labor because of the variation of angles and joints. Yet for a given volume, taking the rhombohedron, we have a maximum number of bars of equal length, and when you meet these circumstances it's an optimum condition of some kind; for what, you don't always know. The problem is how to use it. There is enough section for bending, but in torsion I think we may have something which would give an optimum performance. We'll have to make some tests to see whether the amount of metal introduced is justified. We may be wrong. In your mind, you always make an image, seeing one thing in one way, but the conclusions are only partial. Sometimes you're distressed to find that the results of tests are completely independent of what is thought.

Well, probably I'm taken by the sport of all this – doing some exact prognostication is too long, too difficult; so I tend to rely on the test as the companion of intuition: you know where you are, you can make some corrections, or find some way out. I know it would be fooling myself to start with exact methods in things that are not always capable of exact definition. You know, it's a divine feeling one has when computations check with the tests – the guy thinks he's a hero – but maybe it's the wrong computation, or maybe the wrong test. You can get some rather stupifying results from tests. You just have to accept them with tongue in cheek, because tests can fool you too. We just have to compare before knowing how to evaluate. . . .

The other day in the studio we were making an arrangement of tubes and rods to take some enormous compressive forces, and it was very amusing to see the reaction of the students. They said, 'Yeah, so what? The tubes are enough.' You see the weakness of relying on your physical sense. They are going to murder the idea by simplifying. But no, we must wait and see. Maybe I'm the idiot, but I know we have to be careful of our simple impressions of things, thinking that what a man cannot bend is very strong. It's putting too much of our ego into the whole system.

60. Model of an SSS (synclastic suspended system) frame for floors, 18 inches square in plan (scale, 1:50), made of steel rods of 1/2-inch diameter, bars of 1/4-inch-square section, and aircraft cable of 1/32-inch diameter, 1970–71

61. Preliminary model of a Polyten truss, 72 inches in length, made of steel rods of 3/16-inch and 1/4-inch diameters and aircraft cable of 1/16-inch diameter, 1968–69

This photo was taken just before the model failed, under a load of about 240 pounds, or 60 times its own weight. You could see from the undulation what kind of fight was going on, pushing against bending: instead of a simple deflection, we had something like sine waves, these curves showing that the thing was working and that one could begin to control the system and its deformations, possibly by adjusting the precambering and tension or by further repetitions of the queen post as in the diagram [*above 61*]. We should note that around 1850 Mr Fink had devised a similar scheme, using multiple king posts.

62. Preliminary model of a Polyten truss, 1968–69

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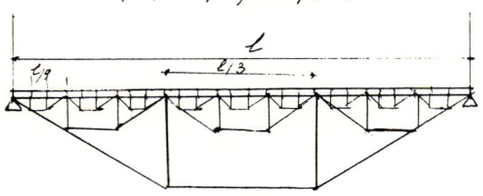
POLYTEN TRUSS – operation $n=3$

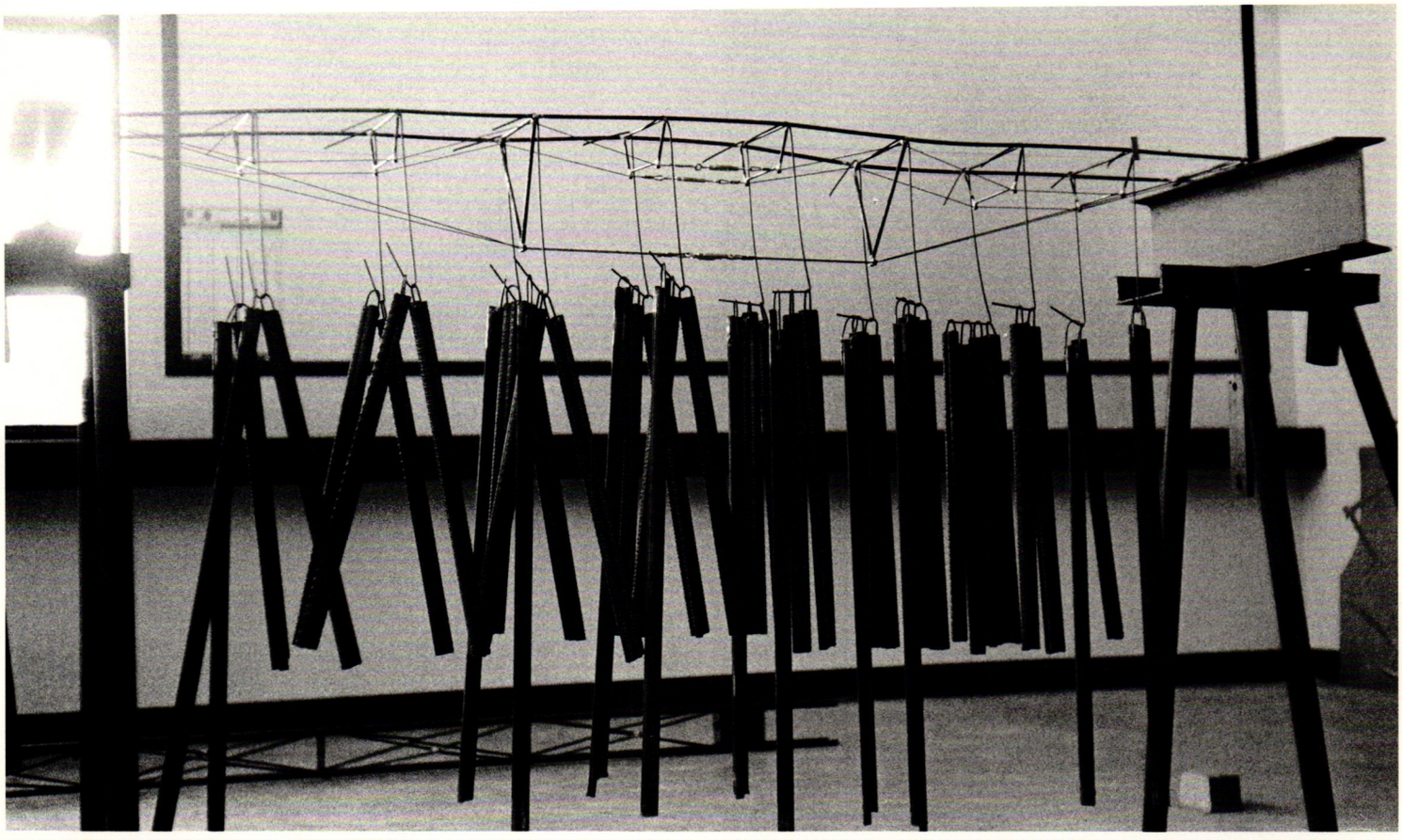
ℓ span, ℓ' reduced span:

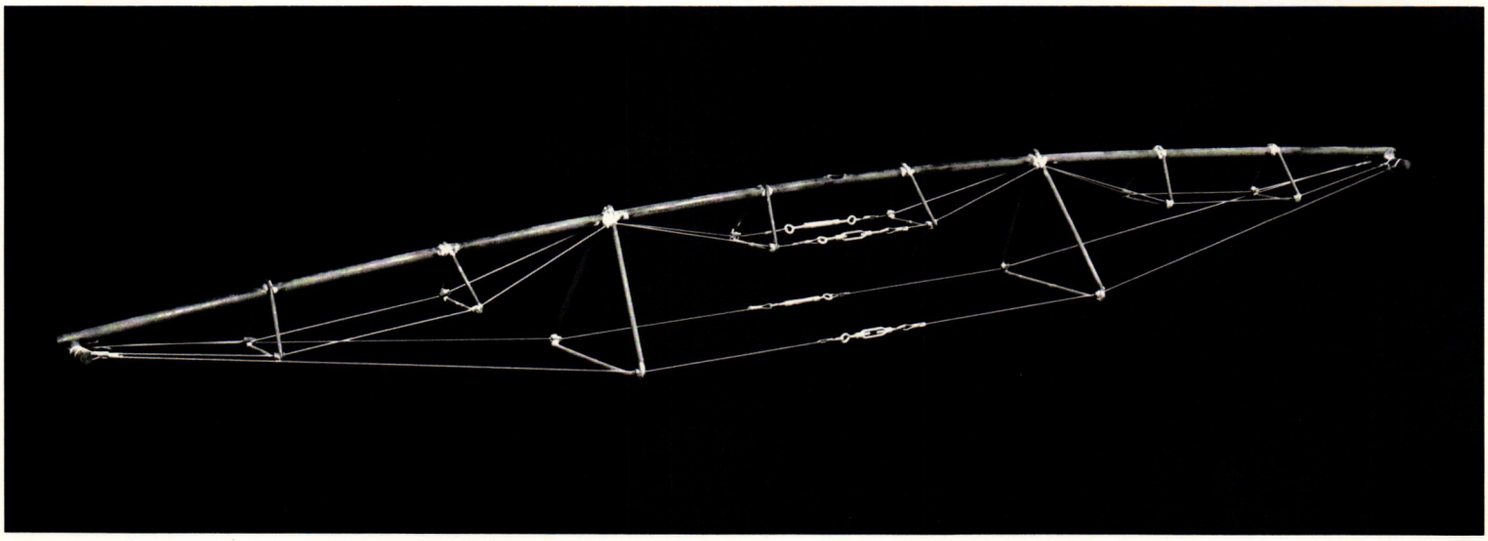
$\ell' = \ell/3^n = \ell/27$

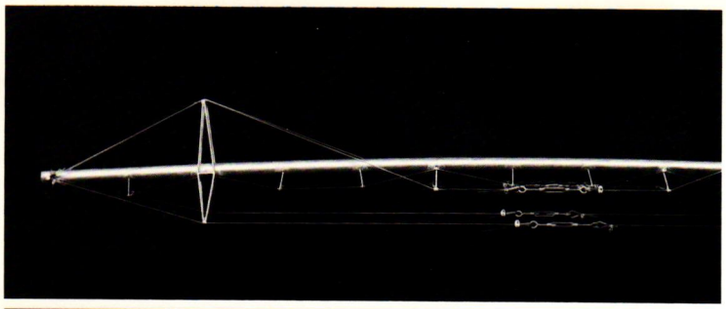
Moment reduction:

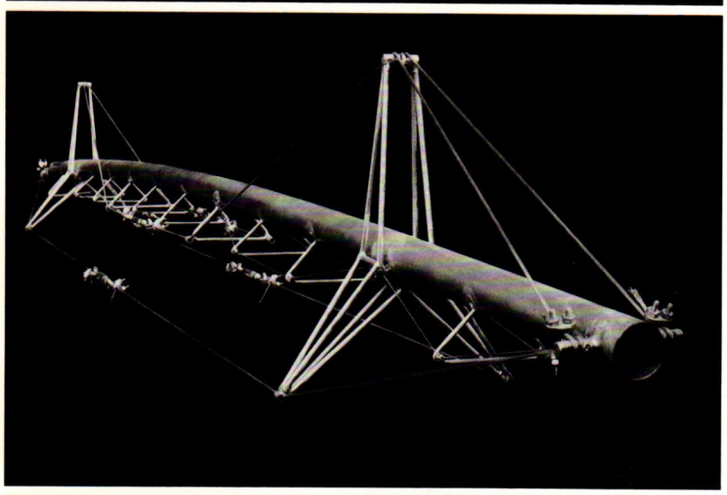
$M'/M = 1/27^2 = 1/729$

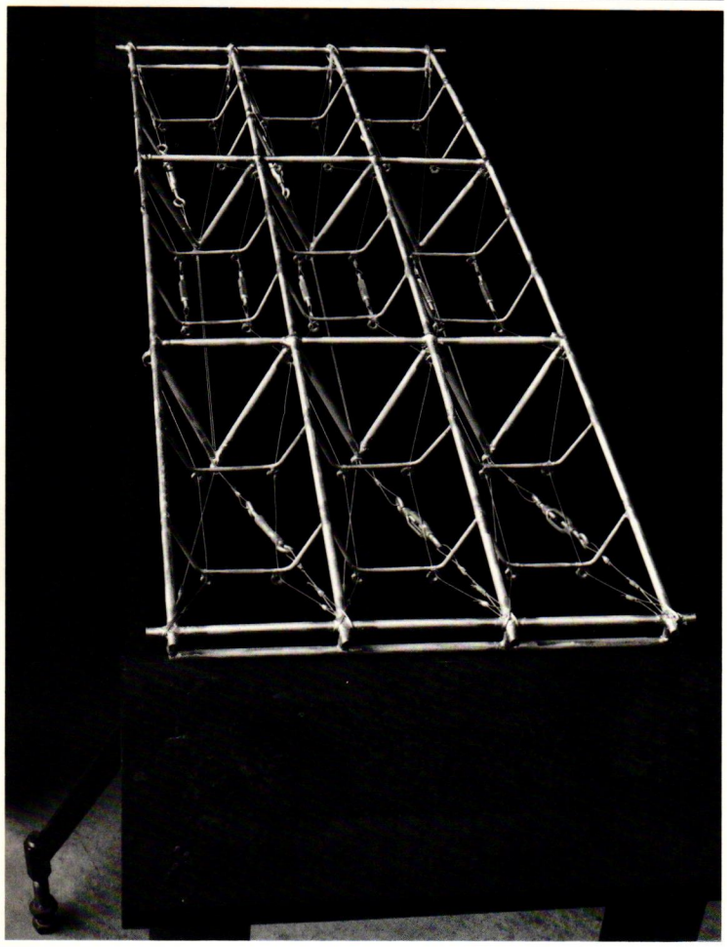












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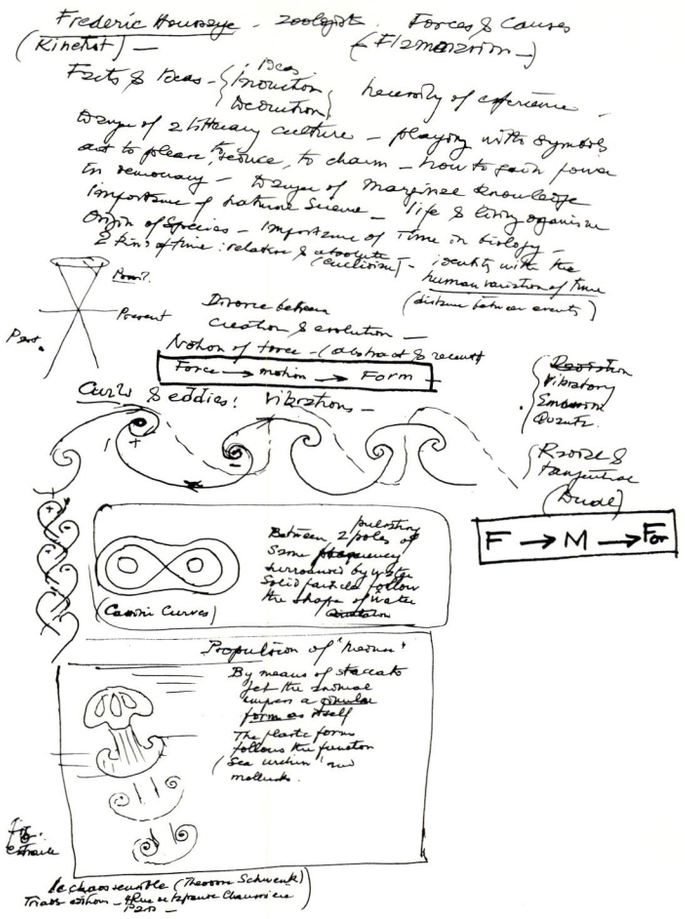
Frederic Houssaye - Zoologiste
Forces & Causes
Kinetist
Facts & Ideas
Induction
Deduction
hierarchy of appearance
Degree of Literary culture - playing with symbols
Degree of Mathematical knowledge
Importance of Natural Science
Origin of Species - Importance of Time in biology
Life & Living organisms
2 kinds of time: relation & absolute (duration)
Duration
Vibratory
Succession
Duration
Radial & Tangential
(Braid)
Past
Present
Future
Distance between
Creation & evolution
Notion of force - (abstract & concrete)
Force → motion → Form
Curls & eddies! Vibrations
F → M → For
Between 2 poles of
Some frequency
Solid particles follow
the shape of the
Caustic Curves
Population of 'Nautilus'
By means of staccato
Jet the animal
Impose a circular
form on itself
The plate form
follows the function
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Le chaos vesuvien (Theorem Schwenk)

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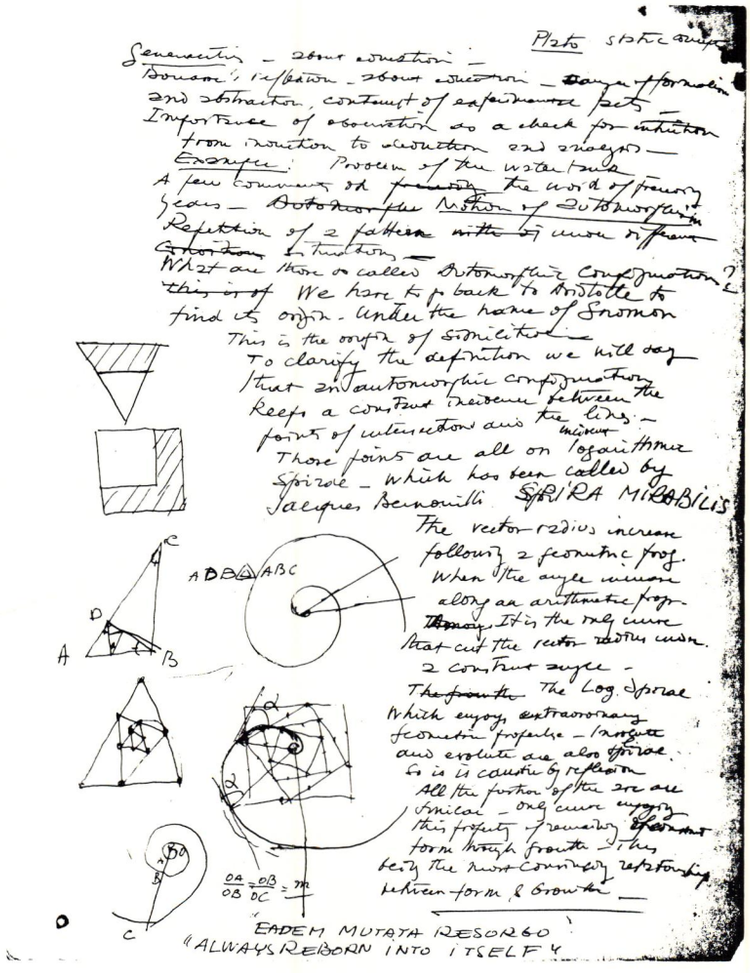
Plato
Sequencing - about evolution -
Succession, relation - about evolution -
and abstraction, content of experimental facts -
Importance of observation as a check for intuition
from intuition to observation and analysis -
Example: Process of the watermill
A few comments on the work of Fourier
Years - Autotransformation - Notion of Autotransformation
Repetition of 2 patterns with or more or fewer
Conversion in function -
What are those so called Autotransformic Configurations?
this is of We have to go back to Aristotle to
find its origin - Under the name of Synonym
This is the origin of similitude -
To clarify the definition we will say
that an autotransformic configuration
keeps a constant existence between the
points of intersection and the lines -
Those points are all on logarithmic
Spirals - which has been called by
Jacques Bernoulli SPIRA MIRABILIS
The vector-radius increase
following a geometric prog.
When the angle increase
along an arithmetic prog.
It is the only curve
that cut the vector radius under
2 constant angle -
The fourth The Log. Spiral
which enjoy extraordinary
geometric properties - involute
and evolute are also spirals
So is it caustic & reflexion
All the functions are
similar - only curve enjoying
this property of remaining
form through growth - thus
being the most convincing representation
between form & Growth -
A
B
C
D
ABC
OA/OB = OB/OC = m
EADEM MUTATA RESURGO
"ALWAYS REBORN INTO ITSELF"

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63, 64. Preliminary model of a Polyten bridge, 120 inches in length, made of a steel tube of 1-and-3/4-inch diameter, rods of 3/16-inch and 1/4-inch diameters, and aircraft cable of 1/16-inch and 1/8-inch diameters, 1968–69

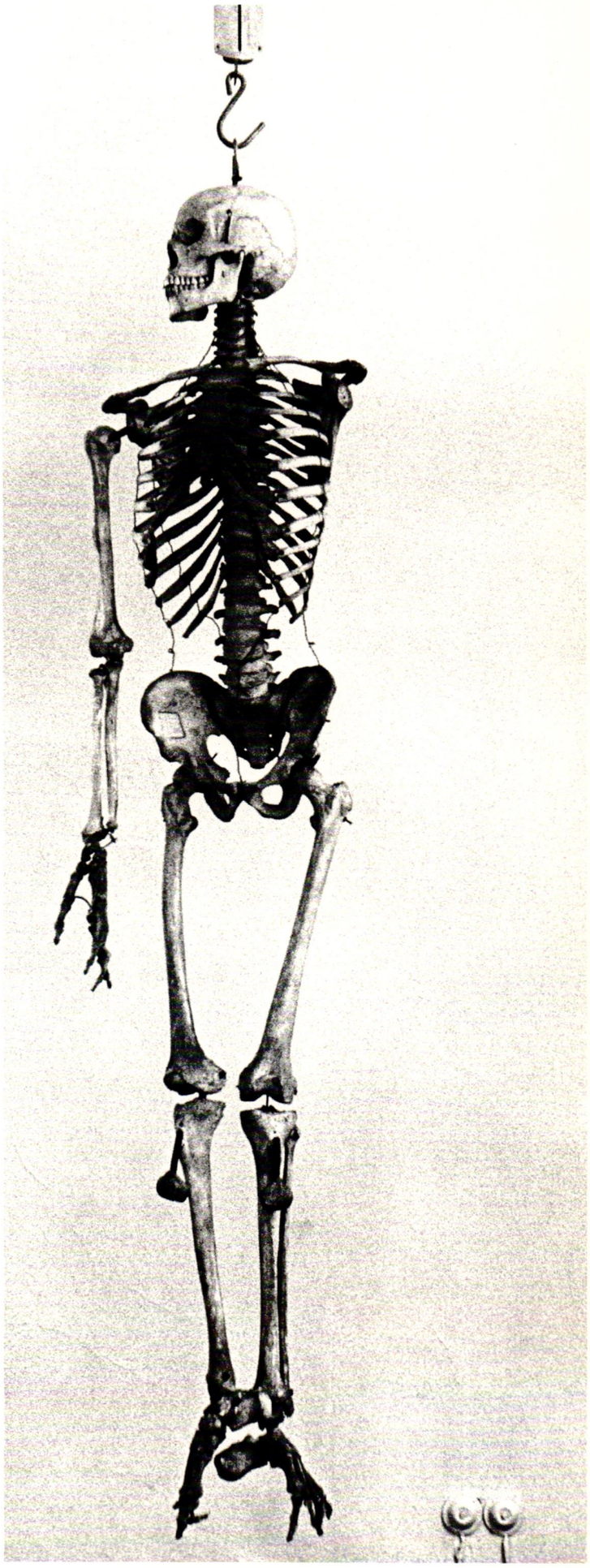
65. Model of a Polyten bridge, 36 inches in length (scale, 1:100), made of steel rods of 1/8-inch and 1/4-inch diameters and aircraft cable of 1/64-inch and 1/32-inch diameters, 1968–69

The rule of the game for trusses is to fight bending, or to substitute bending with tension and compression, which is exactly what the king post and queen post do; bending is cancelled and replaced by compression in the top chord and tension in the bottom. Of course you see that bending can still take place between the points of support. So our choice of the queen post was based on the efficiency of having the same span trisected rather than bisected, and the idea of the Polyten system was simply to extend this classical solution, with automorphic repetitions. . . . You just come to realize how much more ingenious our forerunners were in the art of structures. Maybe we know too many things now – we learn, we analyze, and yet we rarely discover things as wonderful as the queen post. Nobody will ever know his name, but the guy who really had this idea must have been a terrifically intuitive man; every time I use the system, I think about the joy he may have had in building and testing it, to find that it answered his expectations. It's a glorious device, to create fictitious supports, the paradox of columns suspended in the air. You see, its beauty and simplification lie in composition, or the difficult art of taking one plus one and making something that is greater than two. You're putting together two elements which are not necessarily the same – in some way they may even be opposites – so that they become compatible.

In the early trusses, the top chord was an ordinary wood section, working very well in compression, in a limited amount of bending too, and for the bottom chord they had metal, with its advantages in tension. I think the invention of ways to use materials of such different properties together by differentiating their possibilities has had a great impact on the evolution of structures. Not only has this led to increased spans, but also to the introduction of some remarkable specialized materials into our vocabulary, such as high-tensile steel, and perhaps these developments justify some further work with the king post and queen post, especially if we hope to have some chance of success in competing with prestressed concrete.

66–68. Notes and a memento

68



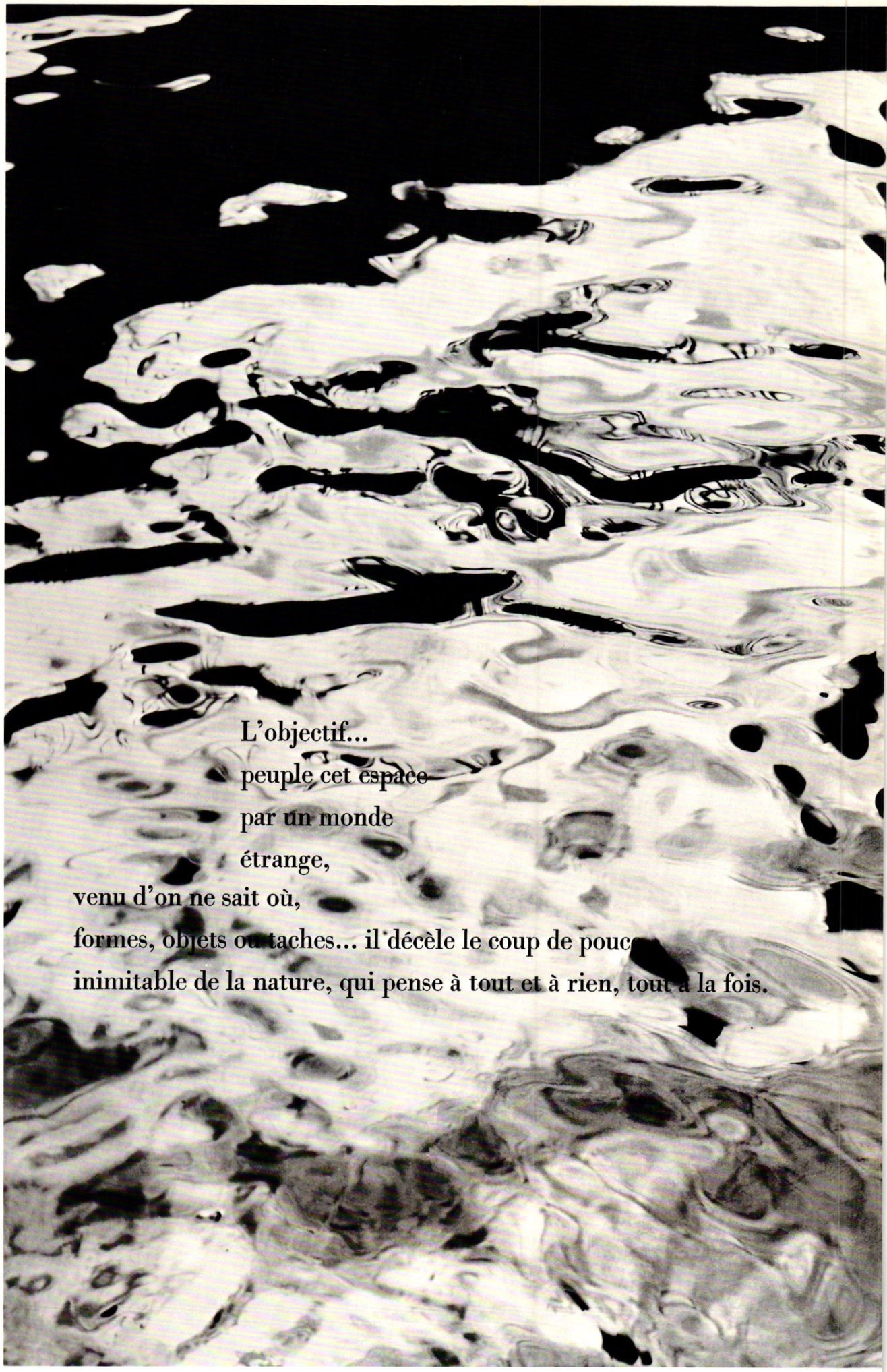
Matières

Texte de Robert Le Ricolais
Photographies de Henriette Grindat

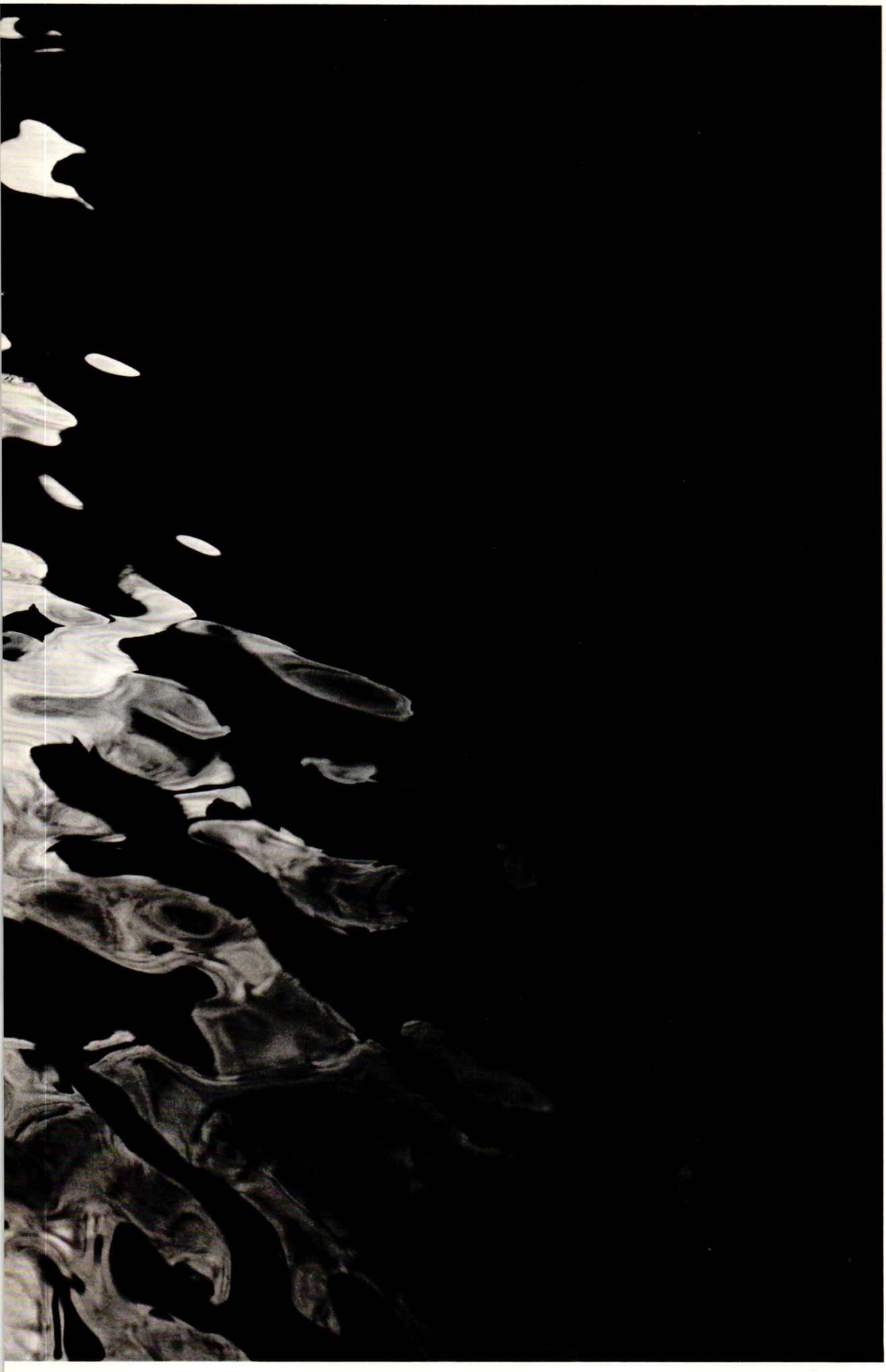
'Things themselves are lying, and so are their images', says the Chinese proverb. A bullet enters the head of a man fighting in the trenches of Spain, the dead man stumbles . . . where is the truth? Where are the truths? . . . They intersect: invisible photons make the death visible. It is really just a matter of an 'arrangement'. Physics, with electrons, Poetry, with words, everywhere wild energies are at hand, so to speak, ready to break loose. No doubt in most cases our perceptions are obtuse, and to discover these arrangements, something or someone has to remove a veil. In the photographer's language, our sensitive system is 'fogged'. We want right away to see, to understand, to admire, to reject, and in this haste the subject itself escapes us. While in Victorian times a little bit of ankle would suffice, an entire Brigitte Bardot no longer satisfies.

One must be grateful that some of the plates of this book keep their secrets so well – which is not to say that there is an aura of unreality, that they are, in a word, 'poetic'. Henriette Grindat can face the hazards of the exact representation, of the document, without missing the comfort of following a fashion or convention. There are myths which must be destroyed with an insatiable cruelty. I no longer believe, as I once did, in beauty, in the harmony of nature. Those are ready-made formulas, impregnated with that pious naturalism of the eighteenth century; I believe much more in the bizarre, in the sign, in curses, and there again the language of photography is perfectly expressive, speaking of Révélateur. *There are images Henriette Grindat shows us that border on sorcery or resurrections.*

The camera's eye . . . peoples this space with a strange world, whose source remains a mystery, forms, objects, or just spots left . . . it reveals the inimitable touch of nature, who thinks of everything while at the same time thinking nothing.



L'objectif...
peuple cet espace
par un monde
étrange,
venu d'on ne sait où,
formes, objets ou taches... il décèle le coup de pouc
inimitable de la nature, qui pense à tout et à rien, tout à la fois.

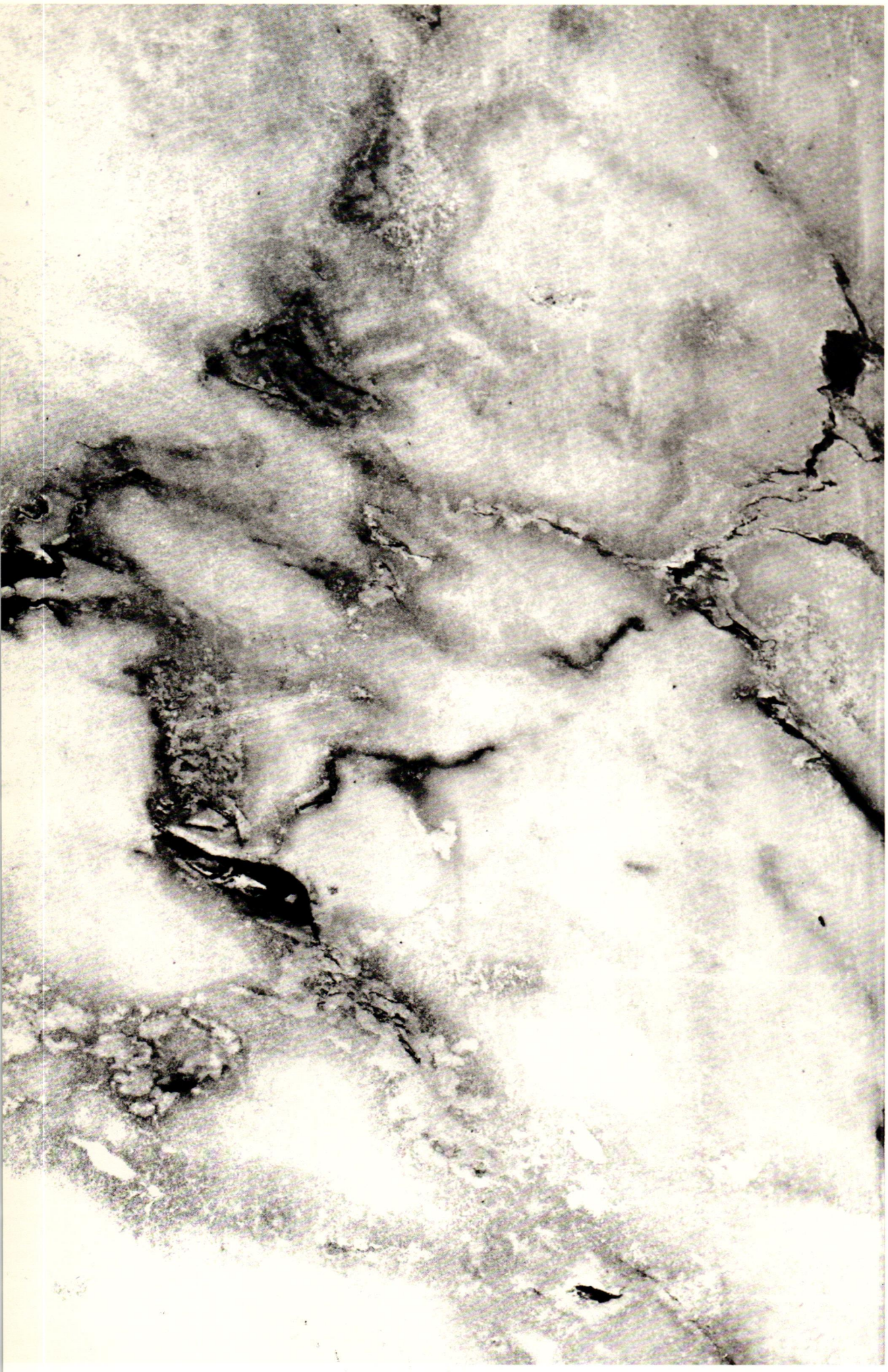


. . . the face of Structures . . . a message in code sent to us in the way things look and deciphered slowly, too slowly before our impatience to know . . . an unfolding so baroque, so unexpected, of the forces governing our Universe, of their gentle moments, of their ragings, of their impulses at the surface of things . . . it is always at the frontiers that the serious incidents arise, the storms and the dramas, right on these frontiers, at the limits, that all the pathos of our sensitive existence resides.

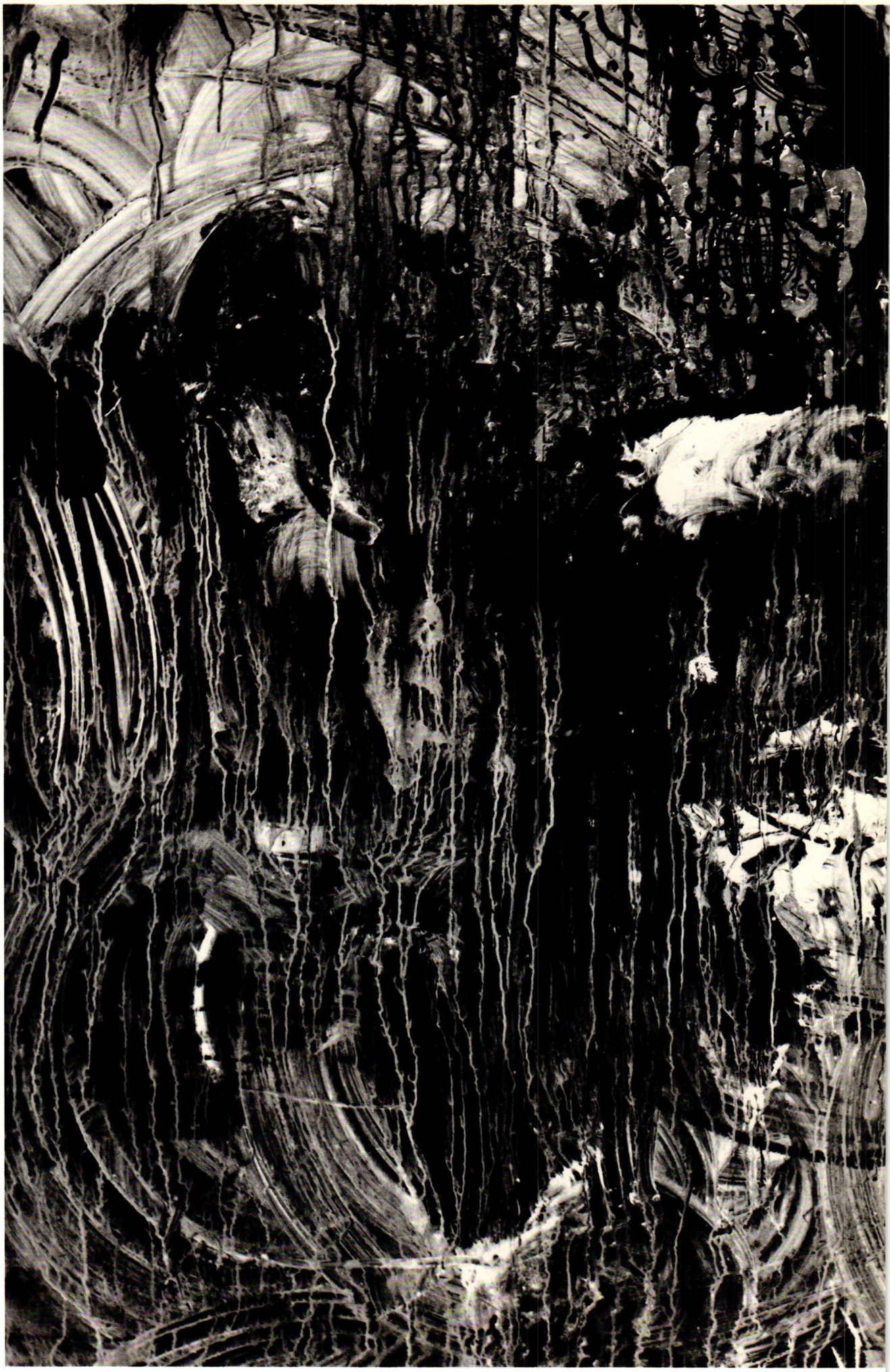
... le visage des Structures
... message en code que nous envoie l'aspect des choses
et qui se déchiffre lentement,
trop lentement
devant notre impatience
de connaître...
déroulement
si baroque,
si imprévu
des forces
qui gouvernent
notre Univers,
de leurs caresses,
de leurs rages,
de leurs impulsions
à la surface
des choses...



c'est toujours aux frontières que se passent les événements graves, les orages et les drames, c'est bien sur ces frontières, aux limites, que réside tout le pathétique de notre existence sensible.



. . . science is but a long series of riddles more or less absurd, or so it seems, when one does not know the hidden undersides. It is in monstrous things that the truths most quickly come to light.

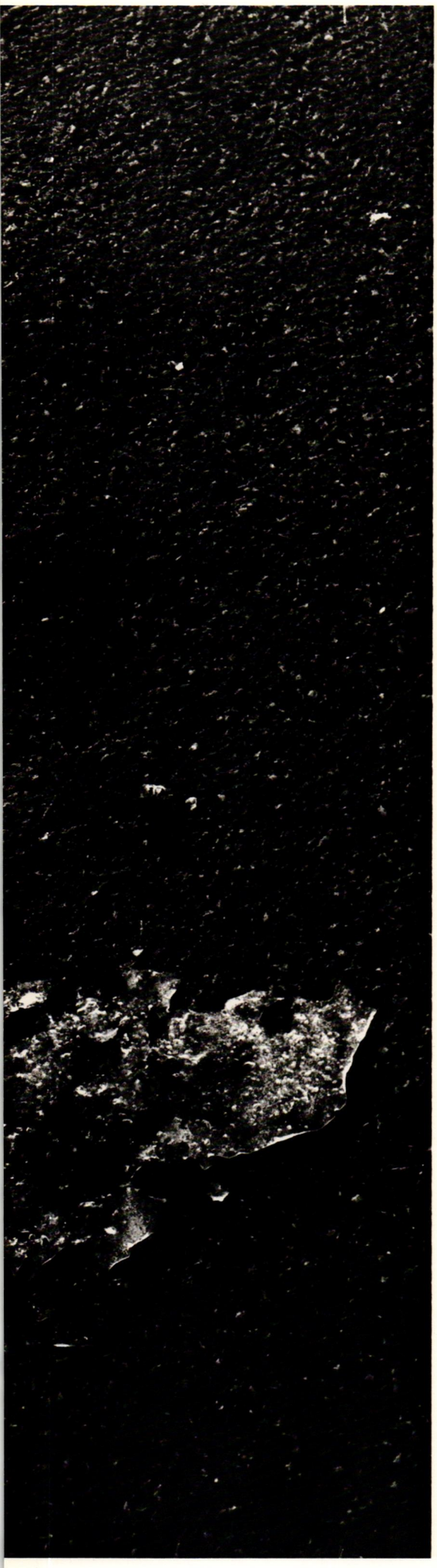




« La science n'est qu'une longue série de devinettes plus ou moins absurdes, ou en ayant l'air, quand on ne connaît pas les dessous. Ce sont les choses monstrueuses qui dévoilent le plus facilement les vérités. »

. . . the lie is glaring, and also the inconsistency of ready-made ideas . . . the antithesis: Soul and matter . . . Is it not a prodigious sleight of hand that gives the illusion of this duality?

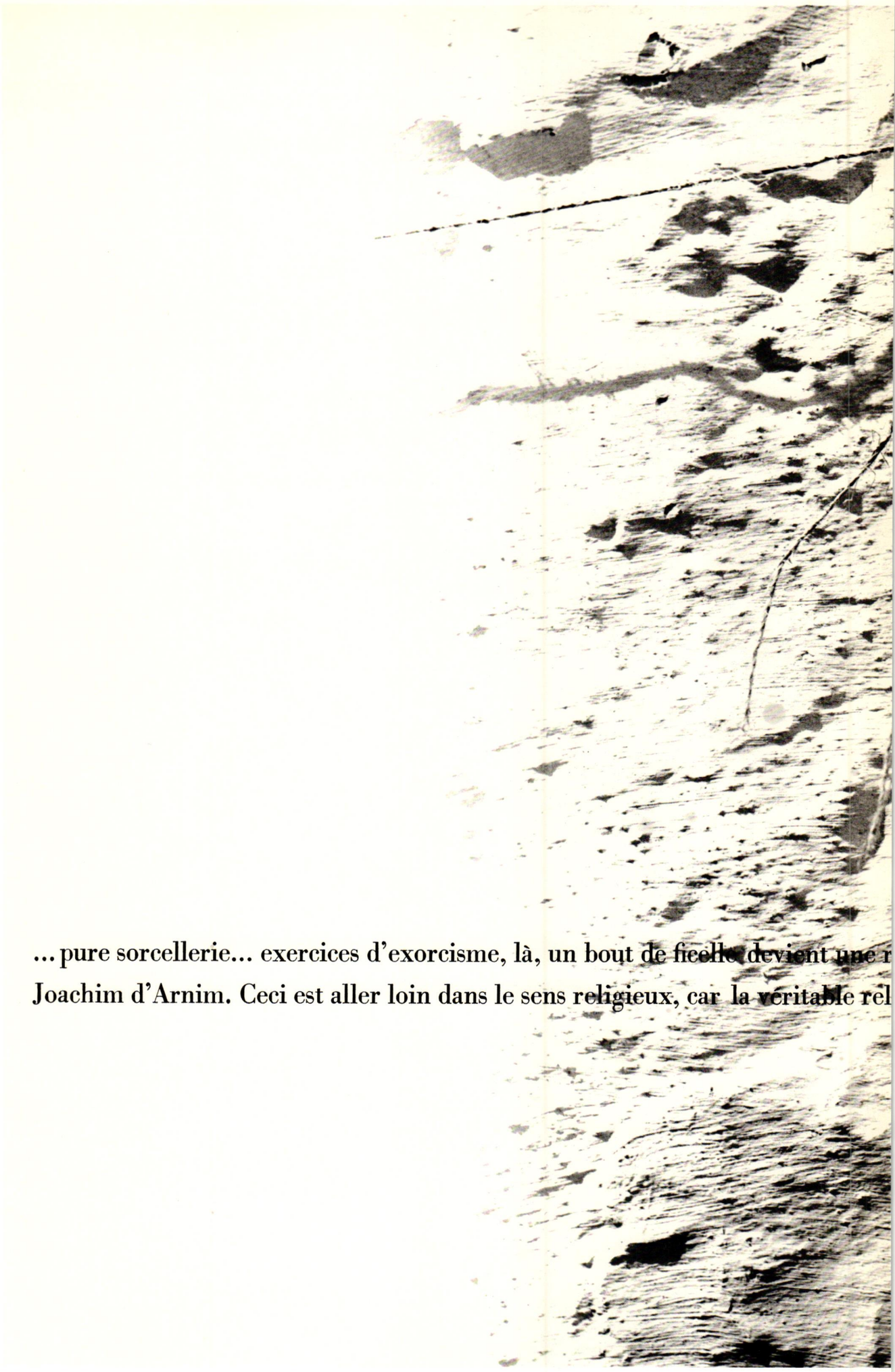




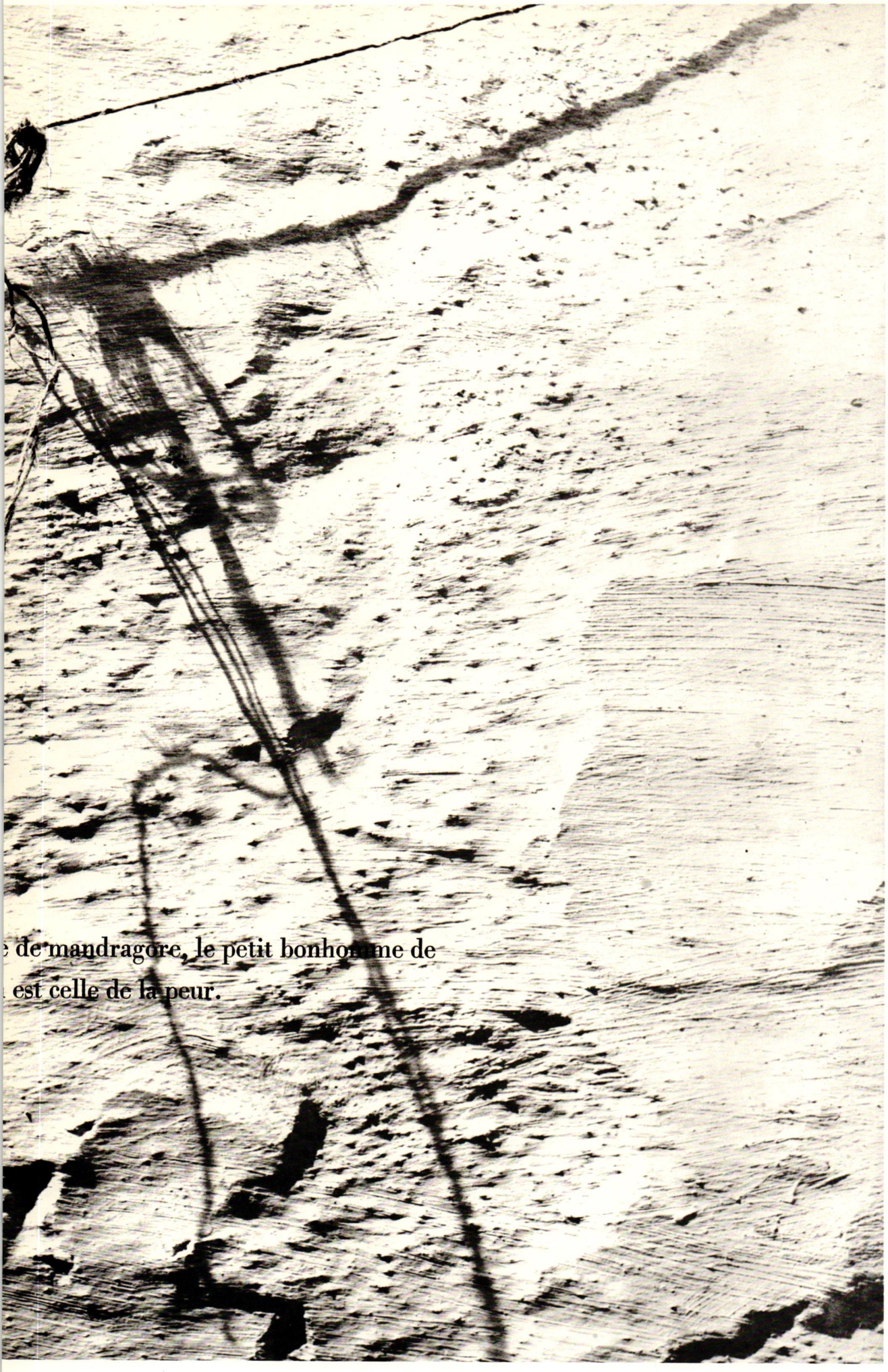
... éclate le mensonge
et aussi
l'inconsistance
des idées toutes faites...
l'antithèse :
Ame et matière...

