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ABSTRACT

Twenty-five representatives active in research for architecture made major contributions to the profession by presenting their findings to conferees at the AIA Architect-Researcher's Conference. The final papers that were made available for this publication contain the essential contents of the original presentation. Special consideration was given to coordinate the text, graphics, and slides to make the final proceedings as complete and comprehensive as the original presentation. Topical coverage includes the latest research findings, developments, and techniques identified through research in architectural offices, building industries, universities, and governmental agencies. The major areas of discussion were--(1) economic feasibility analysis, (2) mechanical and structural building systems, (3) design and programing methods, (4) prefabrication and component building systems, (5) urban and regional planning, (6) computer applications to design, and (7) environmental influences on man. (TC)

AIA

ARCHITECT - RESEARCHER'S CONFERENCE

PROCEEDINGS

FIFTH ANNUAL MEETING

WISCONSIN DELLS, WISCONSIN
SEPTEMBER 25-26

1968

AIA
ARCHITECT-RESEARCHER'S CONFERENCE

PROCEEDINGS

Fifth Annual Meeting
Wisconsin Dells, Wisconsin
September 25-26
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Edited

By

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Annual AIA Architect-Researcher's Conferences result from the desire of individuals actively engaged in research for architecture to review current research efforts and to discuss the ramifications for the profession. As a consequence, the topics presented and discussed at A-R conferences often precede general awareness of new design and building techniques, products and materials developments, or evalautions of architectural methods and design influences.

To establish broad coverage of current research investigations for presentation and discussion at the Fifth Annual Conference, the program committee concentrated on research recently completed or currently underway in the Profession, Industry, Schools, and Government Agencies.

Special recognition should be given Bill N. Lacy, AIA Research for Architecture Committee Chairman, for his conceptual organization of the conference and his extensive efforts toward obtaining outstanding research topics in Schools of Architecture. Harold Horowitz was responsible for the excellent representation of research activities currently going on in government agencies. Robert M. Dillon established contact with building industries for program participation resulting in outstanding research topic coverage. Charles Thomsen, with the aid of Steve Kliment, elicited advanced research coverage from work going on in architectural offices. These and other members of the Committee served as moderators for the individual sessions.

The Program Committee is especially appreciative of the enthusiastic support given by the University of Wisconsin Environmental Design Center faculty, staff and graduate students in sponsoring the conference and to the Wisconsin Chapter, American Institute of Architects for their hosting of the pre-conference activities.

The assembly and editing of these technical papers for printed proceedings has been made possible through the Educational Resources Information Center/Clearinghouse on Educational Facilities at the University of Wisconsin, Madison, Wisconsin.

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P R E F A C E

The latest research findings, developments, and techniques presented in this proceedings were made possible through current research conducted in the following types of organizations:

ARCHITECTURAL OFFICES
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Twenty-five representatives active in research for architecture made major contributions to the profession by presenting their findings to conferees at the AIA Architect-Researchers Conference. The final papers that were made available for this publication contain the essential contents of the original presentation that was given by each speaker at the time of the conference. Moderator, reactor and audience participation is not included as part of the final proceedings. Special consideration was given to coordinating the text, graphics, and slides in order to make the final proceedings as complete and comprehensive as the original presentation.

The editor would like to extend a special thanks to all of the speakers for devoting additional time and effort in preparing papers and photographs to make this proceedings possible. A very special thanks are due Carol Batteen and Carol Rossini for their generous aid and advice in addition to spending many hours skillfully typing and proofreading the final text.

PHILIP M. BENNETT
Editor

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* Not included in Conference Proceedings

ECONOMIC FEASIBILITY ANALYSIS

By

PAUL FARRELL

Legal Counsel
Smith, Hinchman, & Grylls Associates, Inc.
Architects-Engineers-Planners

INTRODUCTION/OBJECTIVES & METHODS

A. Objectives. There are two basic types of investor information produced by this analysis;

1. PROFITABILITY GUIDELINES: A concise statement of the relationship between three key financial variables:

   a. RENTAL INCOMES
   b. CONSTRUCTION COSTS
   c. RETURN ON INVESTMENT

   These guidelines are developed to answer these questions: What Unit rent must be charged in order to realize a specific return for probable construction costs? What is the maximum construction cost justified in order to give the investor a reasonable return given present rental market levels?

2. RISK SIMULATION: Next, one probable mix of rent, construction cost and rate of return is selected as a basis for comparison. The relative effect of varying other investment inputs is tested against this basis. Occupancy ratios, operating expenses, depreciation schedules, interest rates, etc., are each varied and a record is kept of the effect of these variations on such financial indices as Annual Pretax Return, Cash Flow After Taxes, and Net Present Worth.

B. Method of Analysis/The Computer. The information necessary for this financial analysis was generated by a computer program developed particularly for this purpose. The computer program (REAP) developed particularly for this model which incorporates familiar return on investment, discounted cash flow and profitability index concepts used in the

analysis of real estate and other capital investments.* The advantage of using the computer for this analysis is obvious. With an IBM 1130 computer it was possible to rapidly calculate fifty discrete sets of project investment variables while incorporating such refinements as the cash flow effects of (1) decreasing annual interest payments and depreciation allowances and (2) increasing annual amortization and tax payments.

A DESCRIPTION OF THE INVESTMENT

The Michigan-Lodge Plaza office building complex will be developed on a ten acre site located at the southeastern corner of the intersection of Michigan Avenue and the John C. Lodge Expressway. The site is in the western part of Detroit's central business district.

The first stage of development includes a four story building with a net rentable area of 151,000 square feet, a seventeen story building with 330,000 square feet net rentable area and parking for 1,140 automobiles.

This report analyzes the economic feasibility of the first stage of development. A second stage of development will result in the addition of 985,000 square feet net rentable area. The project will ultimately contain 1,567,000 square feet of rentable space.

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*see, National Association of Accountants, FINANCIAL ANALYSIS OF CAPITAL EXPENDITURE DECISIONS (1967); Harvard Business Review Reprint Series, CAPITAL INVESTMENT DECISION (1964); Bierman & Smidt, THE CAPITAL BUDGET DECISION (1966); American Institute of Appraisers, ELLWOOD TABLES FOR REAL ESTATE APPRAISING AND FINANCING (1967).

Several other major projects are scheduled for development in this area. Among these are included an addition to the Trade Center, the new Federal Office Building and an addition to the Michigan Bell Telephone office building.

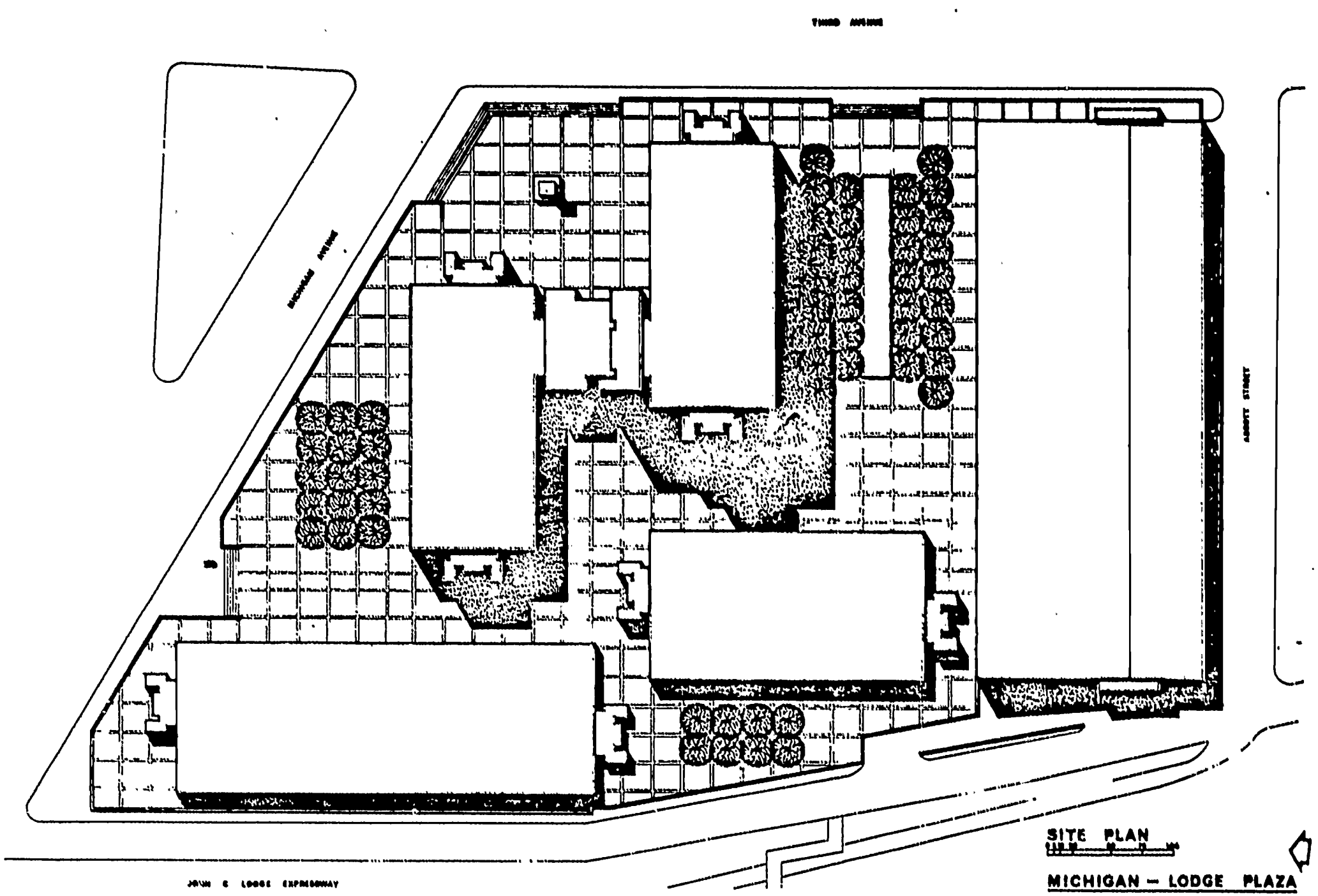
A general site layout of the development is included for reference. Floor plans of the buildings are illustrated in a separate brochure prepared by Smith, Hinchman & Grylls Associates, Inc.

SUMMARY OF ANALYSIS

The three tables which follow summarize certain key data contained in the Input/Output statistical tables.

The Input/Output Tables are divided into two basic sets of information. The first set of information, Profitability Criteria, was used along with preliminary estimates of construction cost and market rental data in determining that a rent of $6.50 per net square foot for the tower ($5.50 for the low structure) would yield approximately 14% return after taxes if the tower could be built at the estimated $26.50 per gross square foot building cost ($25.00 for the low structure). The Profitability Criteria information available in the Input/Output Tables (see also Summary Table II) may be used to analyze the returns of any other rent/construction cost mix which might be justified during later, detailed reviews of the project's feasibility.

The second basic set of information in the Input/Output Tables was developed to test the degree of risk involved in the particular rent/cost/yield mix noted above. This information is summarized in "Summary Table III: Risk Simulation" which illustrates the effect of variations in the basic economic inputs. For example, if a double declining balance of 30% could be



SITE PLAN

MICHIGAN — LODGE PLAZA

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elected instead of straight line depreciation and the corporate tax, then the yield would deviate by +23%; double declining balance depreciation alone would deviate the yield by +11%. Another example: if operating expenses increase 25% from $2.00 to $2.50 per net square foot rentable area, the yield will deviate by -9%. The Input/Output Tables also contain considerable information about the effect of these variations on the capital investment, operating and cash flow status of the project.

Summary Table I which follows immediately is an outline of the more important economic facts about this project.

SUMMARY TABLE I: PROJECTS STATISTICS

1.	Unit cost of construction per gross square foot.		
	*tower	$	26.50
	*low building	$	25.00
2.	Parking construction cost per auto.		
	*structure	$	1,400.00
	*surface	$	450.00
3.	Plaza construction	$	200,000.00
4.	Professional fees		9%
5.	Interim financing; per year		4%
6.	Land acquisition	$	1,030,000.00
7.	Mortgage ratio to project value		75%
8.	Total investment; phase one	$	19.7 million
9.	Annual debt service; 7% interest, 30 year term	$	1,180,000.00

SUMMARY TABLE I: PROJECT STATISTICS
(CONTINUED)

10.	Depreciation, straight line, 45 year useful life.	$	384,000.00
11.	Rental income per net square foot (annual).		
	*tower	$	6.50
	*low	$	5.50
12.	Operating expenses per square foot.	$	2.00
13.	Parking income per auto	$	360.00
14.	Occupancy ratio		95%
15.	Net/Gross Ratio		
	*tower		77.2
	*low		86.8
16.	First year net income before debt service & depreciation	$	2,300,000.00
17.	First year Cash Flow after taxes.	$	700,000.00
18.	Return on equity after taxes assuming sale in tenth year.		14.2%

SUMMARY TABLE II: PROFITABILITY CRITERIA
(14% discount rate)

RENTALS / CONST. COST	$4.00	$5.00	$6.00	$7.00	$8.00
$16.00	0.78	1.18	1.59	2.00	2.40
$20.00	0.60	0.93	1.26	1.59	1.92
$24.00	0.45	0.75	1.03	1.31	1.59
$28.00	0.36	0.62	0.86	1.10	1.34
$32.00	0.29	0.51	0.73	0.95	1.16

SUMMARY TABLE III: RISK SIMULATION
(14% discount rate)

		PROFITABILITY CRITERIA	PERCENT DEVIATION
0.	Basic Investment/Rental	1.04	---
1.	Mortgage ratio increased from 75% to 90% of total investment.	1.90	+86%
2.	Double declining balance depreciation rather than straight line; 30% individual tax rather than corporate tax.	1.28	+23%
3.	Mortgage ratio to 80%	1.19	+14%
4.	Sum of the years digits depreciation	1.17	+12%
5.	DDB depreciation	1.16	+11%
6.	Useful life decreased from 45 to 33 years.	1.10	+ 6%
7.	Net/Gross building ratios increased 2%	1.07	+ 3%
8.	Other construction costs increased $250,000	1.03	- 1%
9.	Other Professional fees increased 3% to 4%	1.03	- 1%
10.	Interest increased from 7% to 7.25%	1.03	- 1%
11.	Interim financing charges increased from 4% to 5%	1.02	- 2%

SUMMARY TABLE III: RISK SIMULATION
(14% discount rate)

	PROFITABILITY CRITERIA	PERCENT DEVIATION
12. Other construction costs increased to $500,000	1.01	- 3%
13. Interest to 7.50%	1.01	- 3%
14. Mortgage term decreased from 30 to 25 years	1.01	- 3%
15. Operating Expenses increased from $2.00 to $2.24 per net rentable square foot	1.00	- 4%
16. Occupancy ratio decreases from 95% to 90%	0.98	- 6%
17. Operating Expenses increases to $2.50 per square foot	0.95	- 9%

THE COMPUTER MODEL (REAP)

On the next several pages is a detailed description of the model used in this analysis. The description is preceded by a diagram illustrating the major variables and their relationships within the model. The model is identified by the acronym REAP (Real Estate Analysis Program). The basic Model takes this form:

INITIAL INVESTMENT:

CONSTRUCTION COSTS
+INTERIM FINANCING
+PROFESSIONAL FEES

INITIAL INVESTMENT:
(continued)

+LAND & OTHER COSTS
TOTAL INVESTMENT
-MORTGAGE
EQUITY

ANNUAL OPERATIONS:

GROSS INCOMES
-VACANCIES
-OPERATING EXPENSES
NET INCOME
-DEBT SERVICE
CASH FLOW
-INCOME TAXES*
CASH FLOW AFTER TAXES**

EQUITY REVERSION:

SELLING PRICE
-UNAMORTIZED MORTGAGE PRINCIPAL
-CAPITAL GAINS TAX
REVERSION AFTER TAXES**

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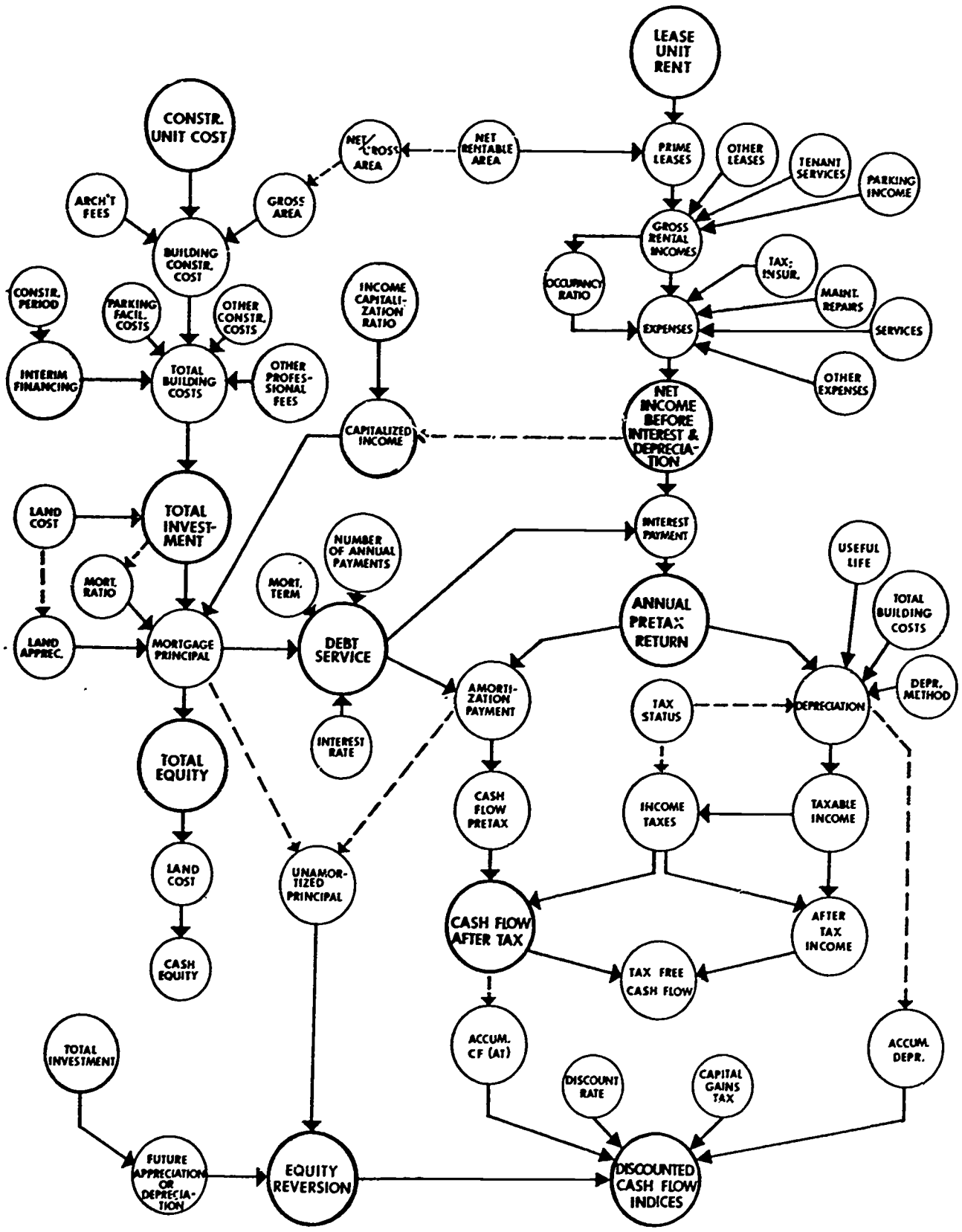
* income taxes equal net income minimum interest and depreciation time the tax rate.

** after tax cash flows including the reversion are discounted and accumulated to the year of sale, then compared to the original equity.



REAL ESTATE ANALYSIS PROGRAM (REAP)

NET INCOME BEFORE INTEREST & DEPRECIATION (NIBID)

NIBID	=	(OR) (GI) minus EXP.
OR	=	occupancy rate; not applied to parking income.
GI	=	gross rental incomes from leases and parking based on unit rents per total net rental units; also includes tenant services.
EXP	=	All operating expenses assumed by lessor, including cleaning, utilities, insurance, property taxes, etc. (does not include debt service, depreciation and income taxes.
CAP. RATE	=	the rate at which NIBID is capitalized to develop an economic appraisal of project value.

TOTAL INVESTMENT (TINV)/DEPRECIATION

TINV	=	TBC plus LAND.
TBC	=	sum of all capitalized building costs: (a) individual building costs = (unit construction cost) (1/net to gross ratio) (net rentable area) (1 + architect's fee); (b) cost of parking facilities (including architect's fee); (c) other construction costs, including utilities removal or installation, landscaping, plazas, demolition, and other site improvements; (d) interim carrying charges including interest on construction loan, insurance of the above construction costs and the construction period;

(e) other professional fees include the fees of attorneys, realtors, mortgage brokers and public relations experts.

(f) contingency.

LAND = the purchase price of the land.

DEPR. = tax depreciation allowance; a function of TBC. Straight line depreciation equals TBC divided by the "useful life" of the project. Double declining balance depreciation equals twice the undepreciated TBC balance divided by the useful life. The "sum of the years digits" method may also be programmed.

MORTGAGE/DEBT SERVICE/EQUITY

MORT = Mortgage principal equals a percent of TINV plus any appreciation in the market value of the land over its purchase price. This appreciation will be reflected in the mortgagee's appraisal. The mortgage principal determined by this method of calculation should be approximately equal to NIBID capitalized.

DSERV = debt service payments are computed as constant payments and are a function of the mortgage term and principal amount, the interest rate, and the number of annual payments. The constant annual payment includes both amortization and interest with the interest portion higher in the earlier years of the mortgage.

TEQ = total equity (TINV minus MORT); with cash equity equally TEQ minus LAND.

CASH FLOW/RETURN/PROFIT/TAXES

APR = annual pretax return equals NIBID minus INT (or cash flow before taxes plus amortization).

INT = interest portion of debt service; both interest and amortization are separately calculated for each annual income period.

AMORT = amortization portion of debt service.

TI = taxable income; APR minus DEPR (or NIBID minus INT and DEPR).

PROFAT = profit after taxes; TI minus income taxes.

TAX = income taxes; federal income taxes equal either (a) a percent of TI based on individual tax rates, or (b) the corporate tax rate of 22% of TI plus a 26% surcharge on income in excess of $25,000. Where taxable income is negative it is assumed that the taxpayer has other income against which his tax deductions may be applied, the result being a "tax benefit" to the extent of the tax which would have been paid on the other income.

CFPTX = cash flow before taxes equals NIBID minus debt service (or APR minus AMORT).

CFAT = cash flow after taxes equals CFPTX minus TAX;

tax free cash flow equals CFAT minus PROFAT.

FINANCIAL INDICES

PAYBACK PERIODS: two payback periods are calculated, one relative to total investment in the project (TINV) and the other relative total equity investment (TEQ). (1) The first is the number of years required to reduce TINV to zero with NIBID income flows. This calculation is based on a 7% interest rate on the outstanding TINV balance. (2) The second payback period is the number of years required to return to the investor his total equity. This reutrn is based on (a) Cash Flows After Taxes and (b) a 7% interest rate on the outstanding TEQ balance. The latter payback period is calculated independent of the increased equity value accruing through annual amortization payments. This increase in equity would be an additional cash flow return to the equity investor when project is sold or refinanced.

INVESTMENT RATIOS: (1) first the "return free and clear" is calculated by dividing NIBID by TINV; then (2) APR, TI, PROFAT, CFPTX and CFAT are divided by TEQ to develop several indices of investment return. These ratios are recorded for rental operating years one, four and nine.

DISCOUNTED CASH FLOW INDICES: three indices are calculated at four selected discount rates; (1) Present worth of future incomes; (2) Net Present Worth, and (3) a Profitability Index. The discount rate which will equate future cash flows and present investment may be interpolated directly from this data.

PRESENT WORTH OF CASH FLOWS: this present worth figure includes both (a) the sum of the discounted annual cash flows from rental operations and (b) the discounted cash value of the equity reversion after taxes (EQRAT). The latter is calculated as follows;

(plus)	Selling Price (TINV plus appreciation or minus depreciation in project value)
(minus)	Unamortized Mortgage Principal.
(minus)	Capital Gains Tax (25% of the Selling Price minus the "basis", where basis equals TINV minus accumulated depreciation.)
(equals)	Equity reversion after taxes.

NET PRESENT WORTH equals Present Worth of future cash flows divided by TEQ.

PROFITABILITY INDEX equals Present Worth of future cash flows divided by TEQ.

In the above calculations annual CFAT is discounted through the tenth year and EQRAT is assumed to accrue as a cash flow at the end of the tenth year. A ten year period was selected since (1) evidence indicates that most capital investments are either sold or refinanced within ten years, and (2) no excess depreciation will be recaptured as ordinary income if the real estate is held for ten years.

FINANCIAL CONCEPTS/DISCUSSION

On the following pages there are a series of charts illustrating various concepts underlying this analysis. Each chart is discussed in the related textual material. The charts have not been drawn to any particular scale; they are only intended to illustrate general concepts.

The following charts illustrate certain basic relationships between the major income variables affecting cash flow from real estate investments.

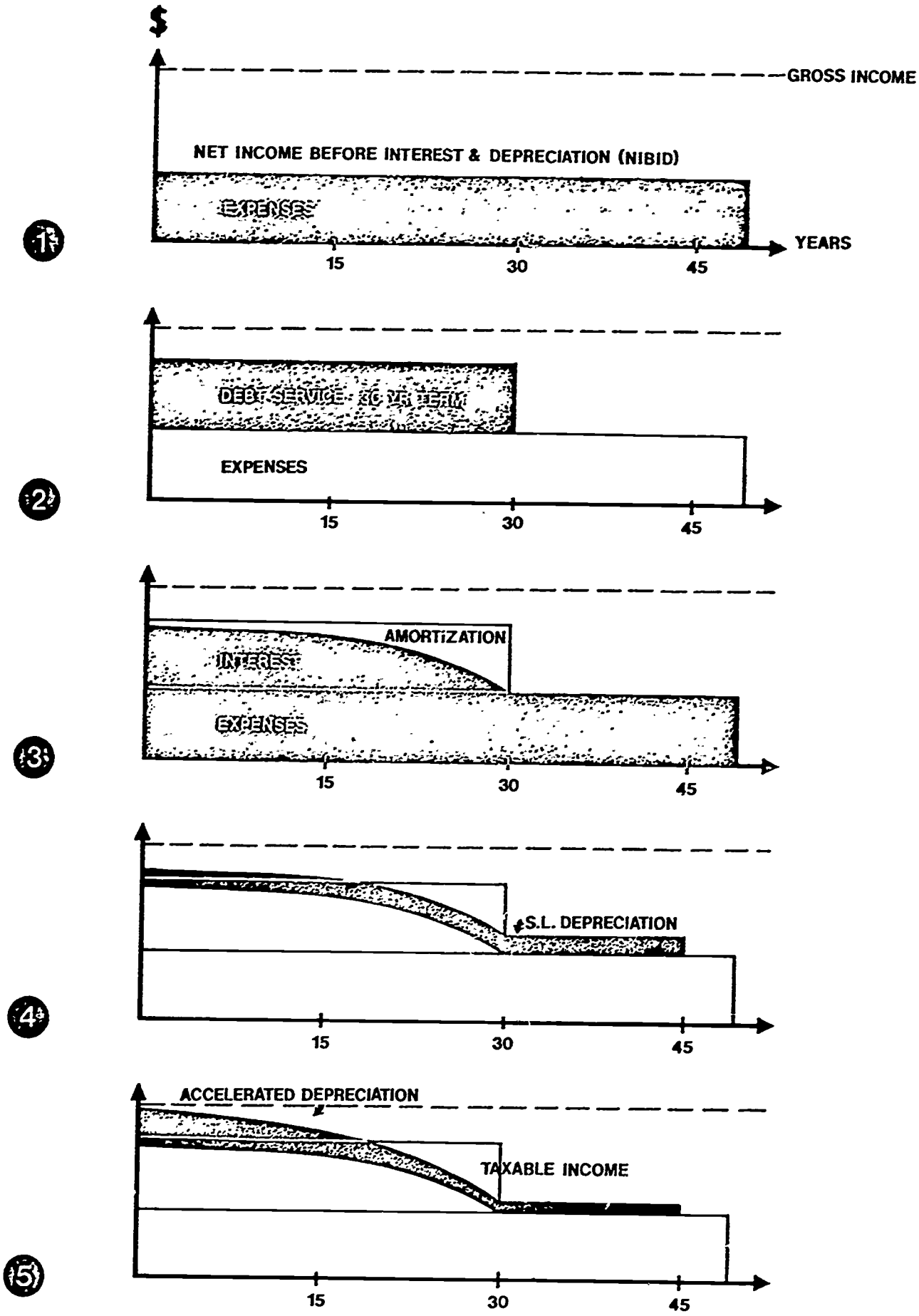
CHART ONE: Assuming 100% occupancy, Net Income Before Interest and Depreciation (NIBID) is the difference between Gross Income and Expenses. (Expenses are shown in black.) NIBID is assumed to remain constant over the period covered by this analysis. In fact, NIBID may remain relatively constant due to lease renegotiations and escalation clauses which shift increases in expenses to the tenant.

CHART TWO: Debt Service is shown here in black as a constant payment amortizing the mortgage principal over a 30 year term.

CHART THREE: During the earlier years of the mortgage term the Interest payment is a large part of the total constant Debt Service payment. Amortization (principal repayment) is relatively small until the later years of the mortgage term. The interest payment and Expenses (both of which are shown in black) are tax deductable while amortization is not.

CHART FOUR: Straight line depreciation is shown here in black. It is a constant percentage of the Total Investment minus land cost and is a function of the "useful life" of the asset. Depreciation, like Interest and Expenses, is tax deductable. And to the extent that Depreciation exceeds Amortization there is a "tax-sheltered" cash flow (cash flow equals NIBID minus Debt Service.) Straight Line Depreciation is here shown in black.

CHART FIVE: The investor may elect to take Accelerated Depreciation rather than Straight Line Depreciation. Total depreciation taken over the useful life of the asset will be the same under either method. However, with Accelerated Depreciation there will be larger tax-sheltered cash flows in the early years of the project. Thus equity investment will be returned much quicker. When the Depreciation deduction no longer exceeds the actual Amortization payment the project will probably be sold


$
GROSS INCOME
NET INCOME BEFORE INTEREST & DEPRECIATION (NIBID)
EXPENSES
YEARS
15
30
45
1
DEBT SERVICE - 30 YR TERM
EXPENSES
2
AMORTIZATION
INTEREST
EXPENSES
3
S.L. DEPRECIATION
4
ACCELERATED DEPRECIATION
TAXABLE INCOME
5

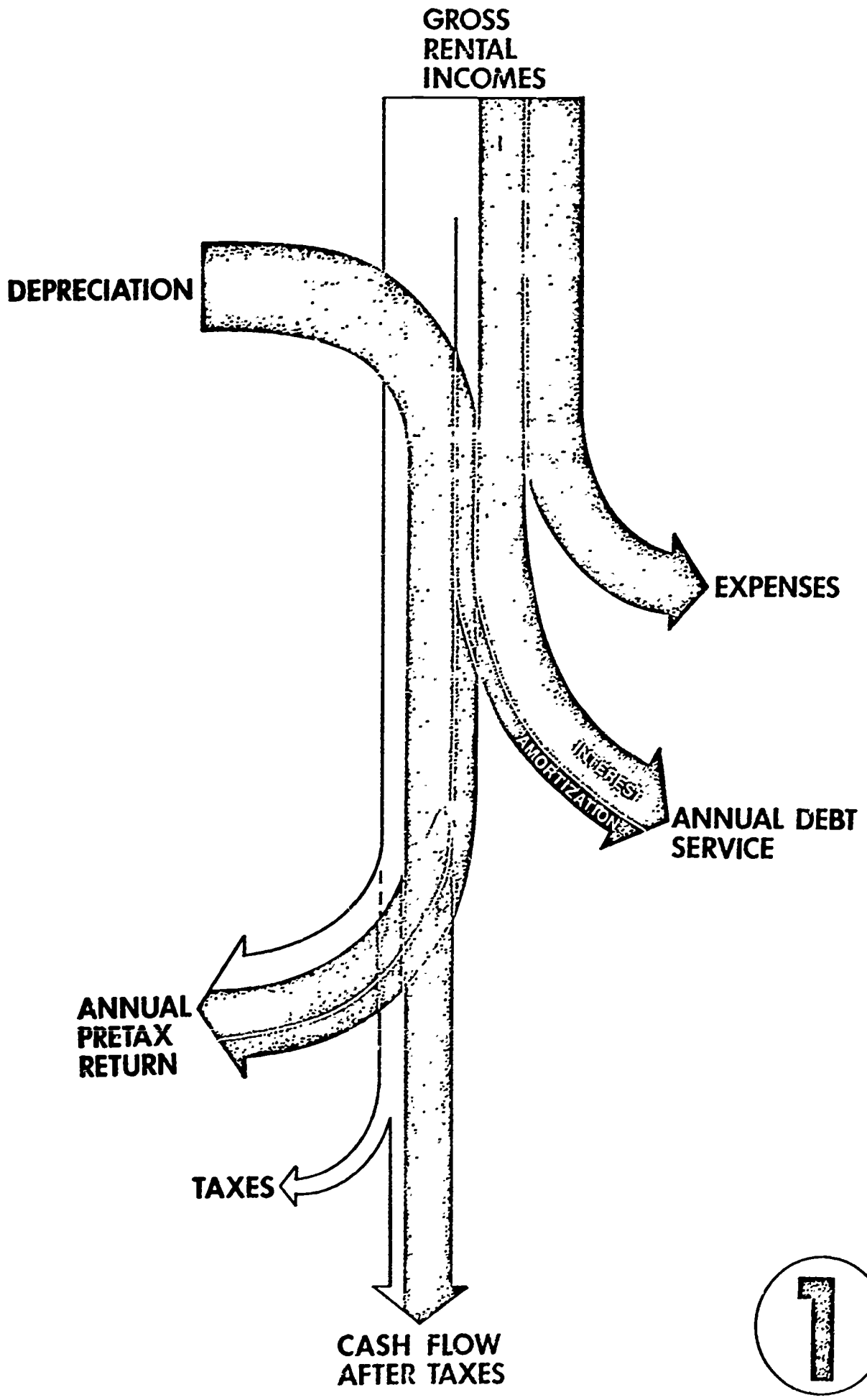
or refinanced to "cash-out" accumulated amortization.

The next three arrow diagrams further illustrate some of the financial ideas behind this analysis. Each chart begins at the top with an inflow of Gross Rental Income. Areas in black indicate tax deductable items; these include: Interest, Expense and Depreciation. Amortization is not deductable but appears in black to the extent that it is covered by the depreciation deduction.

CHART 1: In the early years of the mortgage term, Amortization will be a small part of the Debt Service. Here Depreciation exceeds Amortization thus sheltering part of the "income" remaining after Expenses and Debt Service. This "income" is the Pretax Cash Flow will reduce this sum to After Tax Cash Flow. This is the investor's actual cash return for the year. Annual Pretax Return is the sum of Pretax Cash Flow and Amortization (or NIBID minus the Interest payment). Amortization represents a reduction in the mortgage principal and a corresponding increase in equity ownership.

CHART 2: Here we assume that accelerated depreciation is taken. In this illustration Gross Rental Incomes are less than the sum of Expenses, Interest and Depreciation. Part of the Depreciation thus shelters "other income" of the taxpayer which is included in the Annual Pretax Return. After Tax Cash Flow includes only that part of the "other income" which would have been paid in taxes. The rest is cash which would have been received notwithstanding this "excess" depreciation.

CHART 3: This chart illustrates the situation which might occur near the end of a mortgage term when accelerated depreciation has been elected. Depreciation and Interest are relatively small in comparison to Amortization. Annual Pretax Return here is equal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CASH FLOW
AFTER TAXES

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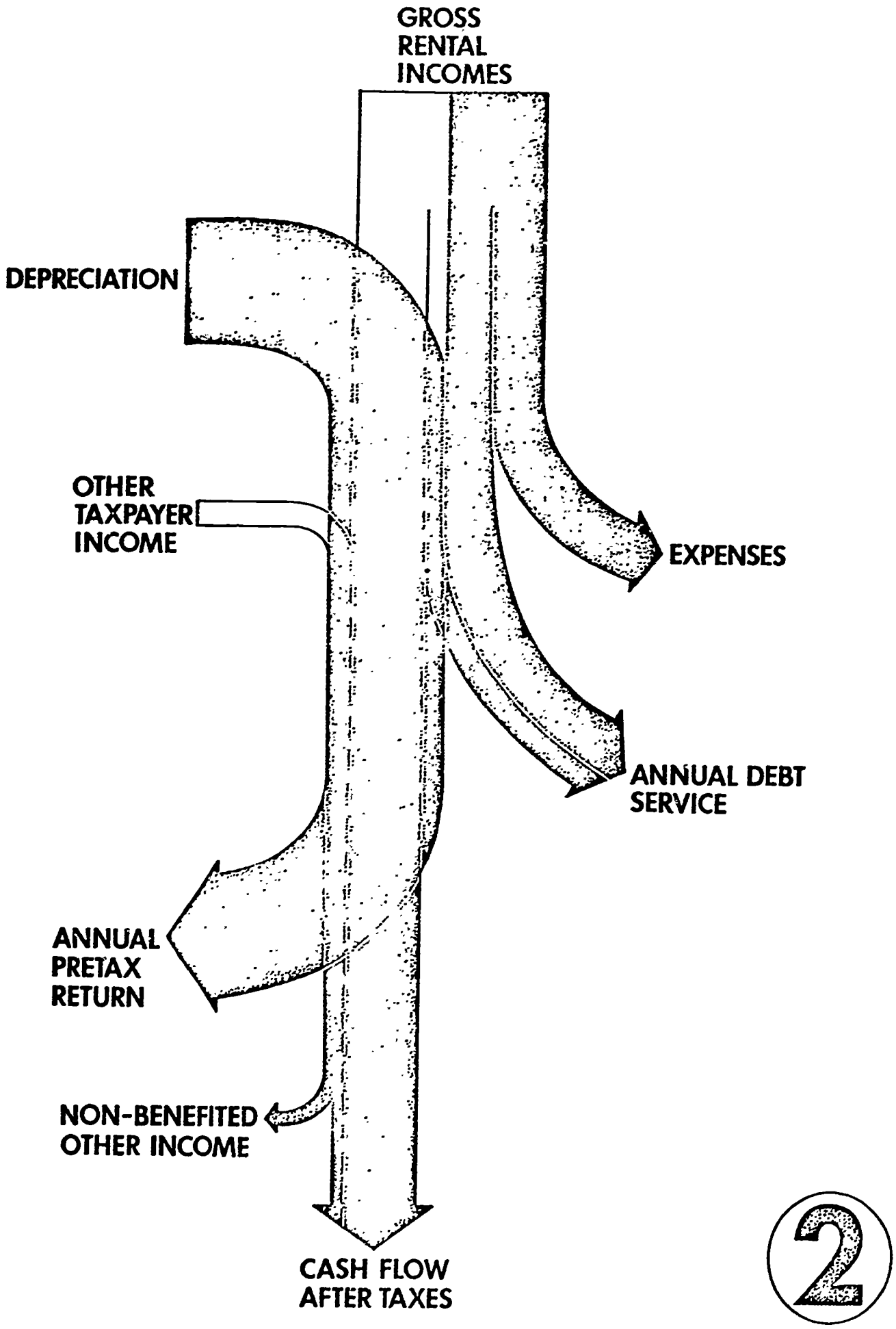
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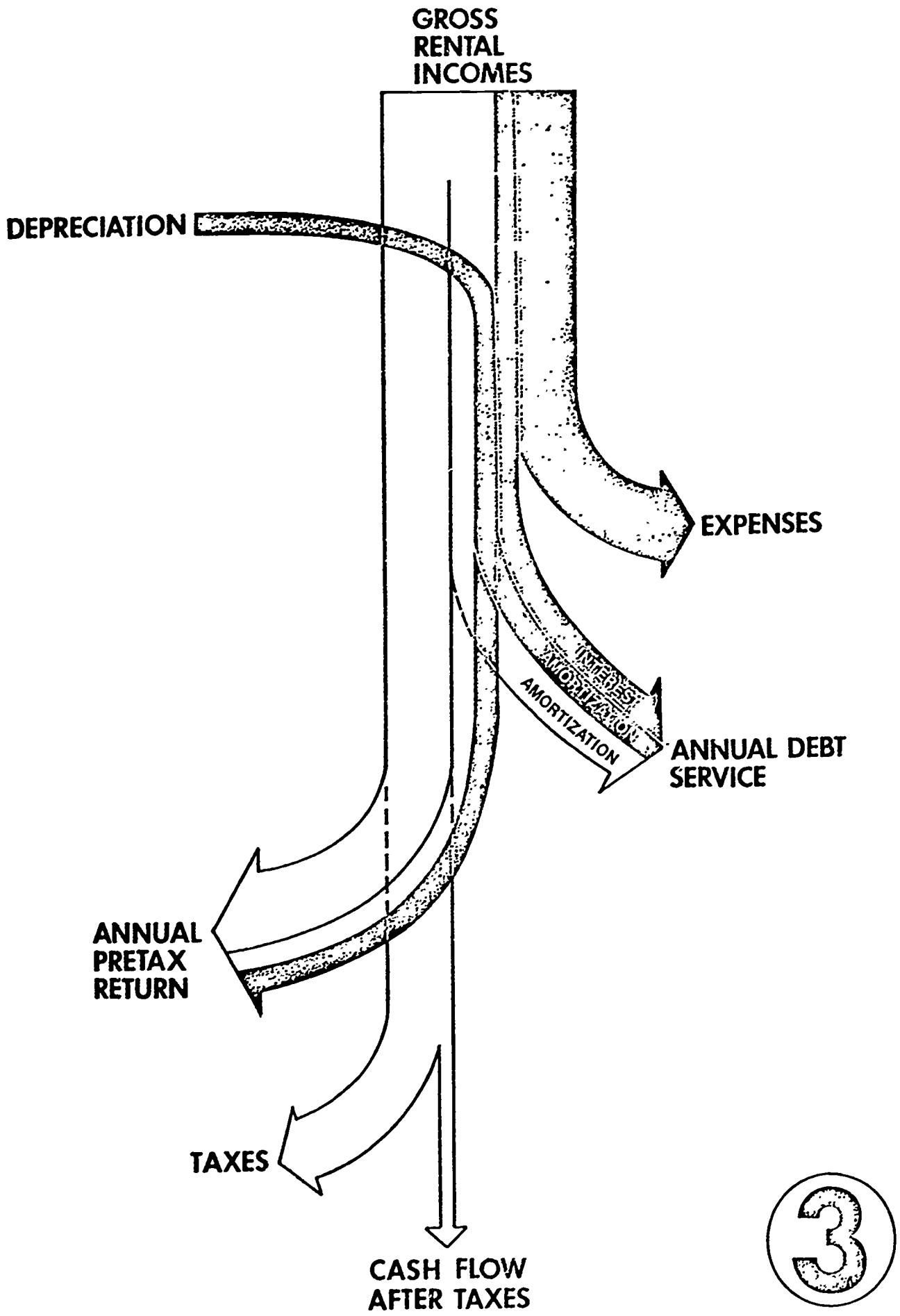
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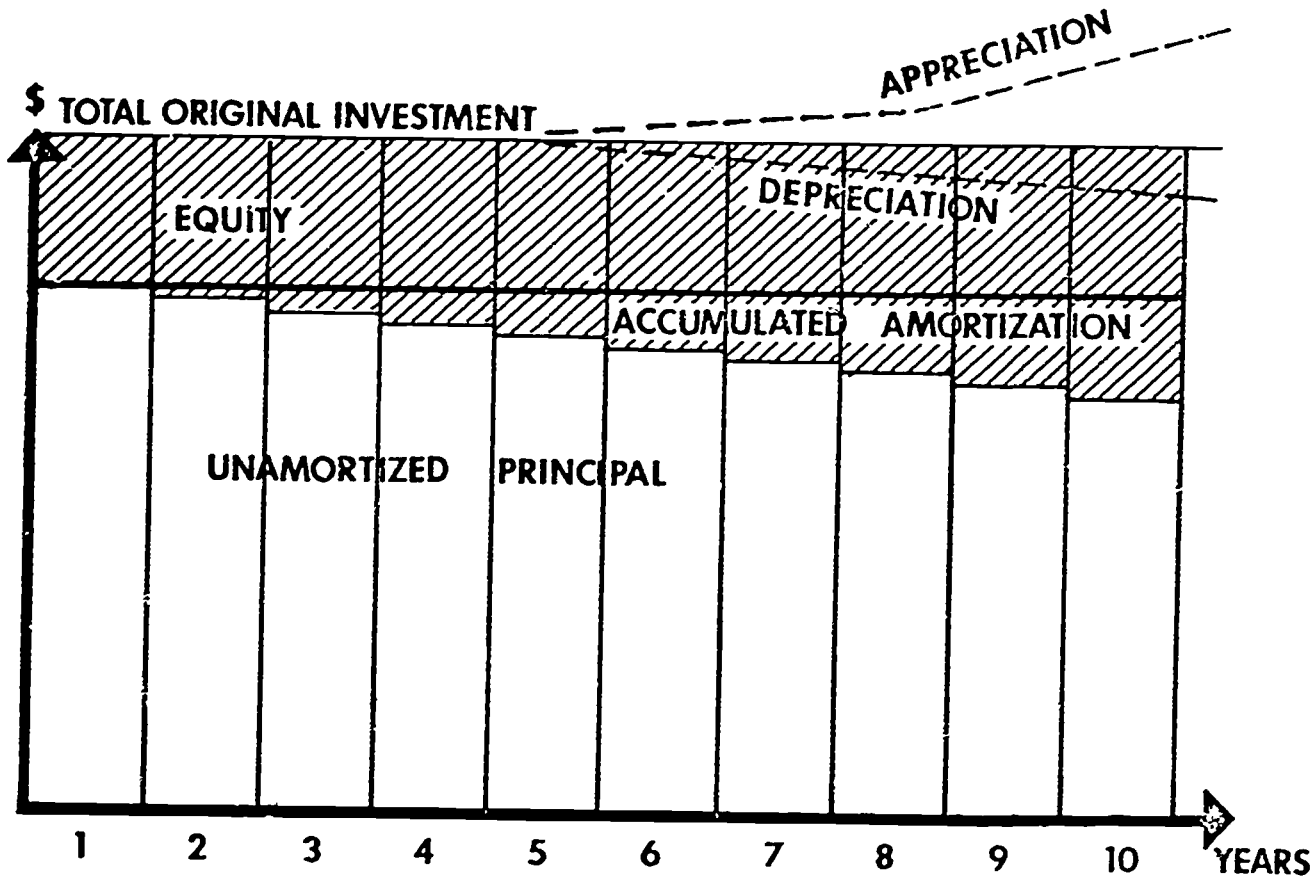
CASH FLOW
AFTER TAXES
3

to that shown in chart 2. However, Taxes are large and After Tax Cash Flow is small. Only part of Amortization is covered by Depreciation. The investor will in all probability avoid this situation through a sale, refinancing or the addition of other investments with large depreciation deductions.

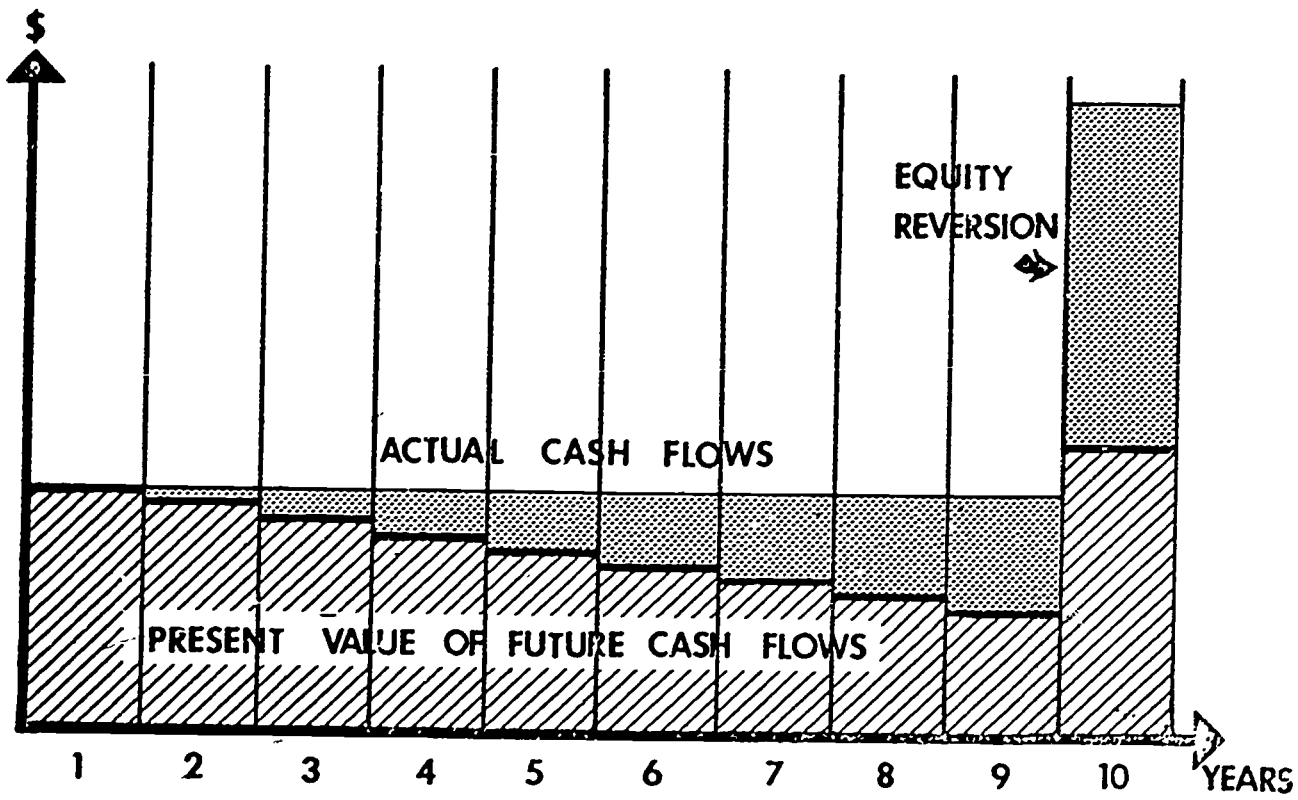
The two charts on the following page illustrate two important aspects of this analysis, the growth in equity ownership and the concept of discounting cash flows:

First, equity ownership in the project will build up during the term of the mortgage. At the end of the term equity ownership will equal Selling Price [that is, Total Investment plus any appreciation (or minus any depreciation) in value] and minus the unamortized mortgage principal. This increase in equity value may be realized by the equity investors only through a sale or refinancing.

Secondly, all future incomes generated by the project will be discounted to present value. This applies to both the annual income from the project operations and to the income accruing on sale of the project. The principle is simple; a dollar received in some future period can be generated by investing some lesser amount today. This principle is particularly useful where annual cash flows are variable. The following simplified example illustrates the effect of discounting cash flows at 10% annually; first with a sale in the tenth year then in the fifth year:



INVESTMENT GROWTH



DISCOUNTED CASH FLOWS

SALE IN YEAR 10:

Year	Actual Cash Flow	Present Value Discounted at 10%
1	100	$ 90.9
2	100	82.6
3	100	75.1
4	100	68.3
5	100	62.0
6	100	56.4
7	100	51.3
8	100	46.6
9	100	42.4
10	100	38.5
Reversion	1,000	385.5
TOTAL	$2,000	$999.6

SALE IN YEAR 5:

1	100	90.9
2	100	82.6
3	100	75.1
4	100	68.3
5	100	62.0
Reversion	1,000	620.9
TOTAL	$1.500	$999.8

DISCUSSION OF PRESENT VALUE ANALYSIS

A. KEY DEFINITIONS

1. PRESENT VALUE: Today's worth of cash received or invested at some future date.
2. DISCOUNT RATE: The interest rate used to determine present value.
3. NET PRESENT VALUE: The present value of future cash inflows minus the present value of the investment (cash outflow).
4. PROFITABILITY INDEX: The ratio of the present values of cash inflow to investment.
5. DCF RATE OF RETURN: That interest rate which makes the present values of cash inflow equal investment. This rate will make the net present value equal zero and the profitability index equal 1.00.
6. ECONOMIC LIFE: The period of time during which the alternatives (investments and cash inflows) will be analyzed.

B. AN APPLICATION OF THE PRESENT VALUE ANALYSIS

P.V. $1.00 10% RATE	YEAR	ONE ACTUAL COST	ONE P.V. COST	ONE ACTUAL COST	ONE P.V. COST
$1.00	1968	50.	50.00	40	40.00
0.91	1969	5.	4.55	8	7.20
0.82	1970	5.	4.10	8	6.55
0.75	1971	5.	3.75	8	6.00
0.68	1972	5.	3.40	8	5.45
0.62	1973	5.	3.10	8	4.95
0.56	1974	5.	2.80	8	4.50
			$71.70		$74.65

B. AN APPLICATION OF PRESENT VALUE ANALYSIS
(Continued)

	NET INVEST.	P.V.	NET BENEFIT	P.V.
1968	50 - 40 = 10	$10.00		
1969			-5 + 8 = 3	$ 2.72
1970			-5 + 8 = 3	$ 2.44
1971			-5 + 8 = 3	$ 2.24
1972			-5 + 8 = 3	$ 2.04
1973			-5 + 8 = 3	$ 1.86
1974			-5 + 8 = 3	$ 1.68

1. PRESENT VALUES:
   (a) NET INVESTMENT $10.00
   (b) NET BENEFIT $12.98

2. DISCOUNT RATE: 10%

3. NET PRESENT VALUE $2.98 (12.98 - $10.00)

4. PROFITABILITY INDEX: 1.298

5. DCF Rate of Return: (OVER 10%)

6. ECONOMIC LIFE: six years

C. EXAMPLE APPLICATIONS

1. Comparison of alternatives architectural materials; initial costs and maintenance costs.
2. Alternative financial schemes; lease versus purchase.
3. Government contract; comparison of the net investment to net benefits of alternative solutions.

4. Real estate joint venture; determination of future land values necessary to return 10% after taxes where land purchase on installment contract.
5. Lease of investment property; determination of the feasibility of the project.
6. Large - scale land development; test of alternative solutions.

D. THE COMPUTER AND PRESENT VALUE ANALYSIS (see "Financial Analysis of Real Estate" AIAJ Aug. 1968):

1. Profitability Guidelines
2. Risk Simulation

COMFORT EFFECTED

BY

AIR HANDLING-LIGHTING SYSTEMS INTERACTIONS

By

J. MARSHALL HEMPHILL

Research Supervisor
Armstrong Research Development Center

In this talk, I'd like to discuss the interaction between the ceiling system, lighting, and air-conditioning systems. There has been a tremendous volume of literature over the last five years which discusses the problems associated with increasing footcandle levels and increasing air-conditioning loads. And, much has been written about energy integration systems which in some manner utilize the heat generated by lighting devices. Also, return air light troffers have been discussed as reducing the space cooling load and as a means of utilizing the so-called "heat of light". Attention is called to the increase in footcandle levels which results when return air troffers are used. Indeed, our testing programs at Armstrong have verified all of these functions and these capabilities are an integral part of our current ceiling systems.

There is, however, another viewpoint which has not been well explored. In essence the question is this: Are there advantages or disadvantages to the various forms of air handling/lighting systems when looked at not from the viewpoint of dollars and cents but from the viewpoint of the comfort of the space occupant. In other words, we have spent a lot of time looking at how to justify or minimize the heat load from the lights and how to get the air in and out of small increments of the building but we haven't looked at the combinations of air supply and lighting systems to see how these influence the comfort of the man for whom we are building. The comfort criteria, certainly a humanistic criteria, might ultimately be a more important decision-maker than differences in first costs or operating costs.

To get at this question we must first consider the thermal comfort problem. For one thing, body thermal comfort has a very narrow tolerance range. Our visual and acoustic comfort criteria are quite broad. We can complete most of our visual assignments with illumination levels ranging from 5 to 5,000 footcandles, a ratio

of 1,000:1. And our acoustic environment can range from 10 db to 70 db with no adverse effects--a range of 1,000,000:1 in sound intensity. But change the room temperature 4 degrees from 75F and complaints come in loud and strong.

Unfortunately, while we have footcandle meters to read to the nearest 0.1 footcandle and sound meters with a, b, and c weighting networks and frequency band analyzers, we have not yet found a comfort meter. So we have to break comfort into its components and evaluate these individually.

To get at our problem let us recall that the body is a thermal engine which must lose heat at a programmed rate within boundaries which can vary widely for short periods of time but which are quite narrow for long periods of time. The typical body heat equation is given as: $H = S + E + R + C$. Now, this simply means that: H - the rate at which body heat is generated must be balanced by four factors: S - the storage factor (the short term effect); E - the evaporative loss; R - the radiant exchange with the surroundings; and C - the convective loss. Heat generated by the body must be stored or it must be lost by evaporation, radiation and convection.

When considering the comfort of building occupants, we discard the storage factor since this is the flywheel which carries us through short term fluctuations in ambient conditions and through rapid changes of our activity rate. This leaves us with the evaporation, radiation and convection exchanges.

Restricting our analysis to typical building spaces where the temperature is maintained in the mid seventies, we find that, first of all, the evaporative effect is influenced only by air motion. Published work clearly indicates that where air motion is held below 50 feet per minute (most air-conditioned buildings

today), ranges in relative humidity between 20% and 70% have little influence on the comfort sensation. Thus, we discard relative humidity as a factor, since control within the broad range is well within the capabilities of even the most basic air-conditioning system. Since today's air supply systems can hold air velocities in the occupied zone below acceptable limits--say 40-50 feet per minute--evaporation, as a means of heat loss, becomes of minor significance. Thus convection and radiation loss become the most important factors in controlling body comfort. Convective heat loss is affected by air temperature and air velocity and the radiant exchange is affected by the temperatures of the room surface surrounding the individual.

Since air temperature and velocities are consistently held within acceptable ranges with a wide variety of air supply and air return systems, the only value which fluctuates is the radiant environment.

With this analysis behind us, we concentrated on the question: "How do the air handling-lighting systems interact to influence the radiant environment?"

Without going into detail, let me now introduce the term MRT. MRT stands for mean radiant temperature. It is the average radiant temperature at a point in a room. It is specific to that point and is affected by the size, temperature, and location of all surfaces in the space. For example, on a cold day we would expect the MRT to get lower as we approach a window, since the cold window surface subtends a larger and larger area as we move toward it. The MRT is a good approximation of the effect of the radiant environment on an individual. It is however, an average and has the same limitations of any average--it can conceal extremes. But let's accept it for the moment as the best tool currently available and move on.

To carry out our research into MRT and various lighting/air handling systems, we built a sophisticated environmental test chamber within a larger controlled temperature building. Let's take a few minutes now to tour this facility, before reviewing some of our more significant findings.

Figure 1 shows the large round controlled temperature building that is the site of our environmental testing program. Located in the round chamber itself is the Mobile Environmental Test Facility, which we call MOFAC (Mobile Facility). A climate varying from zero to 100F is created within the round chamber and the interaction of the air conditioning and lighting systems necessary to control the environment in MOFAC is studied. Incidentally, the building is round since this is the best space configuration for the control of temperatures.

Entering the round chamber, Figure 2 shows the entrance to MOFAC. The ductwork supplying and returning conditioned air is located on this side, as are the other test room services. The exposed window walls of the test rooms are on the far side. The windows are single pane glass and cover approximately one-third of the exposed wall in each room.

The actual environmental test rooms are two in number and are meant to simulate a row office and a corner office in a multistory building.

This schematic plan, Figure 3, shows the row office. The control room is at the bottom and the corner office (indicated here simply as a controlled buffer zone) is at the top. The window wall, the exterior wall, is on the left and the rear wall is very heavily insulated to keep heat gain or loss at one Btu per hour per square foot. Each test room is supplied with air from the conditioning unit, with both temperature and volume

going individually controlled.

Figure 4 is a section through a test room. First of all, note that a plenum is created below the floor of the test room. Controlled temperature air is supplied to this lower plenum, exciting to a crawl space through a ventilating ceiling. The temperatures resulting in the upper plenum are carefully reproduced in the lower plenum, thus simulating multi-story construction. Also note that the ceiling height is 9' and that recessed 2' x 4' light fixtures are used. The window area is one-third of the room exterior wall.

Figure 5 shows the first of the two test rooms, the row office. Venetian blinds are available and there is perimeter heat located at the base of the glass, for tests when it is needed. A large number of thermocouples record air temperatures--over 50 in each room. These are shielded in aluminum foil to minimize the radiant effect.

Also, notice the black Vernon globe thermometers hanging on some of the thermocouple trees. They are used to measure mean radiant temperature. The temperature measured inside that hollow brass sphere is a function of the velocity and temperature of the air moving past the globe and the net radiation exchange of the globe with the surfaces in the room. It is an easy computation to subtract out the air temperature and motion effect, leaving the MRT. Incidentally, we can also compute MRT by the view factor method and have found agreement between these two approaches.

The effect of people in a space can be simulated by simulated occupants or Simoccs. Each one of the screened light banks generates the same amount of sensible heat as two people working at desks (approximately 500 Btu/hr.).

At this point, let's consider our testing program and some of its significant results. First, let's review the earlier points. The body must lose heat to its environment. The modes of heat loss are: radiation and conduction; convection and vaporization. The factors regulating heat loss are: surface temperatures - radiant and conduction; air temperature and velocity - convection; and relative humidity and air velocity - vaporization. Stated another way (Figure 6), comfort is a function of dry bulb, that is, room air temperature, mean radiant temperature, relative humidity and air velocity. As I have indicated, air-conditioning systems today give good control over air temperature, relative humidity and air velocity and thus eliminate these variables as significant criteria for selecting between various air handling-lighting systems. The remaining factor, MRT, is significantly changed with various systems, hence our study was concentrated here.

In setting up the test program we established three basic ceiling plenum types, Figure 7. First of all, there is the static plenum, where both supply and return air is ducted and where there is no forced air movement through the plenum. A variety of return systems are possible with a return air light fixture shown. Next, we can have a return air plenum where air is ducted to the space and returned through the plenum. Ceiling grilles and light fixtures are used to get the air into the plenum, with the latter shown. Finally, the third plenum state is where a supply air plenum is used with a ventilating ceiling. Return is obviously ducted, with, again, a return air fixture shown.

Having identified these three plenum functions we organized eight air-handling-lighting systems for study, Figure 8. Systems I through III used ducted supply with ducted return and represented the static plenum. Low wall grilles, ceiling grilles and light fixtures were the three return systems. Systems IV

and V, return plenum cases, used either ceiling grille or light fixture returns and ducted diffuser distribution. The last three systems - VI, VII and VIII used supply air plenums and ventilating ceilings. Again ducted wall, ceiling and light fixture returns were used. These eight systems cover the vast majority of systems installed today.

