

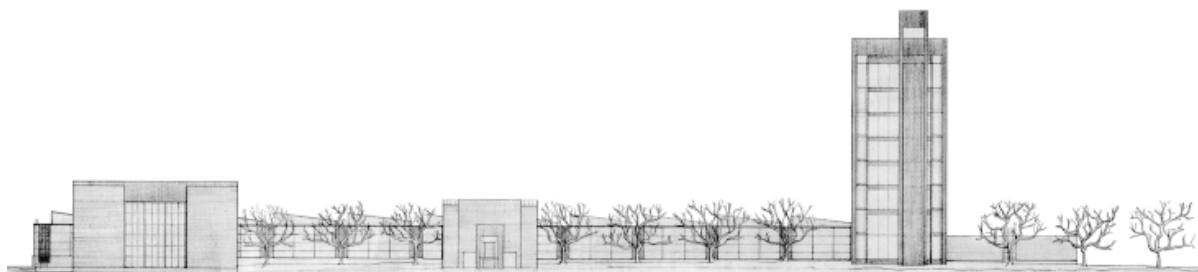
Tubeworks

To my mother, for her unflagging support; to my father, for the tools; to Laura, my partner; to Emily, my daughter; thank you. Thanks to John, Joe, Steve, Stig and Evan, who were there.

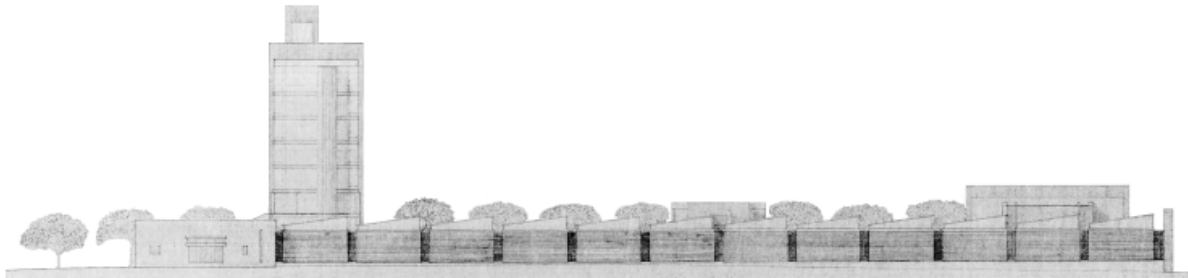


“Poetically, man dwells upon the earth.”
Martin Heidegger

**“I think the stroke of genius really, was not his inventing the electric guitar, but
inventing the amplifier to go with it.”**
Keith Richards, at the induction of Leo Fender into the Rock and Roll Hall of Fame



Elevation from the west shows the open side of the buildings. This is the approach of employees and visitors to the facility from the parking side.



Elevation from the east shows the protected, formal side of the building. This is the view from South Main Street, (U.S. 460 business) which will be seen from passing cars.

Tubeworks

Andrew James Rauch

**Thesis submitted to the faculty of Virginia Tech in partial
fulfillment of the requirements for the degree**

Master of Architecture

Graduate Thesis Committee

Heiner Schnoedt

Dennis Kilper

William Galloway



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The distorted guitar tone is a sound everyone has heard. On the introduction to Mississippi Queen, Leslie West shatters the quarter note rhythm set up by the cow bell with a powerful distorted guitar figure. A high frequency squeal of feedback gradually replaces the fundamental tone as Martin Barre sustains notes during his guitar solo on Aqualung. The move from a clean amplified tone to a distorted tone with radically different attributes could be considered one of the most fundamental signatures of rock music. There are different distortion tones: Eric Clapton's hyper-distorted lines on Swlabr mimic Jack Bruce's singing voice. On Blue Cheer's version of Summertime Blues there is so much distortion the basic guitar sound is nearly obliterated.

The expansive use of distortion is perplexing. In typical English the word 'distortion' has a negative connotation. It is often defined as an inaccurate representation, a misstatement or a perversion. Designers of musical instrument amplifiers initially attempted to faithfully replicate the tone of the guitar over a loudspeaker. Instructions with older Fender amplifiers recommended that the volume of the unit be kept at a moderate setting to prevent distortion. And yet guitarists embrace distortion. Through what must have been an accidental discovery, the guitar's tone is significantly transformed by distortion. The transformation is more than just sound; the feel and technique are transformed as well. In electric guitar playing the amplifier is part of the instrument and is also 'played'. In the strictest sense, the act of amplifying a guitar could already be regarded as a form of distortion. Once electronic amplification of the guitar was possible, distortion was an inevitable imbedded element.

A technical investigation into amplification explains how distortion occurs. Inside his invention, the light bulb, Thomas Edison saw that an electron could be induced to travel between a cathode and an anode. Not noticing the value of this phenomenon outside of lighting, he did no more than note his observation. But in fact the light bulb was very close to a thermionic valve or what is now known as a vacuum tube. The simplest vacuum tube is a diode, a device with two elements inside a jar from which the air has been evacuated. The idea is simple: if heat and or voltage is applied to one of the elements, electrons will flock to the other element, creating a small current between the two. Housing the components in a vacuum prevents the hot parts from burning. If more heat (or more voltage) is applied, even more electrons will transfer. At first this occurs in a linear fashion; the graph of a function describing the phenomenon is a straight line. This means that for every little bit of heat applied

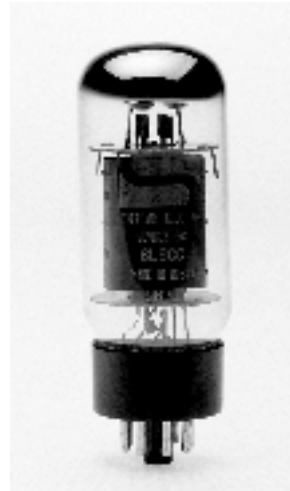


to the cathode, there is a similar little bit of additional current between the cathode and anode. At some point in this progression, a little bit more heat or voltage suddenly produces a big jump in current. At this point, the output is stronger than the input. This is the core of electric amplification and the beginning of distortion. The increase in the volume of the guitar's signal as a result of this amplification, even though it may be a 'clean' tone, is in fact the first order of distortion. Because the signal coming out is louder than what goes in, a transformation necessarily occurs. Hence, the expression distortion is appropriate.

Distortion, as it is typically understood by guitarists, will occur in a circuit when the capacity of an amplifier is exceeded. If an amplifier is designed to amplify a signal by a factor of two, then an input signal of one volt will produce an output of two volts, twice as strong. This increase is called 'gain', and for the amp imagined here, the gain factor is two. For an ideal amplifier this constant gain would graph as a straight line on axes labeled input and output. An actual amp will, however, have limited capacity. For a certain range of input values it may produce a linear response. Beyond this, the output may increase, but by a factor of less than two. Here occurs the phenomenon commonly thought of as distortion by guitarists. The sound begins to break up, the tone transforms more radically, it is no longer 'clean'.

After amplification takes place, a point will eventually be reached such that no matter how much more voltage is input, no more output will be produced. This is called saturation. Like a sponge that can absorb no more moisture, the amplification is at its limit. The effect is audible as a 'fuzzy' sound. The basic distorted sound is accompanied by a side effect, called compression. Compression can be detected in an alteration in the *envelope* of the sound. Envelope describes a sound's behavior from its onset or attack, through sustain to decay and release. Under mild to moderate compression, the sustain of the signal is prolonged. Extreme compression alters the entire envelope. The prolonged sustain that accompanies saturation introduced the guitarist to new possibilities. The acoustic instrument's short, percussive envelope gave way to the electric instrument's long sustained notes, whose pitch and tone could be manipulated during the note's duration.

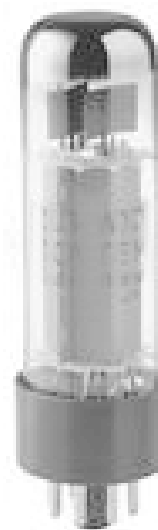
Amplification had an effect on guitar playing that its early developers did not anticipate. Although not obvious at first, it changed fundamentally the way guitarists would approach the instrument. Less notably, although obviously the original intent, it gave the existing guitar style a



louder voice. In large orchestras before amplification, it was futile for the guitarist to solo. The volume of even the largest guitars could not be heard over brass. With amplified instruments, guitarists could reach a large audience with *single-note solo* playing. Charlie Christian not only understood this, as is evidenced by his solo work with the Benny Goodman Orchestra, but advocated solo electric guitar playing to his fellow musicians as early as 1939 as a way to perk up their playing and make more money. His attitude and that of others to come would set popular music on a new tack. And although the moment hadn't arrived yet, the violin, as the object of popular virtuosity, was to be supplanted.

Full bore, distorted, compressed, guitar tones did not come to popular music all at once. The amps, tiny by today's standards, used by the early rock'n'roll bands certainly allowed for louder performances in front of larger audiences, but these were outgrown sooner than amp makers were supplying more power. When these units were turned way up they began to distort and feedback. The behavior of certain models of amplifier made this transformation smoother. The British made Vox AC15 and AC30 amplifiers tended to enter clipping in a smooth, controlled fashion. As the volume was increased, the clean tone gave way little by little to a fluid distortion, not unpleasant, even to one unaccustomed to this sound. Doubtless many users experimented privately with the effects obtained when the amps were turned full up and played aggressively, but this phenomenon was not wildly explored publicly. The Beatles allowed feedback from an amplified acoustic guitar to creep into the intro of their recorded version of I Feel Fine, perhaps validating the sound as well as exposing the effect to a large audience. By the mid sixties purposeful distortion was gaining wider acceptance among musicians. Its sound was thought of as magnificent and rebellious, but there was more to it than just sound. The manipulation and control of distortion through out a piece became a structural device.

Both composers and street musicians know that there is a sense of dynamics that lends drama to a performance. The music must fall and then increase in volume and complexity to build tension and interest. Guitarists understand this and have a powerful tool in their tube amps. The behavior of a tube type amplification device can be described as reactive or dynamic. It responds to the touch of the guitarist in a predictable way, which can allow great emotion in the performance. When the amp is played cleanly with the volume at a relatively low

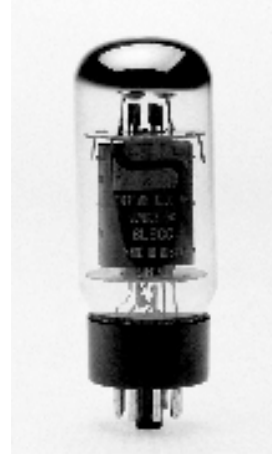


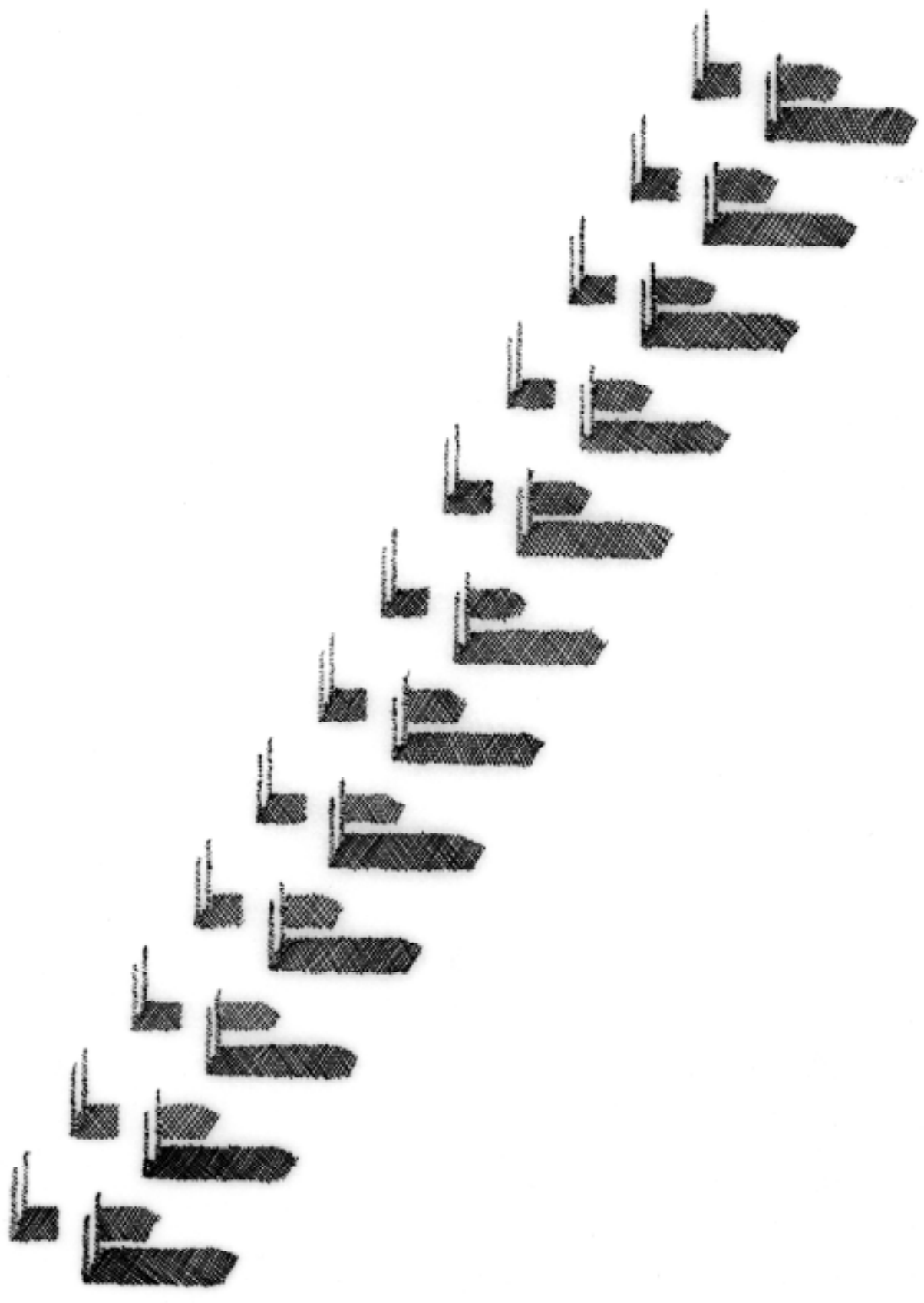
level, the volume control on the guitar will adjust the overall volume of the performance. With a tube amp that's already 'overdriven', as the instrument's control is turned up, the volume will increase somewhat, then reach a point where the sound's change is qualitative rather than quantitative. The output level of the instrument controls how hard the signal hits the input stage of the amp. When the control is backed down the tone cleans up availing the artist a multidimensional dynamic. Running the control through its full range affords an ever changing palette of sounds, from clean and quiet through louder and gutsy to fluid and compressed. This control is well used by the guitarist who fills the space between vocal phrases with rough edged guitar lines, then cleans up for the rhythm passages. In addition, there is a palpable resistance pushing back from the amp that helps to give the artist his metaphysical resistance. As the attack on the strings is varied, as well as the number of strings attacked, the amp responds in kind, almost like a living thing. As the load is increased the amp is working harder, getting behind, and catching up with a sonorous bloom. This can be exploited in a controlled fashion by the right hands.