Ne serait-ce pas
un prodigieux
tour de passe-passe
qui donnerait
l'illusion de ce dualisme ?

. . . pure sorcery
. . . exorcismal
exercises there,
a bit of string
becomes a
mandrake root,
one of Joachim
von Arnim's
little creatures.
This is to go far
in terms of the
religious, for the
true religion is
that of fear.

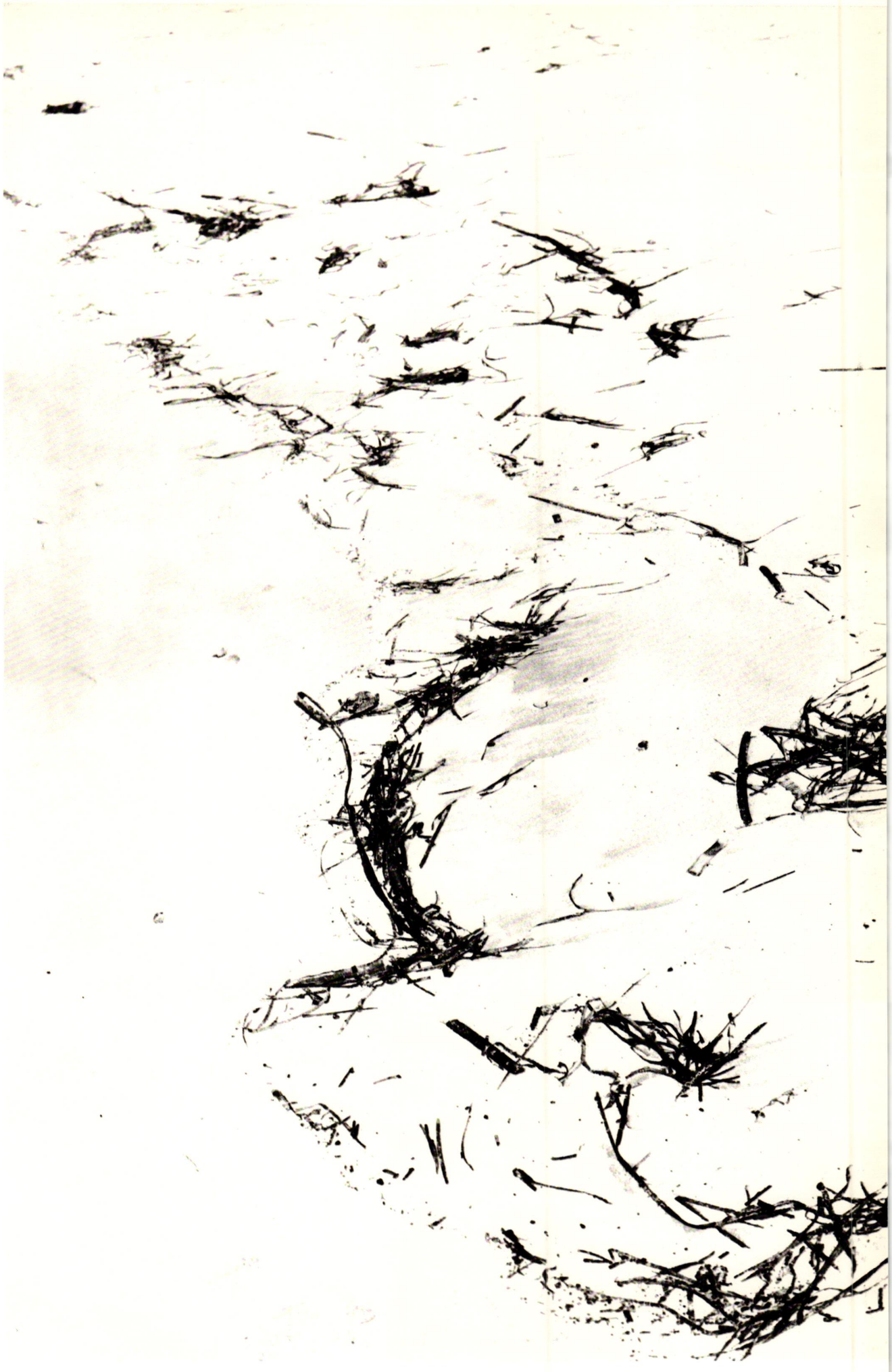


... pure sorcellerie... exercices d'exorcisme, là, un bout de ficelle devient une r
Joachim d'Arnim. Ceci est aller loin dans le sens religieux, car la véritable rel



e de mandragore, le petit bonhomme de
est celle de la peur.

The great changes of terrain for us consist no longer in going far away, for one country comes to look much like another, but rather in going far in terms of Depth . . . those are the only cruises that refresh, being the fruit of a total immobility.



Les grands dépaysements de notre existence ne consistent plus à

aller loin, car tous les pays du monde se ressemblent, mais bien

davantage à aller loin dans le sens de la Profondeur...

ce sont les

seules croisières qui reposent, car elles sont le fruit d'une totale

immobilité.



PIONEER ZONE / MARKETS

CLAUDE LEVI-STRAUSS

PIONEER ZONE

. . . in the inland districts of Brazil, as one moves away from the coast toward the north or west, where the bush extends as far as the Paraguay marshes or the gallery forest along the tributaries of the Amazon. Villages become increasingly fewer and the areas between them greater: sometimes these consist of open spaces, the *campo limpo*, the 'clean' savanna; sometimes they are covered in undergrowth, and are called *campo sujo*, the 'dirty' savanna, or *cerrado* and *caatinga*, which are two kinds of scrubland.

Toward the south, that is, in the direction of the state of Paraná, the increasing distance from the tropic, the altitude, and the volcanic origin of the subsoil account, in various ways, for the differences in landscape and ways of living. One can find there remnants of native communities still living near the civilized centers, as well as the most modern forms of inland colonization. So, it was to this area of North Paraná that I organized my first trips.

It took only a little more than twenty-four hours to reach the vast temperate and humid forest of coniferous trees which lay beyond the river Paraná marking the border of the state of São Paulo and which, by its very denseness, had for so long kept the planters out. Until about 1930, it had remained virtually untouched, except for bands of Indians who still wandered through it, and a few pioneers, usually poor peasants, who grew maize in small clearings.

When I arrived in Brazil the region was being opened up, chiefly because of the influence of a British firm to which the government had granted an initial concession of some four million acres, on the understanding that it undertake to build roads and a railway. The English proposed to resell the land in lots to immigrants, mainly from eastern and central Europe, and to retain ownership of the railway, the viability of which would be ensured by the transport of agricultural produce. By 1935, the experiment was well under way, and the railway was steadily cutting through the forest. It was 30 miles long at the beginning of 1930, 80 at the end, 120 in 1932, and 160 in 1936. Every ten miles or so, a station was built alongside a patch of cleared ground half a mile square, which was intended to become a town. Settlement was in progress, so that, in covering the route, one passed through a succession of places, starting at Londrina, the senior town, which already had 3,000 inhabitants, then Nova Dantzig with 90, Rolândia with 60, and the last, Arapongas, which in 1935 possessed one house with a single inhabitant. He was a middle-aged Frenchman, who wore military leggings left over from the 1914–1918 war and a straw boater, as he thus tried to make his fortune in the wilderness. Pierre Monbeig, who has expert knowledge of this pioneer fringe, tells me that, by 1950, Arapongas had 10,000 inhabitants.

As one traveled through the country on horseback or by truck, following the newly marked-out roads which kept to the ridges, like the Roman roads in Gaul, it was impossible to detect any sign of life. The oblong lots of land were bounded at one end by the road and at the other by the stream running along the bottom of each valley. But the work of settlement had begun down below, near the water; although the *derrubada*, or clearing, was gradually moving up the slope, the road itself, the symbol of civilization, remained enclosed within the thick covering of forest which, for a few months or a few years more, would continue to clothe the top of the hills. But down in the valleys, the first harvests, always fabulous in this *terra roxa*, or purple, virgin land, were showing between the trunks and stumps of felled trees. The winter rains would rot both trunks and stumps into fertile humus, and then almost immediately would wash it away down the slopes, together with the soil which had fed the vanished forest, since there were no longer any tree roots to hold it back. In ten, twenty, or thirty years' time, this land of Canaan might well be reduced to an arid and devastated landscape.

For the moment, the immigrants could think only of the hard-won joys of abundance; Pomeranian or Ukrainian families, who had not yet had time to build themselves houses, and camped, along with their cattle, in wooden shelters on the riverbanks, were enthusiastic about the miraculous soil, so rich that its mettle had to be broken, like that of a wild horse, before maize and cotton could reach fruition, instead of running riot in luxuriant vegetation. A German farmer wept with joy as he showed us the clump of lemon trees he had grown from a few pips. These Northerners were amazed not only by the fertility of the land, but even more so perhaps by the exotic crops, which they had heard of previously only in fairy tales. Since the area is at the junction of the tropical and temperate zones, a few yards drop in level corresponds to appreciable climatic differences, so that it was possible for them to grow everything side by side, plants from their home countries together with American species. Delighted to be able to indulge in such agricultural entertainment, they juxtaposed wheat and sugarcane, flax and coffee . . .

These young cities were totally Nordic; the new immigrants joined the old – Germans, Poles, Russians, and to a lesser degree Italians who, rather less than a century before, had settled around Curitiba in the southern part of the state. The houses, made from planks or roughly fashioned tree trunks, were reminiscent of central and eastern Europe. Long horse-drawn wagons with four spoked wheels replaced the Iberian oxcarts. And here too, the contours of a rapidly emerging future world were more exciting than such unexpected survivals. Day by day, featureless space was acquiring an urban structure; it was changing, as an embryo divides into cells, which in turn form specialized groups, each with its own function. Londrina was already an organized town with its main street, business center, artisans' district, and residential area. But what mysterious forces were at work fashioning the no-man's-land from which Rolândia, and still more so Arapongas, had yet to emerge? Certain types of inhabitants would be compelled in one direction, others in another, and each district would be obliged to fulfill a particular function or vocation. In these rectangular spaces arbitrarily cleared in the heart of the forest, the streets too run at right angles and are, in the first instance, all alike; they are simply geometric lines, with no intrinsic quality of their own. However, some are central and others peripheral; some parallel, and others perpendicular, to the railway line or the road; the former follow the direction of trade, the latter cut across it and, as it were, interrupt it. Business and commerce choose the first, which are necessarily much frequented; and, for the opposite reason, private houses and certain public services prefer the second or are forced back onto them. The combination of the two contrasts – between central and peripheral, on the one hand, and parallel and perpendicular, on the other – gives rise to four different modes of urban life which mold the character of the future inhabitants, encouraging some and discouraging others, prompting success or causing failure. What is more, the townspeople will be of two types – the gregarious, who are attracted to the areas with the most advanced degree of urbanization, and the nongregarious, who are concerned for their individual freedom – and this will give rise to a new kind of counterpoint, which adds its complexities to the first.

Finally, we must take into account those mysterious factors which are at work in so many towns, driving them westward and condemning their eastern districts to poverty or decay. Such factors may be no more than a manifestation of that cosmic rhythm which, since the

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beginning of the human race, has imbued mankind with the unconscious belief that to move with the sun is positive, and to move against it negative, one direction expressing order, the other disorder. We gave up sun worship a long time ago and we have lost the habit of associating the points of the compass with magic qualities, colors, and virtues. But however hostile our Euclidean minds may have become to the qualitative conception of space, we cannot prevent the major astronomical and meteorological phenomena conferring almost imperceptible but ineradicable properties on certain areas. Nor can we alter the fact that, for all men, the east-west direction denotes achievement, while the inhabitants of the temperate regions of the northern hemisphere look upon the North as the seat of cold and darkness, and the South as that of heat and light. No hint of all this transpires in the rational behavior of any particular individual. But urban life offers a strange contrast. While representing the most complex and refined form of civilization, through the exceptionally large concentrations of human beings it brings together within a small space, and through the duration of its cycle, it provides a melting pot for the precipitation of unconscious attitudes, each of which is infinitesimal but which, because of the number of individuals who exemplify them for the same reason and in the same manner, become capable of creating important consequences, such as the growth of towns from east to west and the polarization of luxury and poverty along the east-west axis, a phenomenon which would be incomprehensible, if we did not accept the fact that towns have the advantage, or the limitation – because of that magnifying ability they share with microscopes – of showing, on the plate of the collective conscience, the swarming, microbial mass of our ancestral and still living superstitions.

But are they really superstitions? I see these preferences rather as denoting a kind of wisdom which savage races practiced spontaneously and the rejection of which, by the modern world, is the real madness. Savages have often succeeded in achieving mental harmony with a minimum of effort. What wear and tear, what useless irritation, we could spare ourselves if we agreed to accept the true conditions of our human experience and to realize that we are not in a position to free ourselves completely from its patterns and rhythm! Space has its own values, just as sounds and perfumes have colors, and feelings weight. The search for such correspondences is not a poetic game or a practical joke (as some critic has had the audacity to say it is, in connection with Rimbaud's sonnet on vowels, which is now a classic text for linguists who know the basis – not of the color of phonemes, which is a variable depending on the individual – but of the relationship between them, which admits of only a limited scale of possibilities); it offers absolutely virgin territory for research where significant discoveries are still to be made. If, like the aesthete, fish divide perfumes into light and dark, and bees classify luminosity in terms of weight – darkness being heavy and brightness light – the work of the painter, the poet, or the musician, like the myths and symbols of the savage, ought to be seen by us, if not as a superior form of knowledge, at least as the most fundamental and the only one really common to us all; scientific thought is merely the sharp point – more penetrating because it has been whetted on the stone of fact, but at the cost of some loss of substance – and its effectiveness is to be explained by its power to pierce sufficiently deeply for the main body of the tool to follow the head.

The sociologist can help toward the creation of this total and concrete humanism. The major manifestations of social life have something in common with works of art, namely, that they come into being on the level of the unconscious, because they are collective, and although works of art are individual. However, this is a minor difference, and really only an apparent one, since social phenomena are produced by the public and works of art *for* the public; it is the public which endows them with a common denominator and determines the conditions of their creation.

So it is not in any metaphorical sense that we are justified in comparing – as has so often been done – a town with a symphony or a poem; they are objects of a similar nature. The town is perhaps even more precious than a work of art in that it stands at the meeting point of nature and artifice. Consisting, as it does, of a community of animals who enclose their biological history within its boundaries and at the same time mold it according to their every intention as thinking beings, the town, in both its development and its form, belongs simultaneously to biological procreation, organic evolution, and aesthetic creation. It is at one and the same time an object of nature and a subject of culture; an individual and a group; reality and dream; the supremely human achievement.

In these synthetic towns of southern Brazil, the hidden and stubborn determination behind the way the houses were laid out, the streets given specialized functions, and the various districts different styles seemed all the more significant in that it was both a continuation, and a contradiction, of the whim to which they owed their existence. Londrina, Nova Dantzig, Rolândia, and Arapongas – which had come into being through a decision taken by a team of engineers and financiers – were slipping quietly back into the concrete diversity of a realistic order of things, as Curitiba had done a century earlier, or as Goiânia is perhaps doing at the present time.

Curitiba, the capital of the state of Paraná, appeared on the map through the government's decision to create a town. The site was bought from a landowner and resold in lots that were sufficiently cheap to cause an influx of population. The same method was used later to provide the state of Minas with its capital, Belo Horizonte. In the case of Goiânia, the gamble was a greater one, since the aim was, in the first instance, to create a federal capital for Brazil, *ex nihilo*.

About one-third of the way – as the crow flies – between the southern coast and the course of the Amazon lie vast plateaus which have been forgotten by man for the last two hundred years. At the time of the caravans and the river steamers, it was possible to cross them in a few weeks to get from the mines to the North. After reaching the banks of the river Araguaia, the traveler could go down by boat as far as Belém. The only evidence of this old provincial way of life was Goiás, the tiny capital of the state of Goiás, which lay six hundred miles from the coast and was virtually cut off from it. In a verdant setting overlooked by the irregular crests of palm-studded hills, streets of low houses ran down between gardens and squares, where horses grazed in front of churches with ornate windows, which were half barns, half houses with belfries. Colonnades, stuccoed walls, and pediments, always freshly painted with a wash that was like egg white tinged with cream, ocher, blue, or pink, recalled the baroque style of the Iberian pastorals. A river flowed between mossy embankments which, in places, had collapsed under the weight of the creepers, banana trees, and palms growing among the deserted houses; but the lush vegetation seemed not so much to brand them as ruins as to add a silent dignity to their dilapidated façades.

I do not know whether one should regret or rejoice at the absurdity, but the administration decided to forget Goiás, with its countrified setting, its calades and old-fashioned charm. It was all too small and too old. A completely virgin territory would have to be found for the establishment of the gigantic scheme that was now envisaged. This territory was discovered sixty miles to the east, in the form of a plateau covered with nothing but coarse grass and thorn bushes, as if it had been struck by a plague which had destroyed all the fauna and stunted the vegetation. No railway or road led to it; only tracks fit for carts. A symbolic square, sixty miles long on each side, was marked out on the map of the area. This was to be the site of the federal district, in the center of which the future capital would be built. As there was no irregularity of surface to worry the architects, they could work on the site as if it were a drawing board. The plan of the town was marked out

on the ground; they drew the boundary, and inside it, the different areas, residential, administrative, business, industrial, even the one devoted to entertainment. The latter is always important in a pioneer city: there was a time, about 1925, when, in Marília, which had been founded in a similar way, out of the six hundred newly built houses, nearly a hundred were brothels, most of them specializing in those *Francesinhas* who, together with French nuns, were the most active agents of French influence abroad in the nineteenth century. The Quai d'Orsay was well aware of this, since, in 1939, it was still spending a substantial fraction of its secret funds on the dissemination of so-called naughty magazines. Certain of my former colleagues will not contradict me if I mention that the founding of the university of Rio Grande do Sul, the most southerly state in Brazil, and the preference shown there for French teachers are to be explained by the fact that a future dictator had been given a taste for French literature and French freedom by a young lady of easy virtue, whom he had known in Paris as a young man.

From one day to the next, the papers were full of notices announcing the founding of the city of Goiânia. A detailed plan was given, as if the town were a hundred years old, and alongside it were enumerated the advantages the inhabitants could look forward to – roads, railway, water supply, sewers, and cinemas. If I remember rightly, at the beginning, in 1935–36, there was even a period when land was offered free to those prospective buyers who agreed to pay the legal expenses of the purchase. Lawyers and speculators were the first occupants.

I visited Goiânia in 1937. On an endless plain, half vacant lot and half battlefield, bristling with electric-cable poles and survey posts, were a hundred or so new buildings, scattered in all directions. The largest was the hotel, a cube of cement which, in the surrounding flatness, looked like an airport terminal or a small fort; one felt tempted to describe it as a 'bastion of civilization', not in a metaphorical but in a literal sense, which in the circumstances took on strongly ironic overtones. Nothing could be more barbaric or inhuman than this appropriation of the desert. The clumsy and unlovely building was the opposite of Goiás; neither history, nor the passage of time, nor custom had filled its emptiness or softened its stiffness; like a station or a hospital, it was a place of transit not of residence. Only the fear of some disaster could justify the existence of this blockhouse. A disaster had, in fact, occurred, and the silence and immobility all around was its ominous aftermath. Cadmus, the civilizer, had sown the dragon's teeth. Out of this land scorched and burned by the monster's breath, one expected to see men sprouting. . . .

MARKETS

Without deliberate intention on my part, a kind of mental 'tracking shot' has led me from central Brazil to southern Asia; from the most recently discovered lands to those in which civilization first made its appearance; and from the most thinly, to the most heavily, populated, if it is true that the density in Bengal is three thousand times what it is in Mato Grosso or Goiás. On reading over what I have written, I realize that the difference goes even deeper. In America, I was, first and foremost, looking at natural or urban landscapes, and in both cases these are objects defined by their shapes, colors, and peculiar structures, which confer on them an existence independent of the living beings who occupy them. In India, these large objects have disappeared, having been destroyed by history and reduced to a physical or human dust which has become the only reality. In America, what I saw in the first place was the physical universe, whereas in India I saw only human beings. A sociological order worn away over hundreds of centuries was collapsing, and it was replaced by a multiplicity of interpersonal relationships, so completely did the human density interpose itself between the observer and the disintegrating object. In the light of this, the term *subcontinent*, which is often applied to India in India itself, takes on a new meaning. Instead of simply signifying a part of the Asiatic continent, it seems to imply a world hardly deserving of the name of continent, since disintegration, carried to the extreme limit of its cycle, has destroyed the structure which in the past maintained a few hundred million human particles within organized frameworks; they have now been set loose in a void created by history, and are being driven in all directions by the most elementary motivations of fear, suffering, and hunger.

In tropical America, men are concealed, in the first place, by their rarity, but even in those areas where they have grouped together in more dense communities, individuals remain set, as it were, in the still strongly marked pattern of their newly formed association. However low the standard of living may be in the interior or even in the towns, only exceptionally does it sink to a level at which human beings cry out in pain, since so very little is needed for survival in territory which man began to pillage – and even then in certain specific places – only four hundred fifty years ago. But in India, which has been an agricultural and manufacturing country for five or ten thousand years, the basic conditions of life are no longer available. The forests have disappeared; in the absence of wood, manure has to be used as fuel for the cooking of food and is therefore withheld from the fields; the arable land, eroded by the rains, is carried seaward; the starving cattle breed less rapidly than the people and owe their survival to the taboo on the eating of their flesh.

There could be no more vivid illustration of the basic contrast between the empty and the overpopulated tropics than a comparison between their fairs and markets. In Brazil, as in Bolivia or Paraguay, these important occasions in the social calendar emphasize that production still remains an individual matter; each stall reflects the peculiarity of the person behind it: as in Africa, the female stall-holder offers the customer the tiny surplus of her domestic activities. A couple of eggs, a handful of peppers, a bunch of vegetables or flowers, two or three rows of beads made from wild seeds – 'goat's eyes', red with black speckles, or 'Our Lady's tears', gray and glistening – which have been gathered and threaded in leisure moments; a homemade basket or piece of pottery, or some antique talisman continuing to change hands in a complex cycle of transactions. These doll-like displays, each of them a modest work of art, express a great variety of tastes and activities, as well as an equilibrium specific to each, and both these features are arguments in favor of the freedom which is still generally enjoyed. And if the passerby hears a voice hailing him, the intention is not to shock him with the spectacle of a maimed or skeletonlike body, or to beg him to save someone from death, but to ask him to *tomar a borboleta*, 'take the butterfly' – or some other creature in the lottery known as the *bicho*, an animal game, in which numbers are combined with the figures of a charming bestiary.

We know everything about our oriental bazaar before visiting one, except that we are not acquainted with two things – the human density and the filth. It is impossible to imagine either, until one has actually experienced them. Impact immediately allows one to realize a fundamental dimension of reality. In this atmosphere black with flies and in the swarming masses of people we recognize a natural human setting, the setting in which what we call civilization was slowly secreted, from the time of the Ur of the Chaldees to the Paris of Philippe-le-Bel, by way of imperial Rome.

I have visited all kinds of markets; in Calcutta, the new one and the old ones; the *Bombay* bazaar at Karachi; the markets in Delhi and the *Sadar* and *Kunari* in Agra; Dacca, which is a series of suqs, with families living huddled in the nooks and crannies between the stalls and craftsmen's workshops; *Riazuddin Bazar* and *Khatunganj* at Chittagong; all those at the gates of Lahore, *Anarkali Bazar*, *Delhi*, *Shah*, *Almi*, and *Akbari*; and *Sadr*, *Dabgari*, *Sirki*, *Bajori Ganj*, and *Kalan* at Peshawar.

At country fairs in the Khyber Pass along the Afghan frontier, and at Rangamati near the Burmese frontier, I have visited fruit and vegetable markets, with their piles of eggplants, pink onions, and burst pomegranates, releasing a heady, guavalike smell; flower markets where florists intertwined roses and jasmine with tinsel and angel's hair; the displays of dried-fruit merchants, brown, tawny heaps on a background of silver paper; I have seen and smelled spices and curries, pyramids of red, orange, and yellow powder; mountains of peppers, emitting a pungent odor of dried apricots and lavender which was enough to make the senses reel. I have seen meat roasters, the boilers of milk curds, the pancake makers – *nān* or *chapati*; tea and lemonade sellers, wholesale date-merchants with their produce piled up in sticky mounds of pulp and stones suggesting the excreta of some dinosaur; pastry cooks who might have been mistaken for vendors of flies presenting their wares on a base of cake; tinkers who could be heard a hundred yards away because of the loud rumble of their hammers; basket makers and rope makers with their yellow and green straw; hat makers who had arranged the gilded cones of *kallas*, resembling the miters of the Sassanid kings, in rows interspersed with turban cloths; textile shops, hung with lengths of freshly dyed blue or yellow material, as well as with saffron and pink artificial-silk scarves in the Bokhara style; cabinetmakers, wood-carvers, and lacquerers of bedsteads; knife grinders pulling on the cords of their grinding wheels; scrap-iron fairs, separate from the rest, and cheerless; tobacco vendors with their heaps of golden leaves, alternating with russet masses of *tombak*, alongside bundles of *chilam* tubes; vendors of sandals, stacked in hundreds like bottles in a wine store; sellers of bracelets or bangles, like pink and blue glass intestines lying higgledy-piggledy as if they were the product of a recent disemboweling; potters' shops, with oblong, varnished *chilam* water-vases arranged in rows; jars fashioned out of micaceous clay, and others painted brown, white, and red on a background of tawny earthenware, with vermicular ornamental markings; and *chilam* bowls strung together like rosaries; flour vendors sieving flour all day long; gold and silver smiths weighing tiny fragments of precious braid in shopfronts which were less brilliant than those of the nearby tinsmiths; calico printers striking the white cotton fabric with a deft, monotonous movement which left a delicate colored pattern; and blacksmiths working in the open air. All this formed a swarming and ordered world above which rose a forest of multicolored children's windmills, mounted on sticks and fluttering like leaves stirring in the breeze.

Even country districts can provide equally striking spectacles. Once when I was making a trip by motorboat along the Bengal rivers, we landed on an island in the middle of the Buliganga, a river lined with banana plants and palm trees, sheltering white-tiled mosques which seem to float on the surface of the water. A thousand or more boats and sampans moored in the vicinity indicated that a *hat*, or country market, was in progress. Although no permanent building was visible, a veritable town had sprung up for one day only, and the crowd of inhabitants had set up their stalls in the mud, with a clearly defined area for each particular kind of trade: paddy, livestock, boats, bamboo poles, wooden planks, pottery, fabrics, fruit, betel nuts, and fishing nets. The river traffic was so dense in the channels around the island that they were like liquid streets. Newly bought cows were being taken away without any fuss, each one standing up in its boat and sailing blankly past the landscape, which watched it go by.

The whole countryside in this area is extraordinarily soft and mild. There is something soothing and soporific in the greenery, tinged with the blue of water lilies, and in the swamps and rivers with their gliding sampans; one is tempted to let oneself rot away like the old red-brick walls, which have been pushed out of shape by banyan trees.

Yet, at the same time, there is something disturbing about this gentleness. The landscape is not a normal one; it contains too much water for that. The annual floods create exceptional living conditions, since they cause a drop in vegetable production and in fish catching. High-water time is a season of famine. Even the livestock is reduced to skin and bones and tends to waste away, through being unable to find adequate nourishment in the spongy water-lilies. The inhabitants are a strange people who seem to live more in water than in air and their children learn to use their little dinghies almost as soon as they can walk. This is a place where, during the floods, through lack of any other fuel, the dried residue of processed jute is sold to people who earn less than the equivalent of 3,000 francs (old francs) a month at the rate of 250 francs per 200 stalks.

However, one has to go into the villages to understand the tragic situation of these people, who are close to the most primitive communities in their customs, forms of habitation, and way of life, yet who hold markets as elaborately laid out as a modern department store. Barely a hundred years ago, their bones littered the countryside. They were mainly weavers and had been reduced to starvation and death through being forbidden by the colonial authorities to practice their traditional trade, so as to leave the market open for cotton goods from Manchester. Now, every inch of cultivatable land, even though it may be flooded for six months of the year, is given over to the production of jute which, after processing, is sent off to the factories at Narayanganj and Calcutta, or even straight to Europe and America, so that these illiterate and half-naked peasants still depend for their daily sustenance, in a different but no less arbitrary way, on the fluctuations of the world market. Although they can, and do, catch fish, the rice which forms their staple diet is almost entirely imported; and to eke out the meager income from crops – since only a minority are landowners – they spend their days in pathetic occupations.

Demra is almost a village of lake dwellings, so precarious is the network of mounds, emerging from the water, on which the huts are clustered together among clumps of trees. Here I saw the entire community, even quite tiny children, busy from dawn onward weaving by hand the muslin veils for which Dacca used to be so famous. A little further on, at Langalbund, an entire region is engaged in the making of pearl buttons of the kind used in the Western world for men's shirts and nightwear. A caste of boatmen, the Bidyaya or Badia, who live permanently in the straw cabins of their sampans, gather and sell the river mussels which provide the mother-of-pearl; the heaps of muddy shells make the hamlets look like 'placers'. After being passed through an acid bath, the shells are hammered to pieces and the fragments then made into rounds on a hand-operated grinding wheel. Next, each disc is placed on a stand to be fashioned into shape with the help of a piece of broken file revolving at the tip of a wooden spindle operated by means of a bow. A similar instrument with a sharp point is used to pierce the four holes. Children sew the finished buttons, a dozen at a time, onto foil-covered cards, such as can be seen in Europe in provincial drygoods shops.

Before the major political changes brought about by the granting of independence to the Asiatic countries, this modest industry which supplied the Indian market and the Pacific islands provided the workers with a livelihood, in spite of the fact that they were, and continue to be, exploited by the *mahajans*, a class of moneylenders and middlemen who supply the raw materials and the products needed for processing. The price of the latter increased five or six times, while production in the area dropped from sixty thousand gross per week to less than fifty thousand per month because of the closing of the market; at the same time, the price paid to the producer fell by seventy-five percent. Almost from one day to the next, fifty thousand people discovered that an already pathetically low income had been reduced to a mere fraction of what it had been. Yet in spite of primitive modes of life, the fact is that the size of the population, the quantity of goods produced, and the appearance of the finished articles make it impossible to consider these people as true craftsmen. In tropical America – in Brazil, Bolivia,

and Mexico – the term *craftsmanship* can still be applied to work done with metals, glass, wool, cotton, or straw. The raw materials are of local origin, the skills are traditional, and the work is carried out in domestic conditions; the purposes and forms of the products depend on the tastes, habits, and requirements of the makers.

In Bengal, medieval communities have been plunged headlong into the industrial era and exposed to the vagaries of the world market. From start to finish they are victims of alienation. The raw material is foreign to them, totally so in the case of the Demra weavers, who depend on thread imported from England and Italy, and partially so in the case of the Langalbund button-makers, who use local shells, but also need chemicals, cardboard, and sheets of foil. And, throughout the area, production is planned 'according to foreign standards', the unfortunate workers themselves being hardly in a position to buy clothes, let alone put buttons on them. Behind the verdant landscapes and peaceful canals lined with cottages can be glimpsed the ugly outlines of an abstract factory, as if history and economics had managed to establish, indeed superimpose, their most tragic phases of development on these wretched victims: the shortages and epidemics of medieval times, frenzied exploitation as in the early years of the industrial revolution, and the unemployment and speculation of modern capitalism. The fourteenth, eighteenth, and twentieth centuries come together to make a mockery of the idyll implicit in the setting provided by tropical nature.

It was in this part of the world, where the density of the population sometimes exceeds twenty-five hundred people per square mile, that I fully grasped the historical privilege that tropical America (and to some extent the whole of the American continents) still enjoys through remaining completely, or relatively, unpeopled. Freedom is neither a legal invention nor a philosophical conquest, the cherished possession of civilizations more valid than others because they alone have been able to create or preserve it. It is the outcome of an objective relationship between the individual and the space he occupies, between the consumer and the resources at his disposal. And it is far from certain that abundance of resources can make up for a lack of space, and that a rich but overpopulated society is not in danger of being poisoned by its own density, like those flour parasites which manage to kill each other at a distance by their toxins, even before their food supply runs out.

One has to be very naïve or dishonest to imagine that men choose their beliefs independently of their situation. Far from the forms of social existence being determined by political systems, it is they which give meaning to the ideologies by which they are expressed. Ideologies are signs which only constitute a language in the presence of the objects to which they relate. At the moment, the misunderstanding between East and West is primarily semantic: the concepts or 'signifiers' that we try to propagate in the East refer to 'signifieds' which are different there, or nonexistent. On the other hand, if it were possible for circumstances to change, it would matter very little to their victims if this occurred within a framework that we Westerners would deem intolerable. They would not be conscious of being enslaved but, on the contrary, would feel that they had been liberated, if they graduated to forced labor, food rationing, and regimented thought, since this would be the historical development by virtue of which they would obtain work, food, and some measure of intellectual life. Modalities which appear to us to be forms of deprivation would be canceled out by the convincingness of a proferred reality, which we had denied them on the grounds of its appearance.

Over and above the political and economic remedies that might be found for it, the problem posed by the confrontation between tropical Asia and tropical America remains the problem of the multiplication of the human species within a limited space. We are bound to reflect that, in this connection, Europe occupies an intermediary position between these two worlds. India tried to solve the population problem some three thousand years ago by endeavoring, by means of the caste system, to change quantity into quality, that is, to differentiate between human groups so as to enable them to live side by side. She even conceived of the problem in still broader terms, extending it beyond man, to all forms of life. The vegetarian rule, like the caste system, was intended to prevent social groups and animal species from *encroaching* on each other, and to guarantee each group its own particular freedom by forcing the others to relinquish the enjoyment of some conflicting freedom. It is tragic for mankind that this great experiment failed; I mean that, in the course of history, the various castes did not succeed in reaching a state in which they could remain equal because they were different – equal in the sense that there would have been no common measure between them – and that a harmful element of homogeneity was introduced which made comparison possible, and consequently led to the creation of a hierarchy. Men can coexist on condition that they recognize each other as being all *equally*, though *differently*, human, but they can also coexist by denying each other a comparable degree of humanity, and thus establishing a system of subordination.

India's great failure can teach us a lesson. When a community becomes too numerous, however great the genius of its thinkers, it can only endure by secreting enslavement. Once men begin to feel cramped in their geographic, social, and mental habitat, they are in danger of being tempted by the simple solution of denying one section of the species the right to be considered as human. This allows the rest a little elbowroom for a few more decades. Then it becomes necessary to extend the process of expulsion. When looked at in this light, the events which have occurred in Europe during the past twenty years, at the culmination of a century during which the population figures have doubled, can no longer appear as being simply the result of an aberration on the part of one nation, one doctrine, or one group of men. I see them rather as a premonitory sign of our moving into a finite world, such as southern Asia had to face a thousand or two thousand years ahead of us, and I cannot see us avoiding the experience unless some major decisions are taken. The systematic devaluation of man by man is gaining ground, and we would be guilty of hypocrisy and blindness if we dismissed the problem by arguing that recent events represented only a temporary contamination.

What frightens me in Asia is the vision of our own future which it is already experiencing. In the America of the Indians, I cherish the reflection, however fleeting it may have now become, of an era when the human species was in proportion to the world it occupied, and when there was still a valid relationship between the enjoyment of freedom and the symbols denoting it.



Wells Cathedral: Stairs to Chapter House & Bridge to Vicars' Close Frederick H. Evans

"A Sea of Steps"

FUNCTION AND SIGN:

SEMIOTICS OF ARCHITECTURE

UMBERTO ECO

'Since our society produces only standardized, normalized objects, these objects are unavoidably realizations of a model, the speech of a language, the substances of a significant form. To rediscover a non-signifying object, one would have to imagine a utensil absolutely improvised and with no similarity to an existing model . . . : a hypothesis which is virtually impossible to verify in any society.' – Roland Barthes

1. *ARCHITECTURE AND COMMUNICATION*

1.1. *Semiotics and architecture*

1.1.1. If semiotics, beyond being the science of recognized systems of signs, is really to be a science studying *all* cultural phenomena *as if* they were systems of signs – on the hypothesis that all cultural phenomena *are*, in reality, systems of signs, or that culture can be understood as *communication* – then one of the fields in which it will undoubtedly find itself most challenged is that of architecture.

It should be noted that the term *architecture* will be used in a broad sense here, indicating phenomena of industrial design and urban design as well as phenomena of architecture proper. (We will leave aside, however, the question of whether our notions on these phenomena would be applicable to *any type of design producing three-dimensional constructions destined to permit the fulfillment of some function connected with life in society*, a definition that would embrace the design of clothing, insofar as clothing is culturalized and a means of participating in society, and even the design of food, not as the production of something for the individual's nourishment, but insofar as it involves the construction of contexts that have social functions and symbolic connotations, such as particular menus, the accessories of a meal, etc. – a definition that would be understood to exclude, on the other hand, the production of three-dimensional objects destined primarily to be *contemplated* rather than utilized in society, such as works of art.)

1.1.2. Why is architecture a particular challenge to semiotics? First of all because apparently most architectural objects do not *communicate* (and are not designed to communicate), but *function*. No one can doubt that a roof fundamentally serves to cover, and a glass to hold liquids in such a way that one can then easily drink them. Indeed, this is so obviously and unquestionably the case that it might seem perverse to insist upon seeing as an act of communication something that is so well, and so easily, characterized as a *possibility of function*. One of the first questions for semiotics to face, then, if it aims to provide keys to the cultural phenomena in this field, is whether it is possible to interpret functions as having something to do with communication; and the point of it is that seeing functions from the semiotic point of view might permit one to understand and define them better, precisely as functions, and thereby to discover other types of functionality, which are just as essential but which a straight functionalist interpretation keeps one from perceiving.[1]

1. 'A Sea of Steps', Wells Cathedral stairs, photograph by Frederick H. Evans, 1903

1.2. *Architecture as communication*

1.2.1. A phenomenological consideration of our relationship with architectural objects tells us that we commonly do experience architecture as communication, even while recognizing its functionality.

Let us imagine the point of view of the man who started the history of architecture.

Still 'all wonder and ferocity' (to use Vico's phrase), driven by cold and rain and following the example of some animal or obeying an impulse in which instinct and reasoning are mixed in a confused way, this hypothetical Stone Age man takes shelter in a recess, in some hole on the side of a mountain, in a cave.

Sheltered from the wind and rain, he examines the cave that shelters him, by daylight or by the light of a fire (we will assume he has already discovered fire). He notes the amplitude of the vault, and understands this as the limit of an outside space, which is (with its wind and rain) *cut off*, and as the *beginning of an inside space*, which is likely to evoke in him some unclear nostalgia for the womb, imbue him with feelings of protection, and appear still imprecise and ambiguous to him, seen under a play of shadow and light. Once the storm is over, he might leave the cave and reconsider it from the outside; there he would note the entryway as 'hole that permits passage to the inside', and the entrance would recall to his mind the image of the inside: entrance hole, covering vault, walls (or continuous wall of rock) surrounding a space within. Thus an 'idea of the cave' takes shape, which is useful at least as a mnemonic device, enabling him to think of the cave later on as a possible objective in case of rain; but it also enables him to recognize in another cave the same *possibility of shelter* found in the first one. At the second cave he tries, the idea of *that* cave is soon replaced by the idea of cave *tout court* – a *model*, a *type*, something that does not exist concretely but on the basis of which he can recognize a certain context of phenomena as 'cave'.

The model (or concept) functions so well that he can now recognize from a distance someone else's cave or a cave he does not intend to make use of, independently of whether he wants to take shelter in it or not. The man has learned that the cave can assume various appearances. Now this would still be a matter of an *individual's* realization of an abstract model, but in a sense the model is *already codified*, not yet on a social level but on the level of this individual who proposes and communicates it to himself, within his own mind. And he would probably be able, at this point, to communicate the model of the cave to other men, by means of graphic signs. The *architectural code* would generate an *iconic code*, and the 'cave principle' would become an object of communicative intercourse.

At this point the drawing of a cave or the image of a cave in the distance becomes the communication of a possible function, and such it remains, even when there is neither fulfillment of the function nor a wish to fulfill it.

1.2.2. What has happened, then, is what Roland Barthes is speaking about when he says that 'as soon as there is a society, every usage is converted into a sign of itself'.[2]

To use a spoon to get food to one's mouth is still, of course, the fulfillment of a function, through the use of an artifact that allows and promotes that function; yet to say that it 'promotes' the function indicates that the artifact serves a communicative function as well: it *communicates the function to be fulfilled*. Moreover, the fact that someone uses a spoon becomes, in the eyes of the society that observes it, the communication of a conformity by him to certain usages (as opposed to certain others, such as eating with one's hands or sipping food directly from a dish).

The spoon *promotes a certain way of eating* and *signifies that way of eating*, just as the cave promotes the act of taking shelter and signi-

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fies the existence of the possible function; and both objects *signify even when they are not being used.*

1.3. *Stimulus and communication*

1.3.1. Still, one might ask whether what we are taking to be communication is simply *stimulation.*

A stimulus is a complex of sensory events that provokes a certain response. The response may be a direct one: a light blinds me – I shut my eyes; there has been a motor response without the sensory stimulus even being perceptually resolved (certainly, then, without any intellective process taking place). Or the response may be mediated: I see a car coming toward me at high speed and get out of the way; in this case, at the moment of perception – I have perceived the car and the relations between its apparent speed, the distance separating it from me, and what change in my position could be made in the time that remains – we have passed beyond a simple relation between stimulus and response to an intellective operation in which sign processes have intervened; in fact it may be assumed that the car has been understood as a danger precisely because it has been taken as a sign communicating the 'automobile-moving-at-high-speed situation', a sign that I was able to understand only on the basis of past experiences, on the basis of an experiential code telling me that when a car is coming at a certain speed it constitutes a danger. And if, for that matter, I had inferred the car's impending arrival from a roar some distance up the street, the noise would have been functioning as an *index* (indices having been characterized by Charles Sanders Peirce as signs that direct one's attention to their objects 'by blind compulsion',[3] but nevertheless depending, it must be assumed, on codes and communicative conventions of some kind in order to be recognized as signs).

There remain, however, stimuli like the blinding light, stimuli that would be difficult to interpret as signs. A brick that falls on my head, provided it does not knock me out, initiates a chain of behavioral responses (hands to the head, a cry, swearing, anxious maneuvers to avoid any more of the same) even when I have no idea *what* hit me.

Does architecture present stimuli of this kind, then?

1.3.2. Undoubtedly a stair acts on me as a compelling stimulus: if I want to pass where there is a stair [*1*], I have to raise my feet one after the other, step by step, and I have to do this even if I would rather continue along a level course. *The stair stimulates me to go up*, even when, stumbling over the first step in the dark, I cannot see it.

There are, on the other hand, two factors that cannot be left out of account here, concerning the fact that in all probability I would be going up the stair on the basis of knowing that that is what a stair is for. First, in going up such a structure at some time in the past, I *learn* to go up, and thus I learn to respond to the stimulus; otherwise, the stimulus alone might well fail to produce the expected response. Second, once I have learned that the stair stimulates me to go up (and permits me to pass from one level to another), from that moment on I *recognize* in a stair the stimulus presented and the possibility that is offered of a fulfillable function.

So from the moment I recognize it as a stair and subsume it under the general concept of 'stair', the individual stairway communicates to me the function it permits; and it communicates this to such an extent that from the type of stair (grand marble staircase, winding stairway, steep and narrow stair, moving staircase) I see, perhaps first of all, whether it would be relatively easy to go up or an effort.

1.3.3. In this sense, *what permits our use of architecture* (passing, entering, pausing, going up, reclining, displaying oneself [*2*], shutting oneself off from others, etc.) *is, above and beyond the possible functions of the objects, the meanings connected with these objects, which dispose us to particular functional uses of them.* Indeed, confronted with certain trompe l'oeil phenomena, one may be disposed to a particular use even when the possibility of that function is illusory.

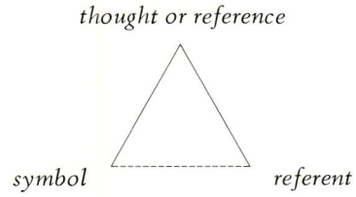
And with regard to some architectural objects – which do not take effect as stimuli in that they do not engage one in a physical response (possibly because having become part of one's immediate environment they function as artifices that eliminate certain stimuli: the vault as shelter from bad weather, for instance) – one may sooner or later fail to even notice a great deal of their functionality (which may be experienced as something 'out of view') while one continues to respond to their communicative effectiveness, as in a sense of security, of spaciousness, and so forth.

2. *THE ARCHITECTURAL SIGN*

2.1. *Characterization of the architectural sign*

2.1.1. If architecture can, then, be considered a system of signs, the first order of business would be to characterize these signs.

While inclined to apply here the semiotic schemata we have availed ourselves of elsewhere,[4] perhaps we should first check to what extent architectural phenomena support the application of other semiotic schemata. For instance, if we were to apply to architecture C. K. Ogden and I. A. Richards's well-known semantic triangle,[5]



we would come up against some serious difficulties. Suppose, for example, that a door is seen as a symbol to which corresponds, at the vertex of the triangle, the *reference* 'possibility of access': then one would be hard put to define the *referent*, the physical reality to which, it is postulated, the symbol indirectly refers. The only way out would seem to be to take the position either that the door refers to itself, denoting its own reality, or that it refers to the function it permits, in which case, for the purposes of semiotics, the right side of the triangle might as well be lopped off, since the reference replaces the referent. (One might try to salvage the triangle by arguing that the *fulfillment* of the function would constitute the referent: the trouble with this is that, as suggested in 1.2.2, the fulfillment of the function is not at all a necessary condition of the communication of the function, and so to insist that it be brought into the characterization of the architectural object as a sign is to insist that semiotics deal with something extraneous to semiotics.) With this schema one would get into even greater difficulties, then, in defining what such a symbol as a triumphal arch refers to: while undoubtedly denoting a possibility of passage, it is, at the same time, clearly connoting 'triumph' and 'celebration'; so here the reference would ramify before replacing the referent, or again the referent would simply be the symbol itself.

2.1.2. Another approach, and one that would seem more promising, is that taken by Giovanni Klaus Koenig in trying to define the 'language of architecture'.[6] Koenig goes back to Charles Morris's definition of sign: 'If anything, *A*, is a preparatory-stimulus which in the absence of

2. Photograph no. 3 from 'Romance (N) from Ambrose Bierce', by Ralph Eugene Meatyard, 1962


4
3
2
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stimulus-objects initiating response-sequences of a certain behavior-family causes a disposition in some organism to respond under certain conditions by response-sequences of this behavior-family, then *A* is a sign.'[7] And again, 'If something, *A*, controls behavior towards a goal in a way similar to (but not necessarily identical with) the way something else, *B*, would control behavior with respect to that goal in a situation in which it were observed, then *A* is a sign.'[8]

Taking these definitions as a basis for his interpretation of architecture, Koenig observes that if he had ten thousand people living in a district he had designed he would clearly be influencing the behavior of ten thousand people, and that this would be an influence more profound and prolonged than if he had delivered some verbal injunction, such as 'Sit down!' His conclusion is that architecture is a system of 'sign vehicles that promote certain kinds of behavior' *par excellence.*[9] Now we could agree with this in general, but it becomes problematic precisely when read in the light of Morris's definitions. Because while the injunction 'Sit down!' is indeed a preparatory-stimulus that in the absence of the actual stimulus-objects can initiate the same response-sequences, while, that is, this injunction is something, *A*, that directs the course of behavior toward a goal in a way similar to the way in which another thing, *B*, would exert control if it were present as a stimulus, *the architectural object is, not at all a preparatory-stimulus that substitutes for a stimulus-object, in its absence, but simply and solely the stimulus-object.* That should be clear from our example of the stair; indeed it is precisely the stair as a sign that defies explanation within the framework of Morris's semiotic theory.

Morris's theory, let us recall, has its own sort of semantic triangle, not unlike the Ogden-Richards one, in that the symbol, or *sign vehicle*, refers indirectly to a *denotatum* and directly to a *significatum* (for which he earlier used the more confusing term *designatum*); the object of a reference is a denotatum 'where what is referred to actually exists as referred to',[10] and the significatum is what the sign refers to (but in the sense that it is 'the conditions such that whatever meets these conditions is a denotatum of [the] sign').[11] As Max Bense, who has taken up Morris's terms while deriving much from Peirce's semiotic theory,[12] explains, the line spectrum from a black-box emitter may designate (or signify) frequencies of radiation emitted by a particular atom, but it does not necessarily denote the presence of that atom; in other words, a sign may have a significatum without having a denotatum (that 'actually exists as referred to'). And Koenig uses the example of someone stopping a car and warning the driver that a mile ahead the road is blocked by a landslide: the words addressed to the driver are the sign, the denotatum is the landslide blocking the road at the specified place, the significatum is the condition of there being a landslide blocking the road at that place. Clearly the person who spoke to the driver might be lying, and if that were the case the sign constituted by his words would have a significatum but no denotatum. What about architectural signs, then?

Koenig finds the notion of significata 'slippery', and so he has preferred the idea that architectural objects must in fact have, besides significata, denotata. But then let us go back to the example of the triumphal arch and accept Morris's terminology and definitions for the sake of argument: even though, as we have suggested, this sign would have more than one significatum, certainly one of its significata would be the possibility of passage; and if the significatum is 'the conditions such that whatever meets these conditions is a denotatum' of the sign, then the denotatum, as one might expect from the fact that the architectural object does not substitute for any stimulus, being itself the stimulus, becomes the triumphal arch itself.[13] (Note that if we were to fill in this schema with other types of significata – as Koenig does in 2.1.4 – we would either fail to come up with denotata or, once again, be introducing something extraneous to semiotics into the characterization of the sign.)

So with the proposition that the relation of signification hinges on the existence of a physical denotatum, Koenig is no closer to a really workable semiotics for architecture than one would be with the Ogden-Richards schema.

2.1.3. The difficulties of Koenig's position derive from accepting the presuppositions of a behaviorist approach to semiotics: the meaning of a sign has to be verified on the basis of response-sequences or objects that can be observed.

But with the semiotic framework preferred in preceding sections of this study, one is not obliged to characterize a sign on the basis of either behavior that it stimulates or actual objects that would verify its meaning: it is characterized only on the basis of *codified meaning that in a given cultural context is attributed to the sign vehicle.* (It is true that even the processes of codification belong to the realm of social behavior; but the codes do not admit of empirical verification either, for although based on constancies inferred from observation of *communicative usages*, they would always be constructed as *structural models*, postulated as a *theoretical hypothesis.*)

That a stair has obliged me to go up does not concern a theory of signification; but that occurring with certain formal characteristics that determine its nature as a *sign vehicle* (just as the verbal sign-vehicle *stairs* occurs as an articulation of certain 'distinctive units') the object communicates to me its possible function – this is a datum of culture, and can be established *independently of apparent behavior, and even of a presumed mental reaction, on my part.* In other words, in the cultural context in which we live (and this is a model of culture that holds for several millennia of history as far as certain rather stable codes are concerned) there exists an architectural form that might be defined as 'an inclined progression of rigid horizontal surfaces upward in which the distance between successive surfaces in elevation, *r*, is set somewhere between 5 and 9 inches, in which the surfaces have a dimension in the direction of the progression in plan, *t*, set somewhere between 16 and 8 inches, and in which there is little or no distance between, or overlapping of, successive surfaces when projected orthographically on a horizontal plane, the sum total (or parts) falling somewhere between 17 and 48 degrees from the horizontal'. (To this definition could of course be added the formula relating *r* to *t*.) And such a form *denotes* the *meaning* 'stair as a possibility of going up' on the basis of a code that I can work out and recognize as operative even if, in fact, no one is going up that stair at present and even though, in theory, no one might ever go up it again (even if stairs are never used again by anyone, just as no one is ever going to use a truncated pyramid again in making astronomical observations).

Thus what our semiotic framework would recognize in the architectural sign is *the presence of a sign vehicle whose denoted meaning is the function it makes possible.*

2.1.4. Koenig contends that the denotata of the architectural sign are *existential* ('quanta' of human existence), and says: 'When a school is built, the denotata of this sign complex . . . are the children who go and study in that school, and the significatum is the fact that those children go to school. The denotata of a house are the members of the family that lives there, while the significatum of a dwelling is the fact that people as a rule divide up into families as far as living under the same roof with others is concerned.'[14] It would be impossible, then, to apply his schema to works of the past that have lost their function (ancient temples or arenas, whose denotata could no longer be the people who used to go there, because they no longer exist and a denotatum must exist actually). Nor of course could we apply it to works of the past whose original function is no longer even understood (megalithic temples, where even the significatum would be obscure, because it cannot be 'the fact that someone used to do something or other there').