All of these systems did an acceptable job in maintaining uniform space temperature at acceptable room air velocities. From these two criteria it would be hard to choose between the system in terms of their effects on the comfort of space occupants. However, there is a notable difference between the systems when we study their effect on the radiant environment. Figure 9 summarizes mean radiant temperature measurements made during a recent test series. The measurements were made when the outside temperature was 95F, with no solar load imposed on the building. This simulates a northern exposure on a hot summer day. The vertical scale is mean radiant temperature. The test rooms were controlled at 74F, which is the base line, so all MRT readings were above room air temperature. The horizontal scale is distance from the exterior wall, where the windows are located. Readings were taken at 2', 7' and 12' from the wall, and as you would expect, the mean radiant temperature decreases as we move away from the glass. Furthermore, note that three families of curves are shown. The solid lines are supply air plenum cases; the dashed lines are ducted supply air diffuser systems with ducted return systems; and the dotted lines are ducted diffuser systems utilizing return air plenums.

The first generalization we can make is that the solid lines represent the lowest mean radiant temperatures. Ideally, we would like the mean radiant temperature to be as near as possible to the room temperature. Thus we can say that the supply air plenum case, which results in cool ceilings and cool floors,

produces the most favorable MRT. The next favorable grouping is those systems using ducted supply and ducted return. This last group results in the hottest plenums and hence the warmest ceilings and floor, due to heat build-up from the lights. Within each group we can further observe that the return air light fixture case (symbolized by a triangle) offers the best performance. This is because air moving through the fixture cools the lens and minimizes the radiant load to the room below. Thus, the best performance is turned in by the ventilating ceiling, return air fixture system.

To illustrate the effect of plenum function on MRT, Figure 10 shows typical ceiling and floor surface temperatures. First of all, note that floor and ceiling temperatures are closely coupled typically within one degree. Also, as this table shows, the supply air plenum produces floor and ceiling temperatures close to or slightly below the room air temperature and thus helps compensate for the radiant load of the lights. On the other hand, static and return plenums result in surface temperatures significantly above the room air temperature, with static plenums being slightly worse. These higher surface temperatures account for the higher MRT values measured with these systems. Based on these and similar data, we have concluded that the system which optimizes comfort conditions is a supply air plenum with return air light fixtures.

It is reassuring to know that this combination also helps to minimize the space cooling load from the lights, by effectively extracting a proportion of the heat generated by the lamps and ballasts, and, in addition, results in substantial improvements in the footcandle level because of increase in the light output of the lamps. Thus both first costs and operating costs can be effecitvely reduced by this system.

Now, how does MRT relate to the room air temperature? Published work by ASHRAE and others indicates that there is an air temperature and mean radiant temperature combination which optimizes comfort probability. Under ideal conditions, when both of these values are approximately 77F, it would appear that most people should be comfortable when doing very little physical work. However, as soon as we turn on the lights we know that the mean radiant temperature must rise above the air temperature. This means that, in turn, the air temperature must then be lowered to compensate for the increase in MRT, if we are to keep people comfortable. Various sources indicate that air temperature should be decreased from 1 to 2 degrees for each degree increase in MRT. The present ASHRAE comfort standard indicates a 1.4 to 1 relationship. Thus, if the mean radiant temperature were to climb to 78F, then the dry bulb should be depressed from 77 to approximately 75F. Since MRT's in the order of 78F to 79F are typical with today's light levels, we find that space design temperatures should currently be 75F or slightly lower.

In summary, our research has succeeded in pinpointing the value of the supply air plenum and the value of the return air light troffer in terms of their effects on the comfort of building occupants. Yet to be explored is a refined study of the effects of non-symmetrical radiation on comfort. As pointed out earlier, MRT is an average value and does not take into consideration a symmetrical radiation patterns--particularly as they occur at a building perimeter with either very hot or very cold temperature outside the building. So, the research must go on.

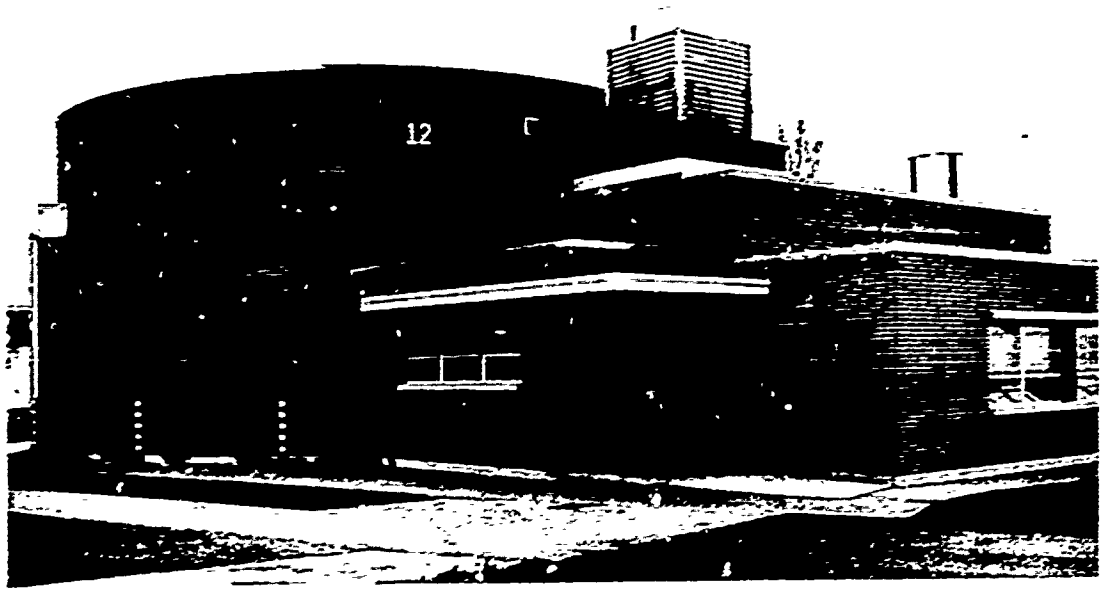
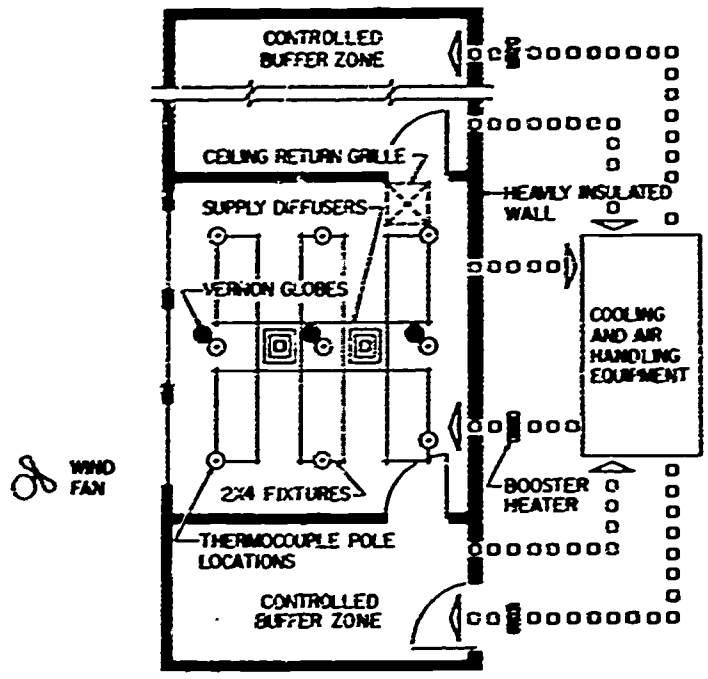


FIGURE 1

FIGURE 2



NOTES:
- LOW WALL RETURNS ARE ONE FOOT ABOVE FLOOR LEVEL UNDER CEILING RETURN LOCATION SHOWN ABOVE.
- INSIDE DIMENSIONS OF TEST ROOM ARE 15X14X9 FEET.

FIGURE 3

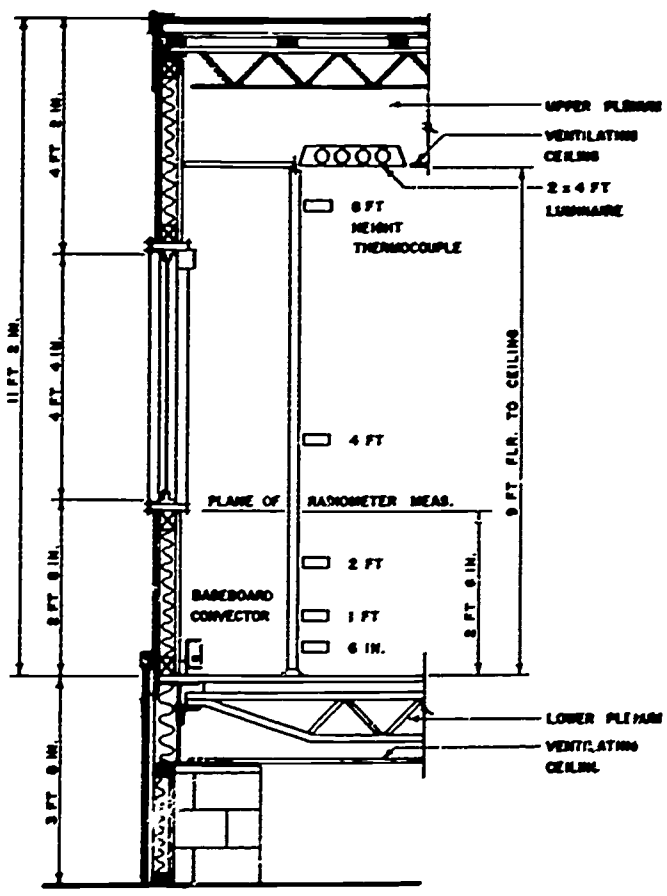


FIGURE 4

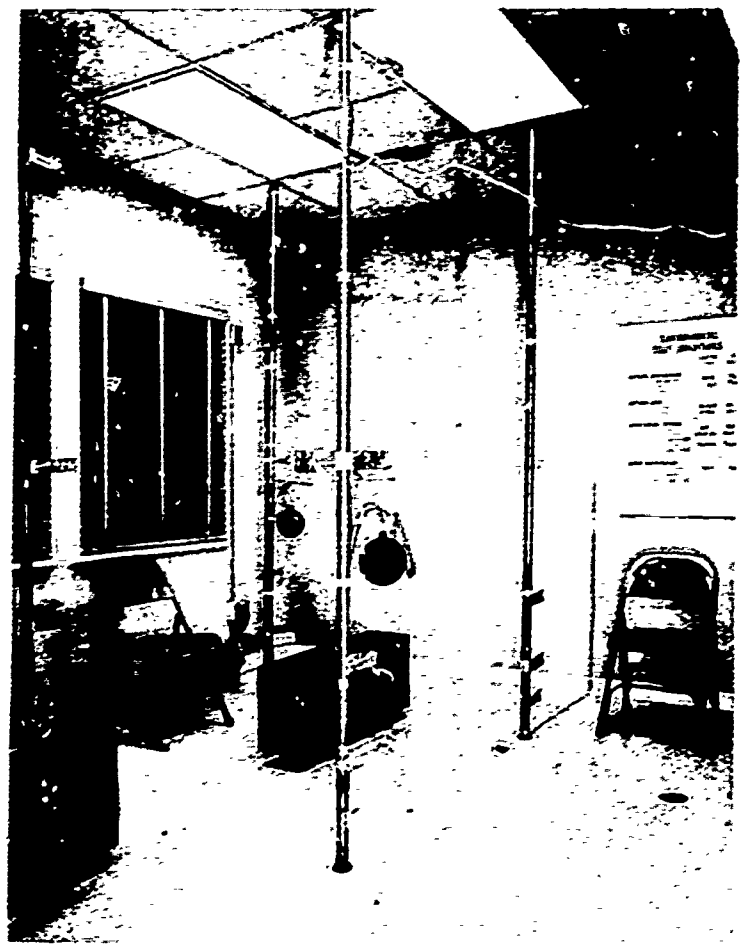


FIGURE 5

$$COMFORT = F(DB, MRT, RH, V)$$

FIGURE 6

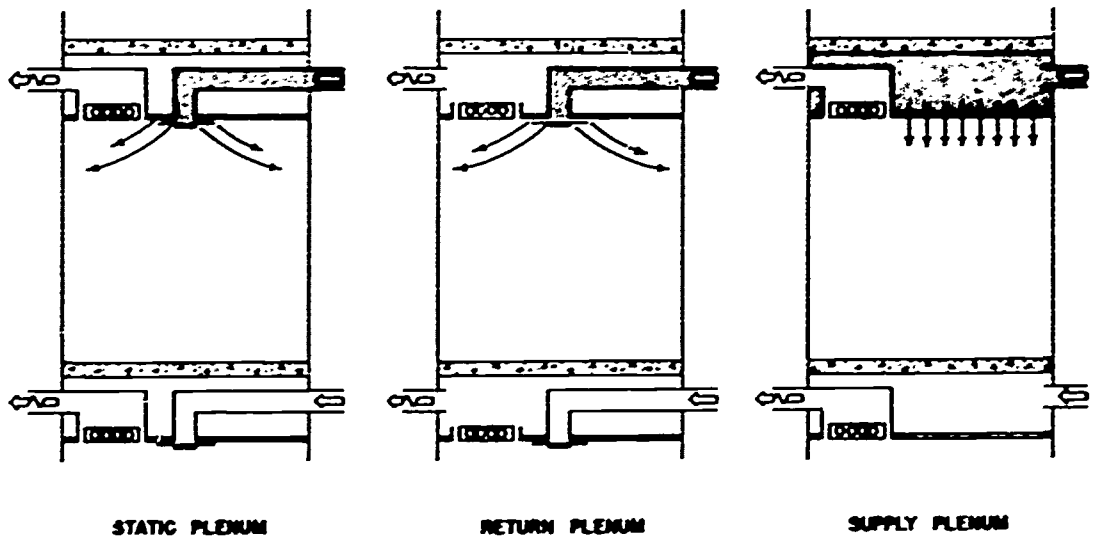


FIGURE 7

RETURN AIR SYSTEM	SUPPLY AIR SYSTEM: DUCTED CEILING DIFFUSERS		SUPPLY AIR SYSTEM: VENTILATING CEILING
LOW WALL GRILLE	I		VI
CEILING GRILLE	II	IV	VII
R A LIGHT TROFFER	III	V	VIII
PLENUM FUNCTION	STATIC	RETURN	SUPPLY

FIGURE 8

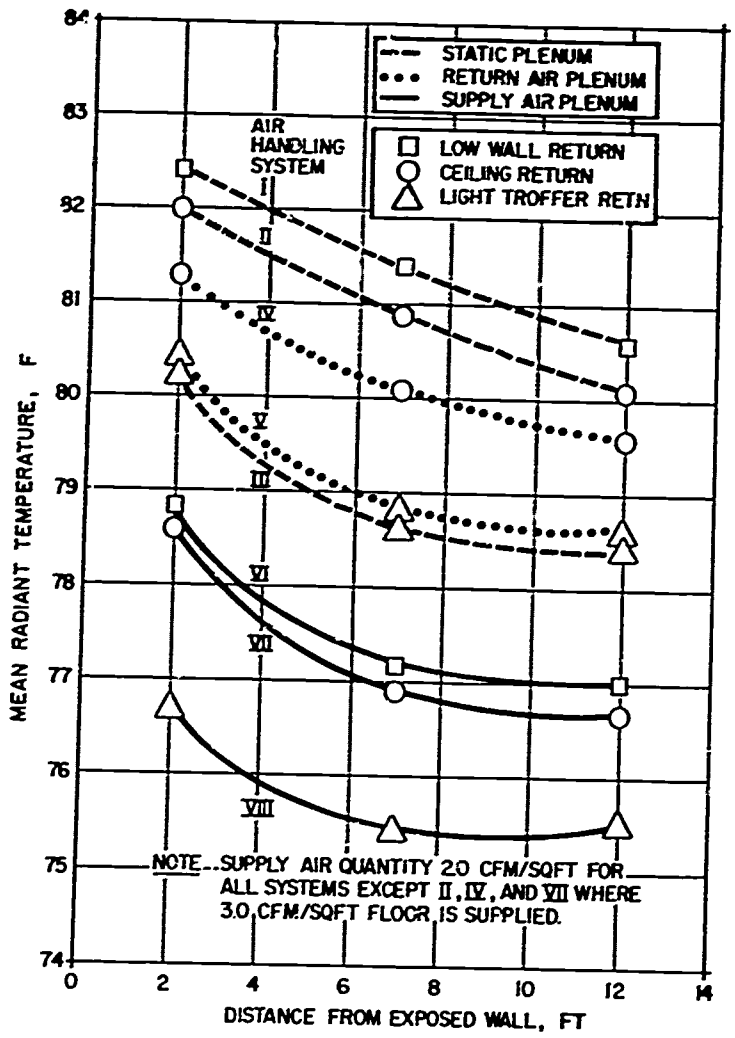


FIGURE 9

	SURFACE TEMP RANGE, F		
	STATIC	RETURN	SUPPLY
CEILING, FLOOR	77.5-80.0	77.0-77.5	73.0-74.0

NOTE: HIGH LEVEL LIGHTING
AIR QUANTITY - 2.0 CFM/SQ FT

FIGURE 10

THE PERFORMANCE CONCEPT

Its Application to Design and Programming

By

MICHAEL BRILL

Senior Systems Research Architect
Institute of Applied Technology
U. S. Department of Commerce

CONTEXT AND BIASES

I. Who We Are.

   A. A new group of architects, engineers, systems analysts, test designers, marketing and production consultants, behavioral and communications consultants with a sense of mission.

II. Where We Are.

   A. In the Federal Government, Building Systems Section of the B. R. D. of the I. A. T. within N. B. S.

III. What We Do.

   A. Philosophize about nature of problem solving.

   B. Develop methods and techniques to solve problems.

   C. We solve problems.

   D. Try to develop a cohesive, testable, transferable body of knowledge for use in government and, more critically, the private sector of our economy.

   E. Stimulate other efforts.

IV. Why We Do What We Do.

   A. There are present problems in the physical environment of great complexity - they are not being solved.

   B. We believe they cannot be solved with the existing:

      1. View of what the problem is.

      2. Techniques.

      3. Resources.

      4. Organization of the process of making.

   C. Problems are in the process, not the products.

OUR VIEW OF THE PROBLEM

I. Inadequate Physical Environment for Our Needs and Aspirations.

   A. Both quantity and quality; they are linked.

B. We will not deal (in this talk) with quantity or not enough-to-go-around problem.

C. Quality problem is both attenuation and poor fit.

D. Attenuation: Complex environments are produced in complex ways. The making involves expertise in many areas, and users or inhabitants are generally not considered (and are not) experts. We users are attenuated and distant from the process and from the decision makers.

E. "Go Fight City Hall" is the sad comment.

F. There is very little attention paid to user satisfaction except after a riot or other disaster.

G. Attenuation generates poor fit:

   1. Physical environments unresponsive to our needs and wants hamper our physical health, mental health, usefulness, and pride.

H. Poor fit has two facets:

   1. Environment.
   2. User.

I. We are concerned with the user because it is really only through understanding the users needs explicitly that the environment can be altered to make good fit.

J. The software rather than the hardware.

K. A systems view of Federal office buildings is that they are simply a piece of government information processing system, along with men, machines, and methods. If we could process information without buildings (as someday we might), we would do it.

L. We have studied the costs of this information processing and find that, over 40 years, 2 per cent is the cost of the building, 6 per cent is the cost of operating and maintaining the building, while 92 per cent is the cost of men - the users' salaries.

Therefore, we are concerned with the user, not the building, as the sensitive element.

M. The same kind of analysis, with similar results, has been done for hospitals.

N. Analyzing housing is more difficult, but our experience shows that many housing projects with high physical standards have become instant slums due to a lack of understanding of users' needs

O. To quote the book, The Exploding Metropolis: "Once upon a time (says a close student of New York's slums), we thought that if we could only get our problem families out of those dreadful slums, then Papa would stop taking dope, Mama would stop chasing around, and Junior would stop carrying a knife. Well, we've got them in a nice new apartment with modern kitchens and a recreation center. And they're the same bunch of bastards they always were."

II. Parallels in Other Areas - Generated Solutions:

A. School decentralization.

B. Neighborhood city halls.

C. Community mental health centers.

D. Advocate planning.

OUR VIEW OF A SOLUTION

I. The Systems Approach and the Performance Concept.

A. Systems approach/six elements:

1. Problem definition and goal statements.
2. Measurement techniques - How will you know when a goal has been reached?
3. Generate alternative solutions and test or measure each one - "modeling" and simulation.
4. Select a solution from tested alternatives.

5. Implement the solution in a real-world context.
6. Post-facto testing or feedback/close the loop.

B. We are primarily concerned with Steps A, B, and F.

C. It is the responsibility of designers and makers for Steps C, D, and E.

II. The Performance Concept.

A. Is part of the "systems approach."

B. Definition: "An organized procedure for stating the desired attributes of a material, component, or system in order to fulfill the requirements of the intended user, without regard to the specific means to be employed in achieving the results" - John Eberhard.

C. Definition: "The means-exempt assurance of a desired state" - Mike Brill.

D. Note that the user is the starting point for the performance concept.

III. What It Does.

A. Advantage is that performance is what users want from physical environments, not the object itself.

B. If you are to specify and measure performance, you assure procurement of what users want.

OTHER PROJECTS USING THE SAME CONCEPTS

I. School Construction Systems Development, California.
II. Special Schools Project, Florida (No. 1).
III. University Residential Building System, California.
IV. Montreal Catholic Schools, Montreal.
V. Metropolitan Toronto School Board.
VI. Public Buildings Service Building Systems Project, Washington, D. C.
VII. Special Schools Project, Florida (No. 2).

VIII. Academic Building Systems, Indiana and California.

IX. Pittsburgh Great Schools Project, Pittsburgh.

X. Laboratory Systems, Binghamton, S. U. N. Y.

XI. Newark Human Renewal Corporation, Newark.

XII. Model Cities Experiment, H. U. D. - RFP.22.68.

XIII. National Institute for Mental Health, I. A. T. Project.

OUR PROJECTS

I. History and Background.

A. John Eberhard, architect and former director of Institute for Applied Technology, is largely responsible for Federal Government's interest and commitment to finding a new way to build and their interest in assuring a "good fit."

B. The success of the performance concept and the systems approach in management techniques, weaponry, and space programs led him to believe the techniques were transferable to the building process with the Federal Government.

C. Federal Government playing a dual role:

1. Using its position as a major program builder to demonstrate the efficacy of a new approach for its own good.

2. Doing basic research and technology transfer where the private sector cannot, or will not, support it.

D. Public Building Service of the G. S. A., as the agency responsible for construction of Federal buildings, agreed to test bed for new techniques.

E. Target alternatives:

1. Hospitals.

2. Officer quarters.

3. General purpose classroom buildings.
4. Office buildings.

F. Office building selected; four buildings set aside.

G. Total of 1,000,000 sq. ft. of new construction.

II. Analysis of Target.

A. Sixteen recent F. O. B.'s analyzed.

1. Gross configuration: percent utilized and model established for management decisions.
2. Tenant profile: size, distribution, configuration, and relation to spans, etc. Concept of the address and organize conformance to D'Arcy Thompson's theories of growth optimums.
3. Four criteria established for selection of target:
   a. Volume of hardware as percentage of total cost of building.
   b. Susceptibility to industrialized techniques.
   c. Degree of direct influence on user.
   d. Potential improvement in performance.
4. Floor/ceiling sandwich chosen. Not entire building - only those portions typical to all F. O. B.'s.
   a. No core.
   b. No exterior wall.
   c. No special spaces.

B. Methodology development.

1. Having selected a target (in general, hardware-type terms, what was to be procured on a performance basis), a way had to be found to generate user needs and to link them to the hardware so as to generate responsive hardware.
2. This link is a spatial attribute.
3. Definition: The characteristics which must be present in the space in order that the users' needs can be met.

4. As a simple example: In a study environment, a user needs to be able to read. One of the required spatial attributes is illumination - not lighting fixtures. We specify how much light must reach his eye from the message surface and allow the designer to select the method which satisfies this requirement from alternatives which might include window, lighting fixtures, illuminated messages (like slides or movies), or more sophisticated illumination methods not yet developed.

C. The project matrix.

1. We have chosen ten spatial attributes, the sum of which will permit users engaged in spatial office activity to function. They are:
   a. Conditioned air.
   b. Illumination.
   c. Acoustic qualities.
   d. Stability and strength.
   e. Health and safety protection.
   f. Planning flexibility.
   g. Activity support elements.
   h. Esthetics.
   i. Maintainability.
   j. Interface compatibility.[1]
2. These are spatial attributes; if we could relate these to the built elements which supply and control them, we have, essentially, a verbal description of the system "in-use."

---

[1] Because we don't have exterior wall and core <u>In System</u>, we must be able to assure that those things which are in system are compatible, where they interface, with out-of-system elements.

3. They are shown here in an input-output matrix. (Figure 1)
4. We have broken the built elements (or systems response) down along, frankly, conventional lines:
   a. Structure.
   b. H. V. A. C.
   c. Utilities.
   d. Finished floor.
   e. Luminaires.
   f. Finished ceiling.
   g. Space dividers.
5. In developing criteria based on the users' needs, we were surprised to discover that there are quantifiable relationships between every spatial attribute and every built element. It has been extremely useful to display all these relationships, many of them not previously clear.

D. The intercepts.
   1. For each intercept (or relationship between software and hardware), information was developed at three levels of specificity:
      a. "Requirement," the qualitative statement of the performance we wish from the environment.
      b. "Criteria," a quantification of such desired performance.
      c. "Test," the evaluation techniques which assure conformance with the specification. (Figure 2)
   2. Without a "test," (whether numerically, quantifiable, or simply by inspection), one cannot delegate design responsibility for there is no way to assure that the criteria have been met.

3. An example of intercept statements:

   Requirement:

   Criteria:

   Test:

E. The expanded matrix.

1. The first matrix describes the project demonstration area, the floor-ceiling sandwich of Federal office space. This matrix relates the environmental attributes the space must have to function (required spatial attributes) and the actual physical building components (built elements) which generate and contain these attributes.
2. The matrix shows these relationships in a building-in-use, the completed end product of the building process.
3. In order to more clearly show the effects of this building process on the product, we must go back in time. Many design decisions represent constraints inherent in the process, not in the product, and have little to do with the users' requirements.
4. For the built elements to satisfy human needs, they must be in place. To be in place, they must have satisfied all the constraints in manufacturing, shipping, and construction, a chronological process. (Figure 3)
5. Similarly, we must go back to the needs of the human user to examine how the required spatial attributes were generated. These attributes, as the human office worker senses them, directly affect his output. Further, these attributes are measures of the quality of the support systems a building must contain to be "effective," that is, to increase output.

6. These systems are life support, task support (man and machine), and psychological support, each of which demands a different range of environment attributes to be beneficial to the human user.
7. A major significance of the full matrix is that it clearly presents the full range of constraints in the building process and states which of these is the critical constraint for any element at any time. It permits the designer of buildings, the maker of buildings, the manager, and the user to predetermine and pretest the most systematic path to the end product.

F. The performance specification.
1. The information in the matrix forms the basis for the specification.
2. There are also managerial, legal, and, by implication, financial innovations in this project.
3. We have issued a draft in November, 1967, have received feedback from all participants, and expect to issue final specification this winter.
4. Building community has shown great interest - is a success so far.

G. Problems.
1. There is a great lack of performance-oriented information. Relied heavily on three sources:
   a. S. U. N. Y.
   b. B. S. D., Inc./Projects.
   c. Our own test engineers and consultants.
2. Test methods are constantly being altered and improved/state-of-flux. Search for performance is "sharpening" the test methods through re-evaluation.

3. "Not-the-perfect-client" problem: P. B. S. builds but does not occupy. Concerned with the hardware more than the software. We did not (not funded) do original research into the user. We accepted a prototypical, state-of-the-art in the literature user. No over-riding psycho-social viewpoint. Heavy on the physiological accommodation.

H. Implication.

1. We wish to build a complete capability to do programming and design systematically in order to transfer the techniques to other government and quasi-government agencies.
2. The "gap" in the project (methodologically and even morally) is in the lack of user research. By this I mean techniques to generate, display, and synthesize user needs information. We are less interested now in the data itself than in how to get it and manipulate it systematically when obtained.
3. Due to this, we have embarked on two other projects to close the "gap." I'd like to discuss them briefly.

THE NEW PROJECTS

I. Project Two: Evaluative Techniques to Aid the Review Process in Designing Mental Health Facilities.

A. The method of designing community mental health facilities is presently unique in the Federal Government. Its concept is that facilities should be developed from the Psychiatric Treatment Program for that community. This treatment program is, of course,

responsive to the "users" of that community and developed from their needs. To evaluate the level of responsiveness that a building's design has made to the treatment program is presently difficult and partially intuitive.

B. A language which can function as a "bridge" between the treatment program and the physical design of the building would be of immense value. We, therefore, wish to develop performance requirements for building design from the types of behaviors and activities that are desired within the physical facilities. These are not performance specifications for hardware but rather performance statements for design and evaluation of that design.

C. A second part of the project takes the Treatment Program up and out into the community. We wish here to develop a way of deciding what "shape" a community must have for a mental health facility to be effective, and what other programs offer opportune links to the Treatment Program. Involved here is a clear description of these factors that define "community" and the interactions of these factors.

II. Project Three: Performance Concepts for Housing

A. The problem was to identify what performance specifications for housing are presently available (the state-of-the-art) and what would be the time and costs to develop those which are missing. In order to describe the lacks, we had to know the full array of performance requirements, the sum of which would define housing.

B. A number of operating assumptions had to be made, and limits were placed on the study through a compressed time frame.

C. Performance (or evaluative) requirements were developed in the following manner. Consult Figure 4 for this discussion.

1. The basic affectable characteristics of human users are physiology, psychology, and sociology.
2. Performance statements may be developed to assure that the needs related to or generated by these affectable characteristics are satisfied through housing to the extent that housing can, in fact, satisfy these needs.
3. Performance statements occur at many levels of differentiation. When they are very specific, they tend to be solution (or "means") oriented, are measurable with existing techniques, and permit some limited innovations in satisfying the stated need. As the statements become broader and more generic, measurement techniques become more complex and less available but allow a very wide range of innovative solutions to meet needs.
4. As developed here, essential needs of the user is the most generic statement and environmental systems support the most specific. The diminishing sequence essential needs...operational needs... requirements...is related to the user, is a measure of his needs, and gets more specific left to right. Environmental attributes is the "bridge" between the user and the Environmental System of Housing. This statement describes the attributes (qualities) the environment must possess or generate in order that the user's requirement can be met. The environmental attribute is what is supplied; the systems response is how it is supplied.

D. Environmental Systems Support describes one or all of the following:

1. Energy sources.
2. Spatial and structural support.
3. Non-physical support.
4. Removal of unwanted output.

E. The development of performance statements for every "level" allows us to indicate needs and to trace possible responses to these needs. This generation of alternative responses widens the range of problem solution.

F. As user activities change, the environmental attributes must be modified and the systems responses must be structured to make these changes. The systems support must, in turn, support the ability of the system to change. See Figure 5.

G. These three elements are the "variables" for activities, and activities charts form overlays on the original chart, allowing a three-dimensional comparison of criteria for compatibility.

H. This discussion of methodology was used to develop the full range of user needs statements for physiology. Psychology and sociology have not been developed, nor has the methodology been tested for their development. Such work is proposed as the next phase of the project.

III. Conclusion.

A. These projects demonstrate the use of the new Intellectual Technology (called the Systems Approach) in Architecture and Planning. They are continuing projects and other work is proposed which should advance the quality of the techniques used and the solutions they generate.

BUILT ELEMENTS

SPATIAL ATTRIBUTES REQUIRED BY THE USER	A STRUCTURE	B HVAC	C UTILITIES	D FIN. FLOOR	E LUMINAIRES	F CEILING	G SPACE DIVIDERS
1 CONDITIONED AIR							
2 ILLUMINATION							
3 ACOUSTICS							
4 STABILITY & STRENGTH OF MATERIALS							
5 HEALTH & SAFETY							
6 PLANNING							
7 ACTIVITY SUPPORT							
8 ESTHETIC							
9 MAINTENANCE & IMPROVEMENT							
10 INTERFACE							

"IN-USE" DESCRIPTION

FIGURE 1

USER:	SPACE:	
SPATIAL ATTRIBUTES	BUILT ELEMENTS	G
ACOUSTICS	*SPACE DIVIDERS*	*3*

REQUIREMENTS	CRITERIA	TEST

FIGURE 2

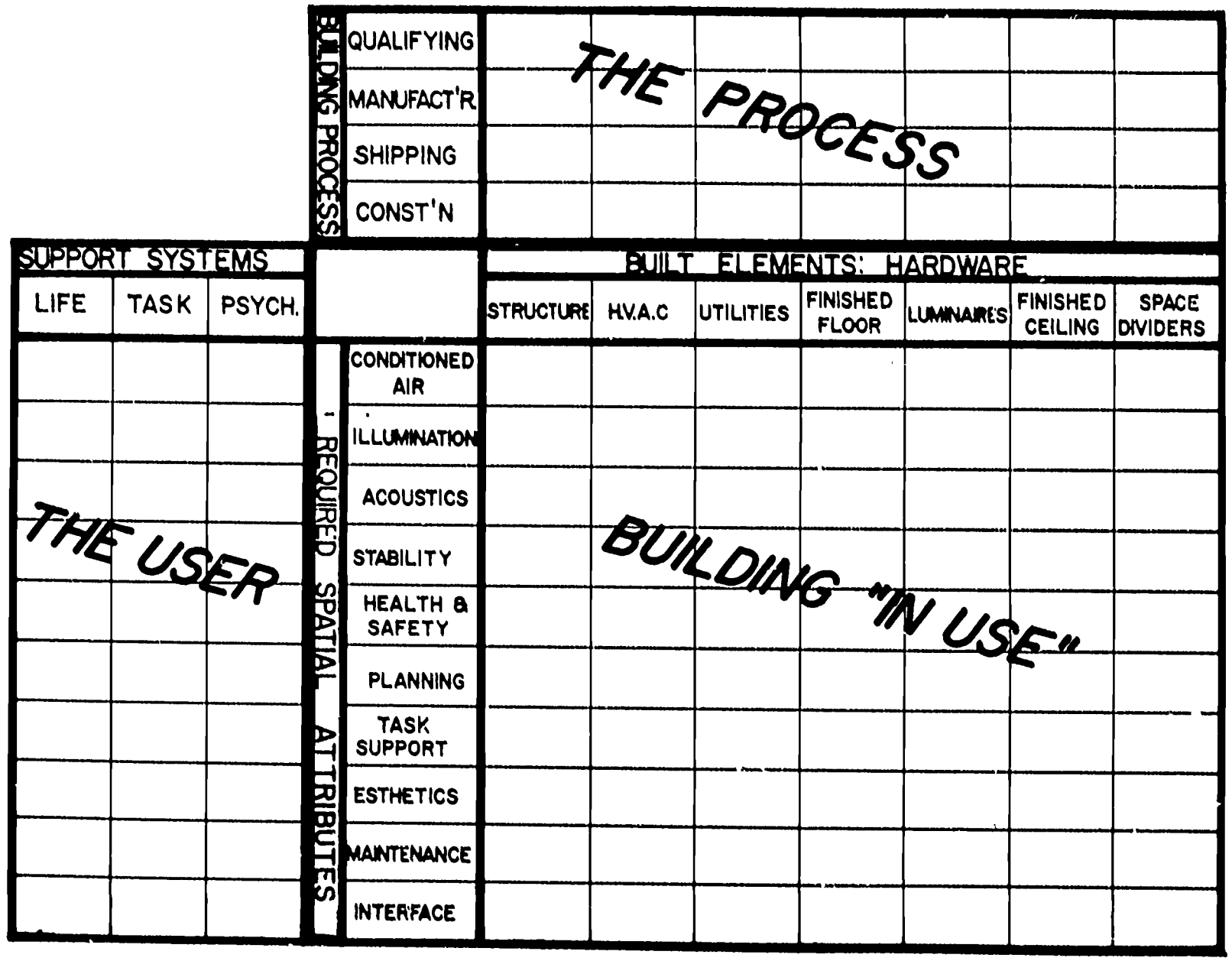

THE PROCESS
BUILDING PROCESS
QUALIFYING
MANUFACT'R
SHIPPING
CONST'N
SUPPORT SYSTEMS
LIFE
TASK
PSYCH.
BUILT ELEMENTS: HARDWARE
STRUCTURE
H.V.A.C
UTILITIES
FINISHED FLOOR
LUMINAIRES
FINISHED CEILING
SPACE DIVIDERS
REQUIRED SPATIAL ATTRIBUTES
CONDITIONED AIR
ILLUMINATION
ACOUSTICS
STABILITY
HEALTH & SAFETY
PLANNING
TASK SUPPORT
ESTHETICS
MAINTENANCE
INTERFACE
THE USER
BUILDING "IN USE"

FIGURE 3

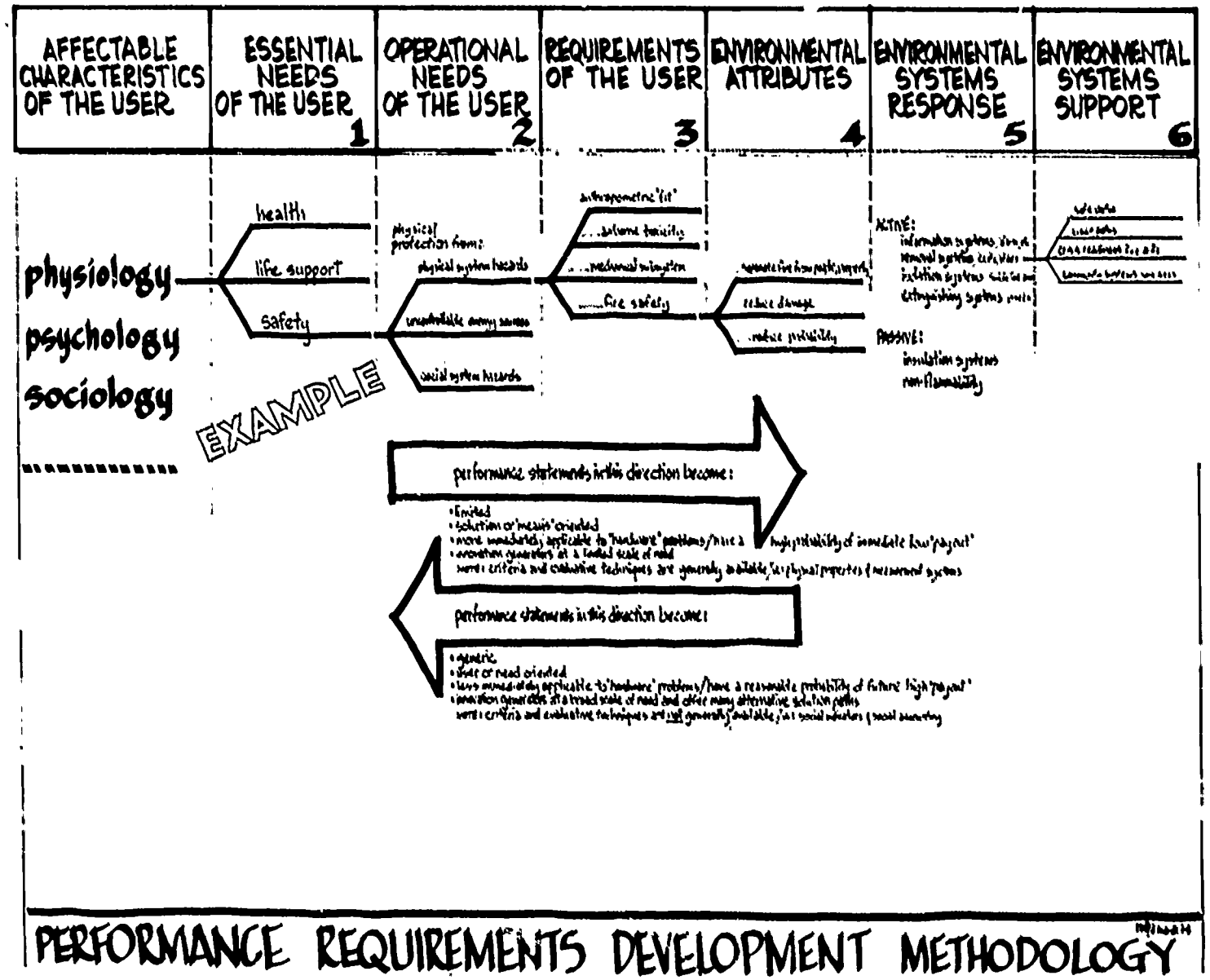

AFFECTABLE CHARACTERISTICS OF THE USER
ESSENTIAL NEEDS OF THE USER 1
OPERATIONAL NEEDS OF THE USER 2
REQUIREMENTS OF THE USER 3
ENVIRONMENTAL ATTRIBUTES 4
ENVIRONMENTAL SYSTEMS RESPONSE 5
ENVIRONMENTAL SYSTEMS SUPPORT 6
physiology
psychology
sociology
health
life support
safety
EXAMPLE
physical protection from:
physical system hazards
social system hazards
fire safety
reduce damage
reduce probability
ACTIVE:
PASSIVE:
insulation systems
non-flammability
performance statements in this direction become:
performance statements in this direction become:
PERFORMANCE REQUIREMENTS DEVELOPMENT METHODOLOGY

FIGURE 4

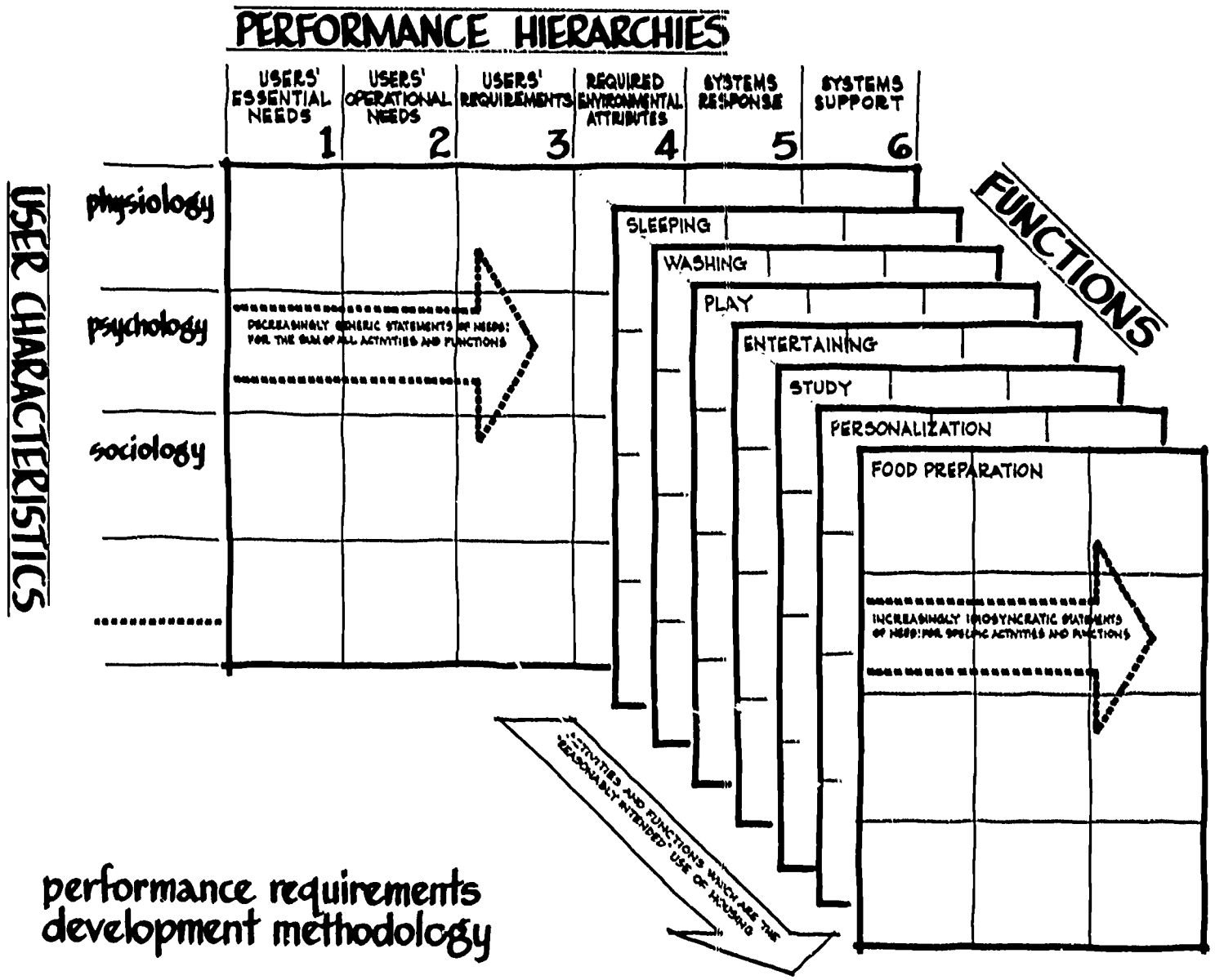

PERFORMANCE HIERARCHIES
USERS' ESSENTIAL NEEDS 1
USERS' OPERATIONAL NEEDS 2
USERS' REQUIREMENTS 3
REQUIRED ENVIRONMENTAL ATTRIBUTES 4
SYSTEMS RESPONSE 5
SYSTEMS SUPPORT 6
FUNCTIONS
USER CHARACTERISTICS
physiology
psychology
sociology
SLEEPING
WASHING
PLAY
ENTERTAINING
STUDY
PERSONALIZATION
FOOD PREPARATION
DECREASINGLY GENERIC STATEMENTS OF NEEDS: FOR THE SUM OF ALL ACTIVITIES AND FUNCTIONS
INCREASINGLY IDIOSYNCRATIC STATEMENTS OF NEEDS: FOR SPECIFIC ACTIVITIES AND FUNCTIONS
ACTIVITIES AND FUNCTIONS WHICH ARE THE REASONABLY INTENDED USE OF HOUSING
performance requirements development methodology

FIGURE 5

SYSTEM BUILDING

Toward a

Protosystem of Unit Generation

By

BARRY JACKSON

Principal
Housing Action System

INTRODUCTION

Urban housing is both an immense problem and a difficult problem, especially in the ghettos. It is the immensity of the problem that demands the redundancy of solution. In the past, the plethora of rules restricted the designer and made the task unreasonably formidable. Beyond that, there are other reasons why a building should be arrayed in a particular way which has nothing to do with design specifically, such as external parameters which deal with unit distribution. How the building looks, although not insignificant, becomes a detail in the face of the difficulty of providing housing which must meet an enormous number of criteria.

There are, at present, two major attempts being made by industry and independent research organizations to develop systematic physical systems of components which are the elements of residential and school buildings (usually called building systems) in which components varying in size from foot-wide wall panels to complete floors are made in a factory and assembled on site, and systematic design approaches (usually called system buildings) where abstract buildings in the design stage are manipulated by computers.

Several approaches to the systematic arraying of elements in a building can be discussed. While they differ theoretically, they offer the potentiality of bringing together diverse elements into a whole system, though only through a great deal of effort.

A program called CRAFT[1] considers the allocation of units based upon a parametric relationship defined by distance between

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[1] E. S. Buffa, G. C. Armour, T. E. Vollman, Computerized Relative Allocation of Facilities Technique (CRAFT), Harvard Business Review, pp. 136-140.

centroids of the units and the importance of the frequency of trips between the elements. Although used experimentally[2] to consider the relationship of activities within a closed and finite system, the CRAFT model is not properly calibrated for such use. With additional experimentation, however, it could be used to simulate a system of apartment units. It has within it the elements that could give balance to the systems devised by Fair[3] et al., which considers the calculations of building system elements on a tartan grid without considering the locational relationships between them. Input to the design is intuitive and is checked against "good design" by the computer.

The ability of the Fair program to perform a series of calculations is a major step forward. For each room, the computer calculates and lists dimensions, area, heat losses, the light level provided by the windows, and the level of artificial lighting required. Some aspects of the design - the provision of bathrooms and lavatories, of storage space, and the ratio of "circular space" (halls and landings) to the whole - are checked against current standards.[4]

The program also checks to insure that units are structurally sound and that the proposed arrangement of components satisfies the disciplines of the building system.[5]

William Newman suggests that the solution of problems in architectural design is made more feasible by the use of a display

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[2] Paul Lew and Peter Brown, Extensions to CRAFT, unpublished paper, Columbia University, School of Architecture, 1968.

[3] G. R. Fair, A. Flowerdew, W. G. Munro, and D. Romley, "Notes on the Computer as an Aid to the Architect," Computer Journal, May 1966.

[4] Ibid

[5] Ibid

and light pen for input and output.[6] Newman has developed a program which was written to demonstrate the use of such equipment. By use of a light pen, wall units, windows, doors can be erased, duplicated, or moved to new positions. The designs are stored in the computer in a form which enables the program to perform numerical processing on the design, including calculating areas.

Logic seems to indicate that the system building can be best associated with an extension of the Basic Housing System[7] as one of its modules.

The Basic Housing System is a functionally related set of data processing programs that determines and evaluates alternative residential building possibilities in a specified area. Required input data are descriptions of lots and existing buildings. The system computes the zoning envelope for every site and determines what buildings are possible on each. For every building, a printed report lists the number of rooms, the height, and all construction and acquisition costs. An additional program computes and prints the financing costs and operating expenses for each building. These output data provide the planner, developer, or investor with the information he requires to make an optimum decision among building alternatives.

System building is, therefore, a part of a larger, overall modular system under development, designed to operate independently or within a total system. At present, the link between

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[6] Newman, "An Experimental Program for Architectural Design," Computer Journal, May, 1966.

[7] Jackson, Barry, "Basic Housing System, Description and Comparison," unpublished manuscript, 1968.

the characterized "zone" module is not operational; therefore, input to System Building which requires rooms and other information is input through the cards directly into System Building.

CONCEPT OF SYSTEM BUILDING

After an accurate determination of zoning envelopes, site configurations, and building economics, there arises a need to determine, at a high level of detail, a particular building which accomodates a particular site under particular conditions.

Let us assume that there is a site, xy, on which it has been decided to place a building. It is oriented with respect to north. The dimensions range between x as a minimal buildable site and a reasonable[8] (to be determined) maximum; y varies between a minimum lot depth to a maximum reasonable site dimension.

The site, xy, has associated with it certain properties and boundary conditions which define external constraints to the system building. These properties may be contours, zoning envelopes, land costs, sub-surface conditions; boundary conditions can be streets of particular size, adjacent site uses and configurations.

There are four rectangular topological lot conditions which can occur. Zoning restrictions a priori restrict the configurations acceptable on each lot. The problem is to array apartment units, a, b, c,...n, to meet predetermined criteria for arrangement,

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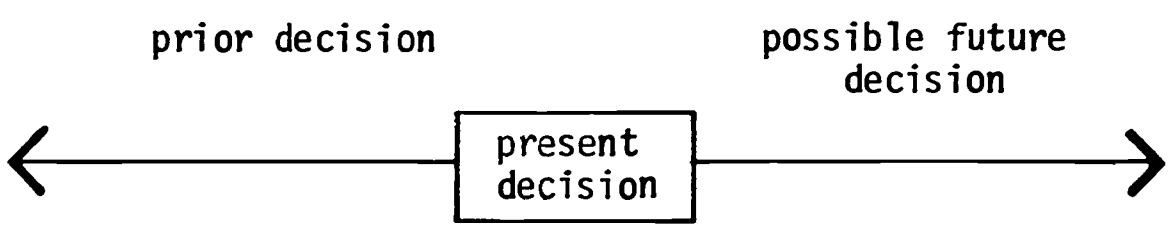
[8] Aside from the legal limitations on building dimensions, system building will be able, in the long run, to cover a several block area.

limited by a set of internal and external constraints. Before the units can be arrayed, however, other constraints to the problem must be considered, such as the location of stairs, elevators, flues, and incinerators, which are generally associated with the building as a system and not with the units themselves.

Generally, these constraints have specific criteria associated with them, so that number and location of elevators in relationship to site and prior to the arraying of units can be accomplished. Stair and corridor locations meeting specific exit criteria can be established.

After the circulation system has been established, criteria can be formulated which locate units in relationship to it. But the relationship of any one unit to another must take into account the prior decisions which have been made locating constraints or other units and the remaining range of decisions that can be made to allow logical possibilities for future development. This can be shown diagrammatically as follows:



The establishment of criteria internal to the unit is a different matter. The series of decisions that has to be made in order to place a unit are a more complex order which lend themselves to the use of Markov Theory. Consider the application of Markov Theory to the problem of arraying the units. We can construct a matrix of the probability that one unit type, a, follows another unit type, a. The transition matrix for n units will be as follows:

$$
\begin{array}{c|ccc|}
\text{Prior Decision} & \multicolumn{3}{c}{\text{Present Decision}} \\
 & a_1 & a_2 & a_3 \cdots\cdots a_n \\
\hline
a_1 & p_{11} & p_{12} & p_{13} \cdots\cdots p_n \\
a_2 & p_{21} & p_{22} & p_{23} \cdots\cdots p_{2n} \\
a_3 & p_{31} & p_{32} & p_{33} \cdots\cdots p_{3n} \\
a_n & p_{n1} & p_{n2} & p_{n3} \cdots\cdots p_{nn} \\
\hline
\end{array}
$$

Where $p_1 + p_2 + p_3 \cdots\cdots p_n = 1$

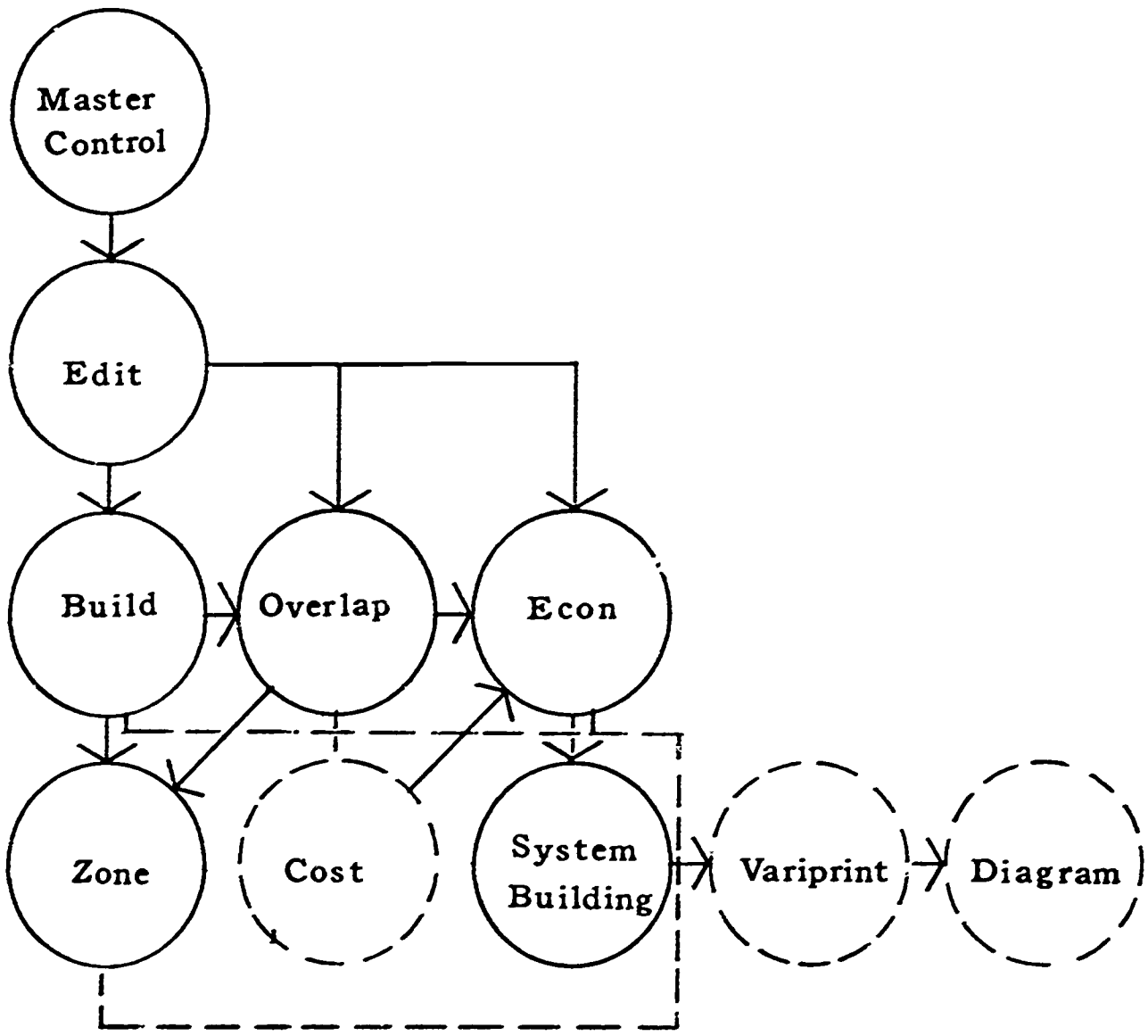
Each row of the matrix has a series of non-negative elements which total 1. The row is called a <u>probability vector</u>.

In addition to the transition matrix, a process for choosing the initial state of the system must be constructed. This may also take the form of a transition matrix in a much simpler form. The transition matrix can take the form of one future decision to each prior decision; however, any rudimentary design requires feedback, and the more sophisticated a design system becomes, the more feedback is required. Intuitive systems use feedback so fundamentally and with such ease that feedback, once recognized as a design component, is taken for granted.

Prior decisions can be clustered for ease of transmission, and an investigation of the array of prior decisions can simplify the design process.

The function of the designing system, in this instance, is not to shorten designing time for the initial problem but to shorten designing time for a large number of projects.

The transition matrix can take into account any number of factors with which the designer or planner is concerned. For example,


Master Control
Edit
Build
Overlap
Econ
Zone
Cost
System Building
Variprint
Diagram

suppose that a 400-unit apartment building is most feasible for a particular site. The market indicates that the unit distribution should be 20 per cent efficiency units, 32 per cent one bedroom units, 36 per cent two bedroom units, and 12 per cent three bedroom units. Let us say, further, that a certain percentage of efficiency units and one bedroom units are for the elderly and that elderly people seem to like living on the third, fourth, and fifth floors of apartments (with elevators); children, on the other hand, should live closest to the playground and single girls nearest on the south side of the building and bachelors on the north side. Apartment distribution is, therefore, a series of conflicting trends which can be resolved by stochatic arrangement of the apartments.

Rather than either designing a typical floor or trying to design the building as a whole (by whatever method seemed appropriate), the designer can concentrate his effort on the relationship between one unit type and another and leave the design of the building as a whole to the computer.

Depending, of course, on the ability of the designer to solve the "packing problem," the machine can array an "infinite" number, or at least a very large number, of whole buildings which would satisfy the series of constraints set up by the designer at the outset.

OPERATIONAL PROGRAM

The development of the computer program has expanded theory into component systems but has allowed more generalities than originally considered. In its present operational form, system building

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[9] The program was designed by the author during the period 1964-65 and programmed in 1967 by Robert Braine.

is a COBOL program written to fill a given building envelope with apartments through the use of four basic routines: (1) building compositions,(2) space allocation,(3) reservoir, and (4) prior decision. The function of these is given below.

1. Building Composition

   The number of apartments to be used in the building is calculated from the following:

   a. The distribution of each apartment type, expressed as a percentage.

   b. The maximum number of zoning rooms for a given building.

   c. The number of zoning rooms associated with each apartment.

   This is accomplished with the following formula:

$N_i = P_i N$ where:

$N = Z_{max}$ N_i = the number of apartments of type i

N = approximate total

Z_{avg} number of apartments in building

$A_{avg} = \varepsilon_i Z_i P_i$ Z_{max} = maximum number of zoning rooms

Z_i = zoning rooms associated with apartment type i

P_i = percentage of the apartment type i

$\varepsilon X_i = X_1 + X_2 + X_3 + \ldots\ldots\ldots\ldots$

There are two causes that permit the actual output results to vary greatly from the results of the above calculations. If the maximum number of zoning rooms far exceeds those actually used, the resultant

building may have a composition that is off by a ratio of approximately Z_{max} / Z_{actual}.

The other cause of error occurs when, due to some peculiarity of the building, the program needs more of one type of apartment than the others to fill the building envelope. This deficiency cannot be avoided without changing the requirements presented in the input data.

The information required for distribution of unit types in the building is coded on Card Type C, and is explained in detail in that section.

2. Space Allocation

For a given location on which there is room to build, system building will decide which apartments meet the requirements of that location. The conditions to be met for any location are two. First, each wall must match each corresponding wall for every adjacent apartment, and, second, the available space on which to build must be as great or greater than the apartments considered. These conditions generally allow more than one apartment type to be found acceptable for a given location. The program then randomly chooses one apartment from this collection. The choice is also weighted according to the results of the composition routine.

3. Reservoir

Having chosen an apartment in the above manner, the program will save all the other possibilities for that location until it finds a valid design for that floor. By retaining apartments, the program

saves time in going back and developing another floor plan in the event the present attempt fails. It also avoids the chance of duplicating an unworkable arrangement since the chance of developing an unworkable floor plan generally far exceeds that of developing one that is workable. Except in some of the simplest cases, this routine can result in a considerable saving in time. Using this routine the program will test every possible solution until one of three things occurs:

a. Either all vacancies are filled,
b. All the possibilities are exhausted, or
c. The number of attempts to fill a particular vacancy exceeds 2000.

If either of the last two alternatives occur, then the program will print out all the information it has generated to date with the message "Floor XX Has No Acceptable Arrangement of Apartments," then search for more input data. There will be no attempt to fill any of the remaining floors with apartments.

