A VERTICAL STREET

by

NAOMI NEWELL

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE
DEGREE OF
BACHELOR OF ARCHITECTURE

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 4, 1970

Signature of Author............................
Department of Architecture, June, 1970

Certified by......................................
Thesis Supervisor

Accepted by........... /\ Chairman, Departmental Committee
on Graduate Students

Archives

NOV 16 1970
A VERTICAL STREET

by

NAOMI NEWELL

Submitted to the Department of Architecture
in June, 1970
in partial fulfillment of the requirements for the degree of Bachelor of Architecture

ABSTRACT

This thesis embodies a development of a particular three dimensional urban growth form: a Vertical Street. It is an attempt to provide vertical as well as horizontal zoning in an additive rather than megastructure form. It allows of use change and individual building of volumes of space in a random way vertically as well as horizontally. The method of fulfilling this objective is one of ascertaining vertical transportation needs and vertical core service needs for the individually built spaces, and then of building the transportation and service into permanent cores, or Vertical Streets. Next, semi-permanent columns are built as needed in an additive way, and the individual builds to these columns and plugs into the street services. Such individual building is to be done in easily demountable or semi-permanent form to allow of changing use of the permanent street services.

Thus was developed a hierarchy of items according to their permanency. I kept trying very hard to build into the individual item the type of permanency which would most benefit urban growth in a changing situation.

Thesis Supervisor: Edward B. Allen, M. Arch.

Title: Assistant Professor of Architecture
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>I</td>
<td>PREFACE</td>
<td>4</td>
</tr>
<tr>
<td>II</td>
<td>INTRODUCTION</td>
<td>8</td>
</tr>
<tr>
<td>III</td>
<td>DRAWINGS</td>
<td>11</td>
</tr>
<tr>
<td>IV</td>
<td>THESIS RESEARCH INCLUDING BIBLIOGRAPHY</td>
<td></td>
</tr>
</tbody>
</table>
This thesis has a long history. It would never have been born had it not been for a course called Graphics in which Nicholas Negroponte had a professorial hand. He wished that each of our group look at some phase of urban development; and I chose to analyze types of growth within the city core both of urban generators and of services. This analysis showed that some things tend to come a certain size, then repeat; some things tend to grow to a certain maximum size related to the population; and some things tend to be totally unpredictable in growth. With his encouragement, this analysis grew into an approach to organizing certain urban facilities.

The approach I reached was one attempting, first, and foremost, to ascertain the natural resources of one area and set a maximum population related to such necessities as available water. Also, ecologists were to set aside to be permanently left open those areas needed to maintain balanced land use. Next came the attempt to organize the no-growth and limited growth activities in such a way (perhaps linearly) that they would relate to each other in a meaningful way. As these activities are relatively predictable, this approach seems feasible. Other areas must be left to develop in an unpredictable way, and means of eliminating conflict between the unpredictable areas and the predictable-growth areas must be found, as well as means of minimizing conflict between various unpredictable activities.
The following year, under the aegis of Professor Edward Allen in a special design problem, I worked out a plan view of an urban growth system which put into two dimensions the previous verbal criteria and notions. At his suggestion, I chose an area presently relatively undeveloped, and tried out the criteria I had established. The area I chose was of the Springfield, Mass., Amherst, Chicopee, Belchertown, Holyoke area including part of the Quabbin Reservoir. This area included an important transportation crossroads in Springfield, mushrooming educational facilities, farmlands in large Connecticut River plains areas, and Berkshire foothills such as Mt. Tom. I superimposed a population of one million people on this area in towns of approximately 100,000 population each, but within one total transport network, including one airport. To the astonishment of both of us, I managed to fulfill every criterion I had initially listed as inviolable. The success of this project was in no small part due to Professor Allen's understanding not only of architecture and urban planning, but to his understanding of me and his patience with some medical difficulties I had at that time.

When I mention such things as medical difficulties, this thesis would never have been started, let alone finished, unless at least five different medical doctors at different times during my M.I.T. career had absolutely insisted that I must keep going with my projects despite serious illness or the threat of it. They were adamant in their stand, and this gave me the backbone to continue.

Neither would it have happened had my family not
indulged the implacable whim of its most zany member and allowed it to be. My mother, who typed my papers (since typing is not one of my accomplishments) and worried me through in good motherly fashion; my brother Joe, who shoved me by brute force through the incongruities of two non-consecutive Calculus terms and took time to answer my questions about structures; my brother Bill, who kibbitzed from his job in Europe and lent me both money and moral support; my brother Fred, who wished me well.

