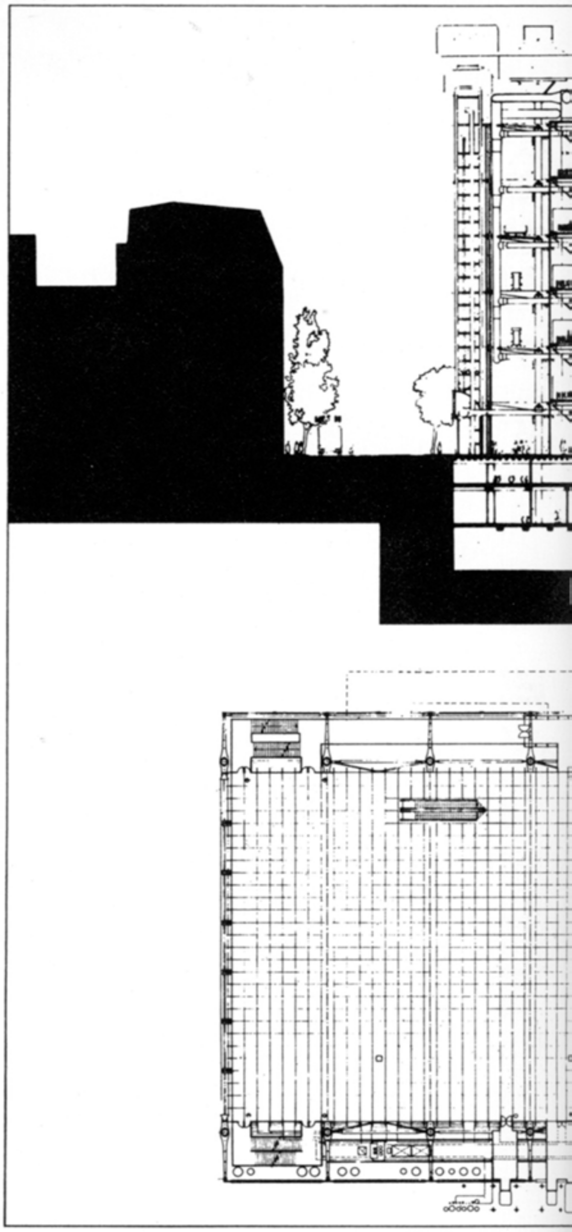
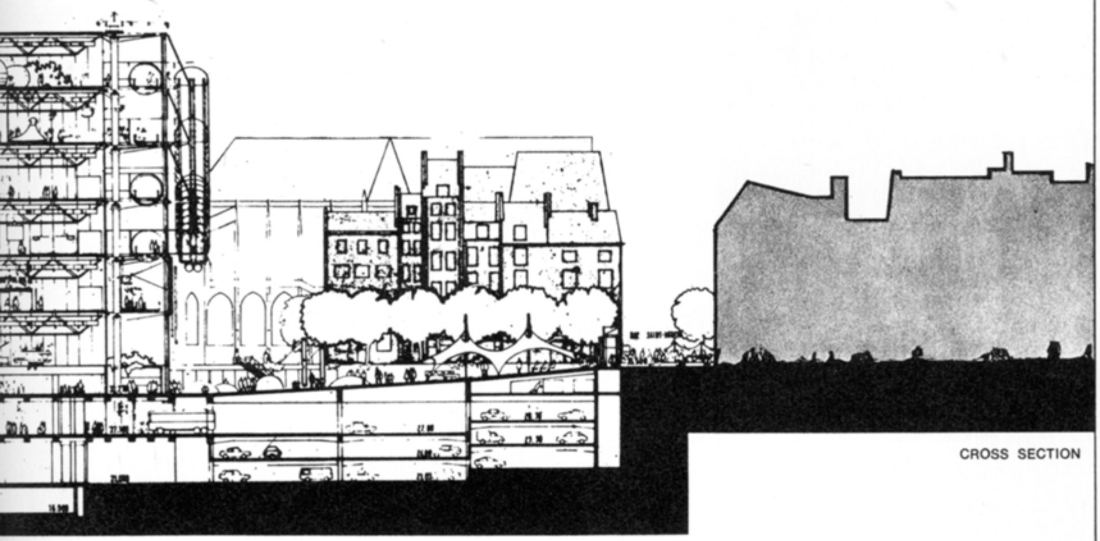
Beaubourg was designed to be a live activity center, entertaining and informing the art historian, tourist, and neighboring Parisian, a place where all could participate in an urban, highly serviced machine, fluid and flexible, easy to change in response to changing needs. It was not to be a closed institution for the haves, but a place where activities are encouraged to overlap from street theater to the world's most refined acoustical laboratory. It was our belief that the more activities overlapped and enriched each other, the more likely it would be that exciting things would happen, opening up possibilities outside the normal confines of a cultural institution; the greater the public involvement, the greater the success.