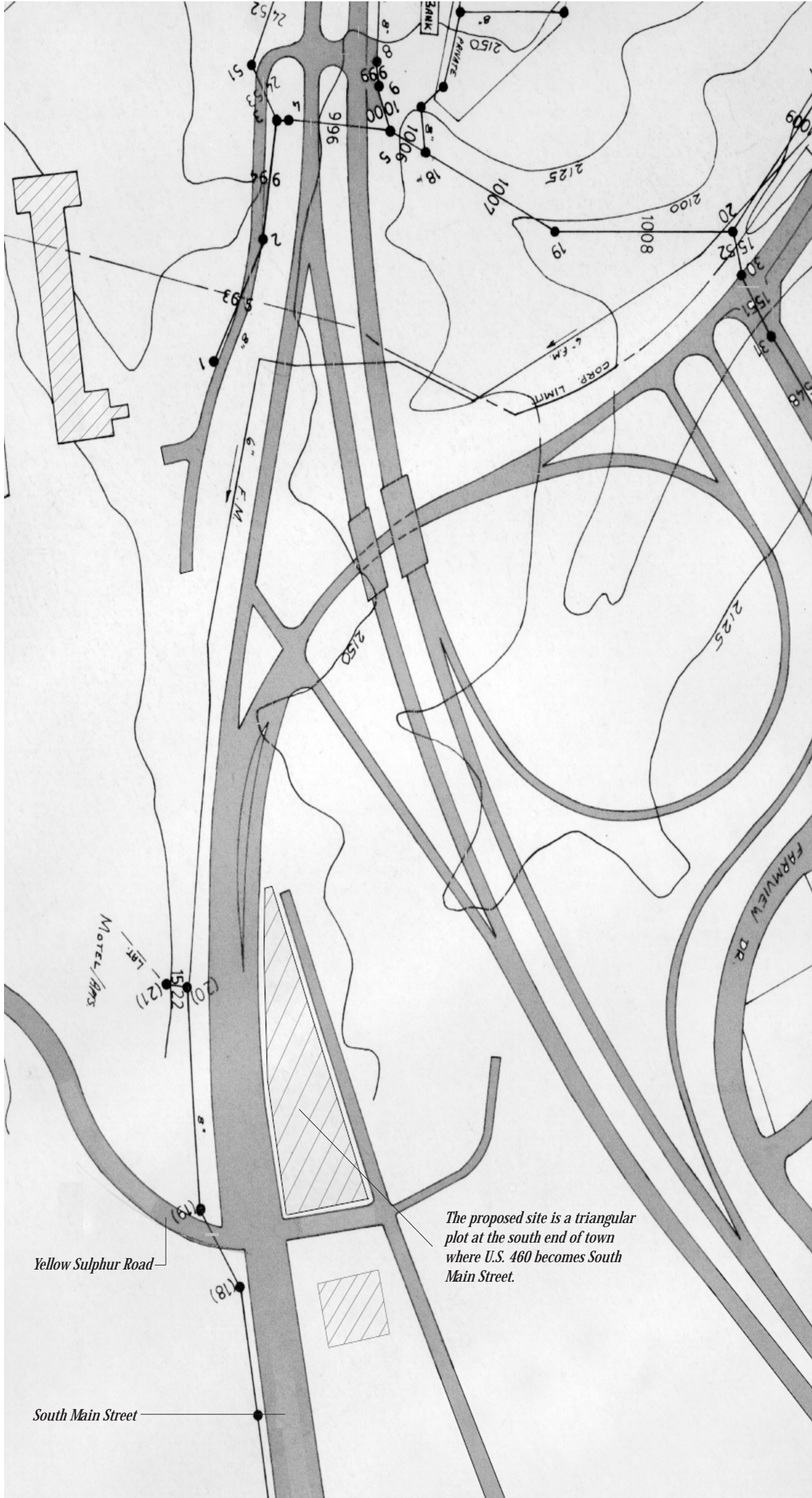
At Woodstock, an already well known Jimi Hendrix reorchestrated the Star-Spangled Banner in feedback soaked rockets of tone. Alvin Lee showed what distortion can do for traditional blues structure with a dynamic rendition of Goin' Home. And a not so well known Carlos Santana displayed excellent control of distortion, feedback, sustain, and dynamics on Soul Sacrifice.

In the context of rock'n'roll, distorted guitars displaced the horn section and began to supplant the string section. A band employing electric guitars gained the capacity formerly owned only by the saxophone and violin. With the intro to Black Magic Woman Santana takes sustain to a new place, holding notes for several measures not with a violin, but with a distorted amplifier. On Europa he becomes the saxophone, embracing the circular breathing of the vacuum tube so convincingly that Brazilian saxophonist Gato Barbieri had to cover him.

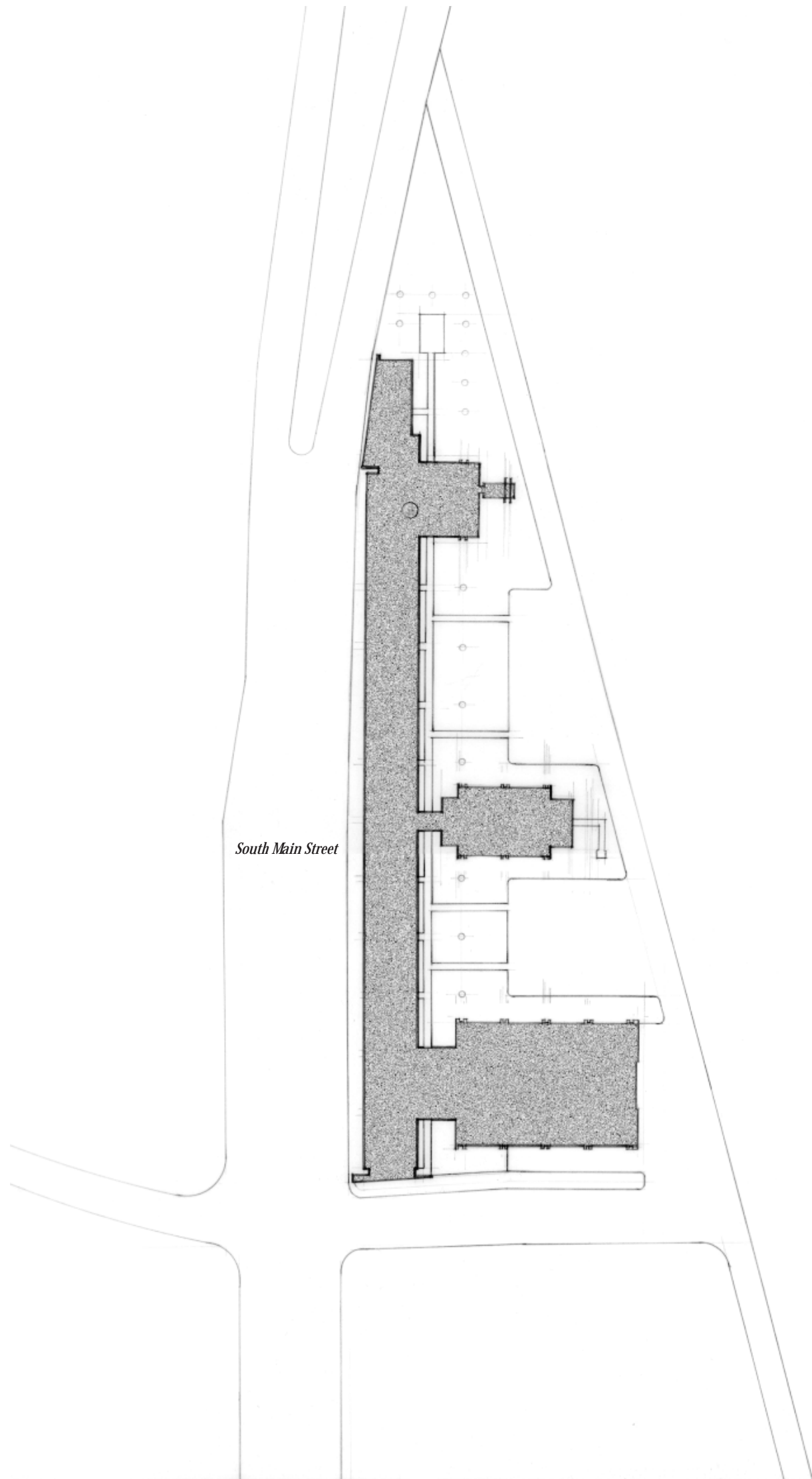
Hendrix, Lee, Santana, and many of their peers realized the importance of dynamics in a performance. Using the electronic distortion of the vacuum tube they strip down the sound, let it smolder, then bring it forth anew. The sound can be shattering, splintered, and raw. It can be smooth, creamy and liquid. It is as far removed as can be imagined from the initial efforts to make the guitar's voice louder. Yet once distortion was employed as a dynamic means of coloring sound, there was no turning back.







Map of south end of Blacksburg, Virginia, showing proposed site.



Site with plan of Tubeworks, a factory to produce vacuum tubes.



Outside the world of music the transistor has supplanted the vacuum tube. Transistors do the same sort of job as vacuum tubes but they use germanium or silicon in their manufacture, thus the current is produced in a solid state, rather than a vacuum. Most electronic devices are built with solid state technology. Exceptions are some musical instrument amplifiers and some audiophile grade stereo gear. For the users of this equipment the transistor is unsatisfactory both spiritually and with respect to sound. The need for tubes has become specialized, to the point where designers are designing amplifiers to the specifications of available tubes. The relative scarcity of these gems makes the notion of manufacturing specific tubes under exacting conditions, in relatively small quantities, attractive. A place to make these glass jewels should respect their history, use, and the careful manufacturing techniques required to make them. It is the basilica of the church of the distorted guitar sound.

Some of the same concepts that govern the making of musical instruments and music itself can be applied to architecture. Of interest here are rhythm and repetition and betweenness. The simplest music consists of rhythms with out regard to pitch. The rhythm of a building can be set up by the repetition of the columns. When columns are close enough together, a current can pass from one to the other which can be felt by the inhabitant. These betweenesses are an invitation to pass through; either in or out, up or down stairs, or maybe just enter, with no destination.

The gallery is a path along which one may walk purposefully from building to building, or more slowly to experience the exhibits installed there. The columns and walls are doubled to create a betweenness that can be inhabited. There is rhythm in the columns that make up the long gallery space. Where the space expands, the relics of the church can be found. Just outside the west wall is an outside path which allows the connected buildings to communicate as well. The inside path is crossed with narrow light and wide shadow in the morning. Late afternoon sun brings wide light and narrower shadow from the piers. At night the artificial light from inside brings the shadow pattern to the outside walk. The floor of the gallery is interrupted by the foot of the stairs where connecting links plug in. These betweenness stairs lead to the other buildings.

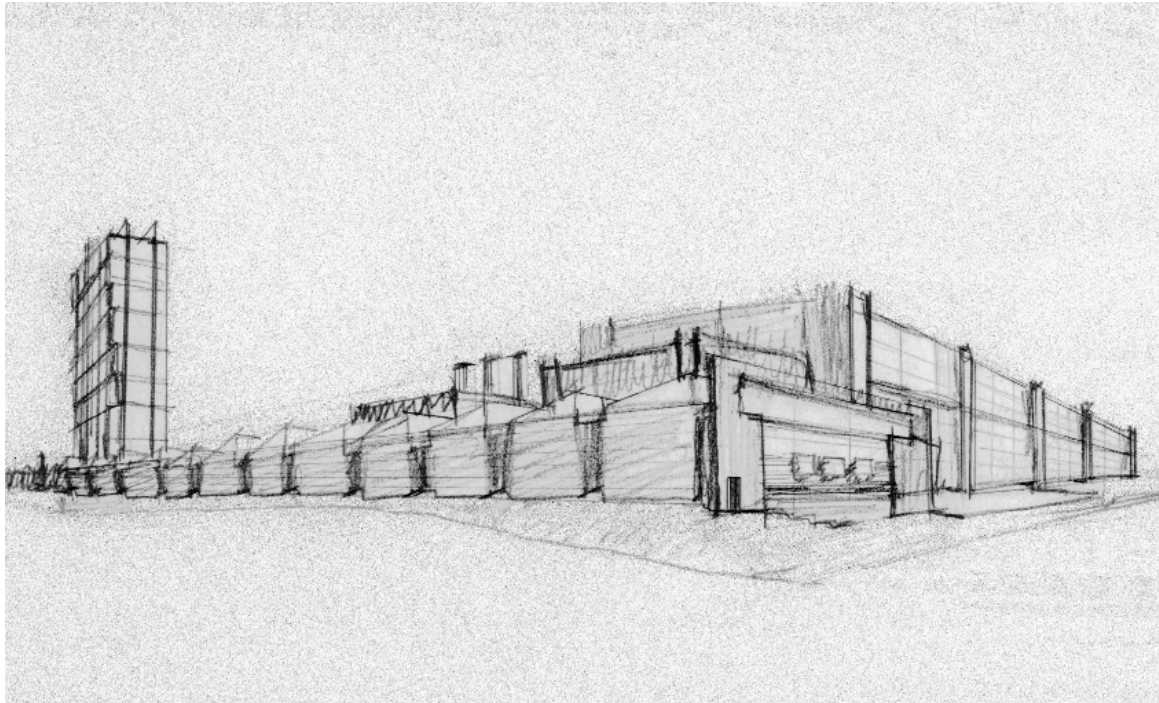
The plant itself is where raw materials are taken in, manufacturing takes place, and finished product goes out. The truck is how the factory meets the outside world. Large trucks appear at the loading dock with raw materials, packaging material, and machinery. Supplies such as solvents for cleaning parts, fuel for high temperature operations, and liquid nitrogen for cooling also arrive here. Component parts are stamped and assembled in the perimeter bays of the plant. Glass bottles are blown. After final cleaning, the components enter the laminar flow clean room. The technicians don special attire; hoods, boots, and suits, in an airlock before entering. In here the parts are installed in the bottles so as to ensure there is no contamination. The tubes leave the clean room to be connected to a pump where air is evacuated and they are sealed. The final stage is the firing of the getter, which reduces the volume of the components in the tube, increasing the vacuum. Successfully fired tubes are tested and matched, then packaged and stocked for shipment. They reenter the world on smaller trucks, in smaller quantities.