Then came the thesis itself. I decided to try to develop a three-dimensional urban growth system based on the previous two urban projects. The type of activity I wished to cater to was that of the densely built urban unpredictable growth. I tried to think of ways that would make it easy to change the use of a given volume, and also to make three-dimensional zoning with vertical, as well as horizontal, ownership possible. I wished to rule out a megastructure. It seemed to me that if services could be supplied in a core, a sort of vertical street would be formed that could be plugged into as buildings now plug into the services of a horizontal street. Thus, the idea of a vertical street came into being.

Professor Burton Rockwell helped me to develop this idea in my Thesis Research. He steered me in the practical application of many of the building services such as electricity, and with his experience in dealing with the mechanical equipment helped me to decide which areas needed the most study. I evolved a system based upon residential and office
uses, for finding out how much of a given building service such as hot water or elevator was needed per running foot of built space; and therefore, how much is needed in each core area. Also, I found methods of judging distances between cores. Professor Rockwell tried mightily, and to a degree succeeded, to help me to keep some sense of perspective in this project which was such a departure from the usual one.

Professor Edward Allen picked up again with the project of the thesis itself, and has managed to weed out my ideas and make suggestions which have been most useful. With his help, and that of Professor Eliahu Traum to aid me with the Structures, and the continuing interest of Professor Rockwell, one personification of the abstract idea of a vertical street has come to fruition.

Along with my feelings of appreciation of and gratitude for all the people mentioned above, I should like to mention one more. Before I came to M.I.T., I sought the counsel of the now Dean Lawrence B. Anderson in trying to choose a course of action. I hoped to enter college as a Special Student, if it were possible. He explained to me that the method was one which was discouraged in the Architecture Department - then told me how to go about it. Lacking his support, I never would have been able to begin this project. The unending patience of the Department with my struggle to fulfill a large number of lacking prerequisites was something for which I cannot adequately express my appreciation, either. This thesis would never have happened without all these people.
II. INTRODUCTION

A vertical street is the subject of this thesis. Previously, I have defined a street as a direction of travel of people, goods and services. Here I have tried to develop this concept into the third dimension so that the skeletal structure of urban development can become a three dimensional one. If this skeleton can be built in a relatively permanent way, then the remaining built volumes may be less permanent and therefore more adaptable. Adaptability is the main thrust of the whole idea.

This street system was superimposed on the two dimensional town system partially explained in the preface. The town which I have used as a basis for this scheme has the following criteria: it has a central total energy system which includes waste and sewage recycling; it is hooked into an inter-city automated highway which makes use of standard sized automobiles with an automatic arm added so that they can be computer-run; it is also connected to a Pero system of core transit which has been explained by Dwight Baumann in "Compatible Automation of New Town Transportation," 1969, and which has been worked out to travel vertically as well as horizontally. The Pero system, as here used, is comprised of a 2- or 3-person vehicle and can have some municipally owned Pero capsules as well as some individually owned ones.

There has been an effort to separate vehicular and pedestrian levels in the most dense areas. Therefore, I have
shown the vehicular level, then the pedestrian one, with the Pero transit level above that. These decisions were made in the previous two-dimensional phases. The method here of putting this idea into the third dimension took the form of standardized shafts for services which can then be massproduced in segments. The use of these shafts at intervals as required to meet the needs of volumes they will service is the basic approach. (The method of ascertaining the intervals is described in the thesis research at the end of the thesis.) Where clusters of shafts are needed, these will be connected to each other by trusses to make a stable vertical street of a permanent nature; a street which is penetrable, one which will serve as a stabilizing, shear-absorbing core for larger built volumes. With the addition of columns where needed and temporarily buttressed against buckling until the volumes are built, the system becomes a complete skeletal system.

The idea has been that the town could build this skeleton for the individual owner, or perhaps a turn-key type of builder might develop services to this point. Then individual owners could buy volumes and build to their own specifications. There would necessarily be more limitations on a volume in the air than the now standard earth-bound one. Weight limitations must be imposed according to the columns. Weight must be taken by welded shear plate connections into the columns as described in the drawings. Fire proofing and limitations of adjacent uses must be much more carefully
Use of roofs below by people as terraces must be worked out. Care must be taken that the services in the street will not be exceeded when they are plugged into and metered for by individuals. In other words, if the street is built for housing, it would be unwise for a laboratory to move in unless adjustments were made in available services. It would be possible for this owner, perhaps, to add a service shaft of his own, provided pollutants could be taken care of to the satisfaction of abutters.