The Design Concept

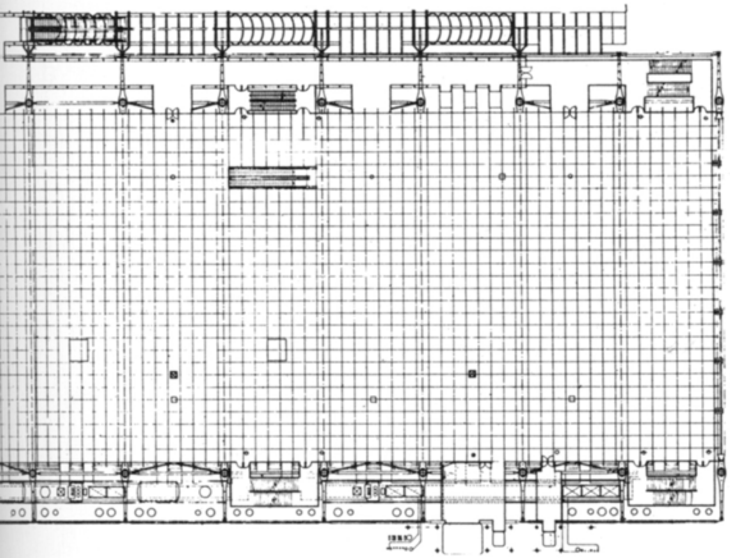
An architecture of possibilities is rooted in the constant of change. For in the dynamic and changing society in which we live, it is impossible to freeze time. Conceived as a flexible container capable of continuously adapting not only in plan, but also in section and elevation to whatever needs should arise, Plateau Beaubourg is an inside-out building. The 25-foot (7.5-meter) thick exterior structural wall zone houses the servicing entrails, movement galleries, and audiovisual information, while forming the structural cage which supports the five trays of column-free loft space. In addition to totally inverting the traditional notion of facade, it affords a technical simplicity by allowing components to be easily adapted, clipped-on, or removed. Beaubourg, constructed completely from prefabricated dry elements, becomes in essence a gigantic ever-changing erector set, as opposed to the more common doll's house with its precious, cosmetic, nonadditive, tailor-made detailing and its inherent lack of freedom and choice. The aim is to create a loose changeable framework with the economic precision of a watch mechanism in which people can freely participate. Their ever-changing activities both inside and outside the building give the construction a dynamic life, replacing the traditional static elevation, so that the building becomes the framework for live performances and not a cosmetic straightjacket. While the history of much of the modern movement has been one of flirtation with technology, it has always been somewhat superficial. We are trying to fully develop the theories of the pioneers, of such people as Wachsmann, Fuller, and Wright.

Flexibility is best illustrated in the partitioning system. Every partition is movable; the



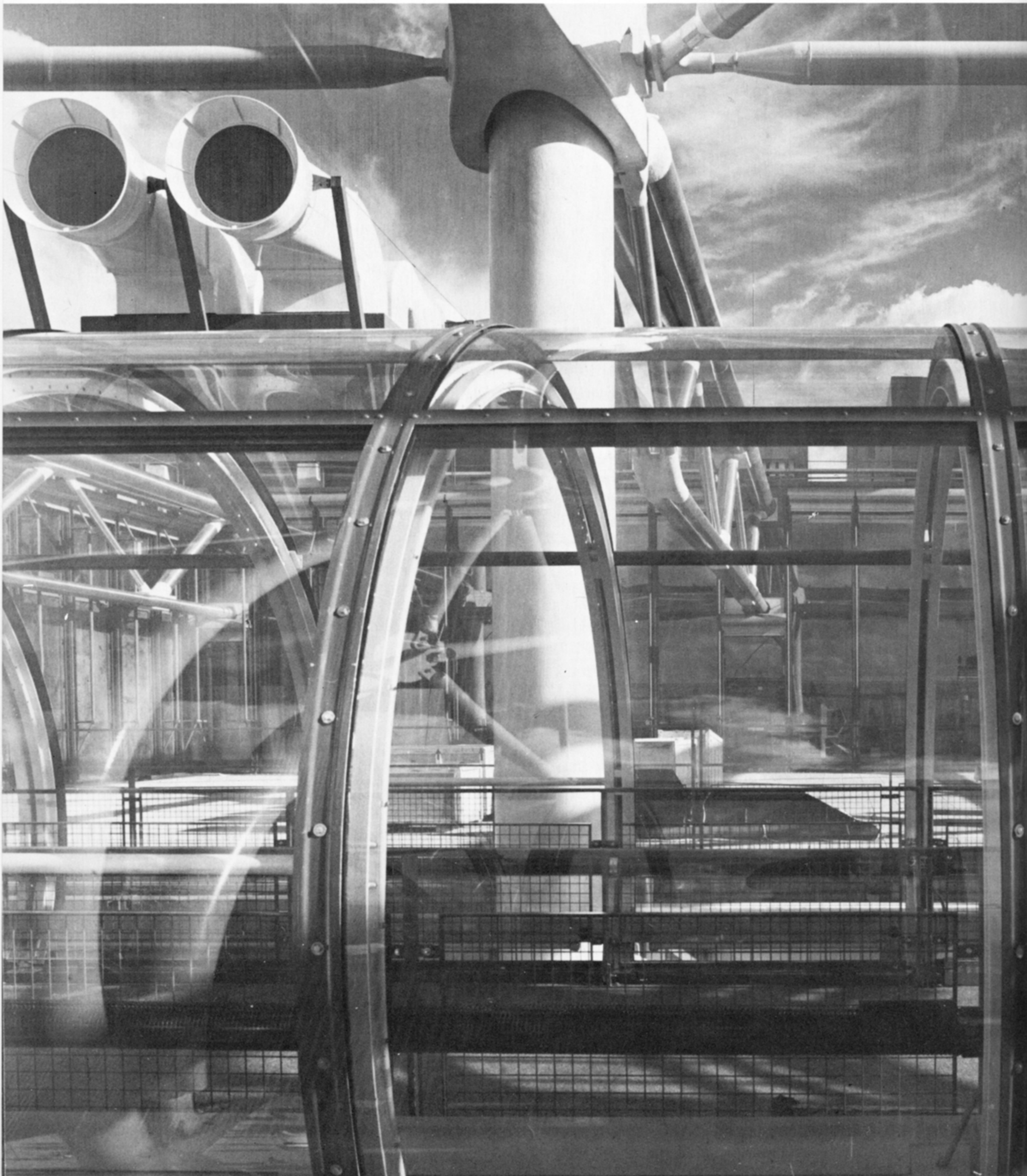


CROSS SECTION



TYPICAL FLOOR PLAN

Beaubourg is a colossal cultural emporium, part British Museum, part Times Square, containing the normally disparate activities of a modern art museum, national reference library, industrial design center, and music/acoustic research facility. Rather than splitting the building into four watertight compartments, the Centre is a well-serviced shed consisting of five superimposed uniform spaces supported externally by a free-standing structural frame, the whole capable of change in plan, section, and elevation so as to accommodate the unforseen.



