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The architecture of the well-tempered environment

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1. Unwarranted apology

In a world more humanely disposed, and more conscious of where the prime human responsibilities of architects lie, the chapters that follow would need no apology, and probably would never need to be written. It would have been apparent long ago that the art and business of creating buildings is not divisible into two intellectually separate parts—*structures*, on the one hand, and on the other *mechanical services*. Even if industrial habit and contract law appear to impose such a division, it remains false.

If there is any division at all that can be tolerated in a humane consideration of architecture, it might be between those parts of structure that combine with certain mechanical services to provide the basic life support that makes a viable or valuable environment, and those parts of structure that combine with certain other mechanical services to facilitate circulation and communication—of persons, information and products.

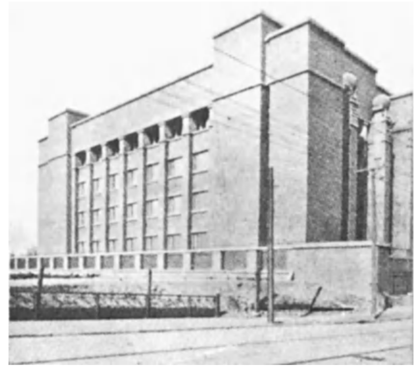
The fact that the outpourings of a radio may be understood as information or environmental background, that the flow of hot water through a pipe may be seen as contributing to the maintenance of an environmental condition or the transmission of a useful product, should warn us that the making of even the division proposed above is open to serious questioning, though the validity of this division for the purposes of the present book, which discusses the architecture of environment, should emerge as the argument proceeds.

Yet architectural history as it has been written up till the present time has seen no reason to apologise or explain away a division that makes no sense in terms of the way buildings are used and paid for by the human race, a division into structure, which is held to be valuable and discussible, and mechanical servicing, which has been almost entirely excluded from historical discussion to date. Yet however obvious it may appear, on the slightest reflection, that the history of architecture should cover the whole of the technological art of creating habitable environments, the fact remains that the history of architecture found in the books currently available still deals almost exclusively with the external forms of habitable volumes as revealed by the structures that enclose them.

The main topic of the present study has therefore only impinged upon the attention of architectural historians when it has incontrovertibly affected the external appearance of buildings, the most notable case being that of the Richards Memorial Laboratories in Philadelphia, by Louis Kahn. By giving monumental external bulk to the accommodations for mechanical services, Kahn forced architectural writers to attend to this topic in a way that no recent innovation in the history of servicing had done. No matter how profound the alterations wrought in architecture by the electric lamp, or the suspended ceiling (to cite two major instances of revolutionary inventions), the fact that these alterations were not visible in outward form has denied them, so far, a place in the history of architecture.

Yet what was visibly manifest in the Richards Laboratories, had been equally visible and manifest in Frank Lloyd Wright's Larkin Building in Buffalo, more than half a century earlier. Few architectural writers have made anything of those strong and monumental forms that Wright gave to the external expression of his pioneer system of mechanical servicing, however, except to cite them as the purely formal source of the external service-works of the Richards Laboratories.

So shallow an interest in so profound a building was both inevitable and predictable however; the art of writing and expounding the history of architecture has been allowed—by default and academic inertia—to become narrowed to the point where almost its only interest outside the derivation of styles is haggling over the primacy of inventions in the field of structures. Of these two alter-



Above: Larkin Administration Building, Buffalo, N.Y. 1906, by Frank Lloyd Wright.
Below: Richards Memorial Laboratories, Philadelphia, Pa., 1961, by Louis Kahn.

natives, the study of stylistic derivations now predominates to such an extent that the great bulk of so called historical research is little more than medieval disputation on the number of influences that can balance upon the point of a pinnacle.

As a result, a vast range of historical topics extremely relevant to the development of architecture is neither taught nor mentioned in many schools of architecture and departments of architectural history. Some are external to the buildings—patronage, legislation, professional organisation, etc.—others are internal—changes in use, changes in users' expectations, changes in the methods of servicing the users' needs. Of these last, the mechanical environmental controls are the most obviously and spectacularly important, both as a manifestation of changed expectations and as an irrevocable modification to the ancient primacy of structure, yet they are the least studied.

Thus, when the research for the present study was first put in hand, the intention was to write a purely architectural history; to consider what architects had taken to be the proper use and exploitation of mechanical environmental controls, and to show how this had manifested itself in the design of their buildings. To achieve this, some grounding in the purely technical history of these controls was obviously required, but I discovered that no comprehensive study of the topic could be found. The one work that was persistently recommended to me as having covered the ground or exhausted the topic, was Sigfried Giedion's *Mechanisation Takes Command*[1] of 1950. It proved, however, in no way to deserve such a reputation—a point to which this argument must return.

What needs to be said here and now is that although there can be no doubt that my view of the topic has been vastly enriched by my enforced studies of primary source material (trade catalogues, lectures to professional societies, specialist periodicals, etc.) the absence of any general and compendious body of study in the field leaves little chance of estimating how balanced and comprehensive is the view that I have derived from these readings.

[1] London and Cambridge, Mass., 1950.

The matter probably cuts deeper than this, because the absence of a body of studies means that the architectural, as well as the technical, aspects may be off balance. Thus, the average producer of a pinnacle-point type of doctoral dissertation on some such subject as 'The Influence of the Drawing Style of Mart Stam on the Aesthetics of *Elementäre Gestaltung*' is a scholastically secure man. He may be setting out to make drastic modifications in the balance of reputations of a group of architects working in a certain place at a certain time, but a known balance of reputations already exists for him to modify, because a continuing body of academic work keeps that balance under review in lecture, seminar and learned paper.

But step outside the security of that continuing body of work, and not only is there no balance of reputations, there are no reputations at all. Nobody knows who were the true masters and innovators, or who merely rode the coat-tails of genius. Ask a historian of modern architecture who invented the *piloti*, and he can tell you. Ask him who invented the (equally consequential) revolving door, and he cannot. Ask who were Baron von Welsbach, Samuel Cleland Davidson or what was first done on the façade of the *West-End* Cinema in Leicester Square, London, and the answer will come very haltingly if at all, and yet these are all matters deserving more than a footnote in any history of what has really happened in the rise of modern architecture.

In such conditions of ignorance and insecurity, and the sheer paucity and poverty of academic discourse on the topic, the reputation of *Mechanisation Takes Command* is perhaps understandable. Even James Marston Fitch, whose sagacious observations on environment and technology have been a constant inspiration to my studies, speaks of Giedion's book as 'a new and revealing study of American technology' despite the fact that his own published works constantly reveal the shallow and unconsidered nature of Giedion's observations.

The true fault of the book lay in its reception. Awed by the immense reputation of its author, the world of architecture received *Mechanisation Takes Command* as an authoritative and conclusive statement, not as a tentative beginning on a field of study that opened almost infinite opportunities for further research. In the ensuing twenty-odd years since its publication, it has been neither glossed, criticized, annotated, extended nor demolished. 'Giedion,' one is told 'hasn't left much to be said.'

This present book represents a tiny fraction of what Giedion left unsaid. This too is a tentative beginning, whose shortcomings, I have no doubt, will become manifest as research proceeds, especially since it suffers from at least one defect in common with Giedion's—the use of the concept of 'the typical.'

The chapters that follow are not exhaustive, therefore they are not definitive. In the light of partial knowledge one cannot specify with certainty, only typify with hope. That is, all one can really do is to indicate the sort of work that was done in a particular period of time, and select a particular building that seems to typify the kind of architecture done with that technique at that time. But in the absence of encyclopaedic knowledge or a going body of research and discussion, it is extremely difficult to be confident that one has picked the most typical building, or the best of a number of buildings exemplifying the same point. Matters of exact primacy in date, who thought of what first, are even harder to fix under these circumstances, but on this point, and in the context of this study, the use of the typical rather than the exactly definitive, can be defended.

While Patent-Office records, of the sort exploited by Giedion and his students in compiling *Mechanisation Takes Command*, make legal primacy of invention capable of being fixed with documentary certainty, such exact dates may be totally valueless in studying the history of architecture. In the practical arts like building, it is not the original brainwave that matters as much as the availability of workable hardware, capable of being ordered ex-catalogue, delivered to the site and installed in the structure. Thus the early patents for fluorescent lighting are almost inconsequential for the history of architecture, but the commercial availability of reliable tubes some thirty-six years later was to be of the utmost consequence. More confusingly, it is possible that one or two major buildings were being air-conditioned (in some senses) two or three years before the earliest air-conditioning patents, and before the phrase 'air-conditioning' had even been coined.[2]

[2] see chapter 9.

In conditions such as these, it may be unwise at present to try to establish absolute primacy of installation or exploitation, and pointless to lavish too much attention on primacy of invention. It has seemed better, in many cases, to settle for a building which appears to sum up forward thinking and progressive practice and let it stand as typical of the best or most interesting work being done at the time, but not to attribute to the concept of typicality those overtones of a platonic absolute implicit (and explicit) in Giedion's elevation of Linus Yale to the status of the very *type* of the Yankee inventor. The use of typicality in the chapters that follow is purely illustrative, the buildings singled out for mention tend less to be the first of their class, than 'among the first.'