4. Prior Decision

The arrangement of units on one floor may affect the results on the floor above it, as in the case of a duplex. The program performs this function with a continuity test. Each apartment is checked against the apartment below it. [10] If a conflict occurs, a

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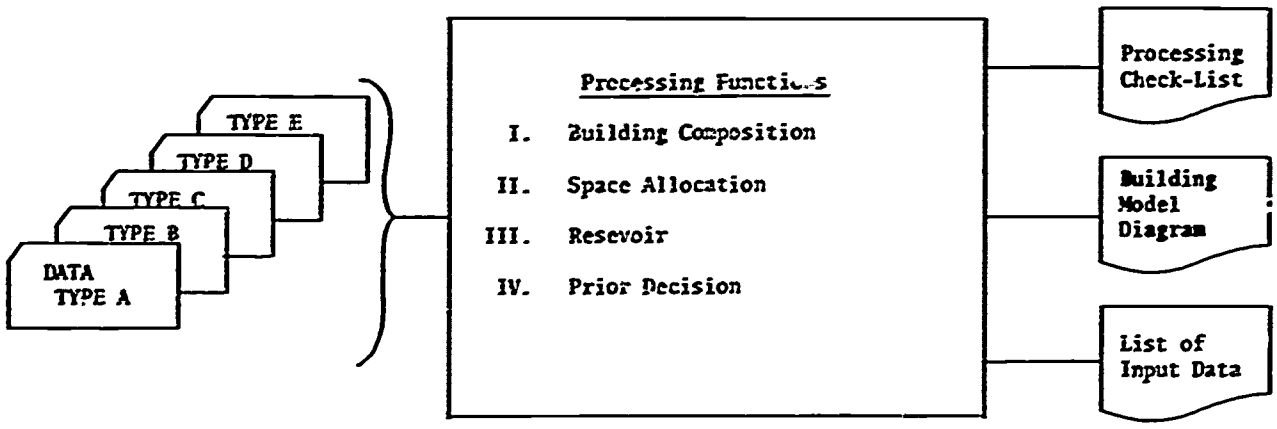
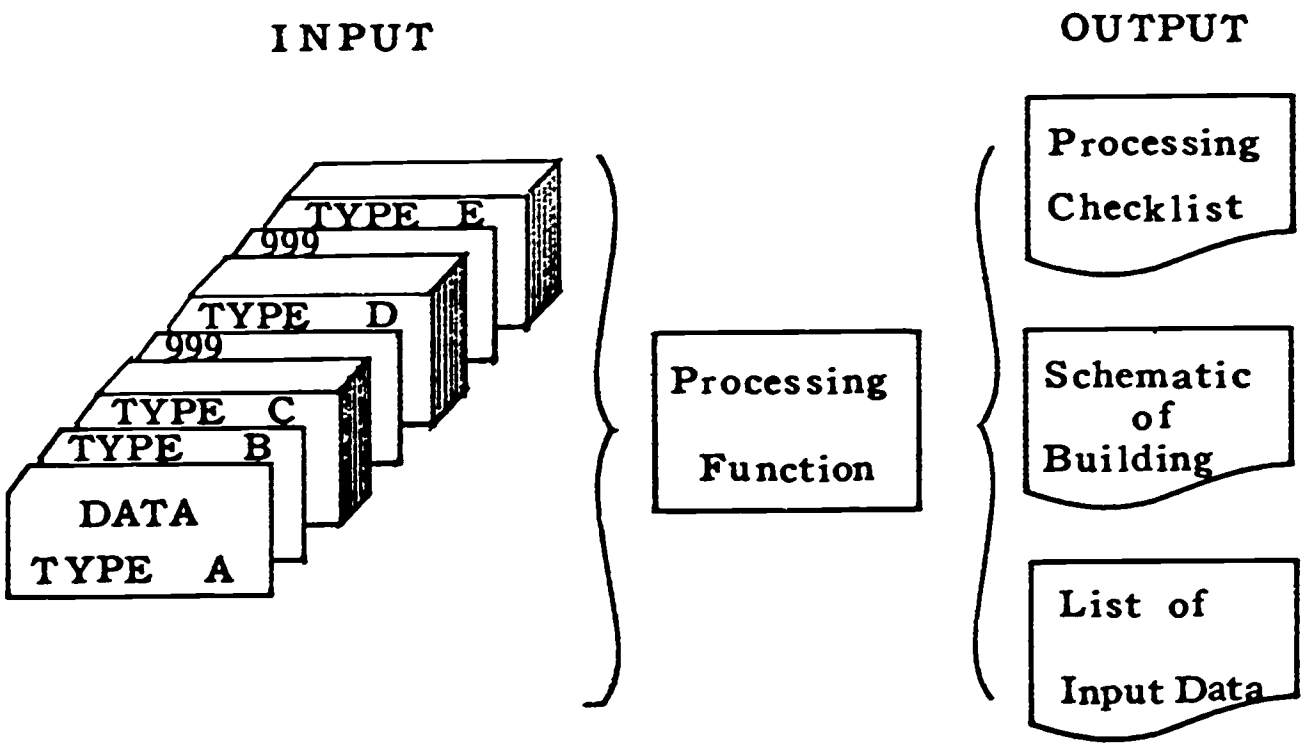
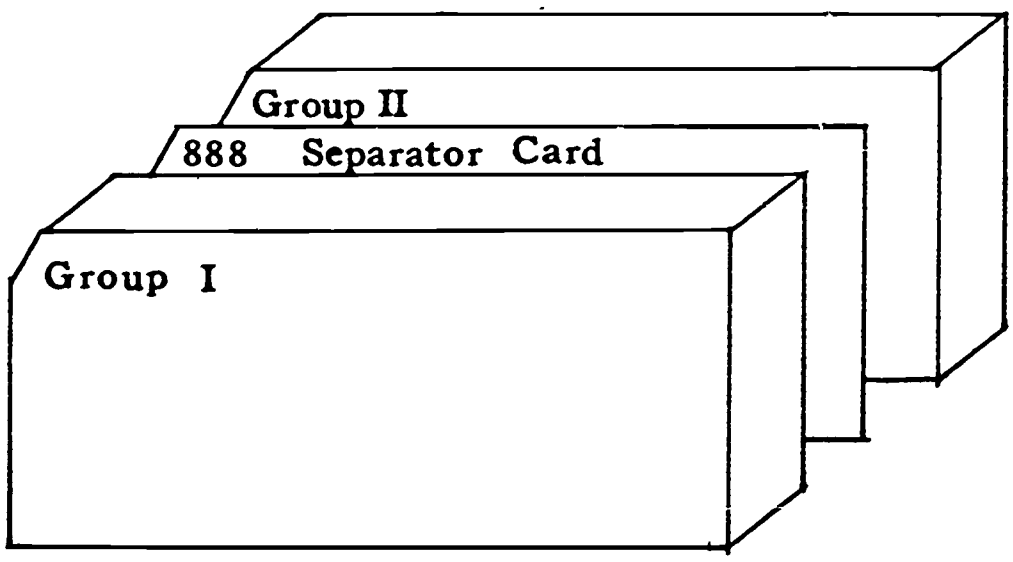
[10] It is not within the scope of the present program to check, while processing one floor, to see if there is an obstruction on the floor above it. The program may, for example, place the bottom half of a duplex below a wash room. (One way to handle such a situation might be to create a constraint card on the floor below the obstruction, with the ceiling of the constraint being the same as the floor of the obstruction.)





BATCH PROCESSING



note is generated directing the program to make the necessary adjustments in the upper unit. The technique implemented here is the base of a whole pyramid of techniques whereby the choice of one wall, floor, or ceiling of one apartment can affect and be affected by the choice of some other floor, ceiling, or wall of some other apartment. In this way the selection of one apartment can be influenced by the previous selections of all surrounding apartments.

INPUT DATA

A data deck consists of a group of five types of data cards which are necessary to describe a building site and the type of structure to be designed for that site.[12]

Composition of a Group:

Type Card	Description	Max. Number of Cards
A	Site description	1
B	Random number card	1
C	Description of apart. by type	10 (1 for each apartment type)
D	Building constraints	20
E	Floor constraints	20

Batch processing is permissible; the only requirement is that each group must be separated by a card of 888's.

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[12] Note: Any space on any card designated as "unused" may be filled with additional comments.

CARD TYPE A - SITE DESCRIPTION

With the exception of maximum number of zoning rooms and number of floors, the information on Card Type A does not affect the running of the program and prints out as identification. The format was designed to be compatible with other elements of the Basic Housing System and the link between the system and the System Building component is presently non-operational.

Column	Field Length	Field Identification
1 - 6	6	Block number
- 7	1	Block letter
- 8	1	Side of block A, B, C, D
9 - 10	2	Base site (western most site)
11 - 12	2	Terminal site (eastern most site)
13 - 24	12	Unused[13]
25 - 27	3	Zoning district
28 - 32	5	Maximum number of zoning rooms
33 - 61	29	Unused[13]
62 - 63	2	Number of floors
64 - 80	17	Unused[13]

CARD TYPE B - RANDOM NUMBER

Column	Field Length	Field Identification
1 - 4	4	Random Number Generator. (If the same number is used for two different runs with the same input data, the results will be the same. Anything but ϕ is valid.)

[13] Any space on any card designated as "unused" may be filled with additional comments.

CARD TYPE B (CONTINUED)

Column	Field Length	Field Identification
5 - 80		Unused: Can identify here the module used (Module - each unit is measured to be a certain number of modules wide; this value gives the number of feet in one module. A value 400 implies one module is 4.00 feet long.)

CARD TYPE C - APARTMENT TYPES

Description of apartments. There are a maximum of 10 of this type of card, followed by a card of 9's in the first three columns.

Column	Field Length	Field Identification
1	1	Identification symbol of apartment used
2 - 8	7	Further identifying comments if desired
9 - 10	2	Width of apartment in modules
11 - 12	2	Depth of apartment in basic modules
13		Front wall of unit
14		Alternative Type 1
15		Alternative Type 2
16		Left wall of unit
17		Alternative Type 1
18		Alternative Type 2
19		Back wall of unit
20		Alternative Type 1
21		Alternative Type 2
22		Right wall of unit
23		Alternative Type 1
24		Alternative Type 2

CARD TYPE C (CONTINUED)

Column	Field Length	Field Identification
25		Floor of unit
26		Alternative Type 1
27		Alternative Type 2
28		Ceiling of unit
29		Alternative Type 1
30		Alternative Type 2
31 - 34	4	Average number of occupants for this unit (0 when the number of bedrooms is given)
35 - 36	2	Bedrooms for this unit (if 0, then one bedroom is assumed for purposes of calculation)
37 - 40	4	Number of apartments per floor (0 when the percentage composition of the structure is given)
41 - 42	2	Percent composition of the building of this unit
43 - 45	2	Zoning rooms of this type unit (a value of 150 implies 1.50 zoning rooms)
46 - 78	33	Unused (additional notes if desired)
79 - 80	2	Card number from 1 to a maximum of 10

The fields "Number of Apartments per Floor" (Columns 37 - 40) and "Percent Composition of the Building" (Columns 41 - 42) are used to influence the final composition of the building.

Each surface of a unit can be one of three types. These types are defined by the designer and need only be topologically equivalent to the cube in the illustration. Walls may jog or curve or take on another geometric form as long as the wall fits with

the wall types of the apartment unit next to it and the floors and ceilings fit with the apartment units above and below.

The problem is one of packing, and there is no limitation on the design of the system because of the cubical nature of the way the computer "sees" the data. In actuality, the computer is building a model of a building and not a building itself, and it is up to the designer to know what he is representing with the machine.

The wall types are represented by number and are coded in Columns 13 - 30 on Card Type C.

It is not necessary to use three different wall surfaces for an apartment unit, but each field under wall alternatives must be filled. If no alternatives are desired, each of the fields should contain the same code.

When considering its decision about which apartment type to put into any particular place, the program does not search through the alternative boundary conditions of the apartment type but rather continues its search in the reservoir of apartments. In fact, if the program can satisfy its demands for apartment distribution, type, size, and other constraints by searching through the array of first choice of apartment designs, it does so, only reaching into the second and third row of the array when it finds it impossible to satisfy its needs in any other way.

The designer, in setting up his array, should be aware that it is preferable to establish two apartments of the same size but of differing wall types as alternatives in the first row of the array rather than the second.

The two major uses of the alternatives are:

1. To constrain the position of an apartment type.
   For example, the placement of one type of apartment on the first floor only (such as a unit for the elderly) will illustrate this principle. This may be done in the following manner: First, a special constraint[14] card is set up for the first floor, specifying an unused number for the front and back walls, say a "2" and perhaps a zero for all other walls. Next, the card describing the special apartment that is to be placed on the first floor describing the special apartment that is to be placed on the first floor only would have an "8" placed in each of the three options for the front wall (Card Columns 13, 14, and 15); all the rest of the walls would have any combination of numbers desired.

   The remaining apartment types, while allowing their placement on the first floor, should also be placed anywhere in the rest of the building where the front and back walls are specified by some other number, say a "7". Therefore, these apartments would have the front wall coded as a "7", and Alternatives 1 and 2 coded as an "8", allowing placement on the first floor or any other floor.

2. To allow one wall type of an apartment to abut a different wall type.
   For instance, if one apartment has a wall designated by the number "6", and it is desired to have this wall match either a wall coded "1" or a like wall

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[14] Refer to Card Types D and E.

coded "6", then the first wall choice would be a "6" and Alternatives 1 and 2 would be a "1".

At present, the program is constrained more by being able to handle too few wall types rather than by what appears to be unlimited alternative possibilities. Walls must fit against each other in order that the apartments can pack properly. To circumvent this present programming shortcoming, optional wall types, coded with zero, can be used. The designer should be aware of these limitations in coding.

If zero is chosen for the three options of an apartment type, that apartment can only be chosen in the event the corresponding constraint wall is a zero.

CARD TYPE D - BUILDING CONSTRAINTS

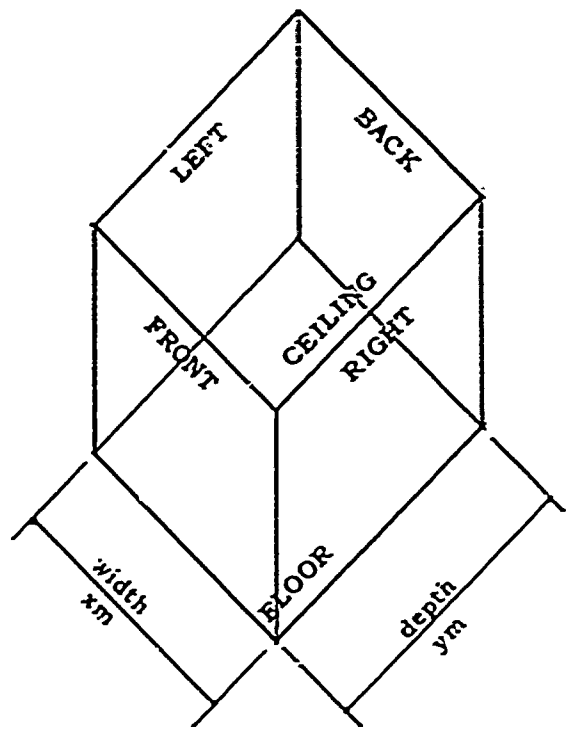
The physical limits and constraints of the structure, which occur on every floor, are defined on this card. There is a maximum number of 20 constraints for such facts as end walls, stairs, elevators, etc. Constraints are defined in the same way apartment wall types are defined; that is, by using code numbers 0 - 9 to describe the walls of and around the constraint (Columns 7 - 11). When a zero is used for the wall type of a constraint, any wall type can be abutted to this constraint.

Every constraint has to be defined by two cards. This causes an anomaly at the end walls where it will print out as one module thick. This should not inhibit the designer; however, if the module used is greater than one foot, the width of the building has to be defined as the desired width plus two M.

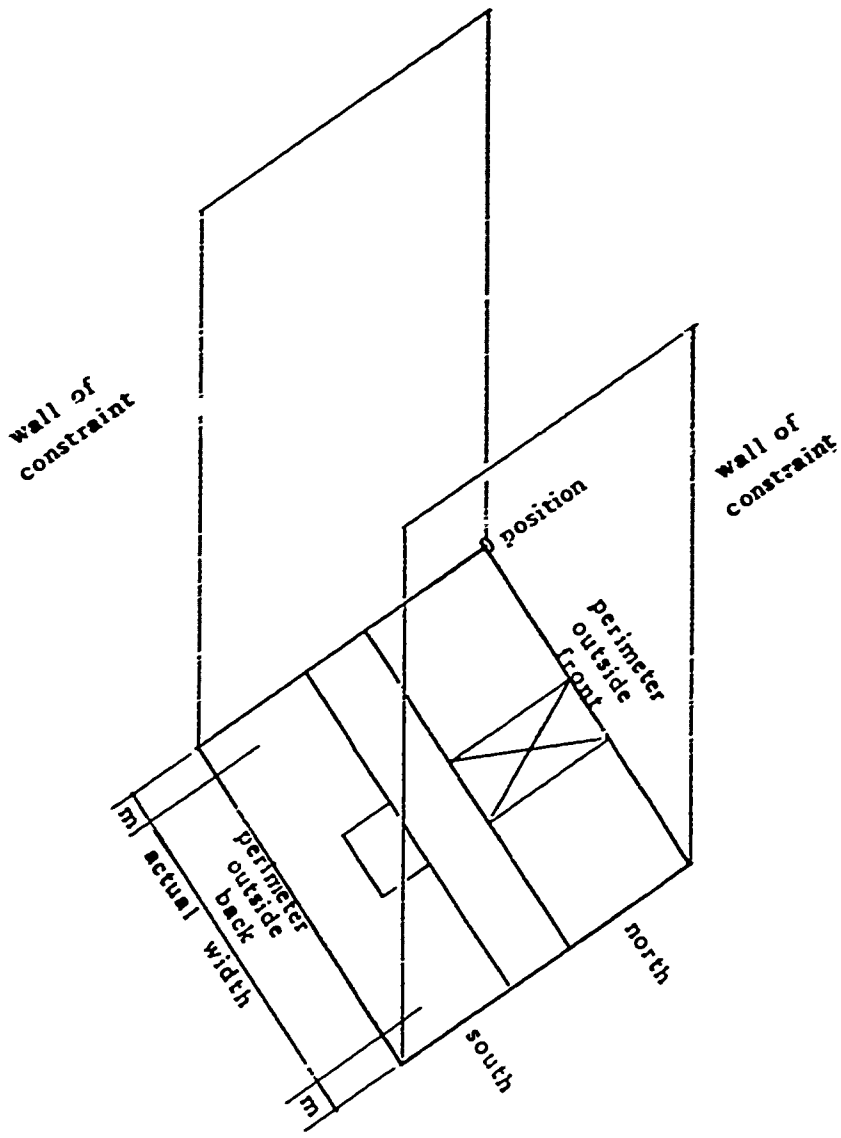
The constraint that is at the "0" position (i.e., that has a "0" in Column 6) should have a space indicator of 1 in Column 16.

The constraint card at the right end of the building - the end wall's second card - must have a "0" in the space indicator column.

Column	Field Length	Field Identification
1 - 3	3	Zero, right adjusted
4 - 6	3	Position relative to the starting position. (The starting position is the front of the structure and has the value of 0 modules.)
7	1	Front wall
8	1	Back wall
9	1	Wall of constraint
10	1	Zero
11	1	Zero
12	1	North (L) or South (R) side of the hallway (if both sides the value is B)
13 - 15	3	Depth of the constraint (necessary on the first card only to get the width of the structure). This constraint should be the end wall.
16	1	Space-indicator. (Tells whether or not there is space on the other side of constraint in which apartments can be manipulated to fit.) 0 indicates there is no more space 1 indicates more space immediately following constraint 2 indicates may be more space following next constraint
17 - 60	44	Unused
61	1	Identification symbol of constraint
62 - 80	19	Further description of constraint



CARD TYPE C



CARD TYPE D

CARD TYPE E - FLOOR CONSTRAINTS

Constraints which occur on individual floors such as janitors closets, lobby, reserved location for special apartment types, or community space, are coded on this card type.

They are grouped by their floor number and are limited to 20. The group of Card Type D is followed by a card of three lines.

Column	Field Length	Field Identification
1 - 3	3	Floor number
4 - 6	3	Position relative to the starting position. (The starting position is the front of the structure and has the value 0 in basic units.)
7	1	Front wall
8	1	Back wall
9	1	Wall of constraint
10	1	Floor
11	1	Ceiling
12	1	North (L) or South (R) side of the hallway (if both sides the value is B)
13 - 15	3	Length of the constraint (necessary on the first card only to get width of structure)
16	1	Space-indicator. (Tells whether or not there is more space on other side of constraint in which apartments can be manipulated to fit.) 0 indicates there is no more space 1 indicates more space immediately following constraint 2 indicates may be more space following next constraint

CARD TYPE E (CONTINUED)

Column	Field Length	Field Identification
17 - 60	44	Unused
61	1	Identification symbol of constraint
62 - 80	19	Further description of constraint

Priority of conflicting constraint descriptions: If two constraint descriptions, one for all floors and one for a particular floor, occupy the same position, the constraint that has its floor specified has priority over the boundary for all floors when the program is working on that floor.

Conceptually, this is not logical, for a designer may place a janitor's closet in an elevator shaft if he is not careful.

When positioning constraints that permit the placement of apartments between them, the distance between constraints should be x_1M (where x_1 is the smallest modular designation), a multiple of x_1M or $x_1M + x_nM$ (where x_n is another modular width of another apartment unit).

System Building, as a first generation program, has several credits as well as inconsistencies. The goal is to develop a system which would produce a series of documents from which the building can move right into construction. All of the component systems will have been designed, specified, and appropriate cost analysis generated. Many of the problems associated with a system of such a type have been solved in programs which could, if linked, produce optimum building allocations.

The following table is intended to aid in the coding of Card Type A. Zones other than R7-2 will be different. This is a guideline only.

Lot Area	Rooms
5,000 sq. ft.	53
7,500 sq. ft.	80
10,000 sq. ft.	107
12,500 sq. ft.	134
15,000 sq. ft.	161
17,500 sq. ft.	188
20,000 sq. ft.	220
22,500 sq. ft.	250
25,000 sq. ft.	275

BIBLIOGRAPHY

Buffa, E. S., Armour, G. C., Vollman, T. E., "Computerized Allocation of Facilities Technique (CRAFT)," Harvard Business Review, pp. 136-140.

Fair, G. R., Flowerdew, A., Monro, W. G., and Romley, D., "Notes on the Computer as an Aid to the Architect," Computer Journal, May, 1966.

Jackson, Barry, "The Basic Housing System," unpublished manuscript, 1968.

Lew, Paul, and Brown, Peter, "Extensions to CRAFT," unpublished paper, Columbia University, School of Architecture, 1968.

Newman, "An Experimental Program for Architectural Design," Computer Journal, May, 1966.

RELOCATABLE HEALTH UNIT SYSTEMS

By

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I appreciate very much the opportunity given to me by the AIA Research Committee and its chairman, Dean Bill Lacy, and by the conference chairman, Byron Bloomfield, to present you with some interim results of research and development work recently conducted at Texas A & M University.

To contribute to the alleviation of severe health problems plaguing the world's developing countries, the first phase of a research and development project for relocatable minimal health units was conducted at our Research and Graduate Center of the School of Architecture at Texas A & M University. This Center, since its origination in 1963, is performing architectural research and development in various environmental problem areas of major social and economic significance. Its research projects involve research architects, architectural graduate research assistants, and various selected consulting experts from inside and outside the University. The projects are of an applied rather than a basic nature and are structured toward the achievement of realistic products as end results. A fundamental premise, and one which characterizes all operations of the Center, is that through the application of rational methods and contemporary technology - successfully proven in other technical areas already - progressive innovative results within architecture and the building field can be accomplished.

The project was sponsored by the American Iron and Steel Institute with an emphasis on the development of integrated lightweight steel construction.

The U. S. Agency for International Development in Washington, as an additional supporting group, originally expressed to the Center the need for a relocatable minimal clinic to be used in underdeveloped areas of Southeast Asia. It was soon felt, however, that the original idea should be broadened toward the more

comprehensive concept of an adaptable system of transportable minimum health units serving as medical outposts for civilians in developing countries all over the world. Additional investigations expanded the original objectives even further to include use in disaster areas as well.

The project involved eight half-time graduate research assistants of various backgrounds paid by traineeships of the U. S. Public Health Service, the U. S. Agency for International Development, and by University assistantships. The team was directed by myself. The time period available covered six months, from September 1967 to February 1968.

The work itself was carried out in five main steps. The first necessarily became a period of familiarization with obvious problems of developing countries and disaster areas. Actual conditions and needs of developing countries (climatological, socio-economic, and health aspects), disasters (types, severity, and after-effects), and existing transportable units (technical aspects) were covered by a comprehensive survey. The results of these initial considerations led to Step 2, the problem statement. With Step 3, the team attempted to establish basic principles for a mobile health unit considering various approaches, configurations, and supportive systems. The development principles then were refined and narrowed to four possible mobile health unit concepts in Step 4. By further restriction of possibilities, integration of certain principles, and introduction of new characteristics, two tentative solutions were finally developed in Step 5. One solution represents a containerized system of highly transportable sub-units which can be combined in various configurations, increasing their usable volume considerably. The other solution, a self-propelled and self-contained expandable unit, can be optimally utilized for revolving health services or disaster relief purposes. This unit, too, can be interconnected for efficient functional space utilization.

The concepts of both tentative MHU solutions had been thoroughly studied in sketches, drawings, and three-dimensional models before their physical shapes were finalized.

The project was developed by a combined team effort. Sub-teams of two to four members worked according to actual requirements and stages of the development as well as to self-motivation and personal preferences. Continuous regroupings of the team members in the sequence of the work process stimulated ideas and insured optimal work efficiency.

The team itself was multi-disciplinary, composed of architects, a hospital administrator, a registered nurse, an industrial educator, and a business administrator. With these diverse backgrounds, a broader overall perspective, in addition to the expertise of the detailed elaborations in the specific field, was achieved throughout the whole research and development process.

The objectives of the project, as stated before, were determined only after a comprehensive surveying phase. Among others, the list of objectives included: The system should serve various medical uses but mainly basic diagnostic, curative, and preventive purposes. The unit should serve as a mission-oriented system to adjust staff and medical relief measures to various situations and number of patients. It should adapt to numerous conditions of the environment; that means varied environmental capabilities, climates, local customs, surroundings, and duration of stay. It should have a neutral or even humane, non-repellent physical appearance to local populations. The design of the unit should consider economy of material and processes, and the effect of climate and deterioration on materials. Multipurpose, compact components with simplicity of design and modular unity should facilitate fabrication and assembly. Highly

specialized parts and new processes should be minimized in favor of use of stock items and well-known production techniques. The system should be immediately marketable with a potential of continuing production. The mobile health units should be transportable by air, land, and water. Transport packages should fit conventional carriers. The dimensions should require a minimum of special permits for movements. Besides being able to be lifted by helicopter, the units should be capable of movement from a few feet to thousands of miles. The assembly process should be a simple, easy system of pre-assembly or on-site assembly not requiring highly trained personnel. The contents, equipment, furniture, etc., should be protected from elements during assembly or disassembly. The units should permit an easy maintenance, cleaning, and decontamination, especially when moving to a new site. Parts should be standard or simple enough for easy repair...etc.

With these and many other objectives in mind, several design concepts had been developed and finally evaluated. In order to achieve some objectivity in the otherwise subjective process of evaluating the tentative mobile health unit concepts, a factor rating was used as a basis of comparison to the stated objectives. The six major objectives and their sub-objectives were decimally rated as to their agreed importance. After finding out each concept's relative compliance to the objectives, special aspects of each concept were discussed and a decision was reached to develop two tentative design solutions, one by combining the characteristic advantages of three concepts, the other by evolutionary redesign of another concept.

TRANSPORTABLE HEALTH UNIT

The first tentative solution became a system of coordinated structural units which can be assembled and combined according to

various functional uses. Each unit is a rigid box frame ring in lightweight sandwich panel construction, 4' deep, 8' wide, and 8-1/2' high. The inner space of this basic structural ring is closed by two 8' x 8' hinged panels, swinging outward up and down in opposite directions. Into each structural frame a number of permanent fixtures are integrated, e.g., air conditioning, lighting, piping, and wiring. The mechanical services thus become decentralized into several nodal points all over the Health Unit. Movable equipment like cabinets, medical items, supplies, power sources, hygiene components, beds, furniture, etc., can be packed inside the basic structural units for transportation. So each transport unit is pre-equipped with a specific set of functional equipment according to its future use. Five different types of basic units are distinguished, coded with outside markings to facilitate identification and administration. They can be combined and arranged in various ways to create functional spaces ranging in size from a first-aid station to a small clinic to a modest ward hospital. Appropriate volume and relative lightweight of these basic containers guarantee an easy handling by all regular modes of transportation (road, railroad, ship, cargo plane, and helicopter). Besides their function as transport packages and decentralized mechanical service cores, the basic units also serve as structural support members. In their final destination site, the containers are properly spaced in 8' intervals, which easily can be done by use of the 4 height adjustable "walking" foundation jacks. After the hinged panels are opened and interconnected to the opposite structural unit to form the floor and roof structure, the side panels (doors and windows), transported also inside the basic structural package, are fitted between floor and ceiling. The actual space increase of the assembled units from transport condition to the operational condition amounts from 100 per cent to 150 per cent, depending on their number and configuration.

Flexibility in use, compact transportability, and space increase are the major assets of this system for relocatable health units. Its adaptability makes it particularly suited for medical outposts for a population which is in need of medical attention in underprivileged regions, in developing countries, or in areas marked by dynamic sociological change as interim solutions to overcome acute health needs. A secondary application of the system will be a medical relief measure for certain disaster areas. With the easy transportability of the units, the system can be distributed worldwide to fit a variety of specific needs. It can grow and change in small increments as the health needs of the area differ with time. In brief, the developed solution represents a highly adaptable system for Transportable Health Units.

AUTO-MOBILE HEALTH UNIT

The tentative second solution represents a self-contained, self-propelled health unit. When expanded, the Auto-Mobile Health Unit increases its usable space by 88 per cent. The mobility of the unit makes it effective for rotating health services in developing regions and for use in disaster areas where short arrival and set-up times are vital. Although its primary means of transportation is self-propelled by road, the Auto-Mobile Health Unit can also be transported worldwide by freight train, ship, airplane, and helicopter. The unit consists of a standard truck chassis, suspension, and steering mechanisms, and motor (also used as a power source for mechanical, electrical, and air conditioning equipment), front, side, roof, and floor panels (custom-made of lightweight structural sandwiches), telescoping expansion members which slide on a phenolic base, and a ceiling system which incorporates plumbing, water storage, lighting, and air conditioning.

The standard unit is equipped with built-in facilities such as a toilet-shower area and optional sinks, washer, dryer, and autoclave. A countertop, refrigerator, and range are available as substitutes for these equipment items. There are also various movable mechanical utilities, modular cabinets, and miscellaneous equipment safety-packed during transportation and ready for use with minimal reassembly and rearrangement. The Auto-Mobile Health Unit has wide flexibility of interior activity areas and can be arranged to perform almost any basic medical function. One single unit can provide a minimal examination/treatment area, a laboratory, an administration area, a cleaning/sterilizing area, as well as a living/sleeping area for one or two persons. These areas can be expanded by interconnecting two or more units, each housing only one or two of the basic functions as well as nursing and health education spaces. An integrated configuration of Auto-Mobile Health Units might consist of one unit housing laboratory and administration, one unit housing living/sleeping for four persons, one unit housing two examination/treatment areas and reception, one unit housing a major surgery area and preparation area, one unit housing a health education area, and one unit housing a six bed ward.

The two tentative solutions for relocatable minimal clinics were exhibited at the Texas Hospital Association Convention in Dallas, May 1968. Other exhibits included the American Hospital Association Annual Convention in Atlantic City, New Jersey, September 1968. The two systems were also presented at the June 1968 AIA/ACSA Teachers' Seminar in Montreal, Canada, as examples of architectural development work in industrialized component systems. First responses are encouraging and contribute to the Center's current administrative efforts to raise further funds for a second development phase to improve the two concepts, to elaborate technological details, and answer open questions in the human engineering field by full-size mock-ups, to supervise

construction of two prototypes as the only basis for realistic cost estimates, to quantify precisely the potential market, and to promote ultimately the production and distribution of the units.

This Mobile Health Unit project clearly is marked by major humanitarian aspects. There is growing evidence that the higher developed economies will eventually realize their true responsibility toward the underprivileged nations. They definitely will have to help these développing nations to help themselves. One important aspect in giving these regions their badly needed medical attention is the provision of an efficient system of basic health units, however, on an immeasurably bigger and more imaginative scale than is generally practiced now.

The deployment of the Mobile Health Units, of course, has to be organized and responsibly planned. Pre-evaluation of the particular local condition is required to determine the actual needs of an area in terms of quality and quantity of units, equipment, supplies, staff, and administration. The distribution, rotation, expansion or replacement of the units, equipment, and staff, as well as an efficient buying and warehousing, decentralized geographically for easy distribution, has to be maintained under some central control for constancy. It has to include the rotation of perishable medical supplies with a hospital or medical facility to maintain freshness and potency. A suggestive, or authoritative, transport control has to determine the most efficient use of all modes of transport, including local modes. The most effective rental, lease, or sales provisions have to be found for each use. Manuals, written in simple language, have to provide assembly, maintenance, and use instructions. Personnel management will be implemented through consistent policies, but special consideration will be given to the utilization of local personnel. The familiarization with the local habits and customs

of the area of use before entering it is essential. Distribution, rotation, replacement, resupply, evaluation, buying, warehousing, rental, sales, leasing, training, promotion, and self-evaluation will be part of a records system. The records also include an interrelated accounting, costing, and inventory system, with a payment control. In an ideal situation, all deployment aspects could be integrated and tied to a computer. The central should be preferably part of a national or multi-national organization, either existing or original. A further tie-in with a national or regional medical or emergency relief program is highly advisable.

It is imperative to emphasize that both systems are merely instruments to deliver health services and preventive health education for people who most urgently need basic health help, and all activity regarding the two relocatable Health Unit Systems should be ultimately directed toward this end. Right now, little can be said about the actual production of these Minimal Health Stations. It appears logical that only a higher developed economy with an appropriate advanced industrial capacity will be able to produce the units rapidly enough in a sufficient number and reliable quality.

The chances for direct application of the developed systems in this country alone are challenging enough. As an initial result of first promotion efforts, the range of agencies or institutions extremely interested is as diversified as the Bureau of Indian Affairs, various hospital extension services in extreme rural areas, e.g., the Appalachians, or states with low-income urban high density areas, i.e., New Jersey.

But the number of underprivileged and disadvantaged is not only growing at an alarming rate in this, the richest and most powerful nation on earth. Basic health needs abroad have to be attacked

more effectively than before if the present increasing gap in the health status between advanced and underdeveloped economies should eventually be diminished. It is encouraging to learn that, for example, the reputable voluntary organization of the American HOPE Ship at the very moment is studying our two concepts very carefully as it sees the necessity to leave a number of adaptable, mobile, and semi-permanent health installations with trained local personnel behind in the various countries after its mission is completed there.

Poverty regions of all kinds on earth could indeed represent one of the most urgent research objects for universities. Like many professions, the architects also have neglected this problem field too long. It ought to be found out how new facilities of all kinds, private and public, for health, housing, work, education, circulation, and recreation, can be economically provided for the maximum number of people, in the shortest possible time, in an optimal environmental context. Architectural research and development in this area doubtless can become highly contributive if we only will learn to collaborate with other problem oriented disciplines. The little research and development health project, which I just had the pleasure to present to you, is an example of how flexible systems for the efficient delivery of basic health services to such people can appear. I think we all are aware that adequate health is only a fraction of the total basic requirements these populations need, requirements which are perfectly justified if we presuppose that the humanization of this, our earth, is still the basic incentive of our work.

ACKNOWLEDGMENTS

Project Team: Professor Gunter Schmitz, Associate Director, Research and Graduate Center; Robert Billington, Robert Cochran, Barry Mosesman, Richard McWilliams, Robert Newton, Ted Sutherland,

John Westmoreland, Anna Maria Wood, Graduate Research Assistants.

Faculty Advisor: Professor George J. Mann, Associate Director, Research and Graduate Center.

Administrative Support: Professor James Patterson, Director, Research and Graduate Center; Professor Edward J. Romieniec, Chairman of the School of Architecture.

REFERENCES

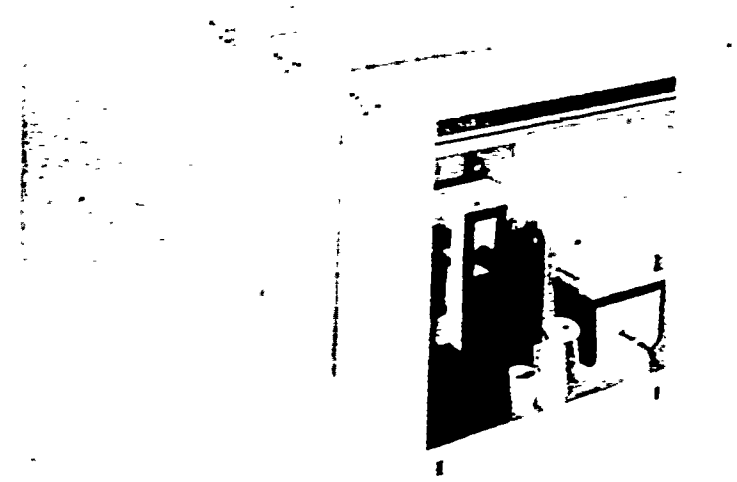
Gunter Schmitz, et al., "MHU-1 Mobile Health Unit, Phase 1," work report, 286 pages, Research and Graduate Center, School of Architecture, Texas A & M University, 1968.

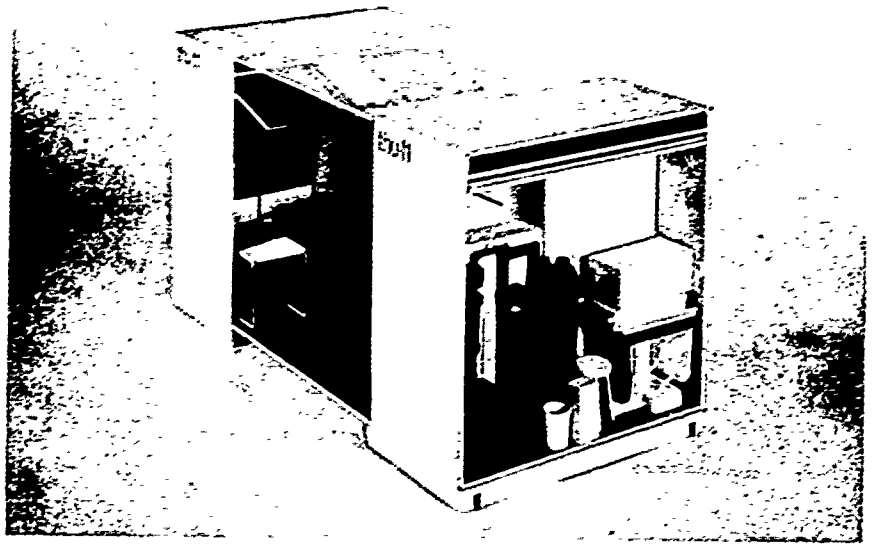
"Mobile Health Units, Phase 1," one-page leaflet, Research and Graduate Center, School of Architecture, Texas A & M University, 1968.

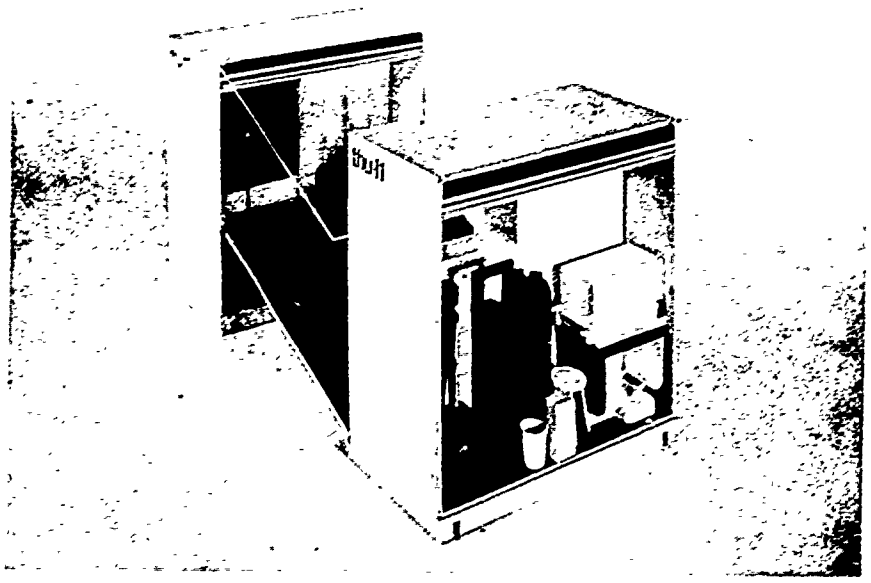
Gunter Schmitz, "Two Systems for Relocatable Minimal Health Units," The Texas Architect, forthcoming September 1968.

Gunter Schmitz, "Pedestal Hospital Bed and Two Mobile Health Units," paper presented at the 21st Annual Conference on Engineering in Medicine and Biology, Houston, forthcoming November 1968.

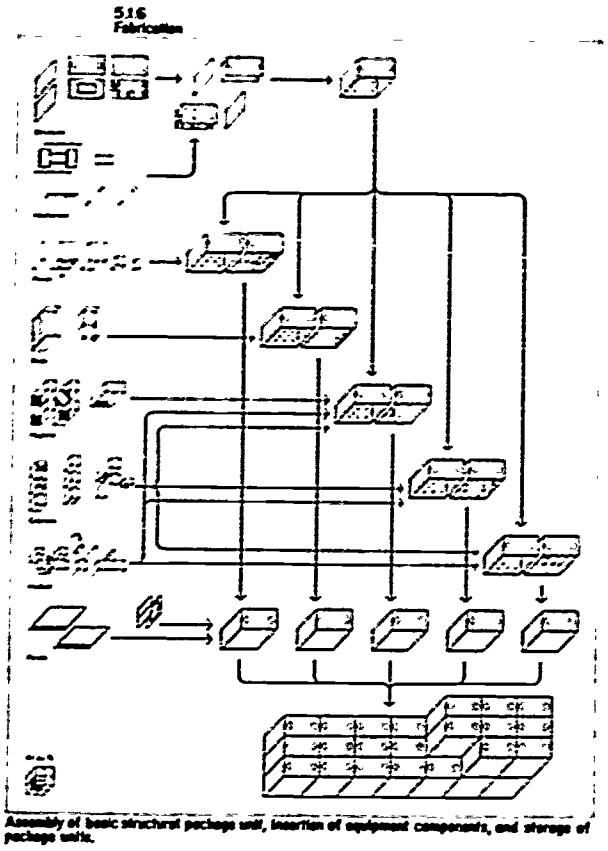
TRANSPORTABLE HEALTH UNIT





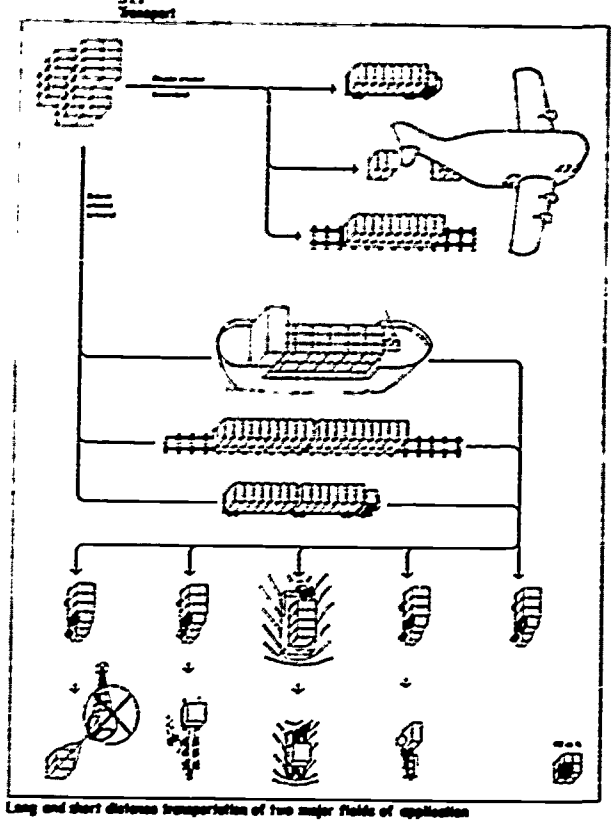


516
Fabrication



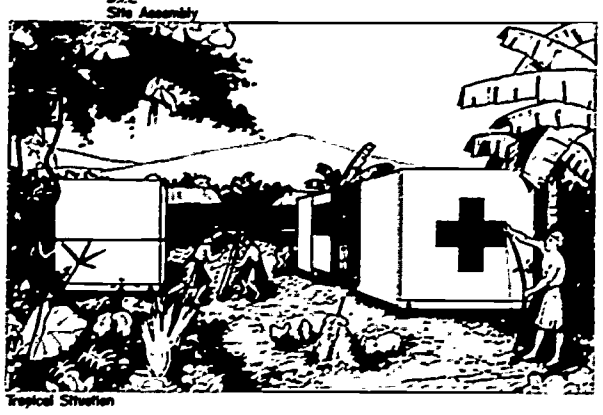
Assembly of basic structural package unit, insertion of equipment components, and storage of package units.

517
Transport



Long and short distance transportation of two major fields of application

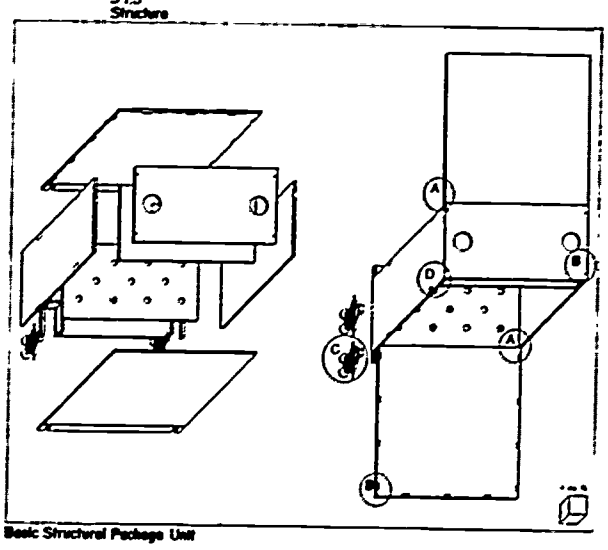
512
Site Assembly



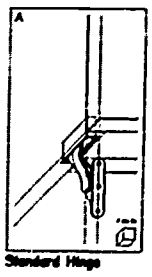
Tropical Situation

Arid Situation

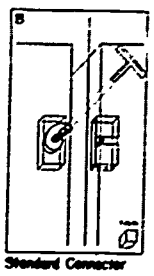
513
Structure



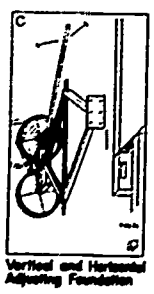
Basic Structural Package Unit



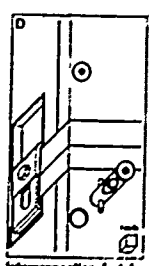
Standard Hinge



Standard Connector

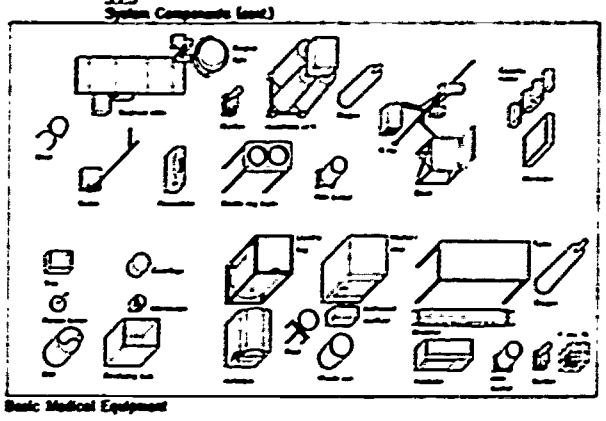


Vertical and Horizontal Adjusting Foundation

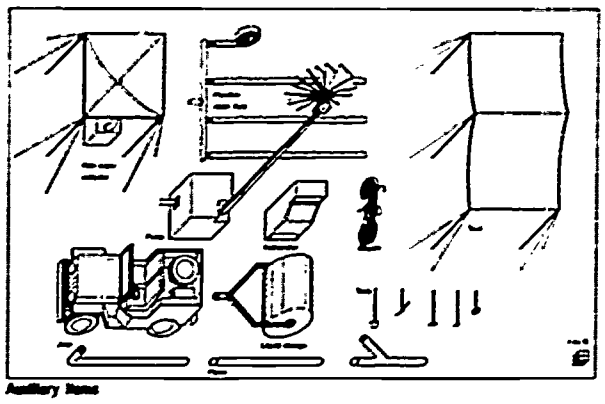


Interconnection Latch and Lifting Device

5.1.5
System Components (cont.)

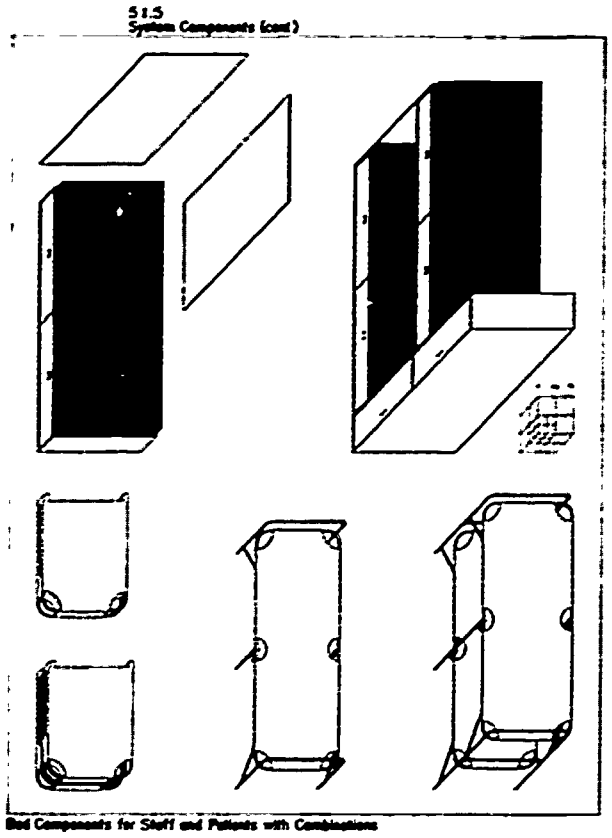


Basic Medical Equipment



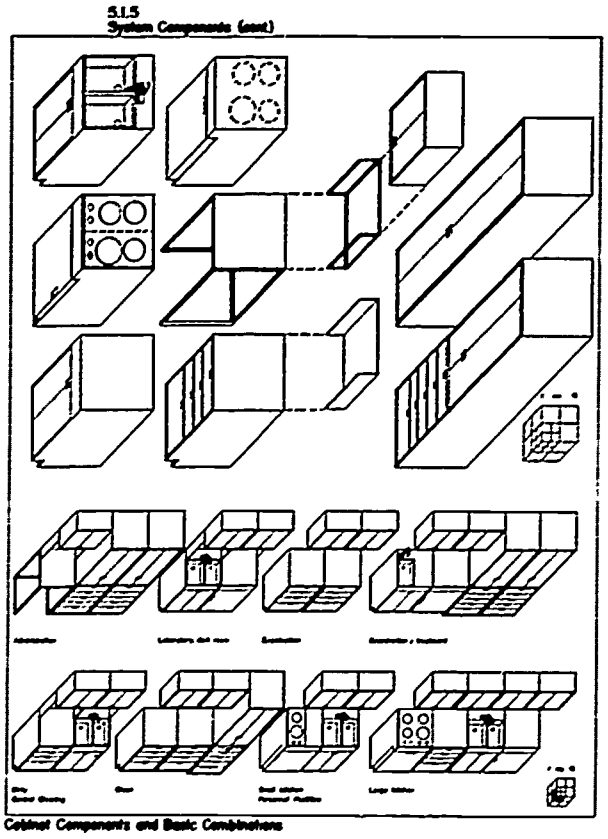
Auxiliary Items

5.1.5
System Components (cont.)



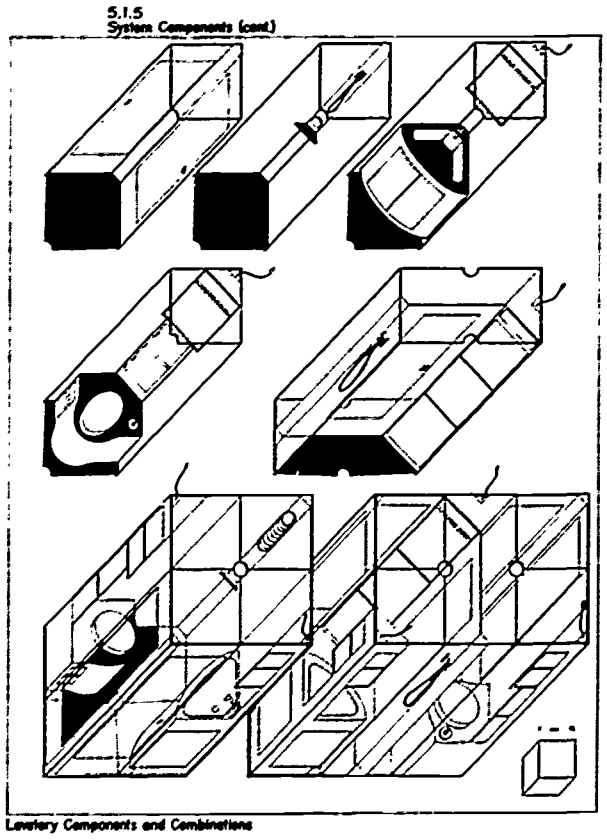
Bed Components for Staff and Patients with Combinations

5.1.5
System Components (cont.)



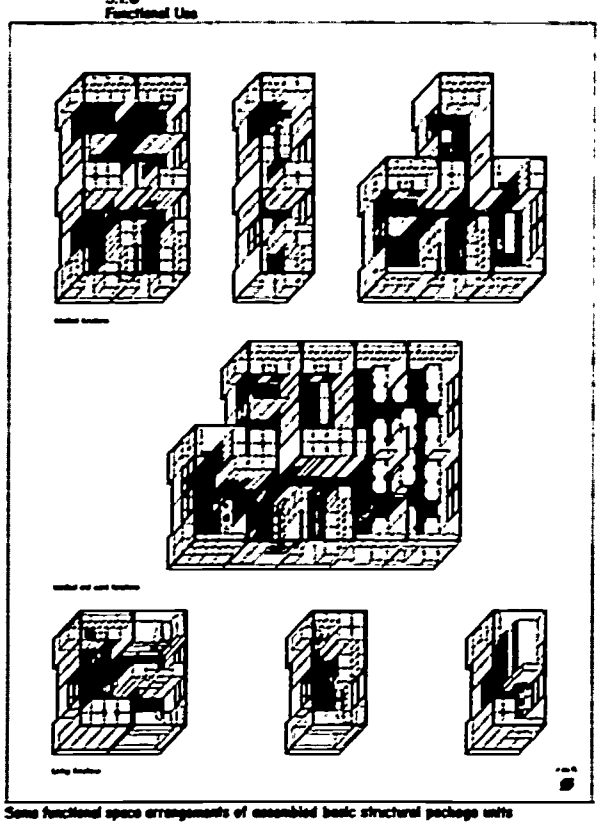
Cabinet Components and Basic Combinations

5.1.5
System Components (cont.)



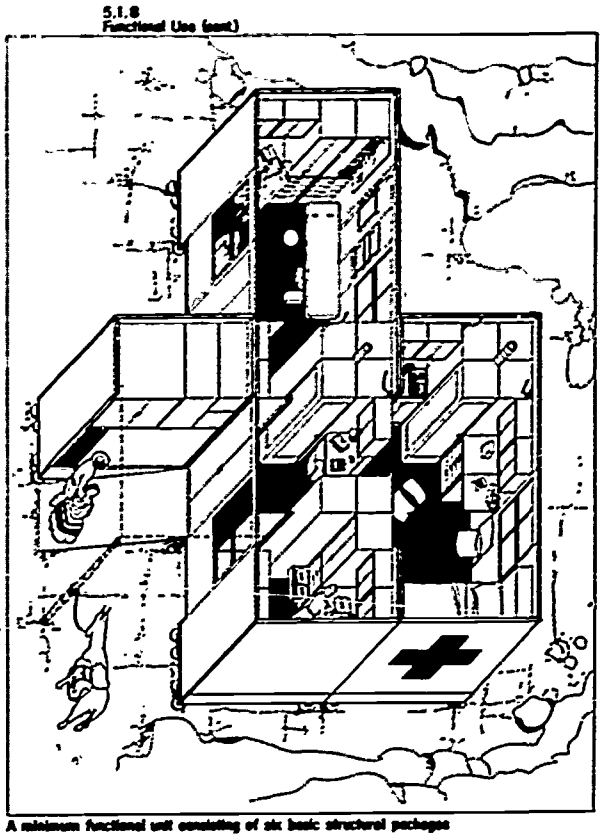
Lavatory Components and Combinations

5.1.8
Functional Use



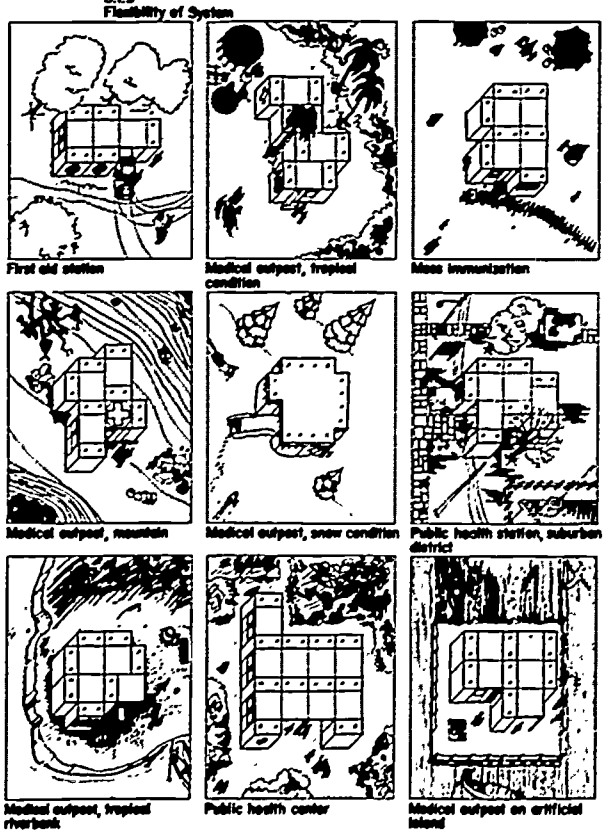
Some functional space arrangements of assembled basic structural package units

5.1.8
Functional Use (cont.)



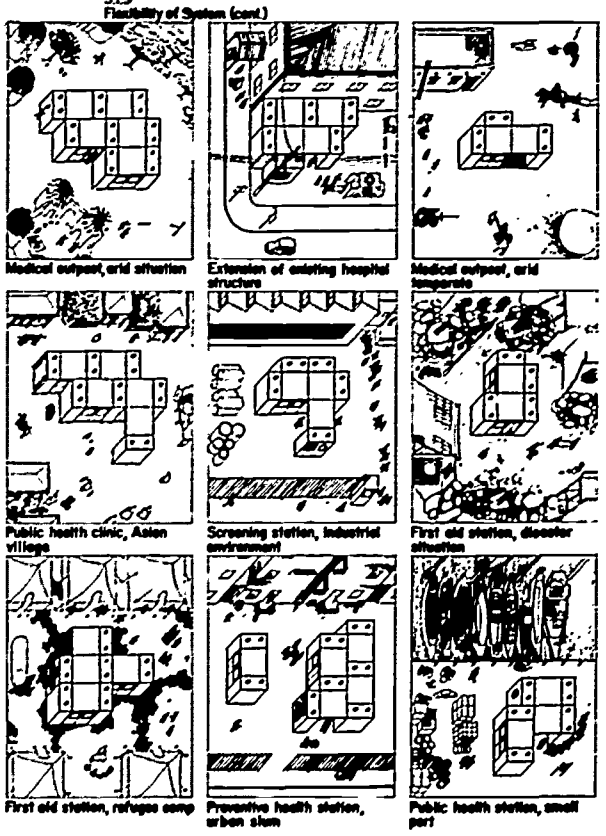
A minimum functional unit consisting of six basic structural packages

5.1.9
Flexibility of System

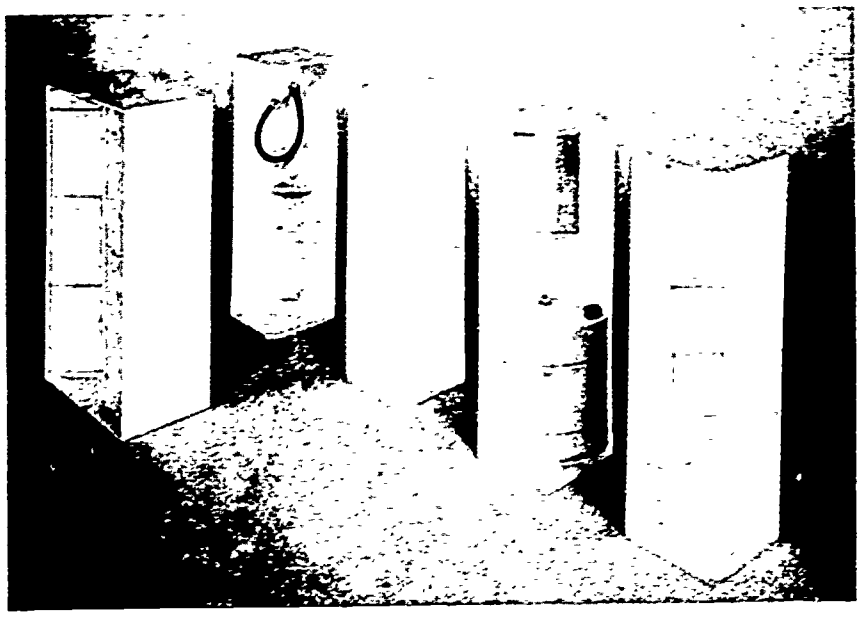


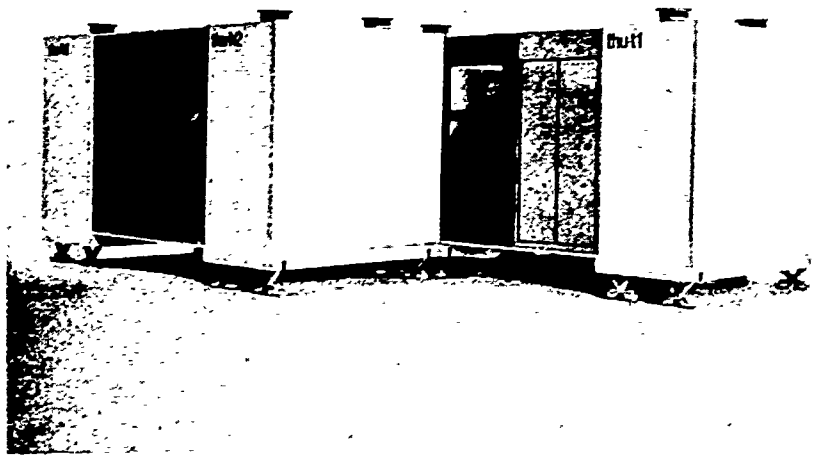
First aid station
Medical outpost, tropical condition
Mass immunization
Medical outpost, mountain
Medical outpost, snow condition
Public health station, suburban district
Medical outpost, tropical riverbank
Public health center
Medical outpost on artificial island

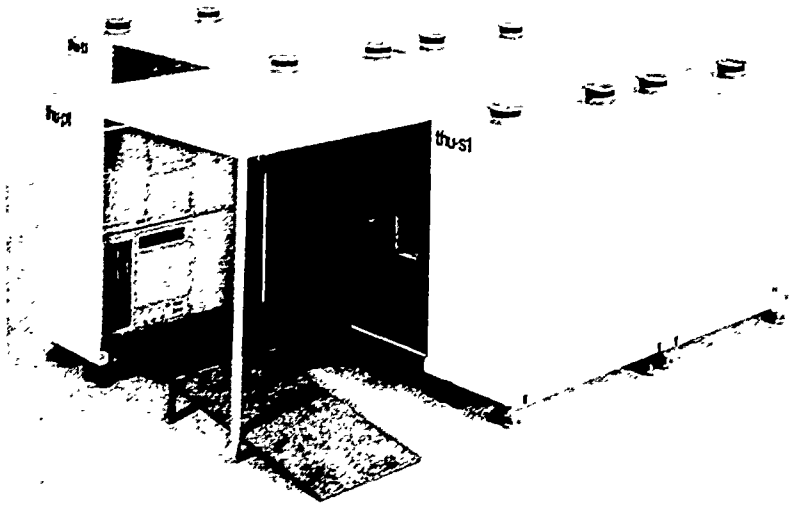
5.1.9
Flexibility of System (cont.)