Bürolandschaft office dividers can be shifted in a couple of minutes, the larger suspended museum partitions may take an hour, and the fire walls could require a day to unbolt. Even the facade is movable as it is free of the vertical structure. Should the situation require a more radical response, it is possible to completely gut the building down to the structure and begin over again.

There is another kind of flexibility in the building which is considerably more sophisticated and complex. It is most clearly shown in the Institute for Research and Coordination in Acoustics and Music, or IRCAM, which comprises one quarter of the program, the quarter located beneath the plaza. Here not only do the different studio types afford a complete range of volumetric options on which are superimposed a plethora of acoustical panels, but the largest studio/concert hall is designed to be continuously variable in both volume and acoustical qualities. Like the other studios, it has an acoustical chamber of double box construction; the outer shell is concrete and belongs to the primary structure, while the inner concrete box is isolated from it by soft rubber antivibration mounts. Little in the inner box is fixed, allowing the studio/concert hall ceiling to be split into three sections, each capable of moving 35 feet (11 meters) up or down; the resulting lateral gaps are filled in with acoustical curtains.

Each of the 180 motor-driven prismatic wall panels can be shifted into any one of seven possible positions. The floor is completely free and of platform construction (which is like a suspended ceiling except on the floor). The sound and light systems are highly sophisticated, enabling infinite configurations. Access to any part of the space is by ladders mounted on rolling transverse beams. Any combination of any parts is recorded on a computer so that it can be recalled at will.

Flexibility should be communicated by the legibility of a building. The people who are going to inhabit the space ought to be able to understand what is happening there and get some clues as to what they can do. One is constantly seeking universal rules so that one's design decisions do not stem purely from arbitrary preferences. To clarify the performance of the parts, we tend to separate their functions so that each part is no larger than absolutely necessary to do its work and plays a single role. Tension chords become the thinnest of solids, compression members are steel tubes; the differing diameters describe the various loads each member must carry. Each element is taken fully to its highest potential by the use of the most scientific means available. Likewise, every joint is univalent, articulated to enable easy erection and dissembling. To allow for control of quality,

Each part plays a single role and is optimally sized to perform its particular function. Every component and every joint is expressed.

Top: Every geberette is designed to support the cradle, containing the movement galleries and escalators, which screws into the socket at the small end. Where no cradle is carried, the end is capped.

Bottom: After casting, the geberettes are inspected for flaws in the factory. Because of the size and complexity of the casting, it was a new venture for the building industry.

cost, speed of erection, in addition to future change, industrial materials manufactured in controlled conditions are fully exploited. The building is truly a vast assemblage, a full-scale erector set—a concept which offers the design team a clear set of criteria for every detail and every connection. The architecture of Beaubourg becomes an expression of the process of building: the optimization of every single element, its system of manufacture, storage, transportation, erection, and maintenance all within a clearly defined and rational framework.

The Development of the Structure

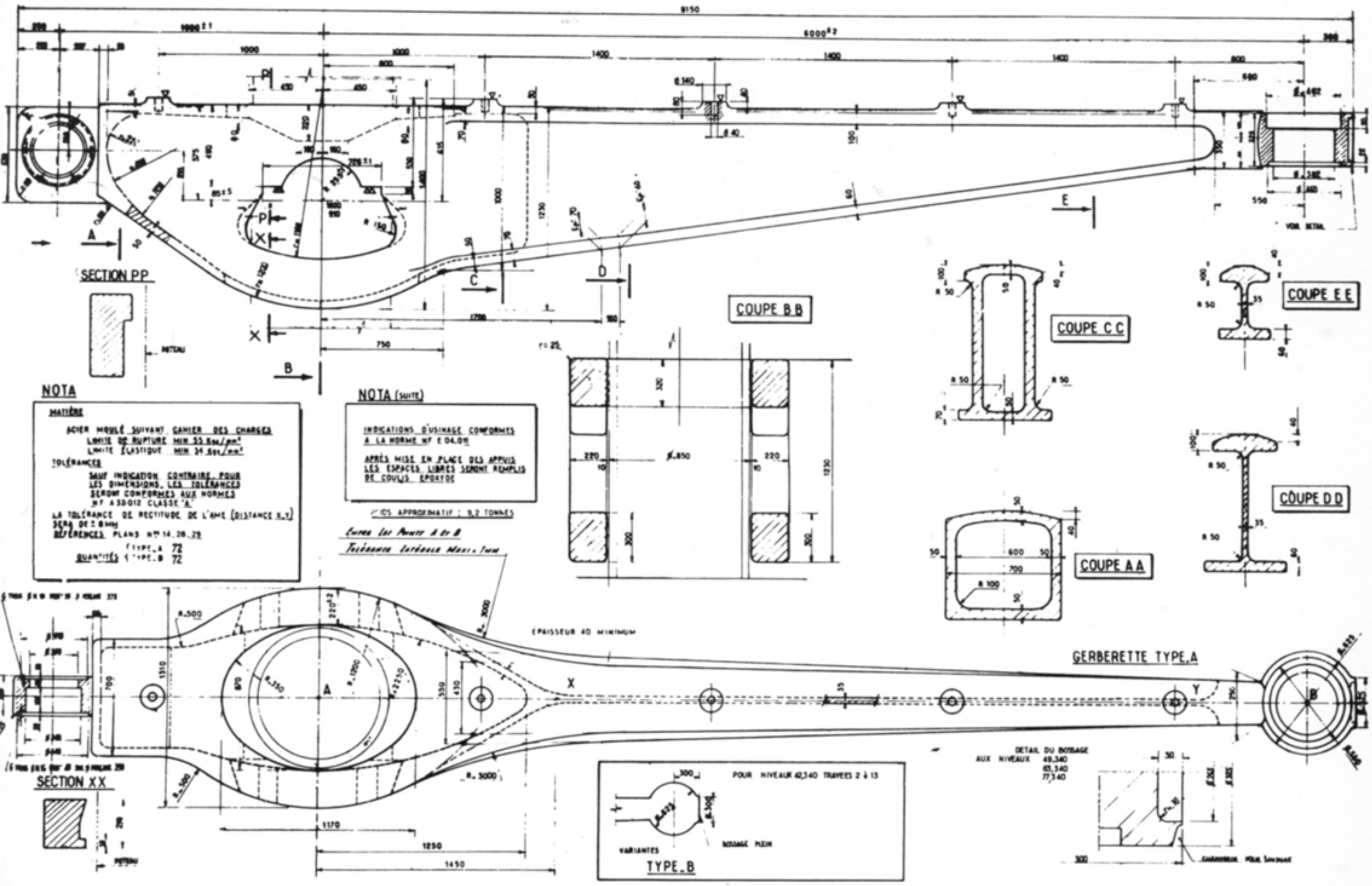
Take, for example, the development of the primary structure. Because of the spans involved and the commitment to prefabrication, there was never any question of making the building in any material other than steel. As soon as it became apparent that there was a time constraint of five years from competition to opening, we realized that it would be utterly impossible to debug the initial idea of moving floors held by friction clamps in the time allotted and consequently abandoned it. The next development was right-angled verendale beams enclosed within floors and ceilings, which offered three totally clear floors sandwiched between alternate mechanical floors. Each beam was held between two pairs of double columns, a notion which turned out to be both inflexible and overweight. It also had an economic flaw: the beam should actually rest between the pairs of double columns so as to evenly distribute the load, which would force the beams to be 25 feet (7.5 meters) longer on each side than the final solution.