This too seems just; this is less a book about *firsts* than about *mosts*. The invention and application of technological devices is not a static and ideal world of intellectual discourse; it is (or has been) impelled forward by the competitive interaction of under-achievers and over-achievers—who might even be one and the same person, for some breakthroughs in application were achieved without matching breakthroughs in invention. But nothing would have been broken through without some extremism of method, and extravagance of personality.

Le Corbusier might admonish in 1925 that 'an engineer should stay fixed and remain a calculator, for his particular justification is to remain within the confines of pure reason . . .'[3] but the fact remains that many of Le Corbusier's own buildings would have been unbuildable or uninhabitable had engineers ever heeded his advice, instead of pursuing their own eccentric and monomaniac

[3] *Urbanisme*, Paris, 1926, p 48.

goals without regard for professional demarcations and social conventions. The history of the mechanisation of environmental management is a history of extremists, otherwise most of it would never have happened. The fact that many of these extremists were not registered, or otherwise recognised as architects, in no way alters the magnitude of the contribution they have made to the architecture of our time. Perhaps finding such men a proper place in the *history* of architecture will be some help in resolving the vexed problems of finding their proper place in the *practice* of architecture.

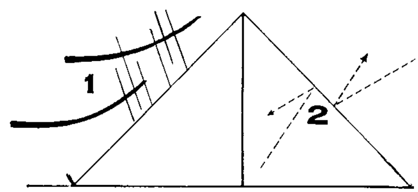
2. Environmental management

The surviving archaeological evidence appears to suggest that mankind can exist, unassisted, on practically all those parts of the earth that are at present inhabited, except for the most arid and the most cold. The operative word is 'exist'; a naked man armed only with hands, teeth, legs and native cunning appears to be a viable organism everywhere on land, except in snowfields and deserts. But only just; in order to flourish, rather than merely survive, mankind needs more ease and leisure than a barefisted, and barebacked, single-handed struggle to exist could permit.

A large part of that ease and leisure comes from the deployment of technical resources and social organisations, in order to control the immediate environment: to produce dryness in rainstorms, heat in winter, chill in summer, to enjoy acoustic and visual privacy, to have convenient surfaces on which to arrange one's belongings and sociable activities. For all but the last dozen decades or so, mankind has only disposed of one convincing method for achieving these environmental improvements; to erect massive and apparently permanent structures.

Partial solutions to these problems have always been offered by alternative methods such as wearing a coat in the rain; getting in a tent out of the sun, or gathering around a camp-fire in the cool of evening. But a coat is an unsociable solution, a tent is short on acoustic privacy even though it may be adequate to keep off prying eyes, and a camp fire, while it can provide heat and light enough to make a useful area of ground habitable, is short on all sorts of privacy and offers no protection against rain.

But, over and above considerations of this kind, one must observe a fundamental difference between environmental aids of the structural type (including clothes) and those of which the camp-



Environmental behaviour of a tent.

1. Tent membrane deflects wind and excludes rain
2. Reflects most radiation, retaining internal heat, excluding solar heat, maintaining privacy

fire is the archetype. Let the difference be expressed in a form of parable, in which a savage tribe (of the sort that exists only in parables) arrives at an evening camp-site and finds it well supplied with fallen timber. Two basic methods of exploiting the environmental potential of that timber exist: either it may be used to construct a wind-break or rain-shed—the structural solution—or it may be used to build a fire—the power-operated solution. An ideal tribe[1] of noble rationalists would consider the amount of wood available, make an estimate of the probable weather for the night—wet, windy, or cold—and dispose of its timber resources accordingly. A real tribe, being the inheritors of ancestral cultural predispositions would do nothing of the sort, of course, and would either make fire or build a shelter according to prescribed custom—and that, as will emerge from this study, is what Western, civilised nations still do, in most cases.

The acquisition of such predisposing cultural habits depends, obviously, on the previous experience of the tribe or civilisation, and this experience could have been painful. In terms of capital expenditure, a structural solution will usually involve a large, and probably hurtful, single investment, while the power-operated solution may represent a steady and possibly debilitating drain on resources that are difficult to replenish. Most 'pre-technological' societies have little choice in this matter, since they are usually short of combustibles or other sources of usable power. For this reason, all the major civilisations to date, those that have shaped world architecture, have demonstrably, and demonstratively, relied on the construction of massive buildings to fulfil their environmental needs, both physical and psychological.

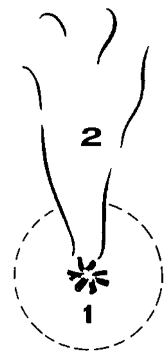
The consequence is that architects, critics, historians and everyone else concerned with environmental management in civilised countries, lack a range of spatial experience and cultural responses that nomad people have always enjoyed. Cultures whose members organise their environment by means of massive structures tend to visualise space as they have lived in it, that is bounded

[1] This tribe has respectable ancestors, who may be found in Laugier's *Essai* and Le Corbusier's *Vers Une Architecture*. The transformations of the basic parable in which they appear, from the Age of Reason to the present text, may afford the interested reader some insights into our changing conception of the technical and social nature of architecture.

and contained, limited by walls, floors and ceilings.[2] There are, obviously, reservations and quibbles that can be raised against this proposition, but its general truth may be observed in many things, such as the persistent manner in which architects and designers visualise 'free' or 'unlimited' space as retaining the rectangular format of walled rooms—Frederick Kiesler's *Cité dans l'Espace* of 1924 is an obvious instance.

[2] see the observations of Paul Scheerbart in chapter 7.

Against this, societies who do not build substantial structures tend to group their activities around some central focus—a water hole, a shade tree, a fire, a great teacher—and inhabit a space whose external boundaries are vague, adjustable according to functional need, and rarely regular. The output of heat and light from a campfire is effectively zoned in concentric rings, brightest and hottest close to the fire, coolest and darkest away from it, so that sleeping is an outer-ring activity, and pursuits requiring vision belong to the inner rings. But at the same time, the distribution of heat is biased by the wind, and the trail of smoke renders the downwind side of the fire unappetising, so that the concentric zoning is interrupted by other considerations of comfort or need.



Environmental conditions around a camp fire.

1. Zone of radiant heat and light
2. Downwind trail of warmed air and smoke

Without pursuing the consequences of these experiences, which may prove to be of fundamental relevance to power-operated environments, further than the exiguous anthropological information warrants, one can still observe that they are experiences that do not enter into the traditions of architecture, even those of modern architecture which is largely concerned with power-operated environments. The traditions of architecture, as we commonly understand the concept, have been forged in societies and cultures that are committed to massively structural methods of environmental management. Furthermore, the accumulation of capital goods and equipment needed to produce even a moderate level of civilised culture in pre-technological societies, required that building materials be treated as if valuable and permanent. It was necessary not only to create habitable environments, but to conserve them. There was rarely any shortage of physically or culturally necessary functions queueing up for the available stock of roofed spaces. Buildings were made to last, and had to be, in order to produce a sufficient return in terms of shelter performance over the years to justify the expenditure of labour and materials that went into them.

Architecture came to be seen as the conscious art of creating these massive and perdurable structures, and came to see itself professionally as no more than that art, which is one of the reasons for its present problems and uncertainties. Societies—through whatever organs they see fit, such as state patronage or the operation of the market—prescribe the creation of fit environments for human activities; the architectural profession responds, reflexively, by proposing enclosed spaces framed by massive structures, because that is what architects have been taught to do, and what society has been taught to expect of architects.

But such structures may be open to objection on a number of grounds; culturally they may be over-emphatic, economically they may be too expensive, functionally they may be intractable to alteration, environmentally they may be incapable of delivering the performance for which society had hoped. All these objections have grown in force as more technological societies have emerged in the northern hemisphere and sought to establish outposts nearer the equator. But the architectural profession has had little to offer beyond further variations upon massive structure, and has normally responded as if these constituted the unique and unavoidable technique for dealing with environmental problems.

In truth, they never had been the unique and unavoidable technique. A suitable structure may keep a man cool in summer, but no structure will make him warmer in sub-zero temperatures. A suitable structure may defend him from the effects of glaring sunlight, but there is no structure that can help him to see after dark. Even while architectural theory, history, and teaching have proceeded on the apparent assumption that structure is sufficient for necessary environmental management, the human race at large has always known from experience that unaided structure is inadequate. Power has always had to be consumed for some part of every year, some part of every day. Fires have had to be burned in winter, lamps lit in the evening, muscle power for fans, water power for fountains used in the heat of the day.