Medical outpost, arid situation
Extension of existing hospital structure
Medical outpost, arid temperate
Public health clinic, Asian village
Screening station, industrial environment
First aid station, disaster situation
First aid station, refugee camp
Preventive health station, urban slum
Public health station, small port




thu-t1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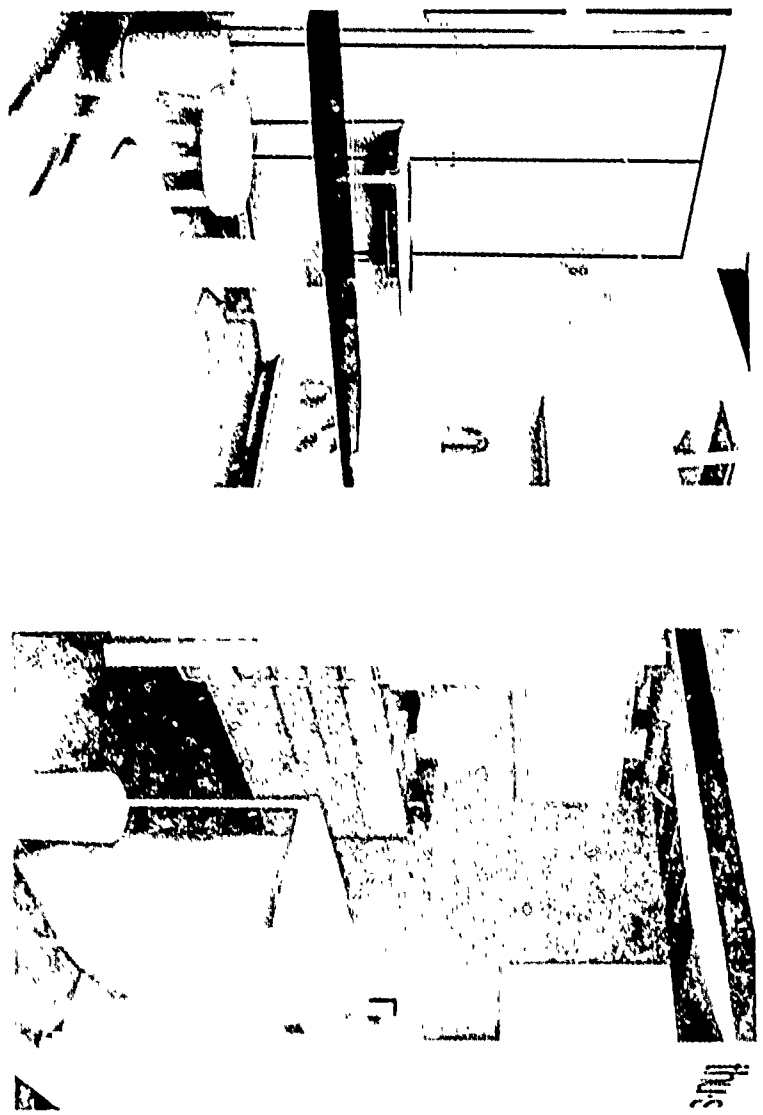
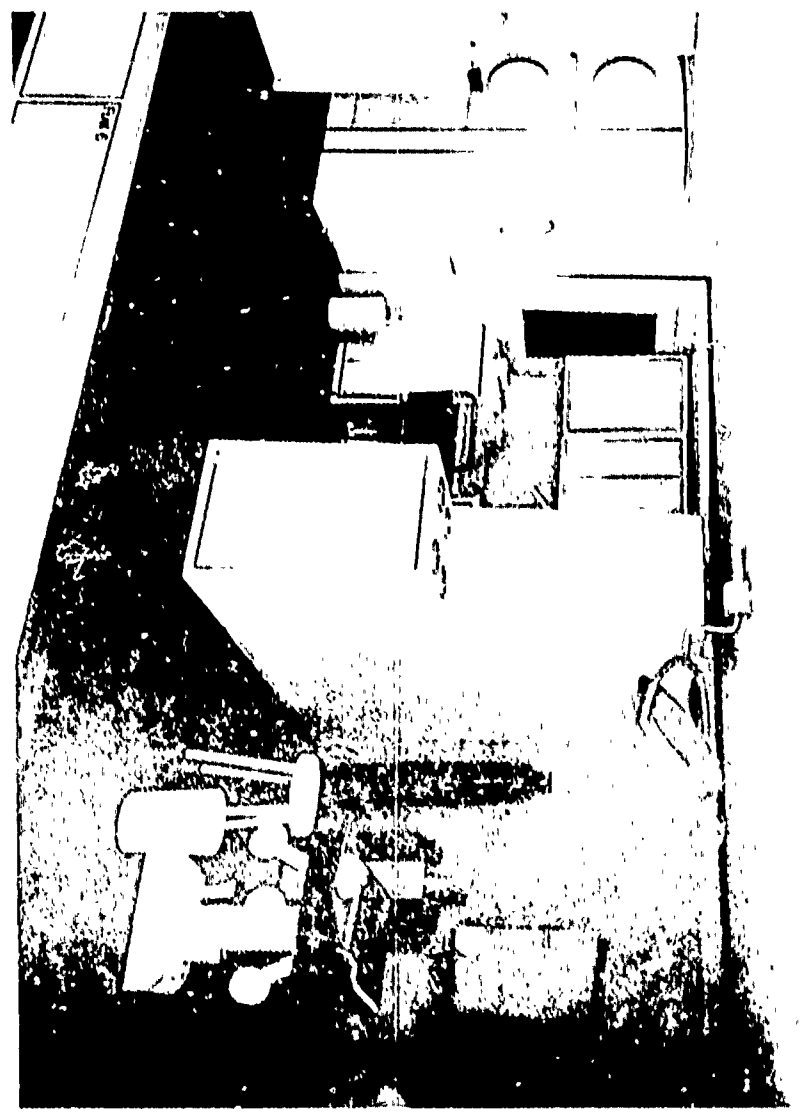
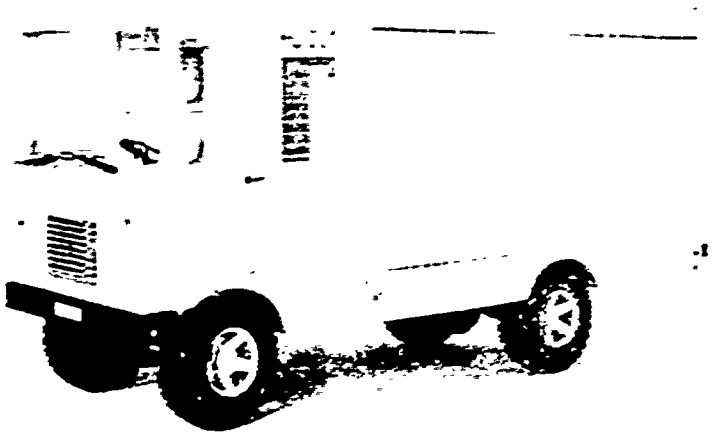
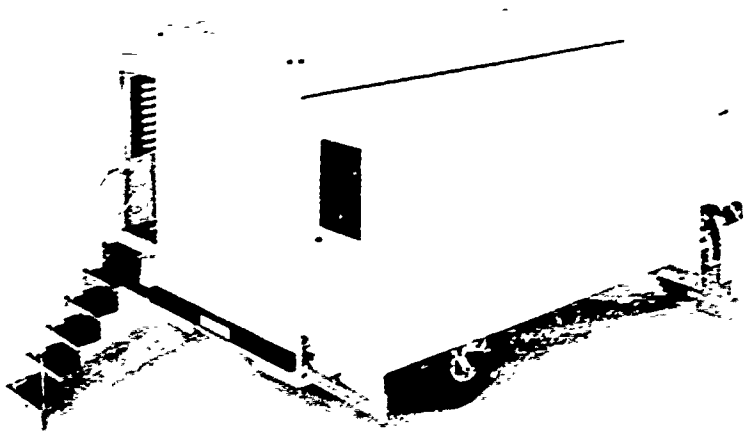
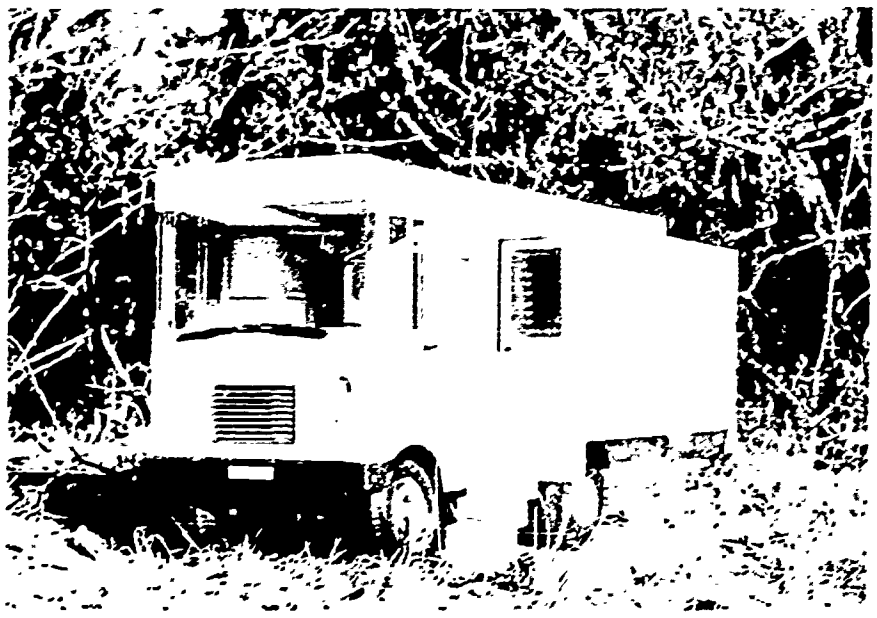


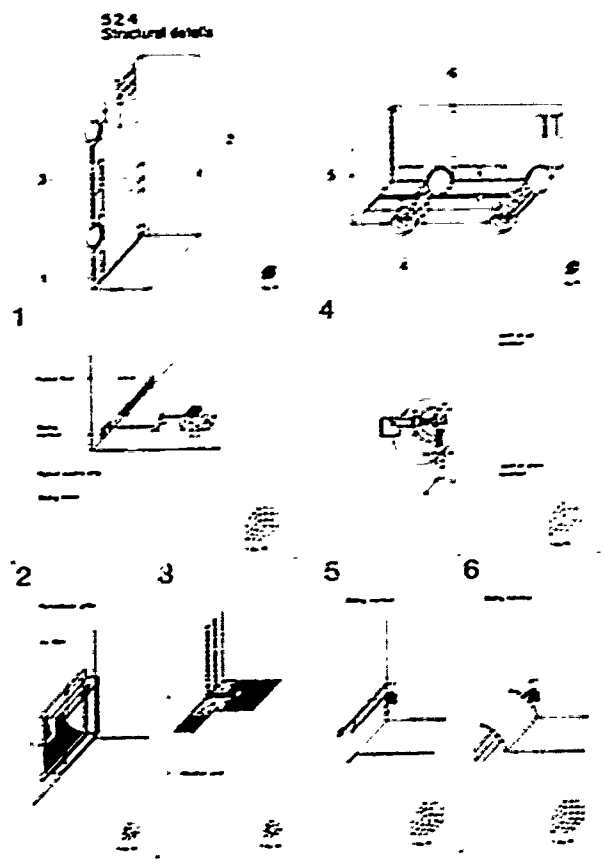


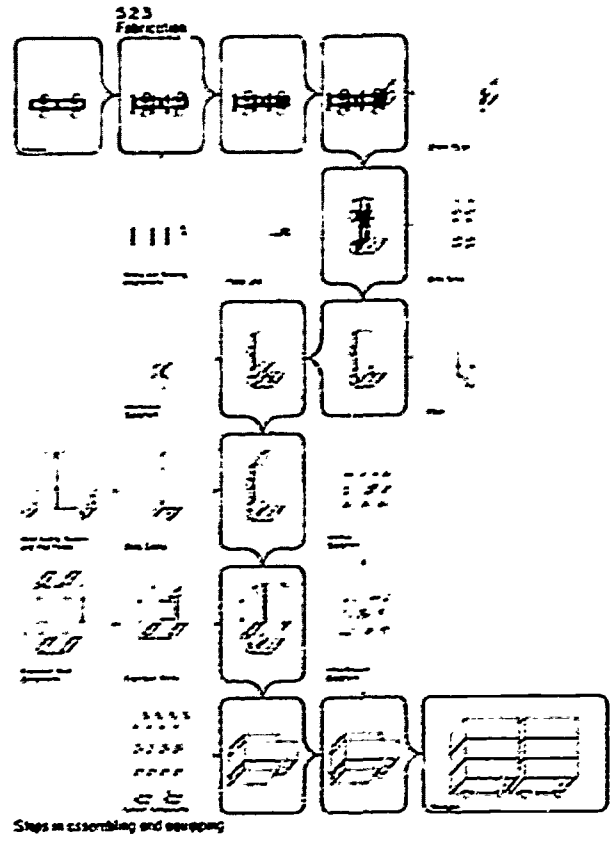
AUTO-MOBILE HEALTH UNIT

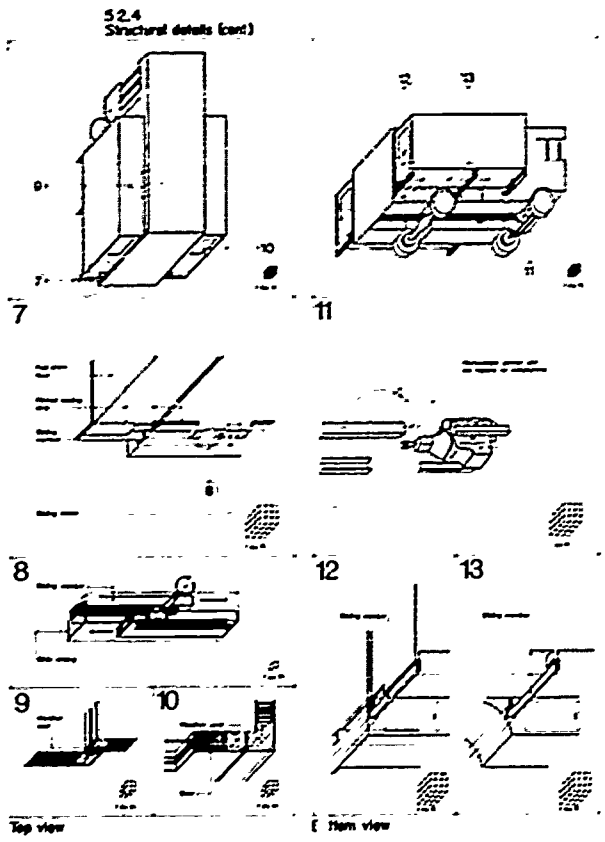


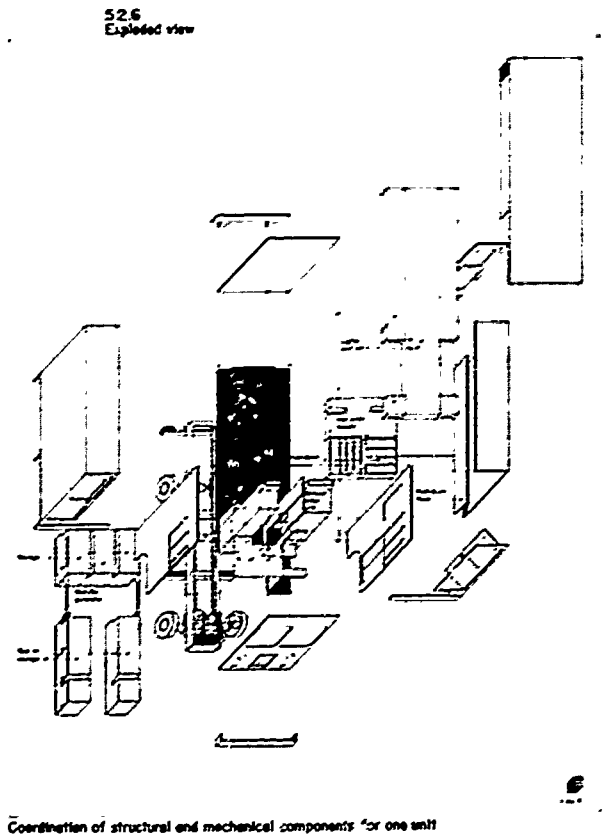




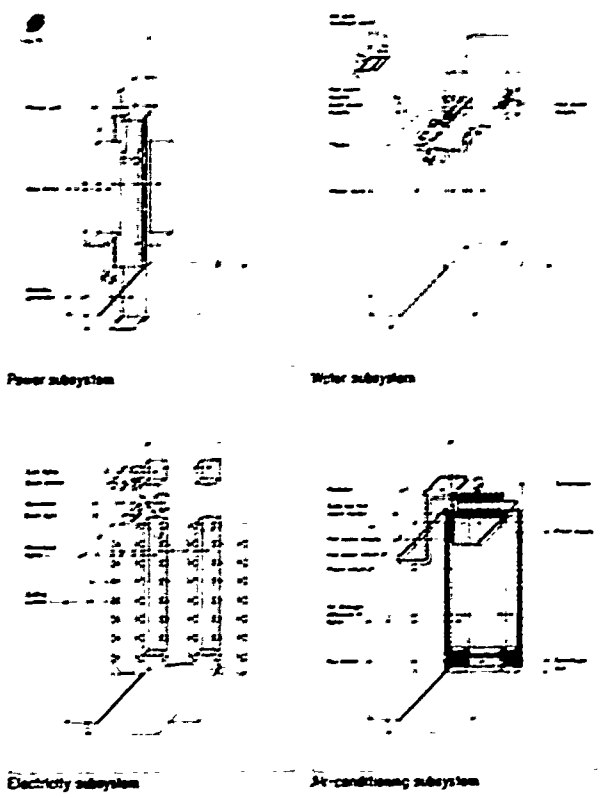

5.2.4
Structural details
1
2
3
4
5
6


5.2.3
Fabrication
Steps in assembling and swagging


5.2.4
Structural details (cont.)
7
8
9
10
11
12
13
Top view
Item view


5.2.6
Exploded view
Coordination of structural and mechanical components for one unit

525
Mechanical systems



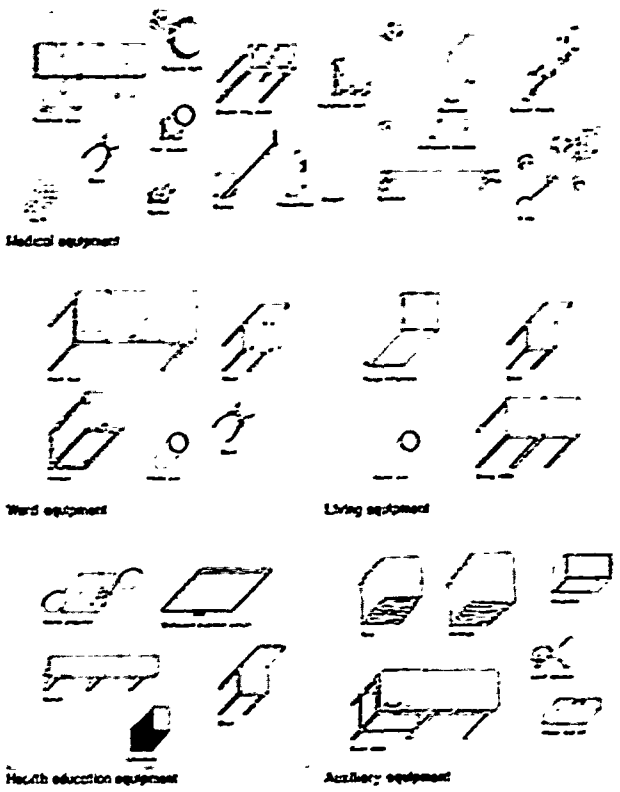
Power subsystem

Water subsystem

Electricity subsystem

Air-conditioning subsystem

527
Equipment components (cont.)



Medical equipment

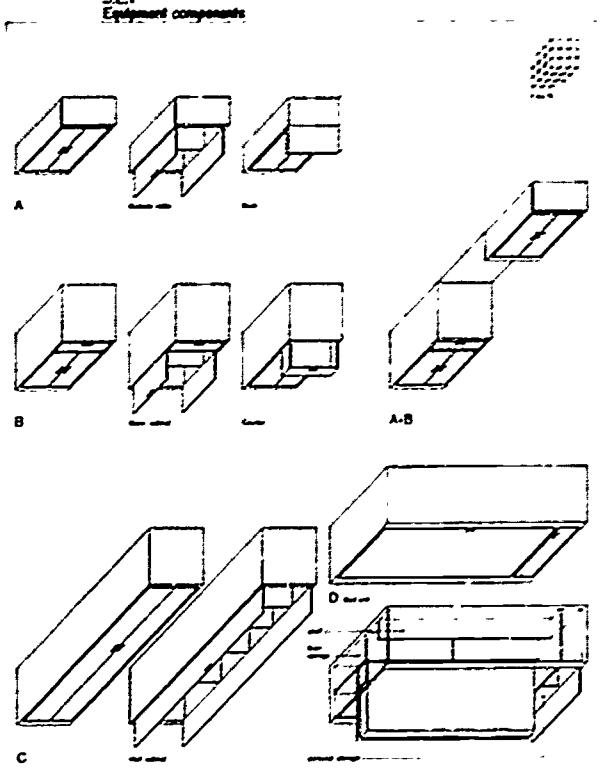
Ward equipment

Living equipment

Health education equipment

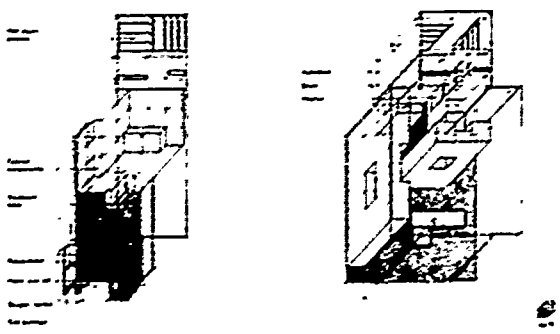
Auxiliary equipment

527
Equipment components

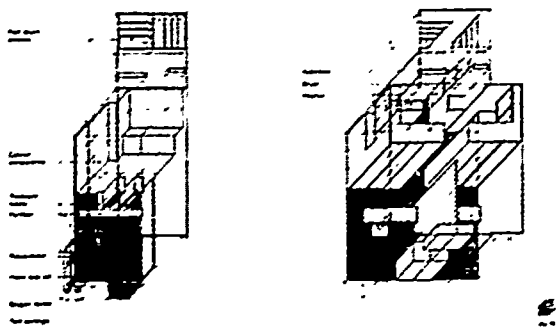


Cabinet components

528
Flexibility of system

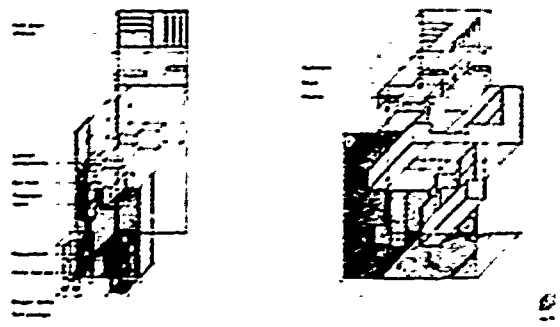


Examination / treatment / lab / administration arrangement in transport and operational condition

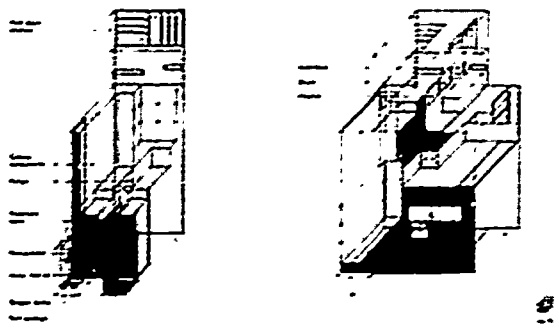


Examination / treatment / lab / administration arrangement in transport and operational condition. Double examination and treatment possible

528
Flexibility of system (cont.)

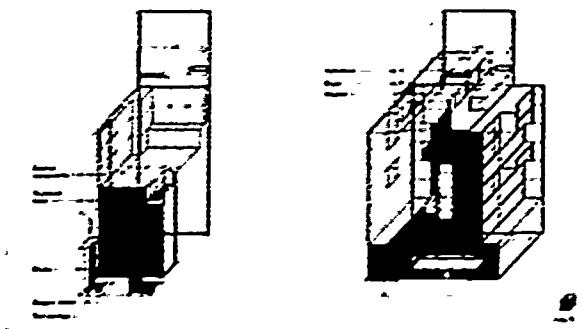


Examination / treatment / lab / administration / reception arrangement in transport and operational condition

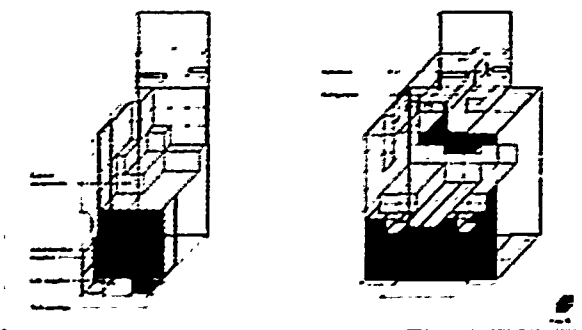


Examination / treatment / lab / administration / living arrangement in transport and operational condition. Living facilities for one or two persons.

528
Flexibility of system (cont.)

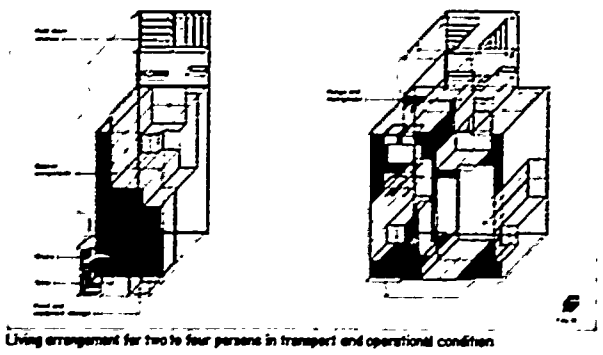


Examination / treatment arrangement in transport and operational condition

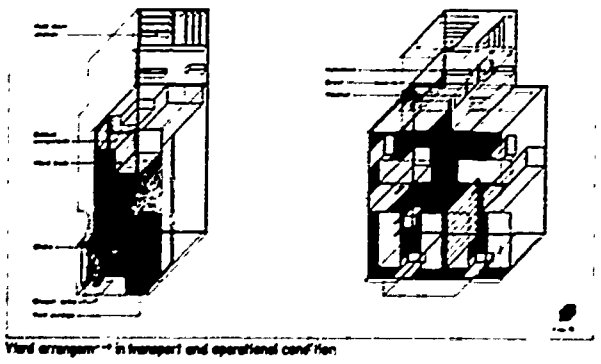


Lab / administration arrangement in transport and operational condition

528
Flexibility of system (cont.)

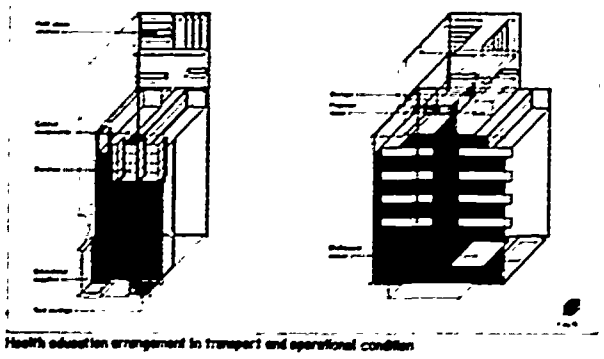


Living arrangement for two to four persons in transport and operational condition

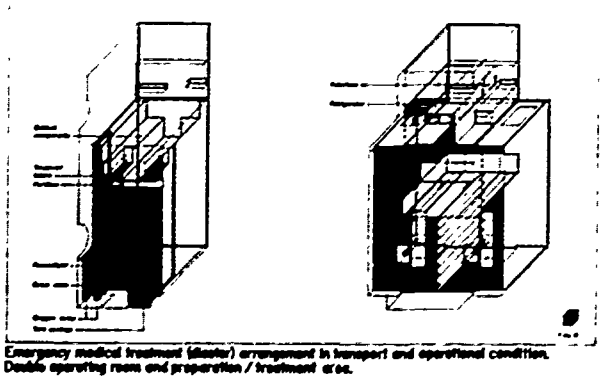


Ward arrangement in transport and operational condition

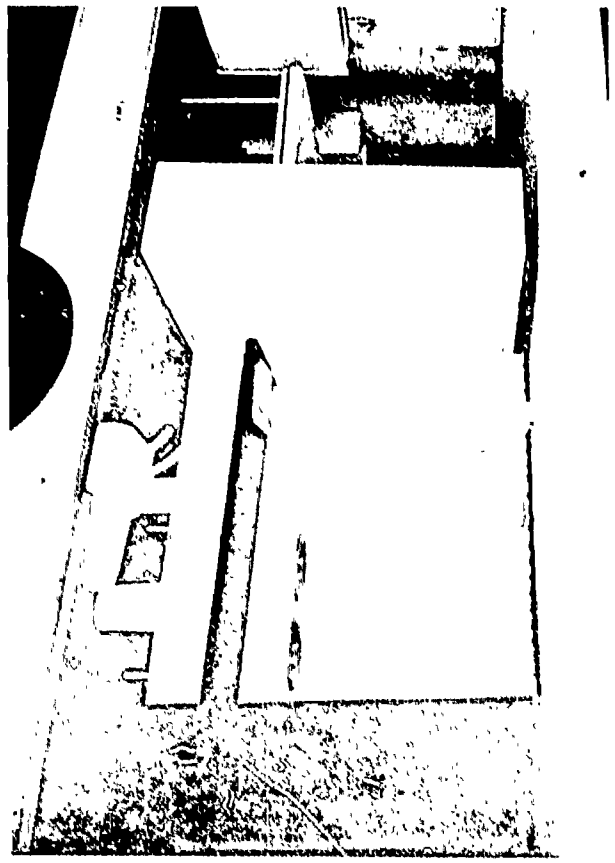
528
Flexibility of system (cont.)

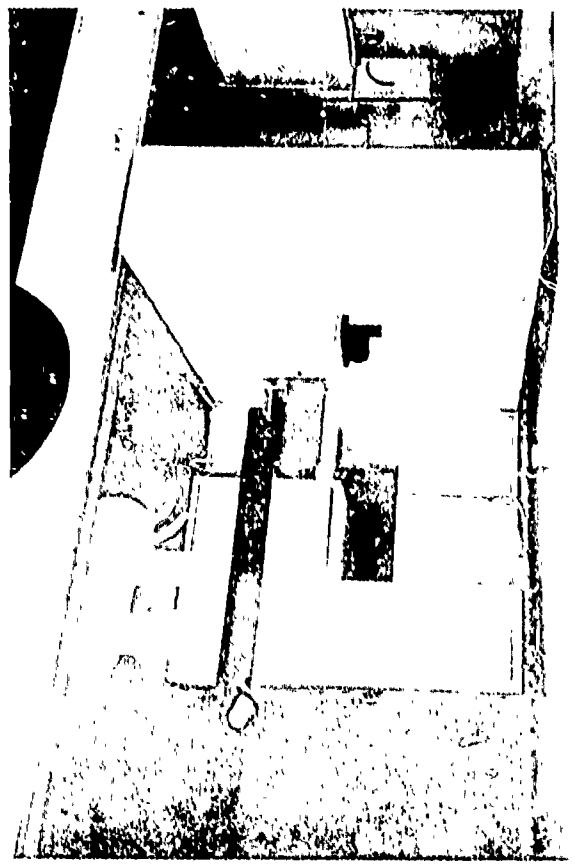


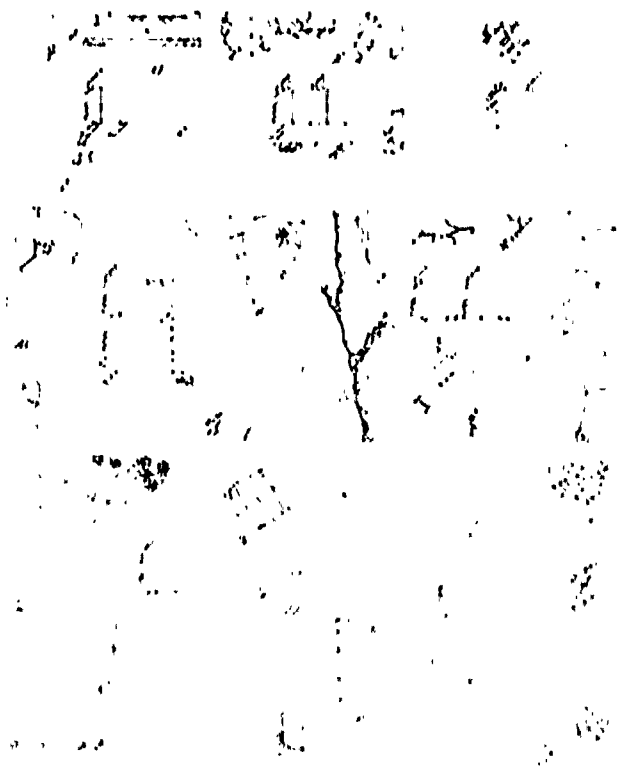
Health education arrangement in transport and operational condition



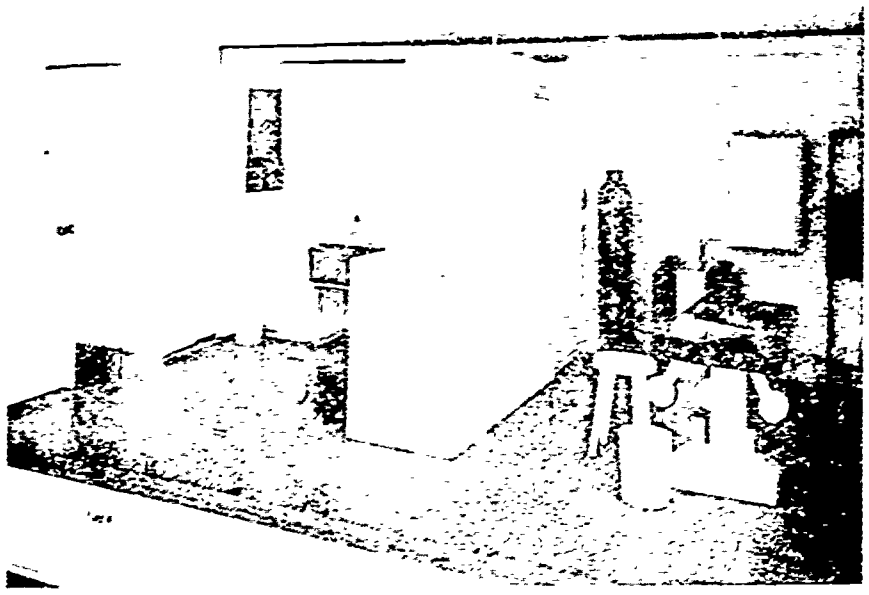
Emergency medical treatment (dental) arrangement in transport and operational condition. Double operating room and preparation / treatment area.

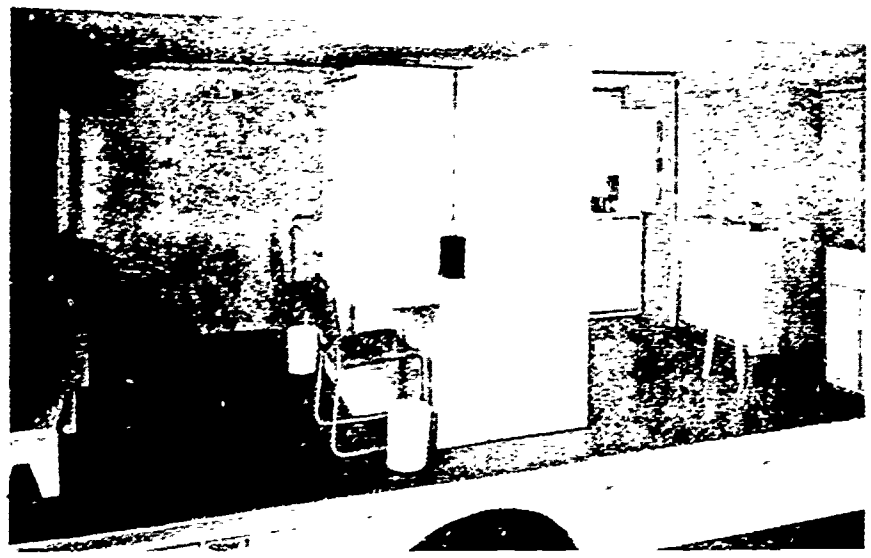


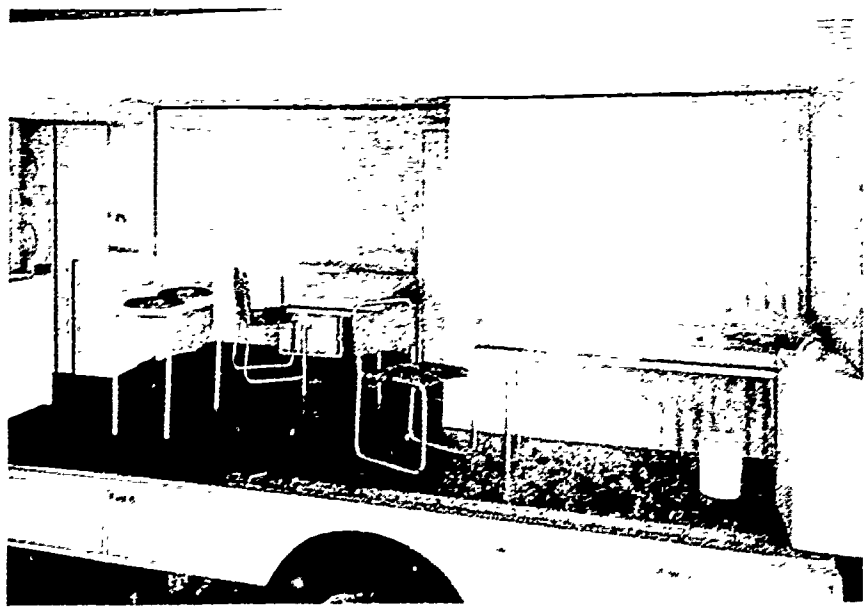




Some unit configurations







LOAD-BEARING STEEL-PLATE HIGH-RISE BUILDINGS

A New Architectural

And Engineering Concept

By

HEINZ R. TRECHSEL

Senior Research Architect
U. S. Steel Corporation Research Center

ABSTRACT

Steel skeleton construction, combined with non-load-bearing curtain walls, is the conventional concept of steel-framed high-rise buildings. To provide alternative means of using steel in the construction of multi-story buildings and to satisfy changing architectural requirements, the concept of the stressed-skin load-bearing steel-plate wall is suggested. In this concept, the exterior wall itself would support the vertical and lateral loads of the building and thus act both as a space-enclosure (wall) and as a structural support. This concept is not unlike conventional load-bearing masonry and concrete wall construction, but because of the superior strength of steel, it can be applied to much taller structures, and because of the steel plate's ability to withstand tensile stresses, large overhangs and great spans over large openings are possible.

This paper discusses the reasons for and results of an extensive study into the potential of the new concept and outlines the unique parameters for the use of load-bearing steel-plate walls in high-rise buildings in regard to such factors as architectural expression, structural integrity, fire protection, fabrication, and erection.

INTRODUCTION

Much of what we consider today the beginnings of modern architecture are structures of wrought and cast iron and of steel. They were built in a truly remarkable variety of forms and styles, such as Paxton's Glass Palace, the Brooklyn Bridge, and the Eifel Tower.

It is not only in these most famous and large-scale structures that the character of steel as a building material and of appropriate structural concepts was expressed so early. In their way, the Paris metro stations with their flowing lines and many skylights with their delicate filigran are as much in character with a material that is available in many forms and shapes and that can be formed and fabricated by many means.

Early curtain walls, such as the one shown in Figure 1, expressed steel construction directly, and their detailing honestly combined small and large members, straight and curved ones, exposed fasteners and exposed joints, all assembled with so much feeling and finesse that even today, after more than sixty years, they still are a far more advanced expression of the material's character than most modern typical grid-type curtain walls or modern panel type walls. We may have advanced in fabricating techniques and material technology, and modern metal walls may be somewhat superior in keeping the "weather" out, but few of them possess the architectural excellence one would hope today's affluence, scientific approach, and high standard of technology would produce.

In some more recent imaginative buildings, we can detect a new awareness of different possible construction methods. The closely spaced columns in the world trade center buildings are more than an unusually small module. Together with the structural spandrel plates, they form in fact a vertical Vierendeel

truss which is designed to withstand the lateral loads resulting from wind action. Similarily, in the IBM building in Pittsburgh, Pennsylvania, the diagonal pattern of the facade expresses a vertical truss which supports both lateral and vertical loads. In both of these examples, the wall treatment expresses, at least to some degree, the novel structural systems used. And yet, even these advanced examples appear to me a retreat from the 1904 office building with its exposed structure and rhythmic module.

If not much inspiration in either form or imaginative material use in modern high-rise building construction can be found, in other engineering fields the problem of both structural support and space enclosure has been solved efficiently: in naval architecture, where giant floating structures have to meet similar requirements as buildings, and in air-fame construction, where the need for weight reduction led to the most advanced types of support-enclosure systems. In both these cases, metal stress-skin structural systems are used, and in both instances structural support and space enclosure are fully integrated into one system. Pursuing these thoughts further, personnel of U. S. Steel Corporation's Applied Research Laboratory investigated the application of the stress-skin support and enclosure concept to high-rise buildings.

DEVELOPMENT

A preliminary feasibility study showed that not only appeared the concept of a stressed skin wall structurally sound, but it could also be economical and could lead to entirely new forms in architecture. It was further determined that the new concept was compatible with conventional construction, although the design, structural analysis, and fabrication of stressed skins in sizes for high-rise buildings would require some radical departures from present day practices.

Based on the feasibility study, an extensive research project was started to develop the necessary structural design theories required, to determine the architectural potential of the concept, to investigate various possible new problems, and to define parameters for the use of what we now call the "Load-Bearing Steel-Plate Wall Concept."

Figures 2 through 16 depict the basic concept of this concept.

Figure 2 shows a plain plate element. To serve as a load-bearing wall, it has to withstand both vertical and horizontal loads. Being a plate, it will also act as a building enclosure.

To prevent buckling at relatively low loads and to eliminate the need for excessive thickness, stiffeners are required, both vertical and horizontal, as shown in Figure 3.

Building enclosures are not generally sealed but can be considered as filters. Thus, openings are needed in the plate to permit light and air to enter and to afford a view of the outside world to the building's occupants.

Assembling several of these plate elements, a wall is created which, with proper flanges, ledges, and other devices, can support the floors of a building. Figure 4 shows a model photo of the basic concept; no effort was made here to treat the wall architecturally, but an attempt was made to show how the wall could be made to function properly by indicating one possible method of support for the floor and by indicating the location of required thermal insulation and fire protection at the interior face of the wall. The plate stiffeners are located on the exterior, providing a smooth interior to facilitate the economical installation of both insulation and fire protection.

The Laboratory to date has conducted extensive research on four major interrelated areas:

1. Structural
2. Architectural and Aesthetic
3. Fire Protection
4. Fabrication and Erection

STRUCTURAL CONSIDERATIONS

Structurally, the proposed stressed-skin, load-bearing steel wall can be analyzed as an extremely large stiffened plate. The structural behavior of such plates is very complex, and extensive theoretical and experimental investigations must be made to develop appropriate design procedures and economical designs. The present study is concerned with the basic theoretical background, and no attempt is made here to present detailed design criteria, methods, or procedures.

STRUCTURAL CONCEPT

When the height of buildings increases, the effects of wind and seismic forces contribute a higher proportion of the loads. The tier building with rigid connections also becomes a less efficient structural system with increasing height. The conventional structural framework resists lateral forces mainly by the finite number of discrete joints, and the walls, when not an integral part of the entire structure, serve only to enclose space.

The suggested bearing wall concept is capable of resisting compression, bending, tensile, and torsional forces. The entire building is designed to act like an extremely large cantilever box beam. A plate structure can be viewed as a skeleton frame with an infinite number of members. Therefore, it is infinitely statically indeterminate. The plate structure requires a set of

partial differential equations for equilibrium or displacement conditions, which involve continuous functions defining the internal forces and the displacements throughout the structure. The solution of these equations has to satisfy prescribed boundary conditions.

Although a full structural analysis would have to be made on the basis of the theories of applied elasticity and plasticity, a good approximation and feasibility determination of the new concept was developed from the above mentioned theories.

On the basis of a structural analysis, an approximation of the required wall plate thickness was made. Although subject to limitations imposed by simplified assumptions, it appears that structurally the stressed-skin load-bearing steel plate wall is possible. The results indicate that the required wall plate thickness for buildings up to 60 stories in height would vary between 1/4 inch and 3/4 inch, the thickness being dependent on building height, fenestration, and number, location, and rigidity of the stiffeners provided.

The results of the initial analytical work were compared with test results of eight tests on 6-foot by 6-foot specimens with various stiffener configurations and with and without window openings. Generally, good correspondence was found between theoretic and experimental data. Both methods showed that the structural analysis of the plate wall in most cases can be accomplished by conventional plate and light-gage methods that should be familiar to practicing structural engineers.

Three basic structural findings are relevant to the potential design architect of a plate wall building:

1. Window sizes should be kept within the limits shown on Figure 5.

2. Windows should not have sharp corners, round windows being the most desirable structurally.
3. Stiffeners of torsional rigidity are required: "T" or tubular sections being far more efficient than simple flat bars.

To the architect designing a plate wall building, the structural concept provides some problems not normally encountered in building design.

To begin with, the interaction of structural, architectural, and fire protection aspects is much more pronounced than in typical frame buildings. Not only is the exterior wall design tied closely to the structural performance, but such normally quite independent problems as floor design and floor support details, window sizes and mullion size and shape all must be considered as part of both structural and architectural design. Of course, these interactions were always in existence, and modern design philosophy teaches that they should be visually expressed. But in practice, except for basic column spacing and floor depth, architectural, structural, and fire protection considerations were solved quite independently. With the plate wall, this freedom is no longer possible. It is believed that this concept returns some of the more interesting aspects of integrating form and function.

FIRE PROTECTION

Fire protection had to be considered because the basic wall as presented here does not conform to all standard code requirements, not necessarily because it is unsafe, but because existing code requirements do not apply. In the studies to date, it was always assumed that the exterior of the plate wall would be left exposed, while the interior would receive some form of fire protective finish.

Figure 6 shows a fire emerging from a single window, and the overlay curves indicate the isotherms. Notice that nowhere on the outside of the wall does the temperature of the fire itself touch the plate wall. In an actual building fire, the temperature of the exterior plate is dependent on several factors: (1) the severity of the fire itself, (2) the size of the window, and (3) on the spacing of the windows. Whereas the severity of the fire is not dependent on the wall construction, both size and spacing of the windows are functions of the wall design. Figure 7 shows a schematic plan of a building wall with large, closely spaced windows under fire conditions. Notice that the high temperatures from the single windows merge to form one big flame at the building's exterior. Under these conditions, an exterior unprotected plate wall might, indeed, be unsafe.

In Figure 8, a wall plan with relatively small and widely spaced windows is shown. The flame emerging from each window remains separate, and the temperature of the steel plate exterior would remain within safe limits even under severe fire conditions. This leads us to reaffirm the earlier criteria that the plate wall should be designed with relatively small windows and that the windows should be relatively widely spaced.

Since it will not always be possible to satisfy these criteria, two alternate methods for providing fire protection were developed. The first consists of flame deflectors which bring the flame further away from the plate wall, as shown in Figure 9. The second consists of suitably spaced tubular stiffeners filled with water to dissipate the heat entering the plate wall near window openings. This suggestion is illustrated in Figure 10. Both methods can be successful, and general guidelines for their use are being developed. In practice, each case will have to be investigated individually to develop safe constructions.

FABRICATION AND ERECTION

The fabrication and erection of the load-bearing steel plate wall would differ substantially from conventional practice. Being a structural element, the use of relatively heavy plate and stiffener elements would preclude their fabrication in a typical sheet metal shop. On the other hand, since the wall would be the finished exterior of the building, the fabrication would require more care than is normally required in structural steel fabrication. In recent years the popularity of exposed structural elements has grown and many fabricators have proven that, with suitable detailing and supervision, the appearance of such elements can be fully satisfactory. Similarily, the erection of the wall will have to be done by a structural steel erector, and again suitable connection details will be required to give satisfactory results.

For successful wall detailing, the architect must free himself of preconceived notions carried over from curtain-wall design principles. In particular, he should recognize that the tolerances generally used in curtain walls cannot be achieved in a plate wall. Where bolts are used, these will be large and can usually not be hidden as is common in curtain walls. For welded connections, it should be recognized that today both shop and field welding are relatively economical. However, refinishing of welds is costly. By proper detailing, the need for such finishing can be eliminated.

ARCHITECTURAL CONSIDERATIONS

Having investigated some of the unusual structural and fire protection aspects, the architectural potential of the load-bearing steel plate wall was studied in depth. As said previously, this concept reaffirms the interaction of form and function. The functional aspects were discussed above from

an engineering point of view. To use them as a basis for new forms appropriate for the plate wall, it was necessary to restate these aspects in architectural terms:

1. The plate wall reaffirms the wall as a barrier. No longer is the wall an expandable element as in typical curtain-wall construction. The plate wall is rather related to the old load-bearing masonry wall.
2. In keeping with this "Barrier Concept," windows and other openings should be kept relatively small and widely spaced.
3. Since the plate wall essentially is a large truss, it is capable of spanning large openings and of providing great overhangs and cantelevers.
4. With the plate wall, other building elements such as floors can be used structurally by providing the stiffness needed in large buildings, further increasing the interaction, interdependence, and integration of the building as a unit.

These basic criteria differ substantially from those applicable to current building design, and thus should lead to new expressive forms. The Laboratory attempted to determine the degree of departure from conventional forms rather than to propose specific examples to be copied later as "typical" for the load-bearing steel-plate wall.

As a point of departure, Figure 11 shows a building with what could be termed a "conventional" plate wall. As would be expected, the form is closely related to masonry construction, expressing the "barrier" and having small windows spaced with some irregularity.

Figure 12 shows a development from the previous sketch. Taking advantage of the tensile properties of the plate wall, the building's volume expands in various directions above ground.

Folded plate concepts could easily be applied to the steel plate wall, as shown in Figure 13.

The new concept may require the adaptation of forming and fabricating practices, leading to new forms of the plate wall elements themselves. Figure 14 shows typical hot-stamped steel panels as used in railroad car construction, and their possible adaptation to building uses.

Of course, many more forms and shapes are possible through the use of plate walls, but it was not attempted to catalog all possible forms. Furthermore, it is difficult to discuss form objectively, and other designers would arrive at different results altogether; the few examples shown only are a few responses of one designer's imagination. Even this one man, had he to design an actual building, may well arrive at substantially different results.

The examples shown on Figures 11 through 14 are purely graphic studies. However, one load-bearing wall panel was actually built with the objective to demonstrate physically in one single panel a multitude of principles and concepts which may be applied to the load-bearing steel plate wall. As Figure 15 shows, the result was a building element which, although largely functional in its elements, gives a definite sculptural overall effect.

Although many of the concept's prime applications are believed to be still in the future, the first buildings using load-bearing plate walls are already under construction, such as the main office building of U. S. Steel Corporation's ore operations near

Virginia, Minnesota, shown under construction in Figure 16. Cost estimates made for this and various other applications indicate that the wall is not only competitive with conventional walls, but that its use may reduce the overall cost of buildings. As more know-how is gained, and as fuller advantage of the various characteristics of the plate wall is taken, it appears safe to say that load-bearing steel-plate walls will become both more functional and more economical.

Since the basic concept of the "Load-Bearing Steel-Plate Wall" is the integration of various functions, the development was handled as a team effort, with the following personnel responsible for major work areas:

Dr. P. J. Fang, Structural Engineering

Mr. L. G. Seigel, Fire Research

Mr. A. L. Filoni, Form and Function

Without the contributions of these researchers, the successful development of the new concept would not have been possible.

FIGURE 1

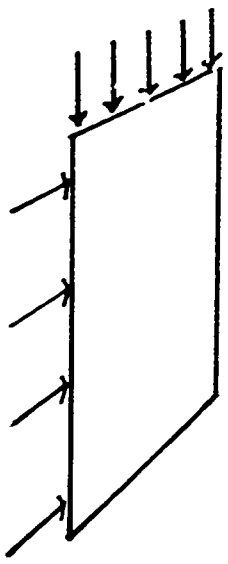


FIGURE 2

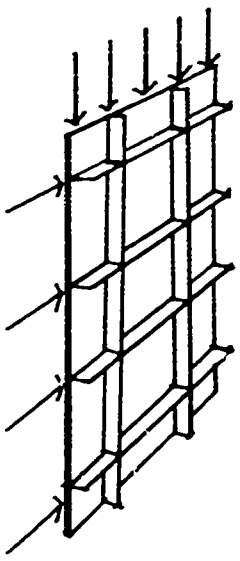


FIGURE 3

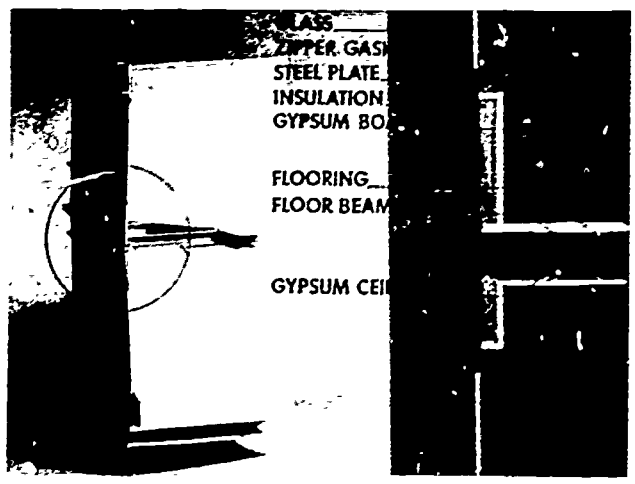


FIGURE 4

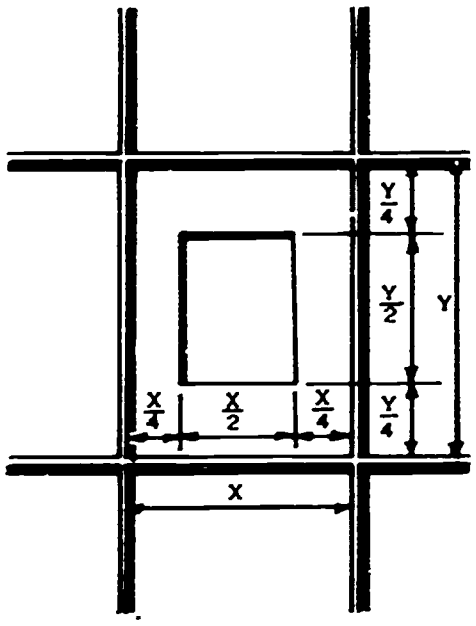


FIGURE 5

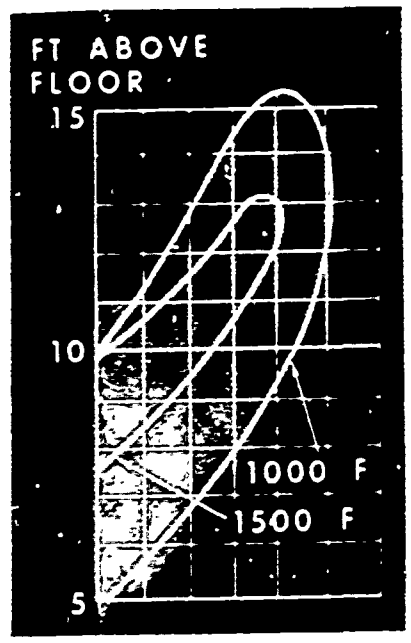


FIGURE 6

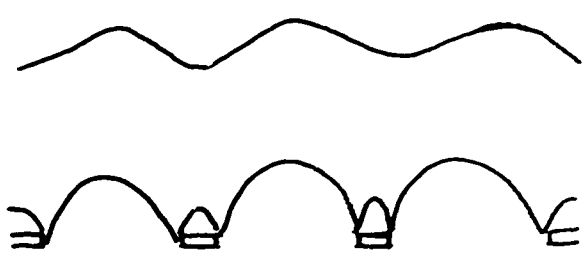


FIGURE 7

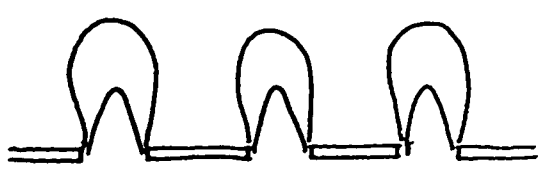


FIGURE 8

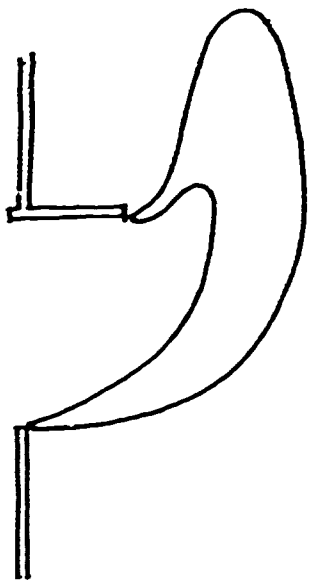


FIGURE 9

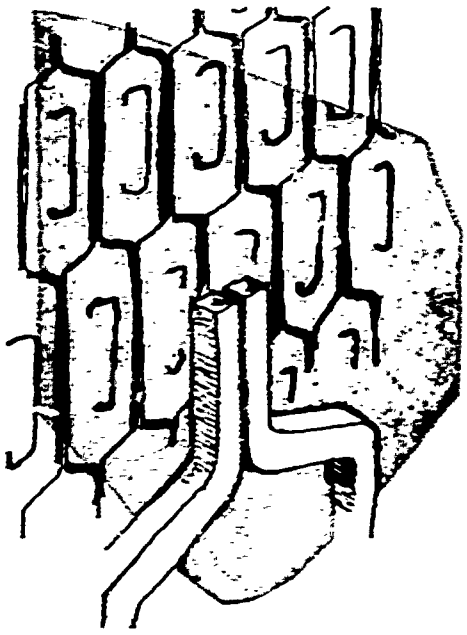


FIGURE 10

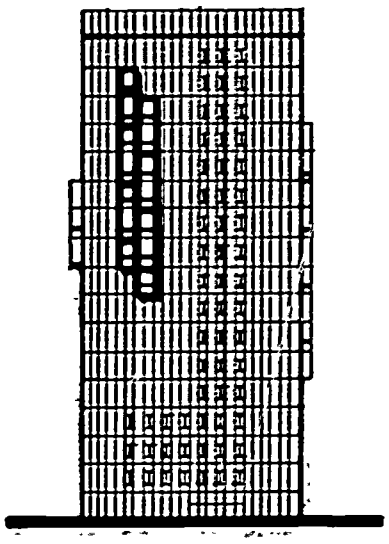


FIGURE 11

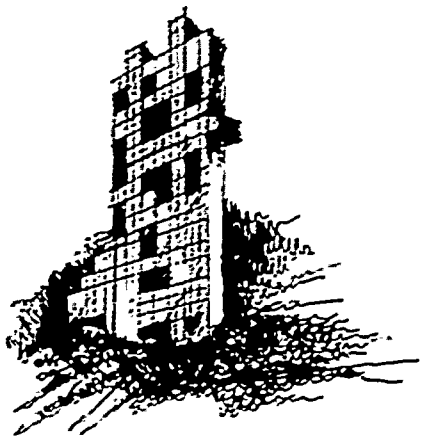


FIGURE 12

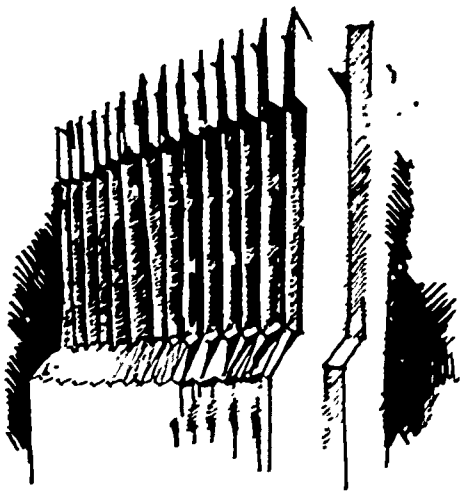


FIGURE 13

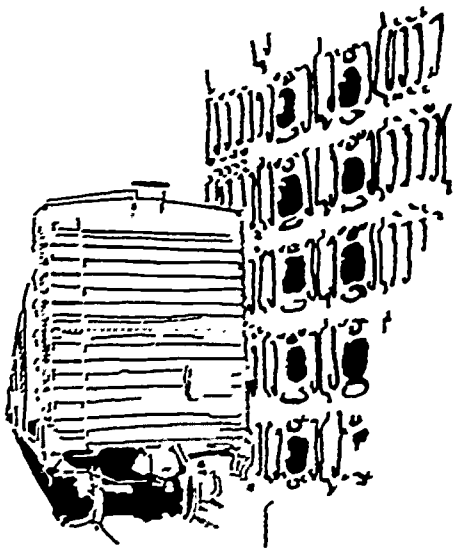


FIGURE 14

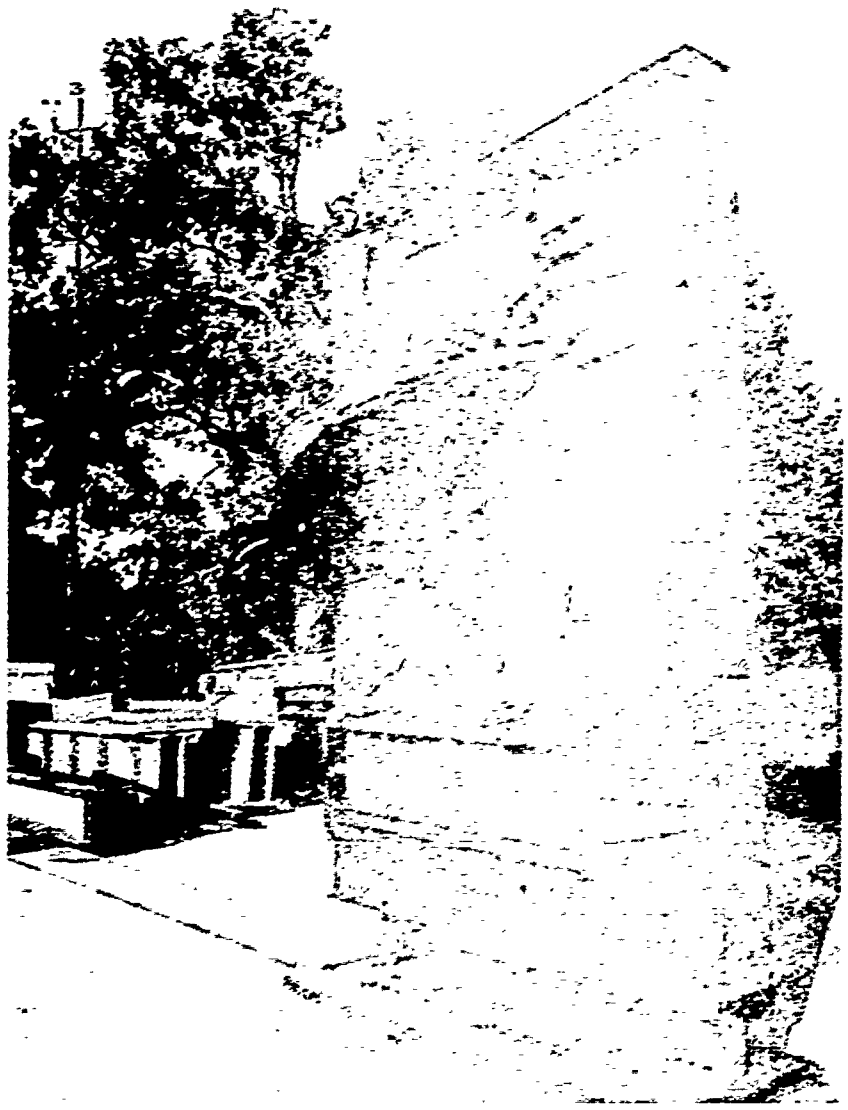


FIGURE 15

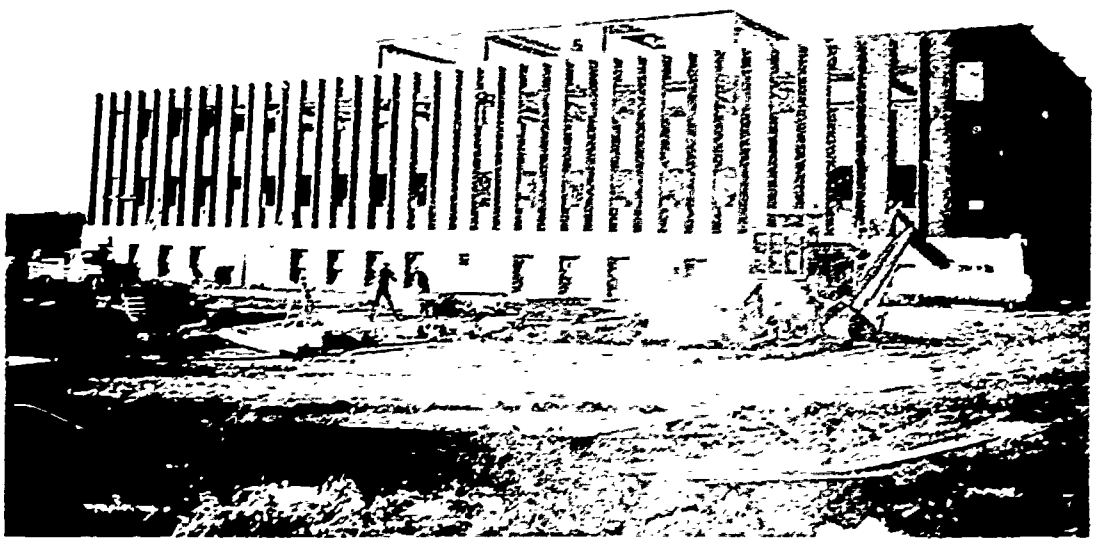


FIGURE 16

DESIGN RESEARCH

By

RALPH WARBURTON

Special Assistant to Secretary for Urban Design
U. S. Department of Housing and Urban Development

It is a pleasure to be with you today to discuss the role of architectural research in Housing and Urban Development. Certainly we can all join in support of the Presidential and Congressional goal, and one of today's most important national issues is a decent home in a suitable living environment for every American family. This goal has both physical and social components.