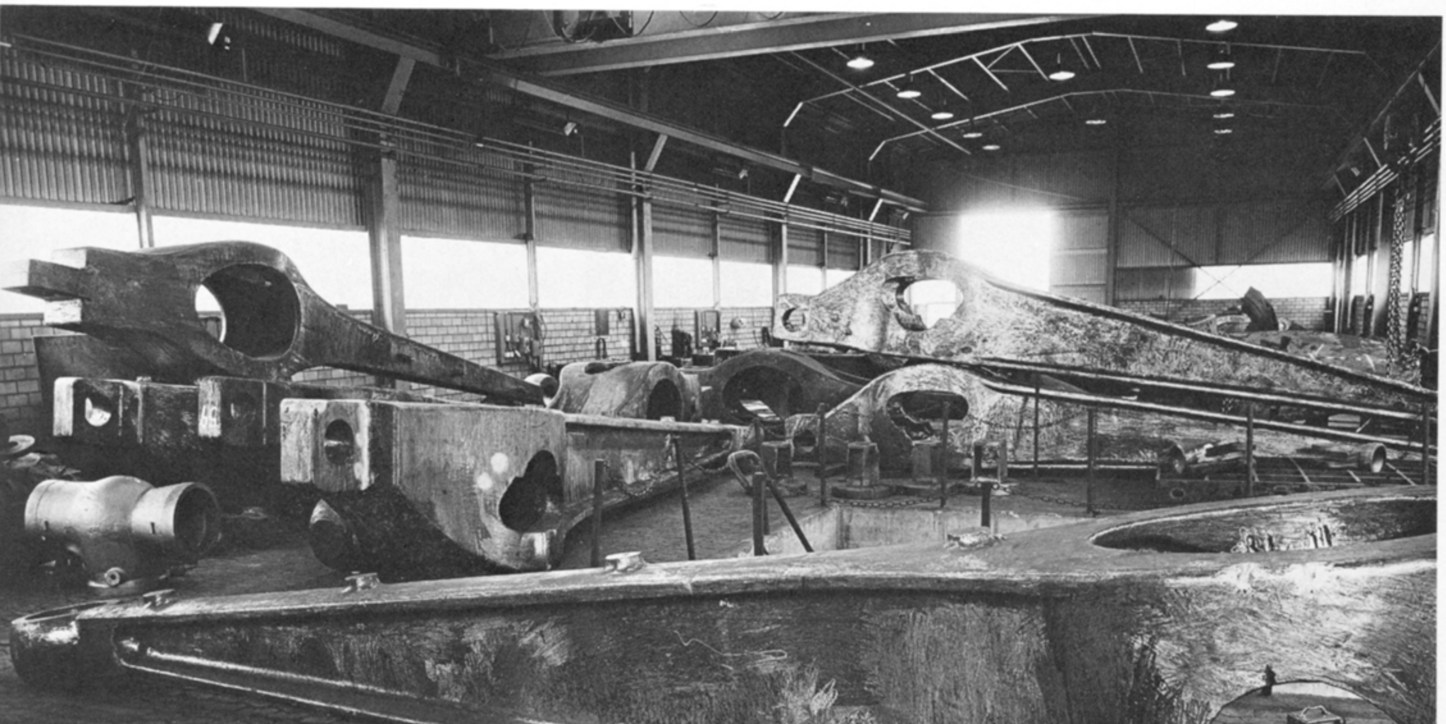
The structural solution finally adopted is simplicity itself. Descended from Gerber's 19th-century suspended bridge designs where the rotation of the moment arm is placed to coincide with the point of no moment, the superstructure is comprised of a suspended span with cantilever brackets. The trussed beams supporting the floors are pinned between the double row of compression columns, the geberettes hinged to their other sides. These in turn were laced together to resist wind, temperature, and horizontal and vertical forces. To take the lateral forces, the braced ends of the building form a gable frame. There are no expansion joints as all distortion forces are completely absorbed by the flexibility of the members or are resisted by their stiffeners; all pieces are, in other words, a little bit too short, forcing them into tension. Astonishingly few members were required. Furthermore, the selection of the geberettes provided a golden opportunity to divorce the line of structure from the line of enclosure. This eliminated a special wall condition and fixed the facades. Hence, all infill elements are the same width and all interior partitions typical.