In other words, with this system, there is much more flexibility, but the flexibility carries with it the responsibility of working out the frictions at each interface: physical, service, or human. The complexity seems multiplied by adding one dimension, and I am fairly certain that the seeming is in reality a truth. And yet, I still find the idea of a three-dimensional skeleton an intriguing one, especially where we are considering a three-dimensional life-form.
It seemed wise to find the problems first, then they were solved.

1. Balanced view helped.

2. Problem hunting at lower levels.

3. Core as at left

4. Horizontal expansion at heights?

5. Service shafts

6. Deepest mass transport

7. Pedestrian mall

The idea is mass, producible vertical shafts for services, connected by buses for a penetrable core or shaft.

Add spiral columns for individual builders.
A VERTICAL STREET SKETCHES

June, 1970 M.I.T.
Naomi Newell

2

8. Use of the System:
   a. Three-dimensional.
   b. Linear & three-dimen.
   c. One core, built.
   d. Two cores, connected.
   e. New street, pass, dimens.

9. Relating columnar structures, horizontal and vertical.

10. Breaking apart the pieces to use them.

11. Another try.

12.
TOWN PLAN

A VERTICAL STREET
TOWN PLAN

June, 1970 M.I.T. Naomi Newell
A VERTICAL STREET

ELEV. PLAN & D'T'LS

B. Arch Thesis

June, 1970

M.I.T.

Naomi Newell
A VERTICAL STREET PERSPECTIVES

June, 1970

M.I.T. Naomi Nuelle
A VERTICAL STREET
THESIS RESEARCH

First off, actually what is a vertical street? The reason for this project is to study what one might be. In densely populated urban areas where uses for spaces change with time, where multiple vertical uses and ownership become an advantage, and where technological advances need to be quickly incorporated into the environment we need new building techniques. Huge loft buildings are not very humane, megastructures even less so; and most everything else suggested to date has been more of a toy than a "real thing." Fair enough: toys are to learn from. They are a beginning.

My thought was that, if we could supply streets vertically as well as horizontally, we could work into a true three-dimensional urban growth form which could act as an urban skeletal structure. But to analyze what a vertical street is, we must first define what a street is in the general sense. To my mind, a street is primarily a way, a possible direction of travel, for both people and the goods and energy needed by people. I should like to deal with a street which makes possible a vertical direction of movement for people and goods, and also life support systems such as heat, energy and water.

This street could be publicly built, or privately built by a developer, although probably ultimately it would be publicly owned. It would make accessible, as individually buildable volumes, spaces above the ground. These volumes could be privately developed, or built by a developer who
sold or leased them. The street would most likely be located near an urban node of dense growth where a change in use of spaces might be implied by the area itself.

For this particular street, I have selected a very restricted set of circumstances in an attempt to find out how to approach the problem. This is a single street, with options to connect horizontally to another, but a single street none-the-less. It is ten stories tall, assuming that if a street of that height can be worked out, then one of a greater height can be tackled later, using this as a pilot model. The horizontal size of one street is something which has to be studied and will be discussed later. It will depend upon how often a total complement of life support systems needs to be repeated.

This street will be restricted to two uses with the idea that we can learn how to approach use-change by making work a system which allows of only two uses. The two uses I have chosen to serve are residential apartments and/or rooms, and office spaces. I have decided to restrict the apartment spaces to a maximum of twenty feet of private space from light, possibly excluding kitchens and baths, and to restrict office spaces to a maximum of thirty feet of private space from the light.

These numbers are fairly standard ones and different reasons are quoted for choosing them by different sources. Somehow, I suspect that the real reason is that 20 feet is about the maximum depth of an individual apartment room, and this assures few interior spaces. Thirty feet for an office area allows of a good-sized conference room plus an interior
intra-office corridor. It should be possible to develop a more sophisticated set of criteria relating interior spaces to the natural world of light and weather. Types of light needed for different uses have been studied by such people as William Lam, and recently the relationship of a human being to the natural world has come under some scrutiny. Perhaps eventually these studies will crystalize into a new set of criteria stipulating that direct sun must enter each apartment for a certain length of time per day, and indicating types of exterior contact that a human needs. For now, I have accepted the twenty-foot and thirty-foot dimensions, however. Having decided for the time being on this set of sizes and uses as a starting point, it then becomes important to cross-check these with the list of needs established for any use space in order to establish quantities of services required. These needs were originally stated as a list of criteria in a previous report, and I shall now take up the items of that list in order and expand on each in its turn. (Please see the appended page of Criteria.)