The plant's north curtain wall is open to the light. The south wall is closed to the sun but for a slit that bathes the elevator cylinder with early light. The betweenness stairs that run from the gallery to the plant mezzanine allow pilgrims to access the upper ambulatory, where they may observe the living relics below.

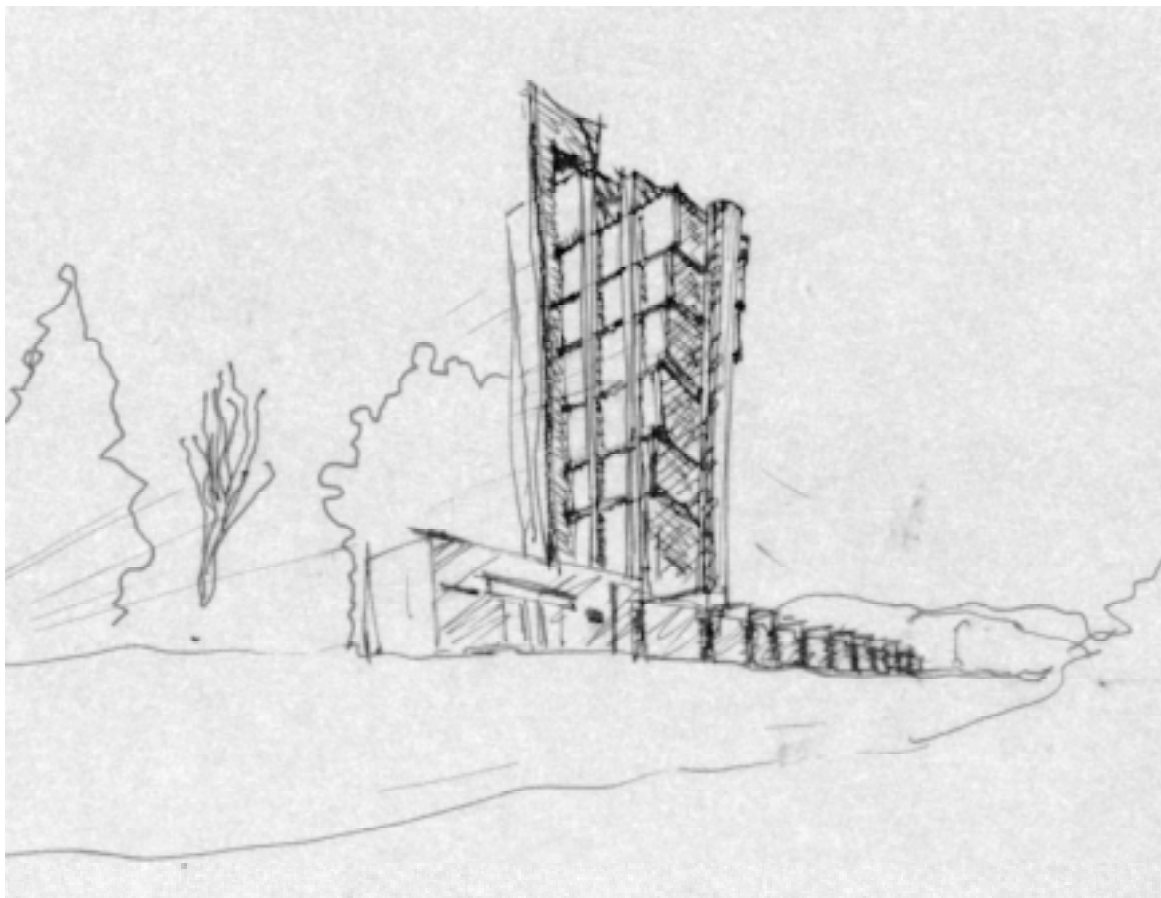
The testing facility allows for subjective and objective testing of the tubes. Here matching and performance testing will be done. Tubes which exhibit certain characteristics of sound can be paired or quarteted for use in particular amplifiers. Subjectively, the tubes will be installed in amplifiers and played both by technicians and visitors. Various combinations can be heard and recorded using different instruments. Samples of the tones can be sent to perspective clients on tape or disk. The testing room uses one column space to connect to the gallery, again by means of stairs.

The tower contains components of the business world. Marketing and sales of the tubes as well as management of the company will take place here. Additional floors contain leased space. The tower docks with the gallery by means of stairs that spill onto the gallery floor from between the walls. These stairs are repeated at each level and serve to connect the building floor to floor. A cylinder outside the envelope contains the elevator. The fire stair is its own distinct element.





A sketch of the building from the north. The wall protects the compound from the street and gives it its formal dress. It is constant against the changing elevation of the street.



A sketch of the building from the south. As traffic approaches from U.S. 460 this is the first thing seen. It is the formal entrance to the town of Blacksburg for arrivals from northern Virginia, Tidewater, or the south.



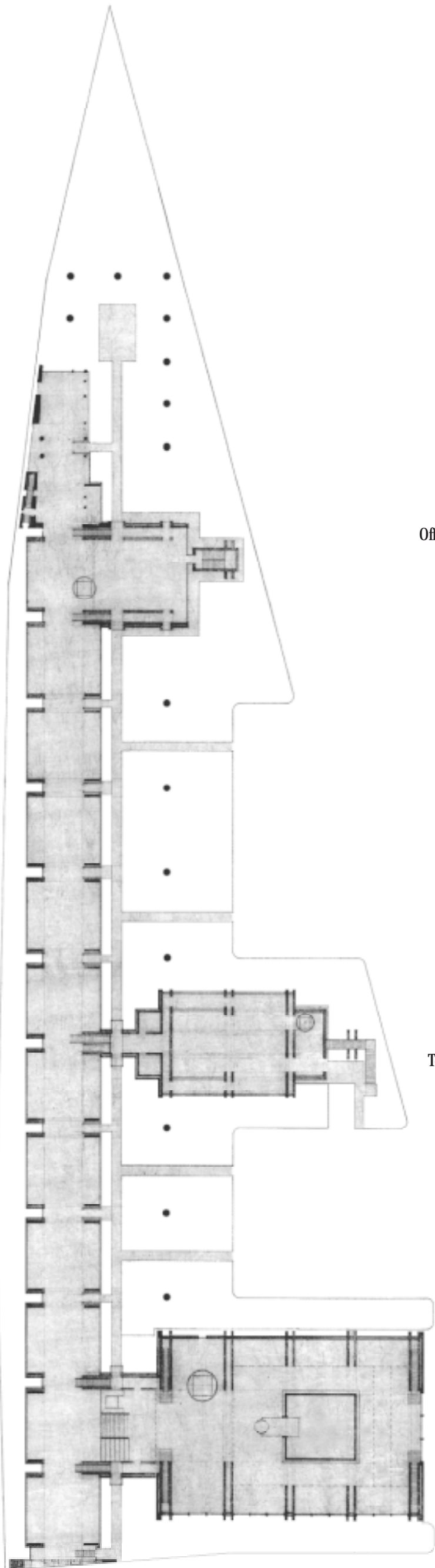
South Gallery
Terminus and
Reception Area