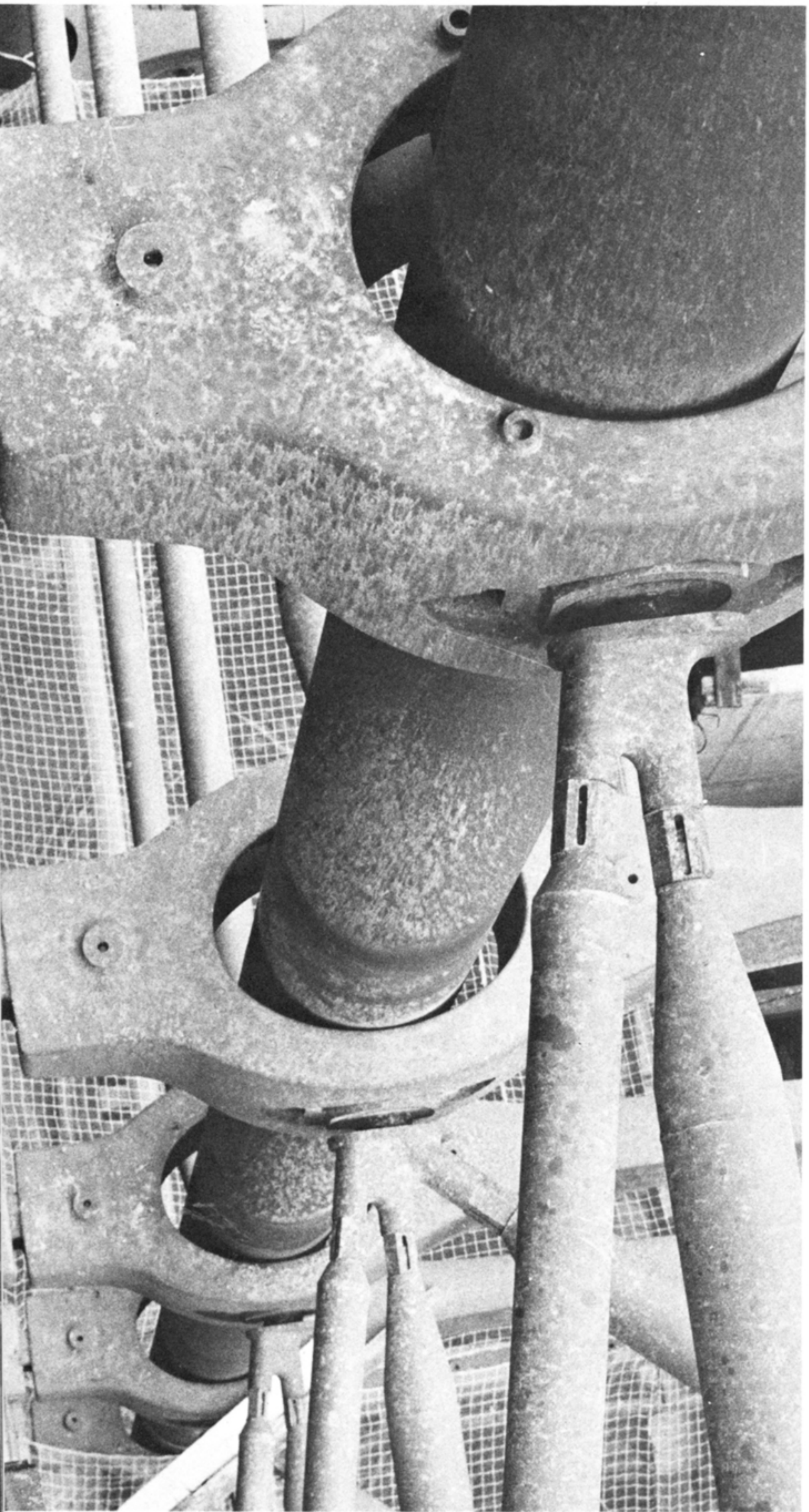
Though we had hoped to use standard components, the engineers soon proved that the scale of many of the parts was such that new techniques had to be developed to cut down on the amount of steel used. Advanced technology was, furthermore, the only way that it would be possible to achieve the volume of production necessary to meet the projected construction schedule. As usual this technology could be found more easily in the shipbuilding and aircraft industries, than in the building industry. So we turned to these industries for clues for steel casting techniques, for instance. Cast steel was chosen for the geberettes and all the nodes both for maximum economy of weight and as a way of expressing the form and detailing of the structure while establishing a method of maintaining strict control over the design as it developed. Because of the size and complexity involved in the production of the casting, it was a new venture for the building industry. Because it is impossible to weld the castings after completion, the way one can with ordinary steel, the technique also added a new constraint to the design team. All attachments had to be considered at the outset, long before the final heat treatment. It went well; the only problem turned out to be the brittle fracture of some of the geberette castings at the factory requiring the development of new backing procedures.

For less permanent needs, a secondary structural system was designed, ranging from the elevator towers to mezzanine supports to a framework for the ducts. As these are temporary in nature, the supports are constructed entirely out of standard steel components. These consist of a steel beam composed of simple channels with tubes for diagonals and steel columns made of four angles welded back to back. Both channels and angles are provided with holes to clip on additional components. Typical of the open-ended detailing of the secondary structure are the mezzanines. Intended to provide a movable intermediary floor, they are designed to be bolted to the trussed beams anywhere in the building, which did, of course, require that every beam be designed and built to carry them.

With the single exception of the columns which were brought to the site in halves and joined in mid-air, all structural elements were prefabricated


SECTION PP
COUPE BB
COUPE CC
COUPE EE
COUPE DD
COUPE AA
NOTA
MATIÈRE
ACIER MOULÉ SUIVANT CAHIER DES CHARGES
LIMITE DE RUPTURE MIN 55 Kgs/mm²
LIMITE ÉLASTIQUE MIN 34 Kgs/mm²
TOLÉRANCES
SAUF INDICATION CONTRAIRE, POUR LES DIMENSIONS, LES TOLÉRANCES SERONT CONFORMES AUX NORMES NF A 32-012 CLASSE 'A'
LA TOLÉRANCE DE RECTITUDE DE L'AME (DISTANCE X,Y) SERA DE ± 8 MM
RÉFÉRENCES PLANS Nos 14, 28, 29
QUANTITÉS TYPE A 72
TYPE B 72
NOTA (SUITE)
INDICATIONS D'USINAGE CONFORMES A LA NORME NF E 04.011
APRÈS MISE EN PLACE DES APPUIS LES ESPACES LIBRES SERONT REMPLIS DE COULIS EPOXYDE
POIDS APPROXIMATIF : 9,2 TONNES
EPAISSEUR 40 MINIMUM
GERBERETTE TYPE A
SECTION XX
POUR NIVEAUX 42,340 TRAVEES 2 à 13
VARIANTES
BOSSAGE PLEIN
TYPE B
DETAIL DU BOSSAGE AUX NIVEAUX 49,340 63,340 77,340