The first category on the list of needs to be investigated was the Life Support Systems, their implications and handling. In the course of the investigation, it seemed wise to make a sub-list of these support systems and to deal with each one separately. This list is a little different from the usual one of life support systems for buildings because in the initial stages it was decided that the energy source for the street would be a central energy system for a whole area.
The Vertical Street

Criteria:

1. It must contain life support systems. These systems must be capable of complete change and overhaul as systems developments occur. There must be sufficient redundancy to allow of change taking place sequentially so that service is maintained.

2. Dimensions must be such that a number of differing building uses can be accommodated. These need investigation and coordination. (All three dimensions, including potential distances between streets.)

3. There must be connection capacity for building to take place off the street. Connection types for different potential material and building methods must be investigated.

4. Connection capacity must also be possible between the streets at various levels (horizontal as well as diagonal - moving stairs - need to be considered).

5. Vertical zoning must be possible and should be investigated. Criteria to be met must include the considerations of:
   - Structural support maxima
   - Reasonable adjacent uses
   - Adequacy of needs - fulfillment in relationship of use to height.
It is therefore necessary to supply on the site only those booster systems needed for the built area from the street and not any energy source. Because of the off-site location of the central energy source it would be easiest to supply energy to the street in the form of piping and wiring, and therefore I considered energy sources to be either electricity, gas, or heated and/or cooled liquids or a combination of both. These would be available to each owner and/or tenant on a metered basis. For this reason the standard HVAC (Heating, Ventilating and Air Conditioning) comes under the Plumbing and Electrical headings with only the energy to the individual owner (lessee) being supplied. This leaves the HVAC equipment choices to the individual owner. The list of support systems then becomes:

**Plumbing**

- Fixture Supply
- Waste, including garbage
- Heating and Cooling Supply
- Pipe for concrete, etc., for future building (to replace construction elevator when possible, as with the system of Prof. Allen mentioned later)

**Electrical**

- Lighting
- Fixtures
- Heating and Cooling (direct or equipment)
- Telephone (and other communication)
Vertical Support

Stairs
Elevators
Pero Capsule
Escalators

Waste Disposal:

Garbage into Sewage Waste System
(or incinerator; mechanical chopper and compressor)
Shredders (for paper goods)
Grinders (for glass, metals and solid material)

Crane

Built-in support for crane for top of street which can be used for future building or renovation.

In looking at each of these items separately, and at some of them together, it seemed that the plumbing and electrical services could each be handled best in a vertical chase, perhaps prefabricated in sections and large enough to contain a central platform at each floor level in order to aid in service and rehabilitation. These chases should be adequate in size to allow of changing over to an entirely new system while an existing one is in use, and also to allow of potential increased services later. In order to allow of easier servicing of existing systems, it might be reasonable to manufacture the lengths of piping and conduit to the same dimension, that size being a full "floor-to-floor height" dimension. This is longer than present sizes, but should decrease handling costs since there would be fewer pieces. Also, piping
might become plastic or pyrex. Although the initial cost would be more, ease of finding problems for service would reduce long-term cost.

In some cases it would be feasible to handle both electrical and some plumbing in the same chase. Electrical and plumbing chases seem to have much the same basic requirements, and could be interchangeable structurally. But there must be space inside an electrical chase for panel boards at each floor to distribute the proper electricity from the bus ducts, and there must be space outside for meters; and there must be space outside plumbing chases for meters for water and/or coolant supply lines. This way, no matter how the built volume were later divided, each tenant or owner could be served adequately.

Sewage could be handled at a subsidiary area treatment plant, and then go on to the city plant, or it could go directly to the city plant for treatment. This could include the garbage disposal as well as other wet waste.

The vertical transport is divided into several types, each with separate potential. Stairs must always exist the full height of any vertical structure for power failure and fire reasons. They must abide by the fire codes in matters of placement and fire rating, although new code provisions would no doubt develop on the logic of the vertical street. Elevators are the usual present-day method of vertical transport, and will surely be here for some time. In so far as this street is concerned, alternative methods of transport have been considered and will be discussed later, but at least one real elevator will surely be necessary to deal with people in the
process of moving furniture, with stretchers, various maintenance services and with future building equipment. It would probably be best to count on elevators for internal floor-to-floor transport inside one street, also.