The design of buildings has always had to make some provision in plan and section, for these marginal consumptions of environmental power—chimneys for smoke, channels for water. Some architects, like the Adam brothers, made ingenious use of 'left spaces' in plan to provide concealed access for servants to light lamps and candles. In general, however, such provisions were of little consequence either in outlay or visible bulk; architecture could continue to treat them as matter for footnotes and appendices (Alberti's generous views on chimneys notwithstanding) and cleave to the massive structure of walls and roofs as its real business.

The word 'massive' deserves to be emphasised. In the Mediterranean tradition, from which most Western architecture is directly descended, the need to render society's shelter-investment permanent—or, at least, perdurable—was normally answered by making it massive. Thick and weighty structures are less easily overthrown by storm or earthquake, less maimed by fire or flood. But such constructions bring with them environmental advantages that had become so customary in three millennia of European civilisation, that they were falsely supposed to be inherent in all structural techniques, and there were baffled complaints when they were found to be absent from light-weight methods promoted out of futuristic enthusiasm for the 'Machine Age.'

The outstanding advantages are acoustic and thermal. A thick and weighty structure offers better sound-insulation, better thermal insulation and—equally important—better heat storage capacity. This last quality of massive structure has probably played a larger part in rendering European architecture habitable than is commonly acknowledged. The ability of massive structure to absorb and store heat that is being applied to it, and to return that heat to the environment after the heat source has been extinguished, has served European architecture well in two ways: the mass of masonry in a fireplace, chimney-breast and chimney, has served to store the heat of the fire during the day while the fire burns, and to return it slowly to the house during the chill of the night when the fire has burned out.

Alternatively, the thick walls of a house in a hot climate will hold solar heat during the day, slowing down the rate at which the interior becomes hot, and then, after sunset, the radiation of that heat into the house will help to temper the sudden chill of evening. In more sophisticated forms that use glass as a filter to discriminate between light-energy, which is allowed to pass, and heat energy, whose passage is barred, similar effects of thermal storage are used in the normal green-house, and the whole technique might well be termed the 'Conservative' mode of environmental management, in honour of the 'Conservative Wall' at Chatsworth, devised by that master-environmentalist Sir Joseph Paxton, in 1846.

This conservative mode seems to have become the ingrained norm of European culture, though it has always had to be modified, drastically in humid or tropical climates, less obviously for every-day use, by the 'Selective' mode which employs structure not just to retain desirable environmental conditions, but to admit desirable conditions from outside. Thus a glazed window admits light but not rain, an overhanging roof admits reflected sunlight, but excludes the direct sun, a louvered grille admits ventilating air but excludes visual intrusions.

Traditional construction has always had to mix these two modes, even without recognising their existence, just as it has always had to incorporate the 'Regenerative' mode of applied power, without fully acknowledging its presence. But if these various modes should not be too sharply distinguished in traditional practice, there is an important geographical or climatic consideration that distinguishes solutions that are more conservative from those that are more selective, and an historical watershed that separates both of these from solutions that are primarily regenerative.

The conservative mode suits mainly dry climates, including those that are dry and cold, as well as Mediterranean or semi-desert conditions; the selective mode finds its most needed employment in moist climates, especially in the tropics. Humidity is the crucial factor here, even more than latitude or temperature, as can be seen very clearly in the traditional architecture of the southern United States. In the humid south-east, its attributes have been summed up by James Marston Fitch as

1. Elevated living floors . . . offering maximum exposure to prevailing breezes.
2. Huge, light-mass parasol-type roofs to shed sub-tropic sun and rain.
3. Continuous porches and balconies to protect walls from slanting sun and blowing rain.
4. Large floor-to-ceiling doors and windows for maximum ventilation.
5. Tall ceilings, central halls, ventilated attics for warm-weather comfort.
6. The louvered jalousie, providing any combination of ventilation and privacy . . . etc.[3]

This is a classic characterisation of the selective mode, preoccupied with admitting moving air, and excluding almost every other aspect of the external environment. The conservative mode that prevails in the hot, dry desert south-west has yet to find so masterly a summation,[4] but its crucial differences are immediately apparent —the massive adobe walls and the relatively smaller openings to insulate indoors from out, the carry-over of shaded courtyards from the Spanish Mediterranean tradition. Whatever part differing cultural traditions, as between Louisiana French and Mission Spanish, may have played in this distinction of environmental methods, neither would have survived had it been totally unsuited to the local conditions, and the critical difference in local conditions is humidity.

And of all the factors involved in environmental management, humidity has, for most of architectural history, been the most

[3] in his essay 'The Uses of History', in *Architecture and the Esthetics of Plenty*, New York, 1961, pp 244–245.

[4] Ralph Knowles and his students at the University of Southern California have made a start, however, with their studies of the thermal performance of Indian pueblos such as Mesa Verde.

pestiferous, subtle and elusive of control. While the deficient humidity of an overdried climate can be crudely made good by splashing water about and using shade to reduce evaporative loss, the removal of excess water from the atmosphere has so effectively defied all pre-technological efforts, that it has usually made better sense for those who could afford it to move elsewhere—the British in India retiring to hill-stations like Simla, New York business men with lung complaints to Colorado.

For excess moisture, only a regenerative solution, consuming power, has so far proven effective. Hence the historical, rather than geographical, division between the two main methods of dealing with humid climates. Structural solutions of the Louisiana type discussed above could only be replaced when certain crucial advances in power technology and its control had been achieved.

These advances were part of a general revolution of environmental technology in which humidity control was a late development, and if there is a critical year in that revolution, it is 1882, the year of the domestication of electric power, an achievement that confirmed previous crude environmental advances, and laid the essential foundations for more sophisticated later ones, such as the control of humidity on which air-conditioning depends. It was this revolution that first posed the problem of alternatives to structure as prime controller of environment, and introduced the regenerative mode as a serious rival to the conservative and selective modes, rather than their modest hand-maiden.

It is a fact—though not an easy one to interpret—that the most vital advances into the regenerative mode were made in that area of 'European' architecture that was least devoted to massive construction—North America. This may have depended on the simple coincidence that the abundant timber of which lightweight American houses were built, also provided abundant fuel for the high performance Franklin stoves and Rumford fireplaces that heated them, or it may be that there is a more directly causal connection, and the skimpy thermal performance of these timber buildings made the invention of high-performance, quick-heating stoves environmentally necessary. Or it may have been something even more coincidental than either of these propositions—that these ingenious devices were almost invented for the sake of inventing something or improving an existing device, without any specific reference to the context in which they were to perform.

Whatever happened, it is clear that by the later nineteenth-century, the North Americans had acquired habits and skills in the deployment of regenerative environmental aids that were beginning to add up to an alternative tradition. The importance of this developing regenerative tradition can be seen in the shifting centre of environmental invention as the century proceeded. Coal-gas as a source of domestic environmental power for light and heat is a purely European development, its founding fathers being Philippe Lebon in France, F. A. Winzer in Germany and England, William Murdock in England. But at the other end of the nineteenth century, there can be no doubt that Edison was the true father of the electric light, and Carrier of air-conditioning. Many European inventors, of course, contributed key devices to these regenerative aids, but their development into practicable systems is a purely American story in both cases.

The history of environmental management by the consumption of power in regenerative installations, rather than by simple reliance on conservative and selective structures, is thus a predominantly American history, at least in its pioneering phases. This is in no way a judgement upon the ingenuity or determination of European architects and inventors; it is more a reflection of the unusual problems and advantages of US conditions. The problems were those of lightweight structures in extreme climates wherever Americans built in wood, and the advantages were those of the relatively lightweight culture that many Americans took westward with them into a zone of abundant power.

Of all these considerations, the lack of the encumbrances of a massive culture (physically or figuratively speaking), may have been the most important. It is striking how often events in the USA are not so far in advance of Europe technically, but the Americans appear to have been more aware of what they were doing, and thus to make a better job of it. To anticipate a comparison to be made in a later chapter, one may cite again that masterpiece of the architecture of the well-tempered environment, the Larkin building. In physical and physiological fact it was less advanced than the Royal Victoria Hospital, Belfast, completed some two years earlier, but the advances achieved at the RVH seem rather accidental, and its quality as architecture is barely to be mentioned in the same breath as the Larkin building's.

Doubtless, Wright's towering genius had a great deal to do with this difference in quality, but that genius fed upon a far greater experience in the handling of regenerative tackle than any of his European contemporaries could boast, within the context of a culture that was far more convinced of the need for their exploitation. Familiarity is the key, without a shadow of doubt. There is nor-normally a time-lag—sometimes of decades—between a mechanical device becoming available, and its full-blooded exploitation by architects.

This has less to do, directly, with problems of development in the device itself, than with the need for architects to make themselves acquainted with it. In their role as creators of actual physical environments, architects have to be both cautious and practical. They have to see something in use, sometimes for as much as a generation, before they feel the confidence to extrapolate new and radical uses for it, knowing that their clients will never forgive nor forget if anything goes wrong, even if it is the inexperience or improvidence of the client himself that causes the malfunctioning.