Office Tower

Gallery

Testing Lab

Plant



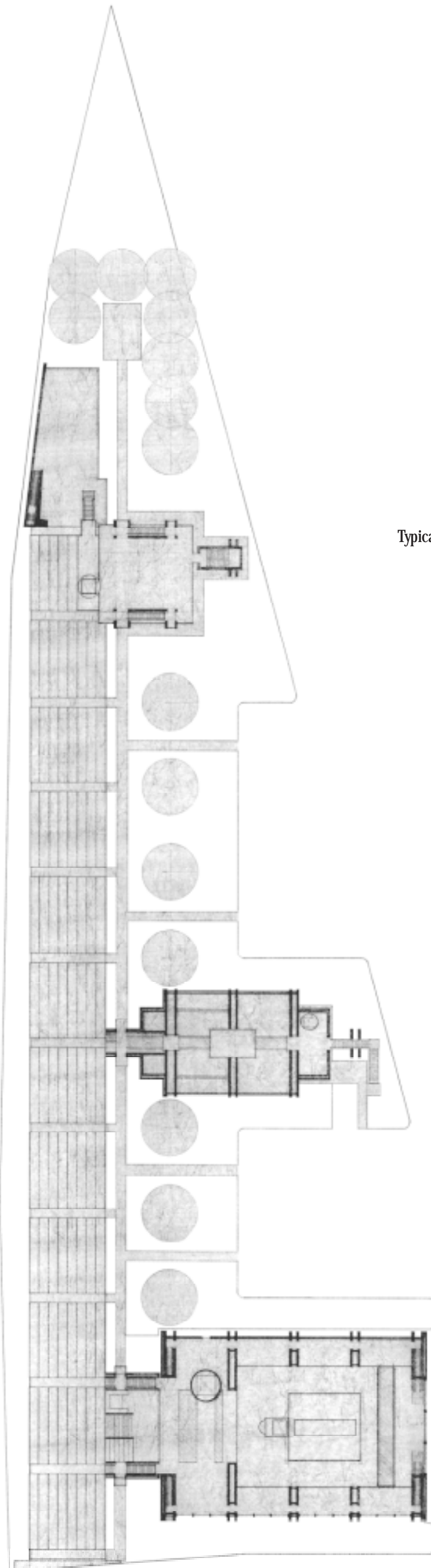
GROUND FLOOR PLAN



South Gallery
Terminus Roof
Terrace

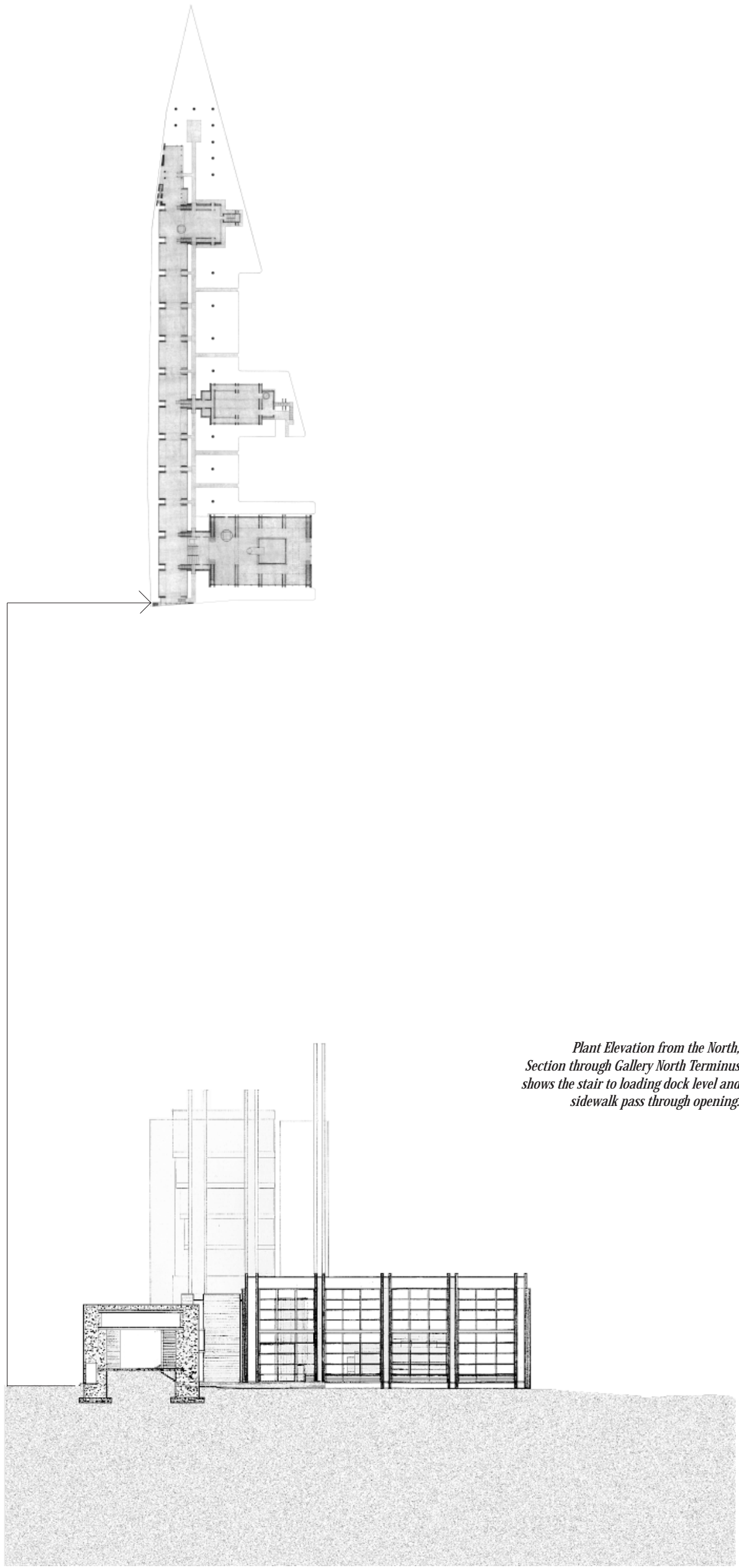
Typical Office Floor

Mezzanine
Level of Plant

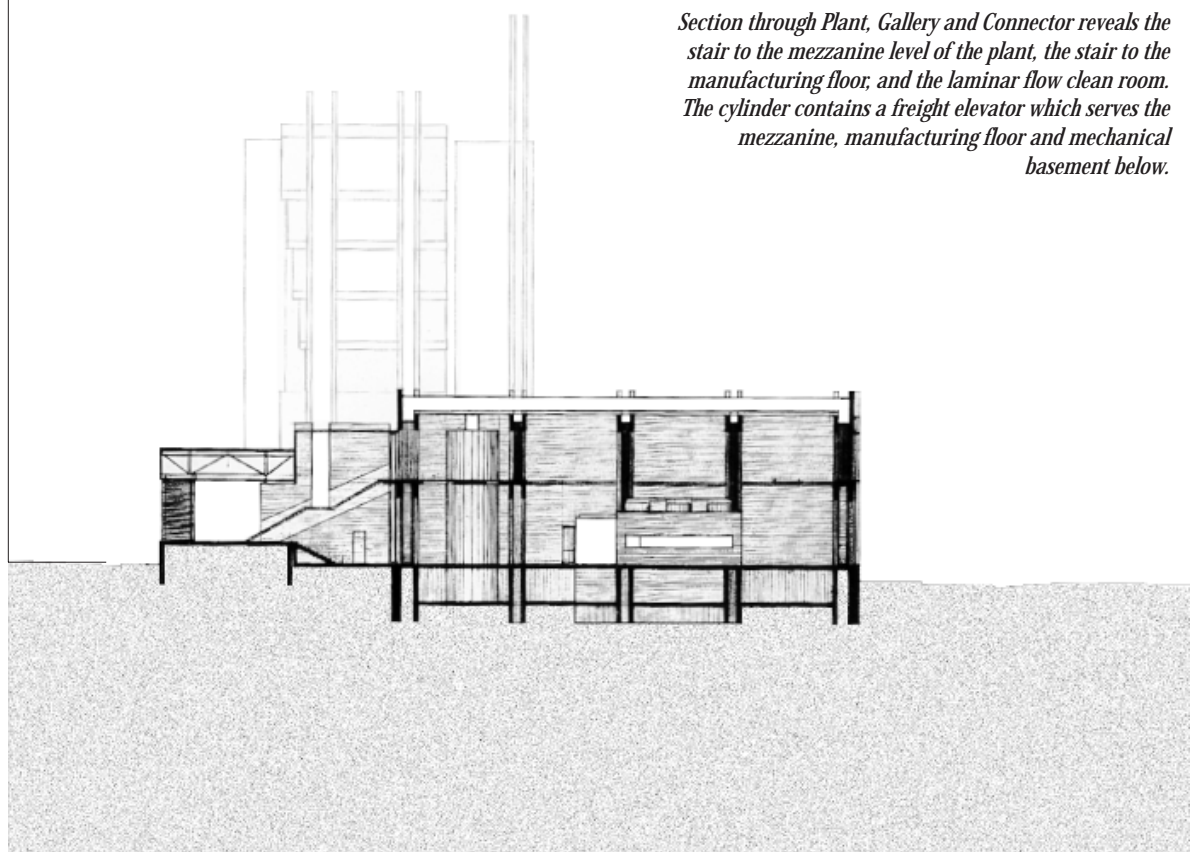
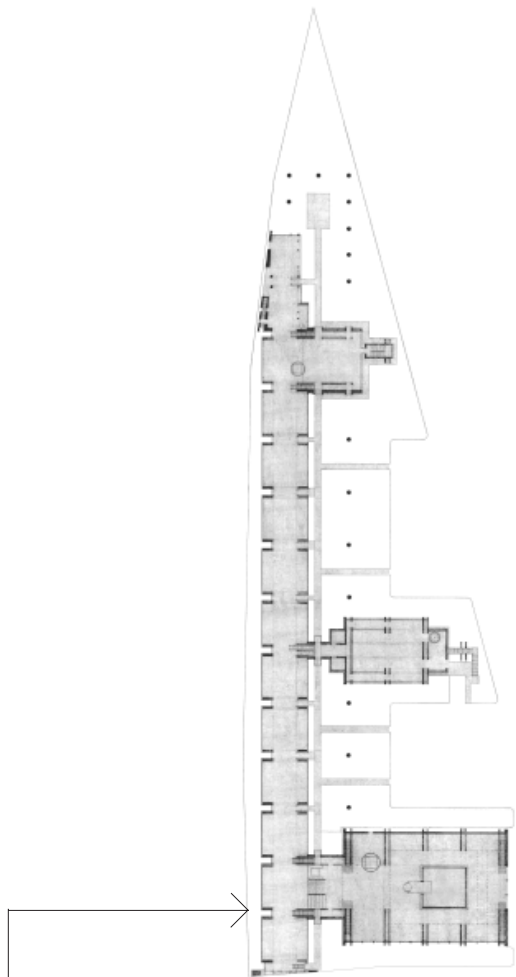


UPPER LEVEL PLAN



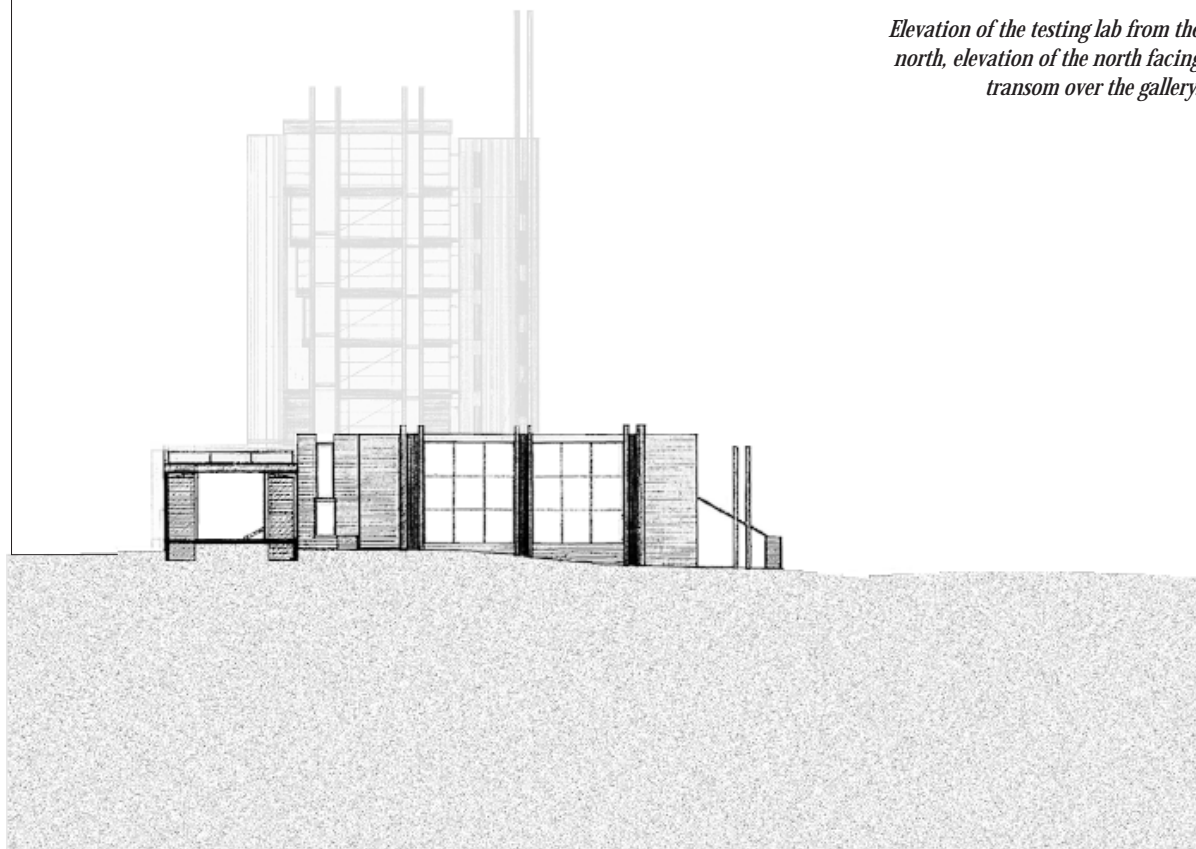
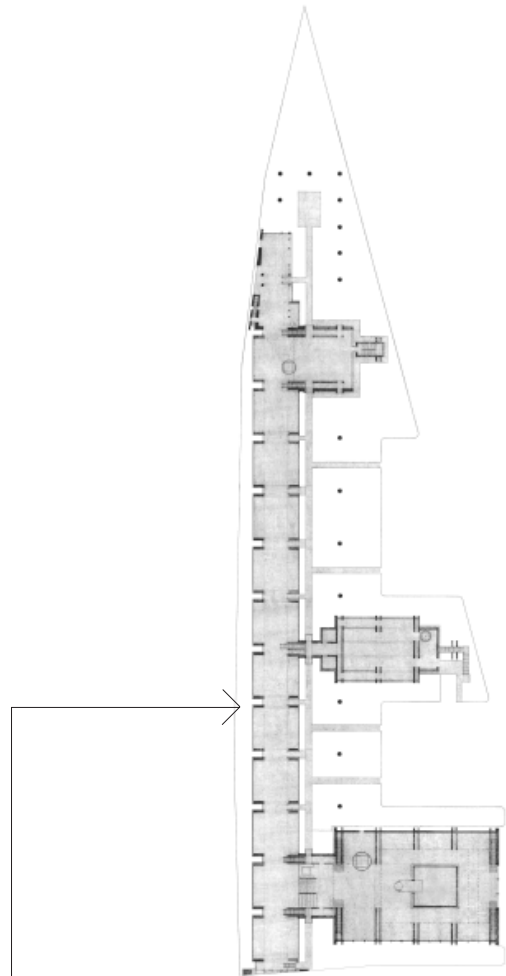


*Plant Elevation from the North,
Section through Gallery North Terminus
shows the stair to loading dock level and
sidewalk pass through opening.*

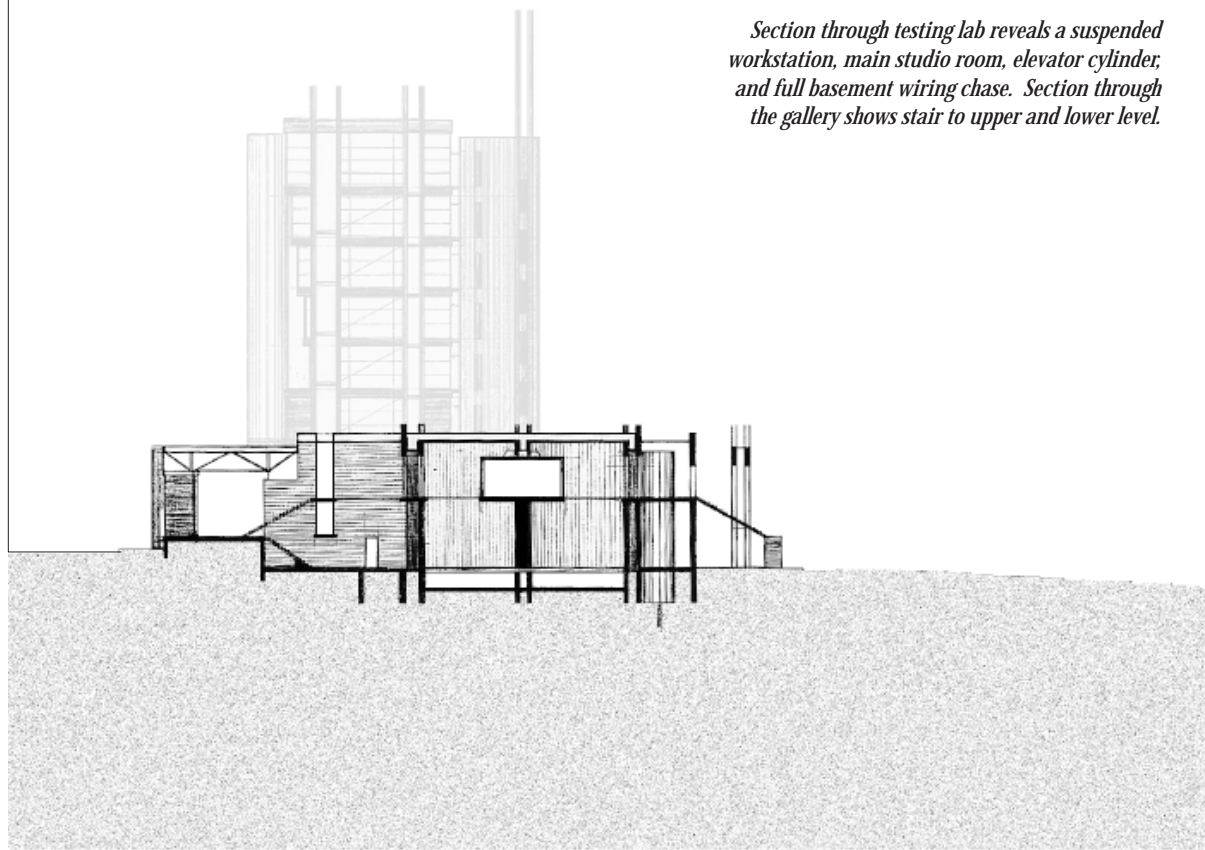
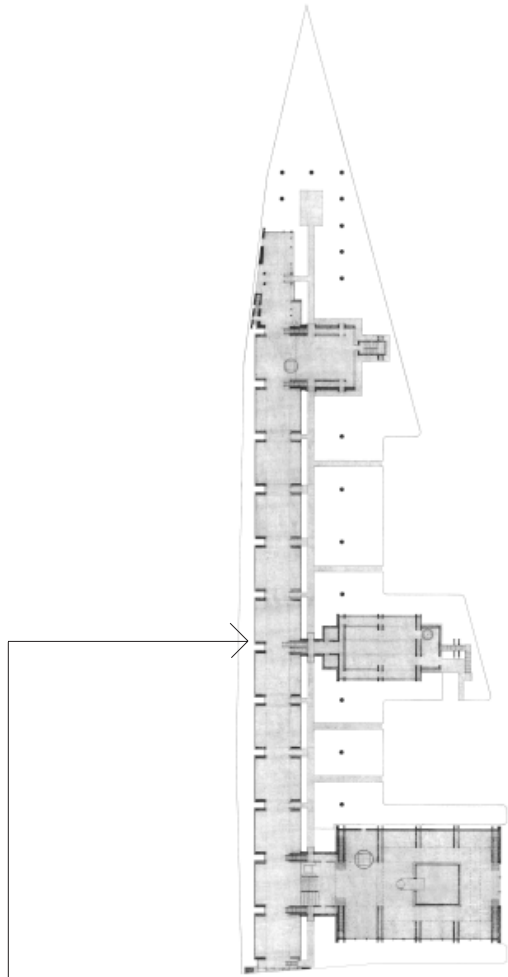


Section through Plant, Gallery and Connector reveals the stair to the mezzanine level of the plant, the stair to the manufacturing floor, and the laminar flow clean room. The cylinder contains a freight elevator which serves the mezzanine, manufacturing floor and mechanical basement below.