The Perc system mentioned above on the list was first talked of in Project Metran as a horizontal system and has since been augmented to contain a vertical component as written about by Dwight M. B. Baumann in his report, "Compatible Automation of New Town Transportation," presented at a transportation workshop on December 8 and 9 of 1969. This system is composed of small 2- or 3-person vehicles running on their own track separate from automobiles and pedestrians, and which can turn vertical when desired. Two vehicles can be joined to form one four-person vehicle. These vehicles, once at the first floor, would join the city public transportation system with no passenger changing, and are able (at a proportion of 16 to 5) to handle more people for the space than elevators. I should like to use this system as a primary vertical transport system in my street for traffic to and from the exterior world. It must be able to serve every level due to potential use change.

Escalators are a possibility where heavy usage is a problem, but can never be the sole system as many handicapped people cannot use them and as they are too slow for a very tall structure. The most reasonable places for them here would be at the lower floors where there could be parking and/or shops open to the public and to heavy traffic for three or four floors, or else to a level part way up the structure which, in itself, might
draw heavy traffic (such as a specialized service like a restaurant).

Waste disposal is a large problem which has not been solved; but one to which the next twenty-five years, with all of its pollution research, should find a solution. Garbage, paper and other combustible dry waste, and hard refuse such as metal and glass are the three major categories of waste which must be handled. Perhaps they could be separated and dealt with in different ways. There is in an experimental state a new shredding device which could shred paper goods and perhaps feed them into a community wide vacuum system which would dispose of them in some way; perhaps, as a by-product from this waste, certain pressed boards or cardboard could be made. Metal and glass may be ground up, also, or possibly some of them could even be salvaged and used again. Perhaps, once ground, this waste could enter a vacuum system, also. Garbage is a problem of major proportion as it is wet in character and also a potential threat due to its odors and its disease-spreading capacity. The most direct way of handling garbage is initially to grind it up in a disposer and flush it into the sanitary sewage system. Some of these systems compress the solids and re-use the water. When these methods become feasible, fine. Until then, the best method may still be to incinerate garbage making sure that most pollutants are removed from the smoke. If incinerators are used at all, it may be wisest to use small, individual ones in each building or vertical street area where supervision is local.

For purposes of renovation and also later building it seems
feasible to build a support into the street at its summit for a crane, the working boom of the crane being a permanent fixture, or alternatively being brought to the site when it was needed. Then, with scaffolding at the local site (even if in the air) and with rollers on certain parts of the scaffolding where it is desirable to build under an existing unit, it would be possible to use the crane at the summit to add new units without making undue problems for existing ones.

Dimensions was the name of the second major category on the original list of criteria. This category deals with several areas of investigation. It approaches the problem of measuring sizes of elements, including necessary elements of differing uses; and areas of services required for differing uses. An attempt was made to establish a reasonable dimension for one street. An attempt was made also to establish a method of finding out which of several possible chosen uses takes precedence in an individual case, and what service and core space it requires. (Both of these questions turned out to be tricky to deal with.) These measurements were approached on the basis of a typical floor, since such a floor is the place where basic needs are assessed.

It has already been suggested that a maximum of twenty feet from light be chosen for housing, and a maximum of thirty feet for office space. Taking fifty square feet per person as a minimum in an office, and one hundred and fifty square feet per person in a residential situation (with 125 square feet per person for fire exit calculations to take care of guests) it is possible to assess service requirements per square foot. To explain the number 150, if the accepted ratio of apartments is
used and the F.H.A. standards are applied, then each person as an average lives in 260 square feet of space. However, with student type living where four people pack into double deckers in a one-person bedroom it seemed possible to reduce this square footage to 70 square feet per person. For the purpose of this street, I cut the F.H.A. minima in hopes of being conservative in assessing service needs in an urban situation, but am aware that this is not desirable - only possible. Hopefully, the whole street would not be dominated by one use - student housing - where teenage group type of behavior is not balanced by any other mode of living.

In order to compare the needs of housing to the needs of office space, it was necessary to equate these two in some fashion. The method evolved is one of figuring out how many people and how much service per linear foot of private frontage is a feasible maximum for a given use. This, of course, relates back to the total square footage when the allowable built depth is taken into account; but the method allows of a direct comparison of different uses with different potential built depths which can be built from the same core (street). I am hopeful that the numbers presented this way can be a greater aid in actual design conditions than a more indirect and cumbersome comparison could. Once the needs per linear foot of private space are ascertained for each allowable use, then the use with the greater need is automatically taken as the criterion in that instance. Thus, the whole street may be designed to serve that use in case, at some point in time, the whole street actually
did serve that use. Table 1, accompanying this paper, is a table of the listed uses and criteria compared in the way described above. It will be described further later.