So, technological potential continuously runs ahead of architectural performance. The gap between the two is commonly occupied by environmental experimentation in fields not commonly regarded as architecture—greenhouses, factories, transportation. Almost four decades separate the first industrial uses of air-conditioning from its confident employment in the kind of architecture that is designed by famous architects, but these long intervals involve not only physical experimentation, but much speculation and brainstorming as well, in which a climate of ideas is generated that makes the eventual architectural exploitation of the particular technology become thinkable.

These speculations do not take place in a philosophical or professional vacuum. Commercial and personal interests are deeply involved, axes are ground, factions are served. Thus most of what emerges from the technical side proves to be overt or covert sales-promotion literature, what emerges from the architectural side is often propaganda directed at clients, professional self-criticism or attempts to twist the future development of the art.

Even where a visionary without a professional interest emerges, as in the case of Paul Scheerbart and his book *Glasarchitektur*,[5] the propaganda aim remains clear, the intention to mould the world nearer to heart's desire is manifest. For the environment touches man where it hurts—and it hurt Scheerbart deeply—so that the literature of the subject is very closely entangled indeed with practicalities. Much of that literature is of such quality and interest that it could probably stand being discussed in isolation as a separate branch of architectural writing, but to do so would be to deprive it of its reality. None of the chapters that follow is con-concerned solely with theory, none solely with practice. The words uttered, like the buildings erected, are exchanges in the close dialogue of technology and architecture, a dialogue that has become closer and more involved throughout the period covered by this book the period in which the possibility of a purely regenerative architecture has emerged for the first time in human history.

[5] see chapter 7 again.

9. Towards full control

As the progress of Le Corbusier's thinking shows, it would have been necessary to invent air-conditioning around 1930 had it not existed already. What makes the situation even more striking is that the development of the art of air-conditioning was itself reaching a point where its future growth seemed to demand a closer integration into the kind of building-design with which architects were normally concerned. For the history of air-conditioning is almost the classic example of a technology applied first in units of large capacity to industrial needs and to correct grossly deleterious atmospheric conditions, and then slowly sophisticated towards a condition where it could be subdivided and rendered subtle enough to handle domestic requirements.

The narrative of this process concerns, once again, the genial application of available scientific knowledge, or time-honoured rules of thumb, in piecemeal packets to piecemeal problems as they became apparent. But if this resembles the history of electric lighting in general outline, it is not dramatised by any single burst of concentrated systems-invention, such as Edison achieved, around 1880, nor is it ornamented by any personalities quite of Edison's quality. Willis Havilland Carrier has as good a right to be known as the father of his art, as Edison of his, but emerges from even the most eulogistic biographies as a man of more limited vision who, at least, began by evolving pragmatic solutions to *ad hoc* problems put in his way by other people. One might even, in an unsympathetic presentation, say that he did not recognise a problem until someone else offered him money to solve it. In his own words, 'I fish only for edible fish, and hunt only for edible game—even in the laboratory.'[1]

He seemed so content to solve problems as they were put to

[1] cited by Ingels, but already legendary.

him—often with startling ingenuity and depth of technical or intellectual resource—that one may doubt whether he had any general mental conception of the art he was founding until long after he had fathered it. The very words 'air-conditioning' are not his own, but were coined by his early competitor, Stuart W. Cramer, who used them more than once, in lectures and patent-documents, in 1904-1906. The Carrier Corporation, on the other hand, was still using phraseology like 'Man-made weather' as late as 1933, by which time the words 'air-conditioning' were general in the trade and were on the point of becoming part of common US usage—and had already appeared in the name of at least one of the numerous companies floated at various times around the personality and talents of Carrier himself.

Yet the phrase 'Man-made weather' is an admirable one, not only in describing the end product of the air-conditioning process, but because it also underlines the extent to which Carrier's mastery of the craft turned upon direct observation of the nature and performance of air as a component of outdoor weather. Thus his most crucial patent, dew-point control, for which application was filed in the *annus mirabilis* of this business, 1906, depended on a personal confrontation with the facts of fog, on a railroad station at Pittsburgh, late in 1902. According to Carrier's own account, recalled in old age, his response to air so laden with water droplets as to impede the sight, was:

> Here is air approximately 100% saturated with moisture. The temperature is low so, even though saturated, there is not much moisture. There could not be, at so low a temperature. Now, if I can saturate the air and control the temperature at saturation, I can get air with any amount of moisture I want in it.[2]

[2] Ingels, *Willis Carrier, Father of Air-Conditioning*, Garden City, 1952, p 15.

Such an observation cannot have failed to occur to others beside Carrier, once the mechanics of atmospheric humidity were understood, but by phrasing the matter in this way, he would almost automatically suggest a mechanism whereby that moisture could be controlled—to govern the absolute water vapour content of a body of air by holding it, in the presence of excess water, at the temperature at which the maximum of water vapour it could be made to hold was the same as the amount desired, and then to remove the excess water droplets and restore the air to the temperature at which it was required to be circulated. This, obviously, meant regulating the temperature of the air twice, once to achieve the correct dew-point conditions required to regulate the total water-content, and then once more, to restore (usually to a higher temperature) the correct thermal content for circulation. Where Carrier put his observations of the fog to the most crafty use was in devising a method of achieving the dew-point temperature that was so brilliant and so paradoxical that it occurred to none of his contemporaries (there seem to have been no competing patents) and is still incomprehensible to many people today. His account of the Pittsburgh vision continues:

> I can do it, too (*scil.*, 'get air with any amount of moisture I want.'), by drawing the air through a fine spray of water to create actual fog. By controlling the water temperature I can control the temperature at saturation. When very moist air is desired, I'll heat the water. When very dry air is desired, that is, air with a small amount of moisture, I'll use cold water to get low-temperature saturation. The cold-water spray will actually be the condensing surface. I certainly will get rid of the rusting difficulties that occur when using steel coils for condensing vapour in air. Water won't rust.[3]

[3] ibid.

A knowledge of normal high-school physics will confirm the propriety of Carrier's method, but common-sense still boggles at the realisation that, for most of the air-conditioning year in most of the climates where air-conditioning is necessary, Carrier was proposing to dry air by pumping it full of water—and this, not as a bench-top trick at a Christmas demonstration lecture, but as a commercial proposition, twenty-four hours a day. It did not become practical at once, however; some years of trial and error with types and dispositions of spray-nozzles, and with baffle-systems to remove unwanted air-borne droplets of water from the saturated air were required. But, in the end, by this technique and a variety of automatic controls (which were not all of Carrier invention) the human race was at last armed with a workably sophisticated device for controlling the most elusive of environmental discomforts—parched or humid air.

But one must emphasise that the human race possessed this long-awaited device only in very large packets, applicable for reasons of bulky plant and crude ducting chiefly to industrial needs. At the time that Carrier began his industrial career with the Buffalo Forge Company in 1902, the large body of experiment and innovating installation then proceeding in a largely unco-ordinated manner throughout the American (and, indeed, world) ventilating and heating industries was oriented almost entirely towards improvements in factory environments, because there alone were the problems big enough, and profitable enough, to bring the manufacturers of plant and its users together in situations where the economic advantage to both sides were clear enough. In other words, air-conditioning was a way of losing less, or making more, money. With one or two freakish exceptions concerning supreme legislative bodies (the British House of Commons in 1838) or chief executives (the dying President Garfield in 1881) who were deemed worthy of environmental aids beyond those awarded to ordinary mortals, industrial needs dominated: refrigeration and ventilation in ships, regulated hot air for drying tea, bulk cooling in breweries, dust-laying in tobacco factories, control of mould growth on celluloid, fibre-humidity in weaving, ventilation in mines. Ogden Doremus might rhetorically enquire, 'If they can cool dead hogs in Chicago, why not live bulls and bears on the New York Exchange?', but until it could be shown that profits on 'Change were sagging, no-one was going to consider the proposition.[4]

In many of the purely industrial applications, of course, human comfort was a lively consideration wherever profitability depended on the efficiency of the work-force—thus, the laying of tobacco dust made it possible for operatives of cigar rolling machines to

[4] in historical fact, Professor Doremus's rhetorical question was to be answered within a mere eleven years of its utterance, for Alfred Wolff installed some form of cooling plant in the Stock Exchange in 1904.

see what they were doing, and thus make fewer mistakes; the ventilation of mines made it possible for miners to stay alive by breathing in locations and situations where there was profitable coal to be worked, but natural ventilation could never reach. Even the Larkin Building would probably have shown less care for controlled ventilation had the external atmosphere been tolerable by the standards of the time—indeed, it has been argued that the avoidance of soiling of documents and fouling of office machinery by airborne smuts was the Larkin Company's main motive for accepting a sealed building. Even in the roughly air-conditioned Royal Victoria Hospital, Belfast, it was dire medical need, rather than thought for human comfort, that dictated the use of Plenum ventilation, and all that that entrained architecturally.