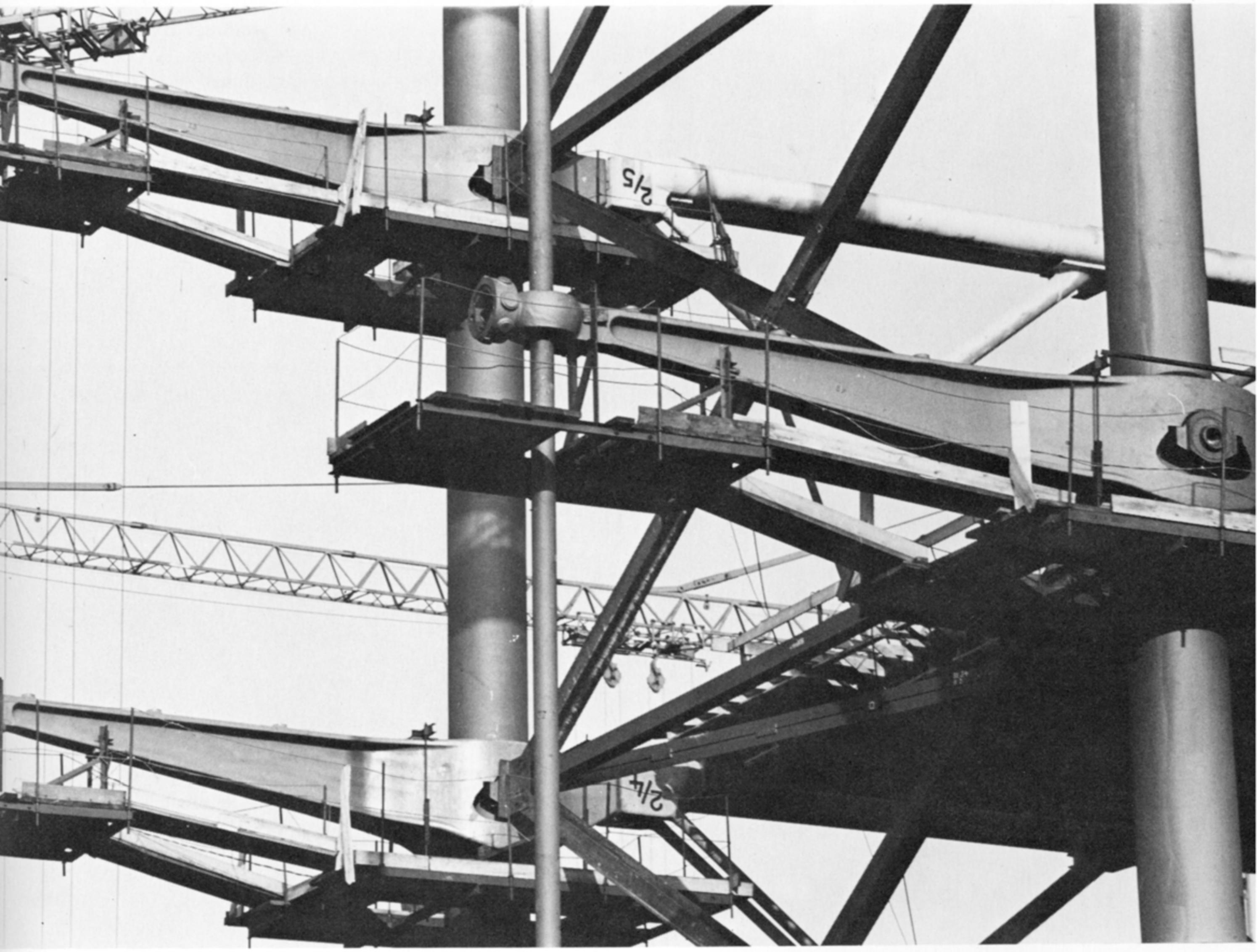


off-site to avoid site welding. By far the largest elements were the trussed beams measuring 148 feet (45 meters) in length and 10 feet (3 meters) in height and weighing 75 tons (67 metric tons). Every Thursday night the main steel contractors delivered three beams by special convoy. A single mobile 500-ton (450-metric ton) crane, capable of lifting 100 tons (90 metric tons) at 30 feet (9 meters) erected the beams. The structure was assembled vertically, one bay at a time. A pair of knobs welded onto each column marked every floor level. Attaching the geberettes became a simple matter of slipping them over the columns and rotating them 90° at the proper floor to lock them into place; this accounts for their somewhat unusual shape. Then the trusses were pinned between the geberettes, which in turn were tied together. A full bay took 10 days to assemble. The entire erection process was simple, speedy, and virtually problem-free, requiring only eight months to complete. And that included pouring the concrete floors.

The Development of the Servicing

Like the structure, the servicing is governed by the same principles of growth and change which led to the visual expression of the way the building works. The greatest portion of the visual stimuli is provided by the blue double-duct, variable-volume, all-air and all-electric air-handling units that comprise the Rue du Renard elevation. There are 13 units, one for each bay. In keeping with the standard French color codes to denote air-handling units, they are painted blue. (Likewise water and electricity are colored green and yellow.) The variable-volume system was picked to allow specific areas to be closed down or independently controlled, in addition to catering to flexible and variable lighting installations, while also allowing for future boxes/offices to be installed and linked into the main systems. An all-air unit was chosen to avoid distribution of water in spaces containing works of art and books. And an all-electric building turned out to be both more economical and less polluting than the alternatives.