Connection Capacity, the next item on the list of criteria, was considered for building private spaces to the core street, as well as for building from one street to the next. This consideration included some structural implications. The connection potential mentioned must be such that it can be adapted to suit a number of different uses, component materials, weights, moments and varieties of actual connectors. Such structure, in some instances, may be related to the mechanical and other service systems, as for instance stairway and elevator shafts which no doubt can act as shear stability in the whole concept as they do presently in a building, if they do not indeed take on a more active role. The total structure must also be able to cope with the wind moments acting on the street when the private built volume is at its maximum.

There must be some fairly distinct layout for public spaces vs. private ones so that vertical transport and public circulation to private spaces is assured throughout. Some public circulation may repeat itself the entire height of the street as will the core services. The structure will of force define these spaces to a degree, simply because it must allow of the services and of the circulation; it must surround and support these things. It must also have the potential to support the private spaces built later, and will define these spaces to a degree simply by defining the type of support it offers, no matter what individual units are chosen.
For the later built private spaces three specific materials have been considered as a starting place for this research. One of these materials is a light-weight concrete core sandwich panel with a vitreous glaze exterior face and gypsum interior face, as developed by Prof. Dietz and written up in the accompanying reprint. Another material investigated was glass filament wound on a plastic foam core, also written up in accompanying reprints. The third material is a light-weight concrete mixture cast in place without framework by special apparatus as experimented with by Prof. Edward Allen of this institute.

The glass filament component is bolted to a smooth surface as a standard detail, and is cantilevered from the core using the height of the side-walls as a deep beam to take the shear force. Fire protection vertically would be a problem here. The concrete panels need something smooth as an end piece, but best sit on a sturdy floor which is already in place. This floor would need a connection to the vertical service core shaft. One suggestion for this floor is a light-weight core such as a space frame with two skin surfaces, the core carrying heat, etc., through itself and the surfaces being fire-proof. The third building system, the extruded light-weight concrete, also needs a connection to help it stay put until it sets.

In order to be consistent with the idea that the services and core are more permanent while the private spaces are less permanent, it would seem that the portion of the connection which is on the permanent shaft should be a permanent one, while the actual individual support should be demountable. One such system
is as sketched on p. 14. The haunches shown in the permanent shaft might well serve as connections for bridges to the next street as well as individual floors.

The last topic listed for investigation on the original list of criteria was that of Zoning. One of the advantages of the vertical street is that it allows of vertical as well as horizontal zoning of space so that any given volume can be owned or leased, built or demolished in vertical segments as horizontal ones can. In this system are many implicit problems; also, advantages. In the interest of over-all structural stability, it is necessary to add zoning restrictions related to stability to the usual ones. It is necessary to prevent one owner from buying all of one side of a street (say, the South side) and building it solid from top to bottom before anyone else builds anything. In order to do this, it seems important to set vertical segments of the shaft and to insist that any building be done in such a way as to balance that particular segment, whether owned by one owner or more than one. This set-up may call for liaison work on the part of the owners to make it workable, but that is probably the lesser evil here. It would also be possible for developers to develop whole segments, and for smaller owners to buy already built volumes from them.

Another zoning problem is that of resolving not only horizontal but also vertical use compatibility. This problem must be solved in juxtaposing each particular group of uses. In the two uses chosen here, i.e., residential and office, any noisy office machinery such as duplicating typewriters must have adequate sound isolation from the area where, for instance,
14.

- PERMANENT SHAFT
- FLOOR
- TEMPORARY FLOOR OF PRIVATE SPACE
- TUBE OR PIPE?
- CABLE?
- FLOOR

NOT TO SCALE

SECTION
infants might be napping. Conversely, screaming infants and sensitive business conferences should stay unscrambled. Conceivably, a 50 D.B. sound loss would be sufficient insulation between these uses, and should be required.

What is more, adequate light must get into the apartments even though they have a shallower maximum depth. In order to assure this, sun angles should be checked to make certain that an office level which projects to its maximum allowable dimension must be sufficiently above (if it comes above at all) any shallower residential unit so that it does not cut the sunlight off from the apartment. This stipulation is in addition to recognized zoning setback regulations which would also apply in bringing sunlight to the ground level. There must be some provision for roofs which are built by one person but accessible only to another so that such roofs can be put to reasonable use. It would, no doubt, also be wise to segregate primary circulation routes for office and residential areas in many instances, especially in the case of open play areas for children that are incorporated into residential circulation. Open spaces must be checked for wind influences so that they are assured of usefulness.

These have been the principal areas of investigation in this research, the major amount of time being put into the table which follows and the conclusions derived from it. In the construction of this table, certain decisions were made about the office and apartment spaces which need to be understood before a real understanding of the table can be reached.