There were, in practice, few situations where simple human comfort offered a profit margin proportionally large enough to make investment worth while, and large enough in absolute terms too, to make investment possible, given the plant then available. Hotel dining-rooms and ball-rooms came within this class, as did Pullman cars and—above all—theatres. The concentration of large audiences in places of entertainment—where they will normally expect to be made comfortable as part of the service for which they have paid—has always posed extreme environmental problems. The form of the buildings commonly employed, where 'crowding due to the presence of galleries' had the same effect as Professor Jacob had observed in Non-conformist chapels, and the need to make them reasonably proof against external noise and other distractions, produced a situation of congestion and enclosure where the heat from the bodies of the audience was more than sufficient to maintain normal room temperatures. Thus it became the custom of the trade during the period 1920–1950 when cinemas were normally full (or nearly so) from around mid-day to late evening, to turn off the heating altogether about two hours after opening, except in very severe winters.

In warmer, Southern climates, the body heat load commonly became an embarrassment or even a hazard. The prevalence of fainting in the audiences certainly had more than purely dramatic causes, and the use of the fan was often as much an environmental necessity as an aid to flirtatious communication. With such a heat load, the chemical vitiation of the air became an even greater burden, but it would have been bad enough without the thermal hazard—some of the nineteenth-century's most spectacular concentrations of carbon dioxide were recorded in the pits of theatres. Nineteenth-century environmental engineers had made a start on these problems long before air-conditioning was even contemplated, of course—large public buildings with auditoria, like the Free Trade Hall, Manchester, or council chambers, as in Leeds Town Hall, were often provided with large thermal syphon extract ducts, powered by braziers or heating coils at their bottoms. In cases like Cuthbert Broderick's design at Leeds, these ducts could emerge above cornice level in bulk large enough to rival the intentional features of 'art architecture' and demand equally artistic detailing as a consequence.

But the availability of large-capacity fans toward the end of the century brought these hazards in sight of solution. Professor Jacob, as usual, gives a reliable survey of the state of the art at the time of his writing, and draws particular attention to two cases:

> The arrangements for the heating and ventilation of the Vienna Opera House are singularly complete. They were designed by Dr Bohm, the medical director of the Hospital Rudolfstiftung. There are two fans, one for propulsion, the other for exhaust. The air is heated by steam coils, and is admitted by the floor and through the risers of the seats. Each gallery and compartment, including the stage, has its own independent supply and means of heating . . . Air is admitted to a basement chamber, into which, in summer, sprays of water are introduced; it is then driven over the steam piping and on into a mixing chamber . . .
>
> Very similar arrangements are found in the Metropolitan Opera House, New York; but there is but one fan, and that is used on the 'plenum' system . . . to avoid draughts from the doors, which are so usual in theatres ventilated on the exhaust principle.[5]

[5] Jacob, *Notes* . . . etc., p 93.

Jacob also cites the case of the Madison Square Theatre in New York, as do other writers, because its Sturtevant fan-system, from 1880 onwards, had provision for blocks of ice to be stood in the intakes to cool the air, and could consume up to four tons of ice per night in summer.

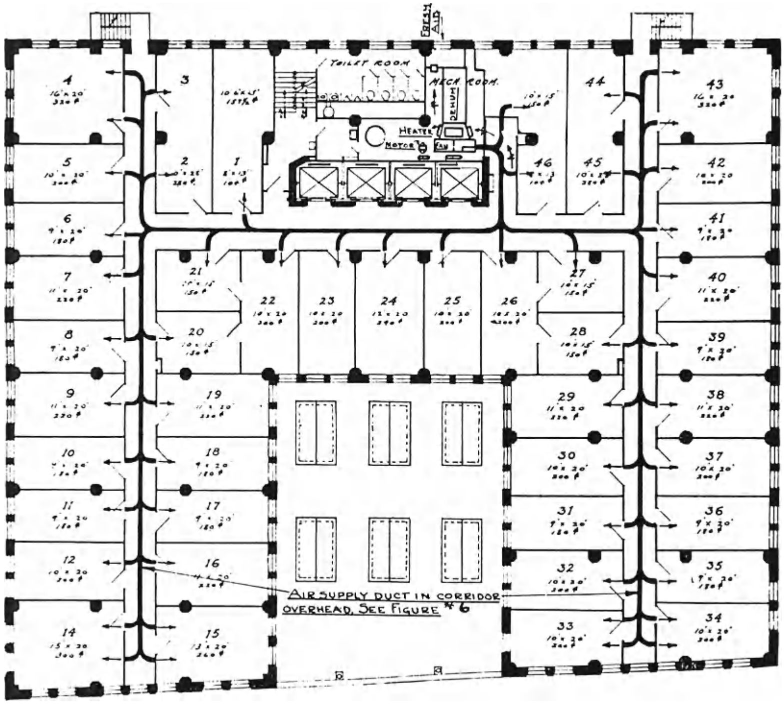
Such cooling techniques could be capricious, of course; according to ambient circumstances, the input air might pick up moisture from the ice by evaporation, or lose it by condensation on the ice surface. Though the probability would normally be that these effects would have the right tendency—that hot dry air would pick up humidity, and hot humid air would, with luck, shed some—the system was not reliable enough to compensate for its cumbersome bulk, messy operation, impossibility of automatic control and constant demand for labour. Air-conditioning looked a more attractive proposition on all of these counts, and was bound to come in as soon as it was mechanically practicable. There appears to be some room for argument about which was the first of such 'theatre comfort jobs' but Margaret Ingels in her life of Carrier, awards the palm to Graumann's Metropolitan in Los Angeles, a Carrier installation with Carbondale refrigerating plant, of 1922.

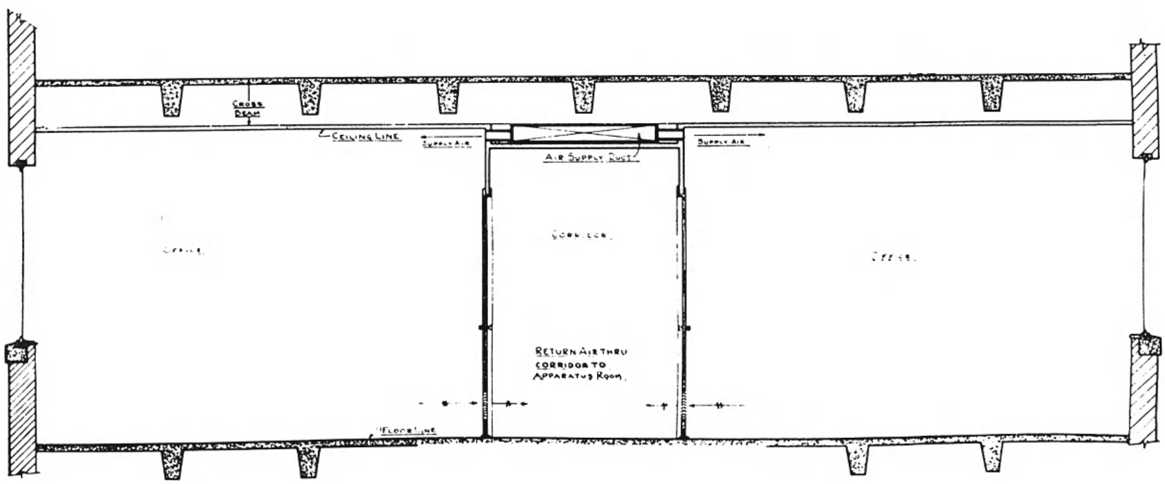
The Graumann's installation, and the numerous other theatre and cinema comfort jobs which followed, all effectively reversed the ventilating proposition discussed in the quotation from Jacob, above. Whereas schemes such as Bohm's at the Vienna Opera had tended to use the space under the ramped seating as a distribution volume for the input air, which entered the auditorium under the seats, the new comfort jobs reversed the flow, bringing air in through diffusers overhead at low velocity, whence it settled in a cooled blanket gently over the whole auditorium, to be extracted through grilles in the risers under the seats. Given the fact that in most auditoria, cooling is a far greater problem than heating, and that this arrangement gives the preferred 'cool-head/warm feet' stratification, overhead input and under-seat extract is now almost a world standard. Most commercial theatres also developed, at an early date, the habit of deliberately spilling some of their conditioned air out of the foyer on to the side-walk, thus offering tangible proof that it was, indeed, 'cooler inside.'

The movie industry thus introduced the general public to the improved atmospheric environment, as well as the improved luminous environment which will be discussed in the next chapter. But could any members of that public enjoy that same improved environment at home, or even at work? Well before the end of the twenties it was clear that anyone who could reduce air-conditioning to an office-block scale, let alone a domestic one, had a bright commercial future. Traditionally, the earliest fully air-conditioned office block is taken to be the Milam Building in San Antonio, Texas, of 1928; architect, George Willis, and engineer, M. L. Diver. In spite of its uninspiring exterior, it was an innovating building on many counts—for instance it was among the first concrete-framed skyscrapers and, at twenty-one storeys, the tallest multi-storey concrete framed structure in the world at the time.