So it is clear how much is lost by accepting such a perspective. If to characterize a sign one has to have some corresponding observable behavior, one would be unable to consider something a sign when what corresponding observable behavior there may originally have been no longer exists, or for that matter when it is no longer even known what behavior it originally referred to. In that case, we could no longer recognize the elements of the Etruscan language or the statues of Easter Island or the graffiti of some mysterious civilization as signs, and this in spite of the fact that (*a*) these sign elements still exist, at least as observable and describable physical phenomena, and (*b*) history tends to see that these observable physical phenomena continue to be filled with meanings, through successive interpretations – in spite of the fact that they continue to be regarded as signs, no matter how ambiguous and mysterious they may appear.

2.1.5. The semiotic perspective that we have preferred – with its distinction between sign vehicles and meanings, the former observable and describable apart from the meanings we attribute to them, at least at some stage of the semiotic investigation, and the latter variable but determined by the codes in the light of which we read the sign vehicles – permits us to recognize in architectural signs *sign vehicles capable of being described and catalogued*, which can denote precise functions provided one interprets them in the light of certain codes, and *successive meanings* with which these sign vehicles are capable of being filled, whose attribution can occur, as we will see, not only by way of denotation, but also by way of connotation, on the basis of further codes.

2.1.6. Significative forms, codes worked out on the strength of inferences from usages and proposed as structural models of given communicative relations, denotative and connotative meanings attached to the sign vehicles on the basis of the codes – this is the semiotic universe in which a reading of architecture as communication becomes viable, a universe in which verification through observable physical behavior and actual objects (whether denotata or referents) would be simply irrelevant and in which the only concrete objects of any relevance are *the architectural objects as significative forms*. Within these bounds one can begin to see the various communicative possibilities of architecture.

2.2. *Architectural denotation*

2.2.1. The object of use is, in its communicative capacity, the sign vehicle of a precisely and conventionally denoted meaning – its function. More loosely, it has been said that the first meaning of a building is what one must do in order to inhabit it – the architectural object denotes a 'form of inhabitation'. And it is clear that this denotation occurs even when one is not availing oneself of the denoted inhabitability (or, more generally, the denoted utility) of the architectural object. But we must remember from the outset that there is more to architectural communication than this.

When I look at the windows on the façade of a building, for instance, their denoted function may not be uppermost in my mind; my attention may be turned to a window-meaning that is based on the function but in which the function has receded to the extent that I may even forget it, for the moment, concentrating on relationships through which the windows become elements of an architectural rhythm – just as someone who is reading a poem may, without entirely disregarding the meanings of the words there, let them recede into the background and thereby enjoy a certain formal play in the sign vehicles' contextual juxtaposition. And thus an architect might present one with some false windows, whose denoted function would be illusory, and these windows could still function as windows in the architectural context in which they occur and be enjoyed (given the aesthetic function of the architectural message) as windows.[15]

Moreover windows – in their form, their number, their disposition on a façade (portholes, loopholes, curtain walls, etc.) – may, besides denoting a function, refer to a certain conception of inhabitation and use; they may *connote an overall ideology* that has informed the architect's operation. Round arches, pointed arches, and ogee arches all function in the load-bearing sense and denote this function, but they connote diverse ways of conceiving the function: they begin to assume a symbolic function.

2.2.2. Let us return, however, to denotation and the primary, utilitarian function. We said that the object of use denotes the function *conventionally*, according to codes.

We will leave the problem of the definition of these codes to chapter 4, but let us here consider some of the general conditions under which an object denotes its function conventionally.

According to an immemorial architectural codification, a stair or a ramp denotes the possibility of going up. But whether it is a simple set of steps in a garden or a grand staircase by Vanvitelli, the winding stairs of the Eiffel Tower or the spiraling ramp of Frank Lloyd Wright's Guggenheim Museum, one finds oneself before a form whose interpretation involves not only a codified connection between the form and the function but also a conventional conception of how one fulfills the function with the form. Recently, for example, one has been able to go up also by means of an elevator, and the interpretation of the elevator involves, besides the recognition of the possible function – and rather than being disposed to the motor activity of moving one's feet in a certain way – a conception of how to fulfill the function through the various accessory devices at one's disposal in the elevator. Now the 'legibility' of these features of the elevator might be taken for granted, and presumably their design is such that none of us would have any trouble interpreting them. But clearly a primitive man used to stairs or ramps would be at a loss in front of an elevator; the best intentions on the part of the designer would not result in making the thing clear to him. The designer may have had a conception of the push buttons, the graphic arrows indicating whether the elevator is about to go up or down, and the emphatic floor-level indicators, but the primitive, even if he can guess the function, does not know that these forms are the 'key' to the function. He simply has no real grasp of the *code* of the elevator. Likewise he might possess only fragments of the code of the revolving door and be determined to use one of these as if it were a matter of an ordinary door. We can see, then, that an architect's belief in form that 'follows function' would be rather naïve unless it really rested on an understanding of the processes of codification involved.

In other words, the principle that *form follows function* might be restated: *the form of the object must, besides making the function possible, denote that function clearly enough to make it practicable as well as desirable*, clearly enough to dispose one to the actions through which it would be fulfilled.

2.2.3. Then all the ingenuity of an architect or designer cannot make a new form functional (and cannot give form to a new function) *without the support of existing processes of codification.*

There is an amusing but telling anecdote, which we owe to Koenig, concerning some housing units provided for rural populations in Italy by the 'Development Fund for the South'. With modern dwellings complete with bathrooms and toilets at their disposal, the local people, who were accustomed to taking care of bodily functions in the fields and unprepared for the mysterious sanitary fixtures that arrived, took to using the bowls as cleaning tanks for their olives: they put the olives on some net they had suspended inside, then flushed and proceeded with the washing. So while we can all see that the form of the standard toilet bowl is 'made for' the function it normally suggests and permits, and might be tempted to recognize a profound aesthetic and logical tie

between that form and that function, *in fact the form denotes that function only on the basis of a system of established habits and expectations*, and thus on the basis of a code. And when another code (adventitious but not illegitimate) is superimposed upon the object, the bowl denotes another function.

Perhaps an architect could build me a house that would defy every existing architectural code, and perhaps this house would permit a pleasant and 'functional' form of inhabitation; but it is clear that I will not know how to inhabit it as intended unless I recognize certain 'directions' for its inhabitation built into it, or unless I recognize the house *as a context of signs referable to a known code*. No one has to give me instructions for me to know what to do with a fork, but if I am presented with a new type of mixer, capable of mixing in a way that is more efficient but outside the sphere of established habits, I will need some 'instructions for use'; otherwise the function of the new form would be an unknown.

This does not mean that the architect is necessarily confined to old, already known forms. Here we return to a fundamental semiotic principle that we have discussed elsewhere, apropos of artistic messages, a principle quite well explained in the *Poetics* of Aristotle: *one can institute moments of high information-content, but only when they are supported by a certain amount of redundancy*; every flash of the unlikely rests on articulations of the likely.[16]

2.2.4. A work of art can certainly be something new and highly informative; it can present articulations of elements that correspond to an idiolect of its own and not to preexisting codes, for it is essentially an object intended to be contemplated, and it can communicate this new code, implicit in its makeup, precisely by fashioning it on the basis of the preexisting codes, evoked and negated. Now an architectural object could likewise be something new and informative; and if intended to promote a new function, it could contain in its form (or in its relation to comparable familiar forms) indications for the 'decoding' of this function. It too would be playing upon elements of preexisting codes, but rather than evoking and negating the codes, as the work of art might, and thus directing attention ultimately to itself, it would have to progressively transform them, progressively deforming already known forms and the functions conventionally referable to these forms. Otherwise the architectural object would become, not a functional object, but indeed a work of art: an ambiguous form, capable of being interpreted in the light of various different codes. Such is the case with 'kinetic' objects that simulate the outward appearance of objects of use; objects of use they are not, in effect, because of the underlying ambiguity that disposes them to any use imaginable and so to none in particular. (It should be noted that the situation of an object open to any use imaginable – and subject to none – is different from that of an object subject to a number of determinate uses, as we will see.)

One might well wish to go further into the nature of architectural denotation (here described only roughly, and with nothing in the way of detailed analysis). But we also mentioned possibilities of architectural connotation, which should be clarified.

2.3. *Architectural connotation*

2.3.1. We said that besides denoting its function the architectural object could connote a certain ideology of the function. But undoubtedly it can connote other things. The cave in our hypothetical model of the beginning of architecture came to denote a shelter function, but no doubt in time it would have begun to connote 'family' or 'group', 'security', 'familiar surroundings', etc. Then would its connotative nature, this symbolic 'function' of the object, be less *functional* than its first function? In other words, given that the cave denotes a certain basic *utilitas* (to borrow a term from Koenig), there is the question whether, with respect to life in society, the object would be *any less useful* in terms of its ability, as a symbol, to connote such things as closeness and familiarity. (From the semiotic point of view, the connotations would be founded on the denotation of the primary *utilitas*, but that would not diminish their importance.)

A seat tells me first of all that I can sit down on it. But if the seat is a throne, it must do more than seat one: it serves to seat one with a certain dignity, to corroborate its user's 'sitting in dignity' – perhaps through various accessory signs connoting 'regalness' (eagles on the arms, a high, crowned back, etc.). Indeed the connotation of dignity and regalness can become so functionally important that the basic function, to seat one, may even be slighted, or distorted: a throne, to connote regalness, often demands that the person sitting on it sit rigidly and uncomfortably (along with a scepter in his right hand, a globe in the left, and a crown on his head), and therefore seats one 'poorly' with respect to the primary *utilitas*. Thus to seat one is only one of the functions of the throne – and only one of its meanings, the first but not the most important.

2.3.2. So the title *function* should be extended to all the uses of objects of use (in our perspective, to the various communicative, as well as to the denoted, functions), for with respect to life in society the 'symbolic' capacities of these objects are no less 'useful' than their 'functional' capacities. And it should be clear that we are not being metaphorical in calling the symbolic connotations functional, because although they may not be immediately identified with the 'functions' narrowly defined, they do represent (and indeed communicate) in each case a real social utility of the object. It is clear that the most important function of the throne is the 'symbolic' one; and clearly evening dress (which, instead of serving to cover one like most everyday clothing, often 'uncovers' for women and for men covers poorly, lengthening to tails behind while leaving the chest practically bare) is functional because, thanks to the complex of conventions it connotes, it permits certain social relations, confirms them, shows their acceptance on the part of those who are communicating, with it, their social status, their decision to abide by certain rules, and so forth.[17]

3. *ARCHITECTURAL COMMUNICATION AND HISTORY*

3.1. *Primary functions and secondary functions*

Since it would be awkward from here on to speak of 'functions' on the one hand, when referring to the denoted *utilitas*, and of 'symbolic' connotations on the other, as if the latter did not likewise represent real functions, we will speak of a *'primary' function* (which is denoted) and of a complex of *'secondary' functions* (which are connotative). It should be remembered, and is implied in what has already been said, that the terms *primary* and *secondary* will be used here to convey, not an axiological discrimination (as if the one function were more important than the others), but rather a semiotic mechanism, in the sense that the secondary functions rest on the denotation of the primary function (just as when one has the connotation of 'bad tenor' from the word for 'dog' in Italian, *cane*, it rests on the process of denotation).

3.1.1. Let us take a historical example where we can begin to see the intricacies of these primary and secondary functions, comparing the records of interpretation history has left us. Architectural historians have long debated the code of the Gothic, and particularly the structural value of the ogive. Three major hypotheses have been advanced: (1) the ogive has a structural function, and the entire lofty and elegant structure of a cathedral stands upon it, by virtue of the miracle of equilibrium it allows; (2) the ogive has no structural value, even if it

gives the opposite impression; rather, it is the webs of the ogival vault that have the structural value; (3) the ogive had a structural value in the course of construction, functioning as a sort of provisional framework; later, the interplay of thrusts and counterthrusts was picked up by the webs and by other elements of the structure, and in theory the ogives of the cross vaulting could have been eliminated.[18]

No matter which interpretation one might adhere to, no one has ever doubted that the ogives of the cross vaulting *denoted* a structural function – support reduced to the pure interplay of thrusts and counterthrusts along slender, nervous elements; the controversy turns rather on the referent of that denotation: is the denoted function an illusion? Even if it is illusory, then, the communicative value of the ogival ribbing remains unquestionable; indeed if the ribbing had been articulated only to *communicate* the function, and not to *permit* it, that value would, while perhaps appearing more valid, simply be more intentional. (Likewise, it cannot be denied that the word *unicorn* is a sign, even though the unicorn does not exist, and even though its nonexistence might have been no surprise to those using the term.)

3.1.2. While they were debating the functional value of ogival ribbing, however, historians and interpreters of all periods realized that the code of the Gothic had also a 'symbolic' dimension (in other words, that the elements of the Gothic cathedral had some complexes of secondary functions to them); one knew that the ogival vault and the walls pierced with great windows had something connotative to communicate. Now what that something might be has been defined time and again, on the basis of elaborate connotative subcodes founded on the cultural conventions and intellectual patrimony of given groups and given periods and determined by particular ideological perspectives, with which they are congruent.

There is, for example, the standard romantic and protoromantic interpretation, whereby the structure of the Gothic cathedral was intended to reproduce the vault of Celtic forests, and thus the pre-Roman world, barbaric and primitive, of druidical religiosity.

And in the medieval period, legions of commentators and allegorists put themselves to defining, according to codes of formidable precision and subtlety, the individual meanings of every single architectural element; it will suffice to refer the reader to the catalogue drawn up, centuries later, by Joris Karl Huysmans in his *La cathédrale*.

3.1.3. But there is, after all, a singular document we could mention – a code's very constitution – and that is the justification Suger gives of the cathedral in his *De rebus in administratione sua gestis*, in the twelfth century.[19] There he lets it be understood, in prose and in verse, that the light that penetrates in streams from the windows into the dark naves (or the structure of the walls that permits the light to be offered such ample access) must represent the very effusiveness of the divine creative energy, a notion quite in keeping with certain Neoplatonic texts and based on a codified equivalence between light and participation in the divine essence.[20]

We could say with some assurance, then, that for men of the twelfth century the Gothic windows and glazing (and in general the space of the naves traversed by streams of light) connoted 'participation' (in the technical sense given the term in medieval Neoplatonism); but the history of the interpretation of the Gothic teaches us that over the centuries the same sign vehicle, in the light of different subcodes, has been able to connote diverse things.

3.1.4. Indeed in the nineteenth century one witnessed a phenomenon typical of the history of art – when in a given period a code in its entirety (an artistic style, a manner, a 'mode of forming', independently of the connotations of its individual manifestations in messages) comes to connote an ideology (with which it was intimately united either at the moment of its birth or at the time of its most characteristic affirmation). One had at that time the identification 'Gothic style = religiosity', an indentification that undoubtedly rested on other, preceding connotative identifications, such as 'vertical emphasis = elevation of the soul Godward' or 'contrast of light streaming through great windows and naves in shadows = mysticism'. Now these are connotations so deeply rooted that even today some effort is required to remember that the Greek temple too, balanced and harmonious in its proportions, could connote, according to another lexicon, the elevation of the spirit to the Gods, and that something like the altar of Abraham, on the top of a mountain, could evoke mystical feelings; thus one connotative lexicon may impose itself over others in the course of time and, for example, the contrast of light and shadow becomes what one most deeply associates with mystic states of mind.

A metropolis like New York is studded with neo-Gothic churches, whose style (whose 'language') was chosen to express the presence of the divine. And the curious fact is that, by convention, these churches still have (for the faithful) the same value today, in spite of the fact that skyscrapers – by which they are now hemmed in on every side, and made to appear very small, almost miniaturized – have rendered the verticality emphasized in this architecture all but indistinguishable. An example like this should be enough to remind us that there are no mysterious 'expressive' values deriving simply from the nature of the forms themselves, and that expressiveness arises instead from a dialectic between significative forms and codes of interpretation; for otherwise the Gothic churches of New York, which are no longer as distinctively attenuated and vertical as they used to be, would no longer express what they used to, while in fact they still do in some respects, and precisely because they are 'read' on the basis of codes that permit one to recognize them as distinctively vertical *in spite of* the new formal context (and new code of reading) the advent of the skyscraper has now brought about.

3.2. *Architectural meanings and history*

3.2.1. It would be a mistake, however, to imagine that by their very nature architectural sign-vehicles would denote stable primary functions, with only the secondary functions varying in the course of history. The example of ogival ribbing has already shown us a denoted function undergoing curious fluctuations – it was considered by some effective and essential, but by others provisional or illusory – and there is every reason to believe that in the course of time certain primary functions, no longer effective, would no longer even be denoted, the 'addressees' no longer possessing the requisite codes.

So, in the course of history, both primary and secondary functions might be found undergoing losses, recoveries, and substitutions of various kinds. These losses, recoveries, and substitutions are common to the life of forms in general, and constitute the norm in the course of the reading of works of art proper. If they seem more striking (and paradoxical) in the field of architectural forms, that is only because according to the common view one is dealing there with functional objects of an unequivocally indicated, and thus *univocally* communicative, nature; to give the lie to such a view, there is the story – its very currency puts its authenticity in doubt, but if untrue it is in any case credible – about the native wearing an alarm clock on his chest, an alarm clock interpreted as a pendant (as a kind of 'kinetic jewelry', one might say) rather than as a timepiece: the clock's measurement of time, and indeed the very notion of 'clock time' (see Bergson), is the fruit of a codification and comprehensible only on the basis of it.

One type of fluctuation in the life of objects of use can therefore be seen in the variety of readings to which they are subject, regarding both primary and secondary functions. We will here attempt only a rough breakdown, with no pretense at completeness.

3.2.2. In the course of history, or passing from one human group to another, an object of use might be found undergoing one or another of these readings:

1. (*a*) *The sense of the primary function is lost* and (*b*) *the secondary functions for the most part remain.* Such is the case with the Parthenon, which is no longer understood as a place of worship, but a number of the original symbolic connotations of which are still grasped, on the strength of an adequate philological familiarity with the Greek sensibility.
2. (*a*) *The primary function remains* and (*b*) *the secondary functions are lost.* Antique lamps taken up without regard for their original connotative codes and inserted in different stylistic contexts (a rustic lamp included among sophisticated furnishings): their primary functionality is preserved, as they are still used to illuminate. (Of course the original secondary functions will in all probability only be replaced by others, or even recovered and deformed, as in some of the following cases.)
3. (*a*) *The primary function is lost*, (*b*) *most secondary functions are lost*, and (*c*) *the original secondary functions are replaced by others, through codes of enrichment.* The Pyramids, for example: they may no longer be experienced as a tomb for a monarch, and most of the symbolic code – astrological and geometric – that presided over their connotative effectiveness for the ancient Egyptians has been lost, but the Pyramids now connote other things, from 'tourism' to the portentous 'forty centuries' of Napoleon's exhortations.
4. *The primary function becomes the object of a secondary function.* This is the case with the ready-made: a selected object of use is made an object of contemplation and then ironically connotes its former use. (For an example by way of analogy, the comic strip blown up by Lichtenstein: the woman-in-tears image no longer denotes a woman in tears – it communicates rather 'fragment of comic strip' – and it begins to connote, among other things, 'the way a woman in tears is seen in comic-strip culture'.)
5. (*a*) *The primary function is lost*, (*b*) *another primary function takes its place*, and (*c*) *the secondary functions are deformed through codes of enrichment.* A cradle from a Mexican village transformed into a magazine holder, put to a new use: the connotations originally connected with the object and its decorations, the connotations valid for the original users, are deformed, so that something different is connoted, such as affinities with contemporary or primitive art, folksy naïveté, 'Latin-Americanness', and so on.
6. (*a*) *The primary functions are vague* and (*b*) *the secondary functions are imprecise and deformable.* Such is the case with Brasília's 'Plaza of the Three Powers': the concave and convex forms of the amphitheaters of the two houses and the vertical form of the central building do not, except perhaps to their users, denote their primary functions – the amphitheaters seem to us pieces of sculpture – and have not become closely connected with any generally recognized connotative meanings; from the beginning there have been those who would interpret the symbols maliciously, seeing in the concave form of the Câmara a great dish in which the people's representatives are helping themselves to large portions of the public revenues.

3.3. *Consumption and recovery of forms*

3.3.1. The dialectical interplay between forms and history is an interplay between structures and events, between configurations that are physically stable (and objectively describable) as significative forms and the constantly changing play of circumstances, which confers new meanings on them.

Now this process clearly underlies what has been called *consumption* of forms, *obsolescence* of values.[21] And in a period like ours, in which the succession of events is very rapid – in which technological progress, social mobility, and the spread of communications combine to change the codes more frequently and profoundly than before – such consumption becomes, of course, quite evident; this may be why, even though it is not a new phenomenon (it arises from the very nature of processes of communication), its theoretical investigation has begun rather recently.

But the same process, while providing the conditions of this consumption, provides the conditions of the *recovery* of forms and the *rediscovery* of senses.

3.3.2. A paradoxical aspect of contemporary taste is that while we seem to be in a period characterized by rapid consumption of forms (because of a rapid succession of codes and ideological backgrounds), we are also in a period of history in which forms are recovered relatively quickly, and for that matter preserved beyond apparent obsolescence. Ours is a time of cultural awareness and philological agility; with our special feeling for history and for the relativity of cultures, it has become almost second nature to 'philologize' [*3*]. The modern 'consumer' of messages learns, decade by decade, to rediscover codes of reading for forms that have become antiquated, to rediscover forgotten ideological backgrounds and revive them in the process of trying to understand objects that developed from them. (The recent vogue of art nouveau is an example.) He learns, it is true, to 'distort' past forms, to read these expropriated messages in some 'free' or aberrant fashion, but he also learns to rediscover the keys to 'correct' readings of them: his cultural awareness leads him to a philological recovery of the proper codes, though his agility in recoveries frequently results in curious semantic 'shifts'.

Moreover, while the normal growth and obsolescence of particular communicative systems (or rhetorical apparatus) followed in the past a sinusoidal pattern – Dante having disappeared entirely to rationalist readers of the eighteenth century, then to be revived by the romanticists – today it is more like a diverging spiral, in the sense that obsolete systems are often 'shelved', not abandoned, and every rediscovery is also an accretion of some kind. Our rereading of art nouveau is based not only on what we have rediscovered of the codes and ideologies of the turn-of-the-century bourgeoisie, but also on codes and ideological perspectives peculiar to our times (codes of enrichment), which permit us to insert antiquarian objects in new contexts, to use them both for something of what they meant in the past and for the connotations that we attribute to them on the basis of our present-day subcodes. It is an engrossing and adventurous process, rediscovering, given a form, the original contexts and creating new contexts – like a great pop-art operation, what (discerning its prototype in the technique of the surrealist ready-made) Claude Lévi-Strauss has called *semantic fission*, an abstraction of the sign from its original context and a reinsertion of it in a new context, which charges it with different meanings.[22] So consumption gives way to accretion, with the preservation and rediscovery of codes of the past going hand in hand with the employment of contemporary codes (Lichtenstein charging the comic-strip image with new meanings and at the same time inducing us to recall the denotations and connotations operative for the naïve reader of comics).

3.3.3. That is not to say, however, that this dynamics, part philology and part re-creation, is always 'positive'. In the past as well there were rediscoveries of former rhetorics and ideologies involving a mixture of philology and semantic fission – what else was humanism, and those anticipations of humanism in the vital, if muddled, rediscoveries of classicality of the Carolingian Middle Ages and thirteenth-century Scho-

3. A recent 'Believe It or Not!'


Ripley's Believe It or Not!
THE SHELL of the HAWKSBILL TURTLE WAS USED BY THE ANCIENT ROMANS AS A SHIELD IN BATTLE AND AS A BATHTUB AND CRADLE FOR THEIR CHILDREN
MODERN APARTMENT HOUSES in Barcelona, Spain, OFTEN ARE BUILT WITH A WAVY FAÇADE --TO EMPHASIZE THE CITY'S SEAPORT ATMOSPHERE
THE FAMED CONCERT PIANIST WHOSE MIND WAS NEVER ON HIS WORK
Ernst Lengyel von Bagota (1893-1914)
ONE OF EUROPE'S MOST CELEBRATED MUSICIANS, INSTEAD OF PLACING MUSICAL SCORES ON HIS PIANO RACK SPREAD OUT A NUMBER OF TIMETABLES --AND MEMORIZED THEM AS HE PLAYED CONCERTS!
3-28
THE OFFICIAL EMBLEM of Penzance, England, BECAUSE THE CITY'S NAME MEANS "HOLY HEAD" IN BRYTHONIC THE LANGUAGE OF ANCIENT BRITAIN, FEATURES THE HEAD OF ST. JOHN THE BAPTIST ON A SERVING DISH
Jonathan Tate
Died 1763, age 14,
Effected by inoculation
The means employed his life to save
Hurried him headlong to the grave
Epitaph in NORTH CEMETERY, VERNON, VT.
THE MAN WHO WAS LIVING PROOF THAT BACHELORS LIVE LONGER!
SEBASTIÃO AGUILAR (1802-1902) of Santarem, Portugal, REFUSED TO MARRY BECAUSE HE WAS THE POSTHUMOUS SON OF A POSTHUMOUS SON OF A POSTHUMOUS SON
HIS FATHER, ANGELO, AND HIS GRANDFATHER, ESTEVÃO, EACH DIED 5 MONTHS BEFORE THE BIRTH OF HIS ONLY SON --BUT SEBASTIÃO, A BACHELOR, LIVED TO THE AGE OF 100
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lasticism? And then, it is true, the rediscovery, pursued rather seriously and over a long period of time, could result in a certain overall restructuring of the contemporary rhetorics and ideologies. But today the dynamics of rediscovery and revival tends to be more contracted and superficial, leaving the underlying cultural system undisturbed; we can see in the present pursuit of rediscoveries a rhetorical technique (now conventionalized) that in fact implies a stable ideology of a sort: a laissez-faire attitude toward values past and present.

We have, besides rapid and conspicuous obsolescence, a stream of recoveries. But our recoveries, in a lightly pulsating alternation of acceptance and rejection, are far from 'revolutionizing' the bases of our culture. It is as if the present rediscoveries of codes and ideologies were the product of an immense rhetorical processor, whose overall operation connotes (and is directed by) the ideology of 'modernity' as *'tolerance' toward the entire past.*

An ideology as indulgent as this puts one in the peculiar position of being able to take up practically anything from the repertory of known forms and read it (or have it read) without ideological repercussions; it permits one to entertain all the ideologies of the past as keys to these modern messages, but these are messages with which even the accretions can fail to make up for a certain loss of significance, because the meanings of the forms are more and more eroded and provisional.

3.3.4. Given this inevitable process, with history voraciously emptying and filling forms, divesting them of meanings and adding new ones, there is perhaps nothing to do but simply resign oneself and rely upon what must be an instinctive wisdom in groups and cultures, which appear to be able, time after time, to find and manipulate forms and significative systems as needed or desired. And yet there is something puzzling and sad about forms that have outlived their usefulness, so to speak, that have lost their original significative power and become rather cumbersome, rather unwieldy and complex, with respect to the uses to which they are finally put. We are surrounded by these relics stripped of sense, or whose sense is now out of proportion with them, relics owing their prolonged life at best to aesthetic or historical interest, but more often to simple momentum or inordinate codes of enrichment that have been found for them (and here one sinks to concoctions of 'rhetoric' in the narrow, negative sense of the term, like the Pyramids as used in Napoleon's exhortations to his troops).

There is also the phenomenon – typical of our period, and sometimes very disappointing – of objects whose primary functions remain intact but whose secondary functions have withered away, certain subcodes having perished long before the basic codes, with slight shifts in taste. This is the case with an automobile that is still good for driving but that no longer connotes the prestige or comfort, or even the 'handleability', it used to. And here we can see the impact of 'styling' operations: periodically providing new symbolic clothing for more or less unchanged primary functions, or enriching with new connotations (or old connotations under new connotative forms) basic functional meanings that remain the same (just as, in the case of the automobile, the ideological background of a culture founded on mechanical devices and their efficiency remains the same).

Indeed a good deal of our manipulation of forms today – employing codes of enrichment with some and putting others aside, or rediscovering one code only to move on to another – is at bottom only a variety of styling. Take the rediscovery of the refectory table: a number of the original connotative subcodes have been restored to the message (there has been some degree of philological accuracy), but in the process these have been complicated with codes of enrichment, the refectory table has been inserted among sophisticated furnishings, semantic fission has had its effect, and the main secondary function of this table, which was to symbolize the frugal repast, has been radically deformed; the end result has been a 'restyled' dining table, for what the refectory table does is provide a new connotative enrichment of the same primary function we had with previous tables, and without ideological repercussions, for it no longer promotes or implies ascetic meals.

So we return to what was suggested earlier: the 'philological' vocation of our time may very well further recoveries of forms, but they are at the same time drained of significance. Perhaps this has something to do with what Nietzsche referred to as the *historical sickness* of the modern world, an excess of awareness, an awareness that, not transformed into renewal, acts as a narcotic.

There might be an alternative, however, a way in which changes in our rhetorical systems *could* mean renewal and changes in our ideological perspectives (whether as consequences of such renewal or as something that promotes it). There might be an alternative to the cycles of rediscovery and oblivion that our world puts *already produced* forms through – and the logic of which belongs really to such special domains as clothing fashions and the antique business.

We are today well aware of the rapid loss of sense to which forms are subject, and their capacity for acquiring new senses. (Whether these new senses seem appropriate or illegitimate at first does not matter, because *use* will determine which of them will be legitimated – imagine that cossacks are found watering their horses at the stoups of Saint Peter's: there would be something like what was listed as the fifth possibility in 3.2.2, but while the cossacks' general might find the resemanticization most appropriate, the sacristan of Saint Peter's would no doubt find it unthinkable, and it would remain to be seen which side history would favor.) And thus since the producers of objects of use now presumably *know* that these sign vehicles they articulate will undergo an unpredictable flux of meanings, since the designers of forms are now presumably aware of the process of dissociation between form and meaning and the mechanisms of substitution of meaning, they might undertake to *design for variable primary functions and 'open' secondary functions.*

This would mean that the object would be no victim of obsolescence and consumption, and no passive protagonist of recoveries: it would be instead a continuing stimulus, communicating the possibility of operations through which it could continually be reworked to fit the situations developing in the course of history – operations that would be acts of responsible decision, based on comparisons of the forms with alternative configurations their constitutive elements could assume and comparisons of these with the ideological perspectives that would be their justification.

These would be protean and open objects, implying, with changes in the rhetorical apparatus constituted by them, a restructuring of the ideological apparatus, or with changes in the way they are used (or in the form they take in use), change in ways of thinking, in how the forms are seen in the broadest context of human activity.

And the ludic activity of repeatedly discovering meanings for things, no longer turned to dilettantish rummagings into the past, could take the direction of *inventing, not rediscovering, different codes.* The jump backward is replaced by a jump forward. Abandoning oneself to the curiosities of history gives way to a kind of *design of the future.*[23]

The alternatives might be put thus: in 'recovering' fragments of an existing city I might perhaps rediscover antiquated rhetorical codes and forgotten ideological backgrounds, but in the game of recovery, as we said, there will as a rule be only superficial consequences, with my basic codes and ideologies remaining generally the same; but if I had before me an urban macrostructure that would clearly accommodate any number of changes in my basic conception of the city and were prompted to invent a particular disposition of it for my future use, my activity could become anything but superficial, for I might have to restructure my basic codes, in deciding what to make of it, and even my ideological perspective, for clearly in deciding what to make of it I might be prompted to alter my behavior overall.

The use of forms, or rhetorics, that hold within them these possibilities of change in conjunction with restructuring of ideological perspectives would be something quite different from our 'philological' activity. In the latter one can enjoy (but only up to a point) the rediscovery of forms of the past and the insertion of them, with semantic fission, into one's accustomed contexts, but in the former one would be dealing no longer with obsolescent forms: one would be engaged in giving new meanings to forms that are made for transformation, and that will be transformed precisely when one decides they should be and decides what directions the transformations should take.

So against the background of the historical dynamics of death and rebirth of already produced forms – sometimes traumatic and vital (humanism), sometimes tranquil and ludic (the recent rediscovery of art nouveau) – appears the positive possibility of an invention of rhetorics that would provide for different ideological perspectives, or for a continual reworking of the signs and of the contexts in which they would acquire meaning.

4. *ARCHITECTURAL CODES*

4.1. *What is a code in architecture?*

4.1.1. Architectural signs as denotative and connotative according to codes, the codes and subcodes as making different readings possible in the course of history, the architect's operation as possibly a matter of 'facing' the likelihood of his work being subject to a variety of readings, to the vicissitudes of communication, by designing for variable primary functions and open secondary functions (open in the sense that they may be determined by unforeseeable future codes) – everything that has been said so far might suggest that there is little question about what is meant by *code*.

As long as one confines oneself to verbal communication, the notion is fairly clear: there is a code-language, and there are certain connotative subcodes. But when, in another section of this study, we went on to consider visual codes, for example, we found we had to list a number of levels of codification (including, but not limited to, iconic and iconographic codes), and in the process to introduce various 'clarifications' of the concept of code, and on the different types of articulation a code may provide for.[24] We also saw the importance of the principle that the elements of articulation under a given code can be syntagms of another, more 'analytic' code, or that the syntagms of one code can turn out to be elements of articulation (possibly at either of the levels of a 'double articulation') of another, more 'synthetic' code; this should be kept in mind when considering codes in architecture, for one might be tempted to attribute to an architectural code articulations that belong really to some code, either more analytic or more synthetic, lying outside architecture.

4.1.2. We can expect some problems, then, in the definition of the codes of architecture. First of all, from the attempts there have been to date to spell out aspects of architectural communication, we can see that there is the problem of neglecting to consider whether what one is looking at is referable to a syntactic code rather than a semantic code – that is, to rules concerning, rather than the meanings conventionally attributed to individual sign-vehicles, the articulation of certain significative structures separable from these sign vehicles and their meanings – or for that matter to some underlying technical convention.

Catchwords like 'semantics of architecture' have led some to look for the equivalent of the 'word' of verbal language in architectural signs, for units endowed with definite meaning, indeed for symbols referring to referents. But since we know there can be conventions concerning only the syntactic articulation of signs, it would be appropriate to look also for purely syntactic codifications in architecture (finding such codifications, and defining them with precision, we might be in a better position to understand and classify, at least from the point of view of semiotics, objects whose once denoted functions can no longer be ascertained, such as the menhir, the dolmen, the Stonehenge construction).

4.1.3. Then, too, in the case of architecture, codes of reading (and of construction) of the *object* would have to be distinguished from codes of reading (and of construction) of the *design* for the object (admittedly we are considering here only a semiotics of architectural objects, and not a semiotics of architectural designs). Of course the notational codes of the design, while conventionalized independently, are to some extent derivatives of the codes of the object: they provide ways in which to 'transcribe' the object, just as to transcribe spoken language there are conventions for representing such elements as sounds, syllables, or words. But that does not mean a semiotic investigation of the architectural design would be without some interesting problems of its own – there are in a design, for example, various systems of notation (the codes operative in a plan are not quite the same as those operative in a section or in a wiring diagram for a building),[25] and in these systems of notation there can be found iconic signs, diagrams, indices, symbols, qualisigns, sinsigns, etc., perhaps enough to fill the entire gamut of signs proposed by Peirce.

4.1.4. Much of the discussion of architecture as communication has centered on *typological* codes, especially semantic typological codes, those concerning functional and sociological types; it has been pointed out that there are in architecture configurations clearly indicating 'church', 'railroad station', 'palace', etc. We will return to typological codes in 4.2, but it is clear that they constitute only one, if perhaps the most conspicuous, of the levels of codification in architecture.

4.1.5. In attempting to move progressively back from a level at which the codes are so complex and temporal – for it is clear that 'church' has found different articulations at different moments in history – one might be tempted to hypothesize for architecture something like the 'double articulation' found in verbal languages, and assume that the most basic level of articulation (that is, the units constituting the 'second' articulation) would be a matter of geometry.

If architecture is the art of the articulation of spaces,[26] then perhaps we already have, in Euclid's geometry, a good definition of the rudimentary code of architecture. Let us say that the second articulation is based on the Euclidean στοιχεῖα (the 'elements' of classical geometry); then the 'first' articulation would involve certain higher-level spatial units, which could be called *choremes*, with these combining into spatial syntagms of one kind or another.[27] In other words, the angle, the straight line, the various curves, the point, etc., might be elements of a second articulation, a level at which the units are not yet *significant* (endowed with meaning) but are *distinctive* (having differential value); the square, the triangle, the parallelogram, the ellipse – even rather complicated irregular figures, as long as they could be defined with geometric equations of some kind – might be elements of a first articulation, a level at which the units begin to be significant; and one rectangle within another might be an elementary syntagmatic combination (as in some window-wall relationship), with more complex syntagms to be found in such things as space-enclosing combinations of rectangles or articulations based on the Greek-cross plan. Of course solid geometry suggests the possibility of a third level of articulation, and it could be assumed that further articulative possibilities would come to light with the recognition of non-Euclidean geometries.

The trouble is that this geometric code *would not pertain specifically to architecture*. Besides lying behind some artistic phenomena –

and not just those of abstract, geometric art (Mondrian), because it has long been held that the configurations in representational art can be reduced to an articulation, if perhaps a quite complex one, of primordial geometric elements – this code clearly underlies the formulations of geometry in the etymological sense of the word (surveying) and other types of 'transcription' of terrain (topographic, geodetic, etc.). It might even be identified with a 'gestaltic' code presiding over our perception of all such forms. What we have here, then, is an example of one sort of code one can arrive at when attempting to analyze the elements of articulation of a certain 'language': a code capable of serving as a *metalanguage* for it, and for a number of other more synthetic codes as well.

4.1.6. So it would be better to pass over a code of this kind, just as in linguistics one passes over the possibility of going beyond 'distinctive features' in analyzing phonemes. Admittedly such analytic possibilities might have to be explored if one had to compare architectural phenomena with phenomena belonging to some other 'language', and thus had to find a metalanguage capable of describing them in the same terms – for instance, one might wish to 'code' a certain landscape in such a way as to be able to compare it with certain proposed architectural solutions, to determine what architectural artifacts to insert in the context of that landscape, and if one resorted to elements of the code of solid geometry (pyramid, cone, etc.) in defining the structure of the landscape, then it would make sense to describe the architecture in the light of that geometric code, taken as a metalanguage.[28] *But the fact that architecture can be described in terms of geometry does not indicate that architecture as such is founded on a geometric code.*

After all, that both Chinese and words articulated in the phonemes of the Italian language can be seen as a matter of amplitudes, frequencies, wave forms, etc., in radioacoustics or when converted into grooves on a disk does not indicate that Chinese and Italian rest on one and the same code; it simply shows that the languages admit of that type of analysis, that for certain purposes they can be *reduced* to a common system of transcription. In fact there are few physical phenomena that would not permit analysis in terms of chemistry or physics at the molecular level, and in turn an atomic code, but that does not lead us to believe the Mona Lisa should be analyzed with the same instruments used in analyzing a mineral specimen.

Then what more properly architectural codes have emerged in various analyses or, recently, 'semiotic' readings of architecture?

4.2. *Varieties of architectural code*

4.2.1. It would appear, from those that have come to light, that architectural codes could be broken down roughly as follows:

1. *Technical codes*. To this category would belong, to take a ready example, articulations of the kind dealt with in the science of architectural engineering. The architectural form resolves into beams, flooring systems, columns, plates, reinforced-concrete elements, insulation, wiring, etc. There is at this level of codification no communicative 'content', except of course in cases where a structural (or technical) function or technique itself becomes such; there is only a structural logic, or structural conditions behind architecture and architectural signification – conditions that might therefore be seen as somewhat analogous to a second articulation in verbal languages, where though one is still short of meanings there are certain formal conditions of signification.[29]
2. *Syntactic codes*. These are exemplified by typological codes concerning articulation into *spatial types* (circular plan, Greek-cross plan, 'open' plan, labyrinth, high-rise, etc.), but there are certainly other syntactic conventions to be considered (a stairway does not as a rule go through a window, a bedroom is generally adjacent to a bathroom, etc.).
3. *Semantic codes*. These concern the significant units of architecture, or the relations established between individual architectural sign-vehicles (even some architectural syntagms) and their denotative and connotative meanings. They might be subdivided as to whether, through them, the units (*a*) denote *primary functions* (roof, stairway, window), (*b*) have connotative *secondary functions* (tympanum, triumphal arch, neo-Gothic arch), (*c*) connote *ideologies of inhabitation* (common room, dining room, parlor), or (*d*) at a larger scale have typological meaning under certain *functional and sociological types* (hospital, villa, school, palace, railroad station).[30]

The inventory could of course become quite elaborate – there should, for instance, be a special place for types like 'garden city' and 'new town', and for the codifications emerging from certain recent *modi operandi* (derived from avant-garde aesthetics) that have already created something of a tradition, a *manner*, of their own.

4.2.2. But what stands out about these codes is that on the whole they would appear to be, as communicative systems go, rather limited in operational possibilities. They are, that is, codifications of *already worked-out solutions*, codifications yielding *standardized messages* – this instead of constituting, as would codes truly on the model of those of verbal languages, a system of possible relationships from which countless significantly different messages could be generated.

A verbal language serves the formulation of messages of all kinds, messages connoting the most diverse ideologies (and is inherently neither a class instrument nor the superstructure of a particular economic base).[31] Indeed the diversity of the messages produced under the codes of a verbal language makes it all but impossible to identify any overall ideological connotations in considering broad samplings of them. Of course this characterization might be challenged, for there is some evidence to support the theory that the very way in which a language is articulated obliges one speaking it to see the world in a particular way (there might be, then, ideological bias and connotation of some kind inherent in the language).[32] But even given that, on the most profound, ultimate level, one could take a verbal language as a *field of (nearly absolute) freedom*, in which the speaker is free to improvise novel messages to suit unexpected situations. And in architecture, if the codes are really those indicated above, that does not seem to be the case.

The point is not that in articulating a church, for example, the architect is in the first place obeying a socioarchitectural prescription that churches be made and used (about this sort of determinant we will have more to say later). And in the end he would be free to try to find and exploit – playing on the dialectic mentioned in 2.2.3, between information and redundancy – some way in which to make a church that while conforming to its type would be somewhat different from any that had yet appeared, a church that would thereby provide a somewhat unaccustomed, 'refreshing' context in which to worship and imagine the relationship with God. But if at the same time, in order for it to *be* a church, he must unfailingly articulate the building in manifold conformity to a type ('down to the hardware', one might say), if the codes operative in architecture allow only slight deviations from a standardized message, however appealing, then architecture is, not the field of creative freedom some have imagined it to be, but a system of rules for giving society what it *expects* in the way of architecture.

In that case architecture might be considered, not the service some have imagined it to be – a mission for men of unusual culture and vision, continually readying new propositions to put before the social body – but a service in the sense in which waste disposal, water supply, and mass transit are services: an operation that is, even with changes

and technical refinements from time to time, the routine satisfaction of some preconstituted demand.

It would appear to be rather impoverished as an art, then, also, if it is characteristic of art, as we have suggested elsewhere, to put before the public things they have not yet come to expect.[33]

4.2.3. So the codes that have been mentioned would amount to little more than lexicons on the model of those of iconographic, stylistic, and other specialized systems, or limited repertories of set constructions. They establish not generative possibilities but ready-made solutions, not open forms for extemporary 'speech' but fossilized forms – at best 'figures of speech', or schemes providing for formulaic presentation of the unexpected (as a complement to the system of established, identified, and never really disturbed expectations), rather than relationships from which communication varying in information content as determined by the 'speaker' could be improvised. The codes of architecture would then constitute a rhetoric in the narrow sense of the word: a store of *tried and true discoursive formulas.*[34]

And this could be said not only of the semantic codes, but also of the syntactic codifications, which clearly confine us to a certain quite specialized 'grammar' of building, and the technical codes, for it is obvious that even this body of 'empty' forms underlying architecture (column, beam, etc.) is too specialized to permit every conceivable architectural message: it permits a kind of architecture to which civilization in its evolving technologies has accustomed us, a kind relating to certain principles of statics and dynamics, certain geometric concepts, many of them from Euclid's geometry, certain elements and systems of construction – the principles, concepts, elements, and systems that, proving relatively stable and resistant to wear and tear, are found codified under the science of architectural engineering.

5. *ARCHITECTURE AS MASS COMMUNICATION?*

5.1. *Mass appeal in architecture*

5.1.1. If architecture is a system of rhetorical formulas producing just those messages the community of users has come to expect (seasoned with a judicious measure of the unexpected), what then distinguishes it from the various forms of mass culture? The notion that architecture *is* a form of mass culture has become rather popular,[35] and as a communicative operation directed toward large groups of people and confirming certain widely subscribed to attitudes and ways of life while meeting their expectations, it could certainly be called mass communication loosely, without bothering about any detailed criteria.

5.1.2. But even under more careful consideration,[36] architectural objects seem to have characteristics in common with the messages of mass communication. To mention a few:

¶ Architectural 'discourse' generally *aims at mass appeal*: it starts with accepted premises, builds upon them well-known or readily acceptable 'arguments', and thereby elicits a certain type of consent. ('This proposition is to our liking; it is in most respects something we are already familiar with, and the differences involved only represent a welcome improvement or variation of some kind.')

¶ Architectural discourse *is psychologically persuasive*: with a gentle hand (even if one is not aware of this as a form of manipulation) one is prompted to follow the 'instructions' implicit in the architectural message; functions are not only signified but also promoted and induced, just as certain products and attitudes are promoted through 'hidden persuasion', sexual associations, etc.

¶ Architectural discourse *is experienced inattentively*, in the same way in which we experience the discourse of movies and television, the comics, or advertising – not, that is, in the way in which one is meant to experience works of art and other more demanding messages, which call for concentration, absorption, wholehearted interest in interpreting the message, interest in the intentions of the 'addresser'.[37]

¶ Architectural messages *can be interpreted in an aberrant way*, and without the 'addressee' being aware of thereby perverting them. Most of us would have some sense of being engaged in a perversion of the object if we were to use the Venus de Milo for erotic purposes or religious vestments as dustcloths, but we use the cover of an elevated roadway for getting out of the rain or hang laundry out to dry over a railing and see no perversion in this.

¶ Thus architecture *fluctuates between being rather coercive*, implying that you will live in such and such a way with it, *and rather indifferent*, letting you use it as you see fit [4].

¶ Architecture *belongs to the realm of everyday life*, just like pop music and most ready-to-wear clothing, instead of being set apart like 'serious' music and high fashion.

¶ Architecture *is a business.*[38] It is produced under economic conditions very similar to the ones governing much of mass culture, and in this too differs from other forms of culture. Painters may deal with galleries, and writers with publishers, but for the most part that has to do with their livelihood and need not have anything to do with what they find themselves painting and writing; the painter can always pursue painting independently, perhaps while making a living in some other way, and the writer can produce works for which there is no market, perhaps with no thought of having them published, but the architect cannot be engaged in the practice of architecture without inserting himself into a given economy and technology and trying to embrace the logic he finds there, even when he would like to contest it.

5.2. *Information content in architecture*

5.2.1. And yet anyone who pays much attention to architecture can see that there is something more to it, something that would distinguish it from mass communication. Architecture seems to offer messages that have mass appeal, that lend themselves to being taken for granted even when they are not highly conventional, but there are at the same time inventive and heuristic aspects to these messages.

While developing from given premises of the society in which it is produced, an architectural object can become in the end something new or different, something *more informative* than mass communication. (Of course the same might be said of mass-communication messages, for sometimes while clearly originating as mass communication they proceed to set themselves apart from that because of ideological, aesthetic, or other peculiarities they develop, either in their makeup or under special readings – because, that is, of information content exceeding the limits of mass communication.) We can see this when the object is a new *machine à habiter* waiting to be interpreted and accepted and perhaps tending to connote some new ideology of inhabitation, in which case the information content is obviously rather high. But it is also true in another sense, in the sense that even when highly conventional, architectural objects stand as *alternatives* to other architectural objects: besides permitting and promoting certain functions, they permit and promote 'critical' readings, in which one *compares them with prior (and subsequent) means and ideologies of inhabitation.* Now this goes beyond saying that they contrast (or are in free variation) with other 'contemporaneous' architectural objects – that is, with objects to some extent 'distributionally equivalent' in terms of what could be built at the time (however limited in operational possibilities, the codes of architecture do not, of course, exclude paradigmatic relations of various kinds, such as those a stair enters into with other elements that may be used to connect different levels). For the curious fact is that architectural messages, like works of art, are both subject to



rapid obsolescence and long-lived, so that the forms and dispositions produced by architects today are almost inevitably juxtaposed with forms and dispositions 'left over' from former, outmoded codes; in other words, while one can assume with a verbal language that diachronic aspects of the system are more or less irrelevant to its users, who would be dealing only with what would fall under a synchronic description of it, that is not the case with architecture. So while the fact that they are both obsolescent and long-lived may be seen as an argument for the development of more open architectural objects (3.3.4), it may also be seen as a special feature of the system generating increases in information content by promoting comparative readings of its objects, indeed by inducing us to become to some extent architectural critics in reading the architecture, past and present, with which we are living.

Finally there is the phenomenon of technique becoming, in architecture as in art proper, *self-reflexive*, with the other functions of the message giving way, for the moment at least, to the aesthetic function: besides permitting and promoting certain functions, the object may have one's attention directed *to itself, to the particular way in which it has been decided to 'go about' permitting and promoting them.*

5.2.2. At this point we might consider again the subject of styling. As we said, styling can be seen as the superimposition of new secondary functions on unchanged primary functions, or as the employment of new rhetorical forms in reiterating conventional messages. Now this can, of course, result in one kind of increase in information content, a kind perfectly consistent with mass communication: there is a slight 'twist' on what one would have expected. The object and its primary function are made to appear, for the moment, fresh and newly appealing, and so this is a rhetorical strategy that can be used to reaffirm something the user already wants and does and knows how to do.

It is conceivable, however, that resemanticization of a conventional object through styling could be directed toward effecting, by means of new secondary functions, a different ideological view of it. The primary function might remain unchanged, as before, but there could be, in the end, a substantial change in the way in which the object is viewed in the overall system of objects, in the overall system of the values held by the objects in relation to one another and in relation to the acts of everyday life.

When a car is redesigned only to provide new rhetorical clothing for the same basic message, there is an increase in information content only with respect to our *rhetorical* expectations, not with respect to our *ideological* expectations.

But if a car that has been a class symbol were redesigned – with the same motor, let us say, and without changing any of the primary functions – to make it a car 'for everyone', then it might well become a substantially different object in use. Styling in this case could result not merely in new surface connotations, but in new connotations that would have ideological repercussions and lead to a comprehensive recodification of the object and its functions.

5.2.3. With these differences and similarities between architecture and mass communication, it is unclear what position the architect is left in with respect to the community of users and their expectations. Can he afford to fly in the face of widely held expectations and confront the users with artifacts that radically challenge their way of life? Or rather, to be effective, must he see that his work is consistent with the expectations prevailing in the society in which he operates, expectations that transcend the terms of architecture and that form systems of the sort that anthropologists study?

4. Los Angeles, photograph by Joel Meyerowitz

An anthropologist faced with a certain community might investigate the codes behind its verbal communications, perhaps reducing them to a general system concerning verbal communications in various societies and languages; he studies kinship structures in the society, perhaps reducing these to a general system having to do with kinship structures in all societies; he might even turn to its 'urbanistic' structures and succeed in reducing them to some system concerning urbanistic dispositions in general. But he ultimately seeks to relate, within the sphere of the particular society being studied, its linguistic forms, the forms of its kinship system, the forms of its village or city layout, etc., integrating all these facts of communication, all these aspects of its culture, into a unitary model, referring them, that is, to an underlying structure that informs them and links them through homology.

Then for the architect who has to build for this same community, we could hypothesize three possible approaches, or three possible attitudes with respect to that underlying structure.

First, his attitude could be one of *thoroughly integrating his work into the reigning social system.* Accepting without question the norms governing the society, he tries to satisfy the architectural demands and expectations of the social body as it stands. He designs buildings to permit the way of life to which the members of the society are accustomed, with no thought of upsetting it in any way. In this case the architect would be trying to identify and closely adhere to the technical codes, the lexicons of conventionalized elements, and the 'grammar' of building in use, and if successful, he would at the same time, even without being aware of it, be adhering to that underlying code that transcends the terms of architecture.