On the physical side, we can ask whether good environment relates naturally to scientific achievements. Have advances in technology sparked simultaneous development of environmental quality? Have engineering projects on a large scale contributed to broad environmental improvement?

Well, for example, we have several ugly towns generated by atomic energy facilities. We also know, for example, of the parallel strands of work in the 1930's on plastics and on the concept of a one-piece bathroom unit, which were not brought together until the 1960's. And we know of the urban problems created by airports and highways, to say nothing of opportunities often missed when rivers are deepened or dammed.

Thus, in spite of science fiction images, we must conclude that technological progress has not often been related to good environment in the past, at least not in a timely way. That is not to say that there is no relationship. It does mean that well-conceived and coordinated research efforts are needed to develop the technology-environment interface in order to provide forward looking design backup for the future.

This need is even more apparent in the socio-physical interface of architectural research since the primary activity of sociologists thus far has been to study the non-material aspects of the culture of society. The subject of "user needs" for environmental

design represents a considerable vacuum at present. As a recent HUD-AIA seminar indicated, we need objective performance standards which are related to their positive effects on people.

There is a hopeful parallel with our space exploration experiments. Much effort has been expended to provide optimum environments for a few astronauts for several days. We must find the optimums for earthly environments that will continuously promote the ideal development of our society.

Can these environments be produced, given the attitudes of citizens and officials and professionals involved in particular aspects of the development process? The answer to this question is yes, if all are willing and able to help bridge the gaps that separate ideas, people, and ideas and people.

We at HUD believe that the solution of large and complex urban problems requires a comprehensive and energetic attack focused directly upon this important goal. With the Housing and Urban Development Act of 1968, we are rapidly approaching the point where a comprehensive array of governmental mechanisms is available.

To outline these historically, I would begin with the first component of the present Department, which was the Federal Housing Administration, whose initial activities in mortgage insurance programs were authorized in 1934 to assist families in purchasing their own homes.

In 1937, the public housing program was authorized to help provide housing for very low income households. Under this program, annual contributions are made to local authorities to defray the 40 year debt service on dwellings so that rent paid by the

tenants generally represents only operating and maintenance expenses.

The next major program was authorized after World War II in 1949. Urban renewal assists localities in redeveloping blighted areas by helping write down the cost of land. Grants can be made for up to 2/3 of project cost.

In 1954, the urban renewal program was broadened, and the 701 program of comprehensive planning assistance was enacted.

The 221 (d) (3) program authorizing below-market interest rates in moderate income FHS housing was enacted in 1961, and this was aimed at partially filling the considerable gap between public housing and middle income levels.

Special help was extended to the elderly in 1962.

In 1965, the Department of HUD was established and the rent supplements program was created to help poor families afford decent private housing.

In the Housing and Urban Development Act of 1966, the Model Cities program was born.

Model Cities is a program of programs since it provides intensive block grants to cities who coordinate a wide variety of physical and social programs to meet the needs of a specific model neighborhood over a five year period. The planning process for Model Cities involves intensive citizen participation, which I am sure Assistant Secretary Taylor will discuss with you this evening.

Also in 1966, President Johnson, by Executive Order, assigned to HUD's Secretary the leadership role in urban affairs, authorizing

the Secretary to initiate cooperation between the various government agencies with programs affecting urban affairs.

The omnibus Housing and Urban Development Act of 1968 provides a new challenge to the field of design research with its introduction of many new programs which will fill in previous voids in Federal assistance to urban areas. Of considerable interest are the provisions of financial assistance to new town developers and to non-profit housing sponsors.

A principal thrust of this legislation is housing, with the declaration of a national goal of 6,000,000 new housing units for low and moderate income families in 10 years. This averages out to a six-fold increase in our current annual production of this housing - and nearly a 50% increase in the annual production of all housing!

Two major new assistance programs are provided: Section 235 (ownership) and Section 236 (rental), under which HUD is authorized to assist mortgagors or mortgagees so that the equivalent monthly housing cost paid by the low or moderate income family is not more than 20% of their income. HUD can provide this assistance down to an equivalent interest rate of 1%.

These and other additions, coupled with increased funding and more sensitive direction of older programs, provide an array of Federal assistance efforts to help localities solve their community development and housing problems.

Over the next decade, the housing industry (researchers, designers, developers, builders, financiers, local agencies) is asked to consider:

1. A new market, whose specific needs and desires are not understood in detail.

2. The desirability of low and moderate income home ownership.
3. The employment of neighborhood residents in the design and construction process.
4. The employment of occupants in project management.

The 1968 legislation also contains an important quality component related to design. Congress commended HUD for its recent efforts to improve architectural standards. These include the establishment of the biennial Design Awards program in 1964. (Architectural researcher Carl Koch assisted the 1968 program as a Juror.) Also commended was the establishment of an urban design staff in the Office of the Secretary, which I represent, and the appointment of Regional Advisory Committees on Design and Planning to advise each of our seven regional offices. Each of these committees consists of a distinguished architect, urban planner, landscape architect, and engineer. (As a matter of interest, HUD has about 500 staff members in these professional disciplines.)

The Congress also directed that stronger emphasis be given, consistent with prudent budgeting, to encouraging good design in low and moderate income housing in order that the housing can be more attractive as well as better suited to the needs of occupants, and we are moving forward aggressively in following this directive.

This historical development of HUD programs has suggested a clear pattern of increasing national need - now over 30 years old. Is the research response to this current national need for housing quantity and housing quality to be the outmoded and fragmented efforts of the past or is it to be up-to-date?

What are the ingredients for a quantum jump in housing quantity and quality? They include the following objectives:

1. Utilize more intensive design and planning efforts to meet user and community needs.
2. Incorporate advances in building technology.
3. Increase the potential for nationwide volume production at a more rapid rate.
4. Lower the initial unit cost and maintenance costs to the developer and occupant.

Taking the last item for example, higher low and moderate income housing construction standards have usually been based on the assumption that the units will be subjected to harder use by the disadvantaged families and that the higher initial costs are justified to mitigate increasing costs of operation and maintenance.

Given a fixed top cost limit for such housing, the result is that other aspects of the design will have to be compromised. This can affect both space and equipment.

But space reduction and construction durability are incompatible goals in many ways. There is bound to be more friction between the user and his environment if the environment unduly restrains the freedom of the user.

Of course, the development of a more efficient interaction between space and equipment will help in that, for example, the areas beneath beds and atop closets can be more effectively used. But there certainly is a minimum free space which is required for a family to have the flexibility to respond to the multiple needs of all of its members for an evolving productive life.

In considering form as well as equipment, the competing values of production and individuality must be faced. The automobile industry may give us clues regarding these trade-offs. But,

how will changes in a family's housing influence their social advancement if both they and their neighbors regard a particular house or its equipment, such as air conditioning or garbage disposals, as a sign of their social position?

The relative answers to these kinds of questions will importantly affect housing design. We cannot complain that the inhabitants of architectural environments are unsympathetic users if their needs and values and capacities to absorb new ideas were not well understood at the beginning of the design process.

To gain a better national understanding of these questions and other housing and urban development issues, HUD has been supporting research for some years. These activities have included the subjects of urban transportation, comprehensive planning, urban design, community renewal and housing. Ancillary efforts such as the expanding experimental housing program, which relaxes insurability requirements on forward-looking developments, are also important. Porter Driscoll, Director of the FHA Architectural Division, will be discussing this with you tomorrow in detail. Many of the other presentations at this conference illustrate projects which have received HUD research assistance, as has other work with which you are familiar.

In 1967, the HUD Office of Urban Technology and Research was established, which consolidated and intensified our research activities. Then, a twenty-fold funding expansion was achieved - from $500,000 per year to $10,000,000 per year. $11,000,000 is to be allocated to this function for the current fiscal year.

During the past year, the Office of Urban Technology and Research has undertaken a number of activities to prepare for a long-range research and development program. The bulk of attention was given to laying out new programs of analysis, experiment, and development to address urban concerns effectively.

But many valuable technological and management innovations now exist in concept or in limited application and would be in widespread use but for the existence, or supposed existence, of a number of constraints. These include zoning ordinances, building codes, craft labor rules, financial policies, city administrative practices, the lack of idea sharing mechanisms, etc.

To determine their character and magnitude, the Department conceived and launched an "In-Cities" experimental housing program. Under this project, a research contractor is developing an integrated nation-wide experiment to measure objectively the factors which affect the rapid introduction of innovative low-cost housing in our urban areas.

This research contractor will select a number of promising housing innovations and some 10 to 20 cities which offer useful opportunities for investigating the problems of introducing these innovations. He will then negotiate with non-profit sponsors, architects, building contractors, government agencies, and others for the conduct of the housing sub-experiments in the chosen cities. He will collect the cost, time, sociological, and other data with which to measure both the effectiveness of the innovations and the impact of various constraints upon their introduction. Methods for minimizing various constraints will be sought, and, when they cannot be avoided, their effect on cost, time, and other important factors will be measured.

This information will be made generally available for planning further and more widespread use of innovative approaches to supply housing throughout the nation. Throughout the program, emphasis will be placed on satisfying the true needs and desires of lower income families. We expect to commit over $5,000,000 of our R & D funds to this project in addition to some

$10,000,000 worth of related mortgage and construction funds to provide thousands of living units.

To seek out the best ideas, approaches, and management competencies for this project, HUD deliberately chose to use a competitive procurement method open to bidders of any organizational type and background. This is an R & D procurement procedure that is well known and one which we can expect to use with increasing frequency within HUD. Nineteen separate organizations, many including architects and identifying sub-contractor groups, submitted proposals to become prime contractors. The size of the response and the quality of many of the proposals was most gratifying. Three potential contracting groups, composed of a very broad, sizeable, and experienced professional staff, each demonstrated an impressive understanding of the experimental design problems to be studied and advanced substantially different experimental approaches. Therefore, the Department decided to extend the competitive process through a first, contract-definition phase.

The letter of award for the second phase was given several months ago to Kaiser Engineers of Oakland, California, in association with Building Systems Development, Inc., the General Research Corporation, the Organization for Social and Technological Innovation (O.S.T.I.), the Real Estate Research Corporation, the Turner Construction Company, and the Battelle Memorial Institute.

As the composition of this group indicates, urban research is largely a multi-disciplined affair for those experienced in urban development. The insights of any one discipline seem not to be infinitely transferable. This indicates the probability that the generation gap between ideas and their effective application to urban situations can be bridged when procedures are developed to structure the appropriate junctions of all the disciplines involved.

We need to consider systems of systems. I am parenthetically reminded of an unfortunate proposal by a major company that should have known better. They set up a project under a well-qualified head and had branches in various specialties reporting to him. One of the specialties was the systems analyst, a man untrained and unskilled in urban concerns. Yet, under the work descriptions, it was he and not the project leader who was to put the effort together! - and he was not capable of dealing with the objective values necessary for that task.

Values, as well as cooperation, are needed if design is to positively affect our total urban environment. This is a challenge to you and to me, to all of us, to this conference.

Many disciplines working together can produce a good car, sometimes a good building. Your help, your increasing commitment, is needed if we are to correctly make the jumps in scale and produce a good city.

ADVANCED TECHNOLOGY

IN ARCHITECTURE AND URBAN DESIGN

Prefabrication

By

RENATO SEVERINO

Adjunct Professor
School of Architecture
Columbia University

At this time research in architecture must be directed towards the development of low-cost dwellings. The housing crisis is acute and grows progressively worse. The present systems cannot meet the need in terms of either quality or quantity. The time and money that the society can afford make it impossible.

Therefore, our research proposes a new methodology, a new approach to the problem, not a particular design. Our assumption is that architecture should not be concerned so much with various types (i.e., commercial, residential, hospital, school, etc.) or styles, as with various specific functions which it must serve on various limited scales. In developing this approach we are concerned with two basic questions: How can we best serve those functions, and how can we incorporate the service of those functions into a fully meaningful space. We conceive of these questions as one of the most relevant sets of questions in architecture today.

In the hope of initiating a dialogue on the problem of housing that might lead away from the old obstacles and towards new insights, we propose the following methodology: the incorporation of equipment and space to serve various functions into compact, movable units that can be situated in a flexible space. Through the use of these movable "function objects," space can be modulated at will, it can become equipotential, that is, used at all times to its fullest extent for different purposes through the rearrangement of "function-objects." This methodology can be valid for all needs, and all men in all parts of the world. It could create a tool to communicate the problems of housing to a universal audience; it could become an architectural "lingua franca."

The question then becomes how can we affectuate this methodology. The solution lies in the technologies currently in use in other industries. We can see that the automotive, naval, and other

industries can produce space containers, with varying degrees of mechanical and environmental sophistication, and can do so for a weight per volume unit cost in place, that is, a fraction of that for conventional dwellings.

This is achieved through total industrialization. This method is capable of minimizing weight and bulk of materials, minimizing waste, maximizing production efficiency through highly controlled working conditions, utilizing closer tolerances in both fabrication and erection, and relying heavily on materials such as light-weight metals and plastics, and producing rigid components at the central place to be shipped in finished form to a site.

Consistent with industrialized technology is the ability to differentiate between large-scale structural organization, basic unit spaces, and the more highly organized, sophisticated and specific sub-spaces which are contained within them, which we call "function-objects." The basis for the design of both structural components and function-objects came from previous research into the relationships between weight, cost, transportability, and erection procedures.

A series of thirteen basic structural-mechanical components were designed which could be transported to a job site in finished form and ready for final connections. These components were designed within strict, realistic constraints of weight and size to facilitate shipment, handling, erection, and to minimize bulk and aggregate dead weight structural loads. Also, in order to reduce the wasted space of separate, often parallel or redundant structural and mechanical systems, and the time and labor of field installation of mechanical components, a totally integrated structural-mechanical system was designed to service any of the possible spatial organizations of the separate components.

These components are so designed that interior space can be created in almost any scale. One possibility that was selected for further study was a space the size of which is required by European standards for a family of five persons. This was a unit space 1152 square feet in area. We considered a rectangular space 24 feet by 24 feet by 17 feet high (two levels of 8 feet each plus one foot for structural and mechanical requirements).

It is within this major space that all personal and family activities take place, regardless of the individual living habits of the family members, their relationships to eachother, or the particular organization of the family unit.

There are hundreds of possible solutions to the different needs of family situations within this unit space through the use of different kinds, different numbers, and different groupings of function-objects.

Function-objects are units complete in themselves, which serve one or more of the needs or functions of particular individuals or sub-groupings of individuals within the basic family unit.

These function-objects can be added to or subtracted from the unit space and moved about within it (with some minor restraints) to shape that space and create other more general sub-spaces. Being independent entities (like furniture), they can be replaced without materially affecting either structurally or mechanically the unit space or the basic structural-mechanical organization of the larger environmental configuration.

Although all of the examples we investigated in our research were considered on the basis of real materials, we were primarily concerned with the spatial and functional aspects. As part of

this research, a full-scale mock-up of a dwelling unit was built the Spring of 1969 at Columbia University and was used as a tool to investigate the possibilities of spatial organization with various function-objects. The model, being full size with maneuverable function-objects, allowed us to experience many possibilities of interior space configurations. The model also served to show, more readily, function-objects in terms of their sizes and in terms of the spaces they left free for familial use. Only with this scale could we fully visualize the implications of the objects and spaces we were proposing.

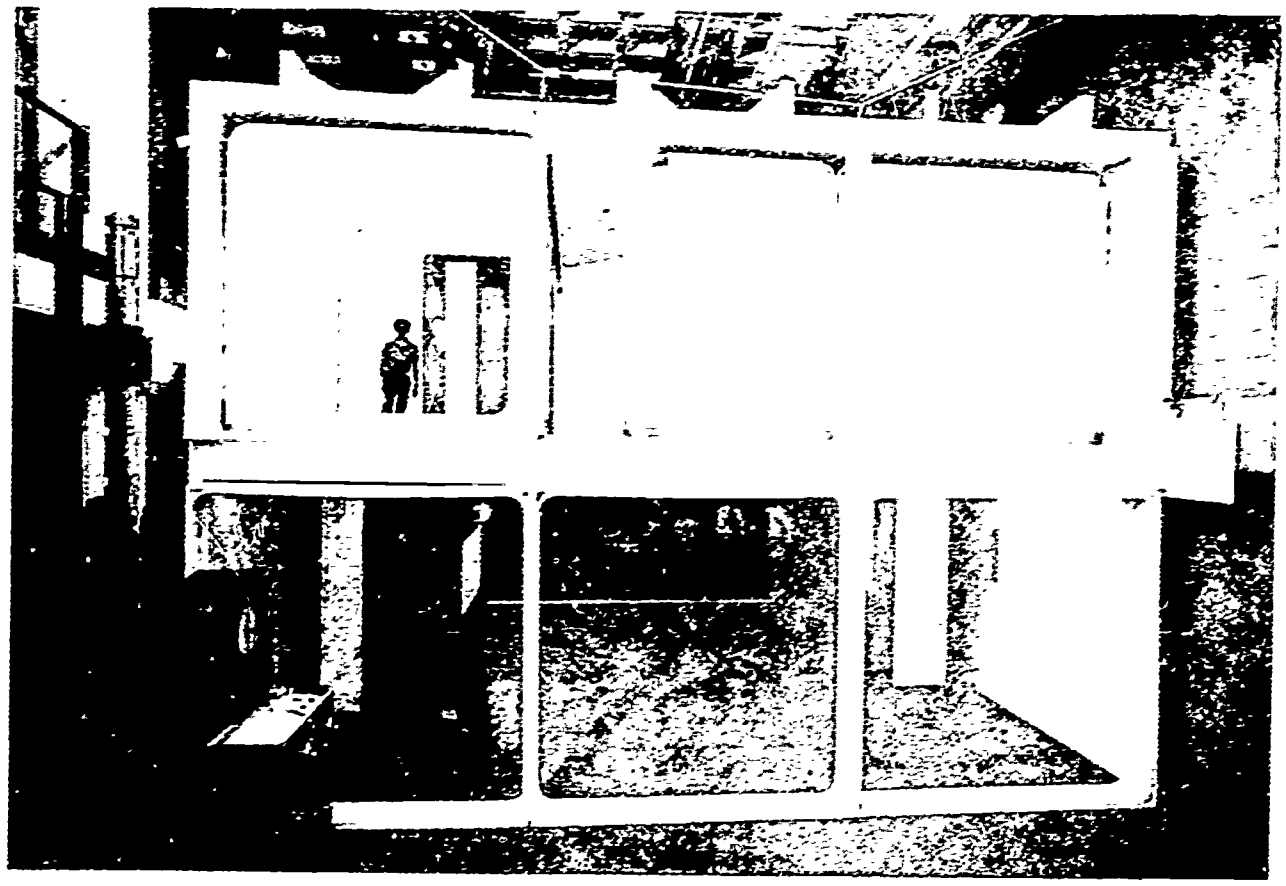
Although we seem to be considering only the internal environment, primarily because of the present pressing need for low-cost dwelling units, we recognize the fact that the external environment, the aggregation of many units, is of vital importance and that the sociological implications of these external spaces and the public acceptance of the entire methodology must be studied in great detail.

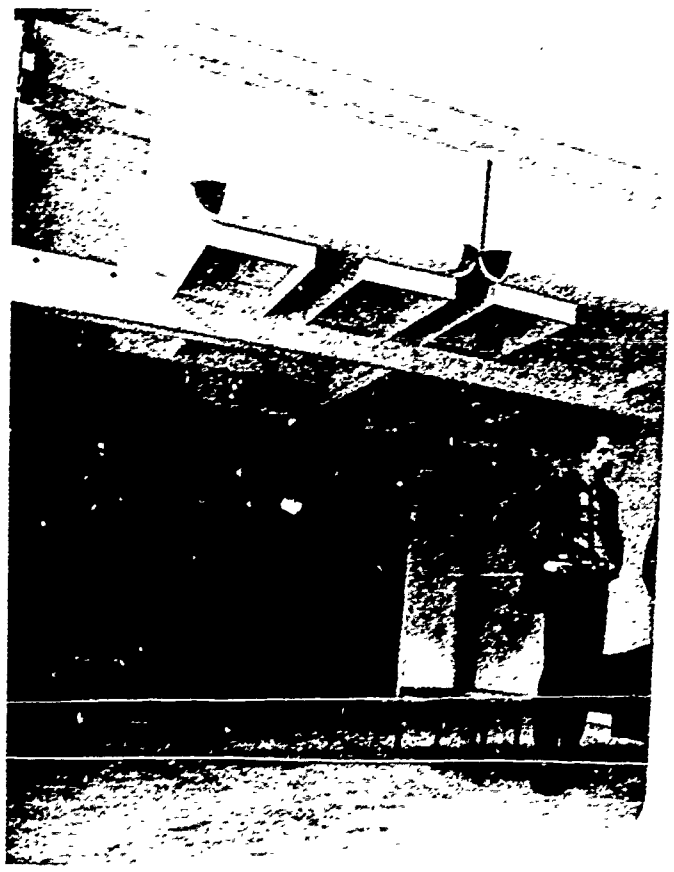
This new methodology develops possibilities for new internal spaces and for reshaping the total dwelling environment to such a point that old-fashioned, expensive cosmetic decoration will be both unnecessary and unwanted due to the possible range of freedom each family can have in determining the physical form of their personal spaces.

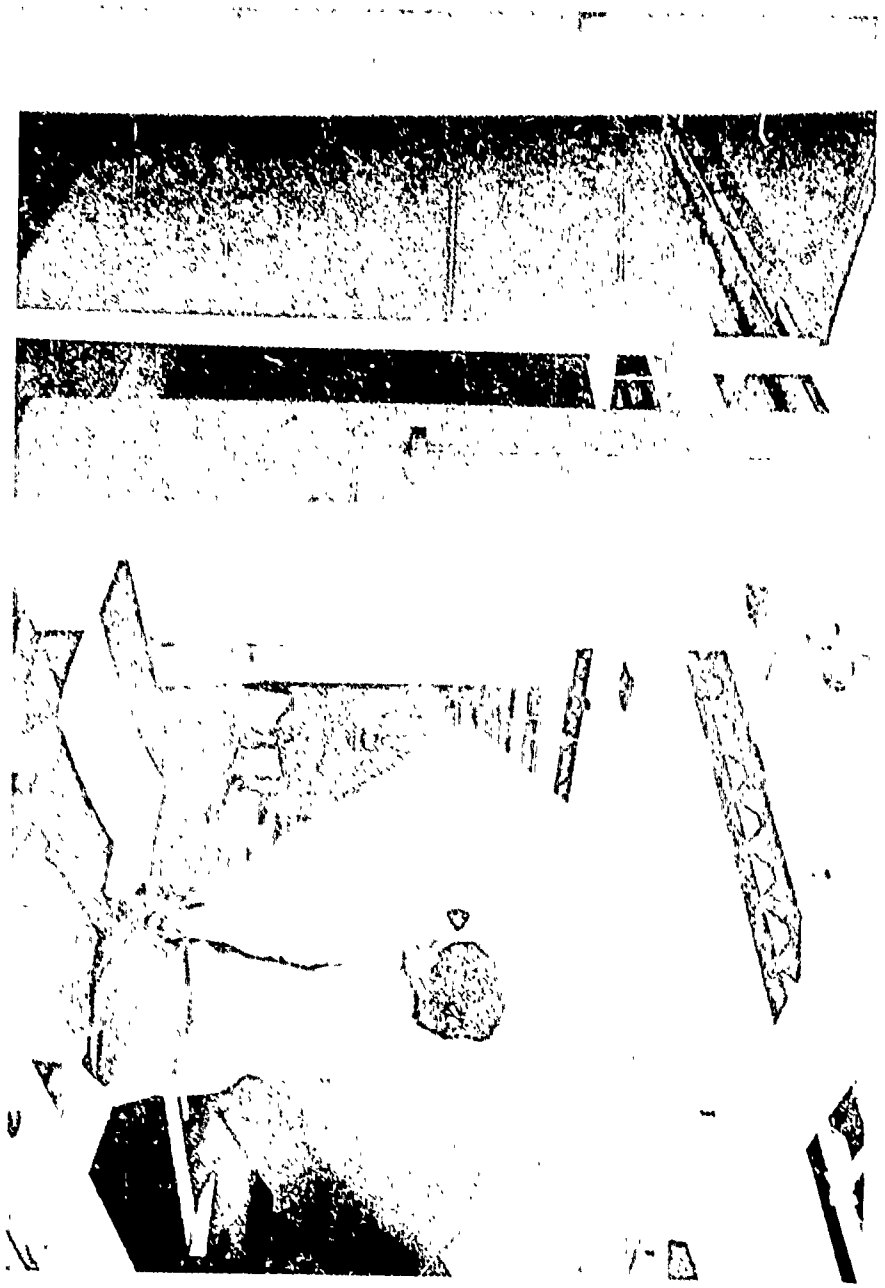
And, indeed, the possibility of assembling spaces and/or buildings in a few days and dismantling them wholly or in part, when required, can keep cities vital, relevant, and responsive to our changing needs without the inconvenience and dislocation we presently suffer.

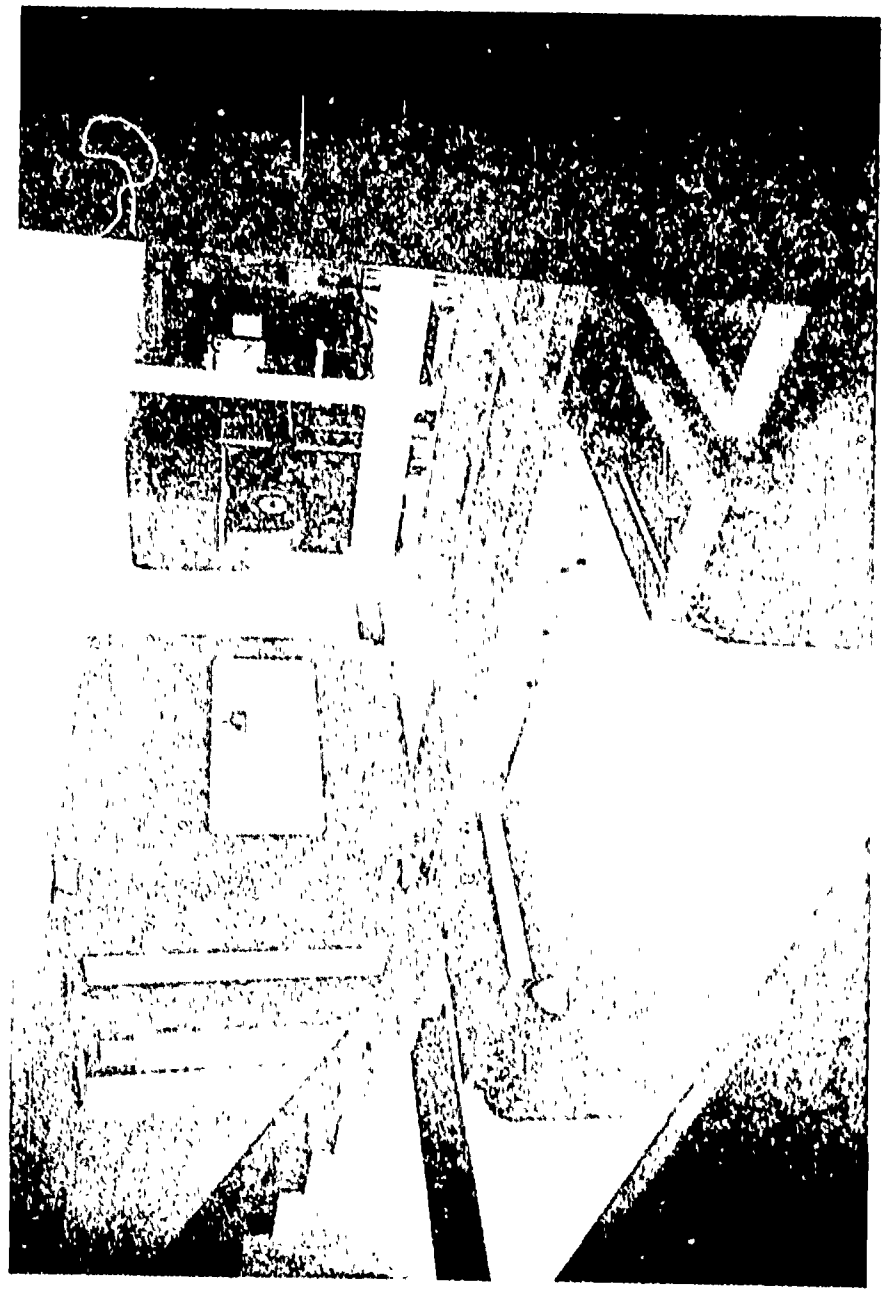
These photographs were taken of this model built at Columbia University. The flexibility of arrangement and the increase

of visible space arising from this approach are apparent. This model indicates how the reclamation of interior space - both functionally and aesthetically - can be achieved.









TECHCRETE

By

CARL KOCH

Principal
Carl Koch and Associates, Inc.

INTRODUCTION

Industrialized building implies a new concept of rationalized construction embodying a forward-thinking philosophy of planning and design, use of advanced management techniques, and organization of materials and manpower. Most impcrtant, the system involves a continuity of production, standardization and integration of the different phases of the production process which requires a steady demand flow. Techcrete - "the most advanced American building system" - according to Progressive Architecture, has demonstrated its qualifications for fulfilling these requirements.

AIM

Techcrete is developing a national production, research, and marketing organization for industrially produced building. The corporation is launching a major effort using its present extensive technical knowledge and experience to accomplish the following:

1. Provide design and organization framework for massive industry participation in manufacture of standardized component parts,
2. Organize market volume which can absorb increased supply of component parts,
3. Establish and operate a sales-service and development operation capable of organizing design and standardized component factoring.

BACKGROUND

Housing cost and quality in this country are automatically measured against conventional or prebuilt frame construction. But frame construction a) has approached a final plateau of economic effi-

ciency, and b) is of limited practicality at the level of urban densities recognized as the major unsolved problem area. The trailer approach, however efficient to produce, is seriously restricted by its lack of flexibility and the limitations of available, practical, and light-weight construction materials.

THE PRODUCT

Techcrete, in response to reality, offers a system which can compete with frame construction in cost and undercut it. Concrete - low cost, desirable for its fireproof, soundproof, and low maintenance qualities - is susceptible to significant improvement in production technique, thus offering great cost-saving potential. The following criteria represent the system:

1. A flexible design approach permits the wide use and appearance range which meets variation in site, climate, and density and local preference within the discipline of this industrial process.
2. A production method which lowers cost and increases quality.
3. A sophisticated total building process which speeds up and simplifies building from conception to occupancy.

The Techcrete system was designed in our office with Sepp Firnkas as structural engineer. Techcrete results from more than ten years of continuing study and over $10 million in completed projects, each of which contains some degree of innovation.

The first definite proposal for this system was the East Hills Project, Pittsburgh, Pennsylvania, for ACTION. The unfamiliar approach was not accepted, but the idea was carried out in an experimental project in New Haven, Connecticut. The present system

took shape during a study for the Boston Redevelopment Authority, 1963, and was first tested in Roxbury, Massachusetts, and New London, Connecticut (completed in 1965). This initial experience, refined and enlarged in Academy Homes I and II (completed 1964), and further projects in Roxbury demonstrated the achievement of an inexpensive building method for urban housing in today's market.

The experience to date underscores obvious advantages of the system:

1. Concrete is a practical material for low-maintenance urban building.
2. The basic structure can be fabricated using existing facilities in most metropolitan areas of the country. Well-established manufacturers can thus provide immediate national outlets for the Techcrete system.
3. The potential for maximum efficiency, already impressive, has only begun to be realized by the Techcrete system. Inherent in its design philosophy is the ability to make rapid technological improvements in materials, mechanical equipment, and assembly, which production volume and continuity assure.
4. Standardization in the Techcrete system permits the flexibility necessary to meet complex and varying national design, performance, and code requirements.
5. Time - from preliminary design to occupancy - a major cost factor, has been drastically reduced. Speed of erection to date is over four dwelling units per day per crane, permitting significant reduction of financing costs.

DESIGN FLEXIBILITY

The Techcrete system at the outset avoids the restrictions and

monotonous appearance of a standard plan or a standard building. Partitions are not a part of the bearing wall system and prestressing allows long spans. Therefore, planning and design are freed from many of the structural requirements imposed by conventional methods. The building project designed to meet the client requirements can be carried out by the individual architects who, for the first time, have complete cost, both technical and engineering, and other data vital to creative design available.

Techcrete will provide computerized engineering design computations (CPM's). Accurate cost analysis without time and money comsuming delays is possible. The cost effect of design changes can be immediately ascertained.

The system is economical for both high rise and low rise apartment buildings and can accommodate a variety of related uses, e. g., parking, shops, commercial, schools, and offices. The system allows an almost infinite variety of plans. Sub-systems are interchangeable, allowing change in use, upgrading, and replacement.

MANUFACTURE

The precast structural components can be produced under controlled conditions in semi-automated factories by production-line principles which give high quality, low cost casting. The design of the system reduces labor and increases speed of assembly with fully mechanized lifting equipment. Further sophistication will produce more savings through altering the material/labor ratio, which is a major key to lowered costs.

POTENTIAL

With a steadily increasing backlog of urban housing demand reaching ever more explosive proportions, there is no question of the need for an urban building system.

We have a number of projects in our office, totaling over $50,000,000, in all stages, from feasibility studies to final working drawings.

It is our hope that with this activity as a catalyst, a large enough market can be created to really mobilize the building industry and the urban client, both private and municipal, state, and federal, to offer Techcrete and other building systems the chance to provide some light in a dark, dreary, and disgraceful urban scene.

AN APPROACH

TO

ENVIRONMENTAL DESIGN

IN THE 1970'S

By

PATRICK J. CUDMORE

Research Architect
Abt Associates

Early in the twentieth century, the philosopher John Dewey conceived the goal of science, which may be described as the attempt by human inventiveness and reason to solve any problem posed by reality, as the prediction and control of the forces of nature. This goal, for Dewey, was to be the servant for a higher humanistic ideal: He assumed that the prediction and control of nature would enhance the natural symbiosis between man and his environment and would thus increase man's sense of security and "at-homeness" in the world.

Have the past forty years verified Dewey's theory? Apparently not. Although science has produced a long series of brilliant and dramatic successes, the mutually beneficial symbiosis between man and his environment has not been enhanced by the progress of science, but has instead been all but destroyed.

What can we conclude? That Dewey's theory was wrong? Not necessarily. Perhaps the problem lies not with his optimistic conception of the role of science, but with the myopic view of the creators of science. We have succeeded in scientifically solving isolated problems posed by reality, but we are discovering that the solutions to these problems--as self-contained systems--interact with one another in unexpected and often destructive ways. We are beginning to discern that the new role of science will be the most difficult and challenging one of all. This new focus of science will be to conceive of the world, or what we know of it, as a "total system." Only in this way can we possibly re-establish the original symbiosis between man and his environment on a higher and more sophisticated level.

Any scientific solution to this meta-problem must involve the utilization of two factors--new management techniques and analytical methods--which were developed specifically as tools to rationally examine all aspects of an extremely complex problem and to insure

its logical, effective, and economical resolution.

Historically, these two new instruments first emerged in the mid-1940's to assist in reaching rational World War II defense policy decisions. This required a unified understanding of both the relevant technologies and the economic and/or defense implications of their implementation. Technology forecasting and research and development planning, and the advanced management techniques required to implement them, evolved to meet these needs and have been widely adopted by the defense establishment, research institutes, and industry in the last decade. The attendant techniques of systems analysis and operations research have been even more widely adopted.

These managerial and methodological developments have been introduced at a critical time. Exploding urbanization is sweeping the world like a blight, and has been accompanied by massive social turbulence and tension. The urban environment man has constructed for satisfying fundamental human needs seems instead to be frustrating them in many ways. A breakdown in the efficiency of the institutions that manage our cities has led to under-management of the problem, and has constricted the participatory democratic process through which it must be resolved. By undermanaging reality, we are finding ourselves unable to control or predict it. We have created a decision vacuum in which any force other than reason can shape reality. This failure of science, of reason, has manifested itself socially and psychologically in forcing a use of, and yet a fear of, irrational forces. As our cities so visibly reflect, those forces may be greed, hatred, unbridled emotion, or in the case of the building industry and its design-related professions, they may be inertia or ignorance and the consequent reliance on "intuition." Unless we return to reason, we will witness the continued deterioration of our physical environment, which will in turn accelerate the already apparent

frustration of those individual and social rights our society is supposedly structured to provide.

Therefore, the thesis of this paper is that the field of environmental design must be subjected to a thorough reappraisal of its function, structure, and goals. The new managerial and methodological techniques derived from the fields of defense and industry hold out the promise of redirecting the current practice of architecture and planning, of radically altering design education, of revolutionizing the building industry, and of thereby helping to solve some of our more complex urban problems.

This new approach is desperately needed, and must not be initiated in ten or twenty years, but now. Not only is our urban environment intolerable today, but massive building efforts and mass migration to our cities promise to compound its problems. In the next fifteen years some two trillion dollars will be spent on new construction in the United States, and thirty million people will be added to our urban population.

Fortunately, the nation's attention is beginning to focus on our urban problems and an intensive search is being conducted to determine what changes can be made to achieve significant improvements in our urban environment. A new spirit of cooperation and dedication is being demonstrated in projects at the local, state, and national levels. The "model cities" program demanded that applicants use inter-professional teams to study both the social and the physical aspects of their urban problems. This was a unique attempt to understand not only physical renewal needs, but also the root causes of social problems, and to suggest ways of overcoming them. The Urban Redevelopment Act of 1968, hailed by the President as "the most far-sighted, most comprehensive, most massive housing program in all of American history," promises to provide vital federal support for new towns and an

innovative rent subsidy and home ownership plan in addition to more renewal and Model Cities programs. The Department of Defense recently sponsored a major competition for low-cost housing and received massive response and innovative new designs from both the design profession and the building industry. The American Institute of Architects just completed a major study of the deficiencies of environmental design education and will soon proceed with more definitive studies to determine what recommendations and changes would best be implemented in a national educational program. The Department of Housing and Urban Development and the National League of Cities are working on the development of regional urban research centers. Some of these efforts are directed toward comprehensive and analytical study of some of the forces that control our urban environment. It is through these and comparable efforts that we will come to understand what the environmental design professions will be doing in the 1970's.

I had the opportunity recently to participate in one of these exploratory efforts, and I think the approach we used was significant enough to warrant a brief description and discussion of its implications. Abt Associates Inc., in a joint venture with Daniel, Mann, Johnson, and Mendenhall (hereafter referred to as DMJM), recently worked on the largest single research effort on urban problems ever undertaken in the United States. This was a systems analysis of the low income housing problem, the purpose of which was the design of a national experiment to improve the housing process. In this effort we utilized interdisciplinary research teams involving specialists in the social sciences, technology, systems analysis, operations research, planning, architecture, engineering, law, construction, labor, and local government. Where in our judgement it was appropriate, we applied advanced statistical, analytical, and design techniques to assist in attacking the problems of low-cost housing.

This "in-city" experimental housing research and development program was sponsored by the Department of Housing and Urban Development. It is designed as a two-year experiment that would construct forty thousand low-cost housing units in twenty-three major cities. Through the experiment, HUD hopes to acquire sufficient technical and managerial expertise to build six hundred thousand units a year beginning in 1970.

In the proposal, Abt-DMJM made three major recommendations:*
First: that major innovations and improvements in the areas of low-cost housing require an experimental focus much wider than an orientation primarily toward materials technology and design problems. The most pervasive and fundamental problems in low-cost housing are institutional and human, not technical or material, although there are important problems to be attacked in the latter area as well. This basic understanding of the problem should provide the focus for the overall research strategy.

Second: that in developing an accurate and relevant assessment of the costs and benefits of low-cost, low-income housing, it is vital to consider a wide framework of total social costs and benefits. Focusing simply on the direct money flows that are involved in actual projects can lead to unwise project choices and general social inefficiency in the long run.

Third: that the problems of housing design are among the most difficult and complex issues with which our society must learn to deal. This complexity and difficulty implies that every

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*From "An In-City Experimental Housing Research and Development Program for the Department of Housing and Urban Development," Volume I, Abt Associates Inc., Daniel, Mann, Johnson, and Mendenhall, a joint venture, 1968.

resource of advanced scientific and analytic techniques should be mobilized to help grapple with these problems. However, we should never allow ourselves to forget that the very complexity and social orientation of the problem implies that there are very definite limitations to the use of formal mathematical and analytical techniques in the solution of the low-cost housing problem.

This study represents the first national effort to apply our best managerial, methodological, and technological expertise to a comprehensive systems analysis of an urban problem. We structured the low-cost housing experiment by treating housing as a production process. In a production process, improvements in output and efficiency can be developed either by changing the inputs to the process or by eliminating and adjusting constraints that substantially inhibit the efficiency of the process itself. Any analysis of the total production process for housing uncovers many constraints that substantially impede the production of low-cost housing and that inhibit the development and rapid application of technology which may improve efficiency in housing development. These constraints include:

1. Lack of information about user behavior and needs
2. Inadequate market mechanisms
3. Inefficient industrial organization of the residential construction industry
4. Problems related to the attitudes of labor organizations
5. Limitations of financial institutions and practices
6. Land availability and land costs
7. Patterns of government rules and institutions
8. Legal constraints
9. The organization of the design process for low-cost housing

Changes in output or efficiency do not happen accidentally. They happen either when they are planned from the outside or when firms have sufficient incentive to undergo the risks associated with the greater fixed costs of capital facilities and staff personnel. Because most effective action in these areas is impeded primarily by human and institutional factors, we focused our efforts upon the development of incentives and the removal of process constraints. While we did give some attention to technologically based experiments, we felt that the most useful information would come from experiments with new and more appropriate systems of organization in the housing industry.

Our basic experimental design proposed institutional or organizational experiments in a number of selected critical problem areas. After an analysis of the housing needs and institutional constraints of each city, specific projects from a number of these experimental modules were used in each selected city. Individually or in combination, these modules were designed to generate the information required for the specification of an institutional structure that may reasonably deal with the low-cost housing problem. The module approach to this demonstration was developed as a result of careful appraisal of both the production process for housing and the environment within which this process must operate. Modules were chosen as the focus for experimental design because they permit the development of a flexible project design package in each city which is coherently related to other city experiments. The modular approach also protects against experiment failure because even though one module of the experiment in a given city may not function as desired, those remaining insure that there will be some useful output from the site.

The approach used by Abt-DMJM for this experimental program is based upon a realistic analysis of those sections of the housing industry in which meaningful work can now be accomplished. It is

an approach that can and should be used in every major housing and urban renewal project in the immediate future. For the short term the primary contribution that can be made in environmental design is an analysis of those institutional constraints which affect the building industry, and a set of specific, practicable recommendations for change. For the long term, however, this approach is inadequate.

For the long term, significant economies can probably be gained through new technologies, and lasting solutions will probably only be realized through substantive, rather than incremental institutional changes. Long range projects, such as new cities and the continuous redevelopment of old cities, will demand basic behavioral research and thorough analysis of user needs to determine performance design criteria upon which we can base design efforts and technological research and development. These efforts will demand that we acquire all the information and knowledge necessary to permit reasoned control and prediction of those forces which shape our environment. Too often public policy is based on inadequate information about the social and economic implications of a physical process. Our cities are replete with examples of poorly formulated public policy for which our society pays a substantial social cost. To gain this information, we must go beyond a systems analysis of the existing environment. The long lead times between scientific understanding and the development of useful technology require careful forecasting and planning.

Technological forecasting is defined as "The probabilistic assessment of future technology transfer"* and yields possible technological environments of the future. Research and development

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*Jantsch, Erich, Technological Forecasting in Perspective, Paris: Organization for Economic Cooperation and Development, 1967.

planning uses technological forecasting and other techniques for: predicting possible futures; the improvement of response relationships between technology and investment; and defining goals and objectives statements to assist the planner/decision-maker in optimal allocation of resources to research and development projects. It is a tool that helps planners define long-term strategies and justify proposed goals. As the cost of research and development grows, it is becoming an increasingly useful tool in assigning priorities to research and development efforts.

It is estimated that five hundred to six hundred medium and large-sized American companies now spend some fifty million dollars a year on in-house technological forecasting. An additional fifteen million is spent on technological forecasts conducted by consulting firms and special institutes. Since there is now available to the designer of planning, forecasting, and resource allocation systems, an inventory of tools in economics and management science, the new problem is one of choosing an appropriate planning system design. The cost of using these various tools varies with their level of sophistication. Planning system alternatives can be tailored to needs of specific clients and evaluated from a cost/benefit perspective.

When exploratory and normative technological forecasting is integrated with the planning process, both the social and technological requirements of society are projected and planned for. A natural consequence of this is a change from product-oriented to function-oriented planning. The value of technological forecasting has been proven by the accuracy of its predictions, by the profits accrued from the timely introduction of new products, and by its value in long-range strategy formulation. With the exception of the building industry, practically every major industry in America has to some degree taken advantage of this invaluable tool. Were such a forecasting system available to the building

industry and its design-related professions, the benefits would far outweigh the costs. Through the use of this management discipline, we could assess possible future environments and the corresponding requirements needed to attain them. By encouraging the achievement of particular goals through specific research and development, we would actively influence the speed of such a process, hasten the implementation of a new technology, and dissipate the inertia of the social system.

Consider, if you will, the resources we as a profession have at our disposal today. Our building industry is entering the most innovative period in its history; complex projects of increasing size are requiring basic sociological and technological research, and the nation is beginning to commit its best talents and resources to solving the problems in our cities. The design professions are at a major turning point in their history and are faced with a clear choice. Should we continue our intuitive, visual, egocentric and fragmented approach to the problem and possibly squander our new-found resources? Or should we use these new managerial and methodological systems to reorganize our professions in a comprehensive, coordinated effort to predict, plan and control those forces that shape our environment? If we take our professional and ethical responsibilities seriously, the answer is obvious.

A National Institute of Environmental Research should be established using research and development planning and technological forecasting systems to help manage the two-trillion-dollar building investment we will make in the next fifteen years. The present fragmented approach to project- or product-oriented planning must give way to function-oriented planning. Through such an institute we could increase our knowledge about our environment and identify those actions and experiments which would most effectively ease the urban crisis. We could then assist the federal

government and big business in deciding which alternative actions or tools would best be employed to carry out these functions, predict the consequences of taking such actions, evaluate the consequences in terms of established social and performance criteria, and choose the best combination of components to effect the desired change. Through such a model, we could test the efficacy of ideas such as mass-produced low-cost housing or new transportation systems. In areas such as labor, law, and finance, the long-term benefits that would be accrued if a particular social or technological innovation were implemented could be projected and the benefits of relaxing certain institutional constraints could be evaluated. We could, through such an institute, avoid excessive duplication in industrial, academic, and federal research efforts and direct research toward those areas which promise the greatest social benefits at the least social cost.

Through a national environmental research institute, we could advise and help coordinate efforts at the regional urban research centers now being established. Regional research in areas such as long-range regional forecasts, waste treatment, environmental health, and industrial and economic development could be designed to optimize national as well as regional benefits. These regional centers will probably conduct urban management and environmental design training seminars. The institute could function as a clearinghouse for the best ideas from other regional centers and from the field. The regional centers would have access to this information and would be able to use it in their seminars, and in continuing education classes.

Curriculum development for environmental design education will probably be conducted in such regional centers as the American Institute of Architects continues its educational research program. The national institute could coordinate curriculum development and provide invaluable information about new design methodologies

and alternative future environments around which a future-oriented curriculum could be developed. Design problems could be programmed for a given future point in time, and all of the relevant social, economic, and technological variables that are expected to exist could be projected in interdisciplinary gaming simulations.

It is at the local level, however, that the impact of a national environmental research institute would be most evident. Promising new experiments in mixed-use development could be sponsored to develop more desirable interfaces between uses. Local development corporations could be sponsored to carry the responsibility for programs most efficiently handled at the neighborhood level, such as housing. New experiments with "design teams" could be sponsored to develop new ways of managing the design process. National coordinated behavioral research at local levels would lead to a better understanding of group dynamics and could possibly help develop more effective ways of involving local citizens in the management of their cities. The quality of life and the physical environment in our urban areas would improve substantially as we began to reasonably and creatively manage those forces which shape the city.

The creation of a National Environmental Research Institute is not an unreasonable proposal. The institute would be a non-profit professional institute co-sponsored by the American Institute of Architects, the American Institute of Planners, and the American Society of Landscape Architects. It would hopefully also attract organizations in related fields, including the ASCE, CEC, NSPE, and AICE, and would be funded by grants from private, industrial and federal sources. It would give the design professions, at very little cost, an opportunity to once again become contributing participants in the total environmental design process.

How would an architect or city planner function in such an analytic interdisciplinary, future-oriented environment? One of the

characteristics we have encouraged in design schools is a sense of independence and disdain for organization. We think complex organization means depersonalized bureaucracy and have no wish to participate in an Orwellian nightmare. Ninety percent of us flee to very small firms to single-handedly save man's physical environment. What we fail to recognize is that man creates his environment for the satisfaction of fundamental human needs, that these needs are extremely complex, and require reasoned, creative management of man's social and physical environment if they are to be met. By isolating the profession from the total environmental design process, we have lost our power to control it, and have unwittingly brought the nightmare upon ourselves.

To maintain, as we do, that "the ultimate object of design is form"* encourages product rather than function oriented design. While this definition fairly accurately reflects the current attitude of the architectural profession, it limits our comprehension of the total problem.

Beauty should be defined functionally. The success of a design is not measured by its form but by the degree to which it succeeds in fulfilling complex social and physical needs. As a profession we have succeeded brilliantly in providing forms, but not all forms are valid. No form is valid unless it embodies the solution to a defined problem and the architectural profession is unable to single-handedly define the problems posed by the complexity of our contemporary society.

Fortunately, the profession is beginning to see complexity as a reality with which it must learn to live. Through projects such

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*Alexander, Christopher, Notes on the Synthesis of Form. Cambridge: Harvard University Press, 1964.

the HUD low-cost housing experiment, we are discovering that only interdisciplinary teams working with new methodologies can begin to understand that complexity. And finally, we are discovering through these new alliances that we can actually begin to define the problem and predict and plan ways of managing it. We have the tools at our disposal to reinstate the mutually beneficial symbiosis between man and his environment. It is our professional and ethical responsibility to see that we do.

ABOUT THE SPEAKER:

Patrick J. Cudmore is a research architect with Abt Associates Inc., a rapidly growing research and consulting firm in Cambridge, Massachusetts. The company's interdisciplinary research teams use the techniques of systems analysis, social sciences and operations research to solve a wide variety of social, educational, economic, and environmental problems.

Some of the contracts the company is currently working on include the design and implementation of an integrated, long-range forecasting and planning system for resource allocation to NASA technological development projects; a systems analysis study of water and the city that explores the dynamic interaction of urban activity and the hydrological environment for the Department of the Interior; and consultation and program evaluation services for several Model Cities agencies.

Some of the projects the company has already complete include the design of a human player simulation called SIMPOLIS, which was played at the Design In held in New York City last spring; an airport access study in the Washington Baltimore area for the Department of Commerce, and a study of incentives to industry for water pollution control for the Department of the Interior, portions of which were used in the President's last annual address to Congress.

Patrick J. Cudmore attended the United States Air Force Academy, graduated with honors from the Catholic University of America, and received his Master of Architecture degree from the Harvard Graduate School of Design. As research architect at Abt Associates, Mr. Cudmore devotes most of his efforts to the environmental design, and design related-projects undertaken by the firm. In this capacity he did an analysis of the design process

in low-cost housing, stressing the utilization of advanced management and systems analysis techniques in solving complex design problems. This study was done as part of an "In City Experimental Housing Research and Development Program" in a joint venture with Daniel, Mann, Johnson, and Mendenhall. It was the largest single research effort on urban problems ever undertaken in the United States and was sponsored by the United States Department of Housing and Urban Development. Mr. Cudmore is currently working on a contract for the New York State Urban Development Corporation to evaluate the feasibility of developing loft industries in the New York City area, and on a contract for the American Institute of Architects to study the future of the architectural profession.

THE VICTOR GRUEN FOUNDATION

FOR ENVIRONMENTAL PLANNING

Methods, Financing, and Organization

By

JERRY POLLAK

Planning Director
Victor Gruen Associates

GENERAL STATEMENT OF PURPOSES AND PRINCIPLES GOVERNING THE ACTIVITIES OF THE VICTOR GRUEN FOUNDATION

The general aim and purpose of VGF is to engage in activities which would assist in the improving of the human environment.

The term "human environment" is used to describe those physical conditions of the inhabited areas and of those areas which serve human functions, including all those necessary to sustain human life and those which are desirable to make human life more enjoyable (for example, recreation, enjoyment of nature, etc.).

The shaping of a new human environment and the reshaping of the existing one is deemed to be one of the important influences on public health, public welfare in creating means for personal enjoyability of life, in safety, national, and international security. The quality of the human environment influences the life of individuals, of groups, of cities, states, of the nation, and of the world, not only in the physical but also in the psychological sense.

The shaping and reshaping of the human environment in our epoch, which is experiencing an unprecedented population explosion, an unprecedented rate of urbanization, and an unprecedented speed of scientific and technological development, has become an extremely urgent one. This has been recognized by leading statesmen and other personalities, nationally and internationally. To underline this statement, I will just use two quotations:

> "The Cities - their needs, their future, their financing - these are the great unspoken, overlooked, underplayed problems of our times."
> (John F. Kennedy, President of the United States of America, 1962)

"Our society will never be great until our cities are great. In the next forty years we must rebuild the entire urban United States...There is the decay of the centers and the despoiling of the suburbs. There is not enough housing for our people or transportation for our traffic. Open land is vanishing and old landmarks are violated...A few years ago we were concerned about the ugly American. Today we must act to prevent an ugly America."
(Lyndon B. Johnson, President of the United States of America, 1964)

The subtitle of the name of the foundation contains the word "shaping" in relation to the man-made environment. This term was used in order to indicate that the general principles and purposes are neither solely concerned with the two-dimensional approach of conventional planning nor with the aims of architecture in the conventional sense of designing individual structures.

The term "shaping" wishes to indicate not only a three-dimensional approach but also one which considers and strives for new shapes and forms as they might be connected with the utilization of our technological apparatus, with economics, with administrative practices, with sociological conditions. In other words: With all factors which influence public and individual life in the sense of general public welfare, health, safety, security, enjoyment through the human senses, psychological factors, etc.

It is, therefore, recognized that the task of shaping the human environment is not the concern of one specific profession but the one of a multi-disciplined team of architects, planners, engineers, scientists, sociologists, economists, educators, psychologists, jurists, public administrators, etc.

It has been recognized by thoughtful men and women that in our age of specialization - which is the result of the growing complexity in all fields of science and technology - the danger of diminishing communications and dialogues between various disciplines exists, and that this lack of understanding and communication between various "specialists" jeopardizes the task of improving the human environment. Parallel to the development of more and more specialists goes a dwindling of those who can be characterized as "generalists," namely, such men and women who, though they might have special knowledge in one discipline, are trained to think and act in leading and coordinating positions in the interest of general overriding goals and aspirations.

Thus, the general aims and principles of VGF are to assist in all efforts which could make a contribution towards the shaping of a better human environment, of bringing about active cooperation of multi-disciplinary groups for the achievement of this general goal, of helping to educate young men and women toward assuming the future role as "generalists," and of supporting efforts of other institutions, like universities, colleges, etc., in the above named directions.

Realizing and recognizing the urgency of the task and also the futility of human efforts to engage in predictions over time spans in which events, lying beyond our comprehension, might occur, the general aims of the Victor Gruen Foundation are directed towards efforts which could make a contribution to the shaping and reshaping of the human environment in the foreseeable future; that means within a time span of about 15-25 years. This means that the activities in the scientific research and educational field will lie within the framework of existing or foreseeable political and economic conditions, within the framework of existing or foreseeable scientific or technological development, and thus be directed towards attainable goals.

MEANS FOR THE CARRYING OUT OF THE GENERAL PURPOSES AND PRINCIPLES

1. Organized and categorized research material suitable to assist scholars, students, and all those who in the future will participate in various activities of VGF to have access to source material in the particular field of activities of the foundation. Such resource material would, for example, consist of books and other writings, lectures, and speeches through which Victor Gruen has expounded the basic aims of the foundation in the past.

2. Books and publications of others working in a significant manner in the same direction. A library of movies and slides which visually illustrates or contributes to the general aims of the foundation. Statistical material and other research material useful for the general aims and purposes.

3. The arranging of conferences, discussions, seminars of multi-disciplined teams in order to bring about greater understanding between various "specialists" in the directions of the general aims and principles of the foundation and in order to formulate specific research projects or study projects. (One of the special research programs which has been developed by Victor Gruen in outline form will be an attempt to develop a system for urban structure based on the consideration of three major factors, namely "people," "time," and "space"; by superimposing those aspirations and restrictions which can be evolved from the consideration of requirements of "people," "time," and "space," it is hoped that a general schematic model can be arrived at which, though extremely flexible, will prove applicable to national and international urban planning concepts; to act as a catalyzer for research and planning studies which might be undertaken by educational institutions or by various working teams and, to assist such

efforts through funding. To assist through scholarships or other financial contributions in the education of such young men and women who demonstrate promising qualities in developing into "generalists" in the field of the shaping of the human environment. To publish and disseminate research results, studies, writings, and visual material like movies, photos, or slides.)

Some of the above-mentioned aims might be accomplished by grants, gifts through individuals or groups of individuals. The criteria for the selection of such individuals or groups will be solely based on educational background, interest in the general principles and aims of the foundation, aptitude and ability to work in the interest of those aims and without any regard to creed, color, or ethnic background.

The educational aims of the VGF will be carried out by lectures, panels, discussions, forums, participation in radio or television programs, by exhibits, publications, etc. These activities may be carried out directly by the VGF or in cooperation with institutions of learning, other non-profit organizations, educational television or radio, etc. In all cases where monetary returns should result from the publishing of books or other publications, from exhibitions or radio or television programs, such monetary gains will flow to the VGF and/or other participating non-profit corporations.

4. The creator of the non-profit corporation is Mr. Victor D. Gruen. He has devoted much of his professional life and his personal work to purposes closely related to the general principles and aims of the foundation.

Included in this discussion is a brief slide presentation of three projects indicating the new approach to environmental planning for:

1. The creation of a new city - Valencia,
2. The redevelopment of the Central City - Rochester, New York,
3. Trends towards creating a new pedestrian environment - Fresno Mall.

THE DEVELOPMENT AND APPLICATION OF MANUFACTURED MODULES FOR URBAN REHABILITATION

By

FREDERICK A. THULIN, JR.

Research Staff
U. S. Gypsum Company

SOCIAL NEED AND TOPIC RELATIONSHIP

The principal needs for Totally Manufactured Building Modules are in (1) urban redevelopment, (2) relocatable single family dwellings, and (3) relocatable office - commercial - institutional space. The urban redevelopment use consists primarily of new small business accomodations in the blighted areas of major cities. The relocatable single family dwelling use is now principally being met by mobile homes. Unites States Gypsum Company used modules in Lawndale for relocatable temporary housing. In general, the relocatable office - commercial - institutional use consists of mobile classrooms, temporary clinics, and "instant" temporary office and commercial space.