Its air-conditioning method was simple in general conception, though complex in application.[6] A common refrigerating source in the basement supplied, firstly, an air conditioning plant for the main public rooms on the lower floors, and secondly, a set of standardised smaller plants for the standardised office floors. These sets of machinery were distributed at the rate of one to every two floors, near enough, throughout the height of the block, and were located between the toilets and elevators at the back of the floor-plan: each set supplied conditioned air to two floors through ductwork in the furred spaces above the ceilings of the central corridors, and the corridors themselves served as the return ducts, exit grilles from the rooms being provided in the doors. This effected a reasonable and economic compromise between the unavoidable necessity of working with fairly large units of plant, and subdivision of their output without consuming too much rentable floor space with large vertical ductwork.

[6] there is a useful description of the building in *Heating, Piping and Air-Conditioning*, July 1927, pp 173*ff*.





Milam Building, San Antonio, Texas, 1928, by George Willis; facing page: exterior view; left: plan of typical floor and below, section of standard duct and corridor arrangement.

In such situations where commercial practicability was both the initial motivation and the ultimate veto, the consumption of floor-space by duct-work was a life-or-death consideration, since even the comforts of air-conditioning were rarely attractive enough for the rental to be elevated to the point where the loss of square-footage was offset. Carrier's solution—and ultimately everybody else's—was to distribute filtered and moisture-controlled air at high velocity through small diameter ducts, and heat it or cool it at the point of delivery under the windows of the offices by means of pipe-coils warmed or chilled by water supplied on a separate network. Also at the point of delivery, the unwelcome side-effects (noise, draught, etc.) of high-velocity distribution were tamed by using injector nozzle systems to make the conditioned air draw considerably more than its own bulk of room air through the casing of the unit, the mixture of new and locally recirculating air emerging quietly and at unobjectionable speed as a curtain in front of the window glass.

The embryo of this concept, and some of its essential parts, already existed in the board-room installation at the Lyle Corporation offices in 1929, to which reference was made in the last chapter, but it was not yet a sufficiently workable proposition to be used by Carrier in the Philadelphia Savings Fund building of 1932 (see next chapter). The full 'Conduit Weathermaster' installation as a standard kit did not exist until 1937, but something very like it can already be seen in the illustrations to an article, *Preliminary Planning for Air-Conditioning in the Design of Modern Buildings*, by two Carrier employees, Realto Cherne and Chester Nelson, which appeared in *Architectural Record* in 1934. But the importance of the article as an historical marker goes well beyond this point: the illustration shows, unmistakably, an office block divided up into small room-units, not a large single industrial or theatrical volume; the text says, 'This discussion will be limited to air-conditioning for comfort . . .',[7] and the whole represents the earliest ascertainable occasion on which air-conditioning appears

[7] *Architectural Record*, June 1934, pp 538*ff*.

to have been discussed at the level of the kind of conventional professional wisdom that is embodied in architectural check-lists.

The emphasis in air-conditioning had clearly changed; but for the tide of recession and economic collapse that swept North America, the use of air-conditioning in large, multi-celled buildings would probably have become established before the thirties were over. As it turned out, however, the rate of progress was slow, and the expensive installations at Radio City that so impressed Le Corbusier were without significant rivals after 1932. In some ways, it may be argued, this delay may have benefited both architecture and air-conditioning. With the Second World War following even before economic activity was fully recovered from the Slump, a total of more than a decade was amputated from the expected growth of air-conditioning. Real progress was not fully resumed until after the end of the forties, by which time the mechanical possibilities for office-block air-conditioning had been reinforced by a new technical aid in the field of lighting, and a new set of aesthetic preferences in the design of building envelopes.

The innovation in lighting was the fluorescent tube, which, with its relation the gas-discharge tube, had existed as a potentiality since the beginning of the century. Claude, in France, and Moore, in England, had produced workable discharge tubes at an early date—Moore tubes had been used to outline the façade of the West-End Cinema in London in 1913, and Claude's favoured discharge-gas—Neon—had added a new word to the language before 1930. But it took from Edison's 1896 experiments with fluorescent bulbs until the simultaneous announcement by Westinghouse and GEC of their 'Lumiline' tube in the summer of 1938, to get the fluorescent tube into the catalogue and onto the market.

To the world at large, and in the minds of architects, the fluorescent tube was essentially a post-War innovation, and was prized primarily for its economy of current and its lack of concentrated glare. But even in the first Lumiline announcement, the relevance of the fluorescent tube's diminished heat output to problems of air-conditioning was mentioned. And in any case, the use of fluorescent lighting was soon to generate new glare problems when it was employed in even and continuous grids over office ceilings as a source of PSALI in areas too remote from the perimeter windows of the block to receive much usable daylight. But such use of PSALI (Permanent Supplementary Artificial Lighting of Interiors) at the core of very deep floor-plans could never have come about without the neat confluence of the potentials of air-conditioning and fluorescent light. The heat output of enough incandescents to give a tolerable level of illumination for paper-work would have been more than any ventilating system could economically have swept out. But with a diminished heat output, air-conditioning could cope economically, and once this was possible it also became possible to make a long overdue rationalisation of the standard US office tower's plan-form.

Traditionally, it had always exhibited a notch or re-entrant in the back (Europeans will probably know it best from the plan of Holabird and Roche's Marquette building which is so often illustrated in accounts of the Chicago School) and this re-entrant served to bring light (and ventilating air) to the centre of the block, including its ancillaries, such as toilets and elevator shafts, as well as rentable office areas. But a plan bitten into in this way was more difficult to subdivide and contained more awkward corners that were difficult to let, than would the plain rectangle of what was to be called the 'full-floor' type of plan, with its ancillaries islanded in the centre—a possibility that existed, profitably, only with air-conditioning and low-heat lighting. Given these, however, it was calculated by a Chicago real-estate man, George R. Bailey, that

> Full-floor development can be produced, complete with air-conditioning, fluorescent lighting and acoustic ceilings, for only about 8% more than a standard floor (i.e., with notchback) without air-conditioning and with only ordinary lighting.[8]

[8] *Heating, Piping* . . . etc., September 1949, p 72.

His calculus was timely—not only was the clear, well-serviced rectangular floor plan attractive enough for its rents to absorb that extra eight per cent, but architects had by now more or less unanimously decided that their post-War skyscraper dreams were going to be realised in a starkly rectangular aesthetic. Both the United Nations building and Lever House were in design and construction at the time Bailey's results were published, and though both were prestige buildings which, for differing reasons, could support 'uneconomical' standards of servicing, the innumerable rectangular glass slabs which appeared in their imitation soon showed that such a format, and its necessary standard of servicing was not at all uneconomic—or, at any rate, not unprofitable. Le Corbusier's vision of the Cartesian glass prism of the slab skyscraper, and Carrier's practical technology for solving any environmental problem that offered an honest dollar had met, literally, in the UN building, and the face of the urban world has been altered.

But, even at that date, the interior of the domestic dwelling was still virtually unmarked by these upheavals of environmental technology—air conditioning was just beginning to find its way into the home in 1950. The story of its arrival had been a long and—for the trade—frustrating one. The ultimate historical reasons probably lie in the peculiarity of the industry itself, and the kind of men who led it. Men like Carrier, even when employed by commercial concerns, usually worked for companies that produced only part of the total kit needed for air-conditioning—the fans, or the refrigerating plant—and saw air-conditioning primarily as a means of promoting the parent company's sales. Almost like independent consultants, they assembled the total plant from the wares of several manufacturers, often by separate competitive tenderings. Nobody in the earlier stages appears to have manufactured, or even offered to sell, a complete installation as a pre-assembled package. The elements of the kit were distributed, according to private lores and mysteries of consultancy and subcontracting, within the interstices of the building-structure, and the layman therefore had difficulty in identifying air-conditioning plant as a commodity or recognisable service such as he might be able to install in some convenient space in his own home.

What made this situation the more frustrating for the trade's visionaries and opinion-makers was that such convenient spaces existed almost universally throughout North America, in the common house-basement, and that those spaces already contained testimony of the wide-distribution of the skills needed to install air-conditioning, in the shape of the ductwork taking hot air from the furnace to the various rooms—indeed, these ducts would often have served well enough for conditioned air as they stood. Even a small opening into this promising market could, like office-block installations, have helped the industry round the awkward corners of the Slump. A rousing editorial in the Chicago magazine, *The Aerologist* during the summer of 1931 coined the splendid slogan: *Wanted, an Air-Conditioning Flivver!*, and called for

> . . . an air-conditioning unit for the home, efficient, moderately priced and relatively fool-proof . . .
>
> Its production on a quantity basis by modern manufacturing methods would soon make air-conditioning more of a necessity than the radio or even the automobile, and its acceptance in the home would soon force its general adoption on a grander scale in practically every other building and conveyance used by man.[9]

[9] *Aerologist*, August 1931, front-cover editorial. Published in Chicago in the twenties and thirties, *Aerologist* was one of the few publications concerned with the general atmospheric good of the human race, not with narrowly technical or hygienic aspects of the topic.