Second, taking an approach of 'avant-garde' subversiveness, the architect might decide to *dispense with the conventional architecture and oblige the people to live with a totally different architecture.* He contrives designs that would presumably permit, instead of their customary way of life, a way of life having little relation to the existing social patterns, which would have to be abandoned. But it is fairly certain that the community would either reject or 'pervert' these new architectural forms, because his work would imply some alien underlying code, a code unrelated to the one governing the community's existing architectural forms, kinship relationships, linguistic communications, artistic productions, etc.

Third, the architect could undertake to *create an architecture that would be new but that would be intended to answer to that basic code.* He tries to anticipate the implications, for the community, of certain new developments (historical, cultural, technological, etc.), how the needs of the users might be changing. He tries to determine, on the basis of various data available to him, what new system of functions might have to be permitted and promoted. And only then – only once he has an idea of what would call for new architectural forms, of what they would answer to, of what would link them with the basic code of the society and make them acceptable and comprehensible to its members – does he attempt to elaborate and introduce the new system of architectural sign-vehicles. In this case, architecture could again be considered a *service*, but in another, broader sense: rather than simply supplying what one has come to expect from it, it undertakes to provide something one does *not yet* expect from it, to investigate what new architecture might *eventually* be desired and possible within the society, to produce an architecture that would eventually be accepted and comprehended in the light of prevailing expectations and related to the whole of the society's systems of cultural communication.[39]

5.2.4. If there is a growing interest in *interdisciplinary* work as the proper basis for architectural design, then, it could be explained by the fact that *in the last analysis the architect has to elaborate his sign vehicles and messages in relation to systems of meanings that lie outside his province*, even though these meanings might be signified for the first

time in his work, given their first sign vehicles in architecture. And for that reason the architect might find himself in the position of having to *reject the existing architectural codes*, when rather than providing for the generation of the messages called for, they hold out only already produced message-solutions that are no longer relevant.

6. *EXTERNAL CODES*

6.1. *Architecture as based on codes external to it*

6.1.1. To recapitulate: (*a*) we began with the premise that architecture would, to be able to communicate the functions it permits and promotes, have to be based on codes; (*b*) we have seen that the codes that could properly be called architectural establish rather limited operational possibilities, that they function not on the model of a language but as a system of rhetorical formulas and already produced message-solutions; (*c*) resting on these codes, the architectural message becomes something of mass appeal, something that may be taken for granted, something that one would expect; (*d*) yet it seems that architecture may also move in the direction of innovation and higher information-content, going against existing rhetorical and ideological expectations; (*e*) it cannot be the case, however, that when architecture moves in this direction it departs from given codes entirely, for without the basis of a code of some kind, there would be no effective communication.

6.1.2. One might, then, hypothesize some architectural codification more open, or less limited in operational possibilities, than the codes already mentioned, perhaps something on the order of what Italo Gamberini has proposed with his 'constitutive signs' of architecture.[40]

These matrices of interior spaces would be, according to Gamberini's classification, (1) *floor-plan signs*, which give a 'bottom' to architectural volumes, (2) *connection signs*, which occur between floor-plan elements placed at different elevations and which may be either continuous connection-elements, such as ramps, or stepped ones, such as stairs, (3) *lateral-containment signs*, self-supporting (fixed or movable) or supporting something, (4) *intercommunication signs*, between the spaces established by the lateral-containment elements, (5) *cover signs*, self-supporting or supported, (6) *independent-support signs*, vertical, horizontal, or even inclined, (7) *qualificative-accentuation signs*, and so on.

Clearly a codification of this kind could underlie a very wide range of architectural messages, having none of the rhetorical or typological rigidity of the codes mentioned before. One might consider these 'constitutive signs' elements of a second articulation; however some of them would denote functions, and consequently might be understood as elements of a first articulation.

Of course even more open would be the elements and purely mathematical rules of combination studied in 'metadesign',[41] which is concerned not with what one might actually have to design but with the generative matrices underlying all design (and which indeed is intended to further a kind of design in which the variability of primary and secondary functions is effectively recognized). But here again we would have a code that does not pertain specifically to architecture, though it might well prove fundamentally useful in architecture.

Then returning to the 'constitutive signs' – the freedom of articulation they hold out beyond rhetorical formulas and already produced solutions having been recognized, there remains the question of their adequacy as a code. *What rules for their combination are there for the architect to follow?* If he rejects as inappropriate the rules implicit in the traditional, rhetorical lexicons, what *then* does he base his combination of them upon? It would appear that the architect is in the paradoxical position of commanding certain paradigmatic resources without knowing quite what to do with them on the axis of the syntagm. He has something of a vocabulary, or at least an alphabet, but his grammar is yet to be found. And everything seems to indicate that it is not to be found within the realm of architecture.

There is only one possible answer. *Architecture must in fact be based not only upon existing architectural codes, from which the architect may depart, but also upon other, external codes* (and it is with reference to these that the users would identify the meanings of the new architectural message).

6.1.3. It goes without saying, for instance, that an urban designer could lay out a street on the basis of the lexicon that embraces and defines the type 'street'; he could even, with a minor dialectic between redundancy and information, make it somewhat different from previous ones while still operating within the traditional urbanistic system. When, however, Le Corbusier proposes his elevated streets (closer to the type 'bridge' than to the type 'street'), he moves outside the accepted typology, which has streets at ground level or, if elevated, elevated in a different fashion and for different reasons – and yet he does so with a certain assurance, believing that this new sign, along with the rest of his proposed city, would be accepted and comprehended by the users. Now whether such a belief is justified or not, it would have to be based on something like this: the architect has preceded architectural design with an examination of certain new social exigencies, certain 'existential' desiderata, certain tendencies in the development of the modern city and life within it, and has traced out, so to speak, a semantic system of certain future exigencies (developing from the current situation) on the basis of which new functions and new architectural forms might come into being.

In other words, the architect would have identified (*a*) a series of social exigencies, presumably as a system of some kind, (*b*) a system of functions that would satisfy the exigencies, and that would become sign vehicles of those exigencies, and (*c*) a system of forms that would correspond to the functions, and that would become sign vehicles of those functions.

From the point of view of common sense, this means that to produce the new architecture Le Corbusier was obliged, before thinking like an architect, to think like a sociologist, an anthropologist, a psychologist, an ideologist, etc., and we will return to that shortly. But first we might consider the peculiarity of the phenomenon from the semiotic point of view.

6.1.4. Only at the last level, the level of (*c*), do we find forms that could be understood as 'architecture'. So while the elements of architecture constitute themselves a system, they become a code only when coupled with systems that lie outside architecture.

Now one might argue that the same thing is true of verbal language – and not because of referents of a language lying outside the language, for that would make the argument too naïve; as we have suggested, the question of referents has no bearing on the processes of signification. The argument would be rather that in a verbal language as well a system of sign vehicles (or a 'plane of expression') is coupled with semantic systems (on the 'plane of content') lying outside it; these semantic systems are systems of cultural units that can transcend particular languages and be designated in different ways in them.

And we could accept this argument as true, in theory. But the point is that it seems to be impossible to demonstrate. One can of course maintain that the union between the sign vehicle *dog* and the cultural unit 'dog' is entirely arbitrary, that the units are independent, but when one attempts to consider the sign vehicle *dog* independently of its meaning, one finds that one cannot really prescind from the fact that it *has that meaning*. Moreover, in order to indicate that meaning as a cultural unit, one is obliged to use another verbal sign-vehicle, and so

one never gets outside the circle of the language; the only way one can designate the cultural units is *through* linguistic units, and the only way one can identify the independent linguistic units is by identifying them as *vehicles* of cultural units. Thus (in practice) the verbal language obliges one to see it as a code in which the plane of content is inseparable from the plane of expression. And it is this that led Saussure to compare the sign to a sheet of paper, the two sides of which can be distinguished, it is true, but never split into two independent halves.

What about architecture, then, if we accept the hypotheses of 6.1.3? Let us use X for the system of architectural forms, Y for the system of functions, and K for the system of social exigencies, or the *anthropological* system – an x might be a table of a certain width, which permits and signifies a certain function y (to eat at a considerable distance from one another, let us say), which in turn allows the realization of an anthropological value k ('formal' relationship), whose sign vehicle that function has become.

Then the units in X, as spatial forms, admit of several kinds of description – two-dimensional (through a set of drawings or a photograph), verbal (through an oral or written description), mathematical (through a series of equations), etc.; the units in Y, as functions, admit of either verbal description or representation in terms of some iconic (cinematographic, for example), kinesic, or other kind of system for 'transcribing' functions; and the units in K, as anthropological values, can be described verbally.

Now it is clear that while a form x is being used it might seem (to the user) quite closely tied to a function y and an anthropological value k – just as closely as a meaning seems (to the speaker) tied to a verbal sign vehicle. But from the point of view of semiotics, it is possible to *describe the units of each of these three systems independently*, without, that is, having recourse to the units of either of the other two.

This is something that was never envisaged by those who have considered the notion of meaning suspect, because up to now studies in semantics have been conducted inside the circle of verbal 'interpretants'. So above and beyond what else it offers, semiotics shows us the possibility of investigating systems of signs where the planes of expression and content are not inseparable – or at least where they can be more successfully separated.

6.2. *The anthropological system*

6.2.1. But in introducing this K, this anthropological system, have we jeopardized the semiotic framework behind everything we said before?

Having said that architecture has to elaborate its sign vehicles and messages with reference to something that lies *outside* it, are we forced to admit its signs cannot, after all, be adequately characterized without bringing something like *referents* back into the picture?

We have argued that semiotics must confine itself to the *left side* of the Ogden-Richards triangle – because in semiotics one studies codes as phenomena of culture – and, leaving aside verifiable realities to which the signs may refer, examine only the communicative rules established within a social body: rules of the equivalence between sign vehicles and meanings (the definition of the latter being possible only through interpretants, or other sign vehicles by means of which the meanings may be signified), and rules regarding the syntagmatic combination of the elements of the paradigmatic repertories. This means, not that the referent is nonexistent, but that it is the object of *other* sciences (physics, biology, etc.); semiotics can, and must, confine itself to the universe of the cultural conventions governing communicative intercourse.

If for architecture, then, or for any other system of signs, we had to admit that the plane of content involved something that did not belong to the semiotic universe, we would be faced with a phenomenon confounding semiotics, or at any rate confounding all the notions we have elaborated, here and elsewhere, on semiosis.[42]

So it is not casually that we have been referring to an anthropological 'system': we have been referring, that is, to facts that while belonging to the universe of the social sciences may nevertheless be seen as *already codified*, and thus reduced to a cultural system.

6.2.2. For an indication of what is meant by K, we might consider studies in *proxemics*, notably those of Edward T. Hall.[43]

For proxemics, space 'speaks'. The distances one puts between oneself and those with whom one is engaged in social relations of various kinds are charged with cultural meanings, just as such things as perceptions of the warmth of another's body, tactile sensations, and odors take on meanings.

That space has significative value has already been demonstrated in the study of animal behavior. For every animal species there is a 'flight distance' (when this limit is passed – five hundred yards for the antelope, six feet for certain lizards – the animal seeks to avoid the intruder of a different species), a 'critical distance' (a narrow zone between flight distance and attack distance), and an 'attack distance' (within which the animals enter into direct conflict). And when one considers animals that accept physical contact between members of their own species and those that avoid such contact, one finds 'personal distances' (the 'noncontact' animal maintains a certain distance between himself and his fellows) and 'social distances' (beyond a certain distance, which varies from one species to another, the animal 'loses contact' with the group). In short, every animal seems to be surrounded by 'spheres' of great importance to it in terms of its relations with other animals, and these have been measured rather precisely.

The problem for proxemics has been to investigate the codification of such phenomena in human culture, and to investigate the different codifications of them in different human cultures.

6.2.3. Hall distinguishes between 'infracultural manifestations', which are rooted in the biological past of the individual, 'precultural manifestations', which are physiological in nature, and 'microcultural manifestations', which are what proxemics focuses upon and which fall into the following three categories:

1. *Fixed-feature space.* To this category belong many of those spatial configurations commonly recognized as being codified – plans of cities, for example, with the definition of blocks of buildings and their dimensions (think of the plan of New York). And already there are remarkable cultural variations: Hall cites the example of Japanese cities, where it is the intersections, not the streets, that are defined, and where houses are numbered not according to their order in space but according to their order in time (date of construction); one might also cite the findings from several anthropological studies on the structure of villages, especially Lévi-Strauss's.[44]
2. *Semifixed-feature space.* Configurations belonging to this category are a matter of the arrangement of 'movable' elements of interior or exterior spaces. And here Hall introduces a distinction between 'sociofugal' spaces and 'sociopetal' spaces. The typical seating provisions in the waiting room of a train station make it a sociofugal space, a space that tends to keep people apart, while the arrangement of chairs and tables in an Italian or French bar is sociopetal. As an example of cultural variation, Hall cites the problem caused by the 'open door' policy of a branch of an American firm in Germany: 'In this company the open doors were making the Germans feel exposed and gave the whole operation an unusually relaxed and unbusinesslike air. Closed doors, on the other hand, gave the Americans the feeling that there was a conspiratorial air about the place and that they were being left out. The point is that whether the door is open or shut, it is not going to mean the same thing in the two countries.'[45]

For each of those categories Hall has set out, in an elaborate chart, attendant variations in kinesthesia, thermal and olfactory sensations, visual and oral/aural phenomena, etc.[47]

6.2.4. It is easy to see that these codified distances would be something one would refer to in the design of architectural spaces. And once they have been adequately defined and classified, they might seem all the more concrete and important as determinants. Hall has suggested that 'the influence of two bodies on each other is inversely proportional not only to the square of the distance but possibly even the cube of the distance between them'.[48]

But one would, of course, have to bear in mind the often surprising variations from one culture to another. As noted above, the meaning of open and closed doors changes radically when one goes from New York to Berlin: in America when you 'poke your head in the door' you are still thought of as 'outside', and in Germany it would be thought that you have already 'come in'. But there are many other ways in which space is defined differently in the two cultures. The German's conception of personal space (reflected in the national anxiety over *Lebensraum*) implies a somewhat different definition of the limit within which one's privacy is threatened by the presence of others. And to move your chair in order to sit closer to someone who has invited you into his home is considered reasonable in America, and in Italy, but it is nothing short of rude to do so in Germany; indeed Mies van der Rohe's chairs are heavier than those conceived by non-German architects and designers, so that moving them would be difficult. Then compare the disposition of furniture in a German or American house with that in a Japanese house, and even greater differences become apparent. Occidentals generally experience space as a void between objects, but to the Japanese – think of the art of their gardens – it too is a form, capable of figuring as an architectural element in its own right. And our concept of 'privacy' does not exist in Japanese culture, and the Arab's way of 'being alone' consists not in separating himself physically from others but in suspending verbal contact, and so on.

Thus one might question the validity of urbanistic studies determining the number of square feet necessary per person; they might make sense within a given model of culture, but carrying such code data over into the design of spaces for people of other cultures could easily prove to be unfortunate.

6.2.5. So while the distance separating two interacting individuals remains a physical fact, capable of quantitative definition, the fact that this distance has a social meaning – and different meanings in different cultures – means that what we are concerned with here is, rather than a physical event (the distance) per se, *the event as endowed with meaning*. The distance is seen as a significant unit of a proxemic system, and the architect taking it as a parameter in elaborating his architecture would be taking it together with its meaning – it would be taken, that is, as a cultural fact, as part of a system of conventions and significations, as belonging to a code. *Thus we would still be on the left side of the Ogden-Richards triangle.* If there is a physical fact constituting a referent here, it would be no less irrelevant with respect to the processes of signification than the referents considered earlier. The architectural sign is again articulated to signify, not a referent, but a cultural unit. Or better, an architectural form (or spatial configuration) x becomes the sign vehicle of a possible function y (the possibility of having a certain distance between one another, let us say), which in turn would be the sign vehicle of a social value k (the value proxemics shows that distance to have).

But then with respect to this K – or with respect to the relation of signification between Y and K – would we not have to characterize architecture as a 'parasitic' language, or as a significative system dependent upon the support of a 'host' system of significations, which in a sense 'gives it meaning'? To put this another way, it appears that the plane of expression constituted by architectural objects has, as its plane of content, another system of significations (consisting of a plane of expression in Y and a plane of content in K).

Now this would in no way be to deny the communicative nature of architecture, or to say that architectural objects are not really sign vehicles. There are, after all, a number of systems of sign vehicles elaborated solely to express in their own terms the sign vehicles of another language (Morse code and the system of semaphor communication, for two).[49] And in fact verbal language itself frequently becomes just such *second-order* language (or 'metalanguage').

We know that in a novel or epic poem, for example, the verbal language employed has to assume the role of conveying certain narrative entities that are distinctive or significant units of a narrative system outside the language (that the narrative system lies outside the language, and not just as a *plane of content*, can be inferred from the fact that these narrative entities, the elements of the 'story', are often not language-bound and are significative in their own right). Indeed the constitution of the narrative system in question can determine the way in which the second-order – and presumably more analytic – code that is to convey it will be articulated. And if different narrative systems do not seem to require or bring about any change in the constitution of the linguistic code (except perhaps in the case of certain experimental novels), that is both because the linguistic code is flexible enough to allow the analytic decomposition and conveyance of the units of quite a variety of narrative systems and because narrative systems have remained relatively stable and uniform over the centuries – apparently, that is, one has not yet had to face the problem of expressing narrative entities of such novelty that no adequate rules of transformation could be found within the existing linguistic code.

But consider what would happen with a second-order code a good deal weaker analytically – the code of architecture – especially when faced with more 'difficult' external systems to convey – a series of anthropological systems, in continual historical development and continually in opposition from one culture to another. We see the prospect of a frustration of that function, either with the code 'forced' beyond its limits or with it simply articulated in spite of its irrelevance. And if there is the possibility of *revising* the code of architecture, it would seem that one might better, in the end, leave behind the problem of trying to elaborate new rules to suit what appears for the moment to be the external system it has to 'speak' and take up the problem of elaborating generative schemes that would remain viable under any number of unforeseeable anthropological systems to come (we said something about this in 3.3.4 and will return to it in 6.3).

6.2.6. Finally, it must be remembered that a code is a structure and *a structure is a system of relations arrived at through successive simplifications with respect to an operational intention of some kind, or from a certain point of view.*[50] So if the architect were to elaborate a code of architecture on the basis of proxemics alone – presumably with the intention of performing certain operations relating to proxemic phenomena – that code would be valid *from that particular point of view*, and not necessarily from another.

To put it differently, leaving proxemics aside for the moment let us say that the architect has decided to restructure the urban fabric of a city (or the 'shape of landscape' in a certain area) from the point of view of the perceptibility of its 'image'.[51] He might then base his operation upon rules of a code concerned precisely with phenomena of image-recognition and orientation (a code that could be elaborated on the basis of data from interviews and basic research on perception, and perhaps even take into account exigencies of commerce or circulation, medical findings on factors contributing to stress, etc.). But then the validity and significance of the operation, based on that code, would

depend upon confining oneself to that particular point of view. As soon as it became necessary for the architect to relate his architecture to some other system of social phenomena as well – the one dealt with in proxemics, let us say – the code concerned with image-recognition and orientation would have to be broken down and integrated with a code concerning proxemic phenomena; and since there would no doubt be more than just these two external systems to relate to, it would become necessary to find the relations between a number of different systems, tracing them all back to an underlying *Ur-code*, common to all of them, on which elaboration of the new architectural solutions would ultimately have to be based.[52]

6.2.7. So the architect, in practice, is continually obliged to be something other than an architect. Time and again he is forced to become something of a sociologist, a psychologist, an anthropologist, a semiotician . . . And that he can rely in this to some extent on *teamwork* – that is, on having experts in the various fields working with him – does not change the situation very much, even if teamwork makes it seem less a matter of guesswork. Forced to find forms that will give form to systems over which *he has no power*, forced to articulate a language that has always to express something external to it – we said there were possibilities of the poetic function and self-reflexiveness in architecture, but the fact remains that because of its very nature (and even though it has traditionally been understood as a matter of pure 'arrangement', regarding only its own forms) these can never 'take over' in it, as they can in other types of discourse, such as in poetry, painting, or music – the architect finds himself obliged in his work to *think in terms of the totality*, and this he must do no matter how much he may seem to have become a technician, a specialist, someone intent on specific operations rather than general questions.

6.3. *Conclusion*

6.3.1. One might at this point be left with the idea that having the role of supplying 'words' to signify 'things' lying outside its province, architecture is powerless to proceed without a prior determination of exactly what those 'things' are (or are going to be).

Or one might have come to a somewhat different conclusion: that even though the systems of functions and values it is to convey are external to it, architecture has the power, through the operation of its system of stimulative sign-vehicles, to determine what those functions and values are going to be – restricting men to a particular way of life and dictating laws to events.

These both go too far, and they go along with two unfortunate ideas of the role of the architect. According to the first, he has only to find the proper forms to answer to what he can take as 'programmatic' givens; here he may accept on faith certain sociological and ideological determinations made by others, which may not be well founded. According to the second, the architect (and we know what currency this delusion has enjoyed) becomes a demiurge, an artificer of history.

The alternative to these varieties of overconfidence has already been suggested, in 3.3.4: *the architect should be designing for variable primary functions and open secondary functions.*

6.3.2. The problem is only too clear in the light of a famous example of modern architecture – Brasília.

It was born under circumstances exceptionally 'promising' for architectural design – by political fiat, that is, from nothing, and with practically nothing but its existence having been decided in advance – and so it was possible to conceive of Brasília as a city that was to institute a new way of life and, at the same time, constitute a complex connotative message, communicating ideals associated with democratic life, with pioneering into the interior of a largely unexplored country, with the triumphal establishment of an identity for itself by a young country still in search of a physiognomy of its own.

Brasília was to become a city of equals, the city of the future.

In design [*6*] it was given the form of an airplane (or bird), with its wings spread out over the plateau that was to accommodate it. In the central body, secondary functions were to be predominant over primary functions: as the place of public buildings, it was above all to connote symbolic values contributing to the identity desired by the young country. In the two wings, on the other hand, where the residential buildings would be, primary functions were to prevail over secondary functions: great blocks of housing units, the 'superblocks' inspired by Le Corbusier, were to permit government ministers and functionaries of the lowest echelons (it is a bureaucratic city) to live side by side without distinction, availing themselves of the same facilities – a full gamut, supermarket, church, school, 'club' for leisure activities, hospital, police station – provided the inhabitants in every unit or block of four units.

And around these blocks would run the streets of Brasília, free, as Le Corbusier wished, from crude intersections, thanks to ample cloverleaves, underpasses, etc.

The architects had, quite correctly, made some study of the systems of functions they were given to believe would be fulfilled in this model city of the future (correlating sociological data, ideological perspectives, information on image-recognition and orientation, laws of circulation, aesthetic factors, etc.). And in elaborating corresponding systems of architectural sign-vehicles, they were judicious enough to see that these had some relation to the traditional forms (and to allow for a certain amount of reiteration of the latter), which would, in theory, permit novel, unexpected articulations to be taken by the users as something other than 'noise': 'archetypal' symbols (the bird, the obelisk) were woven in with the new forms (the pilotis, the cloverleaves); the cathedral, even while a clear departure from the typological schemes to which one was accustomed, rested on some time-honored iconographic codifications (the flower, the opening of petals, the fingers of one's hands held together in prayer, indeed the fasces as symbolic of a union of various states).

6.3.3. They had also, however, proceeded with both of the unfortunate ideas of the role of the architect mentioned in 6.3.1. They had accepted as givens the functions suggested in the preliminary sociopolitical study that had been made, concerning themselves with the forms through which these might best be permitted and promoted. And they imagined that simply by being built in a certain way Brasília would determine its own history.

And what has happened is that in the face of the *structure* Brasília, *events* have taken an autonomous course; and in the course of events different sociohistorical contexts have emerged, with some of the functions anticipated left unfulfilled and other, unanticipated functions taking their place:

¶ The construction workers building the city, who were supposed to live there while they worked, far outnumbered the available accommodations. And so on the periphery of Brasília the Nūcleo Bandeirante sprang up, and a number of *favelas*, squalid settlements made up (at least from the point of view of many of the inhabitants of the city proper) of shanties, sleazy bars, brothels, etc.

¶ The south superblocks were built before, and better than, the north superblocks, which were put up more hurriedly; so while relatively new, the latter are already marked by wear and tear. As a result, the functionaries of the higher echelons are gravitating toward the southern wing of the city.

¶ The rate of immigration has surpassed all expectations, and – even excluding the people in the surrounding shantytowns and those who prefer to commute from far away – the city of Brasília has not been

able to house all the people who work there. Satellite towns have therefore arisen, with their populations increasing tenfold in but a few years' time.

¶ As one might have expected, the representatives of major industries and businesses have not been housed in the superblocks; nor have they moved into the satellite towns. They live along some 'avenues' that have developed parallel to the two wings of superblocks; these are streets of modest enough dwellings, but here, in contrast to the sociality – the communality – of the superblocks, there is privacy.

¶ For other inhabitants, tracts of little houses have been built on the periphery of the city, though for fear of regimentation many of the people in the shantytowns prefer not to live in these.

¶ One result of the elimination of intersections from the street system was an increase in the distance one would have to travel to get from point to point with it. This has all but turned circulation into a special privilege, reserved for those who have cars, and given the distances between the superblocks and between the superblocks and the central body of the city, it becomes difficult to maintain a social life beyond one's immediate 'neighborhood', which adds to the process of social differentiation by location.

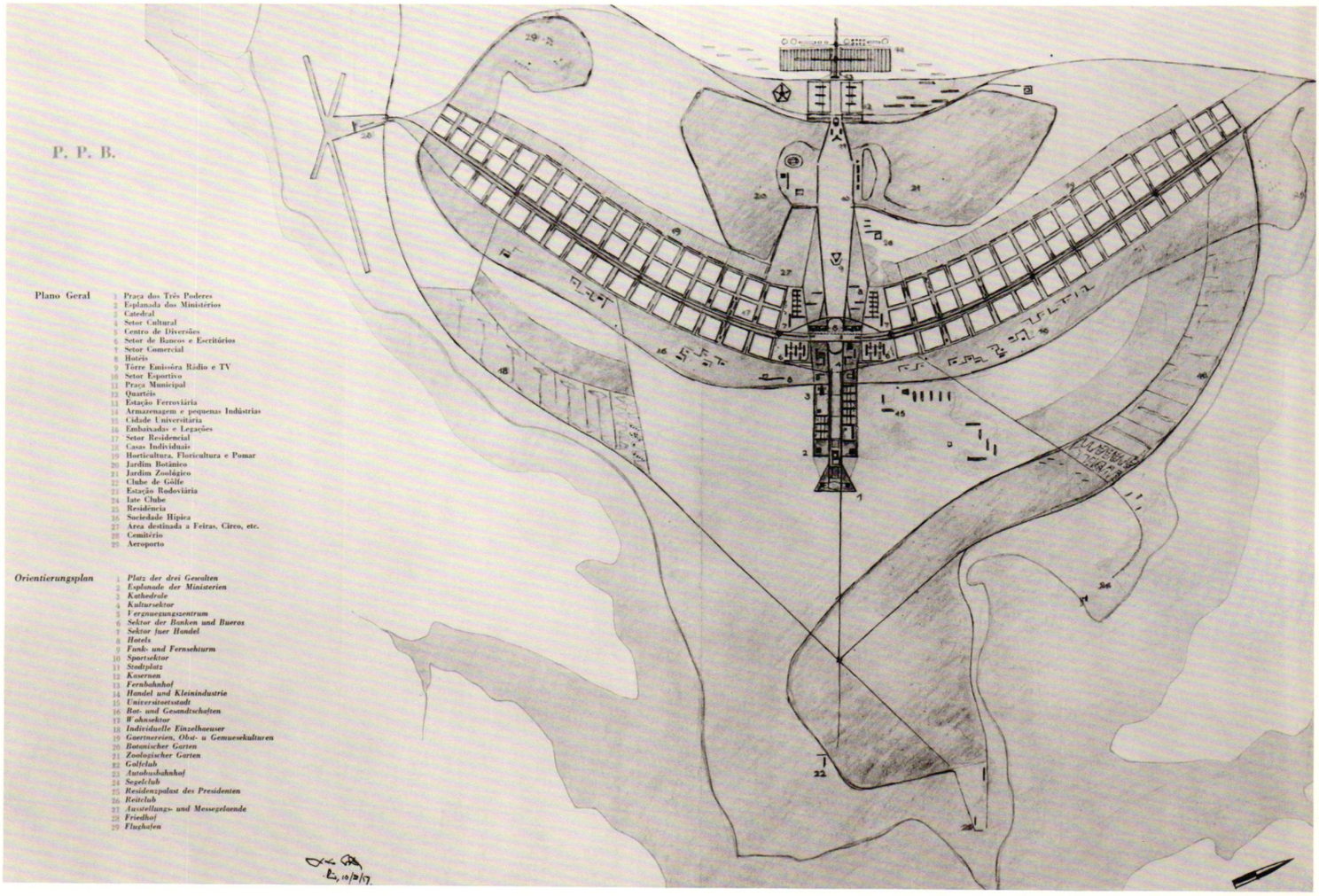
The disposition of things in space, the form of the city, has indeed become a communicative fact, but now – and the phenomenon is more pronounced here than in perhaps any other city – the particular position an individual occupies, and is more or less confined to, in that disposition communicates his 'status'.

6.3.4. In short, Brasília has, far from becoming the egalitarian city it was supposed to be, given form to social differentiation. Primary and secondary functions in which the planners and architects had every confidence have been transformed or replaced. The ideology of a community of equals, which was to have become visible in the urban structure and the imagery of the buildings, has given way to other visions of life in society. And this has happened without there having been any gross mistakes in design on the part of the architects, *given the 'program' they accepted.* The mistake was in accepting that program, with the social systems identified or implied in it, as definitive and timeless, and in assuming that having been designed *for* that program, the architecture would see it realized. Because events have proved the program to be anything but definitive, and the code under which the architectural forms were conceived is simply not the code under which these forms are being interpreted. So while the architects took a position of passive service with respect to the exigencies set out in the preliminary study they were given, undertaking to invent forms that would answer to these, they might better have oriented their passivity toward the fact that, no matter how valid the program and no matter how well designed the forms, *no forms created by an architect are going to prevent events from taking an autonomous course around them.*

To try to identify and effect particular social alternatives may not be a senseless pursuit in social engineering or in politics, for there one can reasonably concern oneself with what is going to happen in society within the limits of a more or less 'manageable' span of time. But for the architect the task is to foresee, beyond the limits of any such span of time, the varying of events around his works.

Brasília might have become more the city of the future it was supposed to be if it had been built on wheels, or with prefabricated, demountable elements – or better than that, along the lines of forms and dispositions flexible enough to provide for different meanings as warranted in the course of events. Instead, it was built as a monument as enduring as any of bronze, and stands there slowly suffering the fate of the great monuments of the past, whose senses history continues to add to or, where that becomes difficult, simply subtract from, which rather than marking a definitive state of events, as intended, continue to be redefined by events.

6.3.5. *While looking outside architecture, then, for the code of architecture, the architect must also fashion his significative forms in such a way that they will remain relevant under different codes of reading.* Because the historical situation in which his attempts to identify the code would be grounded is going to be outlived by the significative forms he feeds into this situation. The architect may have to get his bearings to some extent from the sociologist, the economist, the psychologist, the anthropologist, and so on, but he must at the same time acknowledge, in the way he fashions forms to answer to the exigencies they have shown him, the possible failure of their hypotheses and the degree of error and obsolescence to which their work is subject. And he must realize throughout that his work will at best cooperate with, not prescribe, the movements of history.


P. P. B.
Plano Geral
1 Praça dos Três Poderes
2 Esplanada dos Ministérios
3 Catedral
4 Setor Cultural
5 Centro de Diversões
6 Setor de Bancos e Escritórios
7 Setor Comercial
8 Hotéis
9 Torre Emissôra Rádio e TV
10 Setor Esportivo
11 Praça Municipal
12 Quartéis
13 Estação Ferroviária
14 Armazenagem e pequenas Indústrias
15 Cidade Universitária
16 Embaixadas e Legações
17 Setor Residencial
18 Casas Individuais
19 Horticultura, Floricultura e Pomar
20 Jardim Botânico
21 Jardim Zoológico
22 Clube de Gôlfe
23 Estação Rodoviária
24 Iate Clube
25 Residência
26 Sociedade Hípica
27 Area destinada a Feiras, Circo, etc.
28 Cemitério
29 Aeroporto
Orientierungsplan
1 Platz der drei Gewalten
2 Esplanade der Ministerien
3 Kathedrale
4 Kultursektor
5 Vergnuegungszentrum
6 Sektor der Banken und Bueros
7 Sektor fuer Handel
8 Hotels
9 Funk- und Fernsehturm
10 Sportsektor
11 Stadtplatz
12 Kasernen
13 Fernbahnhof
14 Handel und Kleinindustrie
15 Universitaetsstadt
16 Bot- und Gesandtschaften
17 Wohnsektor
18 Individuelle Einzelhaeuser
19 Gaertnereien, Obst- u Gemuesekulturen
20 Botanischer Garten
21 Zoologischer Garten
22 Golfclub
23 Autobusbahnhof
24 Segelclub
25 Residenzpalast des Presidenten
26 Reitclub
27 Ausstellungs- und Messegelaende
28 Friedhof
29 Flughafen

SEMIOLOGY AND URBANISM

ROLAND BARTHES

My remarks here will touch on a few problems facing urban semiology. But I should say at once that anyone wishing to outline a semiotics of the city would have to be at the same time a semiologist (specialist on signs), a geographer, a historian, an urbanist, an architect, and probably a psychoanalyst as well. As this is plainly not the case with me – far from all that, I am in fact barely a semiologist – what I am about to present will be the reflections of an amateur, in the etymological sense of the word: amateur of signs, one who loves signs; amateur of cities, one who loves cities. For I do love cities and I do love signs. And this double love (which is probably a single one in the end) leads me to believe, perhaps with some presumption, in the possibility of a semiotics of the city. On what condition, then, or rather with what precautions, what preliminaries, will an urban semiotics be possible?

That will be the theme of the observations that follow. I would like to begin by reminding you of something that is of common knowledge, as a point of departure: human space in general (and not just urban space) has always been significant. Scientific geography, and especially modern cartography, could be considered a kind of obliteration, or censorship, imposed by objectivity (which is only another form of the imaginary) upon signification. And before turning to the city itself, I would like to call to mind something from the cultural history of the West, particularly that of Greek antiquity: the human habitat, the οἰκουμένη – as we can understand it through the early maps of the Greek geographers (Anaximander, Hecataeus) or through the mental cartography of men like Herodotus – constitutes a genuine discourse, with its symmetries, oppositions of places, with its syntax and its paradigms. A map of the world of Herodotus, realized graphically, would be constructed like a language, like a sentence, like a poem, on oppositions: hot lands and cold lands, known lands and unknown lands, then the opposition between men on the one hand and monsters and wonders on the other, etc.

Passing now from geographical space to urban space proper, we might recall that the notion of *Isonomia*, elaborated in the Athens of the sixth century by Cleisthenes, is a genuinely structural conception, whereby the center alone is privileged, since all the citizens have with it a relationship that is at the same time symmetrical and reversible. In that period of history one conceived of the city, then, exclusively in terms of signification, for the utilitarian conception of an urban disposition based on functions and uses, which currently enjoys nearly uncontested supremacy, was a subsequent conception. I just want to remind you of a certain historical relativism in the conception of significant spaces. Finally let us note that, quite recently, a structuralist – Claude Lévi-Strauss, in his book *Tristes tropiques* – has done some work in urban semiology, even if on a reduced scale, with a Bororo village, whose space he has studied from an essentially semantic standpoint.

In the light of these conceptions of inhabited space, in which its significance is well recognized, it is odd that in the theoretical work of urbanists to date, if I am not mistaken, the attention given to problems of signification has been quite limited. There are exceptions in other fields, of course; a number of writers have spoken of the city in terms of signification. One of the authors who have best expressed the essentially significant nature of urban space is, to my mind, Victor Hugo. In *The Hunchback of Notre-Dame* Hugo has a chapter that is most beautiful and remarkably perceptive – 'This Will Kill That': 'this' is the book, or printing; 'that', the monument, or architecture. There Hugo shows, in a rather modern way, that he understands the monument and the city truly as a kind of writing, as an inscription by man in space. Hugo's chapter is dedicated to the rivalry between two writings, the writing with stone and the writing on paper. And the same subject, it might be added, is again found to be of a certain topicality in the reflections of the philosopher Jacques Derrida on writing. Among urbanists proper, one name comes forward as soon as signification is mentioned, and justly that of the American Kevin Lynch, who seems to have gotten closest to the problems of an urban semantics, inasmuch as he has concerned himself with thinking of the city in the very terms of the consciousness that perceives it – that is, with finding the image of the city in the readers of the city. And yet, from the point of view of semantics, Lynch's research remains somewhat ambiguous. On the one hand, there is in his work a certain vocabulary having to do with signification (he attaches great importance to the legibility of the city, for example, and this notion means a great deal to us), and like any good semanticist, he has a feeling for *discrete units*: he has tried to find in urban space separate units that would, due allowances being made, somewhat resemble phonemes and semantemes – units that he calls paths, edges, districts, nodes, and landmarks; these are classes of units that could easily become semantic classes. But on the other hand, in spite of this vocabulary, Lynch's conception of the city remains more 'gestaltic' than structural.

Apart from explicit approaches to the semantics of the city, we can note, however, a growing consciousness, in the study of urban space, of the functions of symbols. In a number of urbanistic studies, based on quantitative evaluations, and on questionnaires, we see the purely qualitative factor of symbolization – which is sometimes used today even to explain other facts – recognized even if reluctantly, even if only nominally, in the introduction or conclusion. For example, we find in urbanism a technique that has become rather popular, simulation; now the technique of simulation, even when handled with a somewhat narrow-minded and empirical attitude, compels one to go deeply into the concept of the model, which is after all a structural, or at least a prestructural, concept.

On another point as well these urbanistic studies have to recognize the exigencies of meaning: one gradually discovers that there is a kind of contradiction between signification and another order of phenomena, and that consequently there is an irreducible specificity to the meaning. For example, urbanists and others doing research on city planning have been forced to recognize that in certain cases there is a conflict between the functionality of a part of the city – a district, let us say – and what I would call its semanticity (its semantic power). Thus they have noted, a little naïvely (but perhaps one must begin with naïveté), that Rome presents one with a continual conflict between the functional necessities of modern life and the semantic charge that comes from its history. And this conflict between meaning and function is the despair of the urbanists. There is, moreover, a conflict between meaning and reason, or at least between meaning and the calculative reasoning that would like planning to be able to represent all the elements of a city in the same terms: it is becoming increasingly clear that a city is a fabric, composed not of equal elements whose functions could be put down in a ledger, but of strong elements and neutral elements, or as linguists say, of marked elements and unmarked elements (we know that the opposition between the sign and the absence of sign, between full degree and zero degree, is one of the major processes in the elaboration of meaning). It is very clear that a city possesses this kind of rhythm; Kevin Lynch has noted it: there is in any city, from the moment it has been truly inhabited by man, and made by him, this fundamental rhythm of signification, which is the opposition, alternation, and juxtaposition of marked elements and unmarked elements. Finally, there is a conflict between meaning and reality itself, at least between meaning and the reality of objective geography, that of

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maps. Investigations conducted by social psychologists have revealed that, for example, two districts lying side by side according to the map – that is, according to the real, according to objectivity – are radically separated in the image of the city from the moment they receive two different meanings: the meaning is experienced in complete opposition to the objective data.

The city constitutes, then, a discourse, and this discourse is genuinely *parole* ('speech'): the city speaks to its inhabitants; we speak our city, the city we are in, simply by inhabiting it, moving through it, looking at it. Yet the problem is to make an expression like 'language of the city' come to more than a mere metaphor. It is very easy, metaphorically, to speak of the language of the city as one speaks of the language of the cinema or the language of flowers. The real scientific leap will have been made when one can speak of language of the city without metaphor. And one might say that this is exactly what Freud had to do when he first spoke of the language of dreams, ridding such an expression of the metaphorical meaning in order to give it a real meaning. We, too, must face this problem: how does one pass from metaphor to analysis when speaking of language of the city? Once again I will refer to some specialists on the urban phenomenon, who although far removed from these problems of urban semantics have in any case noted (and I quote from a research report) that 'the data utilizable in the social sciences are such in form that an integration of them into models appears problematic'. Now if it proves very difficult for us to insert in a model the data provided us, with regard to the city, by psychology, sociology, geography, demography, etc., this is due to the fact that we lack, indeed, a final technique, that of symbols. So to transform these data, to pass from the metaphor to the description of meaning, some new, energetic scientific activity is needed; it is in this that semiology (in the broadest sense of the word) could perhaps, through a development that cannot be foreseen, be of some help to us.

It is not my intention here to tackle the question of the discovery procedures of an urban semiology, although I think these procedures would probably consist in cutting the urban text into units, then distributing these units into formal classes, and thirdly, finding the rules of combination and transformation of these units and models. I will confine myself to three observations that are not directly related to the city, but that perhaps could be useful in beginning an urban semiology, inasmuch as they give a brief indication of the current state of semiology and take into account the fact that the semiological 'landscape' has gone through some changes in the past few years.

The first observation is that 'symbolism' (which should be understood as any discourse involving significations) is today no longer seen, generally speaking at least, as a matter of a regular correspondence between signifiers and signifieds. In other words, a notion that was basic in semantics a few years ago is beginning to crumble: the notion of the lexicon. One can no longer think of semantics in terms of the lexicon, that is, as a set of lists of signifieds and coincident signifiers. This kind of crisis, this erosion of the notion of the lexicon, is naturally felt in many areas of research. First, there is the distributional semantics, presently being established, of the followers of Chomsky, such as Katz and Fodor, which has put the notion of the lexicon under heavy attack. Then, leaving the field of linguistics for that of literary criticism, consider thematic criticism, which has reigned for fifteen or twenty years, at least in France, and served as a springboard for the studies in what we call new criticism, and which now finds itself, if not threatened, at least limited, or remodeled, sacrificing the signifieds it proposed to decipher.

In the field of psychoanalysis, finally, one no longer talks about a one-to-one kind of symbolism; in the work of Freud, that is clearly the dead part: it is no longer possible to imagine a psychoanalytic lexicon. All this has resulted in the discrediting of the word *symbol*, because up to now this term has always let it be supposed that the relation of signification hinged on the signified, on the presence of the signified. Personally, I use the word *symbol* for a significant organization, syntagmatic and/or paradigmatic, but no longer semic: one must make a clear-cut distinction between the semantic range of the symbol and its syntagmatic or paradigmatic status.

In this light, it would seem foolish to want to draw up a lexicon of the meanings of the city, putting places, districts, functions, etc., on one side and meanings on the other, or rather places as signifiers on one side, with functions as signifieds on the other. We have had a list of the functions that the districts of a city can assume for quite some time. Roughly speaking, we find thirty-odd functions for a city district (at least for a district of the center city, an area that has been studied rather well from a sociological point of view). Now this list, even if it could be completed, enriched, and refined, would constitute only a very elementary basis for semiological analysis, and a basis that would later probably prove problematic: not only on account of the weight and pressure of history, but also because the signifieds themselves are, like mythical beings, extremely labile, and always, finally, at a certain moment, act as signifiers of something else. The signifieds pass; the signifiers remain. Hunting for signifieds can therefore be no more than a provisional procedure. The signified, if one manages to catch it, serves only to tell us something about a particular state of the significant distribution. Furthermore, we should note that there is a growing interest in the importance of the empty signified, the empty place of the signified. In other words, the significance of the elements is beginning to be understood as a matter of their correlative position, and not of their content. Tokyo, for example, one of the most fascinating urban complexes imaginable from the semantic point of view, has a kind of center; but this center, occupied by the imperial palace, which is in turn encircled by a deep moat and hidden from view in the greenery, is experienced as an empty center. More generally, studies on the urban core in a number of cities have shown that the central point of the center city (every city has a center), which could be called the hard core, is, not the culminating point of any particular activity, but a kind of empty 'focus' for the image that the community arrives at of the center. Here too, then, an image that is in some way empty is necessary for the organization of the rest of the city.

The second observation is that symbolism must be defined essentially as the world of the signifiers, of the correlations and above all of the correlations that can never be fully or finally closed. From the point of view of descriptive technique, the distribution of elements (of signifiers, that is) somewhat overrides the semantic discovery. This holds for the Chomskyan semantics of Katz and Fodor, and also for Lévi-Strauss's analyses, which are based on the clarification of a relation that is not a relation of analogy but one of homology, as is demonstrated in his book, rarely cited, on totemism. So one might well discover, once the semiotics of the city is begun, that it is necessary to make great advances in the distinguishing of signifiers, and advances that involve an immense meticulousness. Here let me draw upon my experience as an amateur. We know that in some cities there are spaces that present a very strong centralization of functions; a good example of this would be provided by the oriental suq, where on one street there are only tanners, on another only goldsmiths, and in Tokyo certain parts of a single district are, from the functional point of view, very homogeneous – one may find there, practically speaking, nothing but bars, snack bars, or places for diversion. Now surely it will be necessary to go beyond this first glance, and not limit the semantic description of the city to these units; it will be necessary to try to pick out microstructures, just as one isolates small fragments of expression in a long sentence. So one must get accustomed to conducting very fine analyses, which extend as far as these microstructures, and, conversely, accustom oneself to very broad analyses, extending to the macrostructures. We all know that Tokyo is a polynuclear city: it has several

nuclei around five or six centers; one must learn how to semantically differentiate these centers, which are marked, let us note, by train stations. In other words, at this level as well, at least to begin with, the best model for the semantic analysis of the city may well be provided by the sentence of discourse. And here again we acknowledge Victor Hugo's old intuition: the city is a writing; the traveler in the city, that is, the user of the city, which each of us is, is a kind of reader, who in accordance with what he has to do and what his movements are draws out fragments of expression to be actualized privately. When we move about in the city, we are all in the situation of the reader of Queneau's 100,000 million poems, able to find a different poem by just changing a line; we are somewhat these readers of the avant-garde, without knowing it, when we are in a city.

The third and last observation is that semiology at present never posits the existence of a final signified. This means that the signifiers always become signifieds for other signifiers, and vice versa. In reality, any cultural (or, for that matter, psychological) complex confronts us with infinite metaphorical chains, in which the signified is always deferred or becomes itself a signifier. This structure is beginning to be explored, as you know, in psychoanalysis, by Jacques Lacan, and in the study of writing it is beginning to be postulated, if not yet explored. Approaching the city from this point of view, one might finally bring to light a dimension of it that, I must say, I have yet to see, at least brought up openly, in urbanistic studies and investigations – a dimension that I would call *erotic*. The eroticism of the city is the lesson we can draw from the infinitely metaphorical nature of the urban discourse. I am using the word in the broadest sense, for it would be ludicrous to liken the eroticism of a city to that of the district often set aside for sexual pleasures: the concept of a pleasure district continues to be one of the hoaxes of urban functionalism; it is a functional notion, not a semantic notion. I would understand *eroticism* as a substitute for the word *sociality*. The sociality of the city, apart from its practical purpose, apart from its functionality – it is this that an urban semiotics should aim at. The city, essentially and semantically, is the place where we most come in contact with one another, and it is for this reason that the center is the gathering point of every city. The center city is first of all a creation of the young, of adolescents. When they express their image of the city, they always tend to restrict, to concentrate, to condense the center; the center city is experienced as the place where one exchanges social activities, or almost, I would say, erotic activities, in the broad sense of the word. Or better, the center city is always experienced as the space of gathered subversive forces, disruptive forces, ludic forces. Play is a subject often emphasized in studies on the center; in France there has been an extensive series of studies concerning the attraction Paris exerts on the periphery, and it was observed, in these studies, that Paris as the center of its periphery was always experienced semantically as the privileged place of 'the other', and where we ourselves are 'other', where one plays. Conversely, what is not center is what is not ludic space, what is not otherness: family, residence, identity.

Of course it would be necessary, especially with respect to the city, to look further into this metaphorical chain, this substitutive chain of Eros, to look particularly in the area of other major categories, other major human uses, such as that of food, or shopping, which is a truly erotic activity in consumer societies. I refer once again to the example of Tokyo: the large stations, which are the landmarks of the principal districts, are also large stores. Certainly the Japanese station, the store-station, has fundamentally a single meaning, and a meaning that is erotic: purchase or encounter. Following that it would be necessary to probe the deep imagery of the urban elements. For example, many studies have emphasized the imaginary function of the Boulevard, which in any city is always experienced as a river, or a channel. There is a connection between street and water; and yet we know that the cities that most resist meaning and that, moreover, often give rise to problems of assimilation for the inhabitants, are precisely the cities devoid of water, the cities without a waterfront, or without a strip of water, without a lake, without a river, without a watercourse; all these cities are more difficult to live in, more difficult to read.

To conclude, I would say only this: in these observations I never really came to grips with any methodological issues. Why? Because the best way to start the semiology of the city, it seems to me – and this should hold for any semantic undertaking – would be with a kind of naïve attitude, like that of the reader. There would have to be many of us trying to read the cities we are in, starting, if need be, from a personal relationship. Superposing all these readings by different types of readers (because we have before us a whole typology of city readers, from the sedentary person to the foreigner) would then yield the language of the city. So I would say that it is far less important to multiply functional studies of the city than to multiply these city readings, of which, so far, unfortunately, writers alone have provided examples; they are the ones who so far have best dealt with urban semantics. Getting a start from these readings, from this reconstruction of a language or of a code of the city, we could then begin more scientific operations: finding the units, syntax, etc., but keeping in mind throughout that one must never try to fix and rigidify the signifieds of the units discovered, because, historically, these signifieds are always extremely labile, questionable, ungovernable. Every city is constructed, made by us, somewhat in the image of the ship *Argo*, every piece of which was replaced over time but which always remained the *Argo*, that is, a set of quite legible and identifiable meanings. In this effort to approach the city semantically, we must try to understand the play of the signs, to understand that any city is a structure; but one need never try, or even wish, to fill this structure. For the city is a poem, as has often been said, and as Hugo put it, better than anyone else, but it is not a matter of a classical poem, of a well-balanced poem on a subject. It is a poem that explicates the signifier, and it is this kind of explication that in the end the semiology of the city should try to capture and sing.

CLEARING

Interviews with LOUIS I. KAHN

1

I was relating my experience with the Art Commission, where architects present plans of schools on land available in neighborhoods, often too small to have a playground big enough for the pupils to come and at least meet each other at that moment as the whole school in play. School therefore has to assume several yard periods. And that you related to your own time in school, when the assembly was really in a sense the classroom. And the yard certainly was one. And now you get the order to have a classroom which will assemble a half or even a quarter of the school, and the yard is cut down to just what is barely necessary to have only a period, a small period, of meeting outside; you get some fresh air, that's what you do, natural air. And all these seem like the beginning of a paring down of even that, you see, smaller rooms and smaller playfields – once the idea of the total assembly doesn't become an important part of school. So I wondered whether you couldn't just eliminate the playground altogether, and really consider that it has no more power. I don't want to say it quite categorically. My mind switched to thinking in terms of a large piece of land, which would take the place of what? – of the small, inadequate playgrounds which are distributed around neighborhoods. This, I know, would meet with a great deal of disfavor, but when you look at the plans submitted, of meted-out places for swings and for sandboxes and for any other hard-surface play, and everything is measured to *Graphic Standards* proportions, of just minimums, you realize that the architect is bound hand and foot. His imagination can't span – cannot suggest even the elimination of some relatively unimportant, let's say, elements of play, and make even a superior playground by not offering the usual standards but simply a clearing itself, and let the imagination do everything else, the imagination of the child, I mean to say. And from this I thought of the idea that after all if you did nothing else, but had as a premise to assemble land, even if you do not build on it right away, in reservation – that the act of the clearing itself, knowing that the open land is an asset without even knowing its purpose . . . That's what I meant about the power of a location being a beginning, already a beginning when the land is an asserted piece of

land, waiting for the most agreed upon use. The recognition that the size of the land gives a sense of orientation to a neighborhood, a section of the city, if they were larger patches of land. Immediately you are in keeping with a sense of associated uses, similar to the anticipated associations that William Penn thought of, when he allocated even in the forests surrounding the initial development of Philadelphia five locations upon which one should not build. It's the sense of having or, let's say, employing the natural feelings of such a force, of simply a clearing, and is greater than all 'standard' planning, or all the good that's expected from what has been directed through planning.