The office space was assumed to house a maximum of one person to 50 square feet of private space. If the built maximum
of 30 feet from light is adhered to, and a volume is built to its allowable maximum, assuming the spaces to be rectangular (or estimable that way), then there would be 0.6 persons per linear foot of single loaded frontage for private office space. This is 1.6 feet per person.

The residential space is a more tricky problem to bring to terms. It is easy enough to find different lists of minima, and some lists of averages, also. Let's assume, for the moment, that the ratio of apartment sizes follows that of the recommendation from Time-Saver Standards:

2 efficiencies at 400 ft² = 800
4 one-bedroom " 600 ft² = 2,400
2 two-bedroom " 805 ft² = 1,610
2 three-bedroom "1,000 ft² = 2,000

If you then assume the standard of 1-3/4 persons per bedroom, as several sources recommend, you arrive at 26-1/2 people for 10 apartments at 6,810 square feet. This comes out to 260 square feet per person as an over-all average. However, this statistic seems to me never to have run into any less than average-income type of living, as that of the student type, or under age twenty-five type. Fire codes call for 100 or 025 square feet per person as an estimate which could include some guests. After a few estimates of my own based on Harvard Square tactics, and arriving at 70 square feet per person, I decided to be on the safe side in estimating service needs as previously stated and to call 150 square feet my estimate. At a 20-foot depth, and using the
above numbers, there are 0.134 persons per linear foot of apartment frontage (or 7.5 feet per person). Another average which can be pulled from these numbers is that for linear footage per apartment. At the average area of an apartment, and at 20-foot depth, the average linear footage of one apartment is about 29 feet. In other words, some provision must be made at least every 60 linear feet (assuming plumbing can be back-to-back in two apartments) for certain plumbing stacks, and this is a maximum. This is the sort of method used in filling out the data which follows in Table 1 on pages 18 and 19. A visual display of the language used is seen below on this page.
<table>
<thead>
<tr>
<th>TABL 1</th>
<th>Note: Residential: 0.134 persons/linear ft; 7.5 feet/person</th>
<th>Office: 0.6 persons/linear ft; 1.6 feet/person</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Linear Foot of Private Space</td>
<td>Dimension of One</td>
</tr>
<tr>
<td></td>
<td>Office</td>
<td>Residential</td>
</tr>
<tr>
<td>Plumbing</td>
<td>Fixture Supply. Waste (incl. Garbage)</td>
<td>7.6 gal/day</td>
</tr>
<tr>
<td></td>
<td>Heating, Cooling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toilet</td>
<td>W.C./33'</td>
</tr>
<tr>
<td></td>
<td>Vents</td>
<td>1/60' max</td>
</tr>
<tr>
<td></td>
<td>Pipe for Conc.</td>
<td>One/chase</td>
</tr>
<tr>
<td>Electrical</td>
<td>Lighting</td>
<td>Use Bus Ducts and Panel Board to apportion energy - Unreasonable to estimate.</td>
</tr>
<tr>
<td></td>
<td>Telephone</td>
<td>5/33' Equip</td>
</tr>
<tr>
<td></td>
<td>Closet</td>
<td>Closet</td>
</tr>
<tr>
<td>Vertical Transport</td>
<td>Stairs</td>
<td>Varies</td>
</tr>
<tr>
<td></td>
<td>Elevator</td>
<td>1 Elev/275</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superceded by: &quot; &quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>see Remarks</td>
</tr>
<tr>
<td>Waste Disposal</td>
<td>Shredder</td>
<td>.33/foot</td>
</tr>
<tr>
<td></td>
<td>Grinder</td>
<td>For demolition, waste, glass mat.</td>
</tr>
<tr>
<td></td>
<td>Incinerator</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crane</td>
<td>to lift 10 ton units</td>
<td>Use Elev. Shaft?</td>
</tr>
<tr>
<td>Public Space and Core Area</td>
<td>30% (of 30') = 10</td>
<td>27% (of 20')</td>
</tr>
<tr>
<td></td>
<td>(incl. Pub. Toilets)</td>
<td></td>
</tr>
</tbody>
</table>
## Formulas Used

| Residential: 100 gal/person/day x factor of 2 for peak |
| Office: 25 gal/person/day x factor of 5 for peak |

### Remarks and Special Topics

- Sufficient to do total building by hot water heat.
- On office floors: 5'-0" from W.C. to vent.
- For future construction purposes:
  - Need more than sufficient space, but can handle with bus ducts and local panel boards, so not a large space problem.
  - Rentable floor area: 6'/1000# Rentable floor area
  - Raceways: 1'/100# floor area
  - One Equipment Clos./4000# zone