Effectively, history was to run in the opposite direction—effectively 'every other building and conveyance' would be air-conditioned before there would emerge a domestic air-conditioner as ubiquitous as the family flivver, and the process was ultimately to take almost two full decades from the publication of the *Aerologist* editorial. In the mean time, there were to be isolated and expensive installations in luxury homes, some, indeed before 1930, such as those in the Chicago area by the redoubtable Samuel R. Lewis. The General Electric Company installed an experimental room cooler for evaluation in Carrier's own house in 1929. There followed a flurry of interest in room cooler units, though most of them, unlike the example just cited, were not self-contained but serviced by a refrigeration plant somewhere else, usually in the basement.

Carrier, by now involved willy-nilly in manufacturing, *via* his Standard Products division, had an 'Atmospheric Cabinet' room cooler on the market by 1932, but this was still too bulky a block of equipment to recommend itself as domestic furniture. Most of the central-station units intended to service the house through ductwork from the basement were even more cumbersome. Even in the flattering light of carefully air-brushed advertisements of the mid-thirties, they are seen still to be *ad hoc* assemblies of the needed units, mounted—sometimes—on a common base and grudgingly wrapped in characteristic examples of industrial stylists' case-work of the period—though the Trane Company appear to have despised even this minimal concession to domesticity and continued to glory in a Boilermakers' Aesthetic of pipe-elbows and exposed valves. And they were bulky, commonly occupying a near cube of about six feet by six feet by six feet, heavy to match and costing more than $2000 in some cases. These figures alone would have made them an unattractive domestic proposition for the mass market, even had they been more fool-proof and more nearly self-regulating than they were. Ten years after the *Aerologist* had formulated the need, the Flivver had still to materialise, and the US went to war without any domestic air-conditioning to return to[10].

But there was not long to wait after the War. As usual, hostilities had stimulated the rate of invention and technological development, to the point of precipitating some minor technical revolutions, not all of which had any relevance to air-conditioning as they stood, but all tending to point the way towards a radical miniaturisation of the equipment involved. The cumulative effect of miniaturisation and other improvements was to be suddenly sensational around 1950. Writing with the slightly dazed air of someone who cannot quite believe his eyes, Arthur Carson observed in 1954:

> Research that started in 1946 hit the production line with its discoveries in 1951, when mass-produced home air-conditioning units appeared on

[10] Professor Condit has suggested to me that the slowdown of the progress (and miniaturisation) of air-conditioning in the 1930's may not have been as total as I have suggested, because of the continuing installation and improvement of railway air-conditioning in the US. By 1936 all lounge, dining and sleeping cars on major long distance trains in the US were air-conditioned.

McQuay Company, packaged air conditioners, 1948.

> the market in every shape and form. In 1952 dealers sold out \$250,000,000 worth of equipment and had to turn away 100,000 customers. That year there were only 20 companies in the field; now there are more than 70, with the original 20 multiplying their 1952 output by 400–500%.[11]

Carson perhaps may be faulted on his starting dates, since some of this research appears to have hit the production line earlier than he suggests—both the McQuay Company, and General Electric, seem to have had the kind of air-conditioning pack he is describing in their catalogues in 1948, and there are some doubtful cases as early as 1946. One says 'doubtful cases' because the kind of air-conditioning unit that Carson is discussing is quite specific but not at all what the editorial in the *Aerologist* had anticipated. What had finally wrought the revolution and brought in the air conditioning Flivver was not a central station system servicing the house through ducts, it was not a room-cooler with a remote refrigeration plant, it was not a compound unit like Carrier's Weathermasters. It was a simple, self-contained box, needing connection only to an electrical outlet; it could usually be lifted by one man, or two if

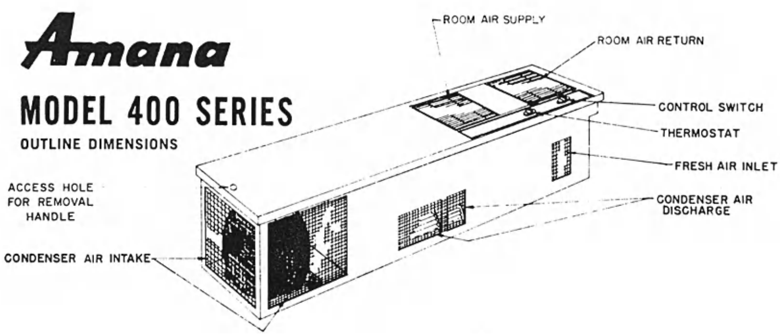
[11] Carson, *How to Keep Cool*, New York, 1954, p 56.

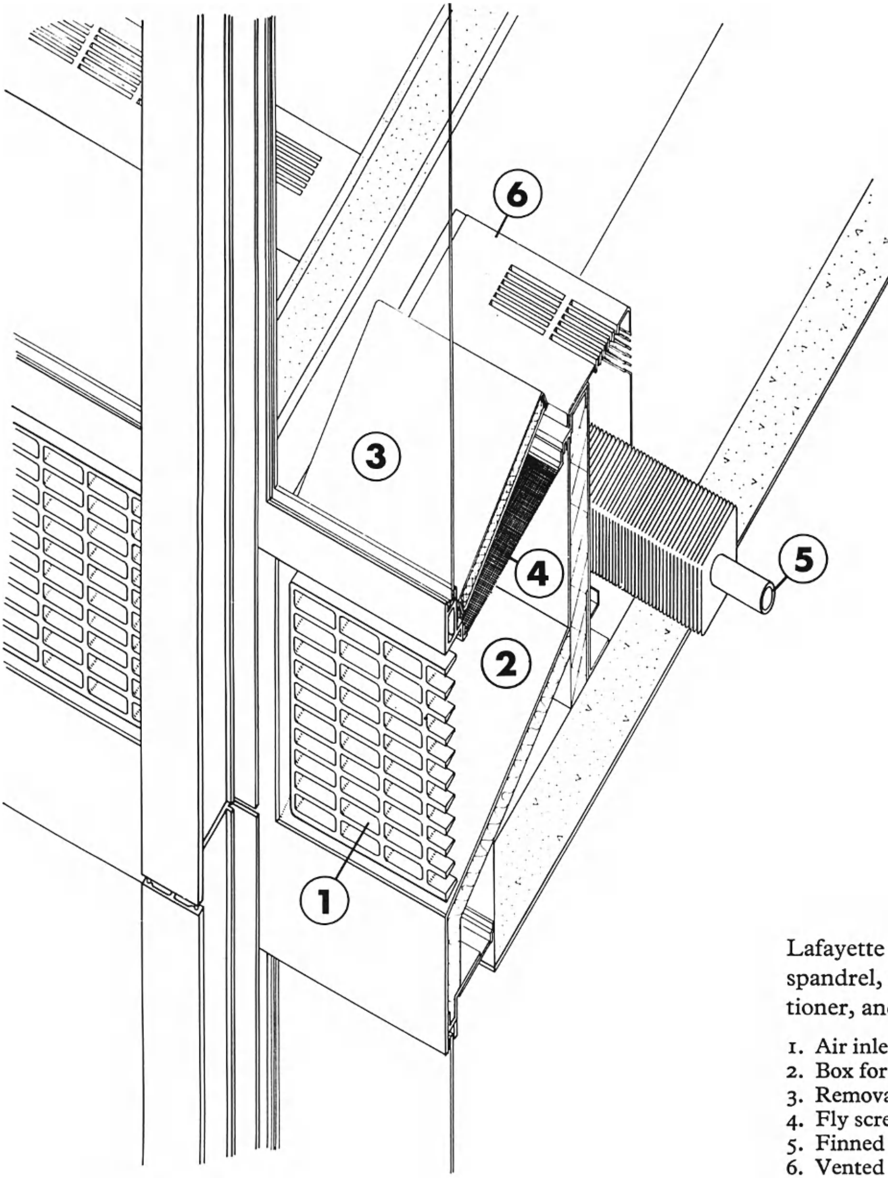
unusually large; its bulk might not be more than two or three cubic feet; and it provided full and complete air conditioning, with the possible exception of winter humidifying which is rarely needed anyhow. What makes some of the early units 'doubtful cases' is that it is not now certain how full a conditioning service they offered, but what Carson is talking about is a self-contained unit that can be installed in a hole in the wall or an opened window, plugged in to the electrical main, and can deliver genuine air-conditioning.

That is all the installation it gets in many cases, rested on a window-sill and the sash closed on top of it—many models nowadays come ready with flaps or fitted plates to block off the residual width of the window opening. Although domestic air-conditioning of the sort Carrier had envisaged, from a central station using ductwork in common with the winter heating, has also proliferated, it has done so in the wake of the self-contained window unit, which has finally made air-conditioning comprehensible as domestic equipment comparable with the cooker, the refrigerator and the television set—a neat box with control knobs and a mains connection. However one regards this device, it is a portent in the history of architecture.