A large location, one large location of land – you see, I feel it is very true and the other is not true. The small piece of land associated with the school, where everything is measured out, is wrong because that measurement is a kind of standard established, and possibly repeated and repeated. You say that a swing requires four feet on one side and eight feet on another, but the spirit of a swing isn't there. And also, you might say, do you need a swing? Maybe a clear piece of land in which you have no swings would make the device for swings, or the device for other play to come out, merely because it is a large piece of land. And the other, which had everything accounted for, is a deadly thing. The spirit of play cannot be found with these little piddling postage stamps. Why give any play, you see, if you cannot give it in full? Because the spirit of play is not just meting out so many square feet so you can just sort of stretch your legs. You either give it or you don't. Therefore abandon the idea of a playground entirely from a school and just simply make a clearing somewhere *worthy* to play in, and that is then a recognition of part of man's desires. There it's expressed. It's not expressed in the others, that mete it out like spoon-fed – token idea of what play is. Play is wild! Play goes in all directions.

Large piece of land. Now if you can't afford to build anything, the act of making the recognition that there must be a large piece of land is a better act than fitting it out. The fitting it out will come. Not only that, but you will be able to sense what you cannot sense as an appropriate space today. Maybe the first act on that piece of land is to build a kind of shelter, not unlike that of a stoa, which is unpartitioned, and it's there as a kind of shelter which is secure in shelter because the trees won't shelter you during the rain; so this is built as a kind of first thing. You wait, you go under this thing when it's raining, you

wait for the rain to be over, and you go back to play again, or you go home, or wait for a bus. But this gives you a sense of the validity, you see, of the establishment of play, and this is what you're supporting. When you're establishing that, your act can be very, very primitive and be truer than giving free notebooks and that kind of thing – that doesn't mean anything! You don't give any notebooks, but you simply are there in class without anything at all. Believe me, you'll learn a tremendous amount, if you don't have that classbook. If you can't give it in the spirit, you see, which means beginning over again sometimes rather than thinking that it is just a continuation in better and better and more and more . . . Rather not that, but strip yourself of the accumulation of established means and begin again in those primitive ways to catch the spirit of learning – where you *don't* have so many availabilities.

But you still can feel the raw desire that's in back of the agreement to have such a place. The word *agreement* is a wonderful word, because it's a simple, down-to-earth, bread-and-butter word, and we need it very desperately. And the word *institution* has bad repute, because it sounds like it's shackled, and confined, and running in one direction only. And that's what I mean really. Look how much spirit there is – you can see the open space. Would you have any hesitation to say that you have made a good act? Not a bit. If you can establish that as being truer in spirit to play. Or even if not play, just a clearing in the light of many houses – that a clearing is part of many houses. Just that. On that a school can be, and also maybe a meetinghouse could be, just simply that. Or a place of shelter. And the freedom of this area where things can be for play.

2

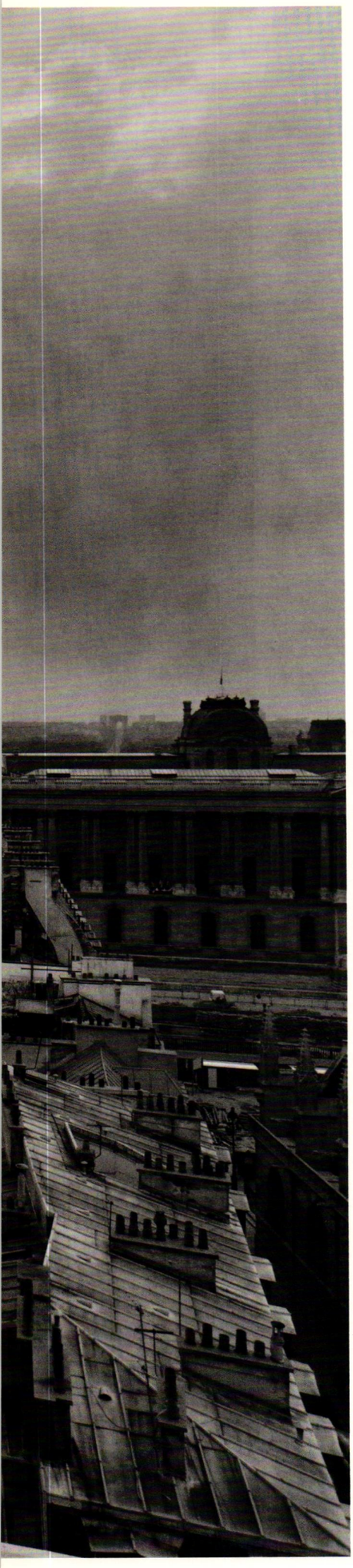
The garden. It has to do with, not nature in the broadest sense, but nature as it applies to a place which has been chosen by man and is developed for man's use in a certain way. And the architect is called in as the advocate of nature, and makes everything in the deepest respect for nature by not imitating it at all, and not allowing himself to think that he's a designer if he imitates how, let's say, the bird plants the tree. But he must plant the tree as he is man, a choosing individual, and as man conscious, nature not being conscious, makes. And then how he thinks, in the garden, as the interpreter of a personal thing – the garden belongs to a person – that it is not a place of invitation; if it is an invitation, it's a very intimate one.

And that he must make a drawing for the garden with the idea that things will grow and that his drawing is really only an instruction for something that starts. And that even every balustrade or every fountain or the choice of stone is something that belongs so much to this garden that the next garden must begin over again. So therefore he *must* destroy his drawings of the garden once it is instructed to be built, and put it into the fireplace. All details, all ideas of the garden must go into the fireplace, because it really belongs to no other garden. Therefore he keeps no record of it; he must begin again as though it were the most intimate act.

3

You might say that nature is the workshop of God, that it is the saws and the hammers and all the means of instrumentation. But the desire to be something, if it strikes this instrumentation, if, let's say, nature makes a nod and says, 'I can make it' – the desire is somehow in back of it, and is a tremendous thing. It is really the incredible. It is the part which is completely unmeasurable. It says to nature something which is not invalid, and nature makes that which it could never make had it not been for the spirit that wants it to be made. Because if nature would go on making what it makes, there would only be the matter of the sun shining and the rain falling and everything just really being right in its place because that's the way gravity wants it, that's the way the winds want it, and that's the way everything that is measurable wants it.





THE TOUR EIFFEL

'Writers, painters, sculptors, architects, passionate lovers of the beauty, until now unspoiled, of Paris, we come to protest, with all our strength, with all our indignation, in the name of disregarded French taste, in the name of art and French history presently in danger, against the erection, in the very heart of our capital, of the useless and monstrous Eiffel Tower. . . . Will this city of Paris continue to listen to the baroque, mercantile fancies of a builder of machines, and irreparably lose its honor and beauty? For the Eiffel Tower, which even the commercial America would reject, means, without any doubt, a Paris dishonored. Everyone feels this, everyone says it, everyone is deeply hurt, and we are only a weak echo of the universal opinion, so legitimately alarmed. Indeed, when the people of other countries finally come to visit our Exposition, they will cry in astonishment: "What? – is this horror what the French have brought forth to give us an idea of their famous taste?" They will be right in mocking us, for the Paris of sublime Gothic art, the Paris of Jean Goujon, of Germain Pilon, of Puget, of Rude, of Barye, etc., will have become the Paris of Monsieur Eiffel.' – E. Meissonier, Ch. Gounod, Charles Garnier, W. Bouguereau, A. Dumas, François Coppée, Leconte de Lisle, Sully Prudhomme, and Guy de Maupassant, among other signers

Maupassant often had lunch at the restaurant on the Tower, but for a curious reason (he did not like it): *This*, he would say, *is the only place in Paris where I am freed of seeing the thing.* Indeed, in Paris, one would have to take infinite pains to avoid seeing the Tower; whatever the season, through haze, twilight, mists and fog, rain, in the sun, wherever you may be, whatever landscape of rooftops, cupolas, or foliage separates you from it, *the Tower is there*; incorporated in daily life to the point that one would be hard put to come up with any particular attribute for it, just stubborn and persistent, like the stone or the river, it is as literal as a natural phenomenon, whose meaning can be questioned endlessly but whose existence cannot be disputed. There is hardly a Parisian eye it does not *meet* sometime during the day; even now, as I write these lines, as I begin to say something about it, it is there before me, framed by my window – and at the very moment the January night blurs it, seemingly intent on making it invisible and denying its presence, two small lights flash on and blink gently while turning at its summit. Through this night too it will be there, linking me over Paris to all my friends who I know will see it; we all form with it a shifting figure of which it is the stable center: the Tower is friendly.

The Tower is also present throughout the world. First as a universal symbol of Paris, it is seen everywhere on earth where Paris has to be expressed in an image; from the Midwest to Australia, there are few trips toward France that are not made, in some way, in the name of the Tower, few school books, few posters or films on France, that do not show it as the major sign of a people and a place: it belongs to the universal language of travel. But more than that, beyond its 'narrow', Parisian sense, it extends into the most general realm of human imagination. Its simple form, matrixlike, gives it the role of an infinite cipher. Alternately, and according to the calls of our imagination, symbol of Paris, of modernity, of communication, of science, or of the nineteenth century, rocket, stem, derrick, phallus, lightning rod, or insect, it is, given the great itineraries of dreams, the inevitable sign. Just as there is no Parisian eye that can avoid taking it in, there is no fantasy that does not sooner or later return to its form and feed on it;

1. View from roof terrace of Samaritaine department store

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take a pencil and let your hand wander – your mind, that is – and often it is the Tower that will appear, reduced to that simple line whose sole (mythical) function is to join, as the poet could express it, *base and summit*, or even *earth and sky*.

This pure sign, almost empty – it is impossible to get away from it, *because of everything it means*. In order to reject the Eiffel Tower (but few would be tempted to do so, for this symbol offends nothing in us) one would, like Maupassant, have to install oneself on it and, so to speak, identify with it. On the model of man – you are the only one who cannot know how you yourself look – the Tower is the only blind spot of the total optical system of which it is the center and Paris the circumference. But through that maneuver, which would seem to limit it, it acquires a new power: an object while one views it, it becomes in turn a view when one visits it, and in turn makes an object of the Paris that, now both spread out and gathered beneath it, just before had it in view. The Tower is an object that sees, or a look that is seen; it is a complete verb, at the same time active and passive, with which there is no missing function or *voix* (as one says in grammar, with a nice ambiguity) to make it defective. This dialectic is not a common one, and makes a singular monument of the Tower; for the world usually produces either purely functional organisms (the motion-picture camera or the eye) destined to see things, but then never really offering themselves to our view – what *sees* being mythically linked to what remains *hidden* (it is the theme of the voyeur) – or else spectacles that are themselves blind, that are left in the purely passive state of that which can be seen. The Tower (and there is one of its mythical powers) transgresses this separation, this common divorce between *seeing* and *being seen*; it accomplishes an unrestrained circulation between the two functions; it is an object that is complete, that enjoys, one might say, the two sexes of 'looking'. This radiant position in the order of perception gives it an extraordinary inclination to meaning: the Tower attracts meaning, as a lightning rod lightning; for those who have an interest in signification, it plays a prestigious role, that of a pure signifier – that is, of a form men are constantly investing with *some meaning* (which they draw at will from their knowledge, their dreams, their history), without, however, the meaning ever being complete and fixed. Who can say what the Tower will be for the men of tomorrow? But, to be sure, it will always be something, and something of themselves. View, object, symbol, there is the infinite circuit of functions that permits it to be always something other than, and much more than, just the Eiffel Tower.

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To answer to this great dream function, which makes it a sort of total monument, the Tower has to escape reason. The first condition of the victorious flight: the Tower must be an entirely *useless* monument. The uselessness of the Tower has always had the air of a scandal about it (the air, that is, of a truth, precious and unavowable). Even before it was built, people were reproaching it for being useless, which was, at the time, thought to be enough to condemn it; in the thinking of an epoch generally devoted to rationality and to the empiricism of the great bourgeois enterprises, the idea of a useless object was intolerable (except in the case of clear-cut works of art, and the Tower was unthinkable as a work of art as well). Thus, in the defense that Gustave Eiffel himself prepared for his project, in response to the artists' protest, he carefully enumerates all the future uses of the Tower; they are all, as one might expect from an engineer, scientific uses: aerodynamic measurements, studies of the strength of materials, physiology of the climber, research in radio electronics, problems of telecommunication, meteorological observations, etc. These are uses to which it could undoubtedly be put, but they appear a mockery beside the formidable myth of the Tower, beside the human meaning it has taken on throughout the world. Here, utilitarian reasoning, no matter how much it may be exalted by the myth of Science, is nothing compared to the great imaginary function – the function that gives men an opportunity to be properly human. However, as always, the gratuitous meaning of the work is never directly acknowledged; it is rationalized under use: Eiffel saw his tower as a serious, reasonable, useful object – men send it back to him in the form of a great baroque dream that moves, naturally, into the irrational.

This double impulse is a profound one: architecture is always dream and function, expression of a utopia and instrument of some convenience. Even before the birth of the Tower, the nineteenth century (especially in America and England) often dreamed of structures of astonishing height, for the century was engrossed in technical feats and the conquest of the skies was again stirring humanity. In 1881, shortly before the time of the Tower, a French architect had elaborated in some detail a project for a sun-tower; this project, technically rather insane since it resorted to masonry rather than iron, also sought the guarantee of a completely empirical utility – on the one hand, a flare placed at the top of the structure was to light up nightly every nook and cranny of Paris with a system of mirrors (complex, one imagines!), and, on the other hand, the top floor of this sun-tower (about a thousand feet high, like the Eiffel Tower) was to be reserved for a sort of aerial sanatorium, where sick people would have enjoyed an atmosphere 'as pure as in the mountains'. And yet, here as with the Tower, the naïve utilitarianism of the enterprise never parts company with the all-powerful oneiric function that, in truth, inspires its birth: use always just shelters meaning. Thus one could speak of a real Babel complex in man: Babel was to *serve* to commune with God, and yet Babel is a dream that goes far beyond what the project implies theologically. And just as the great ascensional dream, relieved of the utilitarian prop, is finally what remains in the innumerable Babels represented by painters, as if the function of art were to reveal the profound uselessness of objects, so the Tower, promptly absolved from the scientific rationale that sanctioned its birth (it matters little here whether the Tower is actually of some use), started off on a great human dream where mobile and infinite meanings run together – it has regained the fundamental uselessness that keeps it alive in men's imagination. At the outset, since the idea of an empty monument is so paradoxical, one wanted to make a 'temple of Science' out of it; but that is only a metaphor, for in fact the Tower is *nothing*; it manages to become a sort of monument degree zero; it partakes of nothing sacred, not even Art; one cannot visit the Tower as one would a museum, because there is nothing *in* it to see. This empty monument receives, nevertheless, twice as many visitors every year as the Louvre, and considerably more than the largest movie house in Paris.

Why, then, does one visit the Eiffel Tower? No doubt in order to participate in a dream of which it (and there lies its originality) is much more the catalyst than the object proper. The Tower is not a common spectacle; to go into the Tower, to scale it, to circulate among its cursives, is, in a manner both unusually elementary and unusually profound, to have access to a *view* and to explore the interior of an object (but this one is pierced, with all the openwork), to transform the touristic rite into an adventure of vision and of intellect – and we should say a word about this double function before passing, finally, to the great symbolic function of the Tower, its last meaning.

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The Tower looks upon Paris. To visit the Tower is to take up a 'balcony' position in order to perceive, comprehend, and savor a certain

2, 3. Views from the stairways of the Tower



Notre Dame



Vue prise de la 4me plateforme de la Tour
avec un objectif de 1^m de foyer
Instantané au $\frac{1}{100^e}$ de seconde

Le Panthéon



Vue prise de la 4me plateforme de la Tour
avec un objectif de 1^m de foyer
Plaques orthochromatiques et écran jaune
Pose : 10 secondes

essence of Paris. And here again the Tower is an original monument. Customarily, belvederes are 'viewpoints' on nature, holding various elements of nature – waters, valleys, forests – assembled beneath them; indeed the tourism of 'fine views' never fails to imply a naturistic mythology. The Tower, though, gives not onto nature, but onto the city; and yet, because of its very status, as a visited viewpoint, the Tower makes a sort of nature out of the city. It composes the swarming of men into a landscape; it adds to the often somber urban myth a romantic dimension, a harmony, a relief; through it, or beginning from it, the city rejoins the great natural themes offering themselves to human curiosity: the ocean, the storm, the mountain, the snow, the rivers. To visit the Tower is, not to come in contact with a historical object of veneration then, as is the case with most monuments, but rather to come in contact with a new nature, that of human space: for not a vestige, memento, or, in short, culture, the Tower is rather the immediate consumption of a humanity rendered natural by this view that transforms it into space.

One could say that in this the Tower materializes an imagination that had its first expression in literature (it is often the function of great books to accomplish in advance what technics will later on only execute). Fifty years before the Tower, indeed, the nineteenth century had produced two works where the fantasy (perhaps a very old one) of the panoramic vision received the assurance of great poetic writing: on the one hand, the chapter in *The Hunchback of Notre-Dame* devoted to a bird's-eye view of Paris, and on the other, Michelet's *Tableau de la France*. Now what is remarkable in these two great *vues cavalières* – the one of Paris, the other of France – is that Hugo and Michelet clearly understood that the panoramic vision added to the marvelous relief of altitude an incomparable power of *intellection*. The bird's-eye view, which any visitor to the Tower can momentarily take as his own, lets the world be *read*, and not merely perceived; that is why it corresponds to a new sensibility in vision: to travel before (think of some of those promenades of Rousseau's, remarkable in their own right), was to be buried in sensation, to perceive only a sort of worm's-eye view of things, and the bird's-eye view, on the contrary, represented by those romantic writers as if they had been struck by a presentiment both of the erection of the Tower and of the birth of aviation, lets one get beyond sensation and see things *in their structure*. It is thus the advent of a new, intellectualistic mode of perception that these works of the literature and the architecture of the view signal (born in the same century and probably of the same history): as put down in ink by Hugo and Michelet (and as looked upon by the Tower), Paris and France become intelligible objects, but without losing – and that is what is new – any of their materiality; a new category appears, that of the concrete abstraction. And there, moreover, is the meaning that can be given to the word *structure* today: an ensemble of intelligent forms.

So, like Molière's Monsieur Jourdain with his 'prose', every visitor to the Tower is engaged in 'structuralism' without knowing it (which is not to deny the existence of prose and structure). In the Paris spread out beneath him, he distinguishes spontaneously some points that are discrete – because they are known – and yet he persists in connecting them, in perceiving them within a great functional space; in short, he separates and he combines. Paris offers itself to him as an object that is virtually *prepared*, laid before his intellect, but that he must construct himself by a final activity of the mind: there is nothing less passive than the *coup d'oeil* the Tower gives Paris. This activity of the mind, even in the modest gaze of the tourist, has a name: deciphering.

What is, in fact, a panorama? An image that one attempts to decipher – in which one tries to recognize some familiar places, to identify landmarks. Take any view of Paris as seen from the Eiffel Tower; you will discern the Chaillot hill over here, the Bois de Boulogne over there; but where is the Arc de Triomphe? You don't see it, and this absence obliges you to inspect the panorama again, to search out this point missing from your structure; your knowledge (whatever you may know of Parisian topography) struggles with your perception, and in a sense, that is intelligence: to *reconstitute*, to make memory and sensation cooperate so as to produce in your mind a simulacrum of Paris, the elements of which are laid before you – real, ancestral, but nevertheless disoriented by the global space in which they are given to you, for this space was unknown to you. Thus one approaches the complex, dialectical nature of any panoramic vision; on the one hand, it is a euphoric vision, for it can glide slowly and lightly over the full extent of a continuous image of Paris, and at first glance nothing 'pops up' to interrupt this great sheet of mineral and vegetal planes, perceived at a distance from the felicity of altitude; but on the other hand, the very continuity engages the mind in a certain struggle – it wants to be deciphered, some *signs* must be rediscovered in it, a familiarity coming from history and myth. That is why a panorama can never be consumed as a work of art (the aesthetic interest of a scenic painting vanishes as soon as one tries to *recognize* in it particular points springing from knowledge); to say that there is a certain beauty in Paris spread out at the feet of the Tower is no doubt to acknowledge the euphoria of the aerial vision that recognizes nothing other than a well-integrated space, but it is also to mask the thoroughly intellectual effort required in viewing an object that demands to be divided, identified, and related to memory. The pleasure of sensation (and there is nothing more pleasant than a lofty view) is not enough to put off the questioning nature of the mind when faced with an image.

The intellectual character of the panoramic view is only confirmed by the following phenomenon, which indeed Hugo and Michelet had as the principal motive for their *vues cavalières*: to take a bird's-eye view of Paris is inevitably to imagine a history; from the top of the Tower, the mind takes to dreaming of mutations of the landscape that is in view; through the wonder of space, it plunges into the mystery of time. It lets itself be affected by a sort of spontaneous anamnesis: extent in time as well becomes panoramic. Let us go back (it is not at all difficult) to the level of an average knowledge and of an ordinary interrogation of the Parisian panorama. Four great moments loom at once into view – in our consciousness, that is. The first is prehistoric; Paris was shrouded then with a sheet of water, from which only a few solid points were barely emerging; on the first platform of the Tower, the visitor would have had his nose nearly level with the waters, and would have seen nothing but a few low islands, the Etoile, the Panthéon, a wooded islet, Montmartre, and two bluish pickets in the distance, the towers of Notre-Dame – then to his left, bordering this great lake, the steep banks of Mont Valérien; and inversely, if the traveler were to go up Mont Valérien today, when there are mists, he would see the last two platforms of the Tower emerge from a liquid bed. This prehistoric association of Tower and water has, so to speak, been maintained symbolically up to the present, for the Tower is built partly on a little inlet of the Seine (filled in to the level of the Rue de l'Université) and still seems to rise from a gesture of the river whose bridges it watches over. The second history that comes into view from the Tower is that of the Middle Ages. Cocteau used to say that the Tower was the Left Bank's Notre-Dame; though the cathedral of Paris is not the highest of its monuments (the Hôtel des Invalides, the Panthéon, and Sacré-Coeur are higher), it forms with the Tower a symbolic couple – acknowledged, one might say, by the folklore of tourism, which willingly reduces Paris to its Tower and its cathedral: a symbol articulated on the opposition of the past (the Middle Ages always suggest a density of time) and the present, of stone, old as the world, and metal, sign of modernity. The third moment the Tower lets us read is a broad, undifferentiated history, for it goes from the Monarchy to the Empire, from

4, 5. Photographs taken from the fourth platform

the Invalides to the Arc de Triomphe: it is indeed the History of France – as experienced by French children at school – and many of the episodes, present in every schoolboy's memory, touch on Paris. Finally the Tower surveys a fourth history of Paris, the one in the making; modern monuments (the U.N.E.S.C.O. building, the French Radio-Television building) are beginning to put some signs of the future into its space, and the Tower makes it possible to harmonize these novel materials (glass, metal), these new forms, with the stones and cupolas of the past; Paris, in its temporal extent, under the gaze of the Tower, is being composed like an abstract canvas, somber squares (from an ancient past) being put into juxtaposition with the white rectangles of modern architecture.

Once these points of history and space are posed, in the view from the height of the Tower, the imagination proceeds to fill in the Parisian panorama, to give it its structure; but what intervenes then are human functions. In rising above Paris the visitor to the Tower would feel like the demon Asmodeus lifting up an enormous lid concealing the private lives of millions of human beings; the city becomes then an intimate world, whose functions (whose liaisons, that is to say) he deciphers. Along the great polar axis – perpendicular to the horizontal curve of the river – there are three zones in tiers, as if a body had been laid out head downhill, three functions of human life: at the upper end, at the foot of Montmartre, is pleasure; in the middle, around the Opéra, materialism, business dealings, commerce; toward the bottom, at the foot of the Panthéon, knowledge, study. Then on the right and on the left, enveloping this vital axis like two protective muffs, are two large zones of habitation, populous and luxurious respectively; and further out, two wooded tracts, Boulogne and Vincennes. It is believed that some kind of ancient law impels cities to develop toward the west, in the direction of the setting sun; to this side goes the wealth of the fashionable districts, the east remaining the place of poverty. And the Tower, in its positioning, seems to follow discreetly this movement; one would think that it is accompanying Paris in the occidental drift, which this capital does not escape, or even that it calls the city toward its pole of development, to the south and the western horizon, where the sun is at its warmest, thus taking part in the great mythical function that makes of every city a living being: neither brain nor organ, a little withdrawn in position from its vital zones, the Tower is just the witness, or the overseer that fixes discreetly, with its slight signal, the whole structure – geographical, historical, and social – of Parisian space.

This deciphering of Paris brought about by the Tower's view is not only an act of mind; it is also an initiation. To go up on the Tower to contemplate Paris there is the equivalent of that first trip, the trip the young man from the provinces used to make, 'going up' to Paris, for his conquest of it. At the age of twelve, the young Eiffel himself took the Dijon stagecoach with his mother and discovered the 'enchantment' of Paris. And the city, a rather superlative capital, summons this movement of accession to a higher order of pleasures, values, arts, and riches; it is a sort of precious world, a knowledge of which makes a man of one, marking one's entry into the real life of passions and responsibilities. The trip to the Tower suggests this myth, which must be a very old one, once again; for the tourist who goes up the Tower, no matter how peaceable he may be, Paris mustered in view by a deliberate and individual act of contemplation is still, a little, the Paris braved, defied, and possessed by Balzac's Rastignac. Accordingly, of all the places visited by the foreigner or the person from the provinces, the first obligatory monument is the Tower; it is a Door; it marks the passage to a certain knowledge: one must make a sacrifice to the Tower in a rite of inclusion from which, precisely, the Parisian alone can exempt himself; the Tower is indeed the place where one is able to incorporate himself into a people, and it is the very essence of the capital that the Tower, as it looks on Paris, gathers and presents to the outsider who has paid it his initiation tribute.

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From the contemplated Paris, we must now recede toward the Tower itself; here it should come to life as an object (before mobilizing as a symbol). Usually, for the tourist, an object is firstly an *inside*, since there could be no 'visit' without the exploration of an enclosed space: to visit a church, a museum, a palace is at first to shut oneself in, to 'make the rounds' of an interior, somewhat in the manner of a landlord – any exploration is an appropriation. This tour of the *inside* answers, moreover, the question posed by the *outside*: the monument is an enigma, and to get into it is to penetrate it, to master it. Thus, in the touristic visit, one again encounters that initiation function mentioned above apropos of the Tower journey; the troop of visitors that enters a monument and follows processionally its interior meanders, before reappearing outside, rather resembles the neophyte, who is obliged, in order to accede to the position of an initiate, to go through a series of steps obscure and unknown to him, inside the initiatory building. In the religious protocol as in the practice of tourism, therefore, enclosure is a function of the rite. The Tower is in this respect, too, a paradoxical object: one cannot be enclosed by it since what defines it is its drawn out, linear form and the openwork of its material. How can one be enclosed in a void? How does one visit a line? Yet, unquestionably, the Tower is visited: one lingers in it, before using it as a lookout. What happens? What becomes of the great exploratory function of the *inside*, in the light of this sheer and empty monument, which seems to be made entirely of exterior material?

In order to understand how the modern visitor adapts himself to this paradoxical monument offered to his imagination, it is enough to observe what the Tower gives him in its capacity as an object (rather than as a belvedere). The Tower repays him in two ways. The first is technical in nature. The Tower presents one with a certain number of performances – or, if you like, paradoxes – to consume, and the visitor thereby becomes a kind of proxy engineer. There are first of all the four pedestals of the footing, and especially (since the enormity of them is not so amazing) the exaggeratedly oblique insertion of the metallic shafts into the mineral mass; this obliquity is curious in that it has to give rise to a straight form, the very verticality of which absorbs the whole symbolic meaning; this object, defined by its perfect rectitude, seems thus to set out from 'crooked' forms, and here, for the visitor, is a sort of intriguing contradiction. Then there are the elevators, likewise surprising in their obliquity since the imagination currently wants what rises mechanically to glide along a vertical axis, and for those who take the stairs, there is the magnified spectacle of all the details (plates, small beams, bolts) that *make* the Tower, the surprise of seeing how this quite straight form, which one consumes from all corners of Paris as a pure line, is composed of innumerable segments, crossed, entangled, divergent: a reduction operation, an appearance (the straight line) reduced to its contrary reality (a network of broken up materials), a sort of demystification brought about by no more than this magnification in the level of perception, as with photographs,

6. Elevator in the north leg

7, 8. Views to the southwest

9. Beneath the Tower

10. Elevator in the north leg

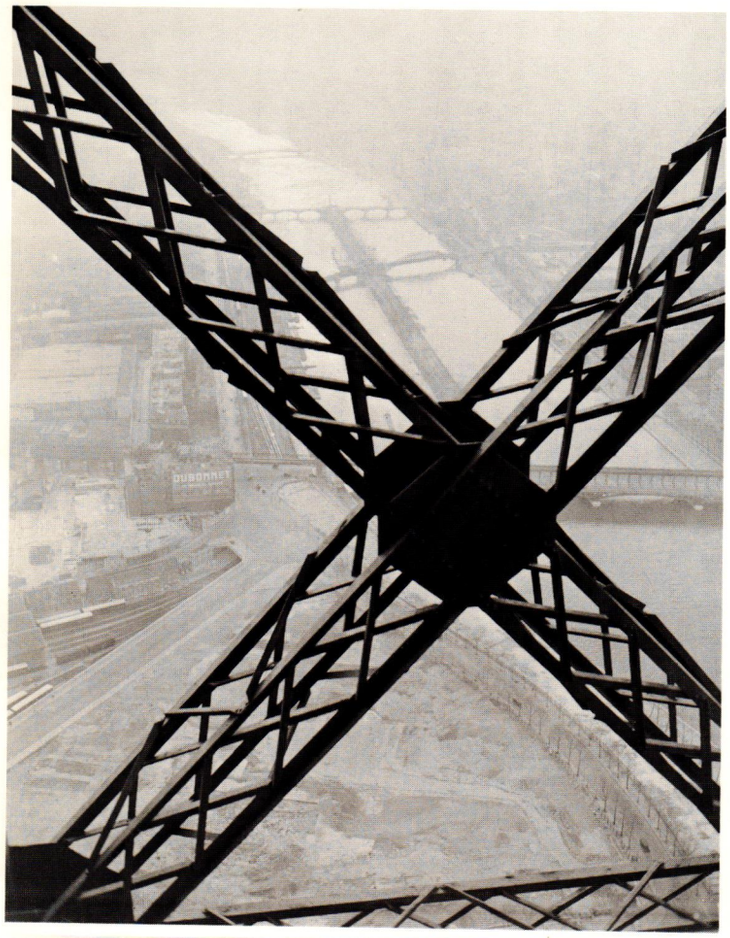
11, 12. On the fourth platform

13. Restaurant on the second platform

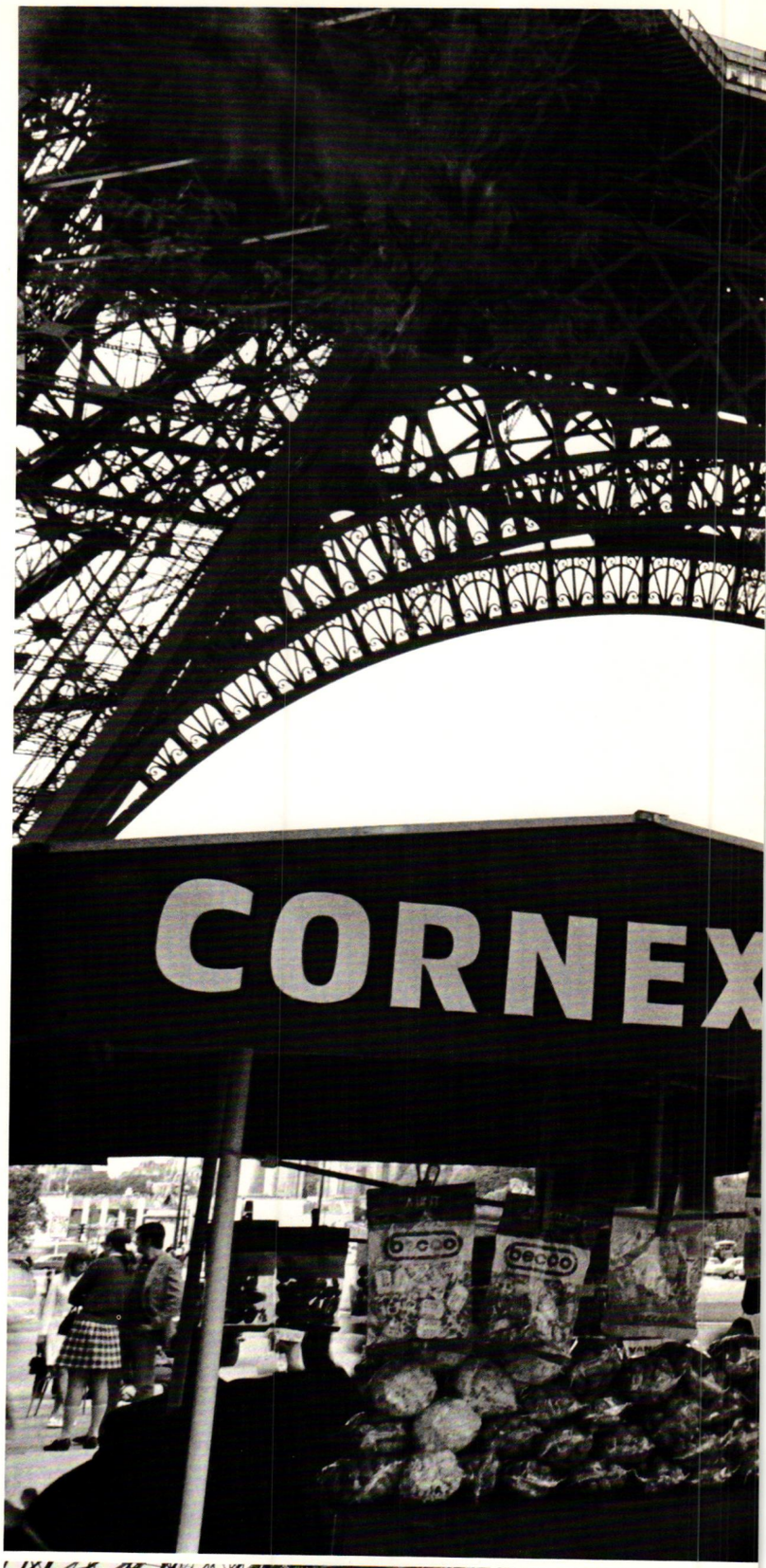


7 9
8 10, 11, 12

. . . in the very heart of our capital . . .










QUI




À VOS PARENTS
À VOS AMIS
Envoyez des
Cartes Postales
TIMBRÉES
DE LA TOUR EIFFEL


DESCENTE DIRECTE AU SOL
CHARGE MAXIMA
40 PASSAGERS
CIGARETTE
CET ASCENSEUR NE
FONCTIONNE PAS
THIS LIFT IS NOT
DIESER FAHRSTUHL IST
AUSSER BETRIEB

where the curve of a face, if it is just a bit enlarged, appears to be made up of a thousand differently lighted little patches. Thus, the Tower-object provides its observer, if he insinuates himself into it to any extent, with a whole series of paradoxes, the intriguing contraction of an appearance and its contrary reality.

The second way the Tower repays one, as an object, is that in spite of its technical singularity it constitutes a familiar 'little world', with a whole pack of small businesses that accompany its departure from the ground: vendors of postcards, souvenirs, knickknacks, balloons, playthings, and telescopes announce a commercial life that one finds again amply installed on the platforms. Now, all commerce functions to domesticate space; to sell, to buy, to exchange, it is with these simple gestures that men truly dominate the wildest places, and the most sacred structures. The myth of the traders driven from the Temple is really ambiguous. For commerce testifies to a sort of affectionate familiarity toward a monument whose singularity is no longer frightening, and it is a Christian sentiment (a particular one, then, to a certain extent) that makes the spiritual exclude the familiar; in Antiquity a great religious festival like the theatrical performance, a true sacred ceremony, in no way excluded the display of the most everyday gestures, such as eating or drinking: all these pleasures were enjoyed at the same time, not out of thoughtless abandon, but because the ceremonial was never intransigent and did not contradict the quotidian. The Tower is not a sacred monument, and no taboo can prohibit a familiar life from developing there – but even so this can be taken as a phenomenon of some significance. The installation of a restaurant on the Tower, for example (food being the object of the most symbolic of businesses), is a phenomenon that corresponds to a whole sense of leisure; man seems always inclined – if there are no constraints standing in the way of it – to look for a sort of counterpoint in his pleasures: it is what one calls *comfort*. The Tower is a comfortable object, and in that, moreover, it is either a very archaic object (analogous, for instance, to the ancient circus) or a very modern one (analogous to certain American institutions, such as the drive-in movie, where one can simultaneously enjoy the movie, the car, a bite to eat, and the cool night air). Furthermore, in providing its visitor with a whole polyphony of pleasures, from technical wonders to food, not to mention the panorama, the Tower in the end lives up to the essential function of great human places: autarky. The Tower is self-sufficient: one can dream there, eat there, observe there, comprehend, be amazed, and go shopping there; as on a boat (another mythical object that makes children dream), one can feel cut off from the world there and yet like the proprietor of a world.

So one can see how the Tower, while in its physical constitution eluding the theme of enclosure proper to the older monuments, nonetheless establishes a lively rapport with the person who visits it: precisely because the visitor does not penetrate within it; he glides directly through its void, he brushes past it without ever being enclosed there, and when he settles, it is a little like being on a roof – remaining, so to speak, outside the object. In short, the intimate rapport uniting the visitor with the Tower is, not a matter of a kind of burying (as is the case with the classical monument, whose archetype has always been the cave), but a matter of an aerial glide. To visit the Tower is to become its parasite, not its explorer: a transference of the appropriation function, a transference substantiated by the proplike form of the monument. The Tower sustains; it does not contain.

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Between being an object affording one various opportunities (as described above) and a general symbol (we will say something about that shortly), the Tower develops an intermediate function, that of a historical object: in it, a certain derivation can be read, for its construction material and its forms are dated, but this derivation, no matter how rational, nevertheless rejoins in a certain way the vast realm of imagination we are trying to explore here.

Historically, the Tower is not an unexpected feat, arising anarchically from the fantasy of a single brain. We have mentioned that the century had already had several dreams of a '1,000-foot' tower (just what the Eiffel Tower is in height). What brought it to life, however, was a quite concrete technical circumstance: the advent of iron in architecture. The artists' protest was, among other things, directed against one's daring to employ iron in architecture, and indeed Eiffel symbolizes the transition from architect to engineer. With its roots in the economic and industrial conditions of the epoch and consequently bound up with the very development of the bourgeoisie (who were behind every official patronage granted the Tower), the substitution of iron for stone in the construction of human quarters (and no longer just machines) entailed a complete displacement of the realm of imagination. A telluric material, stone is symbolic of foundation and immutability; it is therefore the material singled out for the *dwelling*, insofar as that postulates, euphorically, an eternity; at worst, stone wears away (while keeping its function) but it never comes undone. The mythology of iron is entirely different. Iron partakes of the myth of fire; its (symbolic) value has to do, not with weight, but with energy: iron is both strong and light. But above all it is bound up with an imagination of work: pure resistance, it is the product of a sublime element, fire, and a human energy, that of muscle; its god is Vulcan, and its place of creation the workshop. It is truly an *operational* material. It is understood that this material is symbolically linked to the idea of a harsh, triumphant domination, of men over nature. The history of iron is in fact one of the most progressive of histories, and Eiffel only crowned this history – on the one hand by making iron the material for all his constructions and, on the other, by imagining an all-iron object (the Tower), rising in the Paris sky like a stele dedicated to Iron: all the passion of the century, both Balzacian and Faustian, is summed up in this material.

That is not all. Eiffel (whose background was in chemistry) used iron in various structures, but all of them involved a single idea: the intercommunication of men. Simple bridges (over the Douro) and railway bridges (over the Gironde), viaducts (the Garabit Viaduct), structures for railroad stations (in Pest), locks (the abandoned project for the Panama Canal) – all these works are intended to annul the obstacles nature puts in the way of human intercourse. That was the need, and therefore the idea, of the century. The world was in the process of shrinking, geography was changing, and Eiffel brought to this idea a material, not a new one, certainly, but with a new use. A light substance, iron permitted men a certain lightness in moving from one place to another, in crossing rivers, or mountains; it was already bringing about a victory over gravity (which Eiffel was to complete, thanks to his studies in aerodynamics, with a victory over the wind, and thus open the way to another circulation of men, that of the twentieth century, that of aircraft). Indeed iron gives human circulation a new image; as if fused all at once (though in reality it is minutely assembled), the piece of metalwork seems to be *cast* over the obstacle, rapidly – suggesting that time itself has been conquered, short-cut by a swift move, and foreshadowing the casting of the jet over continents and oceans.

While a useless object, the Tower was, then, a sort of anthological form, summing up all these works of major circulation, the century's conquest of space and time with the help of iron. It is understandable that again as a symbol, and again on Eiffel's initiative, iron served (in an equally novel fashion) to form the framework of the statue of Liberty that Bartholdi erected at the entrance to New York. Metallurgy, transportation, democracy: Eiffel gave to his century, in his Tower, the material symbol of these three conquests.

Of all those construction works, summarized under the idea of circulation, there is one that is privileged, for it comes very close to the Tower, and that is the bridge. In a certain way (excluding some unique endeavors, like the station in Pest and the observatory in Nice), Eiffel built nothing but bridges – he had a veritable passion for this type of work; he used to draw all sorts of bridges, and it was said of him that he sold bridge by the yard. In order to fulfill its circulation function, the bridge must stand in opposition to two natural forces: the waters, which can overflow, and the wind, which while following the river valleys can always change direction (the success of the Maria Pia bridge was in conquering with elegance these two elements, which are particularly violent on the Douro). We know that the myth of the Bridge has always been treasured by humanity: the Bridge is the very symbol of the tie – of the human, that is to say, as soon as that has a plural sense; the view of a bridge (so often represented in painting) gives a feeling of intense humanity. The Tower, too, is a bridge; it has the form, the cast, and the material composition of one, as if Eiffel had crowned the series of his horizontal bridges and arched bridges with a last, extraordinary bridge: an upright bridge, connecting the earth, the city, to the sky – not to the heavens of divinity, but to the sky that less than a century later would be the humanized space of aircraft and spaceships. This perfectly straight bridge joins with the other bridges of Paris; it watches over the flock of them (as Apollinaire expressed it). Put the Tower and the bridges of Paris together in a single image (as happens in certain photographs) and you will perceive the same object, and through this object that is reproduced and varied, the whole humanity of Paris, the city of twenty-five bridges.

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As a historical object, crowning the advent of iron in architecture and the proliferation of construction works all over the earth, from the Douro to Saigon, the Tower was to pose one last problem, that of its plastic qualities, for a 'useless' object could only be justified if it were 'beautiful', if, abandoned on the level of use, it were recovered on the level of art. We know how much the 'artists' of the period, joined by a few intellectuals, were opposed to the Tower, or at least to its design; there were battles 'in the name of disregarded French taste', 'the soul of France' was invoked, 'the baroque, mercantile fancies of a builder of machines' were denounced, the Tower was depicted – in advance – as 'a black, gigantic factory smokestack'. Eiffel could respond sensibly enough to these charges, saying that even where artistic values are concerned one can never prejudge the future. For above all, in its very being, the Tower was opposing to the age-old idea of plastic beauty a new value, which has since conquered the world: that of functional beauty. Indeed, though the Tower is a 'useless' object, it borrows its necessity from technics: it is beautiful because it is born of the order of necessities. There was certainly, in that, a great revolution; the extension of a monument to such a height could be accomplished not by an architect but by a technician; the Tower confirmed, then, the power of sheer technics over objects (buildings) until then subject (at least partially) to art; it was inevitable, therefore, not that art disappear (as those who were protesting against the Tower believed), but that it become modified and recognize new norms, or, if you like, new alibis.

We will not decide here whether the Tower is 'beautiful' or not; but if it does, in fact, stand on its own, disengaged from the traditional norms of plastic beauty, that is because its technical 'necessity' provokes in whoever looks at it a feeling of accomplishment as strong as that brought about by the work of art, a feeling easily separated from purely utilitarian considerations. Functional beauty does not lie in the perception of the good 'results' of a function, but in the spectacle of the function itself, caught in an action prior to its production; to apprehend the functional beauty of a machine or of a piece of architecture is, in short, to suspend time, to delay the use in order to contemplate a piece of *workmanship*: here we are getting into a body of very modern values, which is articulated around the notion of human *making*. Thus, although the Tower is a finished object (and finished for some time now), it is still the 'working out' of it that one consumes aesthetically. This technical accomplishment – it can be sensed even when one does not know the history of the Tower – this making, is essentially *previsional*. Once the principle of iron was accepted, Eiffel had to solve two major problems in conceiving his work: wind resistance and the assembly of the building. It is the victory over the second that makes the beauty of the Tower. Eiffel imagined, in fact, a revolutionary type of assembly: everything was calculated in advance, almost to the millimeter: the dimensions of each piece, the size of the holes (with the help of logarithmic computations), and better still, the nature and position of all the provisional supports necessary to the assembly of the pieces, so that the worker could operate with the greatest facility and in the most secure position.

It was, as one can see, a triumph of prevision (a complete triumph, since the erection of the Tower did not involve a single accident). Thus the human mind was confirming its power not only over material and nature, but also over time, considered as a logical sequence of subtle operations to be precisely articulated.