A building module as defined herein is a multi-sided, premanufactured three dimensional structure which, when assembled with other such structures and on-site constructions, forms a complete building.

Architect Paul Rudolph terms the totally manufactured building module the "twentieth century brick."

The interchangeability that can be designed into the building module system makes possible an infinite variety of building designs. The building module is adaptable to mass production manufacturing techniques which (1) speed up production, (2) increase productivity per unit of labor, and (3) allow for the employment of easily trained semi-skilled workers.

Overall, because of these advantages, the totally manufactured building module has an excellent potential for serving these needs. According to a United States Gypsum Company study, the total 1972 annual requirement will be 577,000 modules (approximately $4,000,000,000). United States Gypsum Company intends to

participate as (1) material supplier, and (2) systems developer.

INTRODUCTORY REMARKS

In 1966, United States Gypsum Company was a supplier of materials to the building industry. Then one day, it became the owner of six apartment buildings in Spanish Harlem's worst slum area and very much in the rehabilitation business. We at United States Gypsum Company took the direct approach toward rehabilitation. We hoped to use materials, tools, and construction methods of the most conventional sort to gut and rejuvenate these buildings.

It was our view, then that this simple building-by-building approach was all that was needed to prove that rehabilitation was a valid approach to the slum problem . . . . at a modest profit for private industry.

Today, with four years of proof, we stand convinced that if rehabilitation is going to work, we must concern ourselves with the redevelopment of entire city blocks and neighborhoods rather than with individual buildings. Additionally, we find that in order to replan and redevelop an entire neighborhood successfully, some of the housing in these neighborhoods must be replaced. The criteria for this replacement housing is severe. It must, obviously, be low cost, but more important, it must help preserve the most desirable characteristics of the neighborhood in which it is used and at the same time give desirable direction to future construction.

Our search for suitable replacement housing has led us to the investigation of the manufactured module. These modules are to be used for neighborhood redevelopment in conjunction with our continuing rehabilitation program.

BACKGROUND OF UNITED STATES GYPSUM COMPANY'S INVOLVEMENT

At this point several questions come to mind. What is neighborhood redevelopment? Why has United States Gypsum elected to follow this route? What might the end result look like? What are the problems with manufactured modules? What are the advantages?

The answers to these questions start with a review of what United States Gypsum has learned from the Harlem project.

A formal hearing for the tenants of the Harlem buildings was held before any renabilitation work was started. At the general meeting there were no complaints about the project itself. But, in their individual survey interview conducted by a social worker, most of the tenants expressed deep concern about the present condition of the buildings and the neighborhood. Their concern was well founded. The deteriorated condition of the buildings aided in their anti-social use. On building No. 307, for instance, there was no door at either the front entrance or the roof opening. Poor lighting was a factor in the block's problems. Public hallways were dark and unsafe. The rear exterior of the buildings faced on a dark, debris-filled alleyway which tenants avoided, understandably, at all times of the day or night. When the buildings were rehabilitated, these and other such conditions were corrected.

United States Gypsum Company found that many of the problems on the block do not stem from the residents but from the fact that the block had become the gathering place for people who did not live there and were considered undesirable by the residents. Part of the responsibility for its becoming such a gathering place must be put on the condition of the tenements.

An important facet of rehabilitation is the involvement of the tenants in the care and maintenance of the building after renovation. The tenants' active cooperation in the rehabilitation program must be obtained. For each of United States Gypsum Company's buildings a "building captain" was selected by his fellow tenants. Additionally, a "block coordinator" was chosen. Their functions were to preside over tenant meetings and to convey complaints to Metro North, the eventual owner of the buildings.

In Harlem, United States Gypsum also learned that a plan cannot be successfully imposed upon the community from without. This only breeds opposition. But if tenants are informed, consulted and are able to express an opinion on the project, things are better for everyone concerned,

During the United States Gypsum Company's project, we were faced with the problem of where to put the tenant families for the four or five months needed to renovate their building. Our solution was to patch up the worst conditions in the vacant apartments in our other buildings and move the tenant families into these units. Extensive repairs were not made since the buildings were scheduled for rehabilitation. This solution was adequate but obviously not the most desirable one.

In summary then we came away from the Harlem project with the knowledge that successful and permanent rehabilitation of buildings had to be founded on the redevelopment of other parts of the neighborhood. We also knew that we needed to do something about interim housing for tenants during renovation.

We began to apply what we had learned when we started our project in the Lawndale District of Chicago. In Lawndale, the owner of the buildings is the Chicago Dwellings Association, a not-for-profit organization, a wholly owned subsidiary of the Chicago

Housing Authority.

To start with, C.D.A. opened a home service center right on the block to be rehabilitated. A handsome brochure was printed for distribution throughout the neighborhood to explain what was going on. Finally, a tenant education program was started to aid families learn how to maintain the property after they moved in. In short, the aid of the city, the local organizations, and the residents of the neighborhood was enlisted to make the project go.

For interim housing United States Gypsum Company fell back on the experience its Research Department had gained working with the mobile home industry. We met with the Chicago Housing Authority and the Ritz-Craft Corporation to discuss the use of mobile homes as interim housing.

The first thing that had to be done was to make the mobile units conform to the Chicago building code. This was done through the use of heavy framing members, gypsum wallboard, multiple exits, and an electric fire alarm system.

Next, the union's cooperation had to be obtained. This was accomplished through a series of meetings between Mayor Daley, officials of the Chicago Housing Authority and the Chicago Building Trades Council. With this done the door had been opened, for the first time in any major city, for the use of low cost factory fabricated living modules.

The rest of this part of the story is history. With the barriers down, vacant lots in the Lawndale area were cleared and prepared as sites for the twenty-six interim mobile housing units that the city purchased.

Each unit is 56 feet long and has three bedrooms to accommodate a family with as many as eight children. The cost to C.H.A. was $7,100 each . . . including furnishing.

After purchase, it was found that one of United States Gypsum Company's Lawndale buildings was structurally unsound and not fit for rehabilitation. We decided to demolish this structure and erect a new apartment to further encourage the redevelopment of the neighborhood. The Lawndale picture now is a combination of rehabilitation, interim housing and new construction. Thus it takes on the characteristics of urban redevelopment as we visualize it in the future.

At this point a new entity comes on the scene in Chicago. Our new character takes the form of an agreement among several trade unions and a group of manufacturers to form a corporation. The announced purpose of this corporation is the manufacture and erection of at least 2,000 prefabricated, low-cost, stackable housing units. With its vested interest in rehabilitation and its experience with the Lawndale units, it was natural for United States Gypsum Company to become involved in this new venture; more about this later.

Our first involvement was to assist with the design of the prototype units. This involvement occurred as follows:

> Mr. Bartling, our vice-president, approached Mr. Charles Swibel, Chairman of the Chicago Housing Authority, to entertain the idea of constructing permanent totally manufactured units for new housing. These initial discussions were held approximately a year ago. Mr. Swibel stated that he would take the matter up with Mayor Daley to see what could be done for the successful promotion of this project. It was essential to obtain the full cooperation of the community, business

and perhaps most important of all, the labor unions. After conferring with the Mayor, Mr. Swibel asked Mr. Bartling to submit complete working plans and specifications to obtain bids from contractors and a building permit from the city of Chicago.

DESIGN OF PROTOTYPE BUILDING AND MODULES BY UNITED STATES GYPSUM RESEARCH DEPARTMENT

Meanwhile, back at the ranch, that is our Research Center in Des Plaines, we were busily developing our products and component systems. Little did we know that within a week we would be scrambling around designing a complete building employing totally manufactured modules on a very tight schedule. Early one November morn, Mr. Bartling suddenly appeared at the Research Center.

He stated that we had to have a building module system and a complete, six living unit town house apartment designed and ready for submission to the Chicago Building Department by December 8, 1967. We protested, but he said that the date was fixed. Somehow, when a vice-president orders the impossible, it's done.

I (Fred Thulin) was assigned as project leader of the totally manufactured building module project. My associate, Don Conway, acted as advisor. Because of the high priority of the project, I was told that I could pick as many members of the Research staff as needed to complete the project. I selected three draftsmen and one person who acted as researcher.

I hurriedly called a planning session of the group and the six of us developed a critical path method network plan that would enable us to meet the target date.

The first thing we had to do was find out about totally manufactured modules. We found that none of us knew too much about them other than cursory knowledge gained from the usual publications.

The first system that we examined was the Century 21 system designed for the Seattle World's Fair Commission by Robert Englebrecht, A.I.A. These buildings consist of 12' x 24' x 9' high modules, identical structurally, but partitioned internally many different ways. These modules are completely factory-finished inside and out, trucked to the site and set into place by a small crane.

Next we studied the Calder homes which are located in Washington, Durham County, England. The architects are Harding and Horsman. These are similar to the Century 21 system in that they use standard wood frame and sheathing and are produced and finished at the factory. However, four modules are stacked to form two story row houses. This seemed more like the type of system needed for our project.

Of course we studied the relocatable Ritz-Craft units that were used in the Lawndale project. We also examined the units that were to be manufactured by Magnolia Homes for the Fredella Village project in Vicksburg. The Fredella Village project which has now been erected was handled under Section 233 of the National Housing Act (experimental housing). The program was then changed to a regular FHA 221 (d) (3) loan at the project completion.

We looked at Paul Rudolph's Charlottsville Student Housing Product in Charlottsville, Virginia. This is a fold-out type of system. We also reviewed the steel frame, steel box, and reinforced concrete modular types. Also, we studied the Chicago building code and the requirements of other authorities

having jurisdiction to determine the applicable ordinances covering our project.

Our preliminary research indicated that building modules can be classified these ways:

1. by construction material,
2. by building code fire rating,
3. by method of delivery from place of manufacture to place of erection.

Of course, they can be classified by occupancy, too, but for the moment since we are considering only residential construction, we will not place this as one of the categories.

Classing the modules by building construction material yields four basic types:

1. wood frame construction,
2. steel frame construction,
3. steel box construction,
4. reinforced concrete.

The classification by building code type is as follows:

1. Type I-A: Four hour fire-resistive construction.
2. Type I-B: Three hour fire-resistive construction.
3. Type I-C: Two hour fire-resistive construction.
4. Type II: Non-combustible construction.
5. Type III-B: One hour ordinary construction exterior protected with three hour material for bearing and two hour material for non-bearing.
6. Type III-C: One-half hour ordinary construction exterior protected with three hour material for bearing and two hour material for non-bearing.

7. Type IV-A: One hour combustible frame construction.
8. Type IV-B: One-half hour combustible frame construction.

Note: The Type of construction required by the various codes is dependent on building size, classification according to occupancy, and location.

Finally, there is classification by method of delivery:

1. highway delivery,
2. local street delivery,
3. helicopter delivery,
4. delivery by on-site hoisting and lifting equipment (this applied only to modules that are manufactured on the site).

Because of our tight schedule, we decided that our modules would be wood frame, completely finished on the inside but finished only to the sheathing on the outside.

Regarding fire classification, we determined that Type III-B was required with this modification: to provide one hour exterior walls, two hour walls between units, and two hours between the first and second levels, and a half-hour roof construction. We designed for highway delivery. This limited the size to 12' width, 60' length and at the very maximum, 11' 6" high. Ten feet was found to be a more desirable height.

With this basic information we discussed the finalization of design with Mr. Bartling. We recommended a contemporary style of architecture. We agreed that the first project would consist of two identical buildings together having a total of twelve living units. Mr. Bartling mentioned that sociological studies

of the neighborhood indicated that the style should be reminiscent of French Provincial and have a gambrel or mansard roof. This, he stated, will make the buildings very similar to the existing structures in the neighborhood. Also, the project was to look as unlike any public housing project as possible. Mr. Bartling stated that according to the sociologists, contemporary styles are unfortunately associated with public housing. This shows how sociology in some instances can dominate over aesthetics.

We completed and delivered working drawings and specifications by the December 8, 1967, deadline. Let me show you the results of our efforts.

DRAWING NUMBER 1

Here you see the front and rear elevation and the two side elevations of the building. Note that with the exception of the dormers, only the exposed surfaces are field applied. This assures a complete, permanent protection against weather for a long period of time. Also, this makes the trade unions happy.

DRAWING NUMBER 2

Here you see the first floor plan. The living room measures 11' 4" x 14' 2". Notice the stairway, the closet and the ample kitchen-dining room-family room. There are two exits. The typical transverse wall sections show the detail of the exterior wall. Note that the units are held onto the foundation and to each other with anchor straps. The floor joists are 2 x 8's, 16' on center. The ceiling joists are 2 x 4's, 16" on center and the interior partitions are 2 x 3's, 16" on center. Note the dormer window detail in the upper module.

DRAWING NUMBER 3

This shows the second floor plan of the module. There are two bedrooms, bathroom ample closets and the furnace and water heater located in a utility closet. May I call your attention to the typical lateral wall section. Here again the masonry veneer is field applied. The exterior wall is one hour fire construction and the wall between units is two hours. The first ceiling and second floor combined have a two hour fire rating and the second story ceiling is one-half hour construction. Again, the straps that anchor the modules to the foundation also anchor the modules together. The ridge portion of the roof is field applied to provide access and to hold the top unit height to 11' 6". The bottom unit is 9' 6" high. I call your attention to the ample size crawl space. The light and ventilation schedules on the drawings meet the Chicago code requirements.

DRAWING NUMBERS 4 & 5

This shows the foundation plan as mentioned previously. This is cast on the job. The wing walls support the stoops. Again notice the metal straps used for tying the units to the foundations.

Here we see the small scale transverse and lateral sections of the building. This clearly shows the field applied and the module elements. On this sheet we also have the plumbing schematics. They are designed for three different codes; National Plumbing Code, City of Chicago, and ASA A-119 (1960). This is the mobile home plumbing requirement. Case three is included only for cost comparison purposes and its use is not recommended.

SPECIFICATIONS

I will not go into the specifications in detail at this time except to mention that in the general conditions the standard A.I.A. form is specified. The supplementary general conditions specify "all workmen engaged in work on the job site shall be members of their respective unions," and "the plant fabricated living unit components shall bear 'union made' label." The specifications are basically broken down into two parts, the on-site work and the in-plant work.

ORGANIZATIONAL ACTION

Mr. Bartling presented the drawings to Mr. Swibel of C.H.A. who was pleased with the general concept.

At about this time action was taken jointly by the building trade unions, three insurance companies, the Chicago Dwellings Association, Chicago Housing Authority, the City of Chicago, and United States Gypsum Company to form a company called COMLIFT. The participating unions have a half interest and United States Gypsum has an interest. The other participators have not as yet been disclosed. The plan of COMLIFT is to build a plant in the city of Chicago using building trade union labor to manufacture modules similar to the ones designed by United States Gypsum Research. Since COMLIFT will not be completely organized until sometime in 1969, the Chicago Housing Authority, the Chicago Dwellings Association with United States Gypsum Company's cooperation decided to have National Homes Company and Magnolia Homes Division of Guerdon Industries, Inc. build a couple of small, trial projects which would serve as pilot experiments upon which COMLIFT can base further designs.

EXPERIMENTAL PROJECT

The first of these experimental projects was erected at 50th and Blackstone. The consulting urban designer was Kenneth Treister, A.I.A. of Miami, Florida.

DRAWING NUMBER 6

Here is a picture of one of the buildings at the project.

Now I will show you a movie of this project showing the placement of typical modules and slides showing several of the details.

COMMENT WITH MOVIE:

Here you see the unit as it arrives on trailer from the factory. Note the wood frame construction. All lumber complies with American Lumber standards SPR 16 with specific grading standards.

Here you see the copper water supply and brass waste piping. The plumbing fixtures include a fiberglas tub and shower enclosure, porcelain water closets and lavatories and a 40 gallon electric hot water heater.

Here is a unit in place ready for lift off. Note the four straps, the truss girder. Here we go. It's up in the air. Now we are ready to lower it into place. Here it is in place.

Here we see a man prying the lower unit into position. Note the separation between units.

The windows are industrial grade, HS-Al aluminum thin-trim windows with insulating glass.

The exterior coverage at the first floor is as shown on your right 0.019" thick, baked finished BD aluminum vertical and pressed batton sheet laminated to 3/4" grooved, exterior glue line plywood sheathing or as shown on the left, 1-3/4" foamed plastic in natural quarried stone random Ashlar pattern applied to 1/2" waterproofed glue line plywood sheathing. On the second floor we have 0.019" thick baked finished aluminum, simulated shingles.

Here goes another unit into place. Note the welder on the job making the plumbing connections. Here's a view of the crawl space. Reinforced concrete footings, poured concrete foundation walls enclose the crawl space.

COMMENTS WITH CAROUSEL SLIDES:

SLIDES 1 THROUGH 5:

Common party walls are one hour fire rated. Two hour rated walls are provided when required. Exterior walls are provided with 4" fiberglas insulation with vapor barrier. The roof is insulated with 6" fiberglas with a vapor barrier. The lower floor is insulated with 2" fiberglas with vapor barrier. The parting wall is insulated with 2" fiberglas with vapor barrier. The roof is 20 gauge sheet metal with 1-1/4 oz. of zinc per sq. ft. galvanized applied over 3/8" plywood. 0.032" thick, 5" aluminum gutters and down-spouts with baked-on vinyl enameled finish are used. This shows the interior of the unit. The exterior perimeter walls are covered with 1/2" Firecore Gypsum Board with two coat vinyl acetate emulsion system in textured pattern. Interior partitions are covered with 3/8" gypsum board and finished in the same manner. In some areas 1/4" Luan paneling with two coats of synthetic resin modified lacquer system are used. Both of these are permanent, washable finishes.

The baseboard, ceiling cove, corner board, door jambs, stop and

trim are prefinished West Coast pine. Baseboard in bathroom areas is 4" rubber. The ceilings are finished with 1/2" Fire-core Gypsum Board finished in the same manner as the walls. The floors are 14 ml vinyl sheet covered with vinyl foam inner layer and felt backing sheet, vinyl asbestos tile or in-door/out-door carpeting.

Each parting wall consists of two separate framing systems, 2-7/8" apart, fire stop at each floor and roof and resting on separate steel I beams. The kitchen which is just behind the stair contains a twin bowl enameled steel sink, grease trap, 12 cu. ft. refrigerator, and 30" electric range. The kitchen also includes a Westinghouse stacked washer-dryer. Rods, curtains, drapes and furniture are included as options. The bathroom medicine cabinet is Kent No. L1028A with welded shelf.

SLIDES NUMBERS 6 & 7:

This shows the front entrance detail. Note before and after the installation of the trim beneath the threshold. Exterior and interior lock and latch sets are Westlock 1100 series meeting federal specification FF-H-106A series 160.

SLIDE NUMBER 8:

Also included as part of the building is the doorbell, mailbox, towel bars, toilet paper holders, door stops, and house numbers.

SLIDE NUMBER 9:

This is another view showing the front of the building. Note only four modules are erected. The building contains a total of twelve modules.

SLIDE NUMBER 10:

Each living unit will have a 10' x 12' enclosed patio area. It will be covered with wood chips in nonasphalt area. Hard surfaces will be stripped asphalt. Fencing is 1" x 4" redwood or cedar 8" on center. Each patio has one eight foot bench of 2 x 4 redwood or cedar on edge, 3" on center and an additional half bench in play or common areas. Note that the rest of the areas are sodded.

SLIDES NUMBERS 10 AND 11:

Three shade or ornamental trees are provided for each dwelling unit on the site. Trees will be a minimum of 2" in diameter and 8 to 12 feet in height. Some of the trees shown here are a little bit higher. The trees are to be placed as follows: One in front of each unit, one in each rear patio and one in general area of the site.

SLIDE NUMBER 12:

Paved asphalt parking areas are provided for off-the-street parking and are screened with fencing. Each site has one asphalt paved play area. The play area is supposed to contain play equipment.

SLIDE NUMBER 13:

This is a detail showing how the junction between units is covered.

SLIDE NUMBER 14:

Now we have to pause for another commercial. This is a picture of Mayor Daley addressing the notables gathered for this noteworthy event.

PRODUCE DESIGN CONNECT WITH MODULES

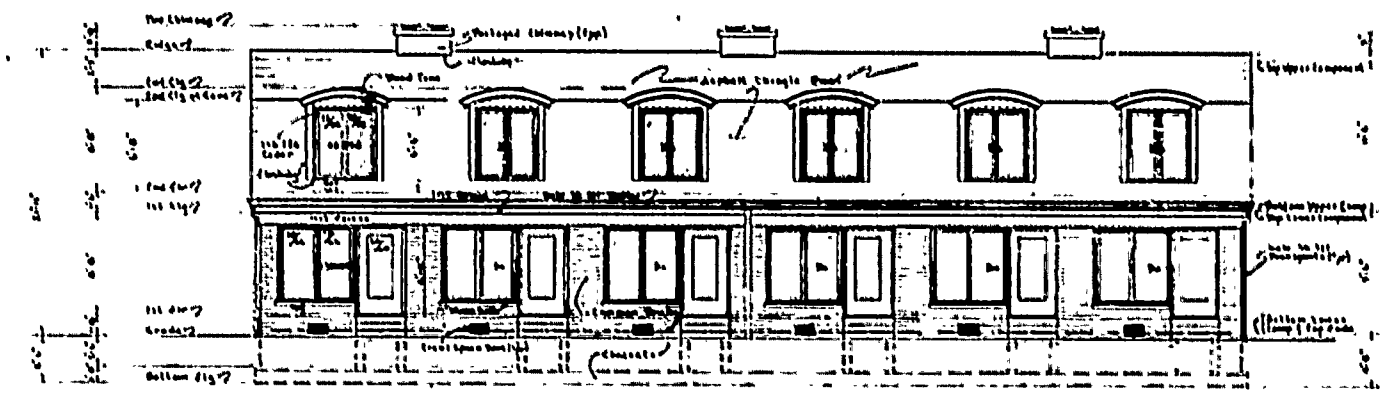
Another problem facing architectural researchers is the problem of product connected with the systems proposed. As mentioned before, the building modules show an excellent example of this. As you have noticed, the modules which we have covered so far are wood frame construction, however, because of the lighter weight and noncombustibility, steel studs appear to be more desirable. Light gage metal products, as you probably are aware, have to meet the requirements of the Light Gage Cold-Formed Steel Handbook. Thus, there is always the problem of calculating studs to comply with this handbook. Fortunately, in years past, we had a very gifted computer programmer who you might say put the Light Gage Handbook in the computer, so we didn't have to do any particular calculations to determine the load-carrying capacity of an 18 gage channel stud.

CONCLUSION

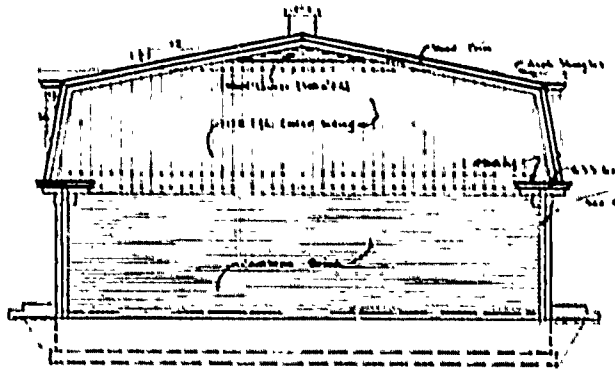
The future for totally manufactured modules appears to be very promising. As I mentioned previously, the COMLIFT group, with which United States Gypsum Company is associated, intends to erect at least 2,000 living units of totally manufactured modules in Chicago next year. Also, I am sure, many other government and private groups will use the totally manufactured module. The totally manufactured module, I do not think, should be considered as a total solution to the housing problem, but should be considered only as one phase of the solution.

DRAWINGS OF PROTOTYPE BUILDING

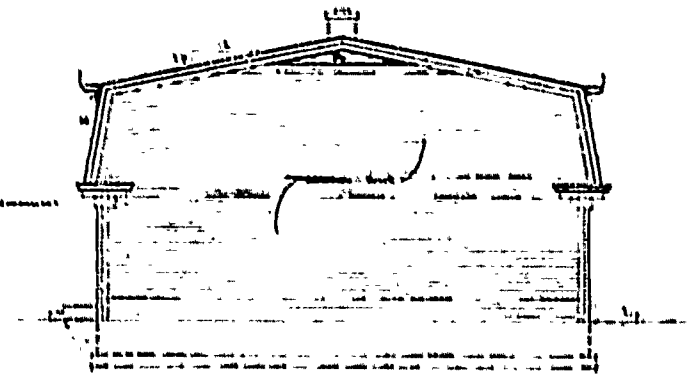
6-0011 (D-1)



FRONT & REAR ELEVATION



STREET SIDE ELEVATION



ALLEY SIDE ELEVATION

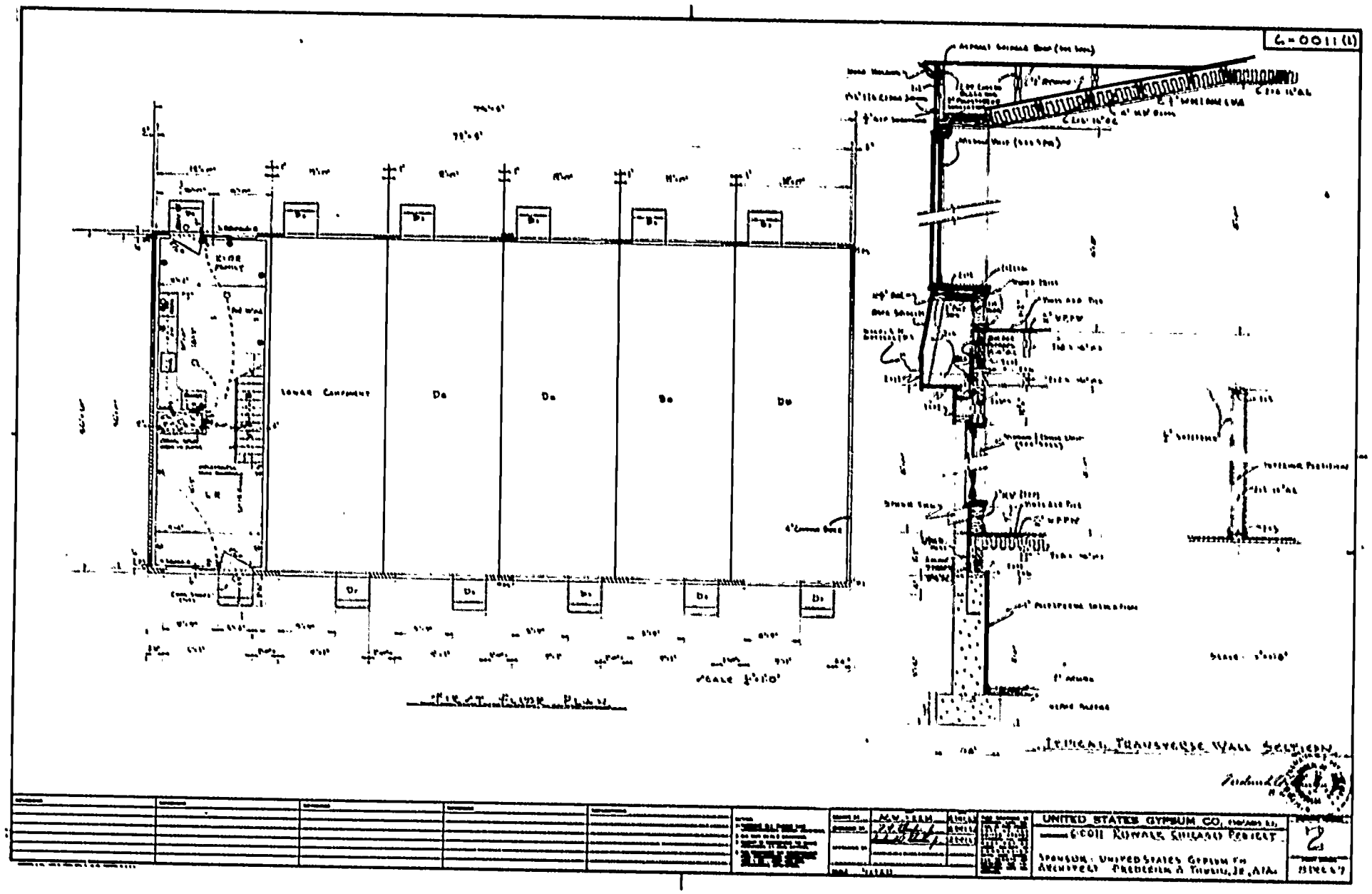
UNITED STATES GYPSUM CO.

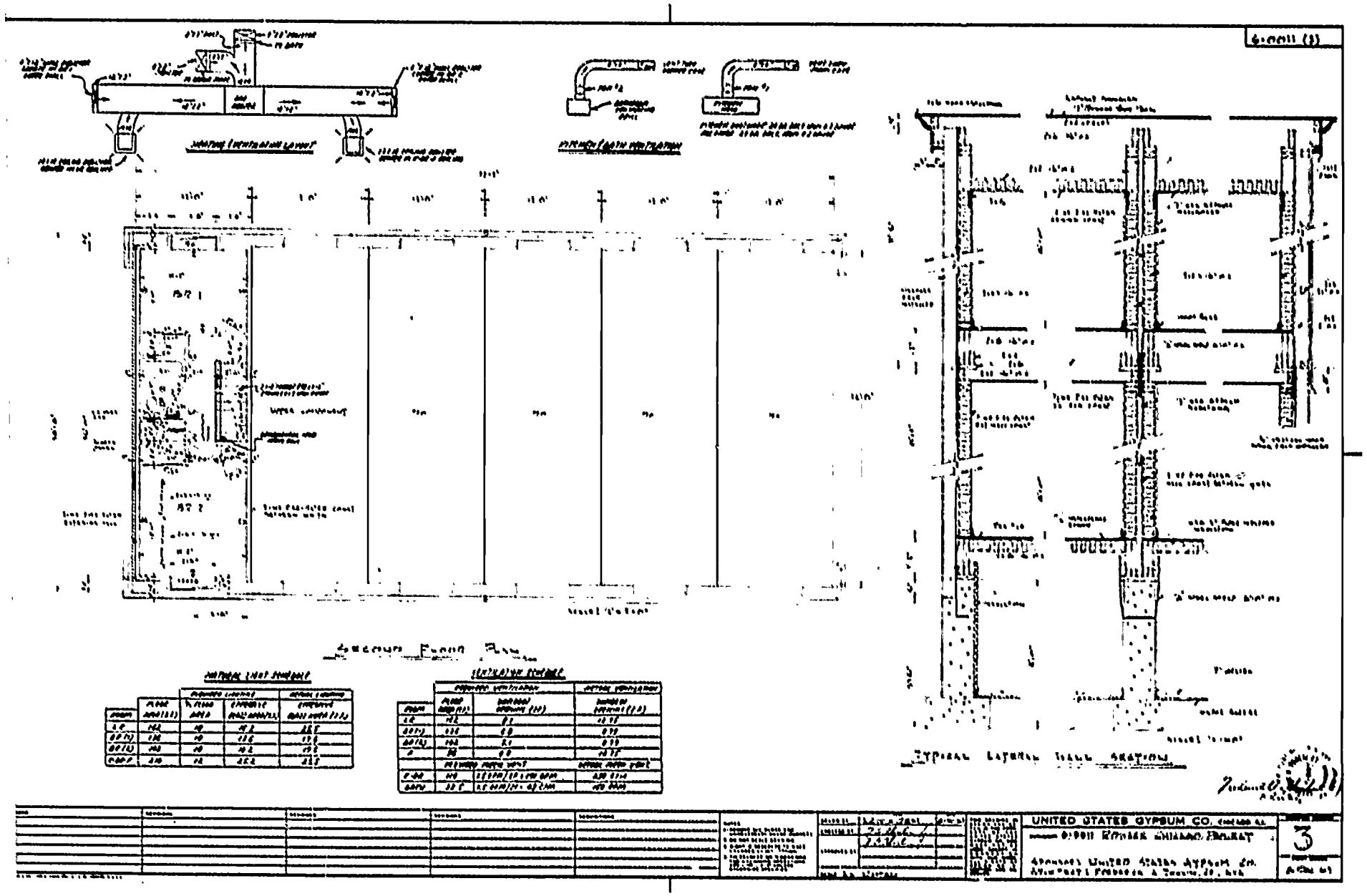
6-0011 Gateway Chicago Project

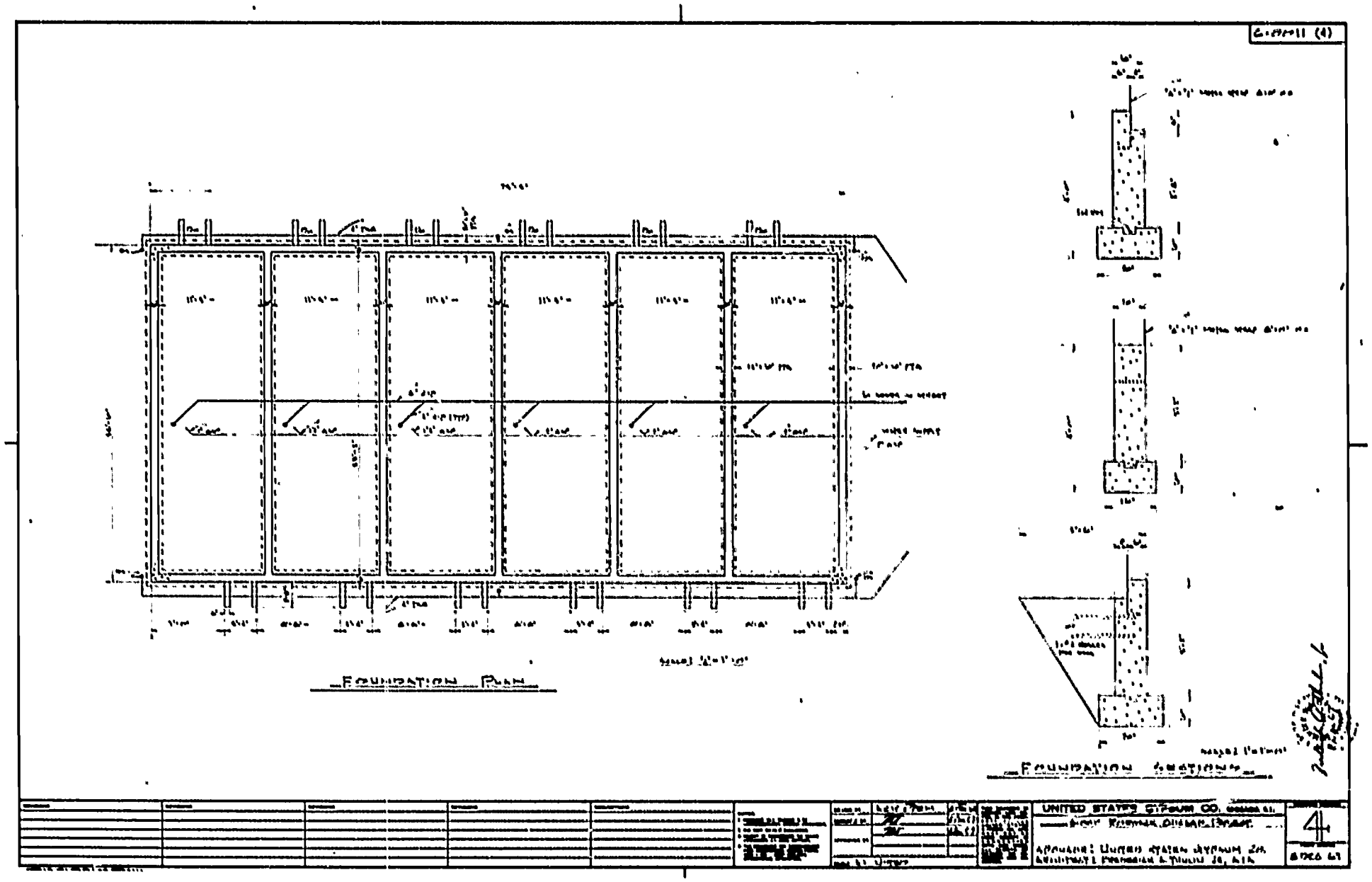
Showroom United States Gypsum Co.
Architect: Frederick A. Thomas, Jr. A.I.A.

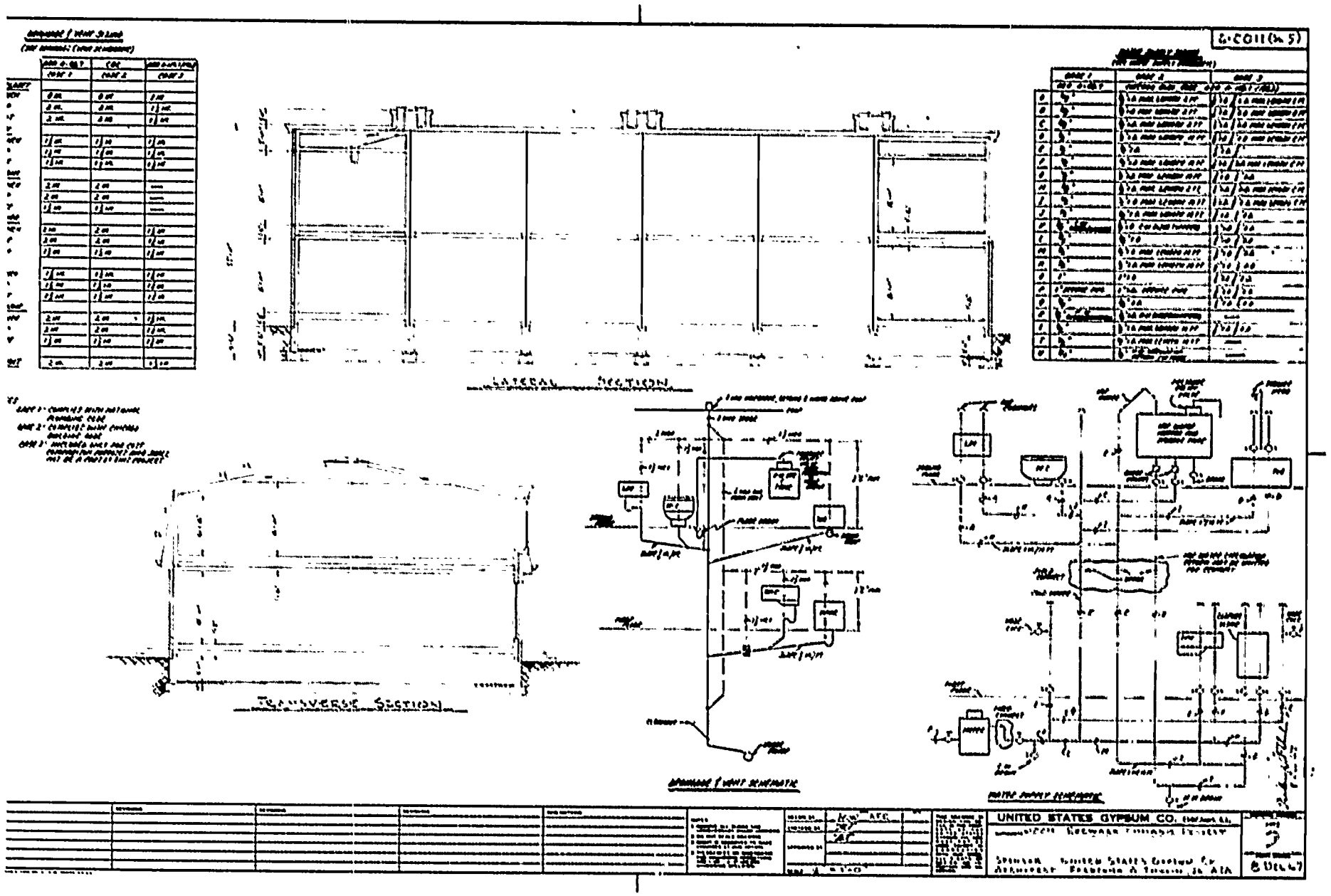
1

8 Dec 67


G-0011 (1)
Typical Transverse Wall Section
UNITED STATES GYPSUM CO.
6001 Kuwait Kuwait Project
Sponsor: United States Gypsum Co
Architect: Frederick A Thulin, Jr, AIA
2


Second Floor Plan
Typical Exterior Wall Section
UNITED STATES GYPSUM CO.
3


FOUNDATION PLAN
FOUNDATION SECTIONS
UNITED STATES GYPSUM CO.
4


LATERAL SECTION
TRANSVERSE SECTION
UNITED STATES GYPSUM CO.

SPECIFICATIONS FOR PROTOTYPE BUILDING

GENERAL CONDITIONS AND SPECIFICATIONS

FOR

ROEWACK CHICAGO PROJECT

Chicago, Illinois

INVESTOR-SPONSOR: United States Gypsum Company
101 South Wacker Drive
Chicago, Illinois 60606

ARCHITECT: Frederick A. Thulin, Jr., A.I.A.
United States Gypsum Research Center
1000 E. Northwest Highway
Des Plaines, Illinois 60016
Telephone: CY9-3381

GENERAL CONDITIONS

The Standard Form of the American Institute of Architects No. A-107, current edition, shall be made part of this contract to the same extent as if bound herein.

SUPPLEMENTARY GENERAL CONDITIONS

1. All workmen engaged in work on the job site shall be members of their respective unions.

2. The Contractor shall obtain and pay for all required permits.

3. The posting of a performance bond will be required.

4. All job site installed work shall comply with the requirements of the Chicago Building Code.

5. Plant fabricated living unit components shall conform to drawings and specifications filed with and approved by the Building Department of the City of Chicago.

6. The plant fabricated living unit components shall bear a "Union Made" label.

EXCAVATION AND DEMOLITION

SCOPE:

1. Shall include excavation for foundation walls, footings, and walks.

2. Also shall include backfilling and rough grading.

3. All work in this section is done on job site.

DISPOSITION OF MATERIALS:

1. Clay needed for backfill and black dirt shall be neatly piled on the site at a location which will not interfere with any of the work involved. Excess earth not needed for backfill shall be removed from the site.

BACKFILLING:

1. After the concrete work is completed and the forms removed, backfill to within 6" of the finished grades as indicated on the Drawings.

2. Finished grading is covered in the "Landscaping" section of these Specifications.

CONCRETE WORK

SCOPE:

1. Shall include all of the new footing and foundation work indicated on the Drawings and the form work related thereto.

2. Also, shall include concrete stoops, and crawl space gravel fill.

3. In addition, shall include concrete walks to front and rear entrance. Provide $400 allowance.

4. All work in this section is done on job site except pre-mixing.

MATERIALS:

1. Portland cement and aggregate shall neet A.S.T.M. requirements.

2. All concrete shall be 5 bag mix with 7:1 water-cement ratio and must be pre or job mixed.

3. All form work shall be made of wood and shall be properly oiled or conditioned for easy removal.

PLACEMENT:

1. All concrete shall be placed when weather is 30°F or above and the temperature is rising.

2. Concrete work shall be protected from frost by straw or other suitable means until cured.

MASONRY

SCOPE OF WORK:

1. Includes masonry veneer work shown on Drawings.

2. Patching and clearing of work after completion.

3. Crawl space vents.

4. All work in this section is done on job site.

MATERIALS:

1. Brick shall be hard burned treated common salmon colored (not buff) brick.

2. Window exterior sills shall be 3" Indiana Limestone.

3. Mortar materials shall be as required for the brick masonry and shall conform to A.S.T.M. Specifications.

4. Crawl Space ventilating grills shall be made of ferrous metal and shall be painted. Size as indicated on Drawings.

ERECTION:

1. All work shall be erected plumb and true and in a good workmanlike manner and comprise all the masonry work shown on the Drawings.

2. Patch and clean all exposed masonry prior to completion of the work.

3. Install crawl space vents in accordance with manufacturer's instructions.

JOB SITE CARPENTRY

SCOPE

1. The placement of plant fabricated living unit components including crane costs.

2. Exterior millwork, wood trim, gable end sheathing and siding (excluding dormer and windows).

3. Sheathing and framing for ridge closure.

4. Sheathing and framing for gambrel roof extension.

5. Cable louvers.

6. Check all hardware, doors and windows in living unit components to see that there is no sticking or that they are otherwise not properly operating.

7. Any other items required to complete the work as shown on the Drawings.

8. Note that this section includes only job site carpentry work. The construction of the plant fabricated living unit components are covered in the "Plant Fabricated Living Unit Components" section of these Specifications.

MATERIALS:

1. Exposed wood trim shall be Number 3 common Western red cedar.

2. Structural framing member shall be Standard Grade White Fir.

3. Siding shall be Number 2 common Western red cedar tongue

and groove.

4. Roof sheathing to be used for ridge closure and lower part of gambrel roof shall be 1/2" waterproof Douglas fir plywood.

5. Galvanized nails shall be used for all exterior nailing.

6. Sheathing for gable end shall be 1/2" USF gypsum sheathing.

ERECTION:

1. Plant fabricated living unit components shall be placed as indicated on the Drawings.

2. After the living unit components have been placed, the field applied items shown on the Drawings should be installed after the flashing has been placed by the sheet metal subcontractor.

3. Note that the crane rental and operator time is to be included in this section of the specifications. Special crane attachment apparatus will be provided by component manufacturer.

ROOFING

SCOPE OF WORK:

1. Comprises all roofing.

2. All roofing is applied on job.

MATERIALS:

1. Roofing shall be 235 pound asphalt self-sealing shingles over

15 pound felt. Both shall be manufactured by United States Gypsum Company.

ERECTION:

1. Roofing shall be installed in accordance with manufacturer's recommendations.

2. Roofing contractor shall provide ten-year free service guarantee.

JOB APPLIED PAINTING

SCOPE OF WORK:

1. Includes staining or painting all exterior wood.

2. Includes painting exterior ferrous metal.

MATERIALS:

1. All materials shall be manufactured by United States Gypsum Company.

2. Exterior stains shall be creosote stain.

3. Exterior primer shall be oil base exterior primer.

4. Exterior primer for ferrous metal shall be rust resistant paint. Exterior paint shall be acrylic base house paint.

APPLICATION:

1. Exterior siding shall receive three (3) coats of stain.

2. All other exterior wood shall receive one (1) coat of exterior primer and two (2) coats of exterior paint. All exterior ferrous metal shall receive two (2) coats of paint over one (1) coat of primer.

3. All work shall be done in a good workmanlike manner.

4. Note that all interior painting is not included in this section of the Specifications.

JOB INSTALLED SHEET METAL WORK

SCOPE OF WORK:

1. Shall consist of flashing, gutters, downspouts, flue extensions and metal chimneys.

MATERIALS:

1. Shall be hot dipped galvanized sheet steel.

2. Downspouts shall have rectangular fluted configuration. Gutters shall have colonial style configuration.

3. Chimneys and flues shall be listed by Underwriters' Laboratories, Inc.

ERECTION:

1. All work shall be erected in a good workmanlike manner.

2. Gutters shall pitch slightly toward downspouts.

3. Flues and chimneys shall be installed in accordance with manufacturer's instructions.

JOB INSTALLED PLUMBING

SCOPE OF WORK:

1. Includes cold water piping, gas piping, waste, soil and roof vent connections to the plant fabricated living unit components.

2. Also includes connecting the upper component to the lower component.

MATERIALS:

1. Water pipe and fittings which are job site installed shall be galvanized steel pipe of standard weight.

2. Gas pipe and fittings shall be black iron.

3. Waste soil vent and house sewer piping shall be cast iron where field installed.

INSTALLATION:

1. All field plumbing shall be done in a good workmanlike manner in accordance with the Chicago Building Code.

JOB SITE ELECTRICAL WORK

SCOPE OF WORK:

1. Includes only electrical service drop to each living unit, wiring and hanging of exterior extrance lights and the connection of the upper plant fabricated living unit component with the lower plant fabricated living unit components.

MATERIALS:

1. Electrical supply to each living unit shall be 100 amp, 240 volts - 120 volts A.C.

2. Entrance fixtures shall be of the recessed type and have a lens which deflects the light on the door and area under the adjacent window and prevent distribution of light to the adjacent units. Allow a $75 allowance for these fixtures.

INSTALLATION

1. All field of electrical work shall be installed in a good workmanlike manner in accordance with the National Electrical Code current edition and the Chicago Building Code.

2. Connect the upper and lower living unit components in accordance with manufacturer's instructions.

PLANT FABRICATED LIVING UNIT COMPONENTS

SCOPE OF WORK:

1. Includes plant fabrication of complete upper and lower living unit components as described on Drawings and in this section of the Specification, and transportation to the job site.

2. The living unit components shall be completely finished on the inside including all cabinet work and appliances shown. The outsides of the units shall be complete through the sheathing, but shall not include facing, siding and covering materials except that the dormer shall be completely shop fabricated on the outside except for painting and staining.

MATERIALS:

1. Exposed wood shall be Ponderosa Pine or Number 3 common red cedar.

2. Joists, planks, scantlings and boards must meet minimum requirements of FHA for one, two and multiple family dwellings. Lumber must be of the proper grade for the intended use and 2 x 4 nominal size or larger must bear the grade mark of a recognized inspection agency using grading rules recommended by the American Lumber Standards Committee.

3. Siding on dormers shall be 1 x 6 No. 2 common Western red cedar tongue and groove.

4. Windows shall be as manufactured by the Andersen Company or local approved mill. Window materials shall be No. 2 Ponderosa Pine. No. 48058 units (two required for each upper component) shall be used for dormer windows. Number 1-58064-R gliding patio wall (two required for each unit) shall be installed in the lower living unit component. Note that the patio wall includes the front and rear entrance doors.

5. Mineral wool insulation shall be Thermafiber as manufactured by United States Gypsum Company and shall be of the thicknessess indicated on the Drawings.

6. All hardware shall be a nationally recognized brand. Provide $100 allowance per living unit.

7. Galvanized nails shall be used for all exterior nailing.

8. Interior and exterior mill work shall be D select Ponderosa Pine.

9. Interior doors shall be flush hollow core mahogany 1-3/8" thick.

10. Flooring shall be 11/16" waterproof plywood (trailer floor).

11. Kitchen cabinets shall be wood with mahogany doors of the sizes shown on the Drawings. Counter tops shall be Formica.

12. All plywood used shall be in accordance with the Specifications of the Douglas Fir Plywood Association and shall be marked DFPA.

13. Ceramic wall tile shall be 4" x 4" glazed ceramic tile with matte finish.

14. Mortar, mastic and grout shall be as recommended by tile manufacture.

15. Grab bars and accessories shall be chrome plated brass as selected by the Architect. Provide $25 allowance for grab bars and accessories.

16. Resilient floor covering shall be residential grade 9" x 9" vinyl asbestos tile.

17. Mastic for resilient floor shall be recommended by resilient floor covering manufacturer.

18. All painting materials shall be manufactured by the United States Gypsum Company.

19. Interior painting shall be Grand Prize.

20. Interior primer shall be oil based interior primer.

21. Semi-gloss enamel shall be used for bathrooms and in space above kitchen range and kitchen counter tops between the base cabinets and the wall cabinets.

22. Interior varnish to be used on mahogany material shall be satin finish varnish.

23. All sheet metal work shall be glavinized sheet steel. This is used for duck work, flues and flashing around dormer.

24. Furnace shall be 24" x 24" in size, shall be listed by Underwriters' Laboratories, Inc., and approved by the American Gas Association for zero clearance. Furnace shall be gas fired and have an input of 55,000 BTU per hour.

25. Furnace controls shall be as recommended by the furnace manufacturer.

26. Water heater shall be gas fired and bear the seal of approval of the American Gas Association. Water heater shall be 40 gallon capacity.

27. Water piping and fittings shall be copper tubing of the size indicated on the Drawings for Case 1 and Case 3. The fittings shall be designed for sweat pipe connections. Water piping for Case 2 shall be galvanized steel standard weight iron pipe. Fittings shall also be standard rate galvanized steel.

28. Gas pipe and fittings shall be black iron standard rate.

29. Waste, soil and vent piping shall be hubless cast iron for Cases 1 and 2, and plastic for Case 3.

30. Plumbing fixtures shall be white and American Standard. Tub

shall be pressed steel; lavatory shall be enameled iron, and water closet and tank shall be porcelain. The kitchen sink shall be stainless steel.

31. Kitchen range shall be 30" wide, white in color, gas fired and shall contain an oven, broiler and four (4) burners.

32. Kitchen refrigerator shall be electrically operated, shall be 24" deep, and shall be of 10 cubic foot capacity.

33. Clothes washer shall be Whirlpool and shall be designed for under the counter installation.

34. All the materials for the plumbing work shall be in accordance with standard ASA A 46.81957 if Case 1 is selected. All materials shall be in accordance with the Chicago Building Code if Case 2 is selected. All material shall be in accordance with ASA A 119.1-1963 for Case 3. The case to be used shall be determined before signing a contract. Case 3 is included for materials cost comparison only and shall not be used for this project.

35. All gypsum board materials shall be as manufactured by United States Gypsum Company. Exterior sheathing shall be United States Gypsum Company gypsum board sheathing 1/2" thick.

36. Interior drywall gypsum board for the walls and ceilings shall be SHEETROCK 1/2" thick and SHEETROCK WR 1/2" thick in bathroom area. Shall be foil backed for exterior walls.

37. United States Gypsum Company PERF-A-TAPE joint system shall be used using DURABOND 90 for pre-fill and embedment coats and PERF-A-TAPE Ready-Mixed Joint Compound for fill and

finish coats.

38. All electrical materials shall meet the requirements of the National Electric Code and shall be listed by Underwriters' Laboratories, Inc. Power panels and distribution box shall be rated at 100 amps, 240-120 volts A.C. and be of the multi-breaker type and provide for six (6) circuits.

39. Conduit shall be armored cable.

40. All wiring not armored cable shall be type TW.

41. Switches shall be of the snap type and tungsten rated for controlling lights.

42. Exhaust blowers in the bathroom shall be of the capacities indicated in the ventilating schedule.

43. Ventilating hood in kitchen shall be of the capacity indicated in the ventilating schedule.

44. Fixtures, medicine cabinet and door chime systems shall be provided. Use a $150 fixture allowance for one complete living unit (two components).

45. All other accessories required for a complete electrical system except for those items covered by field work shall be provided.

46. Glass for windows shall be double strength B glass.

FABRICATION, INSTALLATION AND APPLICATION:

1. All framing shall be erected plumb and true, nail or screw

attached, and in a good workmanlike manner.

2. Doors and windows shall be erected in accordance with manufacturer's instructions.

3. Install gypsum sheathing and drywall materials in accordance with USG recommendations.

4. Install the flooring trim, cabinets, and hardware and other work indicated on the Drawings.

5. Install stair hand rail per manufacturer's recommendation.

6. Install ceramic tile to the 5'6" level only over the bathtub area in accordance with manufacturer's instructions.

7. Install grab bars and accessories in accordance with manufacturer's instructions.

8. Place resilient floor covering on all interior floors in accordance with manufacturer's instructions.

9. Provide three coat paint work using the materials previously specified on all interior drywall and wood surfaces.

10. Note: Mahogany surfaces, namely the doors on the kitchen cabinets and the other doors are to be varnished and not painted.

11. Exterior dormer is to be completed as shown on the Drawings except for painting. Painting will be done on the job site.

12. Install insulation at all locations indicated in the Drawings.

13. Install complete heating system in accordance with manufacturer's instructions.

14. If Case 1 is selected, install all plumbing work in accordance with ASA A 46.8-1957. If Case 2 is selected, install all work in accordance with the Chicago Building Code. For Case 3 install all work in accordance with ASA A 119.1-1963. Case 3 is included for labor cost comparison only and shall not be used for this project. Test work in accordance with the above mentioned codes and standards. Place kitchen range into place and anchor. Also anchor clothes washer and refrigerator securely to the floor.

15. Install all electrical work in accordance with the National Electrical Code. Hang all interior electrical fixtures. Provide all necessary work to install a complete electrical system except for field connection work specified in other sections of these Specifications.

16. Do any other work required to provide complete living unit components within the scope of this section of the Specifications.

17. Provide all the necessary anchorage and apparatus for the crane lifting of living unit components.

18. Deliver all living unit components to the site and supervise their unloading.

CAULKING

SCOPE OF WORK:

1. Includes caulking of all exterior points where water penetration might occur, except for areas which are protected

by flashing.

2. Caulking shall be applied at job site.

MATERIALS:

1. Caulking materials shall be of the polysulfide type manufactured in accordance with Thiokol Corporation specifications.

APPLICATION:

1. Install caulking around door and window openings and at other possible places for water penetration.

2. Provide a ten-year free service guarantee on all caulking work.

LANDSCAPING

SCOPE OF WORK:

1. Includes placement of black dirt, grass seeding and planting.

MATERIALS:

1. Grass seed and bushes and trees to be planted shall be determined by Architect. Provide $200 allowance.

EXECUTION OF WORK:

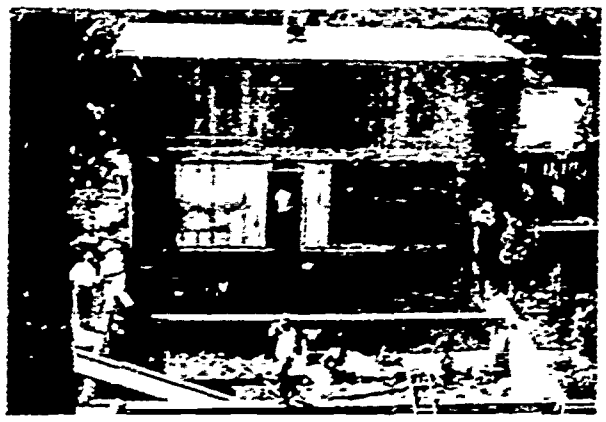
1. Place black dirt to grade elevations indicated on Drawings. Provide additional black dirt if required.

2. Plant grass seed, shrubbery and trees selected. Provide one-year replacement guarantee.

Prepared by:

FREDERICK A. THULIN, JR.
Registered Illinois Architect 01-4413
December 8, 1967

SLIDE 1



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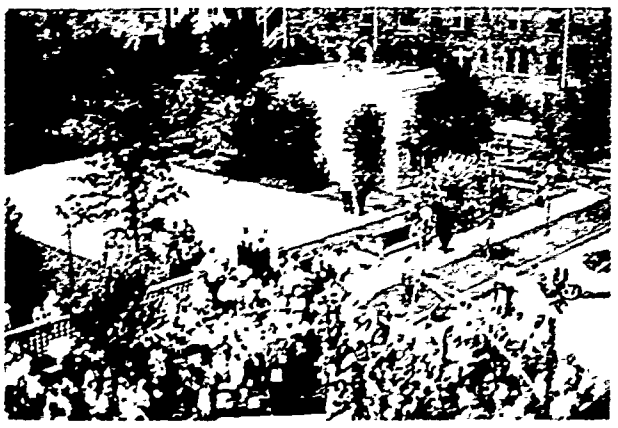

SLIDE 14

MODEL CITIES PROGRAM

By

H. RALPH TAYLOR

Assistant Secretary
Model Cities and Governmental Relations
U. S. Department of Housing and Urban Development

I accepted this invitation without any hesitation for two reasons: (1) Bob Dillon and AIA both have been helpful to me personally, and to the department, as we tried to think through some of the things that need to be done. In that process we have gone to people like Bob and asked them to put their minds to it. Bob brought some people from BRI in during the early days of our research operation when we were trying to think it through; (2) the architectural profession, the design profession, the people who are concerned with hardware and with abstractions like form, and I fear they are abstractions too many, have to play a role in the revolution that is taking place in our city, and I think it is important to us to try to understand how you might plug into it.

We've been building and planning in this country for a long time--building longer than planning--and it looks it. I'm not sure that even today we have any clear understanding of what our objectives should be. I'm not sure at all that today when you get away from people who make speeches in conferences like this, that there is any understanding, and even the thing that precedes understanding, that there is any sense of what it is that people want. It is terribly difficult to plan in the vacuum where there is no objective.

Let me move from those generalities to the Model Cities Program. I almost expected Bob to introduce me as "the one man who understands the program..." and I was going to step up and deny it. Actually, the program is not what most people think it is. It is not a program that in a short period is going to result in a shiny clean neighborhood where everyone lives happily ever after. It is not a program where the emphasis at this time is on things physical, and that isn't because we willed that it should not be on things physical; it's because for the people who live there, the physical is not their top priority.

The Model Cities Program is a program that can be described in a number of ways. In one way it is a financing tool to get some flexible money out to cities. When people from the Congress ask me what this money is going to produce and to be specific and describe what a plan looks like, I get nervous. I get nervous that I'll be in the position I was in when I tried to do this before the Senate Appropriation Subcommittee. I gave what I thought was a very lucid explanation of what the city of Baltimore had proposed. A very hardnosed senator from Colorado looked at me and said, "Now, Mr. Taylor, say it in English." That's a very disconcerting position to be in. I would like to describe the Model Cities Program in terms of a process and in terms of the objectives of that process. If you indulge me, that's the approach I'll take.

The Model Cities Program starts with the assumption that if you don't understand the problems, you're not going to come up with a solution. It moves from there to state that the people in the neighborhood, working in concert with city government, are the ones who have to understand what their problems are. The city government has planners working in the back hall behind the mayor's office and planning consultants that come in with pretty brochures, but they're not the ones who can really understand what's bugging the guys out there in the streets. The people in the neighborhoods, in this day and age, in this moment of civil rights revolution, the revolution of rising expectations, the movement toward participatory democracy, I don't care what you call it, but today, 1968, the people out there say, "We want to be in on the whole process, and you can't tell how we feel without us," and they are right. So that we say not only does the city have to understand what the problem is, but that understanding must be based on a strong neighborhood input. They have to have a very important say, and that say is not directly to Washington. We are not funding independent structures out here

but rather they have to be worked through city government.

I have three principles: Understand the problem with neighborhood input into city government. It is on those three legs of understanding neighborhood and city government that the program rests. We've described the planning that we're looking for as an attempt to get the combination of the outside world, which is city government, and hopefully, the other resources in the community, allied with, and working with the people of the neighborhood, to understand why they are in the condition they are, to understand what the basic causes are. On the basis of that understanding, we asked them to develop some goals and objectives as to where they want to go, what do they want to be like a number of years from now. On the basis of their goals and objectives, we asked them, the local people, not Washington bureaucrats, despite anything to the contrary you may hear in this political year, to develop a strategy as to how to get from where they now are to where they want to be.

Now what is the process of developing a strategy? It's a process of determining priority, of making choices. When you have enough money to do everything, you don't have to make hard choices, and if you don't have to make any hard choices, you don't really need to bother with a strategy. But we're never going to have, in my judgement, the amount of dollars that will free us from the responsibilities for making hard choices and for making sure that what money we do have we use effectively. We are asking the local community, city and neighborhood structure working together, to develop a plan that starts with where they are, the problem analysis; that moves to where they want to be, their ultimate objectives; that set goals by defining how far toward the objectives they can get in a limited time period. We want them to quantify the goals--how many sub-standard houses do you want to have become standard? If your kids are reading three grades

below their age level, how far towards what the rest of the city is doing do you think you can bring these kids in a five year period? Thirty per cent of the units have outside privys - how many of these do you want eliminated?