Firstly, by providing almost total control of the atmospheric variables of temperature, humidity and purity, it has demolished almost all the environmental constraints on design that have survived the other great breakthrough, electric lighting. For anyone who is prepared to foot the consequent bill for power consumed, it is now possible to live in almost any type or form of house one likes to name in any region of the world that takes the fancy. Given this convenient climatic package one may live under low ceilings in the humid tropics, behind thin walls in the arctic and under uninsulated roofs in the desert. All precepts for climatic compensation through structure and form are rendered obsolete—though as James Marston Fitch (and others) have hastened to point out, any consideration of economy in the use of air-conditioning brings the

Lafayette Park apartments, Detroit, Mich., 1961, by Mies van der Rohe; left: exterior of blocks; below: specially developed air-conditioner package to fit under window.





Lafayette Park: cut-away of spandrel, box for air-conditioner, and heating pipes.

1. Air inlet grille
2. Box for optional air conditioner
3. Removable lid
4. Fly screen
5. Finned heating pipe
6. Vented heater casing

time-honoured usages of local tradition back with even greater force.

Nevertheless, the possibility of absolute variety and infinite choice of building form is now with us—and as so often happens with infinite choices, has led to almost perfect homogenisation of what is chosen. In the United States, air-conditioning has now made the established lightweight tract-developers' house habitable throughout the nation, and since this is the house that the US building industry is geared to produce above all others, it is now endemic from Maine to California, Seattle to Miami, from the Rockies to the bayous. Not without reason; the normative American house that Catherine Beecher saw evolving out of the normative US way of life that grew from the increasingly mechanised farming of the middle-west, probably answers to the understood aims and usages of the people who inhabit it quite as well as any localised vernacular house of the Old World suits its tradition-bound inhabitants. The house type was already widespread and still spreading long before air conditioning came along to wipe out its surviving deficiencies, and much of its adaptation to increasingly specialised climatic conditions was the work of tenants and owner-occupiers who fitted packaged air-conditioning to their own homes with their own hands in their spare time.

For this, secondly, may prove to be the most portentous aspect of air-conditioning, that, in the domestic package, it offers the most sophisticated device for environmental management that mankind has ever possessed, in a form that needs little skill to install, and even less to operate. Any normally intelligent householder can install one with normal household tools and many have done so. As far as the little houses of suburbia are concerned, this poses no great visual or architectural problems—the evergreens have already grown up in front of the units, and they are not seen. But in the apartment blocks of cities, such installations can bring the environmental improvements of the householder into direct conflict with the visual intentions of the architect. For every act of

intelligently permissive vision, like that of Mies van der Rohe at the Lafayette Park apartments in Detroit, where a characteristically well-detailed under-window box offers the householder choice between controlled natural ventilation and the installation of an optional air-conditioner purpose-designed to drop into the box, there are too many designs where conflict seems inevitable.

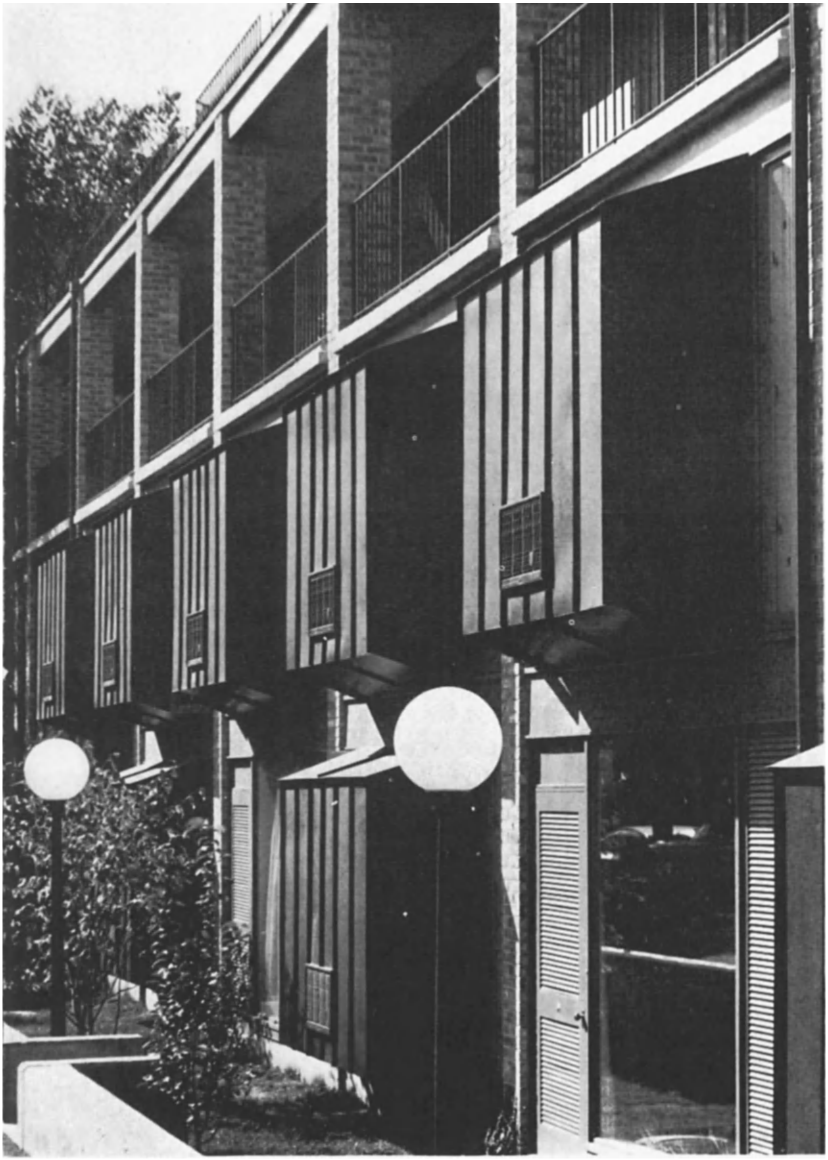
Kips Bay Apartments, New York, 1961, by I. M. Pei Associates; southern façade showing privately installed air-conditioners.

A conspicuous case is that of the Kips Bay Apartments in New York, designed by I. M. Pei and Associates. Since this is a scheme of 1959–61 the absence of provision for air-conditioning is not altogether easy to understand, though the determination of the tenants to fit it, especially to rooms on the south faces of the blocks, is entirely comprehensible. In order to preserve Pei's façade patterns, the managing company is reputed to have insisted that

Row-houses, Eugenie Lane, Chicago, Ill., 1963, by Harry Weese; above and facing page: rear elevation showing air-conditioners in projecting cupboard units.

tenants should install their conditioner packages, not in the spandrels under the windows, but back inside the room and connect them to the outside air with a flexible duct. Since, however, the environmental performance of almost every domestic air-conditioner depends on its being able to dump its surplus heat and moisture directly into the outside atmosphere (as any one will know who has been wept on by air-conditioners in the streets of New York) this hopeful proposition has not proven successful, and most of the tenants have their units back in the spandrels under the window—in a random pattern all over the façade that is not unattractive.

Although many architect-designed buildings are now beginning to make their peace with the seemingly inevitable eruption of room-conditioners on their façades, few have set out to exploit the neat visual detailing of their intake grilles, nor the convenience for interchangeability of their easy installation and removal. A rightly-noticed exception to this indifference is seen in the terrace of row-houses in the Old Town area of Chicago, designed by Harry Weese in 1963. There, the conditioner grilles form rather delicate visual accents on the outer faces of projecting cupboard units that occupy several bays of the frame on the back of the terrace, while the non-structural nature of these projecting cupboard-backs



should make them—as the *Architectural Review*[12] observed—'relatively simple to alter when the air-conditioners have been overtaken by the normal processes of technological obsolescence.'

Unfortunately, this terrace on Eugenie Lane is notable chiefly because it is an exception to the general failure of architects to make provision for this piece of equipment which is rapidly becoming as normal as the kitchen sink. And unfortunately again, this failure of provision does not, in residential work, produce even the accidentally picturesque disorder that often arises from the air-conditioning of standard US single-storey commercial structures, where below eaves level, one is confronted with an orgy of eclectic modernistic details often reaching extremes of uninhibited fantasy and above the eaves the air-conditioning plant is a free composition of geometrical solids of the sort that used to be the common stock in trade of the Purists and Functionalists of the twenties. One seems to see ghosts of the restrained and abstract International Style hovering above the exuberance of the current pop-art version of the American high-life which Oud discovered in the work of Frank Lloyd Wright. Except that what is above the eaves does not represent a conscious attempt at an idealised Machine Aesthetic, but is the outward form of the kit environmentally needed to make the high-life of supermarket-America possible.

[12] *Architectural Review*, May 1964, p 311.