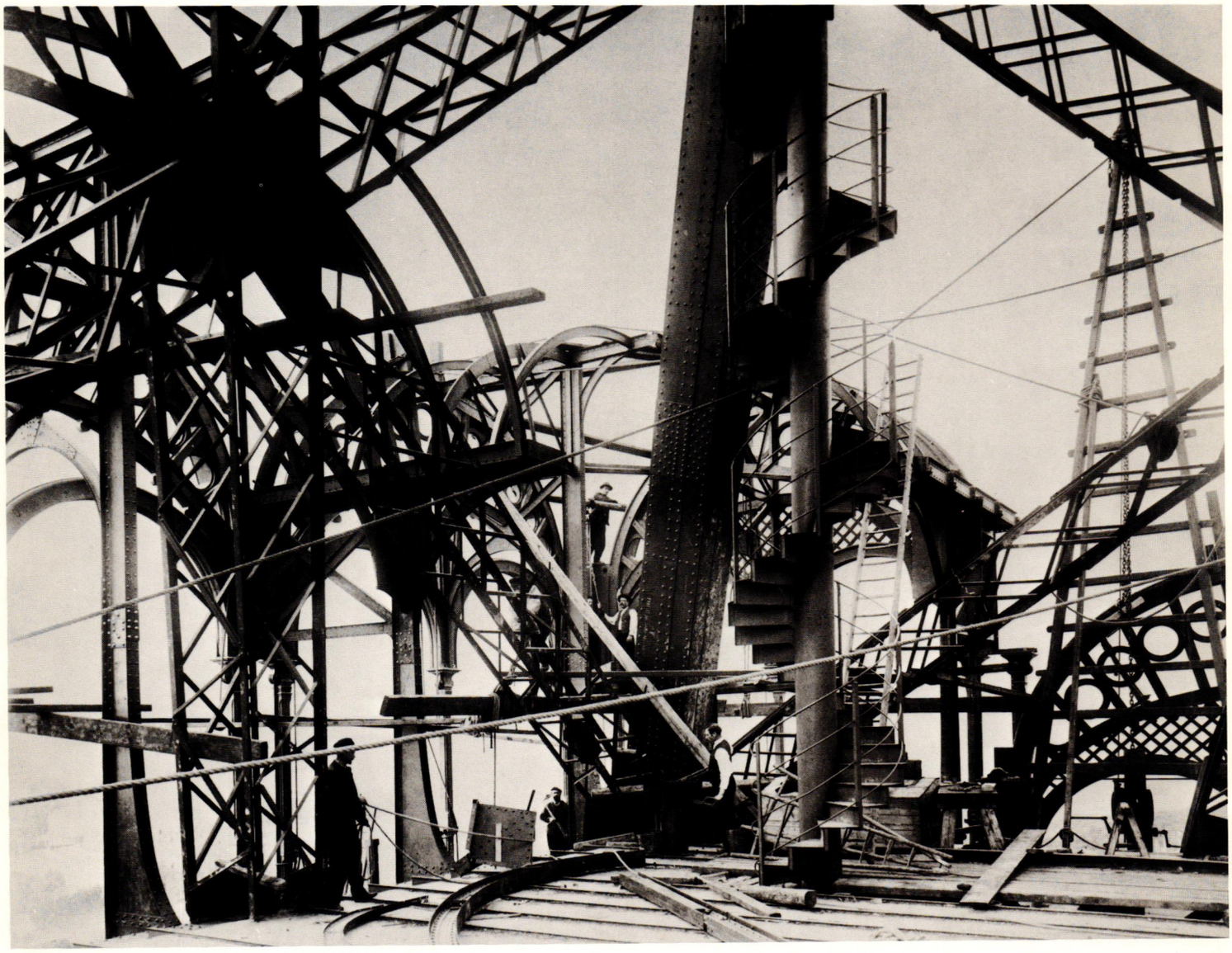
It is this same structured nature of the object that one discovers again, symbolically, in the remarkable proliferation of trinket towers. The Tower has been, and is being, tirelessly copied, multiplied, or, that is to say, *simulated* (which is, as we have seen, a properly 'structural' word), in an endless stream of souvenir trinkets and eccentric ornaments (coiffures, footwear). The multiplication of these little Eiffel Towers, the fancy of the reproductive imagination that is expressed here, the relish with which people seem to buy them up – all of that emanates from two fantasies of construction, as each trinket buyer relives as a proxy the creative adventure of the Tower. The first of these fantasies has to do with what could be called the *miniaturization* of the Tower. The Tower is a celebrated monument first of all for the achievement of its height; in having in his possession a *reduction* of this monument, the trinket buyer experiences renewed amazement: he is able to *hold* the Tower in his hand, to keep it on his table; what constitutes its intrinsic value, namely, the wonder of its proportions, is in some way at his disposal, and a strange, inaccessible, unappropriable object can be mixed in with his everyday décor. Futhermore, the miniature comes close to a rough model; the buyer can vaguely imagine that the reduced model he has on his table is no model of the real Tower, the Tower reproduced, but a model of the Tower to come, of what it will be when built; for in terms of fantasy, there is no difference between the rough model and the trinket: in both cases, the user becomes builder, engineer, conqueror of material. The material, moreover – and here we find the second fantasy of the buyer – can be *varied* by him through the trinket towers, and he can discover there again a surprise and a power, the surprise of a power. There is indeed the pleasure of a gamble infinitely renewed, and thus of a bet that is infinitely successful, in converting all materials into Eiffel Tower, from the simplest to the most unlikely, from iron to eggshell, not to mention copper, shells, matches, and diamonds; what must be satisfied here could be called a fantasy of *panic* creation, for it consists, starting from

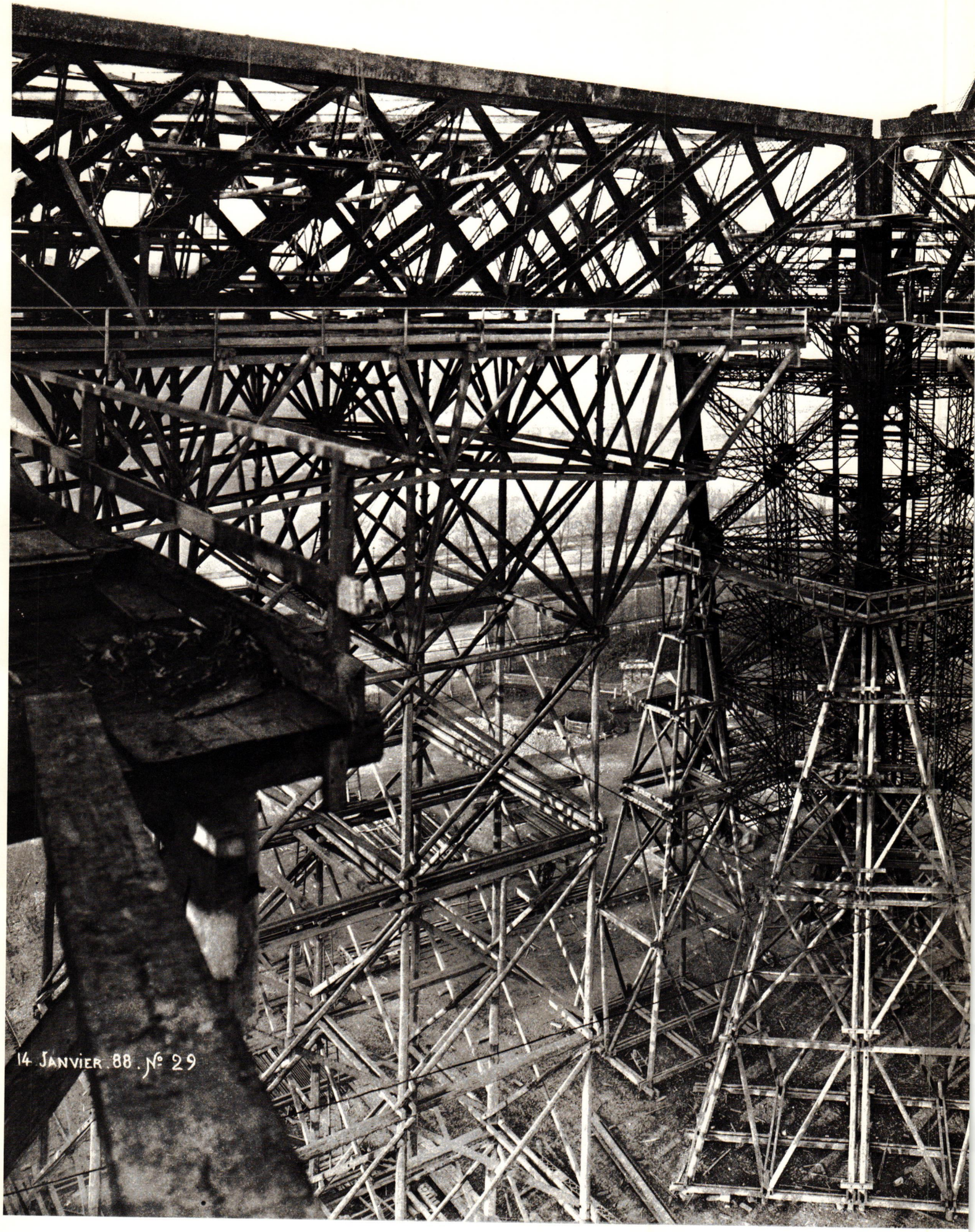
14. The Tower under construction

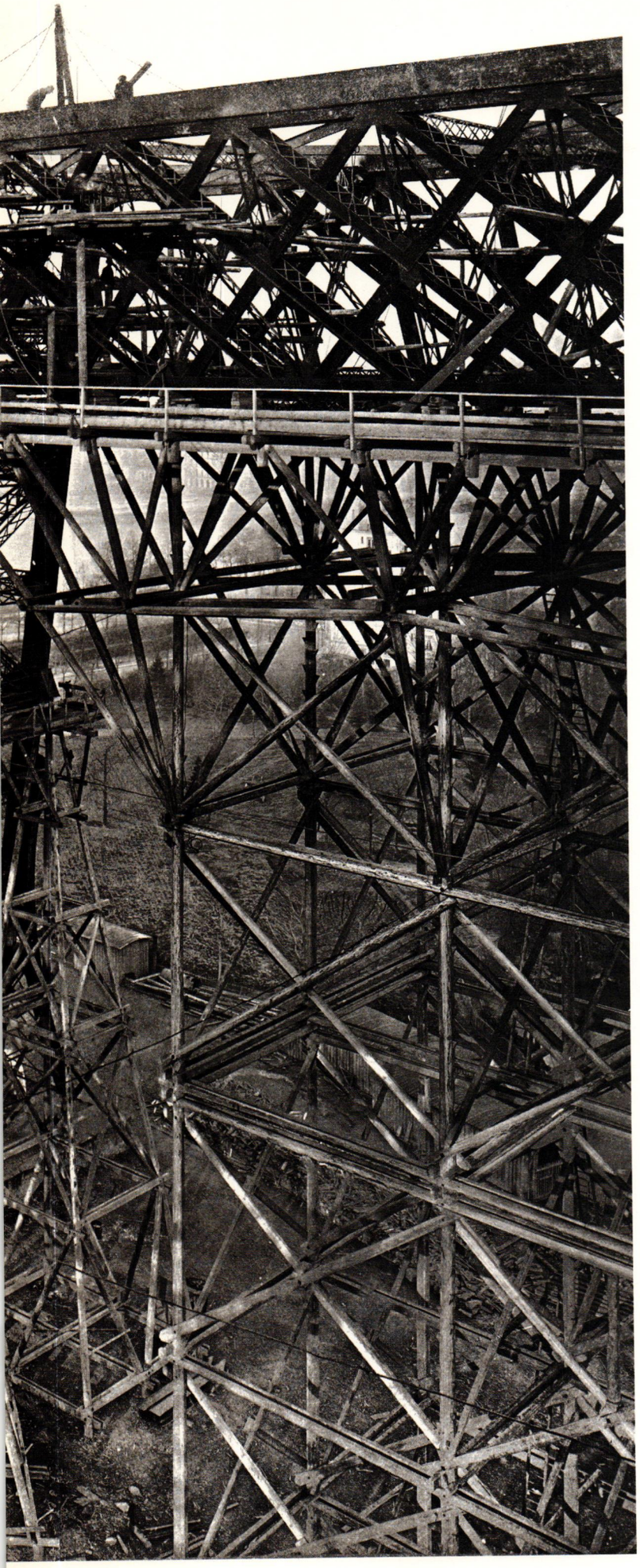
15. The Tower under construction, 14 January 1888

16. Plans, elevations, and horizontal sections

17. Detail from a drawing of the elevators of the Tower




14 JANVIER 88. Nº 29



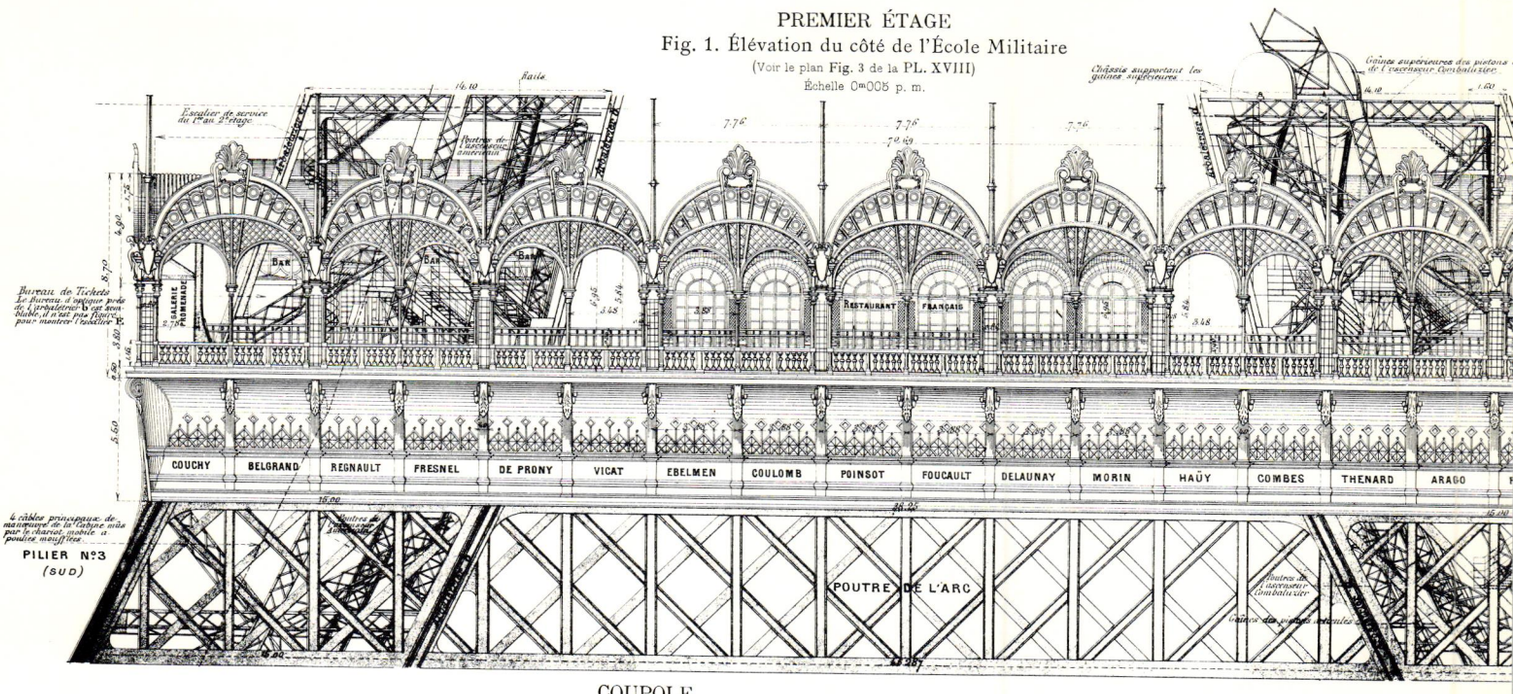
'The immense outlay of work in this great structure cost only 6,500,000 francs, $1,300,000. There are twenty-seven iron panels, each of which required a separate diagram, that in turn formed the basis of a series of geometrical designs calculated by means of tables of logarithms. The metallic pieces number about twelve thousand, and the position of each, and the places for its rivets, had to be decided without error. In the iron plates were drilled 7,000,000 holes, which if placed end to end would form a tube 43 miles long. There were five hundred engineers' designs, and twenty-five hundred leaves of working drawings. It was necessary to employ forty designers and calculators, for a period of about two years. It is thus seen that the iron forms a vast complicated net-work not easily realized when contemplating the gracefulness of the completed tower.'

PREMIER ÉTAGE

Fig. 1. Élévation du côté de l'École Militaire

(Voir le plan Fig. 3 de la PL. XVIII)

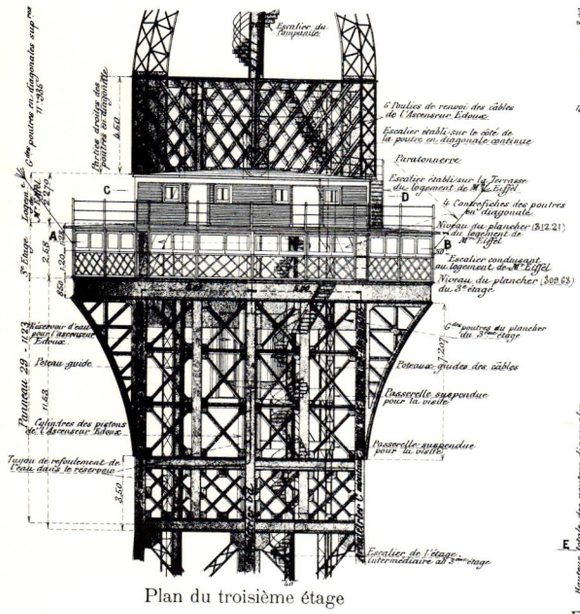
Échelle 0m005 p. m.



TROISIÈME ÉTAGE

Fig. 3. Élévation

Échelle 0m005 p. m.



Plan du troisième étage

COUPOLE

Fig. 4. Élévation

Échelle 0m005 p. m.

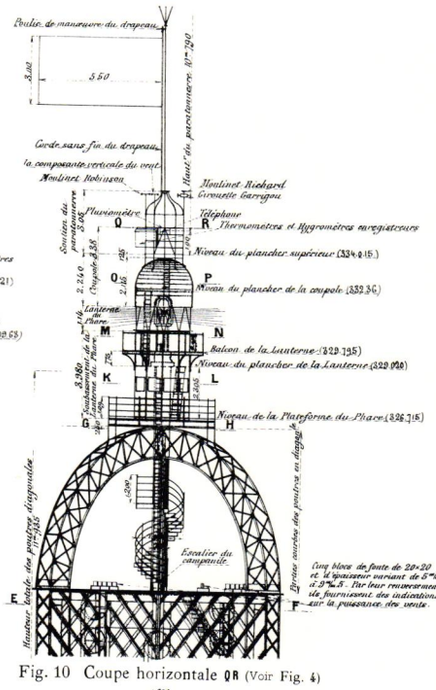


Fig. 5. Coupe horizontale GH

(Voir Fig. 4)

Échelle 0m005 p. m.

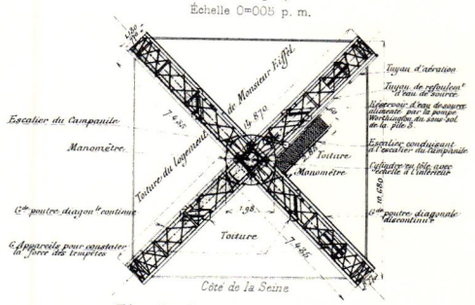


Fig. 8. Coupe horizontale EF

(Voir Fig. 4)

Échelle 0m005 p. m.

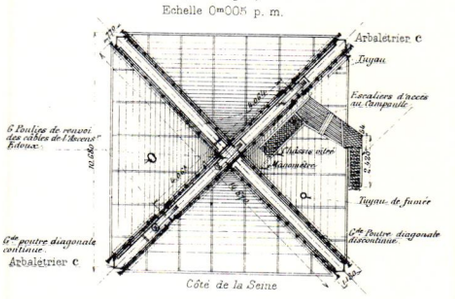


Fig. 9. Coupe horizontale AB

(Voir Fig. 3)

Échelle 0m005 p. m.

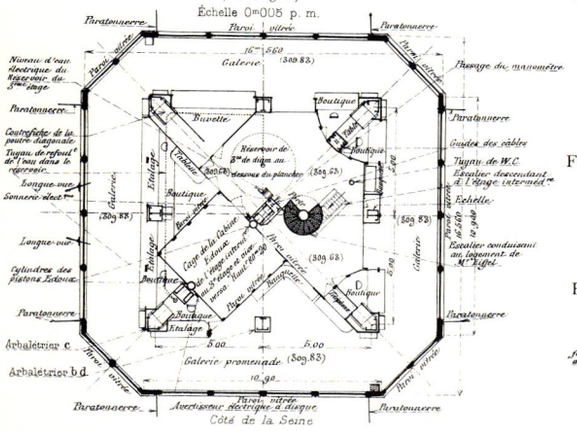


Fig. 10 Coupe horizontale QR (Voir Fig. 4)



Coupe horizontale OP

Fig. 11 (Voir Fig. 4)



Fig. 12 Coupe horizontale MN (Voir Fig. 4)



Fig. 13 Coupe horizontale KL (Voir Fig. 4)

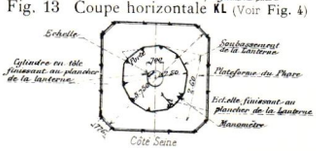
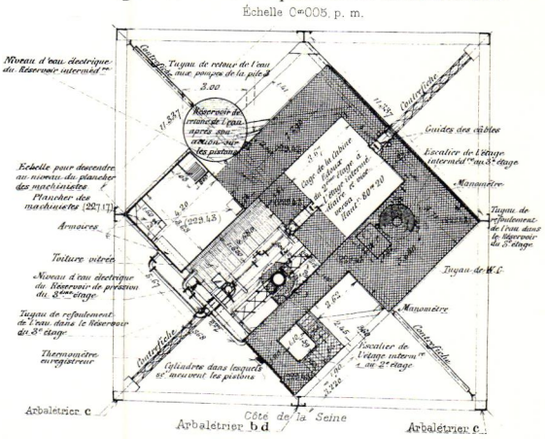
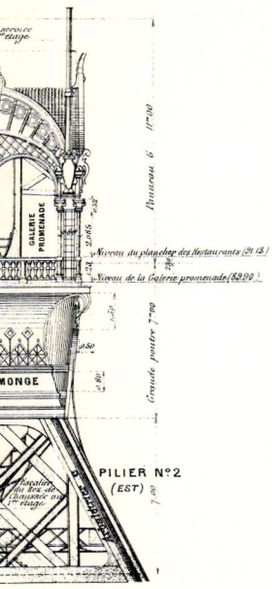


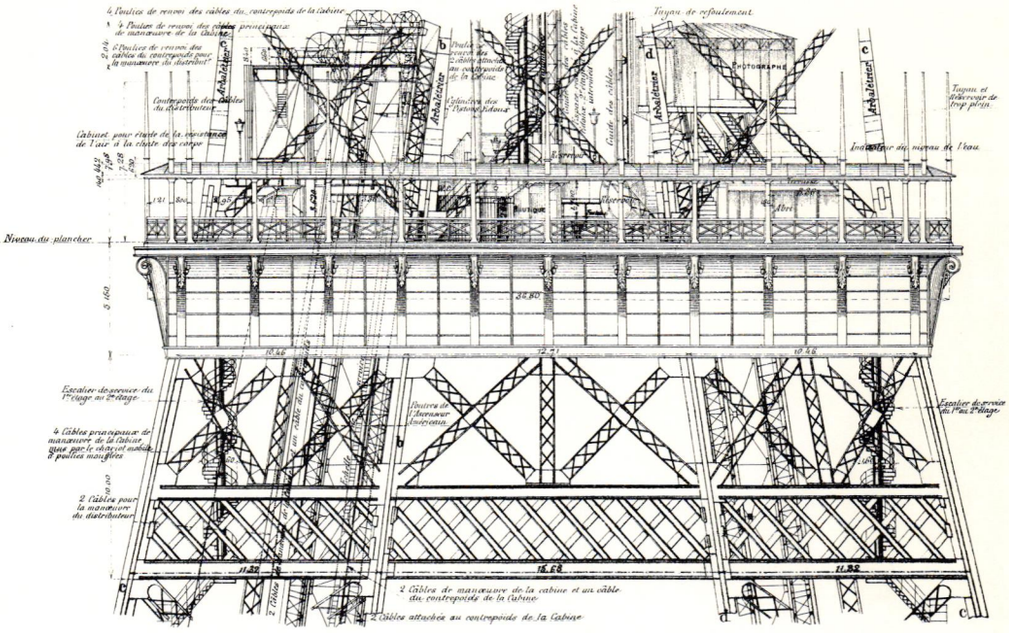
Fig. 14. Plan de la plateforme intermédiaire

Échelle 0m005. p. m.





DEUXIÈME ÉTAGE
Fig. 2. Élévation
Échelle 0m005 p. m.



Plan du logement de Monsieur Eiffel
Fig. 6. Coupe horizontale CD
(Voir Fig. 3) Échelle 0m005 p. m.

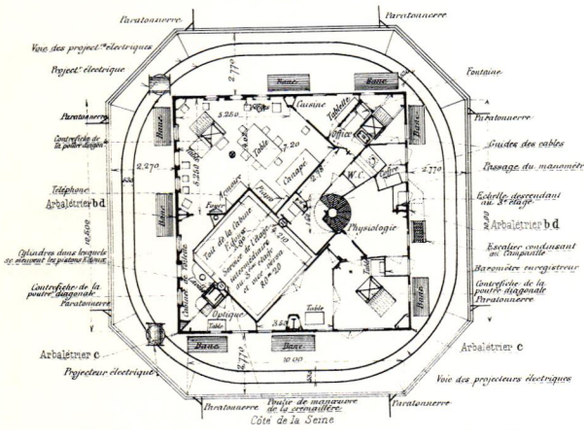


Fig. 1. Noms des savants inscrits sur les faces de la Tour

Face N. O.

Seguin, Lalande, Tresca, Poncelet, Bresse, Lagrange, Bélanger, Cuvier, Laplace, Dulong, Chasles, Lavoisier, Ampère, Chevreul, Flachat, Navier, Legendre, Chaptal.

Face O. S.

Jamin, Gay-Lussac, Fizeau, Schneider, Lechatelier, Berthier, Barral, De Dion, Gouin, Jousselin, Broca, Becquerel, Coriolis, Cail, Triger, Giffard, Perrier, Sturm.

Face E. N.

Petiet, Daguerre, Wurtz, Leverrier, Perdonnet, Delambre, Malus, Bréguet, Polonceau, Dumas, Clapeyron, Borda, Fourier, Bichat, Sauvage, Pelouze, Carnot, Lamé.

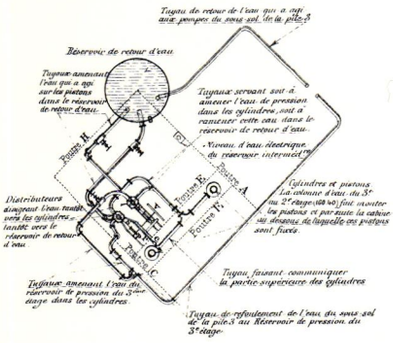
Face S. E.

Couchy, Belgrand, Regnault, Fresnel, De Prony, Vicat, Ebelmen, Coulomb, Poinsot, Foucault, Delaunay, Morin, Haüy, Combes, Thénard, Arago, Poisson, Monge.

Escaliers (Voir Fig. 1)

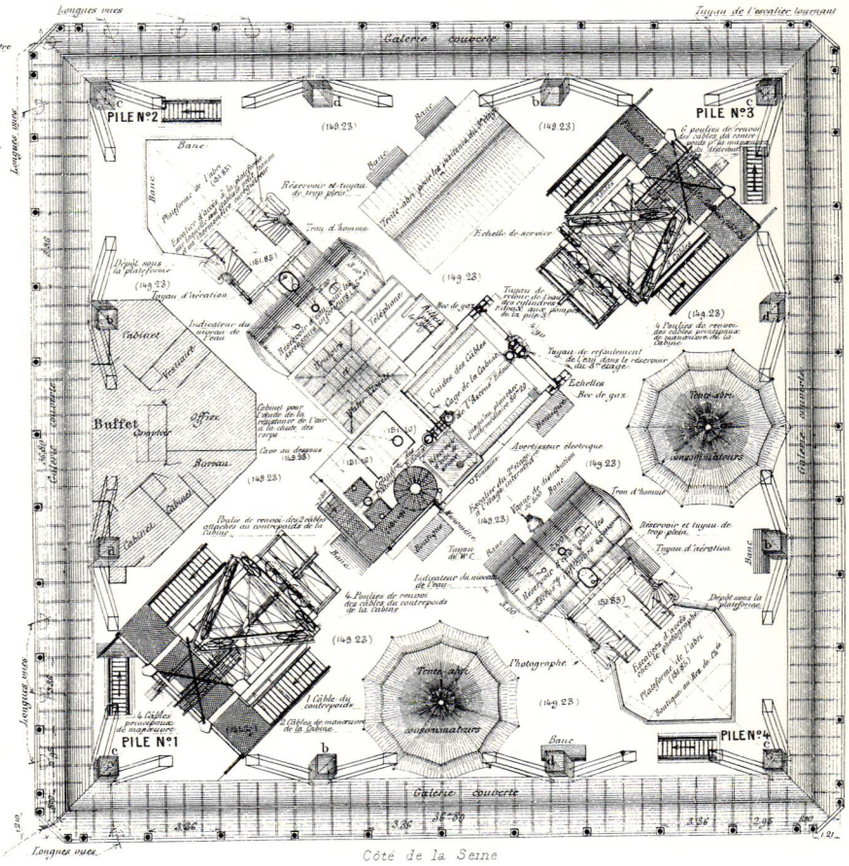
E,E Escaliers d'accès au deuxième étage de la cabine américaine Otis. — e, Escalier pour la sortie (Voir aussi le Plan PL XVIII)

Fig. 14bis. Plan d'ensemble
montrant la manœuvre de l'ascenseur Édoux
Échelle 0m005 p. m.



Nota. — La manœuvre des distributeurs se fait au moyen du volant **V** ou de la crémaillère **c**. Le mouvement est communiqué aux tiges verticales des distributeurs par les pignons dentés **p** et les secteurs dentés **S** ou par les deux roues d'engrenage **r**. Le volant **V** est mû par le mécanicien, la crémaillère **C** par le conducteur de la cabine au moyen d'un câble, à cet effet, la partie supérieure de la crémaillère est attachée à un câble qui passe sur la poulie installée au-dessus du 3me étage (Fig. 6) retombe au-dessous de l'étage intermédiaire et se termine par le contrepoids de la crémaillère.

Fig. 7. Plan du deuxième étage
Échelle 0m005 p. m.



(A.ED) ASCENSEUR ÉDOUX (Voir le plan PL. XXI et les 2 planches de détails XXII[ter] et XXIII[4])

Échelle 0[m]005 p. m.

Fig. 1. Partie comprise entre le panneau 21 et la partie supérieure des poutres diagonales

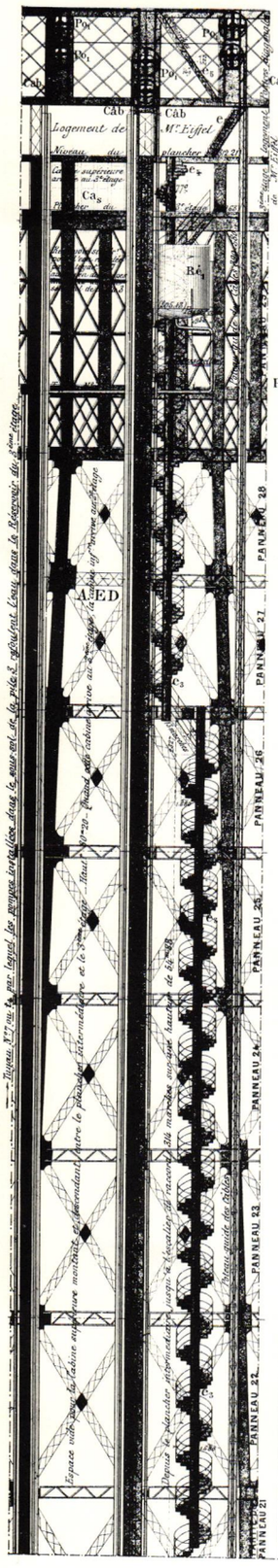


Fig. 2. Partie comprise entre le panneau 14 et le panneau 21

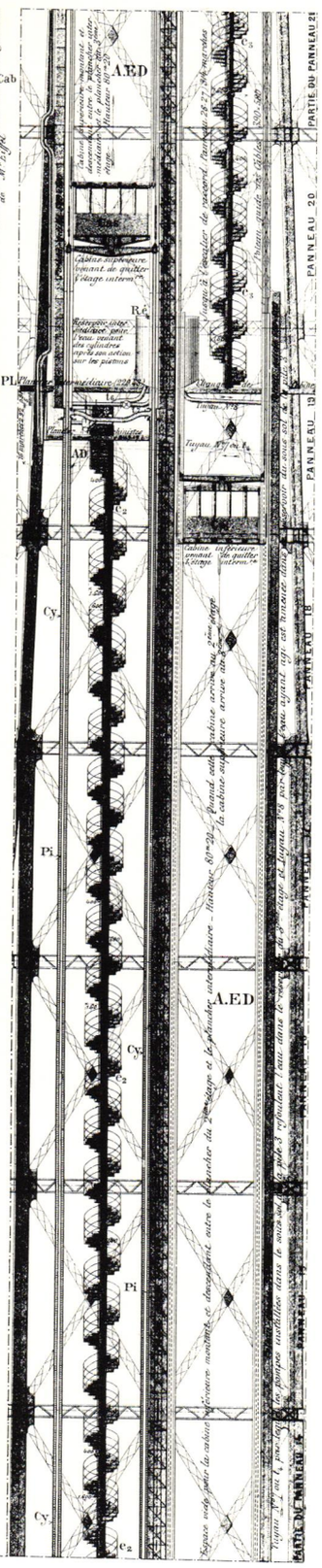
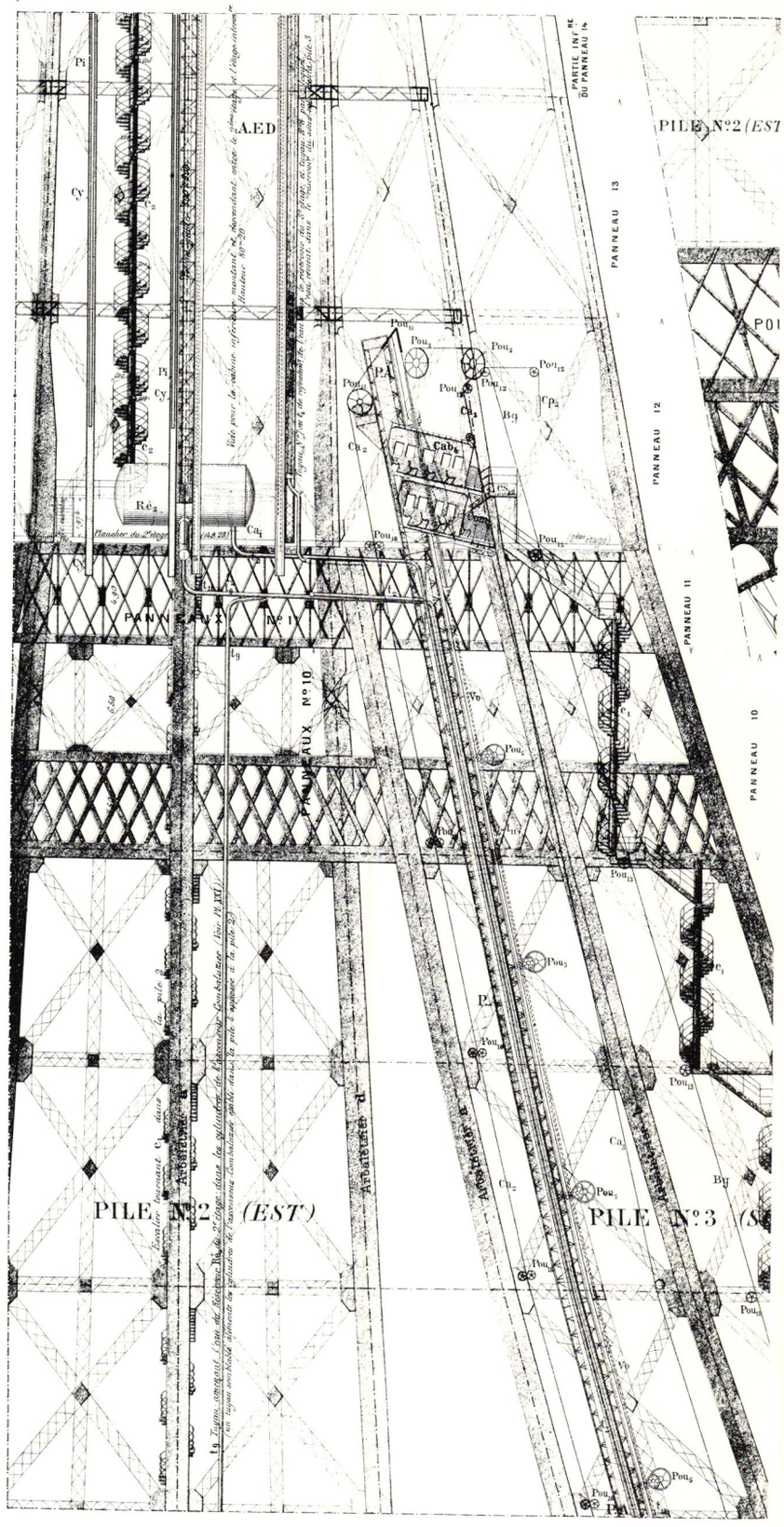


Fig 3. Partie comprise entre le panneau 7 inclus et la partie inférieure du panneau 14



DESCRIPTION DE L'ASCENSEUR ÉDOUX (Voir aussi la Planche XXI et les Planches de détails XXIII[ter] et XXIII[4])

Cy. Deux cylindres verticaux entre le 2e étage (149[m]23) et l'étage intermédiaire (229[m]43), soit 80[m]20). — **Ca$_6$**. Cabine supérieure montant et descendant entre l'étage intermédiaire et le 3e étage (hauteur 80[m]20); elle est soulevée par deux pistons *Pi* qui se meuvent dans les cylindres *Cy*. — **Ca$_1$**. Cabine inférieure faisant contrepoids à la cabine *Ca$_6$*; elle monte et descend entre le 2e étage et l'étage intermédiaire. — **Cab**. Quatre câbles reliant les deux cabines au moyen de poulies de renvoi établies à la partie supérieure de la Tour. **Po$_1$**. Poulies de renvoi des câbles. — **PL**. Plancher de l'étage intermédiaire où se fait l'échange des visiteurs d'une cabine à l'autre. — **A.D**. Appareil de distribution d'eau installé sous le plancher intermédiaire pour la montée ou la descente des pistons de la cabine supérieure *Ca$_6$* dans les cylindres *Cy*. — **Ré$_3$**. Réservoir d'alimentation des cylindres *Cy* établi sous le plancher du 3e étage. — **t$_4$**. Tuyau de refoulement de l'eau des pompes Worthington dans le réservoir *Ré$_3$*. — **Ré$_4$**. Réservoir intermédiaire dans lequel l'eau des cylindres *Cy* retourne, quand la cabine supérieure *Ca$_6$* descend du 3e étage. Ce retour d'eau a lieu par les tuyaux *t$_6$* et *t$_5$* (Voir aussi PL. XXI) de l'appareil de distribution. — **t$_3$**. Tuyau ramenant l'eau du réservoir *Ré$_4$* aux pompes *P$_2$* du sous-sol de la pile 3 (PL. XXI). — Voir le fonctionnement de l'ascenseur, PL. XXI.

Cyl. Cylindre hydraulique avec piston à de mobiles *Pou$_1$* pour former un immense palan principaux sont renvoyés d'un côté de la voie d cabine constitué par un long truc muni de roue contrepoids. — **Pou$_{14}$**. Poulies-guides des câbles l'autre côté; ces câbles passent sur les mêmes établie vers l'origine de la courbe de la voie de de distribution intercalé sur le tuyau *T$_6$*. — **Cy t$_{12}$**. Tuyau d'évacuation ramenant au réservoir sortie du 1er étage de la cabine à l'arrêt au rez-d

a simple idea (the Tower), in conceiving everything and bringing it all about; it will therefore be manifested in the very variety of the objects that lend themselves to the Tower and to which, in exchange, the Tower gives its form: lighting fixtures, fountain pens, letter openers, paperweights, etc., not to mention the simple use of its image when the Tower is printed on handkerchiefs, scarfs, or boxes of Camembert cheese. What is said through this unbridled proliferation is, in short, that the Tower belongs to everybody, or better yet, to every imagination: a profound truth, ratified by the law itself, since the courts recognized some time ago the freedom of anyone to reproduce the Tower. Its image is outside the realm of property rights. The Tower is public.

° ° °

Both view and object, the Eiffel Tower – and perhaps here lies its most intense life – is also a symbol, and this role has developed in an unexpected way. Of course, from the start, the Tower was to symbolize the Revolution (on the occasion of its centennial) and Industry (on the occasion of its great Exposition). However, these symbols did not have a long life, and others have replaced them. As a social symbol, it has become, not one of democracy, but one of Paris. What is surprising is that Paris had to wait so long for its symbol. There were quite a few symbolic monuments in Paris, but these referred to something other than Paris: the monarchy, with the Louvre, or the Empire, with the Arc de Triomphe; only Notre-Dame perhaps, as we said, could be associated with a certain idea of Paris, especially in the romantic imagination, but that was basically because its towers seemed to command, inform, and protect the capital – and indeed this very protection function, born of an elevated position, was spontaneously transferred from Notre-Dame to the Tower, from the moment the latter became the city's highest monument. A second circumstance has reinforced the Parisian vocation of the Tower: its very uselessness. Any other monument, church, or palace referred to a certain use; the Tower alone was nothing but an object to visit; its very emptiness singled it out as a symbol, and the first thing it would symbolize, by a logical association, could only be what was 'visited' simultaneously with it, namely, Paris: the Tower has become Paris by metonymy. Let us note finally in this regard one historical circumstance; of course for centuries Paris had been an international city, the prestigious object of a 'coming up' from the provinces or of a journey from abroad; yet the democratization of tourism, this modern mixture of leisure and travel, which is certainly one of the most important phenomena of contemporary history, inevitably brought on a sort of massive institutionalization of the trip to Paris, and the Tower quite naturally turned out to be the symbol of that institution.

A more subtle element has come into play to confirm the Parisian symbol. Mythically (and that is just the level on which we are considering things here), Paris is a very old city, and in it the monumental past, from the 'baths' of Cluny to Sacré-Coeur, takes on a sacred value: the whole of Paris spontaneously symbolizes the past itself. In the face of this forest of antiquarian symbols – bell towers, domes, arches – the Tower appeared, like an act of rupture, destined to desecrate the weight of prior time, and to oppose to the fascination and entanglements of history (rich as it is) the liberty of a new time; everything about the Tower singled it out for this symbol of subversion: the boldness of the conception, the novelty of its material, the lack of aestheticism in the form, the gratuitousness of function. Symbol of Paris, the Tower, one can say, has won such a position in a struggle against Paris itself, its old stones, the density of its history; it has subjugated the ancient symbols, just as materially it has dominated over their cupolas and their spires. In short, to fully prove to be the symbol of Paris, it had to be able to lift from it the mortgage of the past as well as becoming the symbol of modernity. The very aggression it imposed upon the Parisian landscape (a point emphasized in the artists' protest) has grown passionate; the Tower has become – together with Paris – a symbol of creative daring; it has been the modern gesture by which the present says no to the past. And so the Tower is present, as the cipher of the new age, in the work of many modern painters, from Sisley to Delaunay, with his cubist Tower; Apollinaire, Fargue, Cocteau, and Giraudoux make of it a literary object; as early as 1914 the Portuguese painter Santa-Rita gives a scandalous lecture in Lisbon on the Eiffel Tower and the spirit of Futurism. Even today, with the modernist style receding into history, with the aesthetic of the Tower no longer appearing so bold, and with skyscrapers having accustomed us to feats of construction, the Tower has still not become an old or outmoded monument; periodically associated with the great discoveries of modern times – aerodynamics, radio, television, and even, through its form, rocketry – it has no age; it accomplishes the feat of appearing an empty sign of time.

° ° °

Beyond these social signs, the Tower develops some much more general symbols, belonging to the order of total sensations, at once powerful and indistinct, which come not from a definite sense, like sight or hearing, but from deep within the life of the body (they are called coenesthetic). Here all the great archetypes of sensation mingle, dedicating the Tower finally as a *poetic* object.

The Tower is to begin with the symbol of ascension, of any ascension. It satisfies a sort of idea of height in itself. There are no monuments, buildings, or natural places as thin and as high; in it, breadth is annulled; the material is entirely absorbed in an exertion of height. We know what importance these simple categories, catalogued long ago by Heraclitus, have for the human imagination, which can thereby consume at the same time a sensation and a concept; we know also, especially since Bachelard's analyses, how euphoric this ascensional imagination is, how much it helps man to live, to dream, by being associated in him with the image of the happiest of the great physiological functions, breathing. From afar, the Tower is thus experienced by millions of men as a pure exercise in height; and up close, for whoever visits it, this function becomes complicated but does not cease. We see in photographs of the Tower that at the level of its smallest members there is a subtle concurrence between the horizontal and the vertical; far from *barring*, the transverse lines, most of them oblique or rounded, arranged in arabesques, seem unceasingly to start the rise off again; the horizontal never bulges – it too is devoured by the height; the platforms themselves are never anything but relays, or rests; everything rises in the Tower, up to the thin spire along which it loses itself in the sky.

One can easily grasp how close this imagination of height is to an imagination of the aerial; the two symbols are inseparably linked, the aerial being as euphoric as the height it reaches (the sky is a sublime image, therefore a happy one). However, the aerial theme develops in a quite different direction, and finds in its path some original symbols that the theme of altitude does not share with it. The first attribute of aerial substance is *lightness*. And the Tower is in fact a symbol of lightness. It is known that one of Eiffel's technical feats was to combine gigantism (though of a slender sort) of form with lightness of material; the Tower reduced to a scale of 1:1,000 would weigh only a quarter of an ounce, the weight of a sheet of writing paper. Such a precise piece of information is not needed, however, to know intuitively that the Tower is remarkably light; there is no weight to be seen in it; it does not sink into the ground, but seems to be poised upon it. The second attribute of aerial substance is a quality quite characteristic of extent, for it is commonly found in fabrics – *openwork*. And the Tower is a lace of iron. This theme is reminiscent of the intricately carved stone that has always been recognized as the mark of the

Gothic, and here once again the Tower relieves the cathedral. Being *pierced* is a precious attribute, for it attenuates the substance without annihilating it; in short, this lets emptiness be seen, the voids being manifest without, however, being divested of their privative nature. One always sees the sky through the Tower; in the Tower, the aerial exchanges its own substance with the mesh of its prison, and iron, loosed in arabesques, becomes itself airy. No doubt this aerial character of the Tower has a positive origin: it was necessary to perforate the material to an extreme so that it would offer the least possible hold to the only dangerous enemy Eiffel encountered in his enterprise, the wind. But in this one can catch the subtlest nature of the aerial; it is the substance antithetical to wind, precisely to the extent that it is wind dominated, made quintessential, sublimated. Wind is always the symbol of unmastered power, and therefore of massiveness; paradoxically, wind can be associated, not with the light elements (air and fire), but on the contrary with the heavy, telluric elements (earth and sea); to conquer wind (as the Tower does) is, then, to move toward what is light and subtle, to rejoin the great mythologies of dreams and liberation.

However, the high, the aerial, the light, and the pierced can be found summed up in one last symbol: the plant. The plant is high by virtue of its stem; it is aerial and light at the top, and there is the openwork of its branches. The Tower takes, from the plant, the essential feature – that is to say, the impulse – in the very simplicity of its lines, rising from the ground and converging toward the sky, like those of a stem. But that is not all, for if one gets closer, the Tower no longer appears to be the vigorous shoot of a plant, but an efflorescence; one climbs in it as if into a bloom of air and iron: within it are found the straightness of fibers, the arabesque of petals, the restrained shooting forth of buds, the spreading out of leaves, and the very impulse that draws the complicated and orderly material upward.

But is that the last metaphor of the Tower? Photography, which often reveals the whole truth about an object, shows us perhaps another metamorphosis of it: the animal metamorphosis. Whether one sees it as an insect from whose tough prothorax a pair of legs have been torn, or sees it, rising in the sky, as a bird whose wings have been cut, trying to push its flight higher, well above the clouds, or it appears, more prosaically, to be an immense giraffe offered to Parisians for their astonishment, like the one presented to Louis Philippe by a sultan, which would be at the same time, by an illogical contraction, both the animal and its cage, there is a virtual bestiality to the Tower. Well, we know that the animal metamorphosis is a grotesque theme of poetic expansion, in that Nature passes through the animal when it migrates from object to man; it is in animality that all perversions begin – that of an object coming mysteriously to life, or that of a man who crosses the limits of morality and nature – and the Tower, mythically, takes part in this migration. It is a grotesque being since it holds within it the dream of a perversion of material toward unknown states, though without ever quite reaching them.

It is in finding oneself at the heart of this metaphorical instability (so fertile and so liberating for the mind) that one can grasp the last avatar of the Tower, which is its human avatar. The Tower is a human silhouette; headless, except for a sharp spire, and without arms (though far from monstrous), it is all the same a long bust standing on a pair of legs spread apart. It meets once again, in this form, its protection function: the Tower is a woman who watches over Paris, who keeps Paris gathered at her feet; both seated and standing, she surveys and secures, she oversees and covers. But here, too, the photographic approach reveals another truth about the Tower, as a sexual object; in the great release of symbols, the phallus is no doubt the simplest figure it presents; but through the camera's eye, one can see that the whole interior of the Tower, projected against the sky, is crisscrossed with pure forms of sex.

Let us say no more about the metaphorical space of the Tower. Still there is a dimension missing – the one concerning its limit. Around the monument a sort of magic circle has spontaneously developed, which tells us where the Tower ends: the Tower ends at the line of the *impossible*. From its beginning, through this infinite symbol, men have taken to playing with the limits of the human, as if the Tower invited a transgression of laws, of customs, of life itself. In a sort of dangerous vocation, the Tower does provoke the most unprecedented feats: there is a race up the stairs to the second platform (1905), it is descended on a bicycle (1923), one passes between its legs in an airplane (1945). But above all one plays with life there, and one can die; even before it was finished, a young workman, by way of bragging, ran across the beams of the first platform and killed himself in sight of his fiancée; in 1912 the Bird-Man Treichelt, equipped with a complicated set of wings, threw himself from the Tower and crashed. And it is well known that the Tower is a place for suicides. Only a mythical reason could account for the suicides at the Tower, and this reason must be made up of all the symbolic meanings with which the Tower is charged; it is because the Tower is pure spectacle, absolute symbol, and infinite metamorphosis that it calls forth – in spite of, or on account of, the innumerable images of life it sets free – the last image of human experience, that of death.

View, object, symbol, the Tower is everything that man puts into it, and that is infinite. A spectacle both when looking at it and when looking from it, a useless and irreplaceable building, a familiar little world and heroic symbol, witness of an age and a monument that is forever new, an inimitable object, incessantly reproduced, it is the pure sign, open to all occasions, all images, and all meanings, the unbridled metaphor; through the Tower, men exercise that great function of the imagination, which is their freedom, since no history, however bleak, has ever been able to take that away from them.

18. The Tower on 15 March 1889

19. One of the vendors


15 Mars 89. Nº 53



Notes and Acknowledgments

Maria Bottero, who lives and works in Milan, has in recent years edited the architectural review *Zodiac*. Her ' "Dictionnaire philosophique": Architectural Entries' was written for this volume in the belief that 'satire and Voltairean criticism of conventional architectural ideologies can sometimes be more stimulating than any optimistic panorama'. The original text, in Italian, has been published in *Comunità*, nos. 159–60 (November–December 1969), pp. 164–68, and we thank Rodney Stringer and the author for their help with the English version.

For the curious, a few references follow. The introductory quotation is from Walter Benjamin, *Illuminations*, ed. Hannah Arendt, trans. Harry Zohn (New York: Harcourt, Brace & World, 1968), p. 263. Recent work by Buckminster Fuller is shown in *Zodiac*, no. 19 (1969), and the same issue contains Miss Bottero's 'Scientific Abstraction and Concrete Thought in Buckminster Fuller's Utopia', pp. 224–30. The C.I.A.M. (Congrès internationaux d'architecture moderne) Town-Planning Chart was developed at the congress held in Athens in 1933, and may be seen in José Luis Sert's *Can Our Cities Survive?: An ABC of Urban Problems, Their Analysis, Their Solutions* (Cambridge: Harvard University Press, 1942); according to a footnote on page 248, the section of the chart about 'buildings and districts of historical interest' has been omitted from the general text of this edition 'because it applies only to certain cities [and] was introduced by the Italian delegates, who had to deal with these problems frequently' – so for that text, quoted here in translation, see Charles Edouard Jeanneret-Gris [Le Corbusier], *La Charte d'Athènes* (Paris: Editions de Minuit, 1957), par. 65. The words of Walter Gropius are from his *Scope of Total Architecture* (New York: Harper & Brothers, 1955), chap. 8, 'Architect – Servant or Leader?', and appear also in his article 'Eight Steps Toward a Solid Architecture', *Architectural Forum* 100, no. 2 (February 1954): 157. The definition of 'symptomatic' reading is from Louis Althusser and Etienne Balibar's *Reading 'Capital'*, trans. Ben Brewster (New York: Pantheon Books, 1971), p. 28, in the glossary to which is the following clarification (pages 316–17): 'a word or concept cannot be considered in isolation; it only exists in the theoretical or ideological framework in which it is used: its problematic. . . . It should be stressed that the problematic is *not* a world-view. It is not the essence of the thought of an individual or epoch which can be deduced from a body of texts by an empirical, generalizing reading; it is centred on the *absence* of problems and concepts within the problematic as much as their presence; it ['the problematic, the unconsciousness of the text'] can therefore only be reached by a symptomatic reading . . . on the model of the Freudian analyst's reading of his patient's utterances.' The phrase 'supposed totalizing continuity of the self' is from Claude Lévi-Strauss, *The Savage Mind* (Chicago: University of Chicago Press, 1966), p. 256.

Miss Bottero's striking and persuasive ideas about the architecture of Louis Kahn can be found in her 'Indian Journey: From Le Corbusier to Kahn', *Zodiac*, no. 16 (1966), pp. 242–44, and 'Organic and Rational Morphology in Louis Kahn', *Zodiac*, no. 17 (1967), pp. 240–45.

Finally, the author would like to recommend Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York: Pantheon Books, 1970); Henri Lefebvre, *Le droit à la ville* (Paris: Editions Anthropos, 1968); *The Savage Mind*, cited above, chap. 9, 'History and Dialectic'; and *Progressive Architecture* 50, no. 5 (May 1969), with the cover caption reading, 'The new master builders crowd the architects' domain.'

The following note was graciously added by Miss Bottero at our request – the quotations in it are from *Reading 'Capital'*, cited above, pages 14, 26, 27, and 40.

Before analyzing the thought of Marx, Althusser, in part 1 of *Reading 'Capital'*, deals with the problem of scientific knowledge. 'We read *Capital* as philosophers. . . . we posed it the question of its *relation to its object*, hence both the question of the specificity of its *object*, and the question of the specificity of its *relation* to that object, i.e., the question of the nature of the type of discourse set to work to handle this object, the question of scientific discourse.'

For Althusser, the object of knowledge is *not* the real object that, according to traditional philosophy (idealism and empiricism), is experienced and known by the subject. Althusser rejects the traditional subject-object opposition insofar as it implies, in the binomial relation linking the two terms, a conception of reality and history as transparent, directly perceptible, and continuous over time. Reality, as well as history, is in Althusser's view essentially opaque to immediate perception and discontinuous over time. Furthermore, there is more than that dichotomy between the real object and the object of knowledge ('the *object* of knowledge [is] in itself absolutely distinct and different from the *real object*'). The object of knowledge is no longer absolutely dependent, as it is in classical philosophy, on the speculative activity of the subject. Rather, it is the product of a theoretical *field* that is structured in such a way as to pinpoint and throw light upon certain theoretical solutions. It is the structure of the field, not the will of the subject, that underlies and prepares the emergence of scientific questions (and hence of the relative theoretical answers) in any particular science. Thus the structure of the field of knowledge makes the theoretical answers to the questions formulated in a particular scientific domain *visible*; and this same structure makes the answers to questions that are absent (not formulated) in a particular scientific domain *invisible*.

What is *invisible* within the structure of the field is not some inconsequentiality external to the field; rather, it is something closely linked to, indeed positively surrounded by, the *visible* of the field. There it constitutes a void, a weak point that the structure of the field 'intends' to make *invisible* ('these new objects and problems are necessarily *invisible* in the field of the existing theory, because they are not objects of this theory, because they are *forbidden* by it'). 'And when it happens that, in certain very special critical circumstances, the development of the questions produced by the problematic . . . leads to the *production* of the *fleeting presence of an aspect* of its invisible within the visible field of the existing problematic – this product can then only be *invisible*, since the light of the field scans it blindly without reflecting on it. This invisible thus disappears as a theoretical lapse, absence, lack of symptom. . . . To see this invisible, to see these "oversights", to identify the lacunae in the fullness of this discourse, the blanks in the crowded text, we need something quite different from an acute or attentive gaze; we need an *informed* gaze, a new gaze, itself produced by a reflection of the "change of terrain" on the exercise of vision'.

The *symptomatic reading* carried out by the subject is thus the product of a *change of terrain* that is 'absolutely irreducible to the idealist myth of a mental decision to change "view-points" ', since this *change of terrain* 'brings into play a whole process that the subject's sighting, far from producing, merely reflects in its own place'.

Illustrations: William Klein, an American director, made the film *Mister Freedom* in the late 1960s. (The captions for the stills from it here were kindly supplied by him.) To quote from a flier, *Mister Freedom* is 'the story of an international lawman, a sort of Superman, and the extraordinary adventures he has when he is sent on a mission to France, fighting the Anti-Freedomites.

'When he arrives in Paris, Mr Freedom meets, in strange circumstances, the equally strange Marie-Madeleine, the ex-fiancée of Capi-

taine Formidable (Yves Montand). After numerous adventures and an unsuccessful attempt to get the arrogant Super-Frenchman on his payroll, Mr Freedom contacts his sworn enemy Moujik Man. In an epic confrontation they reach an understanding, and agree to put the troublemaking French Anti-Freedom guerrillas out of action; they will then share France between them.

'But events take some startling turns and their plan is thwarted. Mr Freedom is wounded and taken prisoner. He manages to escape, killing Marie-Rouge, the Joan of Arc of the Anti-Freedom movement. Despite Moujik Man's calls for negotiations, the Anti-Freedomites counterattack. War breaks out.