We're asking the city to quantify in terms of their own capability and commitment, not in terms of existing Federal funding patterns. And that perhaps is one of the key decisions that was made in setting up this program. If we asked cities to tell us how far they could get towards a solution of the problems of the worst ten per cent of their city in a five year period, and told them to do it in terms of the money they can see coming down the pike in already funded programs, we would be asking them to do what, in all honesty, none of them could do. So we have said for the first year action program, make your plans on the basis of resources that are available and we'll help you identify them. But for what you need to do in the five year period, look at your capability and your own strategy and don't look at the restrictions in Federal funding. If the cities do what we have given them the opportunity to do, we may have what this country has never had before - a measure of what it may cost to reach certain objectives in physically defined and finite neighborhoods, typical neighborhoods, those found elsewhere in the country, neighborhoods from which larger projections can be made.

I don't know how many of you are aware of the weakness of all the other kinds of estimates that have been made. I'm not sure how many of you recognize, for example, that the 50 billion dollar cost to renew New York that Mayor Lindsey talks about is based upon the cost of the renewal and poverty program in New Haven, divided by the number of people who live in New Haven, multiplied by the people in New York, with a few hundred million thrown in to make it an even fifty billion. That is the nature of the statistics we have in the urban areas, and what we're hoping to do through

the plan and process that we have asked cities to undertake is to come up with some measure of what it will take to do the job. To go back for a moment, we've asked for problem analysis, for long-term goals, for objectives that they can meet in the five years. Then we asked them to develop a strategy and a one-year plan based on the realities of available funds and a five year measure of the scope of the job. All of this should be done by what I think I can accurately describe as those reluctant bed-mates: city government and the neighborhood.

I don't know, and I'm going to ask whatever press there may be here not to pick this one up; I don't know that it'll work; I don't know if anyone knows if it'll work. I know that there is much hope in the communities because it is a different and it is deeper and it is a more real approach to the problems that the people see than they have ever seen before. I do know that people who would otherwise be out in the streets, having lost all hope, are placing great hope in this process. I do know that we have been able to change the way things are done in the Federal Government so that we are really beginning to focus responsibility on local government and do it in a way that is going to give the neighborhood structure an opportunity to have some influence on most things that are happening in the neighborhoods.

Let me illustrate the point for a moment. One of the reasons no mayor knows what it will cost to do a job is that no mayor knows what money comes into his city. The reason that no mayor has this knowledge is not because mayors are stupid, venal, or inefficient, or they don't care; the reason is that we have developed in this country a historical funding pattern which runs money from the Federal department to a local counterpart without necessarily running it through the city. Federal money goes to county health departments; Federal money goes to housing authorities and renewal agencies; Federal guarantees and below market interest rates subsidies go to private development and to subsidized

houses. Funds go through historic routing patterns that run from the Federal grantor to the local grantee without necessarily involving the city government at all. State governors, incidentally, have much the same problem. Money, and a lot of Federal money, runs through states. Money goes from the Department of Welfare, the welfare component of HEW, or education money, or health money, or labor money, to the State Bureau directly, without relating to the state governor and then you wonder why the chief executive can't plan. He doesn't have the information on which to plan, and he doesn't have control if he did have the information, the way the structure has been set up.

We are in the process of changing the Federal system so that as far as the Model Cities Program is concerned, all money that goes into that neighborhood directly from the Federal Government will run through the mayor; he'll know it. All money that goes into that neighborhood directly from the Federal Government will have to be planned by the local grantee in conjuction with city government and the citizens structure, and if it isn't so planned, we expect to have the muscle to stop the grant. That is a revolution carried out to try to create the responsibility, the potential for responsibility at the local level. It includes all FHA money that goes in for multi-family projects related to the plans. When the sponsor gets his feasibility letter, he is going to be sent back to city government and the citizen structure so that they can have some say on it.

We are beginning to create something. We haven't yet succeeded, not to where it can be seen anyway, with respect to the flow of money that goes through states. We're asking states to participate in this process and we're saying to those states that will cooperate, we'll give you a part in the decision-making in the Model Cities Program. The price of admission to that program is your cooperation. You don't cooperate; the hell with you, you

stay out! I think it's time that the Federal Government stop treating all local governments the same way and start rewarding those that are willing to share a commitment to the same objectives.

Now this planning process that we have described and that we have underway is a very difficult one. I haven't yet seen much evidence of a commitment to physical change coming from the communities. There are two reasons for that: One, people in these neighborhoods don't trust us and there is nothing in the history of the relationship that would justify their trusting us in most communities. They are scared of urban renewal. They see public housing as the old kind of public housing, as concentrations of people who once you put them in there, you forget about them. Highways are just another means of up-rooting poor people without any concern as to what happens to them and their community. The second reason is they don't understand the potential of physical change to improve the way they live and their options, so they not only do not trust, they don't have anything positive in terms of a vision, a picture of what physical change can do for them.

That problem, as to how we can get physical change and how we can get that physical change to reflect the environmental quality that you and I know we are technologically capable of producing, how we can get the understanding into the audience that has to demand it or it is not likely to happen, that is a challenge to the people in the environmental design professions. I don't know the answers, but I do know you're doing some things in a few places that will contribute to finding the answers. I think the kind of thing that Claude Stoller is doing in San Francisco is an example of an effort that will bring some understanding and help to erode some of the layers of suspicion. I'm sure that there are other examples elsewhere. What you need to do is somehow find out in your own communities that are participating in this program what's going

on, offer assistance, be ready to be rebuffed, have the patience not to be put off by the rhetoric that is abrasive. Try to see under the reality of that rhetoric. Try to understand that rhetoric for what it is in that community, and why it is. Try to understand the competition for leadership in that community that is often responsible for the escalation of rhetoric. Try to figure out ways and means of making the entering wedge, of getting the camel's nose of design concern under the tent so that you can move in with them later, and they'll let you and want you. This will mean support of something that should have been supported and encouraged a long time ago, but we're all equally guilty. This will mean support and help to get the black, Mexican-Americans, and Puerto Rican young men into the design professions. Thsi will mean doing a lot of little things that they'll let you do so that they can trust you to help them do bigger things. Unless we do it, unless we build bridges between the design professions, the people who know what the potential is and have the professional skills to help achieve it, and the people in neighborhoods, the people in city hall, too, are part of this, you're not going to be a part of it and the rebuilding that'll take place will be more of the old pattern, will be a lost opportunity, and that would be too bad.

The bridge building that I refer to is another deeper objective of this program. When we're dealing with the problem of the roles of citizens and the participation of citizens, we get into the, well, I called it rhetoric a few minutes ago and I'll keep with that term, but the demand for control is ever present. To me, the crucial criterion is not that the control is demanded, but what the objective is behind it. If the objective is to turn in on themselves, to cut the bridges between the ghetto, whether it be a Mexican-American ghetto, a black ghetto, or a Puerto Rican ghetto, and the white community, then it's wrong, it is dangerous and I've been saying, I don't know how successfully, that they're not going

to use this program to do it. Maybe they can use this program to create apartheid in the Wallace Administration, but they are not going to do it under Secretary Weaver or Ralph Taylor. The only weapon I have is to cut off funds, and we're willing to do it if we have to.

The bridge building that I talked about between the design professions and the community is parallel to the bridge building that I'm talking about all through the program. We recognize that people want to control what directly affects them. If control is for the purpose of having the ability to negotiate on a stronger basis, that is the world of coalition and negotiations that is the American system. If the objective is to break all strings to the larger world, that is another problem. There is always that danger; we have to be aware of it, you have to be aware of it when you're trying to work in your own community. What we are talking about when we are talking about bridge building gets to the question of the nature of the society we are creating for us and our kids.

I don't know how many of you are from Washington; those of you who are will know immediately what I am talking about; those of you who aren't, I hope, will understand quickly. I was in Washington during the April riots. I had reason to be out on official business during curfew, in a government car with a government driver with an official pass. Rioting in the streets of the city, with virtually no civilian traffic, with military at the key intersections, with military patrolling all the shopping centers, being stopped at roadblocks, is not my idea of what this country is all about. We either are going to learn how to build bridges, or we are going to have to face what one candidate for president talks about in terms of soldiers with bayonets five feet apart all through Washington. They may not have been five feet apart, but they were there, and the people who suffer are not just the people who are on the receiving end of the bayonets; the people

who stand to lose the most are the people who have a vision of a different kind of society, because as they look at those bayonets, impaled on them as their kind of society. That really, in my judgement, is what this program, the Model Cities Program, is all about, what this challenge means to you, to learn how to get out into those communities and relate, bring them in, is all about.

Let me talk briefly of the research we have underway in connection with this. No one in his right mind would stand up and say we have answers to these problems. What we think we have is an approach and a process, a process that makes sense because it forces people together if it is going to work, and an approach that makes sense because it provides the maximum flexibility at the local level. Our citizen participation standards, for example, the toughest single thing in this program are on one sheet of paper with two sides. There can be dozens and dozens of different answers to those performance standards, equally acceptable; some are going to fail, and some of them are going to work. What we are prepared to do as a government department is to recognize that we learn from failure as well as from success. We must be willing to accept proposals, concepts, ways of doing things, knowing that some are probably not going to work; but if there is a chance that they'll work, and we'll learn something from their working or their failing, we're going to have to let them go. To do this, to have the learning process, we've got to have some mechanisms to find out what is going on. We have already let close to a million dollars worth of evaluation contracts. We've got three separate studies going on in addition to the one I'm sure you have all heard about, the In-City Experiment, that HUD is doing. We've got on the way a study of a planning process where teams will be looking closely at what really does go on. What are the forces? What are the influences? What practices are crucial and are not crucial? How does planning take place in this uneasy marriage between city hall and neighborhood? What works and what doesn't work? We've

had people looking at it closely enough so that we're going to be able to put out a technical bulletin that will be helpful to the new city starting. It will point out that one of the key things you need to do is to clarify the relationship between neighborhood and city hall: (Don't leave it fuzzy at the beginning). Negotiate it out, set a set of rules and then live by them, because it's when it's left fuzzy that the dynamic of encroachment takes place and a conflict develops, I think it might not have been so bad in the Brownsville situation in New York if the respective power relationships hadn't been left quite so fuzzy. So we plan to study and I hope find out quite a bit about how planning does take place in this context. Another thing that we are going to do is have in at least a half-dozen cities resident observers, who will be bright graduate students who will live in the neighborhood where the citizen structure is willing to accept them. But we need to know a lot more about how people think, what their problems are, what their aspirations are, and how they react to a great number of things than we now know. In our dealings with the ghettos, with a poor population generally, we are operating in a dark room with a blindfold. It is time that we develop more understanding.

The third area where we will be doing considerable research is in the area of measuring institutional change and either adaptiveness to change or resistance to change. What is happening in the cities today is not going to be solved by institutions that aren't willing to change, that aren't willing to recognize what the problems are, are not willing to accept change as an essential fact of life. We are going to have people who will be looking at how institutions react to this challenge and situation. My own estimate is that it'll be a year to a year and a half before we have enough useful information that we can share with the outside world. I have hopes as a policy-administrator type that I'll have feed-back substantially before that. If we can understand better how institutions react and how people react and what the problems are, we're going to be

better able to translate on to the ground what you and your associates know is possible from a technological point of view. In our kind of society, technology is at the mercy of the institutions that can determine whether or not it can be put into place. We are focusing on institutions and people. You are interested in people, too, but you are focusing on technology. We can be and we should be allies in a joint effort to put what each of us knows, and what each of us is interested in, in place in our cities. I think we can be helpful to one another.

EXPERIMENTS IN FORM

Using Computer Graphics

By

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ACKNOWLEDGEMENTS

The material presented here introduces some new concepts in computer input and output systems related to building design and planning problems. Much of the work was done during the summers of 1967 and 1968 at the Computer Research Laboratory at the University of California, Santa Barbara. The project was sponsored in part by the School of Architecture, University of Texas at Austin. The project drew heavily from the resources of the laboratory, which include the equipment developed by Dr. Glen Culler for his research under A. R. P. A. sponsorship, as well as the excellent facilities provided by the University of California. Mr. Gordon Buck and Dr. Roger Wood were instrumental in the design of the system, and we are all grateful to Mr. Dennis Grubbs for his unfailing successes in keeping the Grafacon going. The author is particularly indebted to Art Kasselbaum, who stepped in at a crucial time to help with some perplexing problems, and to Dr. Glen Culler for persistent encouragement.

INTRODUCTION

These experiments with form are unavoidably linked with morphology, or the physical organization of things. They are less directly linked with the possibility of amplifying intelligence. The illustrations are selections from vast numbers of photographs taken directly from real-time displays on the storage tube. The process of inventing form with this system requires describing "the diagram of forces," or generator constraints. In these experiments, intelligence is "amplified" by inventing and communicating large numbers of images of physical forms based on generators and constraints. At this stage, the images do not represent physical matter but rather the physical organization of elements put together in space as they might appear from a certain viewpoint. Clearly, the images cannot offer themselves as fitting solutions to physical problems. They may serve to illustrate exciting new forms evolved in response to imaginative sets of constraining forces.

The system hardware uses a "Grafacon" tablet (Figure 7), an IBM 1800 computer, an 11 inch Tektronix "storage" tube, a two level BBN Keyboard (Figure 8), and associative electronic interfacing. The software derives from that developed for architectural perspective drawing and described in "A Flexible Computer Graphic System," Wood and Hendren, Information Display, March/April, 1968. The new system differs from the old by the addition of the new display tube, the keyboard, and a completely redesigned control software system. The new user interface caused a considerable shift in our thinking concerning user/machine interaction. The display system is capable of a high degree of resolution and the 11 inch format provides sufficient surface area for most visual tasks. A unique feature is that line thickness is under system control so that up to seven progressively darker lines may be specified by the user for a drawing.

The larger system of which this graphic structure is a subset is intended to expand and complement a considerable body of research in environmental design. It is intended that the internal organization of data will ultimately be compatible with the RFMS information retrieval system now being implemented at the University of Texas Computation Center under the direction of Dr. Alfred Dale. This report is limited to the graphical input and display of information. We did find that user behavior with the new control and display equipment changed dramatically, and some fresh ideas concerning information storage are emerging. This paper will explore some of these while aiming principally at sharing some of the intriguing and sometimes humbling experiences while on-line with a graphic-input/graphic-output computer-system.

THE INPUT AND CONTROL SYSTEM

The rather simple recursive operations used in this system involve the following steps:

1. Sketch a starting profile via the Grafacon tablet.
2. Display the perspective transformation of that image (a matter of a second or two).
3. With keyboard commands, perform any of the following operations in any sequence or in any simultaneous combination:
    a. Redraw the perspective view N times and display.
    b. Erase the tube before redrawing each view.
    c. Translate the image in direction X, Y, Z, by increments of U units.
    d. Rotate the image about axes X, Y, Z, by increments of V degrees.

For instance, a typical set of keyboard commands might read: "Redraw 100 times, translate in the Y direction by 1 unit, and rotate about the Y axis by one degree before redrawing each set." (See Figures 1 through 4)

Imagine a starting profile consisting of a horizontal line bounded on either side by short perpendicular segments. The results of the preceding set of commands might be similar to Figure 1, while Figures 2 and 3 illustrate increasing the rotation increment and redrawing the same set of lines. Figure 4 illustrates translating the set and reversing the direction of rotation, while superimposing on Figure 3. It is important to note that these are perspective drawings and that each figure derives from the same set of lines.

FOUR CONCEPTS

Form-Generators. In each of the preceding illustrations, the "form-generator" is the original set of straight line segments (Figure 15 is an example). They are translated in space and the path they trace is presented in perspective on the storage display tube. There are no restrictions on length, position, or number of line segments, and the rotation and translation possibilities provide the means for drawing virtually anything. We arbitrarily chose seven different sizes of dots and seven line thicknesses for the display system. The point of rotation may be located anywhere and be fixed or variable. In many cases, drawings are made by superimposing the operations of several sets of form-generators.

Instruction Storage versus Data Storage. An alternative to spatial data storage for a particular object is to store the form-generator and operation instructions for that particular form. One advantage of this method is that objects such as

buildings may be thought of as combinations of repetitions of elements - a concept closely associated with the way buildings are constructed. For example, a hardwood floor is formed by translating the basic element horizontally. The element or form-generator in this case is one board, and the operation is "translate horizontally." A complete building may be described to the computer in this way. Our preliminary experiments indicate a number of significant advantages over other spatial data lists with which we are familiar.

The Threshold of Visualization. The concept of the "threshold of visualization" emerges as we gain control of information which, graphically displayed, may represent real or semi-real situations.

Clearly, there are gaps in our understanding of how we "visually imagine" a physical situation which has never existed.[1] Apparently, the manner in which a progressive movement to a correct representation takes place is from the oversimplified to the less simple and more exact. It seems from our investigations that the brain starts by making gross simplifications, using them as a working basis, and adjusting them in the light of further experience. We have noted the following situations as progressively more difficult to visualize:

1. An environmental situation or physical object which is identical or similar to situations or objects of common experience.
2. New relationships or original compositions of forms which are familiar (e.g., a new arrangement of common-place items).

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[1] This is an area of many speculative theories. For an interesting discussion, see "Activity Patterns in the Human Brain," W. Grey Walter, Aspects of Form, Lancelot Law Whyte, ed.

3. Simple operations with few and simple form-generators (Figures 19, 20, 24).
4. Complex operations with few and simple form-generators (Figures 25, 26, 47, 48).
5. Complex operations with many simple form-generators (Figures 4, 10).
6. Complex operations with many complex form-generators (Figures 12, 18).

The last four above are not available for experimentation with computer graphic systems. The issue of interest here is the concept that a "threshold" will occur in each of us at some level of "visualization task." At this cognitive stopping point, the brain, with its inveterate habit of simplifying and forming new records to ease its own processes, builds either a grossly inaccurate image or bogs down in confusion.

Consider the question: "What will the picture be if we rotate one line segment about another while simultaneously moving both around in space?" If the computer is asked, it can easily calculate the perspective transformation coordinates and display the picture (e.g., Figure 3). If a man is asked, he must first challenge his brain to put together an image based on the descriptive information. He must secondly find a way of expressing (communicating) the picture, probably verbally or with a sketch. Depending on the task, either or both for him may be impossible. Note, however, that the form, once pictured, may be very simple; it is the transformation that is difficult.

Our experiments indicate that the brain is highly trainable, and one can develop new visualization powers quite rapidly (i.e.,

by working with graphic computer systems).[2] Communicating the picture one "sees" may still be difficult, but undoubtedly the task is made easier when the images are clearly visualized.

Form Development by Generator Constraint. D'Arcy Thompson describes the form of an object as a "diagram of forces... - in the case of a solid, of the forces which have been impressed upon it when its conformation was produced, together with those which enable it to retain its conformation."[3] The concept of "form development by generator constraint" uses the "form-generator" idea while imposing "forces of constraint" on the generators to develop the conformation. For example, consider the form developed by N parallel line segments of length greater than L and less than M. Figure 29 shows several possibilities with this set of constraints. Adding another line and a relative-angle constraint may result in something like Figures 25 and 26. Obviously, as the set of constraints or "diagram of forces" increases, the number of conforming possibilities decreases to one and then limit zero - the point where no form can be found which will satisfy all of the constraints. (This point is reached quite often in design, and one simply begins looking for solutions satisfying high percentages of high-priority constraints.)

Figure 30 shows the shape of an "object" which is the resultant of a number of forces which represent, or are represented by, the generator constraints. It is easy to see that the constraints

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[2] We consistently find that the computer-generated image is quite different from what we expect based on the starting profile and the set of operations. It is interesting that "pre-visualizing" seems considerably more accurate with the eyes shut.

[3] D'Arcy Thompson, On Growth and Form, 2nd Edition, (Cambridge, 1959), p. 16.

might well be the manifestations of various kinds of energy based on the laws of physical science.

DISCUSSION

The characteristic that the 11" display tube[4] will "store" a previous set of output while waiting for a new set separates this system from many other CRT computer graphic systems. Clearly, many programming decisions are heavily influenced by available graphic capability. For instance, the shift of the role of data storage from the computer core memory to the display device (temporary storage) causes a considerable change in the roles we devise for the respective components. In effect, this fundamental difference causes some serious rethinking about the kind of help we might be seeking from the computer - especially computers of limited storage capacity. In particular, we have found a new approach to the problem of describing complex geometries to the computer. The four concepts discussed in Section III form the basis for new thinking about information systems for environmental design.

With the help of the storage display system, we have discovered a means of expanding the visualization capabilities of the mind. The power to dynamically train ourselves to see what we could not otherwise see is, I believe, of great value. It is similar in many ways to expanding one's visual vocabulary by seeing new objects or buildings, but with the difference that the computer system shows the integral parts, their structural and the integral parts, their structural and geometric relationships, and

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[4] A characteristic-summary of the 11-inch display unit is available from Tektronix Inc., Beaveron, Oregon. The displays illustrated here were made with the Type 611, about $2500.

the step-by-step constructive process. The "Threshold of Visualization" and the mental procedures we use to visualize form prior to its physical being are not well understood. Putting together an accurate mental picture of something which has never existed is often very difficult. Even those who are good at it must admit there are situations where one simply doesn't try because there is a point beyond which the relationships are too complicated. As the illustrations indicate, we are often surprised, sometimes bewildered, occasionally delighted, and usually left wondering what an exciting visual world must await our slowly developing powers of visualization.

DESCRIPTION
OF
COMPUTER GENERATED DISPLAYS

DISPLAYS 1 TO 4

Perspective displays of the "forms" generated by redrawing a set of line segments one hundred times while incrementing by one unit in the z (depth) dimension and while incrementing an angle of rotation about a moving point. In Figures 2 and 3, only the angle has been changed. In Figure 4, the set of line segments are translated horizontally, and the direction of rotation is reversed.

DISPLAYS 5 AND 6

The system couples the data input technique to man's natural and highly developed skill in positioning a pencil upon a writing surface. The "Grafacon," with fitted template, is used to enter sketches on-line into the computer and, along with the digital keyboard, to command specific operations to be performed on the sketches. The computer transforms the data and produces various perspective views based on the sketches and keyboard command information.

Perspective sketches such as this simple hillside house are easily made using the graphical input capability of the system. For a more complete description of this application, the reader may refer to "A Flexible Computer Graphic System," Wood and Hendren, Information Display, March/April, 1968.

DISPLAY 7

The user begins by sketching a starting profile and displaying the perspective transformation of that image. The position of

the plane in space is specified by stylus commands in the marginal boxes. The small CRT seen in Figure 7 monitors the position of the stylus, indicating Grafacon control mode.

DISPLAY 8

Keyboard commands allow the user to control the image on the display tube. The names on the keys correspond to subroutines in the program. (The mathematical labels correspond to another system.) The six dark keys on the upper level correspond to routines which are used for specifying such information as "line thickness," "return control to Grafacon," "erase the display," "erase and return to original sketch," "redraw and increment N times." Specified increments in X, Y, Z, and U, V, W, translation and rotation respectively, are input by pushing the corresponding lower level keys, followed by the numerical value on the first row of the lower level.

DISPLAY 9

Figures 9 through 54 illustrate the unique capabilities of the new display and control equipment. The classic system of displaying multiple views of surfaces generated by the computer is still of interest, but new concepts in display may be of far greater use to the designer. The concepts of "Form Generators," "Instruction Storage versus Data Storage," Form Development by Generator Constraint," and "The Threshold of Visualization" are exciting new areas of investigation.

The line resolution of the display system is substantially greater than many other CRT devices. The display area of the tube face measures 21 cm. x 16.3 cm.

DISPLAY 10

One may virtually fill the field with light in order to achieve desired relationships in compositional studies.

DISPLAYS 10 TO 14

Certain kinds of animation are easily done with this system. One may either "erase and redraw" or "redraw and superimpose" while moving people and objects around in three dimensions - all of which is great fun.

DISPLAY 15

A typical "form generator" for visualization experiments.

DISPLAYS 16 AND 17

The operations are translate and superimpose.

DISPLAY 18

The addition of a rotation parameter may lead to results very difficult to anticipate.

DISPLAYS 19 TO 21

Frames of horizontal and vertical lines are rotated about the left-most vertical in various ways. The game is to guess what's going to happen before it does. One is often betrayed by his senses!

DISPLAY 22

"Wonder what would happen if we moved her around as she rotates?"

DISPLAY 23

A dot and a line.

DISPLAY 24

A dot around the line.

DISPLAYS 25 AND 26

Two lines rotating about the moving left end of the horizontal line.

DISPLAYS 27 TO 29

Line patterns in perspective.

DISPLAY 30

A form generated by conforming to prescribed constraints. The resultant of a diagram of forces intended to limit the number of solutions to a few or one.

DISPLAYS 31 TO 38

Forms which we use every day are often repetitions of elements judiciously translated, rotated, or placed. One may think of a building as combinations of repetitions of operations.

DISPLAY 39

The line around the dot.

DISPLAY 40

A stairway to space.

DISPLAY 41

Abstract modeling of traffic patterns.

DISPLAY 42

All of the units starting at the lower right become distributed according to the available passage-ways. Some current work engages behavioral simulation of this type to investigate physical accomodation of dynamic activities.

DISPLAYS 43 TO 46

It is interesting to combine displays of simple behavioral patterms with representations of real objects. We have seen that it is often more interesting to display the way a thing works than it is to display the way a thing looks. The form/functions cliche as a working principle?

DISPLAYS 47 AND 48

If motion is controlled by strict constraining forces, the resulting paths or "forms" are limited to one or a few. In this case, the constraints are satisfied by either clockwise or counter-clockwise motion.

DISPLAY 49

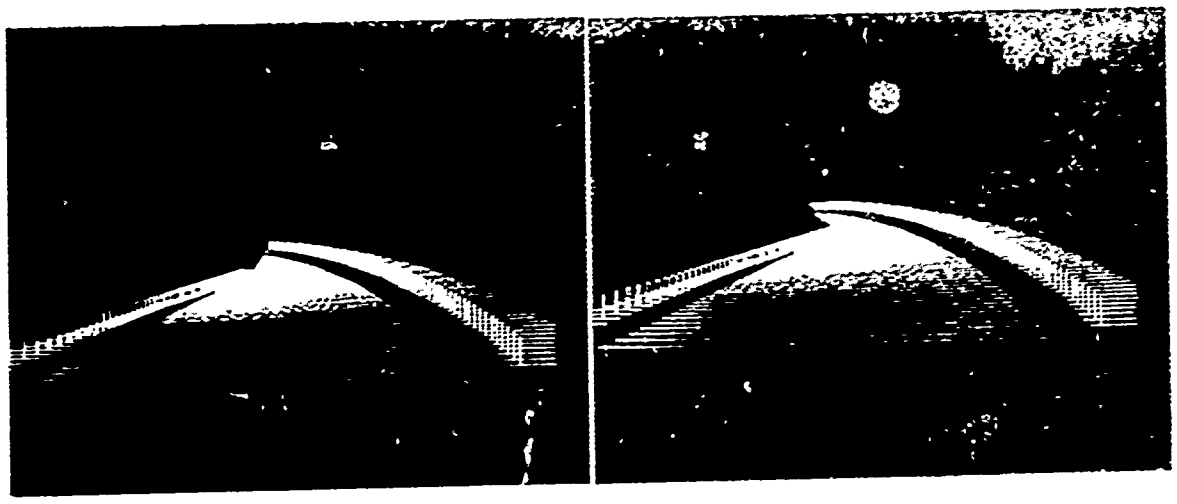
Visual surprises occur with high frequency with this system - note the strength of the triangle vertices and the lower line crossings in this display.

DISPLAY 50

The interference curves occur as we look at a triangle translated vertically.

DISPLAYS 51 TO 54

A family of displays for visualization studies.



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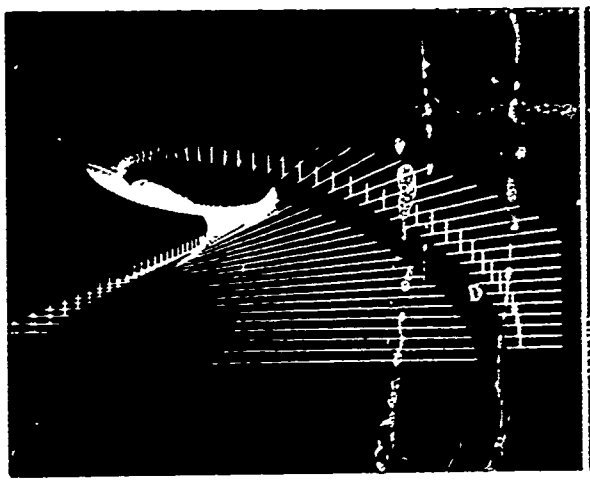

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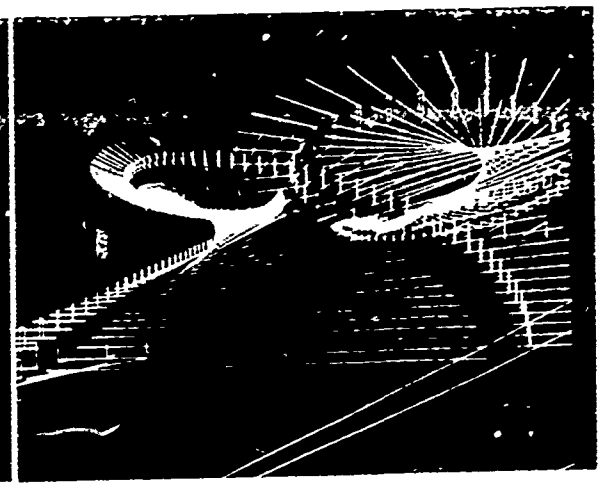

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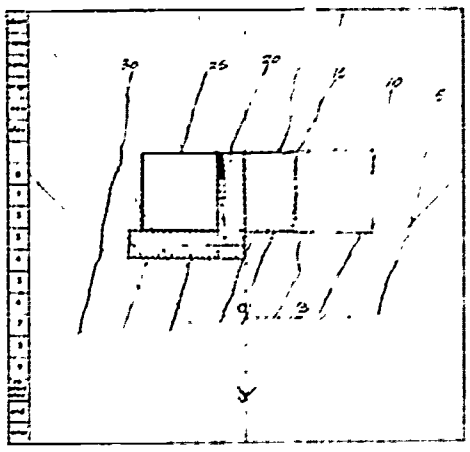

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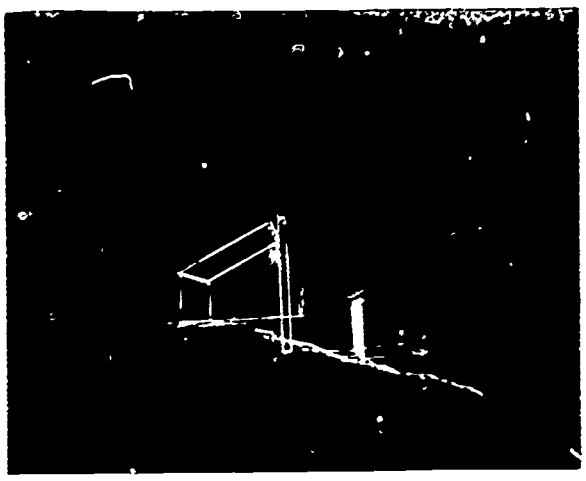

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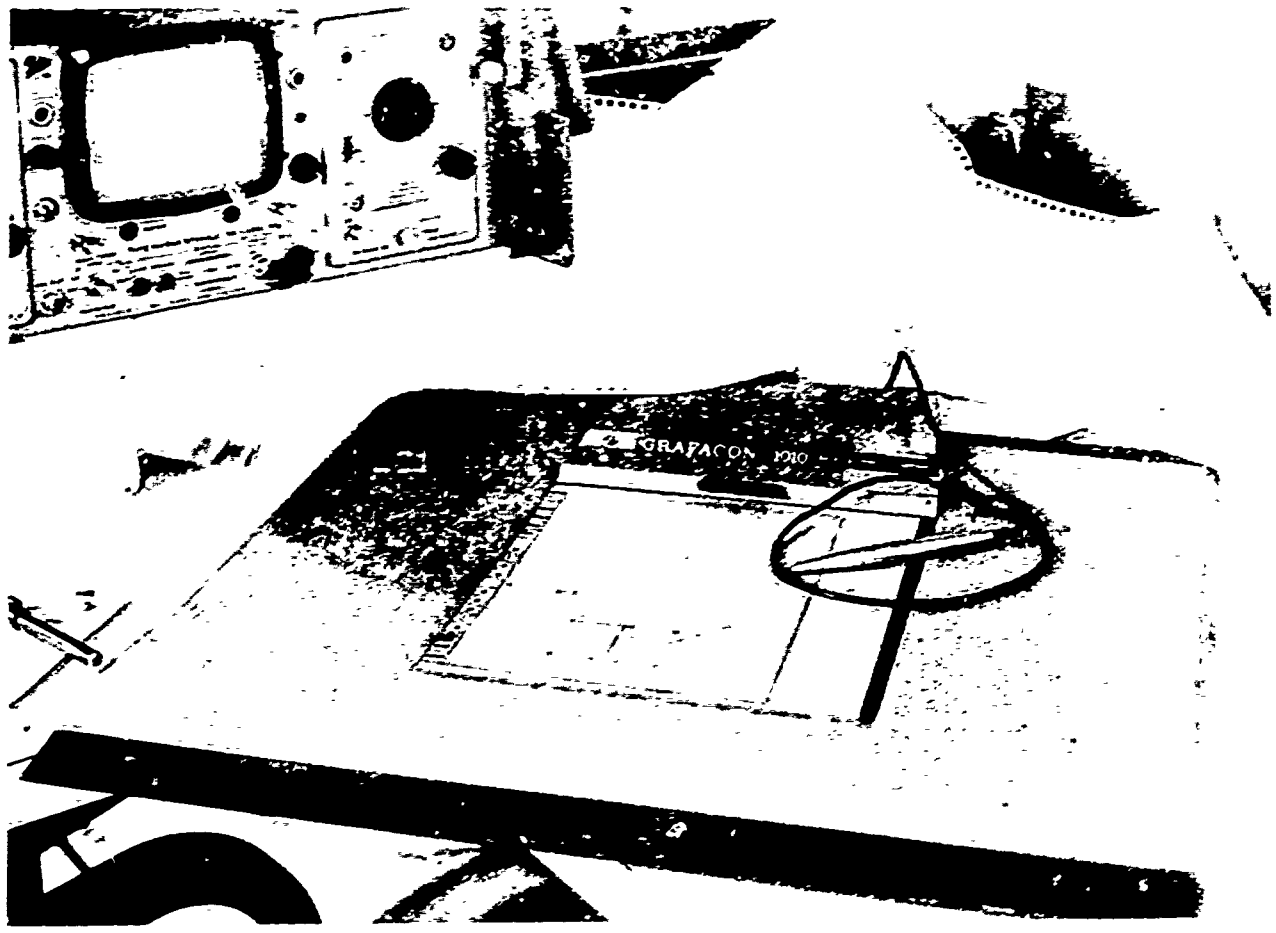

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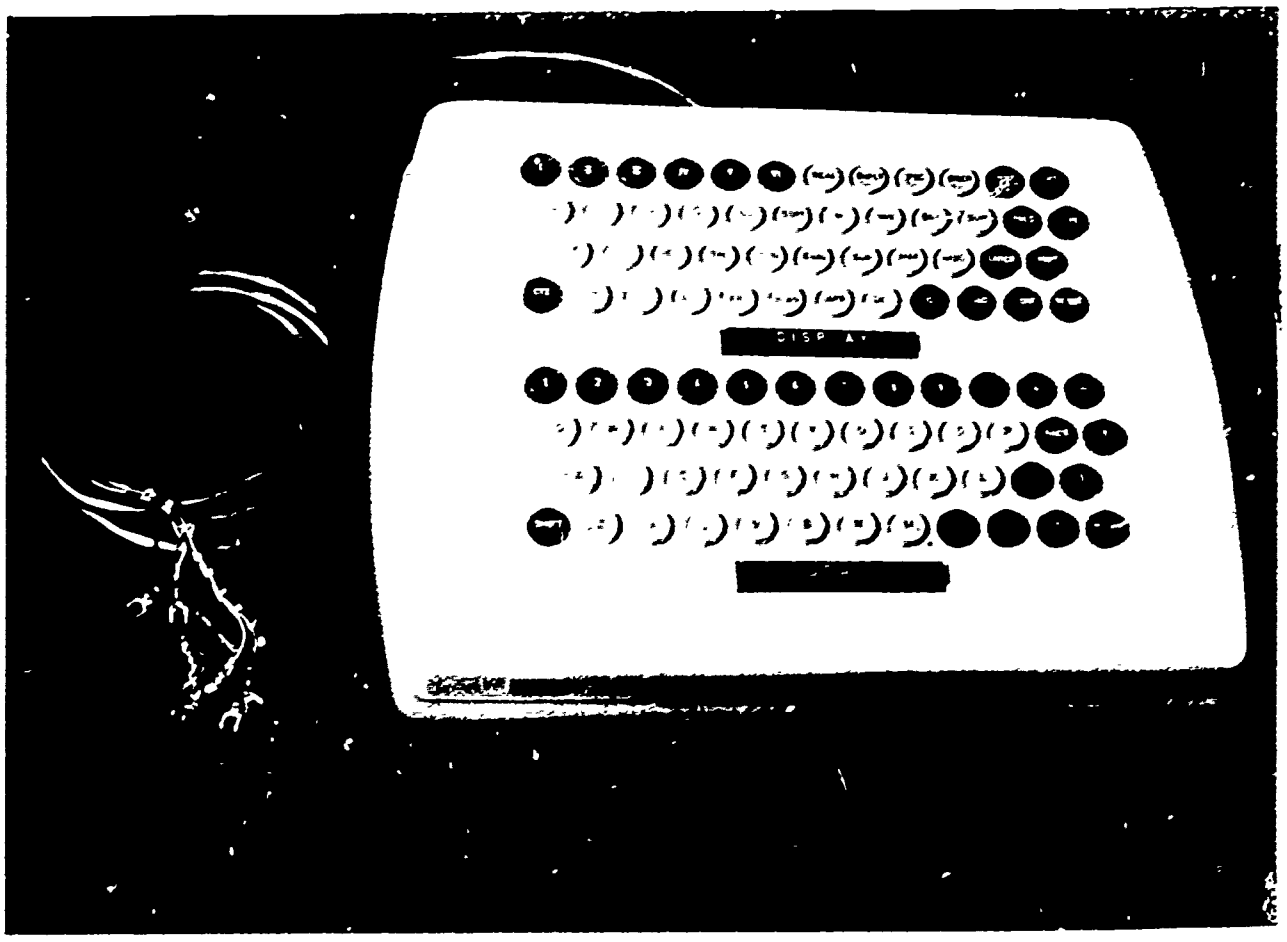

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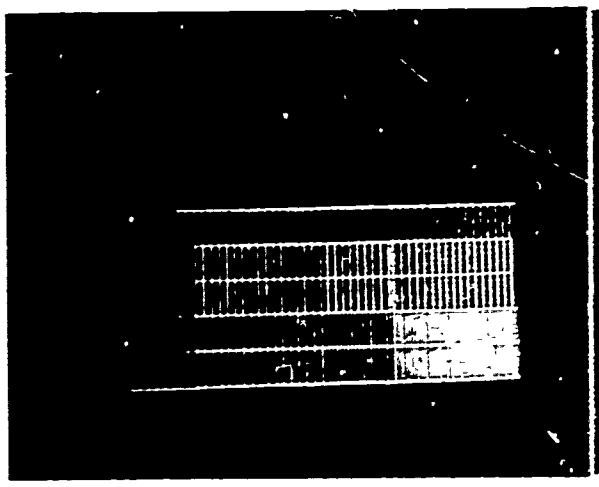

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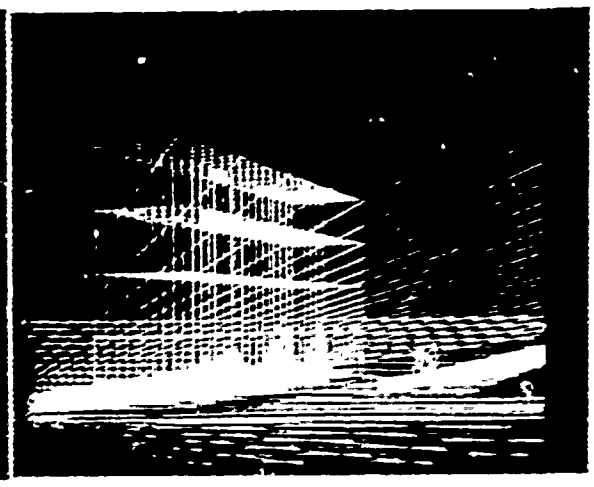

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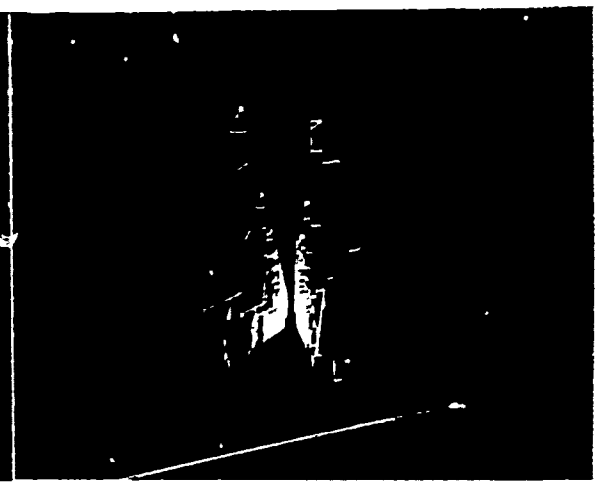

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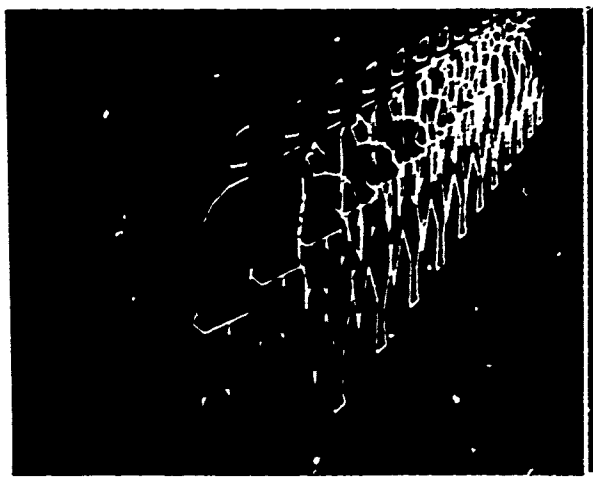

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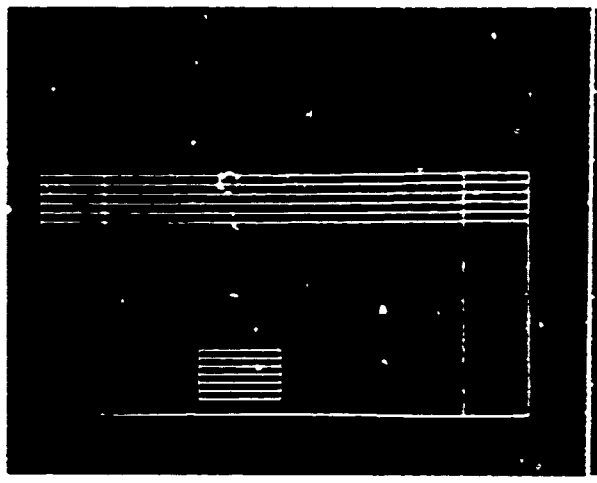

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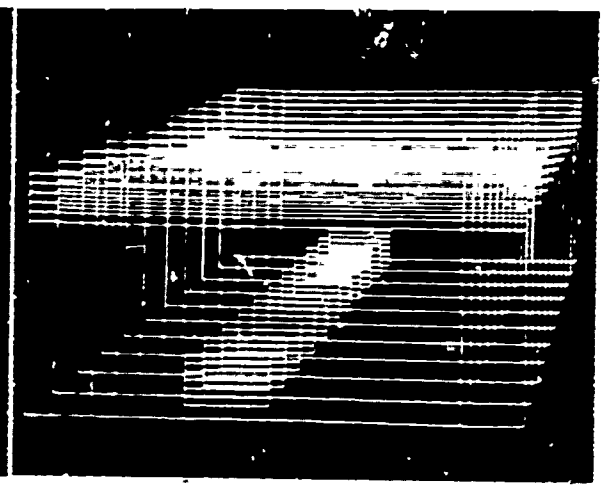

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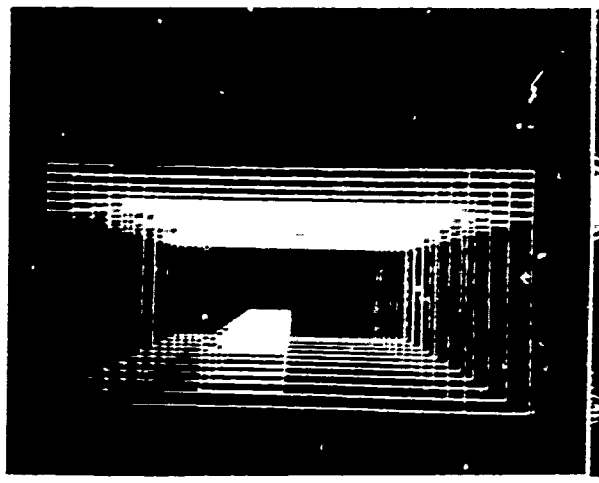

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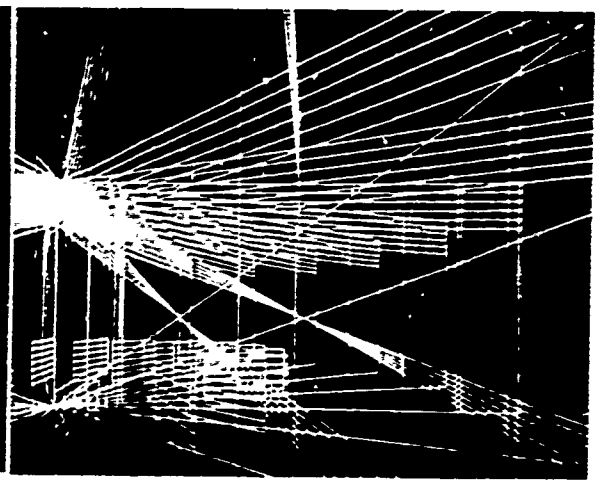

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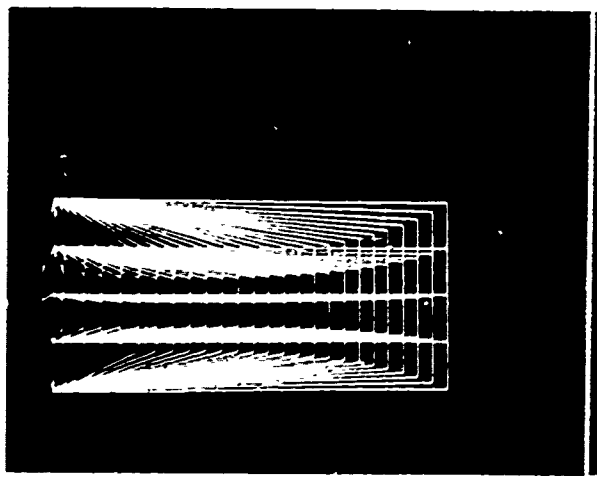

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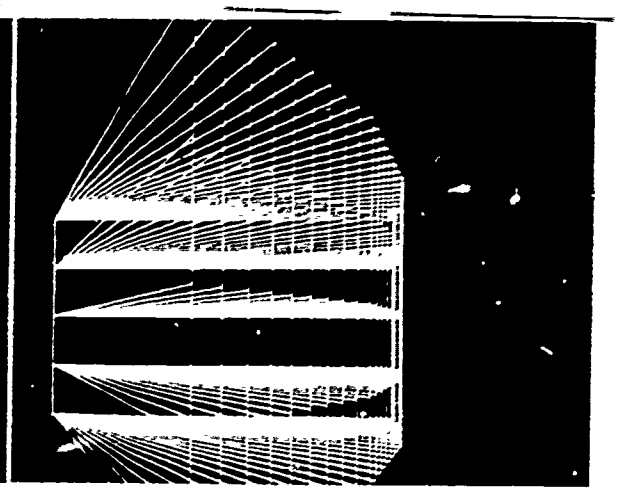

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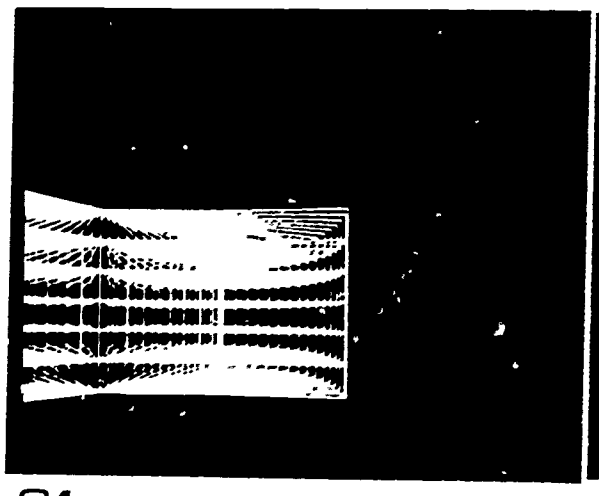

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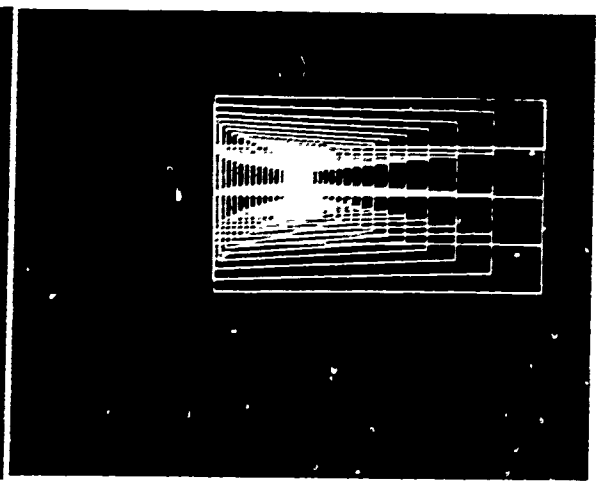

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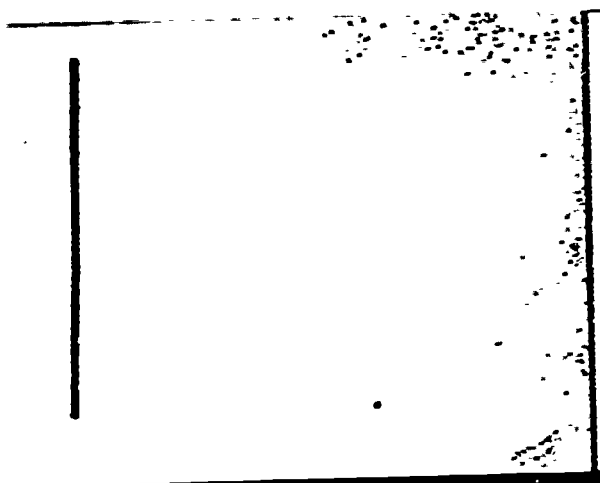

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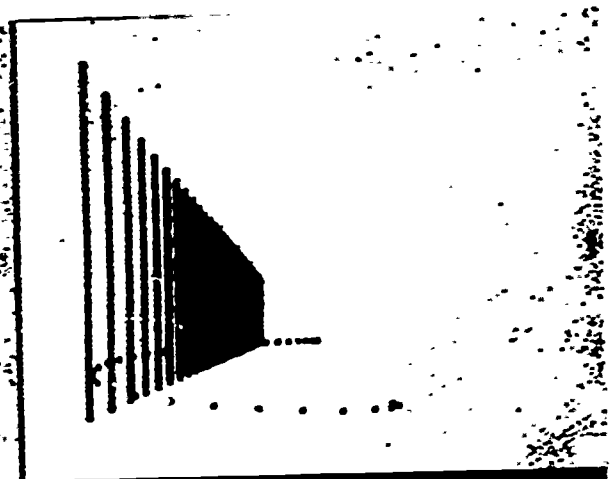

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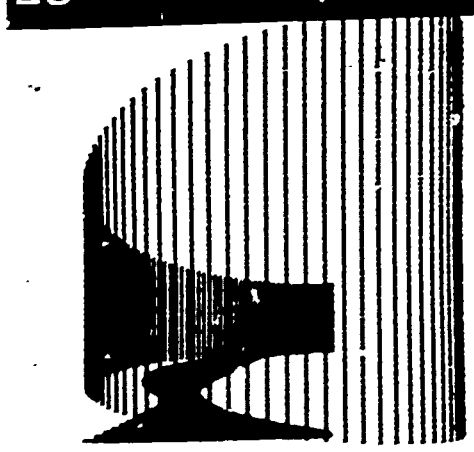

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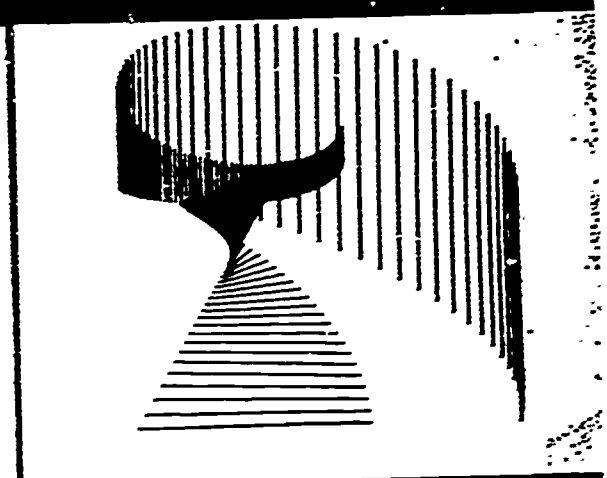

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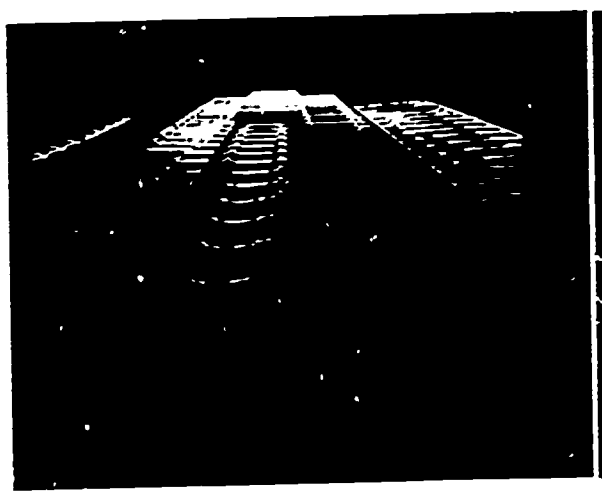

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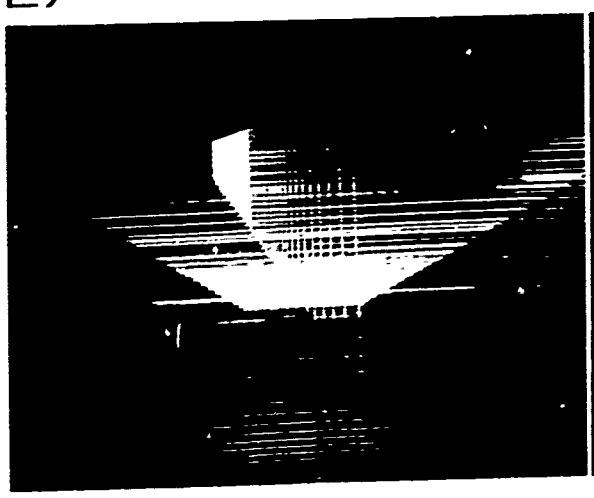

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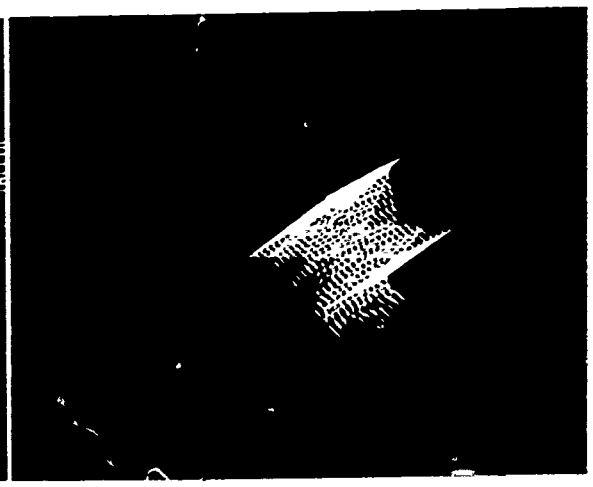

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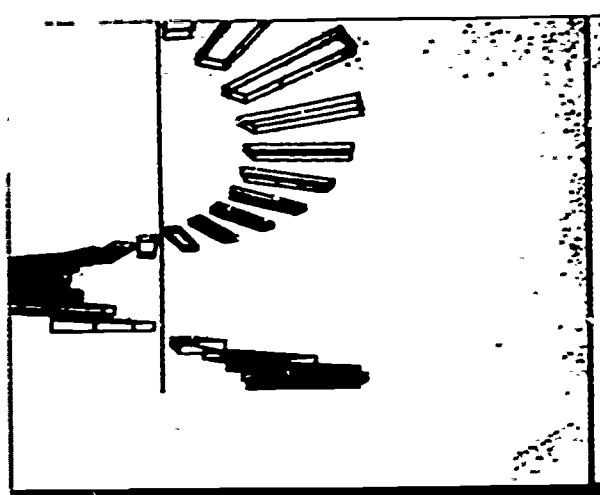

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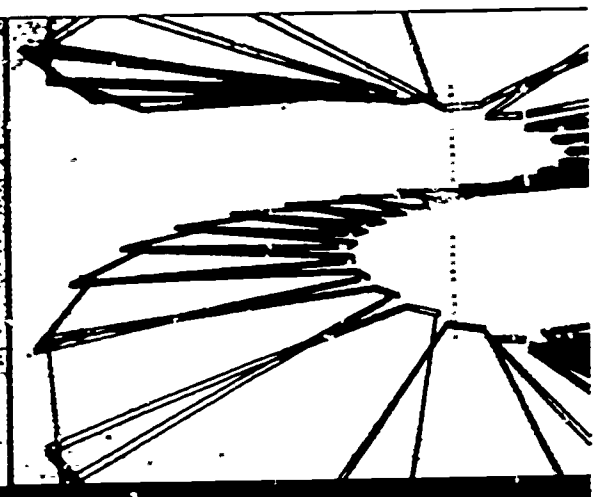

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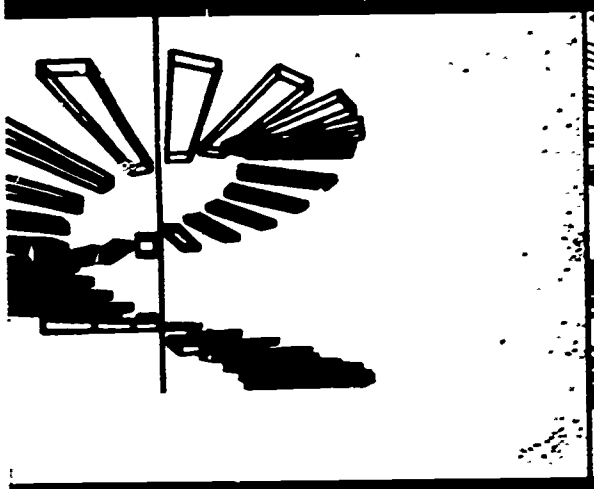

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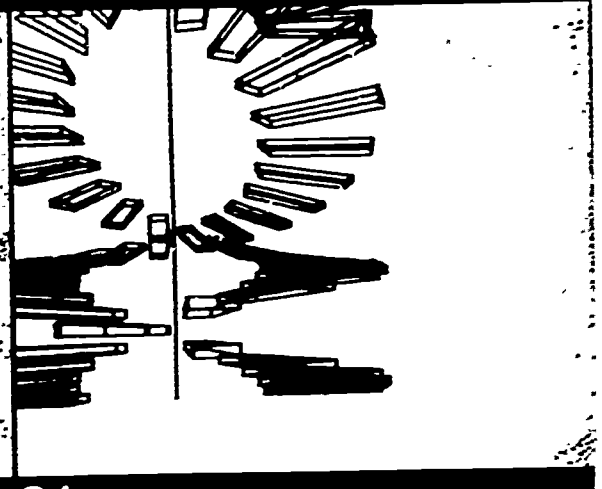

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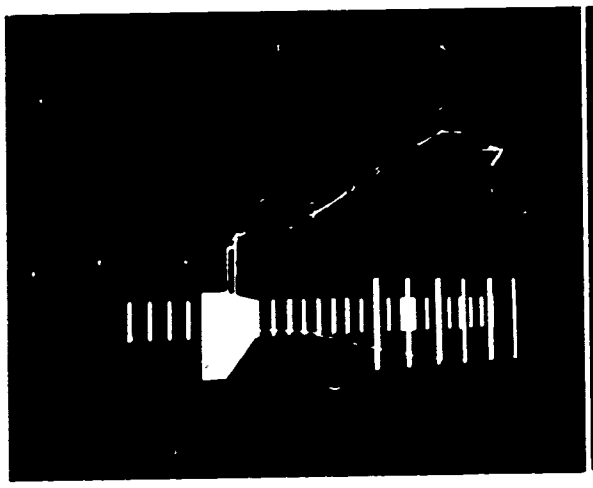

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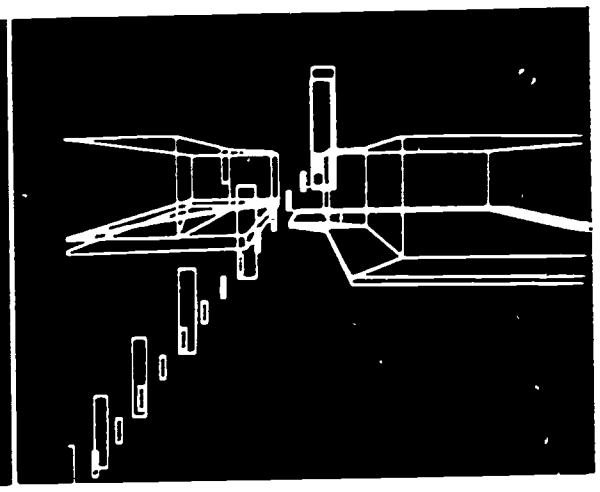

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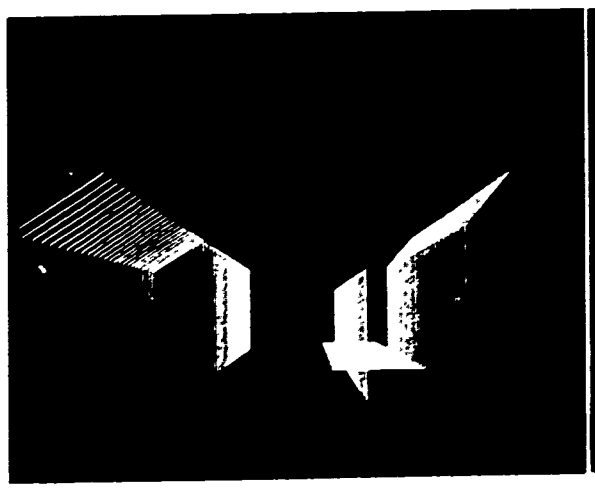