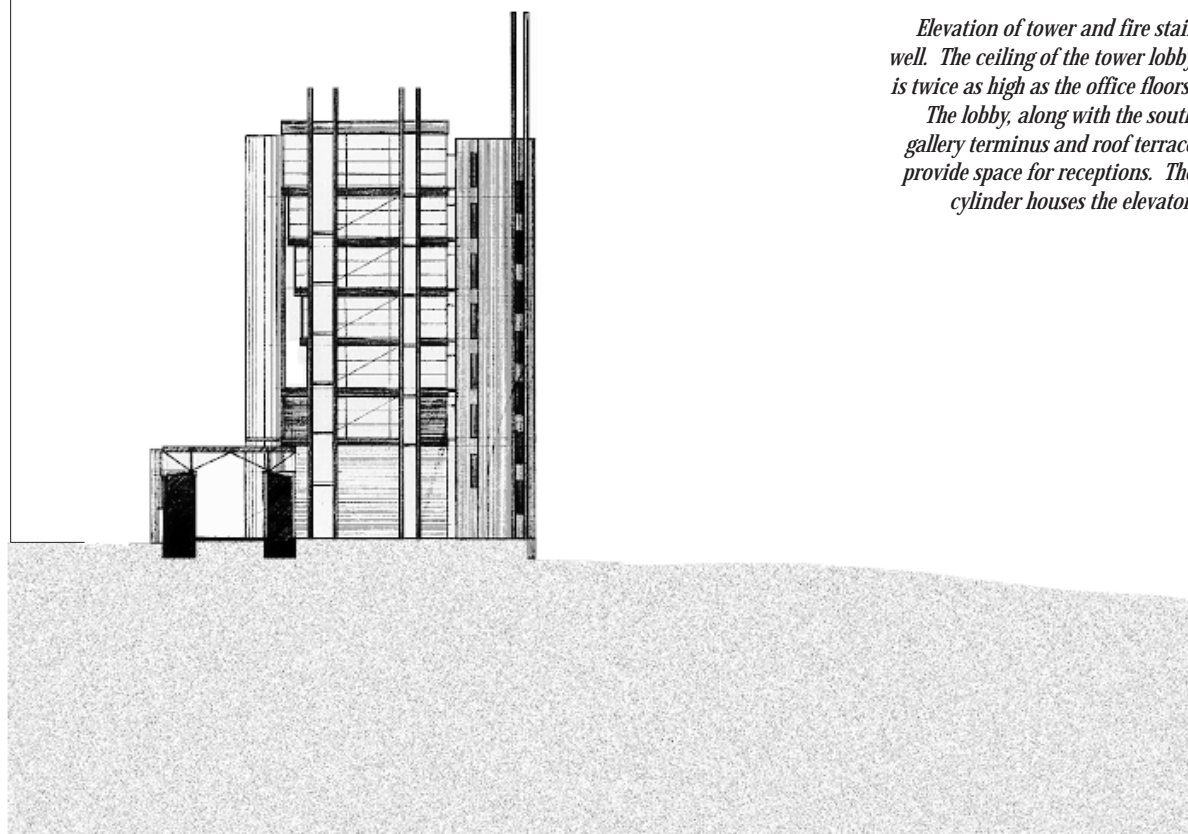
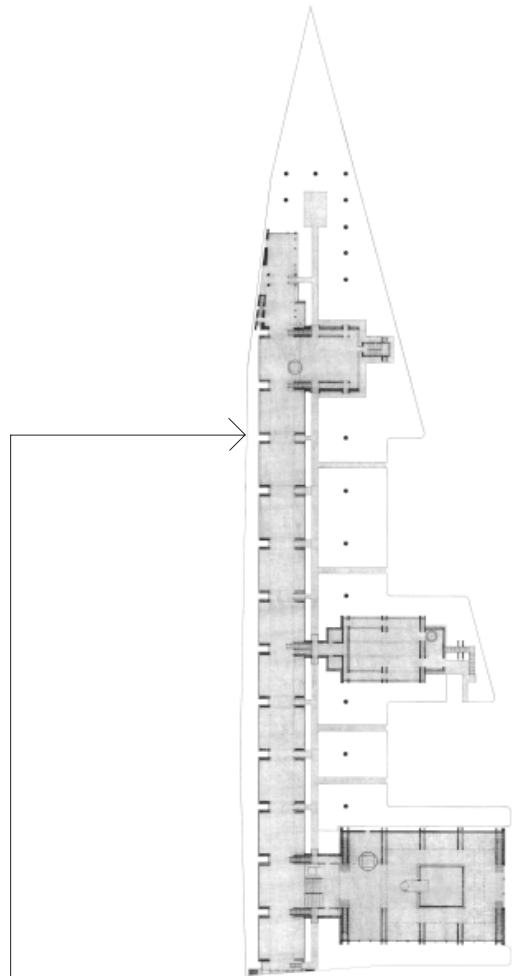


Elevation of the testing lab from the north, elevation of the north facing transom over the gallery.

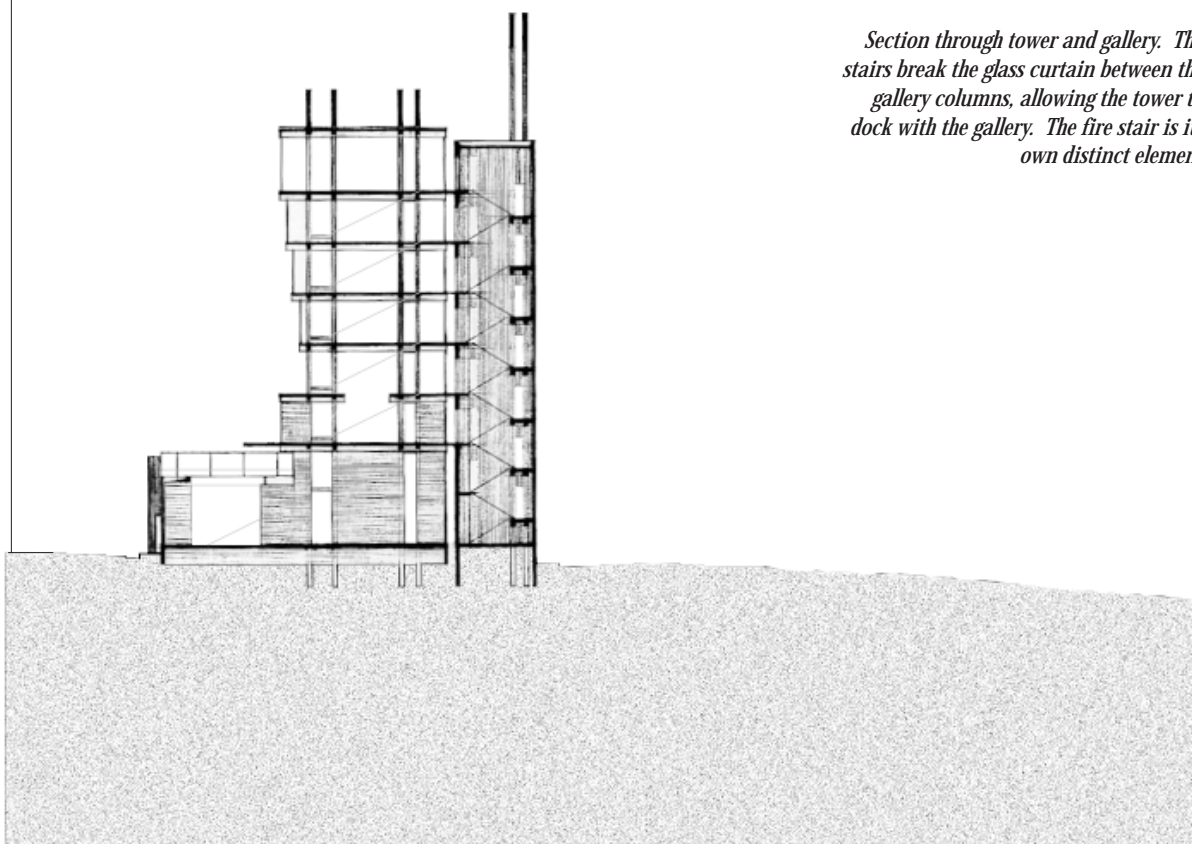
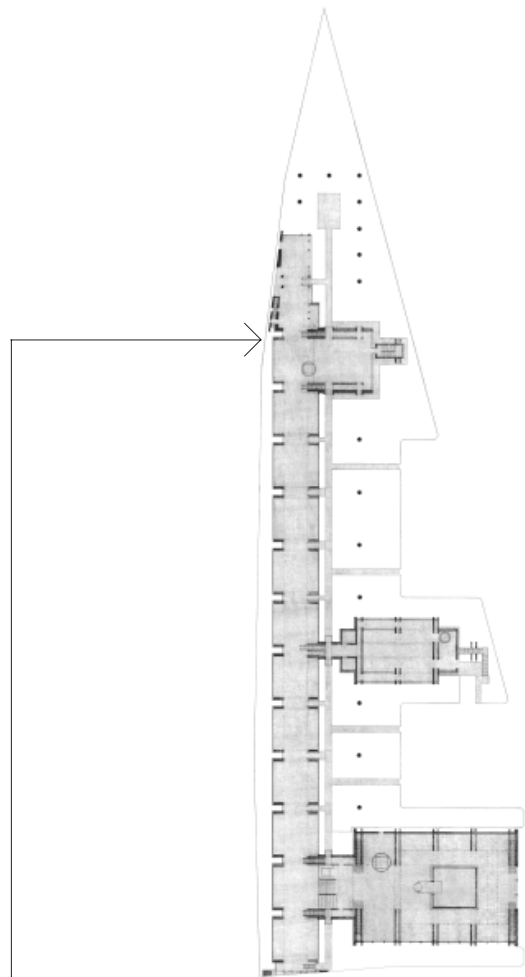


Section through testing lab reveals a suspended workstation, main studio room, elevator cylinder, and full basement wiring chase. Section through the gallery shows stair to upper and lower level.



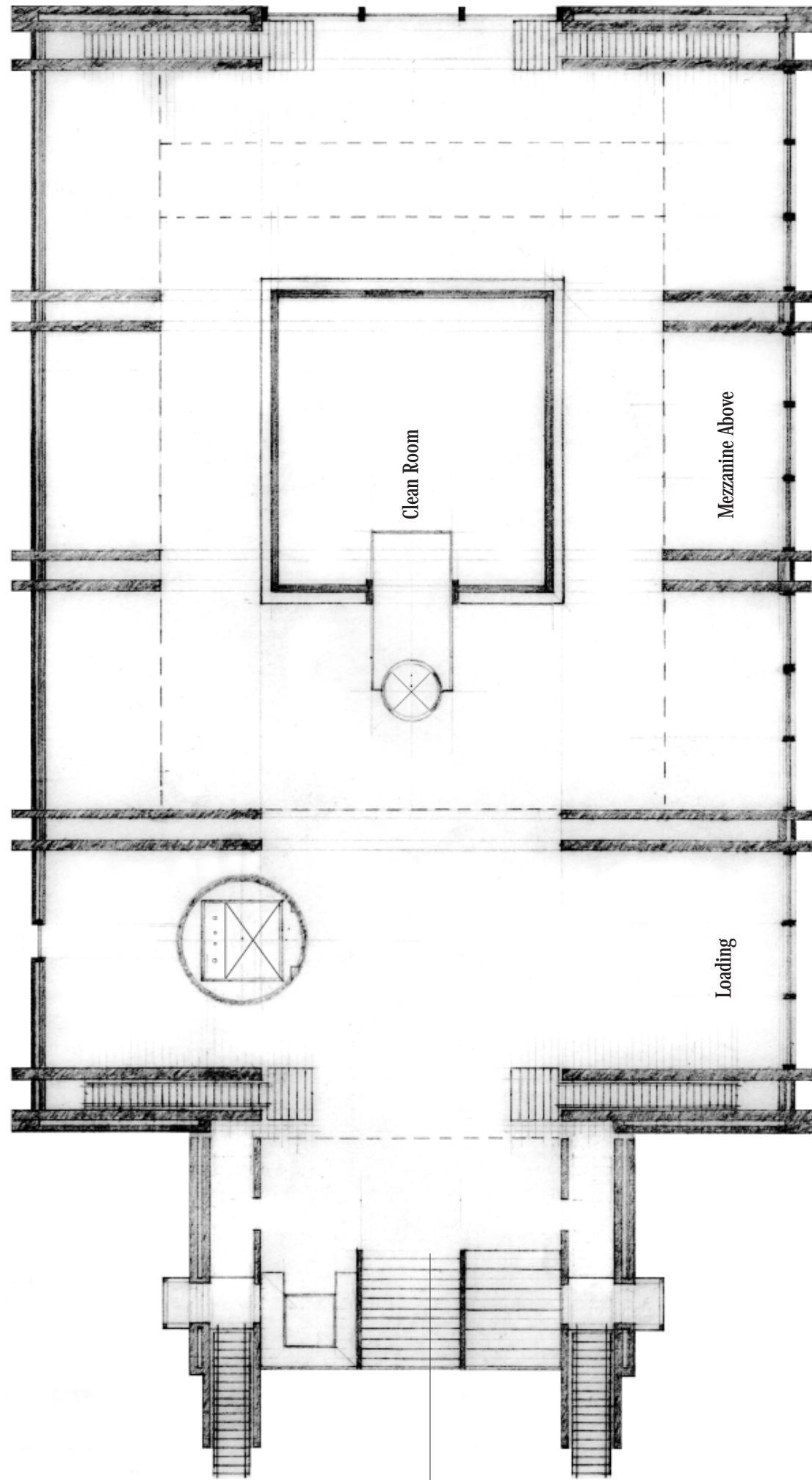


Elevation of tower and fire stair well. The ceiling of the tower lobby is twice as high as the office floors. The lobby, along with the south gallery terminus and roof terrace provide space for receptions. The cylinder houses the elevator.