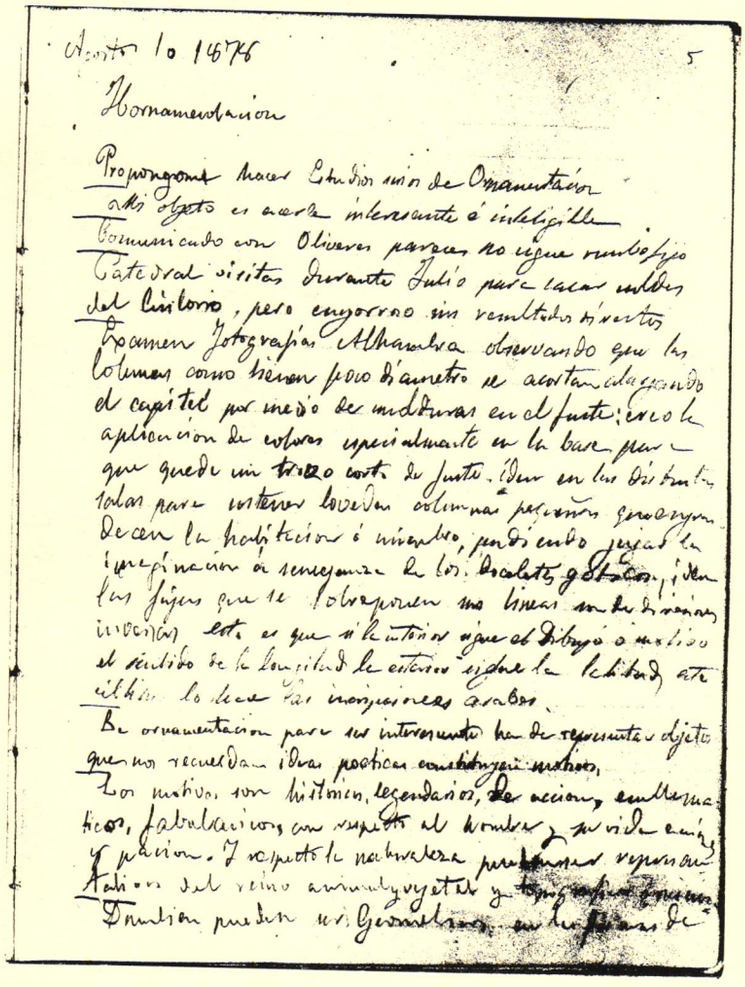
'Depressed and generally in a bad way, he is the sole survivor in the midst of the ruins. Mr Freedom calls up his "Big Boss", Dr Freedom, on his wristwatch television, and tells him the disastrous outcome of the operation. Dr Freedom does not seem unduly perturbed.

' "We won, didn't we?"

' "Yes – but there isn't much left."

' "Good. You did all that was needed. They weren't ready for Freedom!" '

[ORNAMENTATION]



Agosto 1o 1878 5

Ornamentacion

Proponemonos hacer Estudios sobre de Ornamentación
alto objeto es acaso interesante é inteligible
Comunicado con Olivares parecen no seguir rumbo fijo
Catedral visitas durante Julio para sacar unidas
del Historia, pero empezamos sin resultados diversos
Examen Fotografías Alhambra observando que las
Columnas como tienen poco diámetro se acortan disminuyendo
el capitel por medio de molduras en el fuste; en el
aplicación de colores especialmente en la base para
que quede un trozo corto de fuste. Idem en los distintos
todas para entrever bóvedas columnas pequeños generalmente
Decen la habitación é interior, pendientes juicios la
preferencia á semejanza de los Bizantinos, Góticos, é Idem
los fajes que se sobrepusieron sus líneas en las diversas
invenciones esto es que si la entonces sigue el Bizantino á medida
el sentido de la longitud de entonces sigue la latitud ate
el Gótico lo hacen las inscripciones árabes.

La ornamentación para ser interesante han de representar objetos
que nos recuerdan ideas poéticas constituyen motivos,
Los motivos son históricos, legendarios, de acciones simbólicas
ficos, fabulosos con respecto al hombre, su vida cuidados
y pasiones. Y respecto la naturaleza pueden usarse
Animales del reino animal y vegetal y tomar objetos inanimados
Donde pueden ser: Geométricos, en las figuras de

The text included here under the title 'Ornamentation' is a translation of the first part, a middle section, and the end – a little over one-third – of a series of notes written by the architect Antoni Gaudí at the age of twenty-six. The translation was made from the Spanish text published in an appendix to César Martinell's *Gaudí: Su vida, su teoría, su obra* (Barcelona: Colegio de arquitectos de Cataluña y Baleares, Comisión de cultura, 1967), pp. 474–91, and from photographs of the manuscript (Museo Municipal de Reus), for which we thank Juan Bassegoda Nonell, professor of architectural history at the Escuela Técnica Superior de Arquitectura, Barcelona. For their contributions to the translation, we are grateful to Judith C. Rohrer, Luis Manuel García-Barrio, the late Martín Esteban Domínguez, and particularly George R. Collins, professor of art history at Columbia University. It should be noted that the translation finally arrived at is at best a compromise, or one possible interpretation of the text, and that another version may soon be appearing in an English edition of Martinell's book, edited by Mr Collins and published by M.I.T. Press.

Illustrations: *1*, *2*, Ampliaciones y Reproducciones Mas, Barcelona; *3*, Escuela Técnica Superior de Arquitectura, Barcelona (Foto Canosa).

[ARCH BUILDING]

'Arch Building' comes from one of the few articles by the engineer Robert Maillart in which he permitted himself some observations of a general nature: 'Die Brücke in Villeneuve-sur-Lot, nebst Betrachtungen zum Gewölbebau', *Schweizerische Bauzeitung* 85, no. 12 (21 March 1925): 151–54. The remarks translated here followed his technical description and appraisal of a highway bridge by Eugène Freyssinet, and were 'occasioned by the exceptional boldness of the achievement, measured against the views prevailing among us'. For their generous work on the translation we thank Jared Sparks and Harlan Coornvelt.

The photograph facing 'Arch Building' is from the Museum of Modern Art, New York, and appears by the kind permission of Marie-Claire Blumer-Maillart. Max Bill, in his *Robert Maillart: Bridges and Constructions*, trans. W. P. M. Keatinge Clay, 3d ed. (New York: Frederick A. Praeger, 1969), pp. 92–96, shows several drawings and photographs of this bridge, noting that it is 'of special constructive interest in as far as it is built with two box-arches for which it was possible to use the same concrete shuttering twice. Maillart has used here for the first time the pointed arch resulting from a constructive idea instead of using the round arch based on the traditional aesthetic idea. Maillart's project had to be altered on aesthetic grounds and massive side-walls without any static function were cast in place of railings. We have already seen in the Rossgraben bridge how beautiful the simple railings are and we can only regret that false ideas on aesthetics (mostly introduced by those representing authority) are so detrimental to the most imposing structures and decrease their fresh and convincing strength.'

[MEANING IN MAILLART]

David Billington, professor of civil engineering at Princeton University and formerly a practicing structural engineer, has been concentrating recently on the analysis of various complex structural models used for research and as teaching aids and on the refining of mathematical tools for the analysis of thin-shell concrete structures. He has also been working on a textbook for undergraduates that is intended to combine the student's early technological studies with cultural and historical perspectives; this is one part of a teaching and research program begun at Princeton in 1968, entitled Humanistic Studies in Engineering and designed by the author and Robert Mark. For a general view of the intentions behind this program, see Mr Billington's 'Engineering Education and the Origins of Modern Structures', *Civil Engineering* 39, no. 1 (January 1969): 52–57, and his testimony in U.S., Congress, House, Committee on Education and Labor, Select Subcommittee on Educa-

tion, *Amendments to the National Foundation on the Arts and the Humanities Act of 1965: Hearings on H.R. 15196*, pt. 1, 91st Cong., 2d sess., 4–10 February 1970, pp. 63–70.

NOTES TO THE TEXT

1

Thirty years after his death, Robert Maillart (1872–1940) is becoming established as a symbol – of 'art in engineering' or something equally vague – at about the same rate that he is being lost as a fact. Baptized in 1934 by Siegfried Giedion, confirmed posthumously by Max Bill in 1949, and given holy orders by the Museum of Modern Art, he now stands virtually on the rim of sainthood: we will cite Siegfried Giedion, 'Nouveaux ponts de Maillart', *Cahiers d'art* 9, nos. 1–4 (1934): 66–69; Max Bill, *Robert Maillart*, trans. W. P. M. Keatinge Clay (Zurich: Verlag für Architektur, 1949); and an exhibition of Maillart's work held at the Museum of Modern Art in 1947 (24 June–13 October). See also Giedion's 'Construction and Aesthetics', in *Circle: International Survey of Constructive Art*, ed. J. L. Martin, Ben Nicholson, and N. Gabo (1937; reprint ed., New York: Praeger Publishers, 1971), pp. 220–36.

2

Lewis Mumford, *Art and Technics* (New York: Columbia University Press, 1952), pp. 82–83. It must be admitted that Mumford is concentrating on the mass-production aspect of technology, and that he does see the possibility of *imperative* change in the form of type-objects. To complete the quotation: '. . . for the next thousand years. Indeed, we should be ready to accept further variations only when some radical advance in scientific knowledge, or some radical change in the conditions of life has come about – changes that have nothing to do with the self-indulgent caprices of men or the pressures of the market. Then, and then only, does a modification of the type become imperative. Otherwise the ideal goal . . .' While this attitude is logical for mass production, and indeed consistent with certain 'pressures of the market', it leads to a rather limited vision of the opportunities inherent in any technology and in any specific project of civil engineering.

3

This appeared in a 1967 *Water Storage Bulletin* of the American Iron and Steel Institute. The cover caption: 'The new generation of steel water tanks. Eye-appeal governs steel tank designs in Spokane, Washington, and other communities.'

4

In his introductory note (pages 1–2) to John A. Roebling's *Long and Short Span Railway Bridges* (New York: D. Van Nostrand, 1869), published shortly after John Roebling's death, Washington Roebling describes his father's talent in the following way: 'It was especially in . . . the actual construction of works, that the fertility of Mr. Roebling's mind in resources was so pre-eminent. The question with him never was how to do a thing, but which method to select of the number that occurred to him. A large suspension bridge embraces a vast variety of detail in construction as well as execution, dependent upon its location, and upon the nature of the traffic it is to accommodate. In view of this we can partly explain the otherwise anomalous circumstance, why all his bridges are so essentially different from each other, both in general arrangement and minor details. But it also seems to show that the originality of his mind was such as to forbid it from imitating even itself.' Although from the close perspective of a son these bridges seem so different, from the perspective of one hundred years they do demonstrate a single personal style.

5

See Alan Trachtenberg, *Brooklyn Bridge: Fact and Symbol* (New York: Oxford University Press, 1965).

6

See Ralph W. Gilbert, Jr., 'The Challenge and Controversy of the Eads Bridge' (M.S.E. thesis, Princeton University, 1969).

7

See Calvin M. Woodward, *A History of the St. Louis Bridge* (Saint Louis: G. I. Jones and Co., 1881).

8

Ibid., p. 50.

9

See Italo Insolera, 'I grandi viadotti di Eiffel nel massif Central', *Zodiac*, no. 13 (1964), pp. 60–115, for illustrations and discussion of a number of Eiffel's works.

10

Siegfried Giedion, *Space, Time, and Architecture: The Growth of a New Tradition*, 5th ed., rev. and enl. (Cambridge: Harvard University Press, 1967), pp. 450–76.

11

Max Bill, *Robert Maillart: Bridges and Constructions*, trans. W. P. M. Keatinge Clay, 3d ed. (New York: Frederick A. Praeger, 1969), pp. 25–32.

12

Ralph Waldo Emerson, *Essays, First and Second Series* (Boston: Houghton Mifflin Co., Riverside Press, 1883); the quotation is taken from the essay titled 'The Poet', in the second series, page 23. See also Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (New York: Oxford University Press, 1964), for a discussion of the influence of technology on the American literary consciousness.

13

Mirko Ros, *Versuche und Erfahrungen an ausgeführten Eisenbeton-Bauwerken in der Schweiz, 1924–1937*, supp. to *Jahresbericht des Vereins schweizerischer Zement-, Kalk-, und Gips-Fabrikanten* 26 (1937). Ros describes tests on completed reinforced-concrete structures in Switzerland – twenty-two arch bridges, ten girder bridges, and seven buildings – and of these, eleven arch bridges (including the Salginatobel bridge), one girder bridge, and several mushroom-slab buildings are by Maillart.

14

Tensor analyses of thin shells are good examples of elegant formulations useless for design, and optimization studies for structures frequently exemplify results that are trivial for the practicing designer.

15

See, for example, Schuyler's essay on the Brooklyn Bridge, originally published as 'The Bridge as a Monument' in *Harper's Weekly*, 26 May 1883, p. 326. It has been reprinted as 'The Brooklyn Bridge as a Monument' in Montgomery Schuyler, *American Architecture and Other Writings*, ed. William H. Jordy and Ralph Coe, 2 vols. (Cambridge: Harvard University Press, Belknap Press, 1961).

16

Eugène Freyssinet, 'Eugène Freyssinet by Himself', in *A Half Century of French Prestressing Technology*, ed. J. C. LeRoy, A. Marmillot, and R. Provost (Paris: Travaux, 1966), pp. 8–9. The crown hinge that made Freyssinet's bridge at Le Veurdre too flexible was made rigid after the jacking had lifted the arch upward to counteract the deflection resulting from creep.

17

Maillart, unlike Freyssinet (see note 16), accepted the flexibility of a crown hinge, and stiffened his bridges by fusing the arch with the deck, as in the Salginatobel bridge. Thus two first-rank designers chose quite different solutions for the same general problem. Maillart discusses his development of the deck-arch connection in 'La construction des ponts en béton armé, envisagée au point de vue esthétique', *Génie civil* 106, no. 11 (16 March 1935): 262–63. The entire text of this article is translated in an article by P. Morton Shand, 'Robert Maillart: The Architecture of a Great Swiss Engineer', *Journal of the Royal Institute of British Architects*, 3d ser. 45, no. 19 (12 September 1938): 957–69,

and the following is an excerpt from that translation: 'If we want to get the best out of reinforced concrete in bridge construction we inevitably arrive at forms which are often quite different to those masonry forms we are accustomed to, and for that very reason prone to imitate. The difficulty of getting these new and unprecedented forms accepted, to say nothing of making them satisfy oneself, has impelled the engineer – and still more the architect called in to collaborate with him – to try to find ways of compromising between traditional and untraditional designs. This raises the question whether such a tendency is justifiable, and whether it would not be better to confine ourselves to forms deliberately based on purely structural principles. Articulated bridges constructed with hollow ribs divided into a series of box compartments enable considerable economies to be effected, because, apart from the arch itself, both the platform and the spandrels directly contribute to the general resistance of the structure. . . . [But] the realisation that as a link between the arch and the platform solid spandrels serve no useful purpose, except in the middle of the bridge, and that close to the abutments they exert a useless dead weight which is positively a potential danger, has led to the practice of slotting triangular cavities out of them. Once the corresponding part of the platform is freed from traction-strains in this way, the construction gains in straightforwardness, while the elimination of the useless bulk of infilling economises the amount of concrete required. I adopted this solution as early as 1905 in the Tavanasa Bridge. That, in spite of its obvious economy, this model was not followed can probably be explained by its somewhat "unusual" appearance. It was not till 1930 that I had another opportunity to adopt a similar type of construction – and, as it so happened, for a bridge of much larger dimensions. Though in some quarters the Salgina Bridge called forth much the same objections as did its prototype, public taste had clearly progressed during the quarter of a century which had elapsed; for the bridge was enthusiastically accepted by the population of the district it serves, and even technical circles were far less severe in their criticisms than they had been in 1905.'

18

A reinforced-microconcrete model of part of the Salginatobel bridge, at 1:100 scale, was built in 1969 by three seniors at Princeton University, John R. Evans, John A. Barba, and H. Clay McEldowney. The model performed elastically and without visible cracks from tension up to scaled loadings of 'dead load plus over two times the maximum expected distributed live load' and 'dead load plus over four times the maximum expected concentrated live load'. At higher loadings, the strains increased plastically and eventually led to sudden collapse; this type of failure is typical of statically determinate systems, where failure of one cross section leads to overall instability. Other tests of the Salginatobel bridge were simulated with a scaled photoelastic model by Mr Barba, and he found the continuity between arch and deck added significantly to the efficiency of the structure (B.S.E. thesis, Princeton University, 1969).

The techniques employed in the reinforced-microconcrete and photoelastic models are discussed in the following: David P. Billington, Jack Janney, and Robert Mark, *Structures, Models, and Architects* (Princeton: Princeton University, School of Architecture, 1963); David P. Billington and Robert Mark, 'Small Scale Model Analysis of Thin Shells', *Journal of the American Concrete Institute* 62, no. 6 (June 1965): 673–88; G. H. Harris, G. M. Sabnis, and R. N. White, 'Small-Scale Direct Models of Reinforced and Prestressed Concrete Structures', Cornell University, School of Civil Engineering, Department of Structural Engineering Report no. 326, mimeographed (Ithaca, 1966); R. J. Brungraber and R. Richards, Jr., 'Miniature Beams for Instruction in Analysis and Design of Reinforced Concrete', *Journal of Engineering Education* 58, no. 3 (November 1967): 217–19; and Robert Mark, 'The Church of St. Ouen, Rouen: A Reexamination of Gothic Structure', *American Scientist* 56, no. 4 (Winter 1968): 390–99.

19

See Emil Mörsch, *Concrete-Steel Construction*, trans. E. P. Goodrich (New York: Engineering News Publishing Co., 1909), pp. 271–80. In a section titled 'Newer Methods of Arch Construction in Reinforced Concrete', page 283, Mörsch mentions four applications of shapes other than rectangular ones; the second of them: 'According to a method of construction already much used in Switzerland, by Maillart of Zürich, for reinforced concrete arch bridges, the side walls and the deck, which both consist of reinforced concrete, can be built in cantilever form decreasing in depth from the abutments to the crown. Since the combination of the several parts of this section is perfect, it can be employed in its entirety for carrying stresses. This construction appears to be specially adapted only for three-hinged arches.'

20

Fritz von Emperger, ed., *Handbuch für Eisenbetonbau*, 4 vols. (Berlin: Wilhelm Ernst & Sohn, 1908), 1:303–306.

21

Josef Melan, 'Theorie des Gewölbes und des Eisenbetongewölbes im besonderen', in Emperger, op. cit. in note 20, 1:425. For a brief discussion of Emperger and Melan, see Carl W. Condit, *American Building Art: The Nineteenth Century* (New York: Oxford University Press, 1960), pp. 249–53.

22

See Paul Christophe, *Le béton armé et ses applications*, 2d ed., rev. and enl. (Paris: Ch. Béranger, 1902), pp. 271–74.

23

Molitor's project is shown and discussed in Condit, op. cit. in note 21, pp. 253–54.

24

Maillart's essay 'Aktuelle Fragen des Eisenbetonbaues' originally appeared in *Schweizerische Bauzeitung* 111, no. 1 (1 January 1938): 1–5. It had two subtitles, 'Gestaltung des Eisenbetons' and 'Zur Berechnung des Eisenbetons', and a translation of part of it appears under 'Design in Reinforced Concrete' and 'On the Calculation of Reinforced Concrete' in Bill, op. cit. in note 11, pp. 17–18; for our quotations from the essay we have used this translation.

25

For Monier, see G. Huberti, *Von Cementum zum Spannbeton*, 3 vols. (Berlin: Bauverlag Pier Tuigi, 1964), 1, pt. B: 64. For Hennebique, see Christophe, op. cit. in note 22, p. 106.

26

See American Concrete Institute, Committee 318, *A.C.I. Standard Building Code Requirements for Reinforced Concrete* (Detroit, 1963), especially chapter 15.

Although most engineers agree on the need for a building code – that is, a legal document accepted by a city, county, or state legislature and intended primarily to safeguard the public – they strongly disagree on the type of code required. For many, the code is highly useful as a standard reference, serving almost as a rule book that allows one to design rapidly and gain easy approval from the officials charged by legislatures with the administration of the building codes. For others, codes are at best necessary evils and, as Maillart said, 'should never be taught to students, because they can only be injurious to the freedom of their field of vision'.

This controversy goes to the heart of professional engineering, and was brought out in an article by Chester P. Siess, 'Research, Building Codes, and Engineering Practice', *Journal of the American Concrete Institute* 31 [*Proceedings* 56], no. 11 (May 1960): 1105–22, and in the ensuing discussion in volume 32 [*Proceedings* 56], no. 6 (December 1960), pt. 2: 1517–27. A code, according to Siess, is a valuable 'synthesis of contemporary knowledge, practices, and techniques', but in Maillart's opinion it might well restrict the vision of the young engineer. This difference of opinion, however, is perhaps not so much about codes as

about the definition of an engineer. Maillart believed the engineer should be, not a calculator trained to apply such codes, but a constructor who, being personally responsible for his work, would make his own synthesis of current knowledge. And Siess says, on page 1525, that 'inadequacies due to the lack of knowledge [should be blamed] not on the individual but on the profession where it belongs' – an attitude toward codes that is typical in the United States and that stems from at least three conditions of American practice.

First, most structural design is done by consultants, who, being paid a lump sum, naturally try to arrive at a safe solution in a minimum amount of time. Since most designers derive no direct benefit from construction economies, there is little incentive to spend extra time on refining the design or on justifying code exceptions; also, close adherence to codes and a minimum of unusual features both tend to get the design approved rapidly. The result is adherence to the code along with a restricted vision of structural possibilities.

The separation of design from construction is the second condition that emphasizes the responsibility of the entire profession – as expressed through the code – over that of the individual engineer. Maillart, like engineers such as Nervi, Candela, and Finsterwalder, had considerable direct experience as a building contractor, but few American designers have been responsible for construction. Hence design in America tends not to give the kind of weight to constructional problems that in other countries has led to innovations, and relies more on precedents found within the code.

Finally, most structural-concrete design has been influenced by architecture. Even bridges, perhaps the purest form of structure, have been decorated or formed according to some architectural canon. Thus the engineer has been discouraged from trying new forms, not just because of the codes and the political proscriptions isolating design from construction, but also because of aesthetic prescriptions that isolate matters of style from matters of efficiency. For example, to a book published in 1928, by a doctor of engineering, Francis S. Onderdonk, Jr., *The Ferro-Concrete Style* (New York, Architectural Book Publishing Co.), there is the following conclusion, on page 256: 'Of all materials, ferro-concrete offers the greatest wealth of possibilities to the designer. But these possibilities remain unrealized until sensed by a living soul. Hence the Ferro-Concrete Style will not come into its own until architects the world over have awakened to the Spirit of the New Age.' Clearly if the new forms are to be sensed only by architects, there would be little point in engineers making an effort to design outside the context of the code.

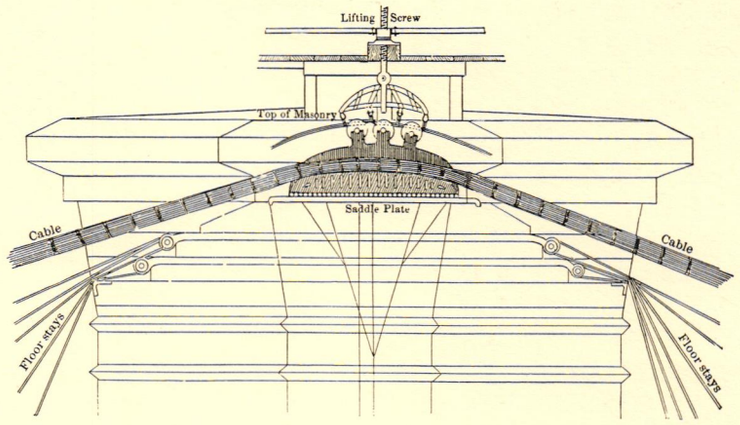
Still, Siess is correct in stating that the code represents a compilation of experience, and articles like his have begun to provide the kind of explanation of code provisions that is essential to overcome the objections of Maillart and others. If the student were to learn the principles of reinforced concrete through the perspective of the development of the code, then he would see that the formulas are only approximate abstractions from a long search for understanding and not arbitrary rules demanding thoughtless allegiance.

27

See Robert Maillart, 'The Development of the Beamless Floor-Slab in Switzerland and in U.S.A.', in Bill, op. cit. in note 11, pp. 165–66. For an interpretation of Maillart's floor slabs in terms of aesthetic meaning, see Giedion, op. cit. in note 10, pp. 452–54. For Pier Luigi Nervi's views, see his *Aesthetics and Technology in Building*, trans. Robert Einaudi (Cambridge: Harvard University Press, 1965), and with reference to the Gatti building floor-slabs, pages 32 and 67.

28

Schuyler, in *American Architecture and Other Writings*, cited in note 15, 2:337–42, finds that the Brooklyn Bridge is inherently impressive as engineering but lacking the 'refinement' an architect could provide: 'Look at this section of the top of the tower, and see how an exquisite



refinement of mechanical arrangement may coexist with absolute insensibility to the desirableness even of an architectural expression of this arrangement. The architecture of this crowning member of the tower has nothing whatever to do with the purpose for which the structure exists. Is it not perfectly evident that an architectural expression of this mechanical arrangement would require that the line of the summit, instead of this meaningless flat coping, should, to begin with, be a crest of roof, its double slope following the line of the cable which it shelters? Here the very channel through which the cable runs is not designed, but is a mere hole occurring casually, and not by premeditation, in the midst of the mouldings which form the cornice of the tower. This is architectural barbarism. . . . The anatomy of the towers and of the anchorages is not brought out in their modelling. Their fingers, so to speak, are all thumbs. Their impressiveness is inherent in their mass, and is what it could not help being.'

29

For examples of the overlapping of technical meaning and aesthetic meaning, see Erwin Panofsky, *Meaning in the Visual Arts* (Garden City, N.Y.: Doubleday & Co., Anchor Books, 1955), pp. 10–14. For a suggestive discussion of the problem of separating beauty (as art) and efficiency (as utility), see R. G. Collingwood's 'The Place of Art in Education', in his *Essays in the Philosophy of Art*, ed. Alan Donagan (Bloomington: Indiana University Press, 1964). Collingwood says, on page 195, that 'if all good design is beautiful, and if beauty is the proper object of the aesthetic faculty, everything well designed is a work of art; and the function of art in life is therefore not ornamental, but structural'. As examples of good design he mentions a racing yacht and a Roman aqueduct, and his remarks could equally be taken as an argument for Maillart's bridges as works of art.

Collingwood's views are further expressed in 'A Philosophy of Progress', in his *Essays in the Philosophy of History*, ed. William Debbins (Austin: University of Texas Press, 1965); the following is from page 116: 'But if the course of history does not show an increase of happiness or an increase of goodness, in what sense, if any, is it a progress? In order to answer this question, let us return to one of the examples we have already discussed. The history of architecture presents us with a process of development in which each new change has brought the process nearer to the point at which it stands today. A development is a progress when it is a development into something better. Now we have seen that there can be no increase of beauty or happiness or goodness. But though the buildings of one age are not more beautiful than those of another – since each has its own proper beauty, not to be assessed in terms of any other – the aesthetic problem of any age's architecture is unique: that is to say, a particular age has the task of realising beauty in a particular way. We, for example, have invented reinforced concrete, and our task is to discover how to make it beautiful. We shall not do it by pretending that reinforced concrete is stone or timber; for it is a material with a very decided nature of its own, and we shall only build

beautifully in it by understanding this nature and expressing it in our designs.' Whether or not Collingwood would have considered the Salginatobel bridge – under construction at the time this essay first appeared, in the *Realist* – a discovery of how to make reinforced concrete beautiful, it is clear that the 'task of realising beauty in a particular way' is one concerning not only particular ages but also particular engineers.

30

Panofsky, op. cit. in note 29, p. 5.

31

Bill, op. cit. in note 11, p. 31.

32

See Panofsky, op. cit. in note 29, pp. 6–10. Panofsky discusses also, on pages 20–22, an approach to the study of different styles and an 'organic' relationship between history and theory, both of which we could profitably consider in the field of engineering: 'The objects of art history, then, can only be characterized in a terminology which is as re-constructive as the experience of the art historian is re-creative: it must describe the stylistic peculiarities, neither as measurable or otherwise determinable data, nor as stimuli of subjective reactions, but as that which bears witness to artistic "intentions." Now "intentions" can only be formulated in terms of alternatives: a situation has to be supposed in which the maker of the work had more than one possibility of procedure, that is to say, in which he found himself confronted with a problem of choice between various modes of emphasis. Thus it appears that the terms used by the art historian interpret the stylistic peculiarities of the works as specific solutions of generic "artistic problems."... Upon reflection it will turn out that there is a limited number of such primary problems, interrelated with each other, which on the one hand beget an infinity of secondary and tertiary ones, and on the other hand can be ultimately derived from one basic antithesis: differentiation *vs.* continuity.... [And since the art historian] cannot describe the objects of his re-creative experience without re-constructing artistic intentions in terms which imply generic theoretical concepts ... he will, consciously or unconsciously, contribute to the development of art theory, which, without historical exemplification, would remain a meager scheme of abstract universals. The art theorist, on [the] other hand, ... cannot build up a system of generic concepts without referring to works of art which have come into being under specific historical conditions; but in doing this he will, consciously or unconsciously, contribute to the development of art history, which, without theoretical orientation, would remain a congeries of unformulated particulars.'

33

See Stephen P. Timoshenko, *History of Strength of Materials* (New York: McGraw-Hill Book Co., 1953), p. 401; I am indebted to Byron Pipes for pointing this out to me.

Illustrations: *1*, Bettmann Archive, Inc., New York; *2*, New York City Department of Public Works; *3*, reproduced from Woodward, op. cit. in note 7, frontispiece; *4*, *6*, drawings, reproduced from J. B. Johnson, C. W. Bryan, and F. E. Turneaure, *The Theory and Practice of Modern Framed Structures*, 7th ed., rev. (New York: John Wiley & Sons, 1900), pl. 24; *5*, Rolf Sauer; *7* (Mischol), *17*, *18* (Mischol), *20*, Museum of Modern Art, New York, by the kind permission of Marie-Claire Blumer-Maillart; *8*, *10*, *13*, reproduced from Schweiz. Verband für die Materialprüfungen der Technik, *Robert Maillart, Ingenieur, 1872–1940* (Zurich, 1940), figs. 29, 30, 25; *9*, diagram by the author; *11*, reproduced from Mörsch, op. cit. in note 19, p. 272; *12*, *14*, reproduced from Emperger, op. cit. in note 20, 1:305, 1:425; *15*, reproduced from Christophe, op. cit. in note 22, p. 272; *16*, reproduced from David A. Molitor, 'Three-Hinged Masonry Arches; Long Spans Especially Considered', *Transactions of the American Society of Civil Engineers* 40 (December 1898), pl. 1; *19*, Studio Nervi, Rome (Foto Oscar Savio).

SIGNIFICANT STRUCTURES

Peter Caws, professor of philosophy at Hunter College, City University of New York, has recently been on 'an extended detour from the philosophy of science into other domains', notably structuralism, a long-projected book on which he hopes to finish on a 1972–73 American Council of Learned Societies fellowship in Paris, and a valuable introduction to which is his 'What Is Structuralism?', *Partisan Review* 35, no. 1 (Winter 1968): 75–91. To quote from the latter: 'One of the fundamental theses ... is that the structure is all-important, the material largely irrelevant; it is as though the mind had to busy itself about something of sufficient complexity, but cared very little about the nature (or the logical level) of its components.... our resistance to this kind of spontaneous absurdity, our demand for logical coherence even where it is unnecessary, is ... a product of the invention of *man* as an embodiment of analytic reason. Until early modern times individual and collective subjectivity were absorbed in Discourse, a human activity (a linguistic one, which in context amounts to the same thing) constituting the world as intelligible and summing up all that could be said about it. The rise of science led to the fragmentation and dissolution of this conceptual and linguistic unity, by drawing attention to separable properties of the world – biological, economic, philological – and pursuing them independently. But it then became apparent that in some sense all these enquiries were about the same thing.... Structuralism, in effect, advocates an engagement with the world, an abandonment of too much self-examination in favor of participation in some significative activity, which in structuring the world will bring the subject into equilibrium with it. *What* activity is a matter of wide choice. There is nothing particularly worthy, as the existentialists thought, in political or even in artistic activity; any number of others are capable of embodying the structure of mind.'

In 'Significant Structures' reference is made to N. S. Trubetzkoy's *Principles of Phonology* and to the analysis of one of Baudelaire's sonnets by Roman Jakobson and Claude Lévi-Strauss. The former, translated by Christiane A. M. Baltaxe, has been published by the University of California Press (Berkeley and Los Angeles, 1969) – the passage quoted in the present text is Mr Caws's own translation – and the latter, in translation, appears as 'Charles Baudelaire's "Les chats" ' in *Introduction to Structuralism*, ed. Michael Lane (New York: Basic Books, 1970), pp. 202–21, 447–48.

Illustrations: *1*, James Bryan; *2*, Catalan Archive of Art and Architecture, Department of Art History and Archaeology, Columbia University (Foto H.E.R.).

INTUITION AND ... STRUCTURAL INVENTION

Rowland Mainstone, Principal Scientific Officer at the U.K. Building Research Station, Department of the Environment, has been concerned there in recent years with investigations into the structural behavior under both static and dynamic loading of buildings and bridges and with the development of new approaches to structural and architectural design. He has at the same time pursued an interest in the historical development of structural forms and of earlier approaches to design, making detailed studies, in association with Harvard and Carnegie-Mellon universities, of two remarkable structures of the past – Hagia Sophia in Istanbul and Santa Maria del Fiore in Florence. A book by Mr Mainstone titled 'Developments in Structural Form' is to be published in 1973 by Allen Lane, The Penguin Press.

An earlier version of the present text appeared, under the title 'The Springs of Structural Invention', in the *Journal of the Royal Institute of British Architects*, 3d ser. 70, no. 2 (February 1963): 57–71. Although the argument remains substantially unchanged – 'I see the invention of new forms (indeed any sort of structural design that is not content merely to play variations on what has been done already according to the set routine of some Code of Practice) as stemming first from close familiarity with, and experience of, previous achievements and secondly, and very importantly, from a generalized understanding of structural actions which gives the necessary depth of meaning to the experience and makes it possible to move beyond it with some sense of direction and some assurance of success' – the author has revised and extended the text and illustrative material, drawing in the concluding section on his 'Scientific Analysis and the Springs of Structural Invention' (paper delivered at the First National Conference on Civil Engineering: History, Heritage, and the Humanities, Princeton University, 14–16 October 1970, and reproduced in the conference's 'Selected Papers', 2:105–33).

The introductory quotations are from Leone Battista Alberti, *Ten Books on Architecture*, trans. James Leoni (1755; reprint ed. [ed. Joseph Rykwert], London: Alec Tiranti, 1955), p. 113, and Samuel Taylor Coleridge, *Biographia Literaria* (New York: E. P. Dutton & Co., 1906), pp. 159–60. It is of interest to note Coleridge's distinction between 'Imagination' and 'Fancy'; to continue the quotation: '. . . [Imagination] dissolves, diffuses, dissipates, in order to re-create: or where this process is rendered impossible, yet still at all events it struggles to idealize and to unify. It is essentially *vital*, even as all objects (*as* objects) are essentially fixed and dead.

'Fancy, on the contrary, has no other counters to play with, but fixities and definites. The fancy is indeed no other than a mode of memory emancipated from the order of time and space; while it is blended with, and modified by that empirical phenomenon of the will, which we express by the word Choice. But equally with the ordinary memory the Fancy must receive all its materials ready made from the law of association.'

NOTES TO THE TEXT

1

See especially Karl Lehmann, 'The Dome of Heaven', *Art Bulletin* 27, no. 1 (March 1945): 1–27; Rudolf Wittkower, *Architectural Principles in the Age of Humanism*, 3d ed., rev. (New York: W. W. Norton & Co., 1971); and E. Baldwin Smith, *The Dome: A Study in the History of Ideas* (Princeton: Princeton University Press, 1950).

2

Erik Hansen, *La 'Piazza d'Oro' e la sua cupola* (Copenhagen: Ejnar Munksgaard, 1960), gives a careful reconstruction.

3

The most comprehensive surveys of Roman building are Marion E. Blake, *Ancient Roman Construction in Italy from the Prehistoric Period to Augustus* (Washington: Carnegie Institution, 1947); idem, *Roman Construction in Italy from Tiberius through the Flavians* (Washington: Carnegie Institution, 1959); and Giuseppe Lugli, *La tecnica edilizia romana, con particolare riguardo a Roma e Lazio*, 2 vols. (Rome: G. Bardi, 1957). For the Pantheon, Roberto Vighi, *Il Pantheon* (Rome: Tipografia Artistica, 1957), and Kjeld de Fine Licht, *The Rotunda in Rome: A Study of Hadrian's Pantheon* (Copenhagen: Gyldendal, 1968), summarize present knowledge. See also Giuseppe Cozzo, *Ingegneria romana* (Rome: Libreria editrice Mantegazza di P. Cremonese, 1928), and Norman Davey, *A History of Building Materials* (London: Phoenix House, 1961).

4

For Byzantine building methods, see J. B. Ward Perkins, 'Notes on the Structure and Building Methods of Early Byzantine Architecture', in *The Great Palace of the Byzantine Emperors, Second Report*, ed. D. T. Rice (Edinburgh: University Press, 1958), pp. 52–104. For Hagia Sophia, see William Emerson and Robert L. Van Nice, 'Haghia Sophia, Istanbul: Preliminary Report of a Recent Examination of the Structure', *American Journal of Archaeology* 47 (1943): 403–36; Rowland J. Mainstone, 'The Structure of the Church of St. Sophia, Istanbul', *Transactions of the Newcomen Society* 38 (1965–66): 23–49; and idem, 'Justinian's Church of St. Sophia, Istanbul: Recent Studies of Its Construction and First Partial Reconstruction', *Architectural History* 12 (1969): 39–49.

5

This chapter of architectural and structural history is still largely to be written, and the present exegesis is only tentative. A full study would have to take into account, besides the works here cited, Mudejar work in Spain, pre-Seljuk work in Armenia, and central-European High Gothic work, plus a number of now isolated examples elsewhere. For later Spanish vaults, see *Ars Hispaniae: Historia universal del arte hispánico* (Madrid: Editorial Plus-Ultra, 1946–), vols. 4, 5, 7; for Armenia, Jurgis Baltrusaitis, *Le problème de l'ogive et l'Arménie* (Paris: E. Leroux, 1936); and for High Gothic, Walter Ueberwasser, 'Spätgotische Bau-Geometrie: Untersuchungen an den "Basler Goldschmiedrissen" ', *Jahresbericht, Oeffentliche Kunstsammlung, Basel*, n.s. 25–27 (1928–30): 79–122. See also Rowland J. Mainstone, 'Guarini and Leonardo', *Architectural Review* 147, no. 880 (June 1970): 454.

6

Mostly in MS B (Institut de France, Paris). The majority are projects for centralized churches, but a few small sketches have, possibly, a purely structural intention and a greater significance than has hitherto been recognized: MS B, fol. 10 verso and fol. 27 recto. A similar group of small sketches by Dürer – MS II (British Museum, London), fol. 167 verso – may, however, be little more than a record of contemporary Gothic practice.

7

The structural aspect of Gothic architecture has been discussed by many writers, from Viollet-le-Duc and Choisy to John Fitchen in his *The Construction of Gothic Cathedrals: A Study of Medieval Vault Erection* (New York: Oxford University Press, 1961). Paul Frankl, *The Gothic: Literary Sources and Interpretations through Eight Centuries* (Princeton: Princeton University Press, 1960), gives an extensive bibliography. For the architectural aspirations of the Gothic, see Suger, abbot of Saint-Denis, *Abbot Suger on the Abbey Church of St.-Denis and Its Art Treasures*, ed. and trans. Erwin Panofsky (Princeton: Princeton University Press, 1946); Erwin Panofsky, *Gothic Architecture and Scholasticism* (Latrobe, Pa.: Archabbey Press, 1951); and Otto von Simson, *The Gothic Cathedral: Origins of Gothic Architecture and the Medieval Concept of Order*, 2d ed., rev. and enl. (New York: Pantheon Books, 1962).

8

The psychology of invention in different fields is discussed by, among others, Jacques Hadamard, *An Essay on the Psychology of Invention in the Mathematical Field* (Princeton: Princeton University Press, 1945); W. I. B. Beveridge, *The Art of Scientific Investigation*, 2d ed. (London: William Heinemann, 1953); Brewster Ghiselin, ed., *The Creative Process* (Berkeley and Los Angeles: University of California Press, 1952); and Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy* (Chicago: University of Chicago Press, 1958).

9

For fuller accounts of this synthesis, see Rowland J. Mainstone, 'Structural Theory and Design', *Architecture and Building* 34 (1959): 106–13, 186–95, 214–21; idem, 'Structural Theory and Design before 1742', *Architectural Review* 143, no. 854 (April 1968): 303–10; and S. B. Hamilton, 'The Historical Development of Structural Theory', *Proceedings of the Institution of Civil Engineers*, n.s. 1, no. 1, pt. 3

(April 1952): 374–402. The last two give references to the principal sources from the earlier and later phases respectively.

10

Eduardo Torroja, *Philosophy of Structures*, trans. J. J. Polivka and Milos Polivka (Berkeley and Los Angeles: University of California Press, 1958), gives the best description of one designer's intuition. But, as Torroja himself knew it would, his intuition died with him, and no mere verbal description could convey it to others.

11

Both Leonardo and Galileo also made use of analogies from natural forms. Leonardo, for instance, likens the cracking of a dome or semi-dome to the splitting of the husk of a pomegranate in the Arundel MS (British Museum, London), fol. 141 verso. Much later, D'Arcy Wentworth Thompson, *On Growth and Form*, 2d ed., 2 vols. (Cambridge: At the University Press, 1942), draws analogies between natural and man-made structures chiefly in the reverse direction.

12

Such 'hinged' bridges are still to be found in the Yangtze delta; see H. Fugl-Meyer, *Chinese Bridges* (Shanghai: Kelly & Walsh, 1937). In cities like Venice and Amsterdam, the characteristic alternation of long and short voussoirs seems today to be mostly decorative; but even this decorative use no doubt betrays a functional origin.

13

Other examples are illustrated in Perkins, op. cit. in note 3; Davey, op. cit. in note 3; Arthur Upham Pope, ed., *A Survey of Persian Art from Prehistoric Times to the Present*, 14 vols. to date (New York: Oxford University Press, 1938–), vols. 2, 4; and André Godard, 'Voûtes iraniennes', *Athar-é Irān: Annales du Service archéologique de l'Irān* 4, fasc. 2 (1949): 187–360.

14

For Santa Maria del Fiore, see Piero Sanpaolesi, *La cupola di Santa Maria del Fiore: Il progetto, la costruzione* (Rome: Istituto poligrafico dello Stato, 1941); Frank D. Prager, 'Brunelleschi's Inventions and the "Renewal of Roman Masonry Work" ', *Osiris* 9 (1950): 457–554; and Rowland J. Mainstone, 'Brunelleschi's Dome of S. Maria del Fiore and Some Related Structures', *Transactions of the Newcomen Society* 42 (1969–70): 107–26. For Gothic vaults, see Fitchen, op. cit. in note 7.

15

Pol Abraham, *Viollet-le-Duc et le rationalisme médiéval* (Paris: Vincent, Fréal & Cie, 1934), classifies different varieties of cracking, and Marcel Aubert, 'Les plus anciennes croisées d'ogive, leur rôle dans la construction', *Bulletin monumental* 93 (1934): 5–67, 137–237, illustrates many examples and summarizes earlier discussions of their significance.

16

Panofsky, in *Gothic Architecture and Scholasticism*, cited in note 7, page 55, gives Gothic trade expressions for buttresses, 'such as *contrefort*, *bouterec*, (hence our "buttress"), *arc-boutant*, or the German *strebe* (hence, interestingly enough, the Spanish *estribo*), all of which denote the function of a thrust or counterthrust'. Frankl, op. cit. in note 7, refers to and quotes much of the other evidence. Of greatest interest are the minutes of meetings held during the building of the cathedral of Milan, for which see especially James S. Ackerman, ' "Ars sine scientia nihil est": Gothic Theory of Architecture at the Cathedral of Milan', *Art Bulletin* 31, no. 2 (June 1949): 84–111.

17

The most detailed drawings of the *tiburio* project are in the Codex Atlanticus (Biblioteca Ambrosiana, Milan), fol. 310 recto and verso; the recto is here reproduced in part. A number of preparatory sketches are in the Codex Trivulzianus (Castello Sforzesco, Milan).

18

The analogy is incomplete in that it takes no account of the fact that we continually make adaptive movements as we resist or exert different forces.

19

Leone Battista Alberti, *Ten Books on Architecture*, trans. James Leoni (1755; reprint ed. [ed. Joseph Rykwert], London: Alec Tiranti, 1955), pp. 57–59.

20

General accounts of this predilection for pure geometry are given in the works by Mainstone cited in note 9. For the Gothic period, see Maria Velte, *Die Anwendung der Quadratur und Triangulatur bei der Grund- und Aufrissgestaltung der gotischen Kirchen* (Basel: Verlag Birkhäuser, 1951), and Paul Booz, *Der Baumeister der Gotik* (Munich: Deutscher Kunstverlag, 1956). Most Renaissance architectural treatises follow the pattern of Vitruvius and Alberti or, like that of Philibert de l'Orme, concentrate on the geometry of stonecutting, on the pattern of Hero of Alexandria's *Stereometrica*. For Wren, see the *Parentalia* . . . (1750; reprint ed., London: Gregg Press, 1965), tract 2; for Guarini, the *Architettura civile* . . . (1737; reprint ed., London: Gregg Press, 1964).

21

The well-known analyses of 1742–43 of the stability of the dome of Saint Peter's are recorded in Tommaso Le Seur, Francesco Jacquier, and Ruggiero Giuseppe Boscovich, *Parere di tre mattematici sopra i danni, che si sono trovati nella cupola di S. Pietro sul fine dell'Anno MDCCXLII* (Rome, 1743), and Giovanni Poleni, *Memorie istoriche della Gran Cupola del Tempio Vaticano* . . . (Padua, 1748).

22

See Robert Maillart, 'Aktuelle Fragen des Eisenbetonbaues', *Schweizerische Bauzeitung* 111, no. 1 (1 January 1938): 1–5. For the development of Maillart's forms, and tests of many of them, see Mirko Ros, *Versuche und Erfahrungen an ausgeführten Eisenbeton-Bauwerken in der Schweiz, 1924–1937*, supp. to *Jahresbericht des Vereins schweizerischer Zement-, Kalk-, und Gips-Fabrikanten* 26 (1937), and Max Bill, *Robert Maillart: Bridges and Constructions*, trans. W. P. M. Keatinge Clay, 3d ed. (New York: Frederick A. Praeger, 1969).

In the early days of reinforced concrete, testing was usually carried out at or near full scale. Today full-scale tests are less common, but tests on reduced-scale models are frequently made, and we are even approaching a situation in which techniques of analysis by computer and knowledge of the relevant characteristics of the materials will permit the behavior of the real structure to be simulated as accurately in a theoretical analysis as in a model test. The choice between the two will then be made primarily on the basis of relative cost and the different ways in which they allow the effects of changes in the design to be explored. But since such a theoretical analysis can still deal only with a mathematical abstraction of the real structure – and an analysis based on model testing, only with a simplified analogue of it – an essential part of the skill of a good designer relying on these aids will be an ability to make valid abstractions or simplifications and to make due allowances later for factors left out; this has been repeatedly stressed by men like Torroja and Nervi also.

23

On the failure of the Tacoma Narrows Bridge, in which torsional motion of the deck persisted for about an hour under a fairly moderate wind before the collapse, see U.S., Federal Works Agency, *The Failure of the Tacoma Narrows Bridge*, prepared by Board of Engineers, Othmar H. Ammann, Theodore von Kármán, and Glenn B. Woodruff (n.p., 1941). On the Ronan Point collapse, which occurred after local damage caused by a gas explosion, see Great Britain, Ministry of Housing and Local Government, *Report of the Inquiry into the Collapse of Flats at Ronan Point, Canning Town*, prepared by Hugh Griffiths, Sir Alfred Pugsley, and Sir Owen Saunders (London: Her Majesty's Stationery Office, 1968).

24

Slightly adapted from Joyce Cary, *Art and Reality: Ways of the Creative Process* (New York: Harper & Brothers, 1958), p. 165.

The author wishes to acknowledge his indebtedness to friends among architects and engineers for stimulus received while the essay was taking shape – in particular to his late colleagues at the Building Research Station, Norman Davey, William Allen, and Graham Denyer – and to critics who have subsequently drawn his attention to ambiguities in the original text.

Illustrations: *1–27*, *29*, *30*, *32–43*, *46*, *47*, *50–53*, *55*, photographs by the author (all rights reserved by the author); *28*, redrawn by the author from the Forster MSS (Victoria and Albert Museum, London), MS II, fol. 47 recto (*top left*), MS II, fol. 92 recto (*top right*), MS III, fol. 4 verso (*bottom left*), and MS III, fol. 79 verso (*bottom right*); *31*, redrawn by the author from the Codex Atlanticus (Biblioteca Ambrosiana, Milan), fol. 332 recto b (*top*) and fol. 152 recto b (*bottom left*, *bottom right*); *44*, reproduced from the Codex Atlanticus, fol. 310 recto b; *45*, British Museum, London; *48 left*, redrawn by the author from the Wren *Parentalia*, cited in note 20, pages 356–58; *48 right*, reproduced from Poleni, op. cit. in note 21, pl. H; *49*, reproduced from Le Seur, Jacquier, and Boscovich, op. cit. in note 21; *54*, Washington State Historical Society, Tacoma.

[ON CREATIVITY]

David Bohm, professor of theoretical physics at Birkbeck College, University of London, has recently been involved in research concerning fundamentals of quantum theory. Among his published writings there are, however, several on broader aspects of science and the activity of the mind. Of particular interest are 'Some Remarks on the Notion of Order' and 'Further Remarks on Order', in *Towards a Theoretical Biology*, ed. C. H. Waddington (Chicago: Aldine Publishing Company, 1968–), 2:18–60, and 'Fragmentation in Science and in Society', *Impact of Science on Society* 20, no. 2 (April–June 1970): 159–69; one might see also his remarks in *Quanta and Reality: A Symposium* (London: Hutchinson & Co., 1962), pp. 61–81.

'On Creativity' is based on a talk given by Mr Bohm at the Architectural Association, London. Earlier versions of the text have been published in *Arena* 82, no. 912 (May 1967): 291–98, and *Leonardo* 1, no. 2 (April 1968): 137–49. The text here is revised and abridged, and as an indication of his recent views on the subject Mr Bohm kindly provided the following note.

ORDER, STRUCTURE, FORM, AND PATTERN

The word *ordering* may refer both to the act of ordering that takes place in perception and to the action of ordering that takes place in what is perceived. These two meanings of the word are both necessary, because order is a kind of 'intersection' between perception and what is perceived; it belongs, not to either of these alone, but rather to a broader movement that includes both.

By means of a thought or a memory, or a word, we may call attention to an order that is already known. If this order 'fits' or is 'suitable' or 'coheres' with the order that is perceived, we may say that it is *relevant* in the context in question; if not, it is *irrelevant* in this context, and we have to perceive in a different order. A proper description has, of course, always to communicate a relevant order – one that is coherent with the order that is to be perceived.

As with creativity, order is so fundamental and pervasive to all our experience and to the whole of our lives that it cannot be defined in words. What can be done with words is to indicate certain lines of perception and experience which may lead us to a nonverbal understanding of a sort of essence of order.

Let us begin by considering the whole of experience as an undifferentiated and undefined totality. Within this totality, one first becomes aware of differences or changes, without knowing just what it is that is different or what has changed. Here, we may usefully call attention to the kind of vision one has in the corner of the eye, where, as is well known, one perceives change without being able to see exactly what has changed or how things are changing. Toward the center of the field of vision, perception sharpens up. Our common usage of language tends to suggest that the sharp perception at the center of the field of vision is basic, while the vague perception at the corner of the eye is only the result of a decrease of sharpness from that prevailing at the center of the field. However, it is being emphasized here that the foundation of vision actually lies in the background of the 'unsharp' perception of change, while the sharply defined images at the center are built up from this background. Similarly, in all perception, sharply defined objects, properties, qualities, etc., are built up from perception of changes in an undifferentiated, undefined, totality of experience. Thus we have to begin with undefined *differences*, which will be further specified only later, as perception articulates and unfolds, in order, structure, form, and pattern.

The first step in this development is to note that in a series or sequence of differences there may be a similarity. As implied in the article, to see such a similarity in the differences is the most primitive perception of order.

Now, any such order will generally have a *limit*, beyond which begins *another order*. Such a limit may be described as a 'break'. If there is a series of 'breaks', the differences in the limits may themselves be similar, thus giving rise to another *order of ordering*. Such order of ordering can go on developing on the same level and on many different levels, to constitute a totality of ordering, which is a *structure*.

Structure is, like order, too pervasive and fundamental to be defined in words. The best way to indicate the essential meaning of structure is to call attention to the action of building by human beings and of growth and evolution in nature. Structuring is indeed a movement of *building* and *growing* and *evolving*, in which a coherent totality of orders, 'fitting' and 'working together' harmoniously, has a certain relative stability or a tendency to continue or survive. Movements not giving rise to such a coherent totality will of course lead to results that are unstable, that do not survive, and that therefore undergo *de*-struction (the breaking up of structure and its falling to pieces).