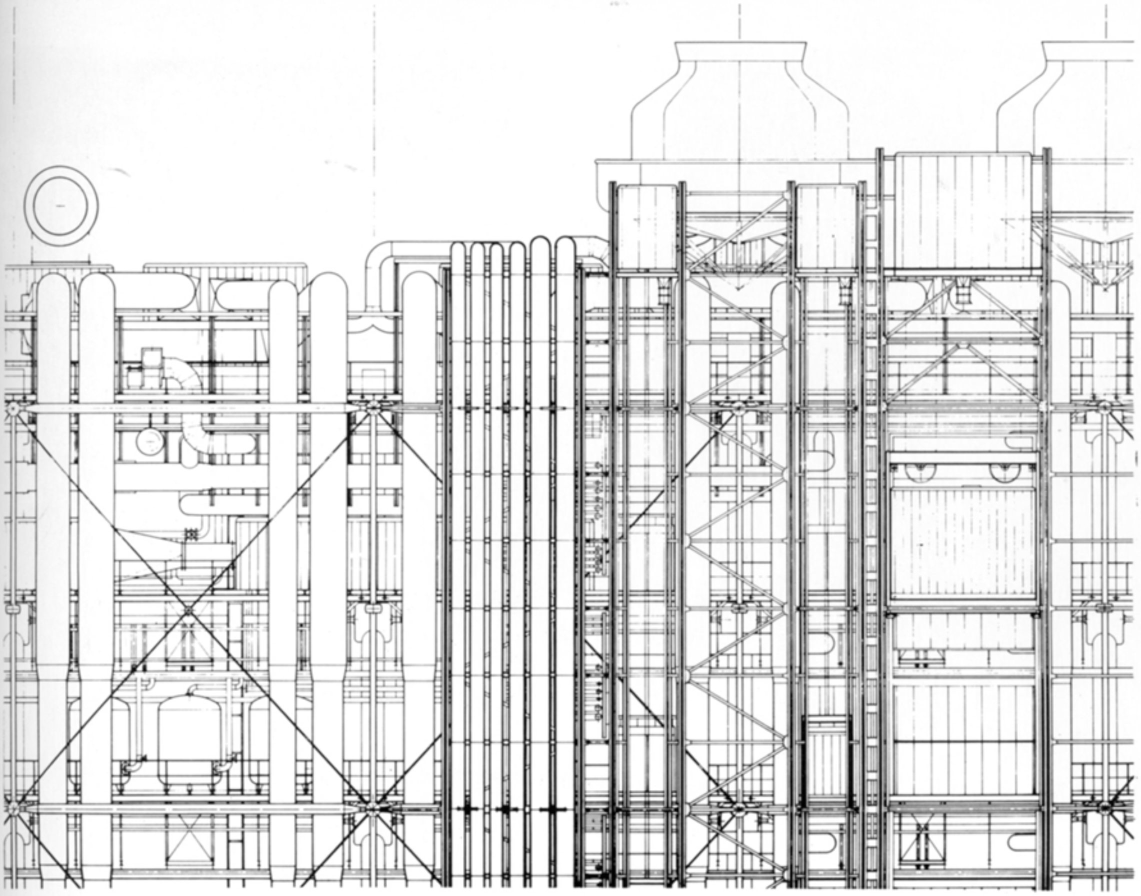
In a fully serviced artificial environment such as Beaubourg, mechanicals typically require 10 percent of the floor area of the building while consuming about 40 percent of the total budget. Half of the primary mechanical zones were concentrated below grade, from which they feed the space above; the remainder were placed on the



Opposite page: The geberette is slipped onto the knobbed column and rotated a quarter turn to lock it into place. The knob on the column becomes the attachment point for the cross-bracing of the facade and the support for the passerelles.

Above: The trussed beams supporting the floors are hooked into the geberette to balance the weight of the cantilever while the geberettes are joined at their outer ends by vertical ties. The structure was created vertically, one bay at a time.


CHEMISES
DOUBLE SIX



Opposite page: The architecture of Beaubourg becomes an expression of the process of building. Nowhere is this clearer than on the Rue du Renard facade.

Left: The Rue du Renard facade structural zone contains all the mechanical services, service elevators, and fire stairs with continuous steel galleries for ease of maintenance and change. Although the superstructure in each bay and floor appears identical, less than half of the modules actually are, which is apparent in this elevation fragment.

roof, feeding vertically down outside on the Rue du Renard facade. All crossovers between, say, electrical conduits and sprinklers, occur on the exterior; once the services penetrate the curtain wall, they run neatly between the structural beams, an arrangement providing both maximum headroom and visual clarity.

The decision to expose the mechanicals led to new problems related to the training of architects, engineers, and contractors. The appearance of services have traditionally been deemed to be of so little importance that one finds them simply indicated on working drawings by dimensionless single lines. In a random order each service subcontractor supplies and fixes his own supports, attaching them to whatever happens to be the nearest piece of building fabric in whatever fashion strikes his fancy. And, of course, hidden behind suspended ceilings lies the result of the tradesmen's free-for-all, an inarticulate spaghetti of tubing and joinery. As there is not any precedent for displaying the mechanical servicing in a building of this size, it was necessary to indulge in as lengthy as possible a period of mutual enlightenment, while bearing in mind the fact that time was short and cost control imperative.

This was compounded by our commitment for quality and maintenance control by having all mechanical elements arrive on the site prefabricated and prefinished. That meant that while every floor and every bay may look identical to the casual observer, they actually are not. Fully half of them vary in either the detailed realization of the facade or the servicing plan, requiring individual consideration of each bay. To provide future flexibility, we were forced to develop the prototypical plan and section for the worst of all possible cases, namely, when the suspension system for hanging the ductwork would be the most skewed. To answer to changing needs, one must initially allow some diversity in the design so that in the future elements such as mezzanines or bathrooms might be added or subtracted. For example, the building is fitted throughout with waste collection boxes in the floor sandwich capable of being quickly hooked up to movable toilet capsules with fireman-type connectors. The bathrooms that were finally built are more permanent than the ideal, although additional toilets have already been added to accommodate the vast number of visitors. The same goes for the grid of water and power lines threaded beneath the piazza which are used for such events as the circus, the children's tent, and the flower stalls.