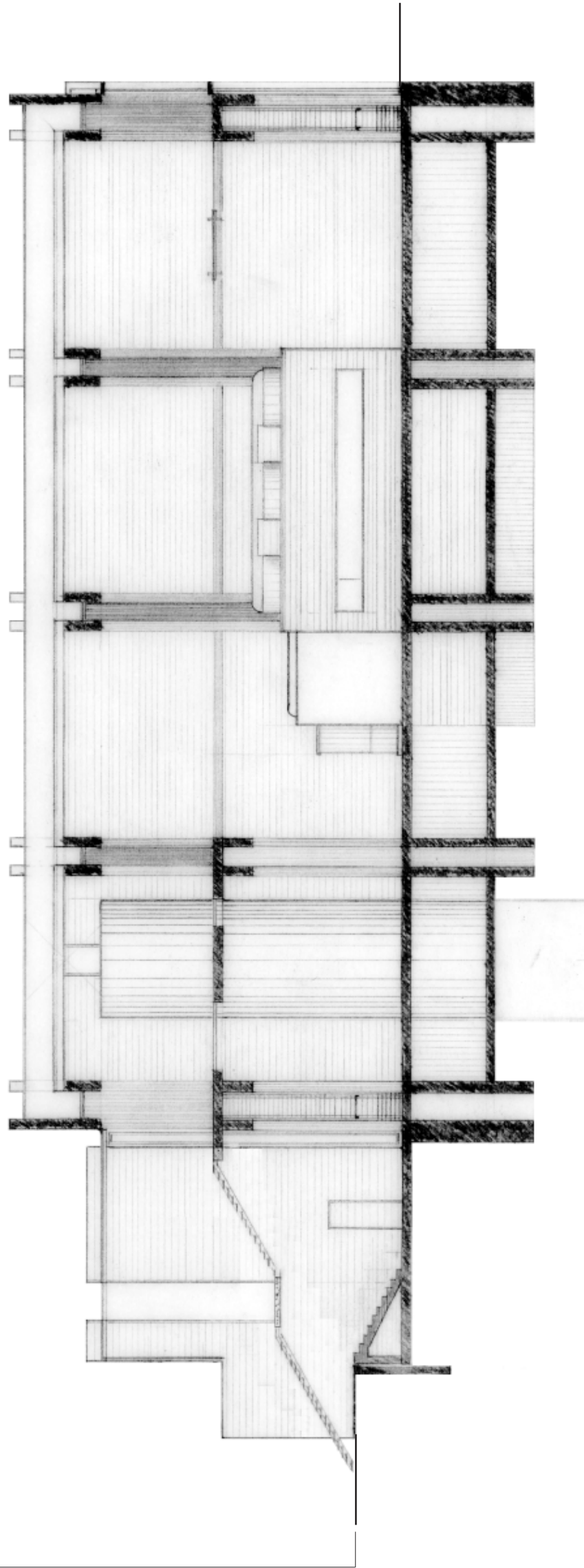


Section through tower and gallery. The stairs break the glass curtain between the gallery columns, allowing the tower to dock with the gallery. The fire stair is its own distinct element





First Floor Plan of Plant

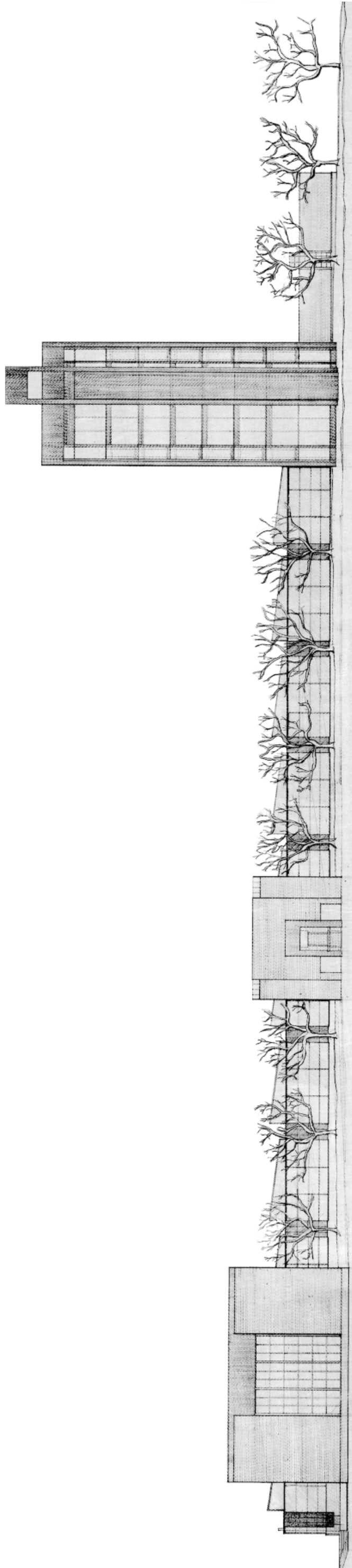


Section Through Plant



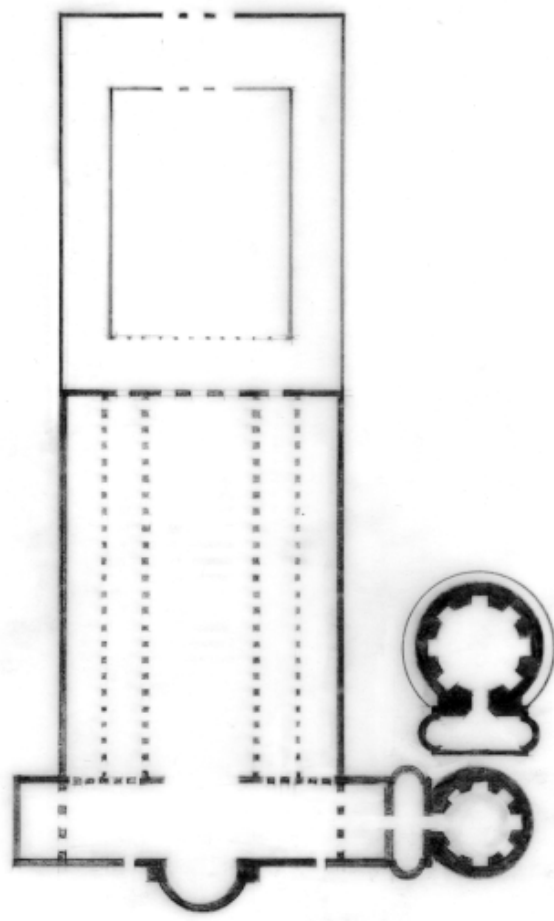


Elevation from the east.

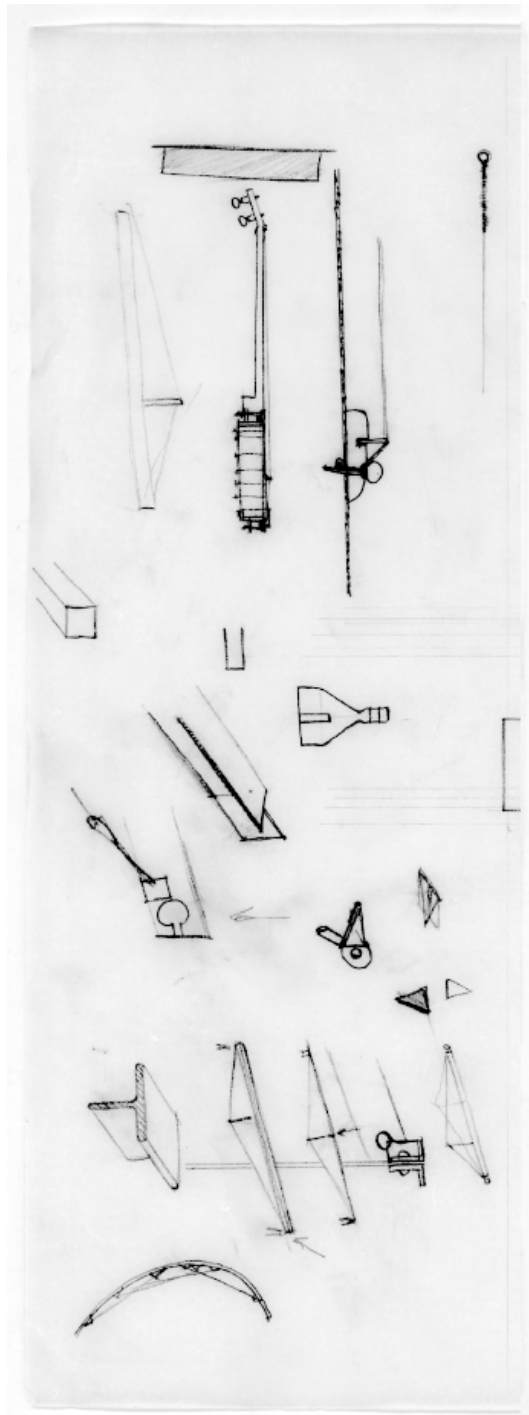


Elevation from the west.

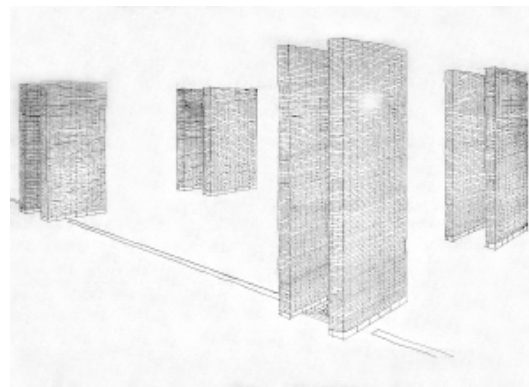
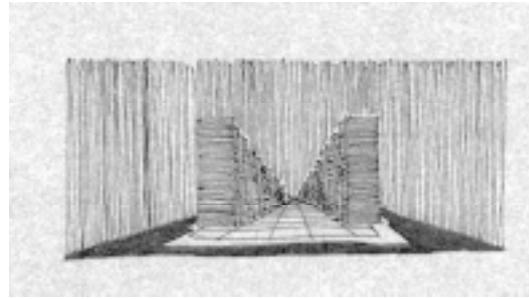




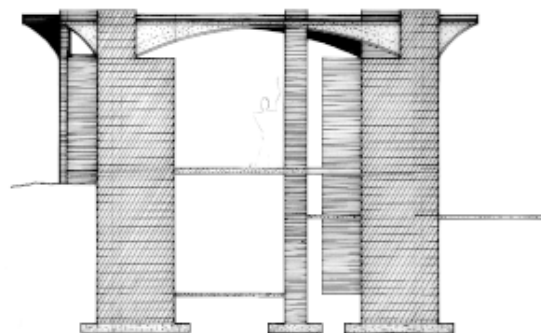
The way the building is ordered can compare to the order of the cathedral. There is a protected court for the approach of the initiates. There is a gallery where the worshipers may gather, a separate baptistry to confirm faith, a reliquary to venerate the relics of history. There is of course a living church where specially attired priests generate new artifacts for the faithful, an industrial transubstantiation in tungsten and glass.



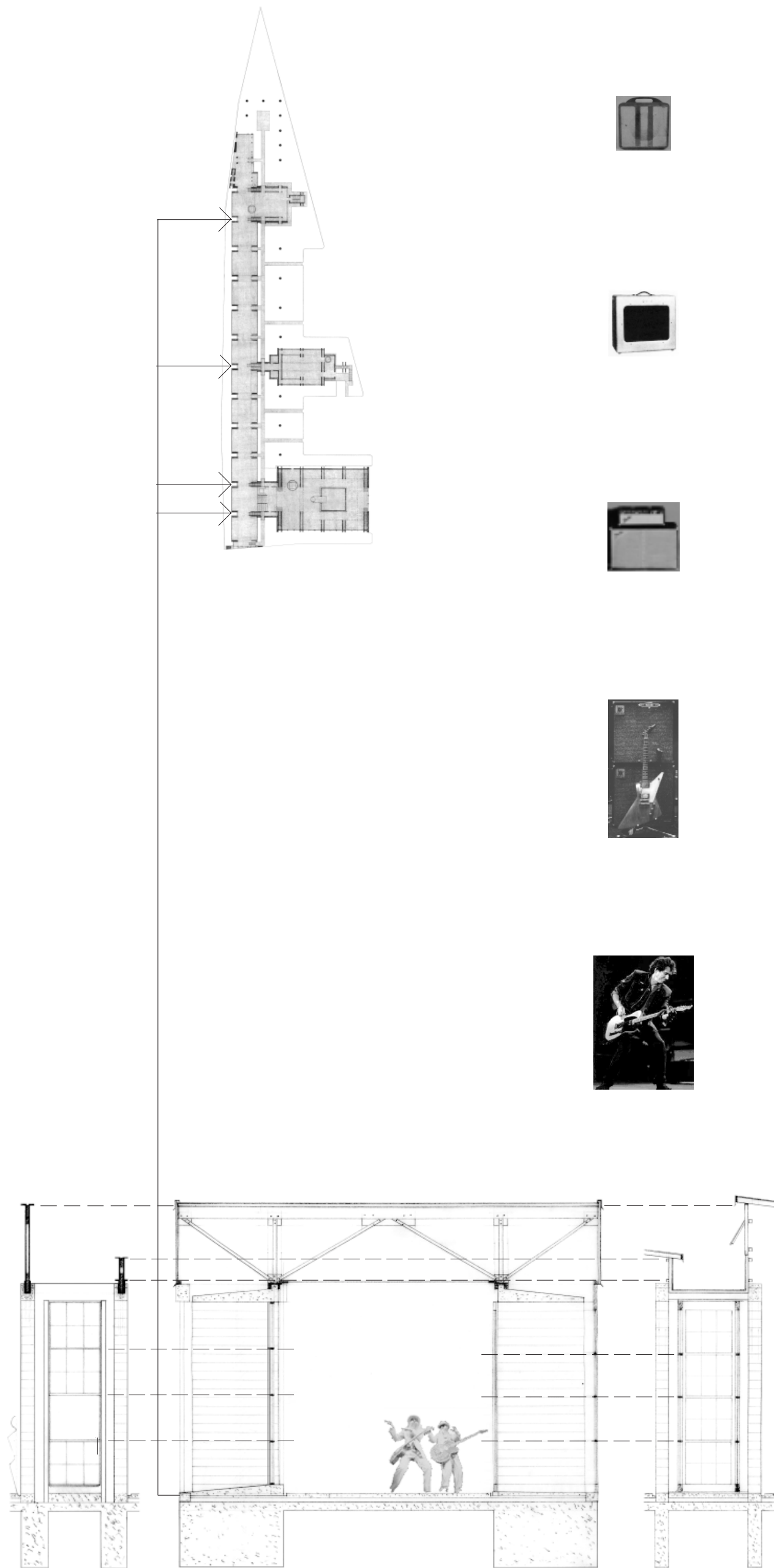
Studies for gallery components in tension using stringed instruments for inspiration.



Preliminary studies for gallery space using paired piers.