### Calculations

- Width 36" + 12"/100 people over 300
- \[ P_{min} = \frac{300 \text{sec} \times P}{\text{trips}} = \frac{sec}{\text{round trip}} \]
- 250 people/2min. = 600/5minute

### Residential

- 1#/person/day
- Fireproof; Corridor fireproof - 12"/100 people (36" min.)
- 15% office population; 2000# Capacity/cab.
- 30Cft/min, Capacity 12., peak 10; 5 Perc bays = 16 elevator bays; 176 ft \[ \text{min}(10\text{c.p.h.}) \]
- Need parking space

### Office

- 1#/person/day
- For paper goods and trash - Shredder
- For Glass, Metals, Concrete demolition - Grinder
- (Max. size - 1500#/hr for 6 hr. for wet garbage
  - Incinerator if disposers unavailable

### Residential

- 1#/person/day - garbage (incinerator)
- For late and future building. Use scaffolding with rollers.

### Additional Information

- Includes public areas as public toilets in office space; laundry, mail, stor., play areas in residential; public corridors, services.
From this table it can be seen that certain service elements are to be repeated at particular maximum intervals. Electrical panel boards with their need to be in electric shafts, and fire stairs, both items of substantial structural size, must be repeated at a maximum of 100 feet. Public toilets on office floors must be repeated at least every 200 feet, and every 100 feet would be preferable. This means that core space must be left for them. It means that major plumbing would be needed that often, and if plumbing shafts were built at all they could be used for any other plumbing needs, even those which need not be repeated so often. It would seem from these numbers that, at least every 200 feet, each major service needs to be repeated suggesting that this number would be an appropriate maximum size of one street in any one horizontal direction from the original base point. If the street, then, spread in a straight line, it might be as much as 200 feet long and still be within the limits of "one thing," depending upon the distance that people are willing to be from the Perno vertical transport system.

The relative sizes of the core at different points is a question which also needs careful consideration. Since the office use requires 30% of the total floor area for public and core spaces, and the private spaces can be built 30 feet deep while the residential use requires 27% of the total for public and core space for a 20 feet private depth, the relative core needed for office floors to residential is as 10 feet is to 6 feet. Residential kitchens and baths, as well as public laundry facilities and storage, might help toward efficient coordination.
of the core and public facilities of these two uses. Open play spaces in terrace form in residential areas might be possible also.

These are examples of the use to which I hope to put the previous table during the design process. As the number increases of space uses to be coordinated, so do the codification and coordination problems increase. It will be interesting to see whether the things I have chosen here will truly turn out to be the important ones, and whether I have codified them in a way which is serviceable. So here we go......
BIBLIOGRAPHY

Architectural Record, Apartments and Dormitories,

Architectural Record, Timesaver Standards; a Handbook of
Architectural Design,

Baumann, Dwight M. B., "Compatible Automation of New Town
Transportation," (paper delivered at the Transportation
for New Towns and Communities Workshop, December 8-9, 1969
at the Institute of Public Administration, 1250 Connecticut Avenue N. W., Suite 360, Washington, D. C.)

Campbell, Kenneth J., F.R.I.B.A.; John W. Davidson, D.A. (EDIN),
A.R.I.B.A.; and Albert G. H. Dietz, Sc.D., FASCE;
"Reinforced Plastics in Multi-Story Building," (Preliminary
Copy of a report to be presented at the 22nd Annual Meet-
ing of the Reinforced Plastics Division to be held at the
Shoreham Hotel, Washington, D. C.). The Society of the
Plastics Industry, Inc.

Kinsey, Bertram Y., Jr., and Howard Sharp, Environmental Technolo-
gies in Architecture,

Otis Elevator Company, "Vertical Transportation, 1964" (Otis

Stetina, Henry J., "Floor, Ceilings and Service Systems with
Steel Construction," printed by American Institute of
Steel Construction (a paper presented at a conference of
the Building Research Institute, Washington, D. C.,
Dec. 7-8, 1955).
Strakosch, G. R., "How to Plan Elevator Service for College Buildings." (From a paper presented at the 11th annual eastern regional meeting of the National Association of Physical Plant Administration, New York.)


"Elevatoring Buildings.", Reprint of a five-page paper with no date and no source mentioned which was found in M.I.T. Rotch Library in Pamphlet File under "Elevators". This paper gives graphs and formulae for figuring different elevator needs.