One of the basic examples of structure given in the article is that of a house. We begin with the bricks. Each of these is itself a structure, resulting from a relatively stable ordering of microcrystals, grains of sand, etc. These orders are limited by the surface of the brick, where begins another order (of mortar or cement), which is in turn limited and gives way to another brick. The bricks and mortar, relatively stably ordered, then give rise to a wall, which is another order of structure. The limits of this wall are its surfaces and its intersections with other walls, etc. All the walls, suitably ordered (along with the ceilings, roof, floors, etc.), constitute the structure of the house. This structure clearly has further orders in it, which are new relative to those of the bricks in the walls. Thus, since the arrangement of walls gives rise to a *closed* order – in the sense that there is no way to go from 'inside' to 'outside' without going through the walls – windows and doorways are introduced into the structure to allow such passage (and this implies that a closed curve traced out on a wall could not continuously be 'shrunk' to a point, if it goes around the space of a window or doorway).

So a structure is seen to contain a totality of orders that cohere harmoniously in one whole. And as indicated in the article, the observation of structure in nature discloses many such totalities.

By considering the overall ordering of the limits or boundaries of a structure, such as a house, one's attention is called to *form*. In the case of geometric objects, the form is in essence the same as the shape.

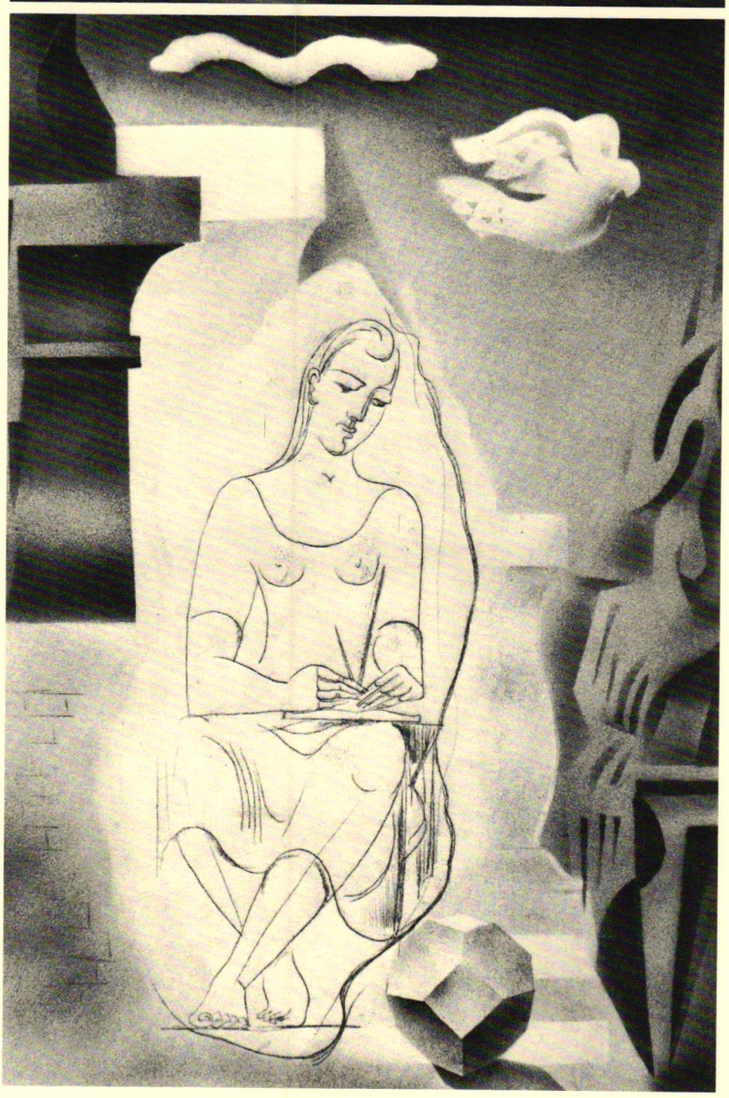
However, more generally, form may have a more abstract meaning, as a totality of ordering of the limits of a structure. Thus, a language is a structure limited by a vast totality of rules that have grown up over a long time – some of these are specified, but most are implicit and unspecified – and to the extent that these rules are themselves ordered coherently as a whole, the language may be said to have a form.

It is necessary to consider here an important distinction between *form* and *pattern*. Pattern means, in essence, a sort of model, from which something else is built, or to which something else is made to conform. According to the dictionary, *pattern* and *patron* have the same root. Then a pattern is an order that is imposed on a structure from outside (as if by a 'patron'). It is therefore a special kind of form. Generally, however, form is not imposed from outside, but grows and develops naturally from the action of structuring. Thus, the form of a tree, with its trunk, branches, leaves, twigs, etc., is the outcome of the growth of a tree (a tree made out of plastic, on the other hand, would have an imposed form, or a pattern).

The imposition of pattern is clearly a *mechanical* kind of ordering (in the sense of the word used in the article). Of course, a certain minimum of pattern is necessary in our lives. But, as pointed out, there is a tendency to extend such patterns into contexts in which they cannot coherently be imposed. A creative action is thus one that is not ultimately dominated by the mechanical imposition of the order of a pattern. It is one in which the order, structure, and form grow naturally in harmony with the total context of the action.

In this regard, it is necessary to keep in mind that structuring, like ordering, is as much an act of perception as it is an action taking place in what is perceived. When the mind is not a prisoner of imposed patterns of thinking, feeling, and observing, then new structuring takes place freely in perception. And out of this comes a new action, in which man can harmoniously create new structures in nature and in society. But, as indicated in the article, this requires intense attention to the order in which the mind is moving, from moment to moment.





[ABSTRACT]

'Burroughs has repeatedly assured his readers that a good deal of his writing is direct dictation from Hasan-i-Sabbah, the founder of the eleventh-century Ismaili cult, the Assassins. This dictation is supplemented by Burroughs's own "fold-in" technique, whereby pages are taken at random, folded in half vertically, laid alongside a similarly-folded page so that the two pages fuse. The lines are then edited, rearranged, and "let out" ("words know where they belong better than you do") until a satisfactory juxtaposition is achieved. Such a technique, Burroughs believes, results in the formation of new and striking images.' – *Contemporary Authors: A Bio-bibliographical Guide to Current Authors and Their Works*, vols. 9–10, ed. James M. Ethridge (Detroit: Gale Research Company, 1964), p. 63.

Or as Mr Burroughs has put it himself, in an interview published in *Writers at Work: The 'Paris Review' Interviews, Third Series*, ed. George Plimpton (New York: The Viking Press, Compass Books, 1968), p. 154: 'Now, for example, if I wanted to make a cutup of this [*picking up a copy of the* Nation], there are many ways I could do it. I could read cross-column; I could say: "Today's men's nerves surround us. Each technological extension gone outside is electrical involves an act of collective environment. The human nervous environment system itself can be reprogrammed with all its private and social values because it is content. He programs logically as readily as any radio net is swallowed by the new environment. The sensory order." You find it often makes quite as much sense as the original. You learn to leave out words and to make connections.'

'THINGS THEMSELVES ARE LYING...'

Robert Le Ricolais, Senior Fellow in Architecture at the Graduate School of Fine Arts, University of Pennsylvania, has since 1953 shared his experiments with graduate students in the Department of Architecture, and his observations, often brief and unsettling, have meant much to the Master of Architecture studios held with Louis Kahn. Mr Le Ricolais was born in France in 1894, and before coming to work in American universities, in 1951, he had already a varied career: engineering for a number of industrial firms, including the Nantes office of a liquid-air company from 1930 to 1943; the publication of a paper on his Isoflex system of superimposed sheets of corrugated material, 'Les tôles composées et leurs applications aux constructions métalliques légères', *Bulletin de la Société des ingénieurs civils de France*, May–June 1935, for which he received the society's medal of distinction, and the publication of an early paper on space-frame structures, 'Essai sur des systèmes réticulés à 3 dimensions', in two parts, *Annales des ponts et chaussées*, July–August 1940 and September–October 1941; after World War II, work on structures for the French national railroads, and timber constructions of various kinds, including experimental space-frames, a church, schools, several houses with hexagonal partitioning in plan, and in the French Cameroons a hangar using his Aplex system (shown on page 84), which although a prototype met the limited budget and resisted a gale a short time after it was put up; also a period of airbrush paintings (two of which are shown at left), 1935–40.

On his work of the fifties, one of his former students, Tim Vreeland, writes: 'The concept of the structural grid has since earliest times been at the heart of Le Ricolais' thinking, i.e. the breaking down of a spanning structure into ordered systems of similar elements to achieve an optimum distribution of stresses within the system and to achieve as little overall weight as possible.... by avoiding primary elements of large size supplemented by smaller secondary members, a much more even and direct transmission of forces to the edge support was achieved; and secondly, great economy of construction was realized by overall lightness and repeated use of a similar element.... The basic element was rigid, capable of acting in tension or compression, but essentially forming part of a total compression system.... Then in 1958 he turned his interest to pure tension systems, attracted by the enormously increased advantage of lightness it offered due to the much smaller sectional area of a tension cable over a compression strut.... None of the lessons of the earlier compression grids were lost, however. Again, specifically radial systems were [avoided and systems were] sought which subdivided the span into a uniform grid usually of square, triangular or hexagonal patterns. In some of the experiments isolated compression members were introduced between two layers of tension cables to increase the tautness of the cables and the effective depth of the resulting truss. Autumn 1958 was almost exclusively devoted to student explorations of this type, and many variations of this idea were discovered.' That is from 'Robert Le Ricolais', *Architectural Design* 30, no. 10 (October 1960); see pages 412–16.

For a few of Mr Le Ricolais's studies and writings since 1950, see 'Contributions to Space Structures', 'Structural Approach in Hexagonal Planning', and 'Topology and Architecture', *Student Publications of the School of Design, North Carolina State College, Raleigh, N.C.* 3, no. 3 (Spring 1953): 1–5, 10–15, and volume 5, no. 2 (Spring 1955): 10–16; 'Structural Anticipations' and 'The Trihex: New Pattern for Urban Space', *Progressive Architecture* 42, no. 9 (September 1961): 210–14, and volume 49, no. 2 (February 1968): 118–19; 'Robert Le Ricolais: 30 ans de recherches sur les structures' and 'La nature des choses', *Architecture d'aujourd'hui* 34, no. 108 (June–July 1963): 85–101, and volume 40, no. 141 (December 1968–January 1969): 58–61; 'Espace et structure: A la recherche d'une mécanique des formes', *Sciences: Revue française des sciences et des techniques* 40 (November–December 1965): 20–35; 'A Simple Method of Computation for Planar Networks' and 'Octahedronal Cells for Tensioned Steel Structures', in *Space Structures*, ed. R. M. Davies (Oxford: Blackwell Scientific Publications, 1967), pp. 1026–38; 'Introduction to the Notion of Form', in *DATA: Directions in Art, Theory, and Aesthetics*, ed. Anthony Hill (London: Faber and Faber, 1968), pp. 48–57; and 'Under Sea Transit', *Architectural Design* 40, no. 5 (May 1970): 228–29; see also the forthcoming *Zodiac*, no. 22. He would recommend, however, the following books, for the pleasure they may afford the student of structures: C. V. Boys, *Soap-Bubbles: Their Colours and the Forces Which Mold Them* (New York: Dover Publications, 1959); Richard Courant and Herbert Robbins, *What Is Mathematics?: An Elementary Approach to Ideas and Methods* (New York: Oxford University Press, 1941); André Delachet, *Contemporary Geometry*, trans. Howard G. Bergmann (New York: Dover Publications, 1962); and David Hilbert and S. Cohn-Vossen, *Geometry and the Imagination*, trans. P. Nemenyi (New York: Chelsea Publishing Company, 1952).

Presenting him with the 1962 grand prize for architecture of the Cercle d'Etudes Architecturales, André Malraux called Mr Le Ricolais the father of space structures, adding that his ideas have influenced the greatest architects. But he has remained an elusive figure – perhaps especially for students and readers who have been exposed to the variety of his continuing researches. Generally discussing his past work most briefly, he prefers to consider what sorts of structure or idea should be tried next: 'I'm interested by paradox in form and motion, for instance, square bubbles and railway stations where trains never stop.... The forms we invent are not sculpture, though aesthetics be a conclusion of our work which does not displease me; it deals, in fact, with models, with investigations around objects yet to be baptized, newborn, whose civil state has yet to be determined. This investigation is not headed toward objects of specific application. It is difficult to classify them in terms of known forms, and because of the fact that orienting toward a practical investigation limits invention, our basic search remains yet in the abstract camp. But it is certainly true that we have some notion about their application.'

To draw out more of his attitude, then, or the nature of his fascination with structures, several interviews were held and taped, over a three-year period beginning in 1969; the present text is based on the transcripts, with the addition of some material from his notes and papers. (It should be noted that the models shown are but a few of the many made, that the scales given in the captions are approximate, and that rigid joints were usually made by brazing; the models were built by Mr Le Ricolais's students over the years, and he would have liked to thank each one by name.)

The following, which can be taken as a kind of postscript, was written by Mr Le Ricolais early in 1969.

A FEW WORDS ABOUT RESEARCH

The story of Science is more important than the story of scientists, the first dealing with facts, the second with anecdotes based mostly on opinions. As interesting as the life of a Prince of Science could be, his message is beyond himself; he may die, but his discovery will remain. Moreover, his experience of life is a personal one, and cannot be transferred to anyone. This is why, as small as my achievements may be, I do not see a great need to relate here the reason of my personal addiction to the study of Structures.

Maybe first, the word *structures* deserves a few comments, since it appears to me to be of a fairly recent origin. The Ancients were probably more specific than we are today and, instead of the vagueness of

the term, preferred to refer to *one* particular structure, a bridge, a roof frame, a wall, a column, etc. All these entities being of different purpose, they could not distinguish what was common to all of them. It is only during the last century that the strength of materials received its first pages.

Compared to pure Mathematics, it is somewhat curious to see that in spite of Experimenters of great talent – Galileo, Pascal, Le Père Mersenne, and many others – it took such a long time to come to the notion of Force, which is today an integral part of our vocabulary. In the eighteenth century, the notion of moment of inertia would have been completely incomprehensible, and it would have been hardly conceivable for a practitioner that steel and wood were subject to a common law. The detail of the craft hindered the fundamental; the Ancient knew better the how than the why, and we must admit that in modern times we know a little more of the why, but ignore a great deal of how. Or, perhaps more exactly, the man who knows the why has not the how under control. We realize the gap between theory and practice.

If ignorance has its ridicule, some 'mandarins' of Science are not immune. I had the misfortune of meeting one of those who seriously pretended that outside differential equations every technical work was 'unscientific'. I understood that since he had overworked himself to master their manipulation, such relationships were for him the paradigm of Science. Inadequate simplifications are a great danger, and the tendency of our time toward abstraction is undeniable. But abstract thought need not always be conveyed through abstract, pedantic language, adding two possibilities for incomprehension instead of one. Sometimes, one has to have recourse to unfamiliar words or expressions, and in such a case it is advisable to give a preliminary definition of the vocabulary used. One should remember the common saying, What is clearly conceived is usually clearly expressed.

The uncertainty of our intellectual powers leans toward a method of ordering our thoughts in such a way that conclusions soon become a system. This, it seems to me, is the computer method: in order to reach a predetermined, objective goal, one writes a program, often disregarding the treachery of the terms and confusing the obvious with the true. We rush toward a self-established system on uncertain bases, accepting without discussion, as ultimate truth, an order of things simply established by tradition or other conveniences. From time immemorial, who questioned the orthogonal division of space into north, south, west, and east, plus heaven and hell? Already the Cartesian coordinates, x, y, and z, were present in man's mind, and direction has become an instinct. Yet can we really believe that these yield the optimal partition of space? Certainly they provide a coherent analytic system for comprehending a three-dimensional world, but crystallography and soap-film configurations show us that the right angle is constantly ignored. And no one questions the continuity of time, enslaved as we are to the watch, which rules all the sequences of our activity. Who could accept a definition of granular time or fluctuating space with ever changing boundaries?

To modern scientists, continuity may appear as a delusion of our senses, and the notion of relativity leads us to think of the universe in finite terms; the continuous and the infinite would be fictions created in our minds and negated by reality. 'God's mind is in the innumerable but finite', says the astronomer Roger Denjoy – this perhaps because of the limitation of the human mind, extenuated before colossal numbers. The continuous and the infinite are the crutches of our failing intelligence in scrutinizing the too rich and too complex accumulation of single objects or facts.

To think is to be confronted with anxiety, and in some way it calls for a kind of suffering. As the Greeks used to say, to learn is to suffer. Maybe grants and research fellowships have now made that suffering endurable. Maybe the discoverer of the ultimate truth will find his own kind of Golgotha; our own has been a rather pleasant one, being not of the mettle which makes martyrs. We trudgened through the years on the verge of the obvious, trying to distinguish between the trivial and the complex. I should say that ignorance has been our greatest ally. To explain this pursuit is simple: the unknown art of arrangements, where aesthetics is a compelling, but not the unique, factor in the decision to make. Curiously enough at the end of a long career, it seems that in some way I have always looked for the same multifaceted problem, which could be defined as the art of making holes. (I deliberately choose the plural to avoid the unavoidable terminal hole.) What makes this problem of holes so fascinating – could it be the love for paradox? or the recurrence of an ancient symbol? Perhaps the first of symbols drawn by man, in Paleolithic times, was some kind of oval, related to the feminine sex or to the notion of entrance, but much more an image than a descriptive representation. And its explication can never be concluded – the duality of the within and the without, open and closed, solid and void. From the beginning the image implies the double operation of going from the dimensions of space to those of a plan and back again. About ten thousand years later, we come across the hierogram which is Solomon's seal, the symbolic meaning being stability; if it is projected into space, we are confronted with an octahedral frame, which is curiously an optimum volume formed with undeformable, triangular faces.

Illusory as it may be, it is of some interest to trace a tentative scheme for future discoveries or inventions. Despite the variety of intellect of the Researcher, equipped with his own methods and practices, we can here recall Auguste Comte's famous aphorism: Induce to deduce, in order to construct. Let us consider the point of departure, induction, from which we already infer the dynamic power of ideas or the act of intuition bearing on a certain object. 'To think without an object is the madman's torment', said the philosopher Alain. Is it possible to order a discovery or, to a lesser degree, an invention? On a specific point of technology, a team of technicians and specialists can feasibly specify a list of possible solutions, and this is the wishful thinking of research committee meetings. But the limitations of such a pretension are clear, unless it is understood that only an improvement is at stake, because the fundamental character of an invention has to be of a revolutionary nature, so well defined by the word *breakthrough*. Revolutions are not made with systems, but with ideas, and all innovations are considered dangerous in a conservative world.

My personal belief in this matter is that the starting point of an invention is created much less by abstract, bookish considerations than by the attentive and patient observation of a natural structure, or phenomena which we perceive with a sense of wonder, behind the veil of habits. The more we experience in the way of wonder, the greater will be our desire to comprehend. 'One must approach objects as one approaches God', said Gaston Roupnel. The legend concerning Newton's apple is a graceful one – how many apples fell before the laws of gravity were discovered?

The study of natural structures being the first step toward the grasp of any other type of structures, I am convinced of the importance of 'collections'. Taxonomic process, as in the study of botanical species, is a sound beginning, introducing the taste for making distinctions and analogies. Any accurately observed facts are the premises of a fruitful research. However, there is the human tendency to simply make accurate quantitative descriptions of a thing, in some way indicating a desire to establish a relationship between the observed object or phenomenon and the human scale. There is nothing wrong in such an attitude – Lord Kelvin said that if we cannot put figures to what we are talking about, it shows that we know nothing on the subject. But in the immense repertoire of natural, and also of mathematical, forms, it is foolish to conclude with anthropomorphic arguments, taking human scale to where it has not much to say. More important is to observe the variation of phenomena in terms of well-defined parameters.

Much should be said about the search for a maximum symmetry in the realm of structures. A simple but suggestive example could be given: if $x + y + z + \ldots + u = a$, with the members of the series being positive, then a is maximum when $x = y = z = \ldots = u$. Independently, a requirement of modern structures is that they be based on repetition, and repetition of forms involves, as much as possible, repetitive joints. It is doubtful that such elementary considerations could be at the root of any important discovery. It is more often the *composition* of ideas that leads to an effective result.

Perhaps in a very near future our thinking habits will undergo a thorough change, and the intellectual evolution in progress will reach a state where the Qualitative prevails over the Quantitative. This makes it interesting to consider the notion of what could be called the structure of structures. As hinted before, more valuable than a metric knowledge would be the understanding of the variations of those numerical magnitudes, or their invariance, in terms of certain parameters. The search for what remains constant in the course of changes is the permanent theme of mathematical studies. The incidence of this kind of observation will be to convert the studied structures into mathematical images, upon which all necessary transformations can be accomplished. In other words, what counts is much less the things themselves than the relationships between them. We come thus to the combinatorial notion of arrangements.

The alphabet tops by far any other human invention: that all past, present, and future ideas could be encompassed within the 26 letters shows, perhaps more than words do, the almighty power of thought. We are confronted here with the sense of infinity and order that gives mankind a way of challenging death. More than any religion, the alphabet has changed man's condition, and it is impossible to speak about structures without recalling the fantastic power of the Phoenician discovery. The correct alphabet for Structures remains to be found.

To realize what could be meant by the seemingly pleonastic term *structure of structures*, some reference has to be made to Topology. The package of relationships that constitute a structure is translatable into topological symbols defining its invariants, and these invariants tell the general property of that structure. (If we are dealing with triangulated structures, the invariants define the number of faces, edges, and vertices, according to Euler's law.) This is the 'situation diagram', from which we can obtain a dual image, or diagram of forces, by an inversive transformation. More important than this method, which has its own advantages and disadvantages, is perhaps that it introduces the topological notion of connectivity in the study of structures. 'How can architecture, concerned with the art of connecting spaces, ignore topology, which is the science of connectivity?' – these are the words of the scientist Cyril Smith.

What seems to me of great significance here is the erosion of circumstantial details brought forward through topological analysis. We deal then with something that really counts; far from the deceit of what we see, we reach the skeleton behind its disguise, and we have a chance to reach generalities. Instead of dealing with the nearly infinite number of possible planar configurations, we learn to make the distinction between open and closed configurations and are able to transform at our will one into another, according to the principle of duality. It is not uninteresting to relate the fundamental property of indivisibility of the point to the notion of the atom, this to exemplify how a coherent language may possess a predictive power.

E. T. Bell has said that our propensity to geometrize our analysis may only indicate that we have not yet grown up. In the same frame of mind, certain typographic schemes or concepts, highly popular in architectural schools, not only show puerility but can lead to absurd conclusions. The challenge of our time is the substitution of a new order of values for the accepted one, and one must be prepared for the chilling notion of an unfamiliar universe.

Illustrations: *1* (Photo Marc Vaux), *6–8*, *14*, *39*, *43–45*, personal collection of Mr Le Ricolais; *2*, *3*, *9*, *10*, *26*, *29*, *30*, *33–37*, *41*, *42*, *46*, *47*, *50*, *51*, *54*, *61*, *68*, George Pohl; *4*, *11*, *25*, *27*, *28*, *40*, *48*, *55–60*, *62–65*, James Bryan; *5*, *53*, Rolf Sauer; *12*, *13*, *17–24*, *31*, *32*, *52*, *66*, *67*, sketches and notes by Mr Le Ricolais; *15*, *16*, reproduced from Great Britain, Challenger Office, *Report on the Scientific Results of the Voyage of H.M.S. Challenger* . . . , prepared by Sir C. Wyville Thomson and John Murray, 40 vols. (Edinburgh, 1880–95), ser. 5, *Zoology*, vol. 18, pt. 3 (plates), pls. 108, 29; *38*, Bethlehem Steel Corporation; *49*, redrawn from 'Robert Le Ricolais: 30 ans de recherches sur les structures', *Architecture d'aujourd'hui* 34, no. 108 (June–July 1963): 91; the photographs of Mr Le Ricolais's airbrush paintings on page 196 are from his personal collection.

[MATIERES]

The photographer Henriette Grindat, of Lausanne, has remarked that her studies of materials were an early interest, and one that developed over a number of years: 'I bent over the most minuscule objects – mosses, the grains in stones, in short a multitude of natural phenomena that, it seemed to me, should be regarded more closely; forms that we now rarely if ever perceive with the naked eye. I remember how people who didn't understand what my research was about used to react to this prospecting of a world which was quasi-microscopic but which showed itself to be exciting: epidermal layers, polluted waters, tiny spots that one can come across on the pavement or on a wall . . . There were also graffiti, but that's another matter since it is already man interfering with material.'

The text and photographs of 'Matières' were put together in 1964 by Miss Grindat, Mr Le Ricolais, and the Swiss typographer Henri Chabloz. Then with Mr Chabloz's death, the printing of the book was abandoned. Two preliminary copies had, however, been produced, with the type impressed directly on the photographs, and the pages of one of them (unearthed by Leslie Sauer in Mr Le Ricolais's basement) have been reproduced here, with the English versions added.

[PIONEER ZONE / MARKETS]

Claude Lévi-Strauss, professor of social anthropology at the Collège de France, Paris, wrote the remarkable *Tristes tropiques* (Paris: Librairie Plon, 1955) partly on the basis of field work in Brazil from 1935 to 1939. But there were also four chapters on phenomena observed in Asia, and these were omitted from the first English editions.

Now, a new English translation, by John and Doreen Weightman, is to be published by Jonathan Cape Ltd., London, and Atheneum Publishers, New York, with the missing parts restored, and with the kind permission of the publishers 'Pioneer Zone' and 'Markets' appear here.

From an interview with the author in *Mademoiselle* 71, no. 4 (August 1970): 236 – 'The world we live in is dominated by the population explosion. Paradoxically, it makes us much more dependent on nature than primitive societies ever were. We usually imagine that these societies were the slaves of fate, that they were constantly haunted by the need to defend themselves against fierce enemies, or to fight off illness or hunger. In fact . . . they can feed their family and themselves by working two or three hours a day. And we no longer realize that people who don't live on farming or cattle-raising, but on picking and gathering, acquire so refined a knowledge of their natural environment, that they can live plentifully in places which seem completely barren to us, making use of the dozens of nutritive plants they know.'

Umberto Eco is a professor of semiotics at the Università di Bologna, and an editor of several publications in the field, including the new journal *Versus: Quaderni di studi semiotici*. In a review of his book *La struttura assente*, Paolo Valesio noted that Mr Eco might be placed among the intellectuals referred to in Italy (with no political emphasis to the description) as 'militant' – a category that may not have excluded adventurers, and that has not found much recognition abroad: 'Certainly it does not seem to be widely accepted, for instance, in the United States, where the multiform activity of these European intellectuals, who move with agility and elegance from a brief polemic newspaper article to an essay for a scholarly journal or to a fully developed book, is apt to be dismissed with a condescending reference to "coffee shop talk". As already said, there are many instances in which this "militant" attitude does not seem to be productive and useful in any serious way, but on the other hand, in its best examples, it gives to intellectual life in places like Paris and Rome a lively, human quality, a sense of connection of the world of the scholar with society at large, which is often missing elsewhere.'

'Function and Sign: Semiotics of Architecture' is a translation, and to some extent a revision, of the six chapters of section C of Mr Eco's *La struttura assente: Introduzione alla ricerca semiologica* (Milan: Bompiani, 1968) – a revised version of the entire book, under the title 'The Semiotic Threshold', is to be published in English by Mouton & Co. We are grateful to the author for checking over the present translation, and refer the reader to a complementary essay by him, 'A Componential Analysis of the Architectural Sign /*Column*/', *Semiotica* 5, no. 2 (1972): 97–117.

The introductory quotation is from Roland Barthes's *Elements of Semiology*, trans. Annette Lavers and Colin Smith (New York: Hill and Wang, 1968), pp. 41–42.

One additional remark from Mr Valesio's review – 'Toward a Study of the Nature of Signs', *Semiotica* 3, no. 2 (1971): 155–85: 'The complex structure of the book is somewhat misleading: it presents Eco's essay as something more rigid than [what] it actually is . . . : a many-sided, problematic approach to a relatively new field, which is not meant as a systematic exposition of the current state of the research, but rather as a series of inquiries made with a very open mind.'

NOTES TO THE TEXT

1

See Christian Norberg-Schulz, *Intentions in Architecture* (Cambridge: M.I.T. Press, 1965), chap. 5. Compare Gillo Dorfles, *Il divenire delle arti* (Turin: Einaudi, 1959), pt. 2, and idem, *Simbolo, comunicazione, consumo* (Turin: Einaudi, 1962), especially chapter 5; Susanne K. Langer, *Feeling and Form* (New York: Charles Scribner's Sons, 1953), the chapters on virtual space; Cesare Brandi, *Elicona*, vol. 4, *Eliante o dell'architettura* (Turin: Einaudi, 1956); idem, *Segno e immagine* (Milan: Il Saggiatore, 1960); idem, *Struttura e architettura* (Turin: Einaudi, 1968); Sergio Bettini, 'Semantic Criticism; and the Historical Continuity of European Architecture', *Zodiac*, no. 2 (1958), pp. 191–203; and Françoise Choay, ed., *L'urbanisme: Utopies et réalités* (Paris: Editions du Seuil, 1965).

2

Roland Barthes, *Elements of Semiology*, trans. Annette Lavers and Colin Smith (New York: Hill and Wang, 1968), p. 41.

3

Charles Sanders Peirce, *Collected Papers of Charles Sanders Peirce*, vol. 2, *Elements of Logic*, ed. Charles Hartshorne and Paul Weiss (Cambridge: Harvard University Press, Belknap Press, 1932), par. 306.

4

See Umberto Eco, *La struttura assente: Introduzione alla ricerca semiologica* (Milan: Bompiani, 1968), secs. A and B, 'Il segnale e il senso' and 'Lo sguardo discreto'. Generally speaking, we have followed Ferdinand de Saussure's understanding of what a sign is: the coupling of a *signifié* (for which we have used the term *meaning* rather than *signified*) and a *signifiant* (for which we have used the term *sign vehicle* rather than *signifier*); see Ferdinand de Saussure, *Course in General Linguistics*, ed. Charles Bally and Albert Sechehaye in collaboration with Albert Riedlinger, trans. Wade Baskin (New York: Philosophical Library, 1959), and Barthes, op. cit. in note 2.

5

C. K. Ogden and I. A. Richards, *The Meaning of Meaning*, 5th ed. (New York: Harcourt, Brace and Company, 1938), p. 11.

6

Giovanni Klaus Koenig, *Analisi del linguaggio architettonico* (Florence: Libreria editrice Fiorentina, 1964). This book has been superseded by his *Architettura e comunicazione, preceduta da Elementi di analisi del linguaggio architettonico* (Florence: Libreria editrice Fiorentina, 1970), from which we will now be quoting; the quotations will of course be translations.

7

Charles Morris, *Signs, Language, and Behavior* (1946; reprint ed., New York: George Braziller, 1955), p. 10.

8

Ibid., p. 7. For comment on Morris's definitions, see Ferruccio Rossi-Landi, *Charles Morris* (Rome: Bocca, 1953), chap. 4, 'Il problema della segnità'.

9

Koenig, *Architettura e comunicazione*, cited in note 6, p. 28.

10

Charles Morris, *Foundations of the Theory of Signs*, International Encylopedia of Unified Science, vol. 1, no. 2 (Chicago: University of Chicago Press, 1938), p. 5.

11

Morris, op. cit. in note 7, p. 354.

12

See Max Bense, *Aesthetica: Einführung in die neue Aesthetik* (Baden-Baden: Agis-Verlag, 1965).

13

In *Architettura e comunicazione*, cited in note 6, pages 34–37, Koenig says that architectural signs are (or at least used to be, before the time of generalized buildings) *iconic*, since they display directly some properties of the denotata, some properties, that is, of the 'unfoldings' of functions inherent in man's life in society; then he qualifies this, saying that since they represent neither objects nor forms, but rather denote social facts, they are really *prescriptive* signs, requiring specific responses, and that their iconicity must therefore lie in the fact that 'the form expresses the function through space', 'mirroring' the social fact. He has thus brought in such 'slippery' terms as *mirror* and *express* to characterize an iconicity that might well reduce, given his definition of denotata, to the mere presence, or identity, of the form. Better than this, as a *pis aller*, would be to accept what Cesare Brandi has proposed in his *Le due vie* (Bari: Laterza, 1966): a clear-cut distinction between *semiosis* and *presence* (*astanza*), whereby there are aesthetic realities that cannot be reduced to signification, that must be considered in their presence.

14

Koenig, *Architettura e comunicazione*, cited in note 6, p. 30.

15

In this case it is the *aesthetic* function that is predominant in the architectural message, what Roman Jakobson, speaking of acts of verbal communication, has termed the *poetic* function; see his 'Linguistics

and Poetics', in *Style in Language*, ed. Thomas A. Sebeok (1960; paperback ed., Cambridge: M.I.T. Press, 1966), pp. 350–77. But architectural messages display also the five other communicative functions listed by Jakobson: architecture involves communication that is *conative* (or imperative, making one inhabit it in a certain way), *emotive* (think of the calm of a Greek temple, the turbulence of a baroque church), *phatic* (obviously in the many attention-getting devices of architecture – the phatic function might be found to be predominant, then, in such messages as obelisks, arches, and tympana – but also at the level of urban fabric, where 'channels' are opened and established for architectural messages, as in a piazza's ensuring continued attention to the façades of the buildings that surround it), *metalingual* (where, for one example, to relieve any confusion about the code for interpreting the message architecture assumes a self-explaining, or 'glossing', function – think of the benches built into certain otherwise inhospitable American plazas), and of course *referential* (what we will be concerned with here for the most part – that is, the denotations and connotations of architectural objects).

16

See Eco, op. cit. in note 4, chap. A.3, 'Il messaggio estetico'.

17

We should note that the symbolic value of forms was not entirely ignored by the theorists of functionalism: see Louis H. Sullivan's 'The Tall Office Building Artistically Considered', in his *Kindergarten Chats (Revised 1918) and Other Writings* (New York: Wittenborn, Schultz, 1947), pp. 202–13; and Renato de Fusco, *L'idea di architettura: Storia della critica da Viollet-le-Duc a Persico* (Milan: Edizioni di Comunità, 1964), shows that their symbolic value was important not only to Sullivan but also to Le Corbusier. On the connotative value of forms at the level of urban design – turning to the relational forms in the fabric of large urban areas – see Kevin Lynch, *The Image of the City* (1960; paperback ed., Cambridge: M.I.T. Press, 1964), particularly page 91: cities are to be given forms that can stand as symbols for urban life.

18

For a bibliography on this question, see Paul Frankl, *The Gothic: Literary Sources and Interpretations through Eight Centuries* (Princeton: Princeton University Press, 1960).

19

See Suger, abbot of Saint-Denis, *Oeuvres complètes de Suger*, ed. Albert Lecoy de La Marche (Paris, 1867), and idem, *Abbot Suger on the Abbey Church of St.-Denis and Its Art Treasures*, ed. and trans. Erwin Panofsky (Princeton: Princeton University Press, 1946).

20

See Umberto Eco, *Il problema estetico in San Tommaso* (Turin: Edizioni di 'Filosofia', 1956), and idem, 'Sviluppo dell'estetica medievale', in *Momenti e problemi di storia dell'estetica*, pt. 1, *Dall'antichità classica al barocco* (Milan: Marzorati, 1968), pp. 115–229.

21

See the works by Dorfles cited in note 1, not to mention his *Le oscillazione del gusto e l'arte moderna* (Milan: C. M. Lerici, 1958).

22

Claude Lévi-Strauss, *Conversations with Claude Lévi-Strauss*, ed. Georges Charbonnier, trans. John and Doreen Weightman (London: Jonathan Cape, 1969), p. 92.

23

See Giulio Carlo Argan, *Progetto e destino* (Milan: Il Saggiatore, 1965), particularly the title essay, where the notion of works that remain 'open' (the '*opera aperta*') is applied to architectural design. One way of understanding the 'openness' of architectural and urbanistic objects is suggested in Roland Barthes's 'Semiology and Urbanism', in the present volume. Agreeing with certain views held by Jacques Lacan – discussed in Eco, op. cit. in note 4, chap. D.5, 'La struttura e l'assenza' – Barthes believes that with regard to the city the question of meaning becomes less important than a detailed analysis of abstracted 'signifiers'. Thus, 'in [an] effort to approach the city semantically, we must try to understand the play of the signs, to understand that any city is a structure; but one need never try, or even wish, to fill this structure', for 'semiology at present never posits the existence of a final signified', and 'any cultural (or, for that matter, psychological) complex confronts us with infinite metaphorical chains, in which the signified is always deferred or becomes itself a signifier'. Now it is true that any city confronts us with phenomena of enrichment (and substitution) of meaning, but the semantic value of the city emerges not only when one sees it as a structure that generates meaning: it emerges also when, in experiencing it, one is filling it with concrete significations. Indeed, to oppose to the concrete process of signification – in the light of which the city is designed – the notion of a free play of pure sign-vehicles might be to empty the activity of architecture of much of its creative thrust. For if this notion were carried to an extreme, and the significative power of a city considered really infinite – as infinite as the significative power of verbal languages, which in spite of the fact that man has little say with regard to their constitution and laws still permit him to be adequately 'spoken' – then there would no longer seem to be any point in designing a 'new' city: in any existing city there would already be the elements of an infinite number of possible combinations, permitting every type of life within that form. In reality, the problem of architecture is that of defining the limit beyond which an existing form no longer allows the type of life one has in mind, the limit beyond which the architectural sign-vehicles that pass before one appear no longer as a matrix of freedom but as the very image of a domination, of an ideology that imposes, through the rhetorical forms it has generated, various modes of enslavement.

24

Eco, op. cit. in note 4, chaps. B.1–3, 'I codici visivi', 'Il mito della doppia articolazione', and 'Articolazioni dei codici visivi'.

25

Through the use of the wrong code, then, a plan might be read as a section or vice versa; see the amusing situation described in Giovanni Klaus Koenig, *L'invecchiamento dell'architettura moderna ed altre dodici note*, 2d ed., rev. and enl. (Florence: Libreria editrice Fiorentina, 1967), p. 107, n. 17, but see also Koenig, *Analisi del linguaggio architettonico*, cited in note 6, chap. 8.

26

See Bruno Zevi, *Architectura in nuce* (Venice and Rome: Istituto per la collaborazione culturale, 1960), and his earlier book, *Architecture as Space: How to Look at Architecture*, ed. Joseph A. Barry, trans. Milton Gendel (New York: Horizon Press, 1957).

27

The term *choreme* is derived from χῶρος ('space, place'). For a theoretical consideration of the στοιχεῖα as primary elements of the spatial arts, including architecture, see the remarks by Mondrian discussed in de Fusco, op. cit. in note 17, pp. 143–45.

28

See Christian Norberg-Schulz, 'Il paesaggio e l'opera dell'uomo', *Edilizia moderna*, nos. 87–88 (1966), pp. 63–70; that issue of *Edilizia moderna* is dedicated to 'the shape of landscape'. The entirety of Norberg-Schulz's *Intentions in Architecture*, cited in note 1, is important to the preceding and following remarks, but see in particular the chapters on perception, symbolization, and technics.

29

On these, and on the codes that follow, see Koenig, op. cit. in note 6, pp. 38–52 ('L'articolazione del linguaggio architettonico'), and Dorfles, *Simbolo, comunicazione, consumo*, loc. cit. in note 1.

30

On the concept of 'type', see, besides Dorfles and Koenig, the text titled 'Sul concetto di tipologia architettonica' in Argan's work cited in

note 23, where the proper parallel is drawn between architectural typology and iconography; type is defined as *progetto di forma*, which comes close to the definition of figures of speech (as *relazioni generali di inaspettatezza*, or general schemes providing for formulaic presentation of the unexpected) given in Eco, op. cit. in note 4, par. A.4.2.2. See also Bettini, op. cit. in note 1, and Vittorio Gregotti, *Il territorio dell'architettura* (Milan: Feltrinelli, 1966).

31

For Joseph Stalin's well-known view on linguistics, see his *Marxism and Linguistics* (New York: International Publishers, 1951).

32

That language determines the way in which one sees reality is Benjamin Lee Whorf's thesis in his *Language, Thought, and Reality*, ed. John B. Carroll (1956; paperback ed., Cambridge: M.I.T. Press, 1964).

33

See Eco, op. cit. in note 4, chap. A.3.

34

That is, they would constitute a rhetoric in the sense of the term discussed in Eco, op. cit. in note 4, par. A.4.2.2.

35

See Giulio Carlo Argan et al., 'Design e mass media', *Op. cit.: Selezione della critica d'arte contemporanea*, no. 2 (January 1965), pp. 8–30; Renato de Fusco, 'Architettura e cultura di massa', *Op. cit.*, no. 3 (May 1965), pp. 8–21; and Filiberto Menna, 'Design, comunicazione estetica e mass media', *Edilizia moderna*, no. 85 (1965), pp. 32–37 (see for that matter the whole of that issue of *Edilizia moderna*, and note the slant of the graphics).

36

For perhaps the most comprehensive study to date, see Renato de Fusco, *Architettura come mass medium: Note per una semiologia architettonica* (Bari: Dedalo libri, 1967).

37

To quote from 'The Work of Art in the Age of Mechanical Reproduction', an essay by Walter Benjamin in his *Illuminations*, ed. Hannah Arendt, trans. Harry Zohn (New York: Harcourt, Brace & World, 1968), p. 241: 'Distraction and concentration form polar opposites which may be stated as follows: A man who concentrates before a work of art is absorbed by it. He enters into this work of art the way legend tells of the Chinese painter when he viewed his finished painting. In contrast, the distracted mass absorbs the work of art. This is most obvious with regard to buildings. Architecture has always represented the prototype of a work of art the reception of which is consummated by a collectivity in a state of distraction.'

38

See the issue of *Edilizia moderna* dedicated to 'design', cited in note 35, and in particular the introduction, 'Problemi del design', an English translation of which appears on page 126.

39

On how significative systems elaborated not by the 'speaking mass' but by a 'deciding group' are subject to the 'determination of the community', see Barthes, op. cit. in note 2, pp. 31–32.

Reviewing the first version of this text – *Appunti per una semiologia delle comunicazioni visive* (Milan: Bompiani, 1967) – Bruno Zevi, in his 'Alla ricerca di un "codici" per l'architettura', *L'architettura: Cronache e storia* 13, no. 7 (November 1967): 422–23, commented that of our three hypotheses only the second, which seemed to him to be presented as absurd and impossible, would represent the moment of the creative flash, of the 'poetic' utopia that makes history; the first would pertain to purely 'prosaic' works, and the third to a select body of architectural 'literature'. It seems to me that we have to reach a clear understanding of the nature of the dialectic between fidelity to the code and challenging of the code – which is equivalent to the dialectic between *form* and *openness*, discussed in my *Opera aperta: Forma e indeterminazione nelle poetiche contemporanee*, 2d ed., rev. and enl. (Milan: Bompiani, 1967). We have to bear in mind the principle from the *Poetics* of Aristotle: there may be a *flash* of something that does not correspond to the expectations of the public, but these flashes, in order to make an impression, cannot do without the leverage of redundancy, *referring one to the preexisting codes*. The second hypothesis, it seems to me, has to do with subversive operations where unrestrained formal invention, taking no account of the concrete architectural discourse going on in the society, transforms architecture into purely contemplable forms, and thus at best into a kind of radical sculpture or painting. And what the third hypothesis concerns is rather a possible transformation of the givens, such that the givens one starts with are *transformed* at the very moment they are *recognized and reabsorbed* by the new proposal. The delicate question of how much is to be recognized and *rejected* and how much is to be recognized and 'resumed' is precisely the problem of that 'utopian code' rightly recognized by Zevi as one worth pursuing.

40

See Italo Gamberini, *Introduzione al primo corso di elementi di architettura e rilievo dei monumenti: Gli elementi dell'architettura come 'parole' del linguaggio architettonico* (Florence: Coppini, 1959); idem, *Per una analisi degli elementi dell'architettura* (Florence: Editrice Universitaria, 1953); and idem, *Analisi degli elementi costitutivi dell'architettura* (Florence: Coppini, 1961).

41

See Andries van Onck, 'Metadesign', *Edilizia moderna*, no. 85 (1965), pp. 52–57.

42

Reviewing the first version of this text, cited in note 39, Maria Corti commented that in the introduction of the anthropological system into the discussion was 'a trap', one that reopened the problem of the autonomy of semiotics as a science. (Her review appears in *Strumenti critici* 1, no. 4 [October 1967]: 447–50.) While I acknowledge there might have been some malicious intent to it, I would like to point out that I was really trying to resolve the problem, which would have come up in any case, and that her comments, together with a series of doubts advanced by Vittorio Gregotti in conversation, have driven me to making this point a little clearer, even to me.

43

See in particular Edward T. Hall, *The Hidden Dimension* (Garden City, N.Y.: Doubleday & Co., 1966).

44

Claude Lévi-Strauss, *Structural Anthropology*, trans. Claire Jacobson and Brooke Grundfest Schoepf (New York: Basic Books, 1963), chaps. 7 and 8; see also Paolo Caruso, 'L'analisi antropologica del paesaggio', *Edilizia moderna*, nos. 87–88 (1966), pp. 12–16, and Vittorio Gregotti's running commentary in the same issue, an English translation of which ('The Shape of Landscape') appears on pages 149–52.

45

Hall, op. cit. in note 43, p. 128.

46

Ibid., p. 113.

47

Ibid., pp. 118–19.

48

Ibid., p. 122. See also Edward T. Hall, *The Silent Language* (Garden City, N.Y.: Doubleday & Co., 1959), and the various points of view on proxemics in *Current Anthropology* 9, nos. 2–3 (April–June 1968): 83–108.

49

See Eco, op. cit. in note 4, chap. B.3.

50

Ibid., par. A.2.4.1.

51

See Lynch, op. cit. in note 17; Luciana de Rosa, 'La poetica urbanistica di Lynch', *Op. cit.*, no. 2 (January 1965), pp. 78–88; and also Donald Appleyard, Kevin Lynch, and John R. Myer, *The View from the Road* (Cambridge: M.I.T. Press, 1964).

52

For an example of research on procedures of codification at the level of 'ultimate' structures, see Christopher Alexander, *Notes on the Synthesis of Form* (Cambridge: Harvard University Press, 1964). For a parallel drawn between Alexander's work and that of structuralists, see Maria Bottero, 'Lo strutturalismo funzionale di Christopher Alexander', *Comunità*, nos. 148–49 (November–December 1967), pp. 73–82.

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SEMIOLOGY AND URBANISM

Roland Barthes teaches the sociology of signs, symbols, and collective representations, at the Ecole Pratique des Hautes Etudes, Paris, and edits the French journal *Communications*. He has worked for some time on the development of semiology, and anyone wishing to embark on the study of signs and significations should be sure to see his *Elements of Semiology*, translated from the French text, of 1964, by Annette Lavers and Colin Smith (New York: Hill and Wang, 1968), a book distinguished not only by its energetic presentation of the rudiments of the science, but also by the fascination of its brief passages on particular problems and prospects.

'Semiology and Urbanism' was a lecture given by Mr Barthes in Naples in 1967, and our translation is from the Italian text published in *Op. cit.: Selezione della critica d'arte contemporanea*, no. 10 (September 1967), pp. 7–17. There were two references given: with regard to Cleisthenes and *Isonomia*, a reference to Pierre Lévêque and Pierre Vidal-Naquet's *Clisthène l'athénien: Essai sur la représentation de l'espace et du temps dans la pensée politique grecque de la fin du VIe siècle à la mort de Platon, Annales littéraires de l'Université de Besançon*, 2d ser. 65 (1964), and with regard to the amount of attention given to problems of signification in the theoretical work of urbanists, a reference to Françoise Choay, ed., *L'urbanisme: Utopies et réalités* (Paris: Editions du Seuil, 1965).

Mr Barthes kindly let us include here, as an example of his recent reflections on the city, a translation of a passage from his book about Japan, *L'empire des signes* (Geneva: Editions d'art Albert Skira, 1970), pp. 44–46.

CENTRE-VILLE, CENTRE VIDE

Quadrangular, reticular cities (Los Angeles, for example) produce, it is said, a deep malaise; they offend in us a coenesthetic feeling for the city, which demands that every urban space have a center to go to, and to come back from, a complete place about which to dream and with respect to which to advance or withdraw or, in short, invent oneself. For various reasons (historical, economic, religious, military), the West has understood this law only too well: its cities are all concentric; but also, in compliance with the very process of Western metaphysics, for which every center is the place of truth, the center of our cities is always *full*. A marked place, it is there that the values of the civilization come together and condense: spirituality (with churches), power (with offices), money (with banks), merchandise (with department stores), *parole* (with agoras: cafés and promenades) – to go into the center of the city is to come upon the social 'truth', to partake in the splendid fullness of 'reality'.

The city under consideration here (Tokyo) presents a paradox of great value: it has indeed a center, but this center is empty. The whole city revolves about a place that is at the same time forbidden and indifferent, a dwelling masked beneath the greenery, shut off by moats, inhabited by an emperor one never sees (its inhabitant is, literally, an unknown). Day after day, driven with the quickness, energy, and expeditiousness of projectiles in their trajectories, the taxis avoid this circle, whose low profile – the invisibility's visible form – conceals the sacred 'nothing'. Thus one of the two most powerful cities of modern times is built about an opaque ring, of walls, water, roofs, and trees, whose center is itself no more than an evaporated idea, subsisting there not to radiate some power, but to give the whole urban process the support of its central void, obliging circulation to be perpetually diverted. In this way, we are told, imagination takes a circular course, with detours and returns skirting an empty subject.

CLEARING

Louis Kahn must be among the most eloquent architects. And yet when we recorded him on several occasions – in his Master of Architecture studio at the University in 1969, and in his office in Philadelphia in 1969 and 1970 – he seemed too exploratory, too serious about what he was trying to say, to be comfortable about the presence of the tape recorder. The first two sections of 'Clearing' were chosen from the transcripts of those unprepared remarks, and the third came from a talk given by Mr Kahn at Princeton University in the spring of 1968.

THE TOUR EIFFEL

Mr Barthes collaborated with the photographer André Martin to produce *La Tour Eiffel* (Paris: Delpire, 1964), a book in the series 'Le génie du lieu'. What appears here is a translation of Mr Barthes's essay in that book – for her work on the translation, we thank Danielle Mihram – together with another set of illustrations. The introductory quotation is an excerpt from the 'artists' protest', which was published in *Le temps* on 14 February 1887; and the quotation on page 177 is from William A. Eddy's 'The Eiffel Tower', *Annual Report of the Board of Regents of the Smithsonian Institution . . .* , 1890, p. 743.

Reference is made in the text to the work of Gaston Bachelard; see his *The Poetics of Space*, trans. Maria Jolas (Boston: Beacon Press, 1969). On tourism, see 'The *Blue Guide*', in Mr Barthes's *Mythologies*, trans. Annette Lavers (New York: Hill and Wang, 1972), pp. 72–77, from which, 'It is unquestionable that travel has become (or become again) a method of approach based on human realities rather than "culture": once again (as in the eighteenth century, perhaps) it is everyday life which is the main object of travel, and it is social geography, town-planning, sociology, economics which outline the framework of the actual questions asked today even by the merest layman.'

Illustrations: *1*, *3*, *8*, *13*, James Bryan; *2*, *6*, *9–12*, *19*, Rolf Sauer; *4*, *5*, reproduced from G. Eiffel, *La Tour Eiffel en 1900* (Paris: Masson, 1902); *7*, *14*, Bettmann Archive, Inc., New York; *15–18*, reproduced from G. Eiffel, *La tour de trois cents mètres* (Paris, 1900), vol. 2 (plates), pls. 5, XIX (altered), XX, 10.

What the editors might make of this collection of texts would be of little consequence, compared to the texts themselves, and so we will simply say a word about the people who have helped, since the publication of the first volume in this series, *Ecology in Design*, in the spring of 1968, to make this second volume possible. It would not have been possible without the authors, of course, who were generous and patient. The faculty of the Graduate School of Fine Arts must be mentioned for their support and advice, particularly Peter McCleary and Neil Welliver, and the deans, first G. Holmes Perkins, and then his successor, Peter Shepheard. Jane Bryan helped with a good deal of reference work. Jared Sparks proofread and constructively criticized. Finally, the fellow students who early on helped get the work going: John Blatteau, Roy Kato, Martín Domínguez, Robert Jenkins, Stephen Levine, Vincent Maiello, Jeffrey Millman, Jeffrey Pond, Richard Rath, Lynn Scholz (with Susan Burkhardt), Geoffrey White, and especially Philip Johnson and Thomas Gilmore.

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