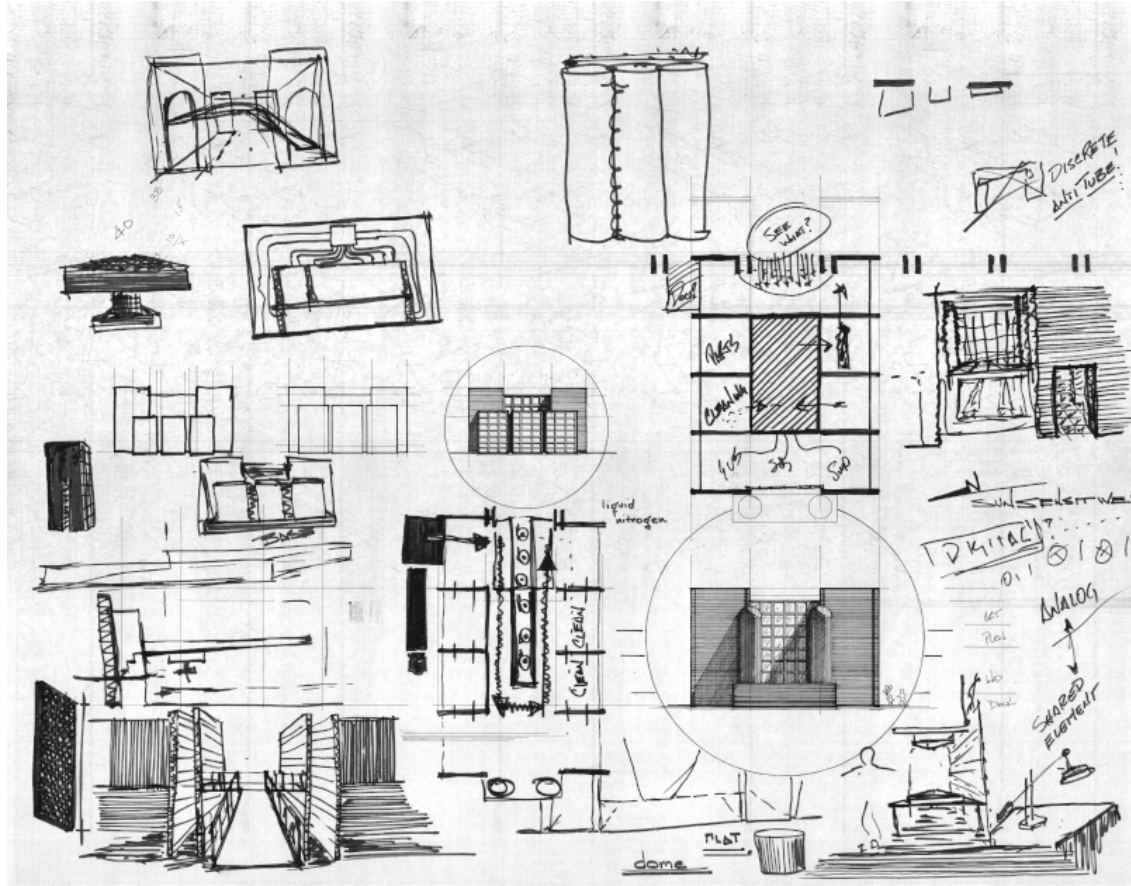


Study for gallery with piers and cast concrete arched roof support.

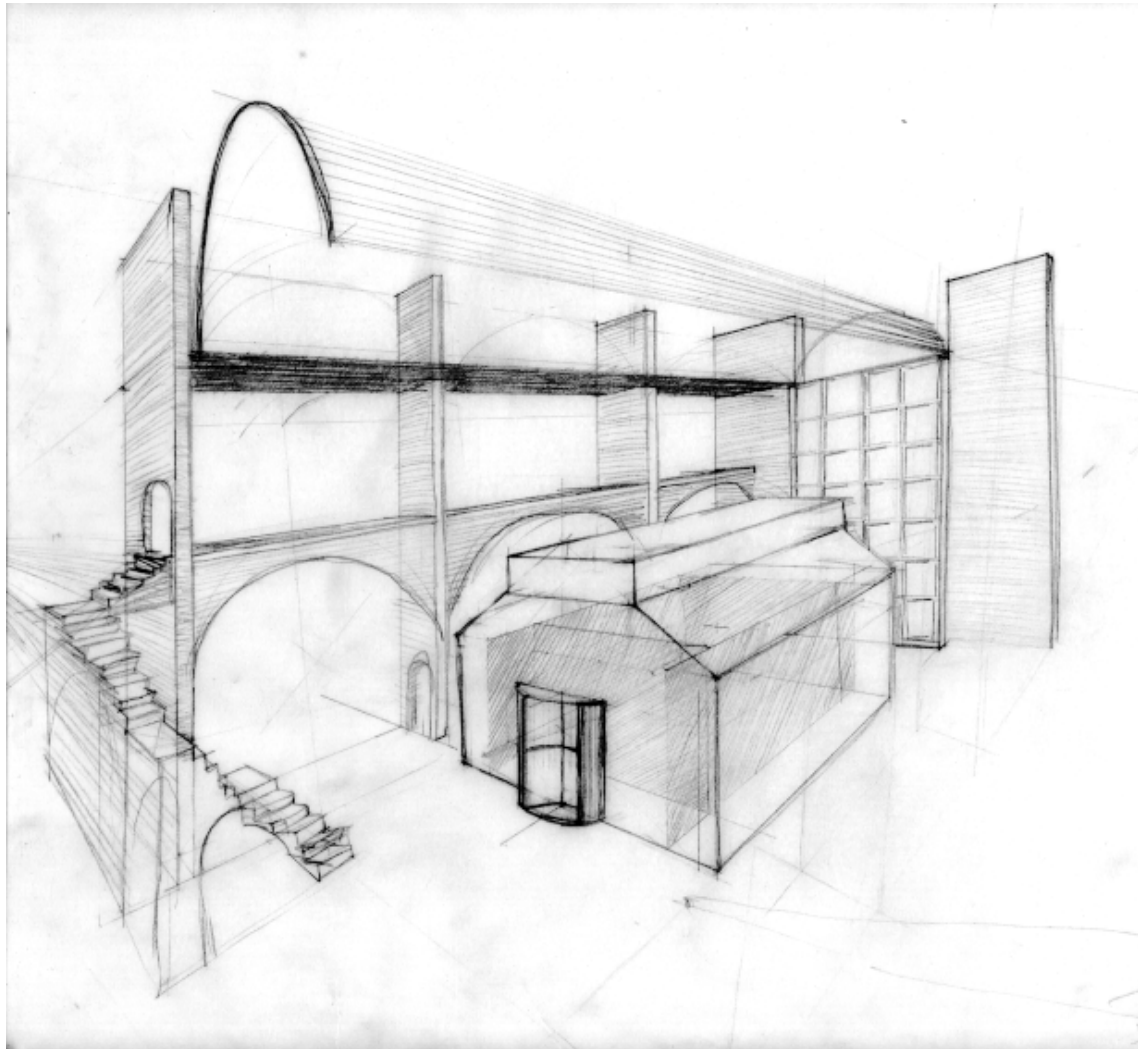


Cross section of gallery corridor with sections through west and east doorways.



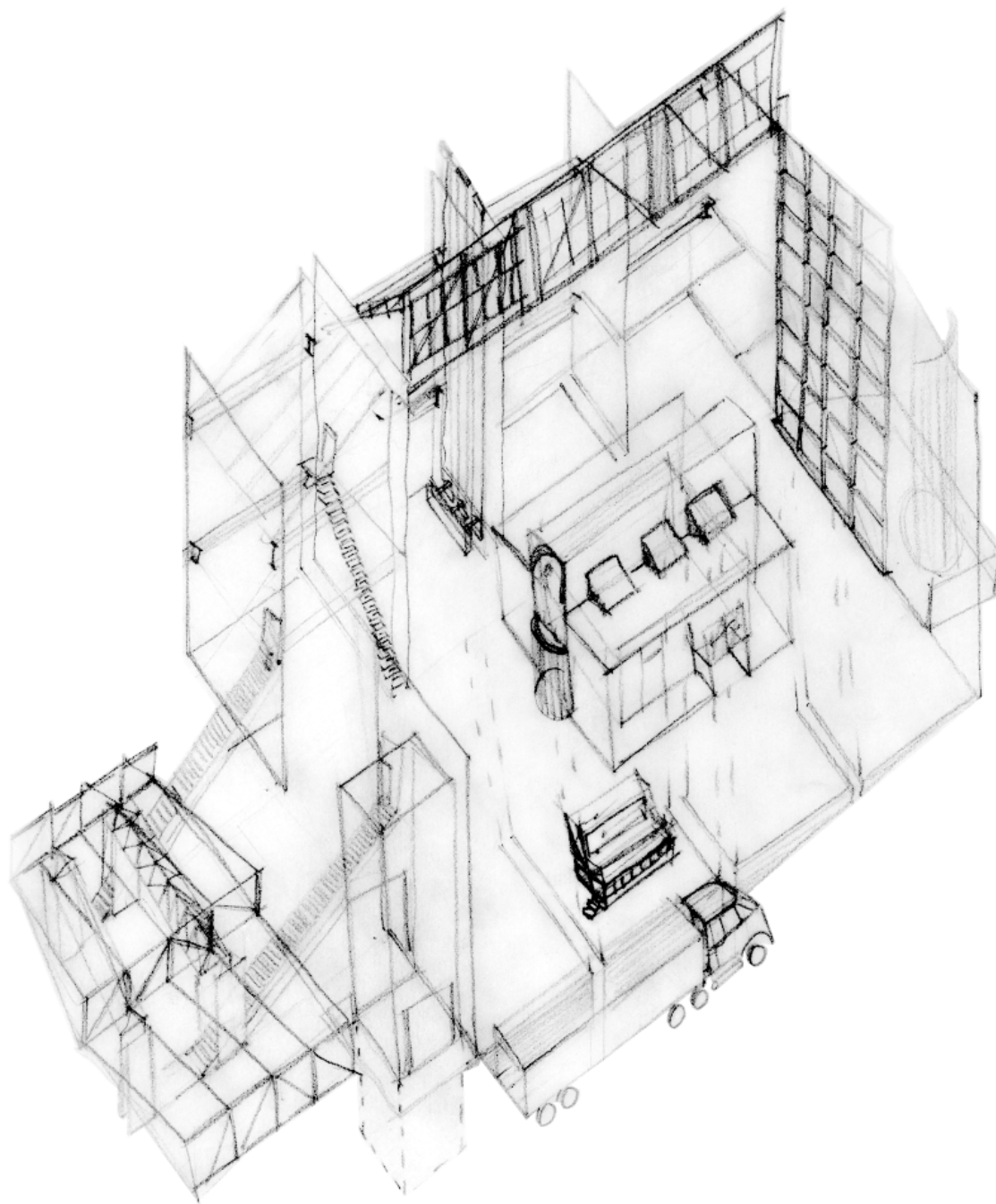


Study of plant elevations, diagrammatic plan, product flow, and building relationships.

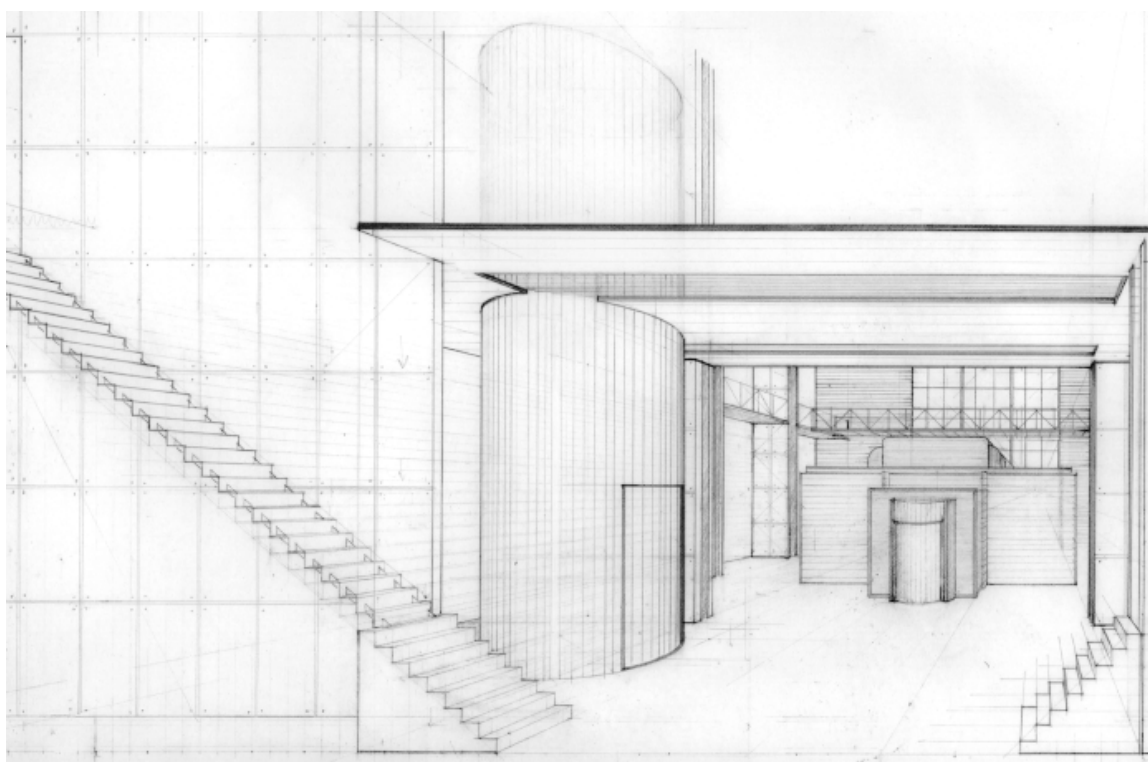


Early perspective of plant showing mezzanine, stair, and clean room.