By treating services as an erector set of exposed components, we were able to speed up the erection and cut down on some of the maintenance required, which counteracted some of the

Right: The interior display of mechanical services, of which the blue supply and return ducts are the most prominent elements, is partially obscured in the forum by the catwalks.

Opposite page: We were unable to develop a new technique of fireproofing structural steel. Hence, the facade is the result of our effort at elegantly ad hoc fireproofing.

headaches we endured. Mechanical subcontractors, professionals not exactly known for their love of innovation or commitment to the ideal of future flexibility, were more than reluctant to be responsible for the supply and fixing of supports onto which they had little or no services to attach. Nor for that matter did they delight in inventing new support systems with higher fire ratings than those currently in existence. But these agonies pale beside the greater dilemma of fire protection.

Fire Protection

Probably the major flaw in the scheme lay in our inability to develop a new technique of fireproofing structural steel. Here we had a major building totally constructed out of steel and backed by considerable political muscle, once-in-a-lifetime conditions for which a steel manufacturer could research and solve this problem. We actually believed that we would make a major breakthrough and find a system of making the steel itself incombustible without resorting to the considerable expenditure of creative effort required in the search for elegant ways to ad hoc fireproofing. It didn't happen.

This left us very much at the mercy of the local fire codes. Or rather the Parisian fire department. As this was the first public building of *grand hauteur*, every regulation ever promulgated in the city of Paris since antiquity was applied in the most stringent manner conceivable to the tune of 50 million francs, some 10 percent of the total construction budget. While no architect in his right mind would ever want to deliberately construct a building in which people could perish of fire (or for that matter, anything else), regulations might have been a bit more imaginatively handled.

Since the fire brigade's ladders could not stretch beyond 90 feet (28 meters), the top floor could be no higher. That meant it had to shrink 64 feet (19 meters), virtually eliminating all the open space within the open structural cage, as we squeezed the program bulk into a smaller volume. Where our floor areas surpassed the regulation maximum fire compartment size of nearly 100,000 cubic feet (2,800 cubic meters), they had to be subdivided to make them smaller. In general normal dynamic fire protection systems where a fuse is broken releasing a steel shutter were forbidden save in small quantities; it led to the arbitrary chopping of the museum floor into two halves, which compromised the tenet of absolute flexibility and transparency (although both halves can easily be reunited later). No inflammable materials (except for the art and the books) were

allowed anywhere within the building shell. These included wood, plastics, fabrics, composite materials, and even padding on chairs, leaving steel, concrete, and asbestos as the only materials we could use.

Design was governed by the fairly straightforward principle of "separate and extinguish." It affected the visual appearance of virtually every element. The trussed beams, for example, appear structurally overweight simply because the structural steel is wrapped in a blanket of fibrous material and then encased in a stainless steel armor to prevent it from melting in a two-hour fire. The building is, of course, sprinklered throughout with either water or halogen gas (used to protect areas with a lot of electricity running through them and to keep from ruining the books and artworks by flooding). In addition there is an elaborate mechanical smoke exhaust system controlled by a computerized rise-of-temperature detection system. Furthermore, a special series of back-up dampers in the ducting prevent smoke from being blown through the rest of the building.

The fireproofing system gets considerably less clear-cut outside the enclosing wall zone. While the exterior steelwork is left exposed, depending on distance, screening, and sprinklers to keep it from failing in the event of fire, the elevation plane itself was by far the trickiest to design. Its various fire systems range from the exterior panels themselves to water-filled columns. The hollow columns are very thick at the bottom and very thin at the top, requiring a pump to make sure that the water circulates completely through them.

Every infill panel in the curtain wall marks a stage in the hierarchy of protection, progressing step by step from the wired glazing to the clear double glazing to the solid panels to those sprinklered panels which actually touch the geberettes themselves. Added to this is a collection of roll-down steel shuttering to protect the glass, which manages also to provide both manual and automatic sun control.

Even more complicated is the Rue du Renard elevation. In addition to being fully sprinklered, all mechanical support elements have half-, two- or three-hour fire ratings, depending on the service they support. Precautions are also taken to avoid half-hour services collapsing onto two-hour services should a fire occur. With the help of the fire department, the infill in the curtain wall has evolved from completely transparent to totally solid. It necessitated replanning most of the interiors three full years after work had begun.

It is impossible to divorce the building from its legal, technical, political, and economic context. At the same time, a major part of any design approach is the way constraints may be absorbed and wherever possible inverted into positive elements. On one hand, new technical needs and regulations, political dictums, and changing user requirements make it difficult to control the building; on the other hand, the way that the building overcame these constraints is a measure of the success or failure of both the building and its philosophy.

Every day over 25,000 people visit the Centre, as many as visit the Louvre and the Eiffel Tower put together, which is 20,000 more visitors than the building was programmed for. This has naturally taxed some of the facilities. To minimize the crush on the escalators, another run needs to be clipped on. This is quite easy as the escalators are hung in a steel cradle which is screwed into the end of the geberettes; those not supporting escalators have their ends capped.

Other things have changed over time. Functions have shifted. Cinemas have been added, a change that proved fairly simple to accommodate despite high smoke exhaust requirements necessary in theaters. More toilet capsules have been added. The number of entrances has dwindled from the original thirteen doors with the possibility of placing doors wherever needed to only two entries, leading to long lines. The administration offices may move out into an adjoining building as the permanent staff has more than doubled since the inception.

The street-oriented Parisian public has taken over every space given to it, starting with the neighboring street shops and piazza and continuing through the public spaces in the building, and are now even conquering the departments in the Centre. These are only the first of many changes as Beaubourg accommodates itself to the needs of the people, envisioned or not. This is what we mean when we call it an architecture of possibilities.

Approximately 25 percent of Beaubourg's visitors never enter the major departments, but just enjoy the escalators, galleries, views of Paris, public forum, and terraces.