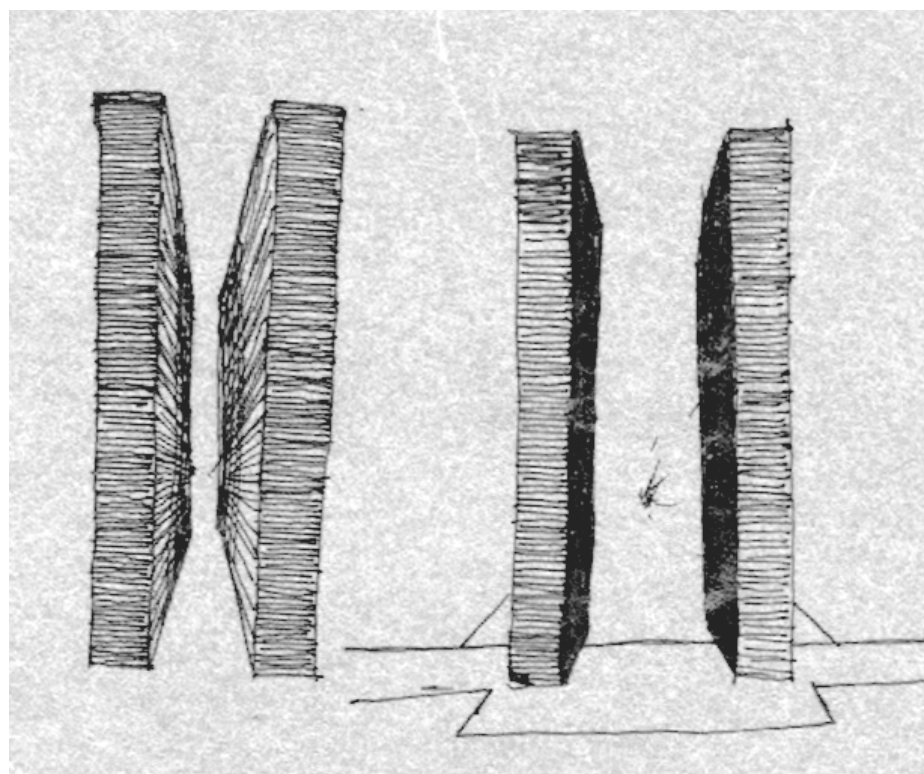
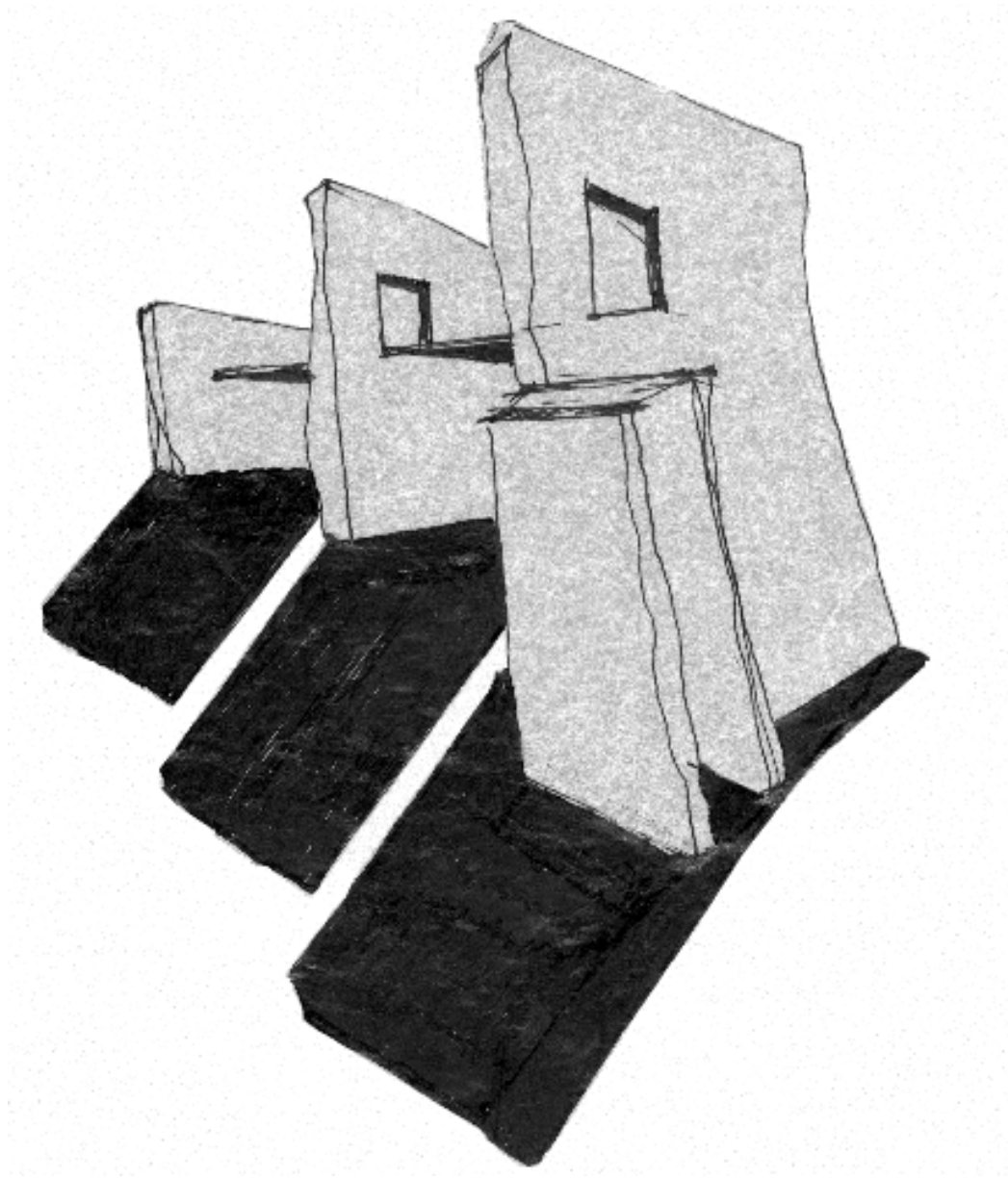


Early axonometric studying dock, flow through plant, and relationship to gallery space.

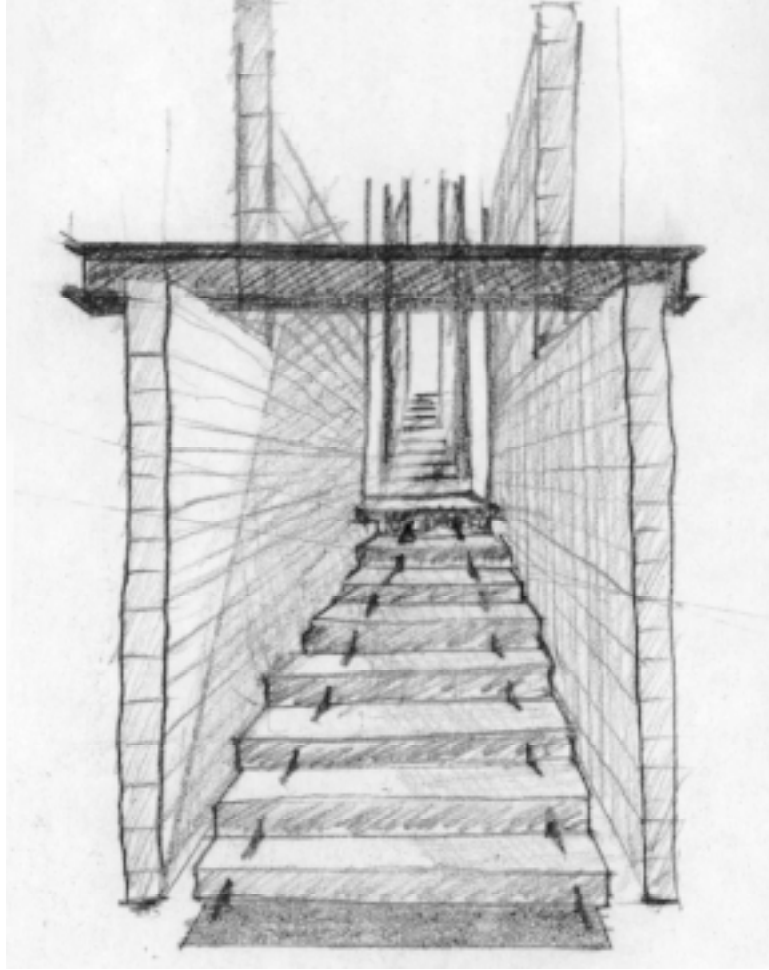


Perspective of plant interior showing clean room, elevator cylinder, mezzanine bridge, and between wall stairs.

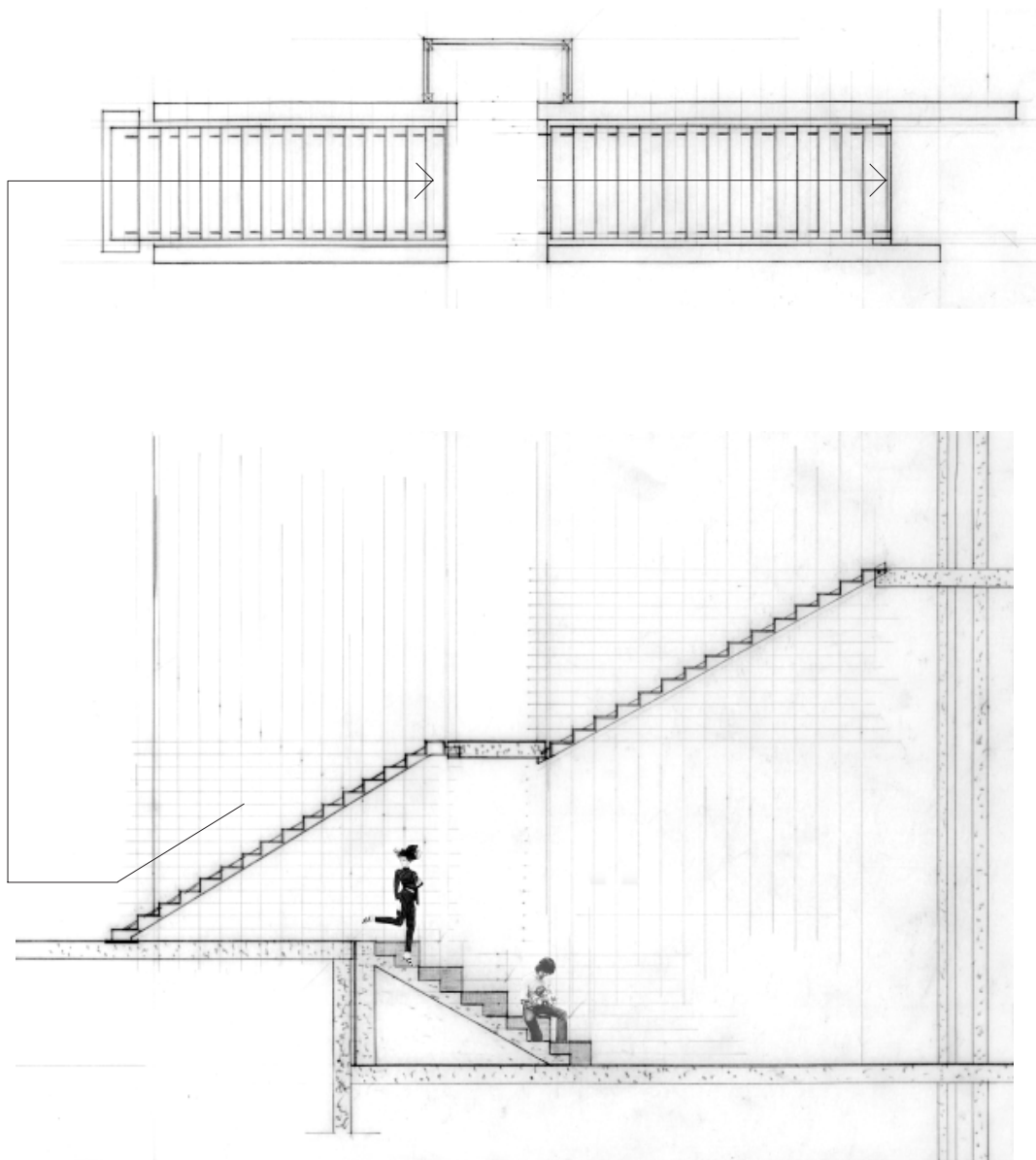




Studies of massing of double walls, feeling of betweenness.

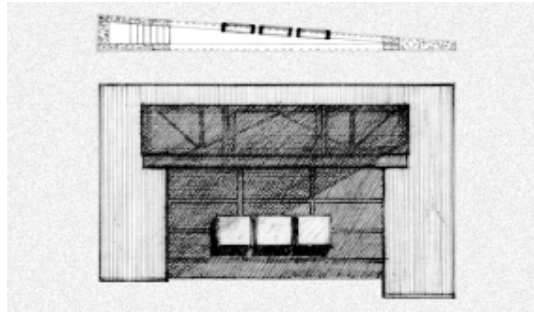


Study of stair between gallery and plant mezzanine.

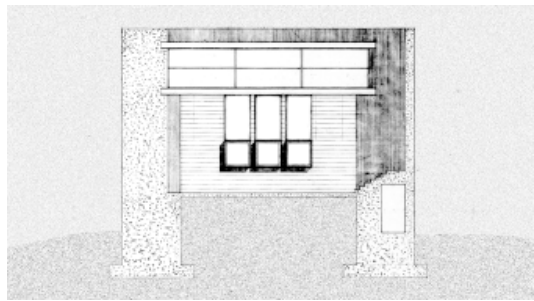


Plan and section of connector stair from gallery to upper level of plant with sectional study of sitting and walking stairs to plant level.

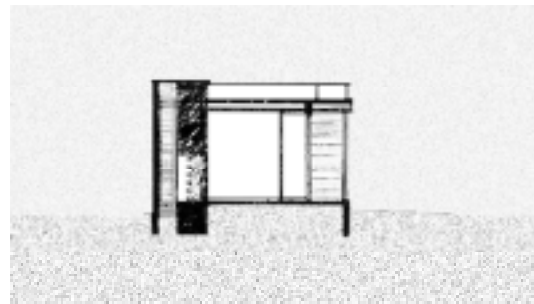




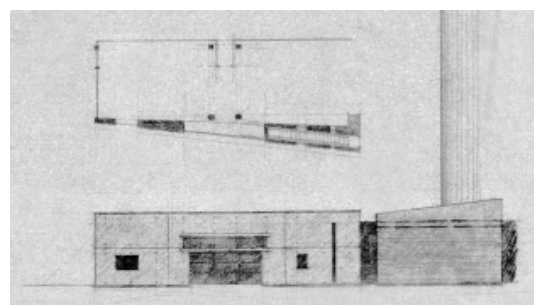
Plan and elevation of north gallery terminus.



Section through north gallery terminus.



Section through south gallery terminus.



Plan and elevation of south gallery terminus.



Andrew James Rauch
December 6, 1958

Bachelor of Arts
University of Pittsburgh
December, 1989

Instructional Fee Scholarship
VPI&SU
1991-1993

Graduate Teaching Assistantship
VPI&SU
Frank Weiner
1990

Master of Architecture
Virginia Polytechnic Institute and State University
June 1998