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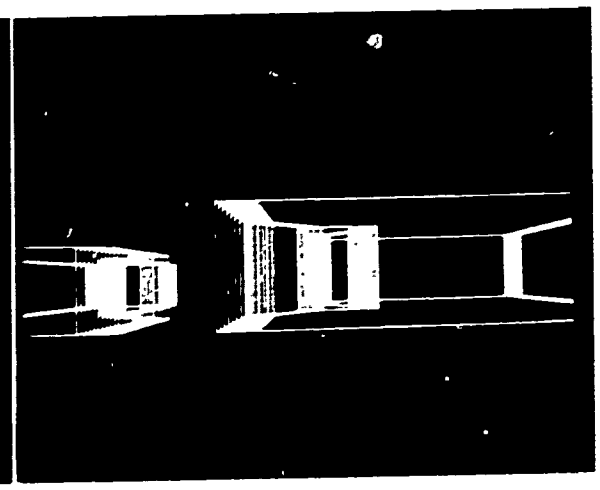

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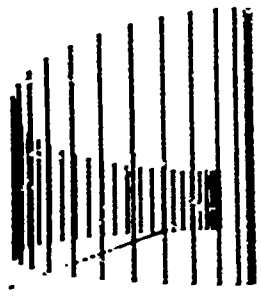

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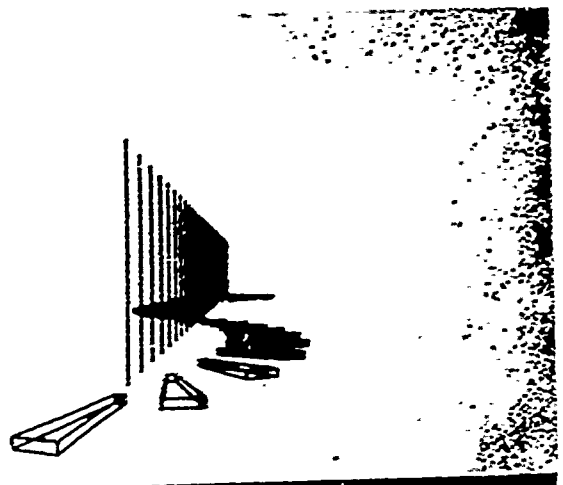

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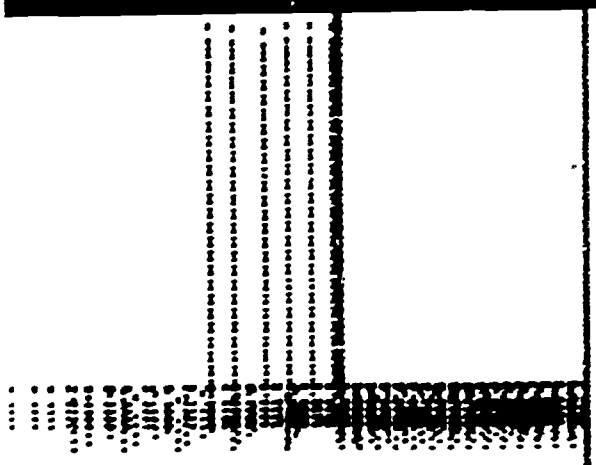

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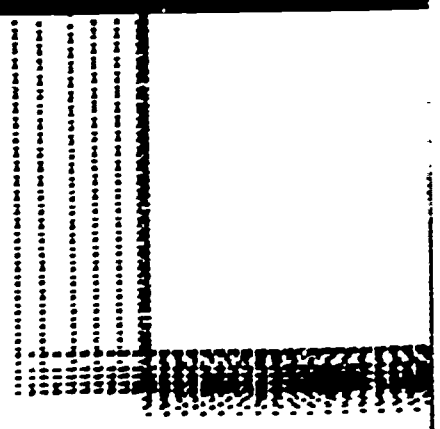

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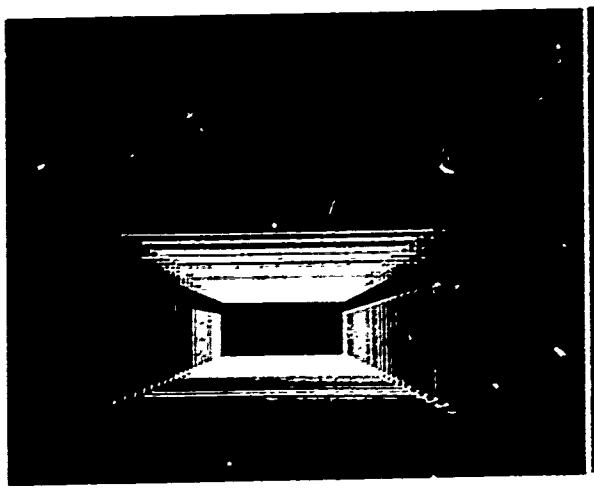

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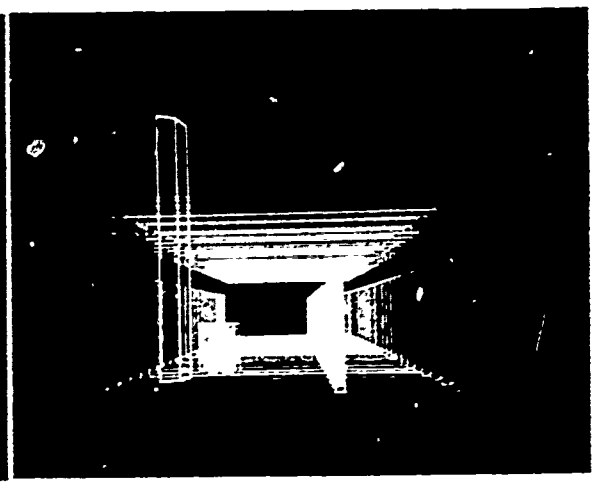

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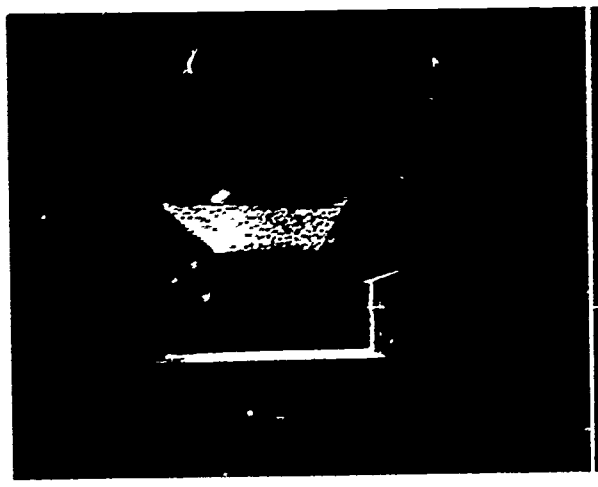

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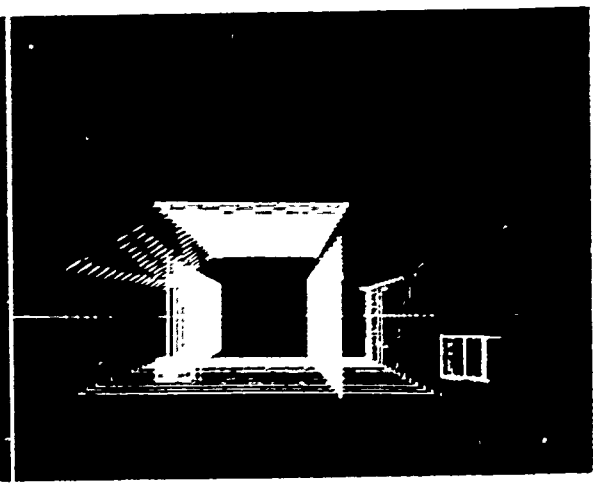

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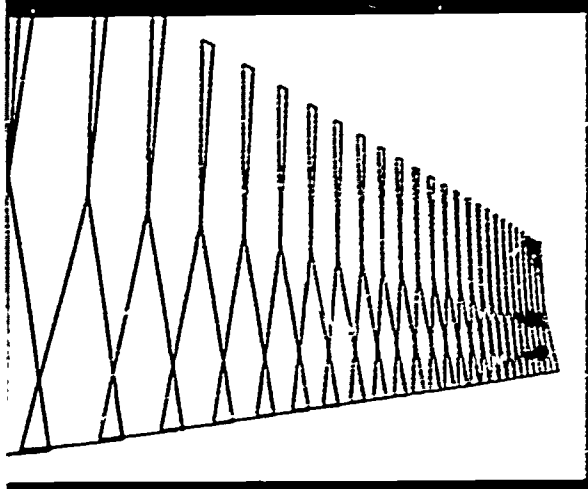

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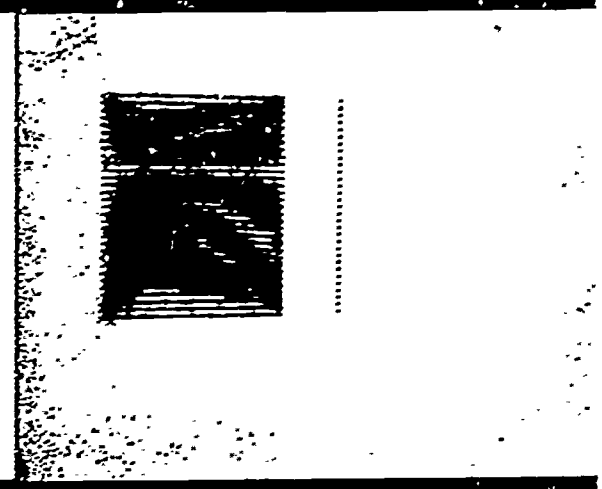

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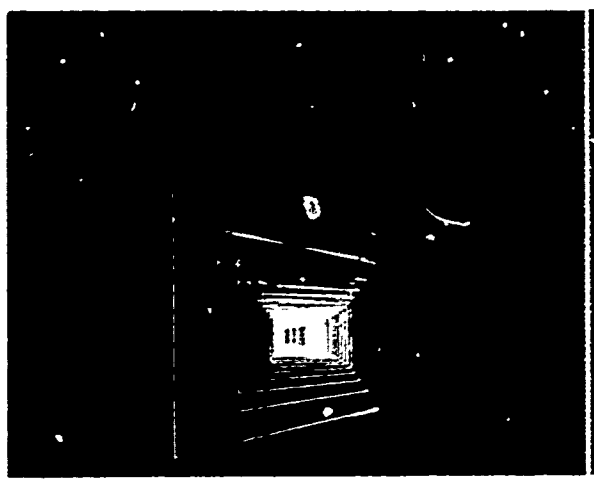

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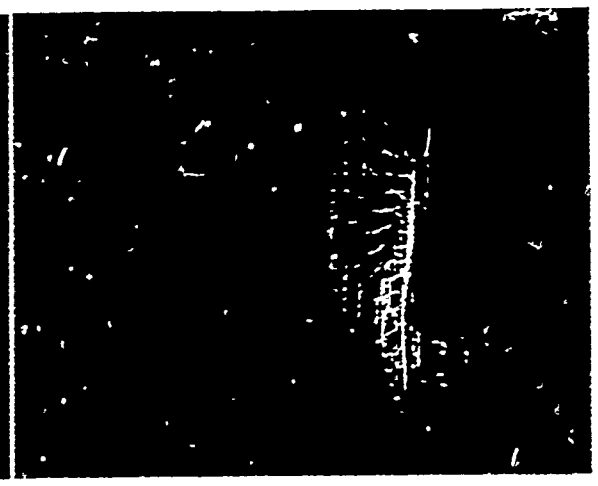

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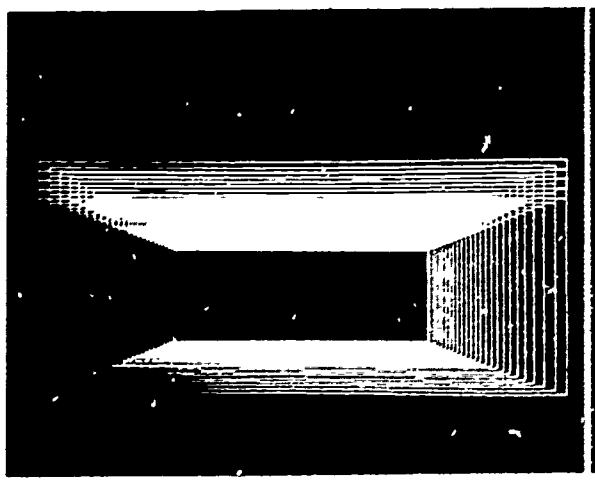

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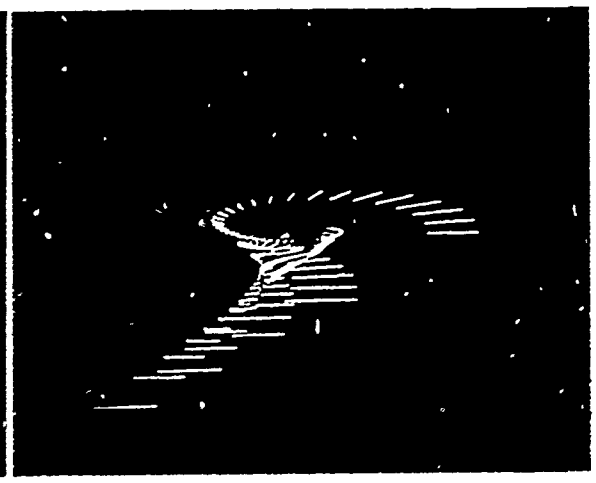

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A CONSTRUCTION INFORMATION

AND

ANALYSIS SYSTEM FOR THE STATE OF NEW YORK

By

DAVID S. HAVILAND

Assistant Professor of Architecture
Center for Architectural Research
Rensselaer Polytechnic Institute

This conference has so far touched on a wide variety of research topics: research into environment (spaces, buildings, playgrounds), research into the process of creating environment, and research into the systems of hardware necessary to build that environment.

Much of this has touched on the problem of implementation; that is, the actual task of getting the job done. Not much, however, has been said about the framework within which we must implement - the construction industry. So, here is still another area for architectural research - research on our industry and the decision-making processes which make it go.

We don't have to spend much time detailing the problems of the construction industry. Accounting for more than 10 per cent of our Gross National Product, it is one of the most important segments of our economy. It is also one of the most fragmented. It acts as a loose coalition of owners, financiers, architects, contractors, subcontractors, manufacturers, suppliers, and mechanics. Owners often create projects with little or no indication of how these projects will affect the industry; architects often design buildings which require regional resources which sometimes do not exist; contractors cannot plan because they have no certain knowledge of what may happen in their area of operation; and labor feels that all it can do is react to demand rather than control its own destiny in the industry.

The result of this fragmentation can be seen everywhere. Unpredicted price increases, strikes, employment fluctuations, varying productivity, and misguided cost estimates can, in part, be attributed to this phenomenon.

Consider what a builder like the State University of New York can do - wittingly or unwittingly - to the construction industry.

With a multi-billion dollar building program concentrated in some thirty locations in New York State, it has the capacity to literally upset the industry in those areas. Even though the projects are planned several years in advance, their influences are not really felt until ground is broken. And then the bottom drops out. Labor cannot be found, men must be brought in, premiums are paid, productivity decreases, and when negotiation time comes around, demands are great. Sometimes the sheer quantity of work so strains the material capacity of the region that there are troubles in this area. The cost of the work exceeds original estimates and the projects begin to drag out.

Nor is the State University the only offender. New York's capitol district has also seen large government center, highway, and private development in the last few years. These efforts all hit the industry at once, and they still tell stories about 15 per cent price increases in two months in this area!

As part of what it feels to be its responsibility to the industry, New York's State University Construction Fund has long considered ways of coping with this problem. One approach which was suggested was that of getting better information to all components of the industry as they make their decisions; and for a number of years, officials of the Fund discussed the possibility of developing a state-wide Construction Information and Analysis System.

The thinking behind such a system was that if it could indeed collect data on the demand to be placed in a region for the next two to five years (that is, the projects which are being considered for that area), and if it could begin to collect data on the supply of resources available to do the job in that region, everyone concerned could begin to develop a "picture" of the construction market for that region and that time. This "picture"

could then be used in making a wide variety of decisions by all concerned.

This established three objectives for a Construction Information and Analysis System:

1. To assess and project construction market conditions on a regional basis,
2. To relate the cost of producing finished construction in any part of the state,
3. To provide other economic information as needed by each of the components of the industry.

If the System could be implemented, it was suggested that owners and architects would be able to intelligently use this market data in a wide range of timing, location, budget, bid package, and even some design decisions. Further, architects, contractors, and labor leaders could use the demand information in their own planning efforts. The system would not give one component control over the others; rather, each would be able to exert some control over its destiny in a complex and generally uncoordinated industry.

With all of this in mind, the State University Construction Fund (with some help by New York's state-wide Office of Planning Coordination) asked the Center for Architectural Research to undertake a small study into the feasibility of developing and implementing such a system. That study is now in progress.

The feasibility study has been a fascinating one to say the least. It began by taking a look at each of the components of the construction industry - owner, financier, architect, contractor, subcontractor, manufacturer, supplier, and labor leader - and attempted to define for each,

1. Their goals and motivations in the industry,

2. The unique set of economically-related decisions each makes in fulfilling its role,
3. The types of information needed to make these decisions,
4. The usual sources of this information.

In parallel with this analysis, the Center undertook a study of the construction market: What it is, how an understressed and overstressed market is created, and what broad effects different types of markets have on decision-making in the industry. This is the most interesting aspect of the study, and, of course, the limitations of time and money preclude the in-depth effort really required. As soon as one begins to look at phenomena like seasonality and productivity, though, he is immediately struck by the lack of data to support his hypotheses. At this point it becomes evident that a Construction Information and Analysis System can also play another significant role: to generate the kinds of information which can be used to get a handle on these problems and then feed this all back into the System itself, improving its own analysis and projection capability.

In looking at the construction market, its demand components are fairly easy to identify. The unit of construction demand is the project, and to the extent that one can find out that certain projects are planned for an area, he can begin to fashion a picture of demand in that area. During the feasibility study, it has become evident that a good portion of this demand information is indeed available, and often for a number of years in advance of actual construction. With the ever-increasing role of government funding of work in the industry, and with government moving into long-range planning, it is becoming possible to identify many large projects long before architects are selected. Because the owner and the architect are the most direct benefactors of such a system, it is felt that it will be possible to obtain a

good deal of demand information two to three years before bidding. This is most important, for the system is not envisioned as a detailed cost forecasting system used during design; rather it is felt that its real effectiveness will be felt in the earlier stages of planning, budgeting, location, and schematic design. Projects must be known as far in advance as possible.

The State University Construction Fund is already operating a mini-version of the demand "side" of such a system by publishing a bid calendar of State University work. It is perhaps symptomatic of the coordination problem that this calendar does not even include other projects already established by other state agencies in New York.

A construction information system will not be able to fulfill its objectives by looking only at demand, however. The supply of resources available to the job - the construction "capacity" of a region, if you will - must also be investigated, reported, and related to demand information. When the Center began the feasibility study, it assumed that there were three prime measures of capacity:

1. The capacity of contractors to do the work,
2. The materials capacity of the region (particularly with regard to those which are locally produced or difficult to transport),
3. The number of tradesmen available.

Initial findings, however, were unanimous in concluding that labor - the third factor - is easily the most critical measure of capacity. Contractors were generally of the opinion that except for unusual cases (e.g., where bid packages are simply too large), the contractor capacity to do the work will develop <u>if</u> the tradesmen are available. Others felt that while material problems can affect cost in special situations, this becomes

insignificant when compared to the effects of insufficient labor to do the job. These discussions have suggested that an initial version of such a system must place a great deal of emphasis on labor as an indicator of construction capacity.

This, of course, will not be easy. Anyone who studies the industry knows that there is no "fixed" supply of labor in a region, that it reacts to the amount, type, and timing of work available in both local and adjoining regions. We can also hypothesize that as demand for tradesmen begins to approach and overtake the regional supply of these, a whole new series of forces may be created: overtime, travel allowance, employment of marginal producers, etc. These and many other factors potentially influence cost; the minute interactions between the supply and demand for tradesmen will be most important to the effective functioning of a construction information system.

So far, the feasibility study has found the labor component of our industry to be most cooperative. Although cautious by nature, some labor leaders feel that many of their problems stem from the fact that they can only react to the forces that are created in their region; they have little advance warning. If such a system could assist them in planning to maintain full employment for their local members, they would be interested.

The task of the feasibility study has also been to define the form that such a system will take. The Center's general approach has been to design the system in concept - seeing what kinds of input will be required, the kinds of output materials that may result, and the kinds of supporting research which will have to be done to achieve the necessary results.

Obviously, a Construction Information and Analysis System will have to be computer-based, accepting input data and producing

reports, listings, charts, and projections on a regular (probably monthly and quarterly) basis. The feasibility study has concluded that if it is carefully designed, such a system can produce "something for everyone." This is important because once it is developed, the system would have to become self-sustaining.

So far, we have only talked about a Construction Information and Analysis System as an abstraction. Let's look at one user - architects, since most of the persons at the Conference fill these roles - and see how it could assist them in making economically based project decisions by providing some useful data.

Decision	System May Be Able to Provide
Feasibility studies on project location, timing, and size	Building cost escalation for specific times and locations
Programing: assisting in identifying project functions and amounts of space required	Building cost escalation for specific times and locations
Selection of major building systems and materials	Cost information by construction type for time and location selected
Selection of major materials and assemblies	Cost information on materials for time and location selected
Revision of previous decisions on space and budget	Cost escalation information for a specific time and location, and of increasing reliability as bid date draws near
Establish size of "bid package" and possibly assemble a bid list	Contractor capacity to do the work; possibly information on current levels of contractor commitment
Establish bid date	Pattern of estimating and bidding in the area for next several months
Establish completion date	Project schedules for similar projects in the past
Check and approve requisitions for payment	Records of progress on jobs similar to one under construction

This information would come to the architect in charts and graphic materials once a month (or possibly once a quarter for some of the more stable data). In return, he will be asked to provide information on projects which he is undertaking in his own office.

The feasibility study has charted similar decision "paths" and developed similar notions of how the system might support those decisions for owners (both long and short-range planning), contractors, and labor leaders.

In closing, I might say that one of the most fascinating aspects of developing and hopefully implementing such a system is that of predicting its possible influences on behavior in the construction industry. The initial conclusions from the feasibility study indicate that if it is approached carefully, at least an initial version of the system can indeed be implemented in New York State. Whether it will be reliable enough to be of any real value in forecasting is hard to determine: It will not be able to forecast until it begins to build a data base, and it can't build a data base until it begins to collect and report information. And even when all of this does begin to happen, we have no real idea how the various components of the industry - the owner, the architect, the contractor, the labor leader - will actually react.

People have always been unpredictable, and the construction industry is not known for its predictable ways. Here, of course, lies the challenge for a Construction Information and Analysis System.

DECISION MAKING

IN A COMPLEX PLANNING PROJECT

The Baltimore Urban Design Concept Team

By

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A proposed 24 mile freeway through the heart of a major city, when viewed as a design and decision process, is in many ways similar to simpler design problems. Indeed, there is a generic process, which we can identify abstractly, to which all design problems conform. What I shall attempt in this analysis is to first identify the general pattern of design and decision process, then to identify some of the major characteristics of the Baltimore project and to compare them to both the simplistic pattern and to what might be suggested as an optimal urban development process.

As we make this excursion into design methodology, we can anticipate certain primary points. First, that process, of itself, is meaningless. It is essential as half of the design unity, as a container for fluid, the other half being the people: the designers, the deciders, and the users. Process gives order; people give life. Second, that the gap between optimal design system conditions and today's U. S. A. urban reality is so immense, it is a wonder indeed that anything decent gets done, yet we must continually seek the cutting edge and move forward.

GENERIC PROCESS

The process consists of four phases:

1. Initiation
2. Design Process
3. Evaluation
4. Realization

Whether the object be a single house or an urban movement system, certain different types of decisions are made in each of these four phases. In simple terms, they are the following:

1. In the initiation phase there is a decision to employ a designer in response to certain felt or assumed needs. What scope will he have?

2. The design process phase is complete when there is a proposal to evaluate. The key decision here is a design decision: which alternative to propose.
3. The decision in the evaluation phase is whether to commit resources and proceed with construction and operation of the facility.
4. Decisions in the realization phase are mostly concerned with questions of how to achieve or modify the plan.

So ends the simplistic phase of this outline.

BALTIMORE - INITIATION PHASE

It was from a variety of different sources that forces in Baltimore converged into a decision by the State Roads Commission to retain the first major inter-disciplinary team to tackle an urban freeway program. This was a significant departure from the usual practice of highway engineers doing the urban freeway job alone. This combination of forces included, first of all, a mobility need for the city; secondly, the highway trust fund has a free-flowing source of funds for urban mobility, impeded only by the difficulty of finding the place to put this facility. The third ingredient was that, as in San Francisco, controversy stopped the highway. The fourth ingredient is the fact that the profession of urban design is coming of age.

It took approximately one year between the time that Archibald Rogers of the local American Institute of Architects Urban Design Committee identified for the State Roads Commission the process which would organize the Urban Design Team to fit the city and the highway together, and the time that a contract with the Urban Design Team was actually initiated. During this year, the City

Council of Baltimore was the primary arena in which the play of divergent forces was acted out. There were those who saw no need whatsoever for any expressway. There were those who felt that the anticipated highway must go through come hell or high water, and that anyone who stopped or delayed it was an obstructionist. When finally the Concept Team was formed and started to work on October 3, 1967, it was launched in a context of mixed emotions and was destined to continue its existence under an intense crossfire, which continues today. Before the Concept Team was put to work, the Baltimore City Council passed 24 miles of City Ordinances, through parks, ghetto, waterfront, historical areas, industrial areas, and the downtown. The decision to retain the Concept Team to, as the contract says, "be sure that the Interstate System for Baltimore City will be an efficient transportation facility as well as meet the social, economic, and aesthetic needs of the neighborhoods," was coupled with the passage of the Condemnation Ordinance. Freedom and constraint in one package.

DESIGN PROCESS

The major objective of the Urban Design Process is to generate that variety of options which can give the community a significant choice over the kind of future environment it will live in. In the context of the highway project, there are three components in this environment: the road itself in relation to the total transportation system; joint development facilities, that is facilities such as schools, housing, shopping, recreation; and other elements of urban structure which would either be deleted and might be viewed as compensatory facilities or new opportunities for growth and development stimulated by the presence of new accessibility. In some locations this means building in the air rights of the highway itself. In others, it involves the air rights and contiguous areas. It also includes buildings

far away that result from the presence of the highway for such things as housing or new industrial areas.

The third component of the design product we call environmental programs. These include the things one doesn't see that affect people, such as relocation compensation payments to owners and tenants. It involves educational planning. When a highway demolishes a 300-400 strip through a city, it demolishes schools along with other elements of the urban fabric. Environmental programs occasionally lead to physical joint development projects. In the Franklin-Mulberry corridor in Baltimore, the Concept Team, together with the School Board and the City Planning Agency, the City and State Governments, have proposed to the Federal Bureau of Roads the building of a new educational park and community facility to be connected to adjacent facilities in the neighborhood. Coordination of all related government agencies is the need here.

It is clear that among the key decisions is the decision about what kind of process should be used as well as what kind of team it should be. Another key set of decisions is who shall be on the team.

The capability to perform useful service to the community in the face of a corridor that passes through every segment of life in the city cannot be met by any one field of expertise. Rather, a combination of the technical, the economic, the urban form, the social, the political, and the managerial fields must be focused together. In Baltimore the team is comprised of a joint venture with primary responsibility and a set of consultants who have advisory roles. The Joint Venture is composed of Skidmore, Owings, and Merrill, Mr. Nathaniel Owings as chairman; Parsons, Brinckerhoff, Quade and Douglas; Wilbur Smith and Associates, traffic consultants, and the J. E. Greiner Company, Baltimore engineers.

Participating as consultant to the Joint Venture has been Charles Abrams, former head of the School of Architecture and Planning at Columbia University. His primary work has been an analysis of the housing problem in Baltimore and the relocation problem due to the expressway in the context of the overall Baltimore housing condition over the next ten years. Lloyd Rodwin of MIT and Anthony Downs of Real Estate Research Corporation are consultants in economics. George Greir of the Washington Center for Metropolitan Studies is the sociologist. Kevin Lynch and Donald Appleyard have been occasionally consulting on our environmental design process, as well as Horst Rittel of the University of California in Berkeley, who helped with the development of the initial planning process. We have recently been aided by the services of Howard Moskof, the Executive Director of the President's Commission on Urban Affairs. His work, which is strengthened from his experience under Mayor Lee and Ed Logue in New Haven, has been to identify Federal, state, and city programs and funds for the implementation of joint development projects.

A set of decisions, which has worked out very well, was made at the start of the project. This was to set up different design teams for different sections of the city in such a way that individuals could identify with and understand not only the lay of the land, but the needs and attitudes of the people on a block-by-block basis throughout the stretch of this corridor. These four teams are coordinated by a city-wide team, which relates to the City Planning and Regional Planning Agencies.

A major issue, involving a key decision, is the extent of community involvement in the design process. This is one of the leading subject candidates for an argument and one in which the Concept Team finds itself under the most crossfire. What we have actually done is to establish recently a field office in the ghetto area. Prior to that, we have met with neighborhood as well as city-wide organizations concerned with various aspects of the highway. We have

attended more than 50 formal meetings and an untold number of informal meetings to gain an understanding of needs of people in the corridors and in the city as a whole. The controversial aspect is from extreme viewpoints. On the neighborhood level, spokesmen from a local group request veto power over a route. On the other side, from the highway interest level, there is pressure to ignore or spoonfeed community groups after the decisions are made.

After a year on the job, a group called Movement Against Destruction (MAD for short) has been formed. It represents a wide spectrum coalition of city groups, from Black Power to the archdiocese, and includes the League of Women Voters and members of professional societies as well as representatives from City Council.

As the teams of nearly 70 people move through the successive design phases of the project, that is, first the research and urban design framework phase, and second, the urban design schematic and feasibility phase, a wide variety of conceptual options is generated. Also, a wide-ranging display of problems is generated.

Among the most significant design options that have evolved are: the combination school-multi-service facilities in the heart of the ghetto area, known as the Franklin-Mulberry corridor; a proposal to shift the route out of the Rosemont area, a middle-class Negro area in West Baltimore; and a major change in the given route system, perhaps the most important design option recommended. This would, in effect, run a bypass route, which would remove and diminish the impact in the central areas of the city, cause less displacement, result in improved preservation of architectural, historic, and neighborhood assets, as well as free up the traffic carrying capability of the freeway system and the central business district streets. The project

will be one year old on October 3 - and it is a two-year project. The hard decisions remain to be made.

EVALUATION PHASE

The evaluation process in a complex project such as this differs so much in character from that of a house that urban design becomes a totally different species from architecture on this level. Multiple clients, instead of the single client, bureaucracy, instead of simple efficiency, are the order of the day.

Who is the client in this case? Ideally, at the policy level, there would be a combination of all those with a responsibility for expenditure of funds or policies. This would mean a combination of Federal agencies, such as the Departments of Transportation, Housing, and Urban Development, Labor, Health, Education and Welfare, etc., and the Federal Bureau of Roads. At the city, regional, and state level there are the State Roads Commission, the Mayor, the various city agencies of Planning, Traffic and Transit, Public Works, etc. At the private sector level, there are representatives of commerce: business, banks, insurance, etc.; representatives of industry, cultural, university, and community interests. As it is in Baltimore, there is a Policy Advisory Board, chaired by the State Roads Commissioner and consisting of the Mayor of the City of Baltimore, the head of the City Department of Traffic and Transit, the Attorney General for the State Roads Commission, and two other State Roads representatives. The Urban Design Team relates on a technical, coordinating level to a committee designated by the Mayor and chaired by his development coordinator of the heads of all city departments. The Design Team meets weekly in Baltimore with this group. At the same time, the Urban Design Team staff members have informal liaison with staff level of all the city, regional, and Federal agencies. There is also, naturally, informal liaison with the private community.

The sequence of design decisions on the Baltimore project is as follows: Design reviews take place internally with Skidmore, Owings and Merrill staff and the Urban Design Director and subsequently with the partners-in-charge. There is then review by the Joint Venture principals. This is frequently preceded by staff level Joint Venture review. Proposals are then evaluated by the direct client, the Chief of the Interstate Division for Baltimore City. This agency is a combined City-State agency with one chief. The proposal then goes through the Coordinating Committee, the Policy Advisory Board, the Bureau of Public Roads, and ultimately the Department of Transportation.

Now that a year has passed, the proposals for joint development have taken on a seriousness that could not have developed until the economics and social and urban design consultants, together with the team members and the community have completed their analysis and made their determinations. A new client is being contemplated. This will enter significantly into the decision-making process. What is being considered now is an urban development corporation. Its task, together with the Concept Team and the City agencies, will be to develop planning and implementation to the point where funding from the public and private sector can be secured to achieve proper corridor joint development. The formation of this new entity is under intensive discussion at this time. Some 16 clusters of development, ranging from housing to industrial, to waterfront development, to schools, community centers, commercial facilities, have now been identified along the 24 miles of the highway.

REALIZATION PHASE

Perhaps the one thing which makes this project so critical, so pertinent and so exciting is that it will culminate in a real, built, physical product - not in a paper plan, although one might

wishfully think that it would be better that the city were a blank piece of paper with time to consider everything before beginning any work. The fact of life is that the highway is being built as we sit here today on the outer extremities of the city. The major remaining decision to be made by the Policy Advisory Board, and now that the community is attuned to its options, by the community through its City Council as well, will significantly alter the face of Baltimore in the years to come. The most critical decision is undoubtedly one of the route itself. This is expected within the next month.

Next in importance will be the future development of the Franklin-Mulberry corridor, an area which has been prematurely demolished already, even before the road schedule for that area had been set, before the Urban Design Concept Team arrived in Baltimore, as 1975. Here the concentration of work of the Team is to develop options that can be started immediately: options of urban development for schools, housing, recreation, and community facilities in concert with transportation.

Another key decision is in the field of housing and relocation. Surveys by our consultants reveal that in the next ten years Baltimore will need some 25-30,000 dwelling units. This is far in excess of what has habitually been built. Ninety per cent of those to be displaced by public and private projects are non-white. Baltimore neighborhoods have not been, in the past, open neighborhoods. How to meet this reality without driving out the white population faster is an issue that will have to be faced soon in connection with the highway and other public programs.

Another key aspect in the realization or implementation phase will be the hopeful resolution of the difficult problem of coordination at the Federal level of the Departments of Housing and

Urban Development and Transportation into efficient machines for properly guiding the insertion of transportation facilities into existing cities with skill and humanity.

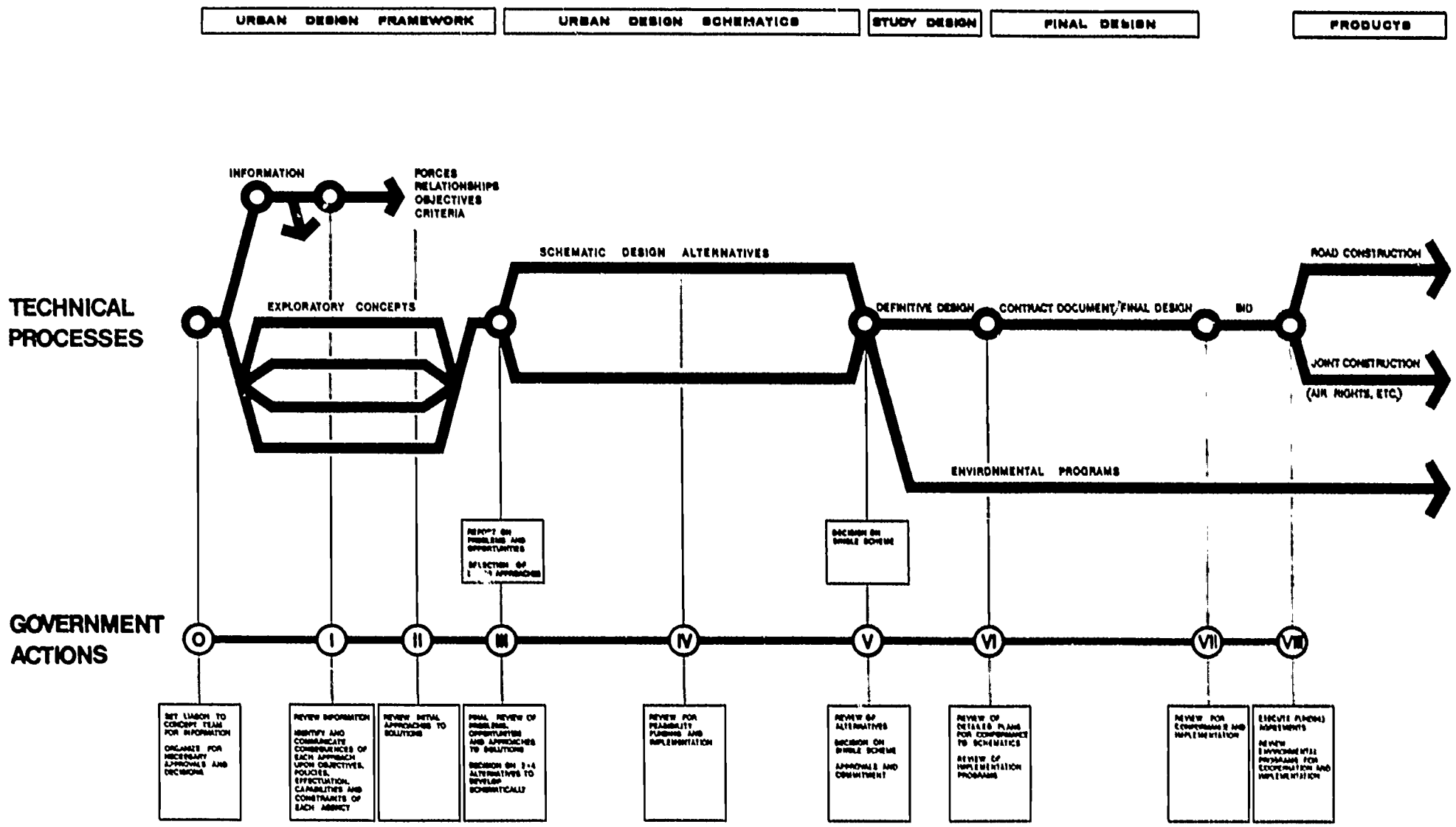
CONCLUSION

Mr. Owings spoke recently to the Baltimore Citizens Planning and Housing Association. The talk was called "Planning in the Fifth Dimension." By this phrase, he meant decisions by the people, properly informed. As at the Czech movie at Expo, the audience was asked to participate in the decision as to which ending - happy or tragic.

The urban design process has this capability to display options so that democracy can be more truly approached. Instead of silent decisions by vested interests, the people, through their elected representatives, can make the key decisions.

BALTIMORE URBAN DESIGN CONCEPT TEAM PROCESS

MAY 1967



HOW LONG WILL YOU LIVE?

By

HENRY L. LOGAN

Vice Chairman of the Board
Holophane Company, Inc.

To make your future longer, one necessary thing is a sufficient, daily, all-year round dosage of sunshine (or its equivalent). Eighty-five per cent of the people in this country do not get it today. They are indoor people whose means of livelihood, geographical location, and conditions of living deprive them of access to enough life-giving natural light.

It is not yet realized that many of the things that trouble our society have their roots in sun-deprivation. Entwhistle has pointed out, "We see today in the organism sector of the human ecosystem a continual increase in the symptoms of cultural degeneration. Apart from the juvenile delinquency and the penetration of the roots of crime into every element of our society, functional disorders of the nervous system are increasing by leaps and bounds."

The nervous system is one of the principal beneficiaries from a daily sub-erythemal dose of sea-level solar radiation.

In 1900 A. D., 85 per cent of our people were rural. Now 85 per cent are urbanized.

This rush to the cities is one of the principal reasons peoples of the western world, with their long winter sun lack, plus all-year round living, learning, and working indoors in cities (with polluted atmospheres which cut the biologically beneficial rays 30 per cent, and behind window glass which cuts out all the rest), find their death-rate peaking in March.

It is true that our life expectancy is still increasing, despite this drawback, but that is only because we are successfully combatting other assaults on our longevity (that operate faster than sunlight deprivation) with more abundant and better food, pure water, sanitation, cures for previously fatal diseases, and so on.

All this is fine, but when all the short-term killers are under control, we will still have to contend with the long-term effect of sunlight deprivation; and this is going to get worse.

Our technology has improved our protections against the hostile effects of nature to the degree that our average life expectancy is now about 70 years, which is 75 per cent longer than a century ago, but we have not truly lengthened life. We have salvaged some of the potential life born into us that the harsh living conditions of previous generations did not allow. While the potential length of life of Man is a subject of continuous debate, there is evidence that it is much longer than our present life expectancy.

Some experts believe that inherent in people is a potential life of from 125 to 175 years. Some people have lived to 150 years, as witness the famous case of Thomas Parr, who is claimed to have died at 153.

In any event, the probabilities are that we are now dying at about half our true natural length of life and that unless we introduce the beneficial effects of sunlight into our interiors, we will not get much past our present performance of 70 years average; in fact, with the increasing pollution of our land, rivers, oceans, and atmosphere, we may begin to go backward.

Man's technological capacity to control his immediate environment by clothing, closed vehicles, roads, and buildings, his capacity to alter his environment by driving uncounted living things out of existence to make room for his satellites - his food, fiber, tobacco, and beverage crops, and his meat and work animals - have placed his very existence in jeopardy.

The urbanization of modern man, which has happened in this century, has been made possible by, among other things, the skills of architects. All the minuses of urbanization were put together in a serious essay last September, in Esquire, titled, "The Human Race Has, Maybe, Thirty-Five Years Left," which came out with a very gloomy picture of the future.

The people who need to be informed are not aware that many of the things that trouble modern society and are driving it, Lemming-like, towards race suicide, have their roots in sun-deprivation.

The work of the world has come within arm's length and must be protected from the hostile swings of nature, so it has come "indoors." The rush to indoors has speeded up to such a degree that the figure for 1975 is expected to be 93 per cent of the people crowded into urban areas, all of whom will have left the sun outdoors, without which life, in the long run, is impossible. Present artificial light lacks the essential bio-effects, and so does natural light through glazing. Artificial indoor climates protect against Nature's extremes but can hardly be said to invigorate.

Most of Western man's waking hours are spent in artificial conditions and under artificial light or emasculated daylight, out of which has been filtered most of the biologically active frequencies - what one investigator calls "light spectrum pollution." Where the workers live in most of North America and Western Europe, their only practical possibility of getting a minimum necessary daily ration of solar radiation is in the summer. The sun does not rise high enough in winter for its life-giving rays to be adequate. In much of Russia the sun does not rise high enough all year round, which is perhaps why the Russians have been the first to make practical, large scale application of what I have

come to call "Bio-Lighting" and why they are developing a literature on the pathology of "light-hunger."

Until now we have been mainly concerned with what we can describe as "Visi-Lighting" - lighting for visibility. This is not to overlook the interest architects have in color, shadows, sparkle, and the other factors that affect the moods of people, which, however, are psychophysical and operate only if visible.

We have not been concerned with the non-visible and extra-visible properties of that part of the electromagnetic spectrum which includes visible radiation, and it is only in this century that these parts of the electromagnetic spectrum (Figure 1) have begun to be investigated for their biologically beneficial, or harmful, direct, or side-effects.

The vast extent to which light, as one of the constantly present environmental factors influences the health and longevity of people, is now emerging from innumerable new researches. Dr. R. J. Wurtman of Massachusetts Institute of Technology, for example, has published a digest of 180 researches dealing only with the effects of light on the glandular system, the general thrust of which is to underline the importance to health of living under solar radiation, or an artificial duplicate of it, but it was published in Neuroendocrinology, and what engineer or architect subscribes to that? Dr. Wurtman's conclusion is that "light is the most important environmental input, after food, in controlling bodily function."

In 1964 the New York Academy of Science published a 694 page book dealing with the influence of solar radiation, particularly as received through the eyes, on our daily and seasonal biological rhythms. The National Research Council has published a series of volumes dealing with "Radiation Biology," of which

Volume 2 covers "Ultra-violet and Related Radiations," and Volume 3, "Visible and Near-Visible Light," with 3140 research references.

"Medical Radiation Biology" by Dr. F. Ellinger covers 4600 researches. Just to pick a few items at random, industrialists will be interested in Backlund's research which indicated that the irradiation of human subjects with erythema-producing doses of ultraviolet resulted in an improvement of work output. In studies on the bicycle ergometer, under laboratory conditions, work output was increased up to 60 per cent.

Ultraviolet radiation increases protein metabolism. In carbohydrate metabolism, which concerns fluctuations of the blood sugar level, the blood sugar of normal individuals is unaffected while that of diabetics is reduced, the effect being similar to the effect of insulin, according to L. Pincussen.

Exposure to ultra-violet radiation results in a drop of blood pressure, according to J. R. Johnson, B. E. Pollock, H. S. Mayerson, and H. Laurens. In patients with arterial hypertension, the fall is most pronounced, averaging 17 mm systolic and 7 mm diastolic. In people with high blood pressure, this may be just the difference needed to protect them from heart attacks or cerebral accidents.

A daily sub-erythemal dose of sea-level solar radiation increases the gamma globulin fraction of the blood (which protects against respiratory and circulatory diseases).

An article in one of the medical journals in 1964 raised the question if the acceleration of the incidence of cancer in this country during the last half century has any connection with the fact that during that period we have become a "glassed-in" people.

Some light was thrown on this indirectly by the experiments of Dr. Ward Griffen and Dr. J. Bradley Aust of the University of Minnesota in their report to the American College of Surgeons, meeting at Chicago on October 6, 1964. When the plasma expander, dextran, is injected into the blood vessels, its large molecules attract water from the body tissues, thus enlarging the total volume of circulating blood. At the same time, it was found that this cut the colonization of cancer cells drastically. Some evidence was found that the negative electrical charge on cancer cells was increased, causing them to repel eachother more strongly. There may also be an effect on the lining of the blood vessels to keep the cancer cells floating and not to allow them to pass out of the blood. In this state of disorganization and inability to pass out of the blood vessels, they apparently float until they die.

The experiments of Oerum, Graffenberger, Marti and Finsen showed that high levels of daylight increased the total quantity of blood markedly. It is a reasonable assumption that this comes about by a similar absorption of water from the tissues, and it may, therefore, set in operation the same kind of mechanism that is accomplished by dextran, thus reducing the incidence of cancer colonies.

In experiments with cancer-susceptible mice, Dr. L. Gabby found that those exposed to pinkish light developed the cancers sooner and died earlier than those exposed to natural light. This ties in with Dr. Pittendrigh's work giving evidence that light affects the operation of the genes in the cells, which changes their chemical balance.

The degree to which solar radiation affects the operation of the body and its state of well-being or deficiency is incredible to the uninitiated, but perhaps the most important thing it does is

to generate Vitamin D. Vitamin D is of vast importance to mankind. It appears to be one of the factors which has determined the development and distribution of the races. It is produced by the skin in the presence of solar radiation.

I mentioned earlier that it is only in this century that the effects of the electromagnetic spectrum on living things and on non-living things had begun to be investigated in depth.

The Joint Technical Advisory Committee of the IEEE and EIA has reported, "Man is finding that some of the thresholds of nature are being exceeded or triggered. Two considerations of increasing interest are - the discovery that there exist one or more natural or man-made resonators in each frequency band and that weak as well as powerful transients can often be harmful. When such phenomena take place the result may be a mutation, a change in chemical formula, a degradation of biological cells, electronic malfunction, or an explosion." (Fact: A missile was detonated at Cape Canaveral, Florida, set off by resonance from a weak transient caused by a taxi despatcher's voice on short-wave radio in Dallas, Texas.)

It should be noted that current arc sources of light, fluorescent, mercury-vapor and the metal additive lamps require electronic gear for their operation. With the anticipated increase in lighting levels, the dosage of unwanted and undesirable radiation will increase. Even now, the electromagnetic smog that is presently being created in some areas is already upsetting homing pigeons (claimed reduction in return in some cases down to 2 per cent).

I mention this in passing as it is an aspect and hazard of indoor generated radiation which may be new to you. It points to the need for more effective shielding in buildings and improved screening of the radiation-producing components of equipment, in the equipment itself.

Of greater interest to us is the new field of Bio-Lighting which gets its importance from the fact that the work of the world has come within arm's length, requiring close, detailed seeing, under protected conditions, forcing workers to move indoors. The workers largely live in areas where the sun does not rise high enough in winter for its life-giving rays to be fully effective, and when it is high enough in summer, its biologically beneficial frequencies are attenuated by the polluted atmospheres hanging over our megalopolies, and further reduced to practically zero by glazing. All apart from the fact that our working buildings are now so large that solar radiation, even if not absorbed by the glazing, could only penetrate the perimeter offices, or perimeter areas, to a maximum effective depth of about 15 feet with the low ceiling heights that building costs force us to adopt.

Our next slide (Figure 2) shows what we are heading into. This is a megastructure to provide housing, service facilities, stores, offices, school, and recreation centers within one building complex. Everything will be within walking, or easy interior driving distance, and all needs will be supplied. It will be unnecessary to go outdoors and the time will probably come when to do so will be considered barbaric.

The next slide (Figure 3) shows the way the wind is blowing.

These slides, Figures 4 (Proposed Waterfront Complex, N. Y. C.), and 5 (Tigerman's "Instant City"), show still other projections of future complexes.

The next slide (Figure 6) is called "Total Habitat" by the photographer and shows one example of how far we have already gone in developing what are now called "Ecosystems" for people. The vital function of the total habitat in the life and health of the organism is well-established in the biological sciences, and man shares

this dependence. Our present artificial ecological system is no system at all. It has grown like topsy, without any coordinated planning and the results show in what is happening to people everywhere.

One thing seems clear: We cannot successfully live in the indoors, into which the human race is rapidly crowding, unless we take the sun in with us; and the only way we can do that is to artificially duplicate sea-level solar radiation at the power level (so many micro-watts per square centimeter per second), which is normally associated with the specific Kelvin temperature determined by research to be most suitable AND THE APPROPRIATE LIGHTING LEVEL.

So, one of the matters that will concern future architectural research is what solar distribution and natural lighting level should we try to match indoors. Technology has left the sun outdoors. Architects must be the leaders in bringing it in.

No matter how one looks at it, there is nothing more healthy for people than proper daily exposure to sea-level solar radiation, either generated by the sun or generated indoors by man, and the development of general lighting purpose, artificial sources along these lines is a "must" to protect people in our modern indoor world.

The New York Times recently described the proposal of a Russian architect to design mining towns for the Siberian wastelands by covering them with plastic domes, or linking structures by closed passages that would keep out the winter cold of 40 and 50 degrees below zero. He proposed to generate a sub-tropical climate like Miami by a combination of insulating techniques and the artificial generation of sea-level solar radiation.

This is a special sitaution which may result in the Russians developing satisfactory indoor, solar radiation sources before we do, although our need is just as great, but there is much research spadework to be done.

Special instrumentation must be developed. The following slide (Figure 7) shows the biological spectrograph of the Argonne National Laboratory which is used in studies of the effect of light and its accompanying sidebands on living organisms. It is so constructed that one millimeter of bench space is equal to one angstrom of the light spectrum. Living organisms can be exposed to very narrow wavelength bands for predetermined periods of time. This is important because the effects of narrow spectral bands, and of various combinations of bands, are different, and they must all be searched out.

For instance, exposure to radiation from the middle U. V. region alone is potentially dangerous as you will note from the following slide (Figure 8).

This next slide (Figure 9) shows that radiation from the near U. V. region alone is beneficial but it lacks the important ability to generate Vitamin D.

From this slide (Figure 10), we notice that when combined in the proper proportions, the near U. V. causes a tanning action which protects against excessive dosage of middle U. V. The rate of synthesis of Vitamin D must be regulated within definite limits if both failure of calcification and pathological calcifications are to be avoided. When middle and near U. V. radiations are combined in the proportions of sea-level solar radiation at, for example 5500° K., Vitamin D biosynthesis is automatically regulated to the proper rate.

We need this kind of data on the entire sea-level solar spectrum, from 5500^{0} to 7000^{0} K., and possibly from 3500^{0} to 7500^{0} K.

Most present lighting equipment is ultraviolet absorbing so that the benefits of solar radiating lamps would be cancelled out in totally enclosed equipment and materially reduced in open equipment.

Glare is a severe handicap in critical seeing operations, so, at the high levels of light required for health, lamp-enclosed or lamp-shielded equipment is necessary. At the same time, most interior building finishes absorb ultraviolet, so the beneficial radiation has to be directed straight to the person. One cannot rely on reflection back from the environment. This dictates research aimed at developing new lighting equipment to meet these specifications and possibly new light-handling materials.

Direct lighting methods will rule, which should be no surprise as direct lighting is nature's method. In order to conserve the therapeutic rays, they will have to be controlled by suitable reflecting and transmitting equipment so that they are directed to people. The same methods that are used to control direct glare with direct lighting equipment will work to control the therapeutic component so that it is directed towards the workers instead of being wasted on the environment.

The type of photometric distribution (Figure 11) shown on the screen would be ideal: practically no light in the direct glare zone (Figure 12) with less light vertically downward than from any other direction so that reflected glare would be minimal. The maximum candlepower would be 350 from the vertical, which is the angle at which vertical illumination is at a maximum and would be the most efficient angle for the delivery of the bio-rays.

The appearance of this distribution on a horizontal plane from one unit component of the light source is now on the screen (Figure 13). With a complete lighting system, the individual rings would disappear because of the overlap.

New technical terms will appear. Lamp output is now rated in lumens. It will also need to be rated in power units per wavelength band, or something equivalent, so that engineers can calculate the power output required to produce safe suberythemal doses for any interior, any lighting level, and any predetermined exposure period. At the present time no standard specification for the U. V. component of solar radiation has been set up, for example. Research to establish the relationship between U. V. dosage at safe levels for different footcandle levels and different Kelvin temperatures is urgently needed.

The effect on building design will largely be in the accommodations that the increasing electrical load requires and those that flow from the use of artificial light as a complete replacement for daylight. These will obviously affect fenestration and curtain wall design, modular unit design, ceiling design, and the thickness of the ceiling-floor sandwich, plus those detail changes which will come about through compatibility integration of all the mechanical components of the indoor climate-producing equipment and the shielding that may be necessary to shut out unwanted electromagnetic interference. The latter will probably lead to the introduction of some new building materials.

No static climate is endlessly pleasant. To fully realize the benefits in health, safety, and longer life of a fully controlled, optimum indoor climate, its components should cycle, just as does the natural optimum climate. Attention will, therefore, be given to devices which will cycle the artificial lighting through taped controls based on optimum natural lighting models

in order to provide the tonic variety necessary for optimum physiological performance. Control of the distribution of the light will be coupled with control of the individual frequencies in order to produce conditions of light and shadow-color closer to those experienced in healthful natural surroundings.

To predict these changes in detail is beyond the scope of this paper, and the resources of the writer, but we are now on the threshold of seeing Bernan's prophecy of 1848 come to pass: "The formation and regulation of artificial climate will assume the character of an art for developing and expanding the mind and body for preserving health and long life."

Finally, total energy consumption in this country in 1945 was 30 trillion B. T. U. In 1965, it was 40 trillion - up one-third. By 1985, it is estimated it will be 120 trillion - up 400 per cent in 40 years and 300 per cent over now! Three times the power we now produce! And this estimate is made without considering the necessity for bringing the sun indoors. That is the shape of the future. It is FANTASTIC.

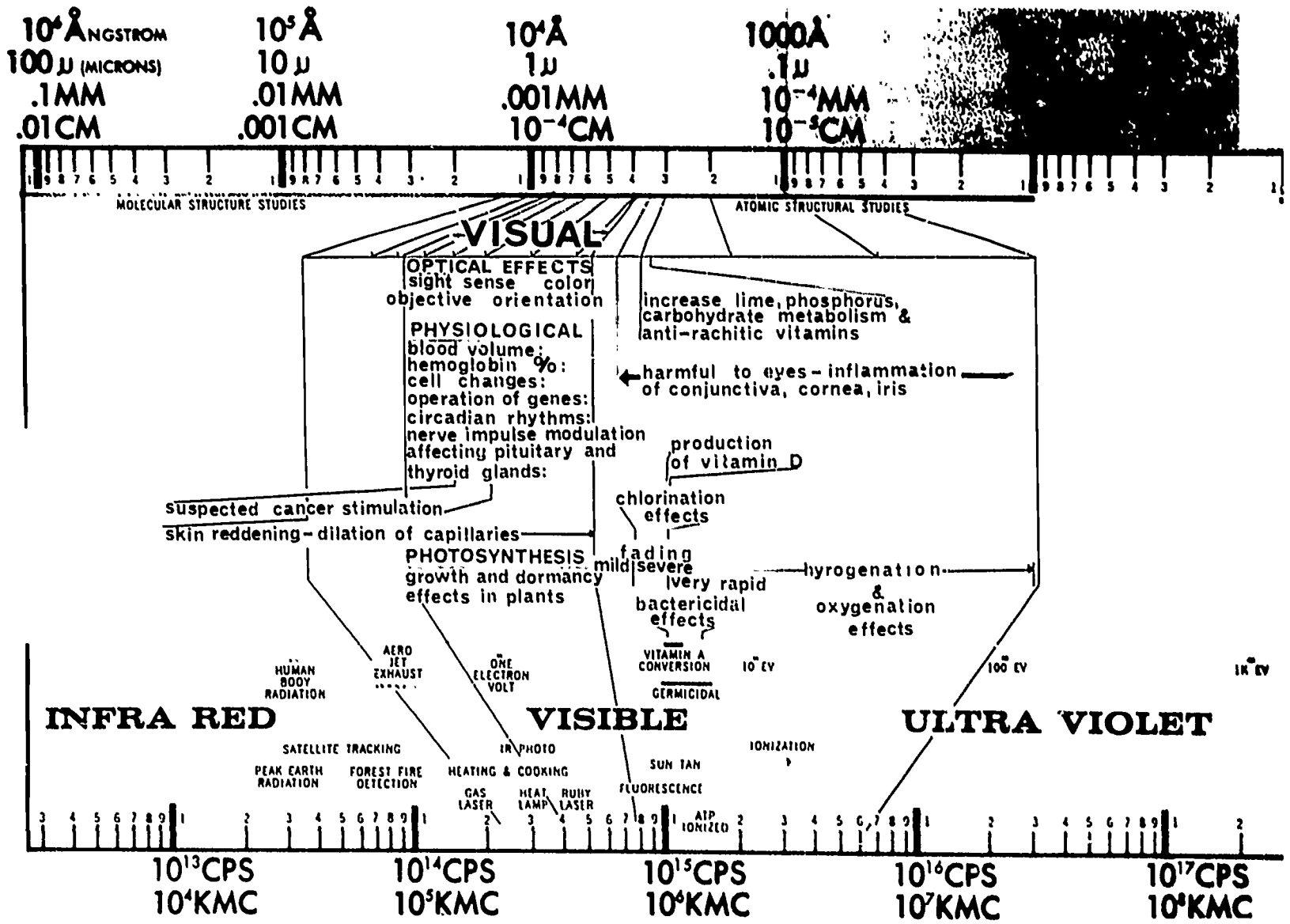


FIGURE 1

ELECTROMAGNETIC SPECTRUM

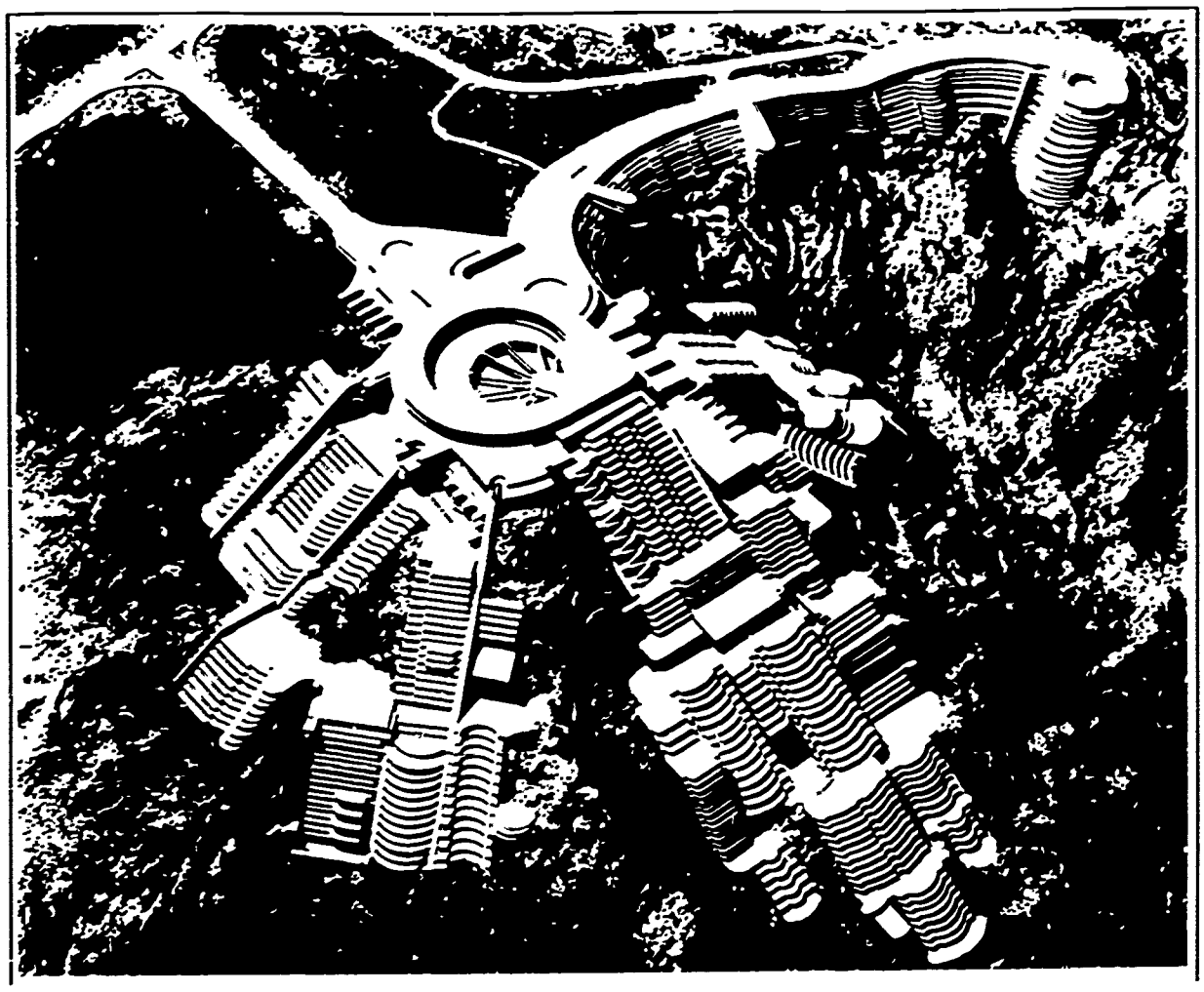


FIGURE 2

MEGASTRUCTURE

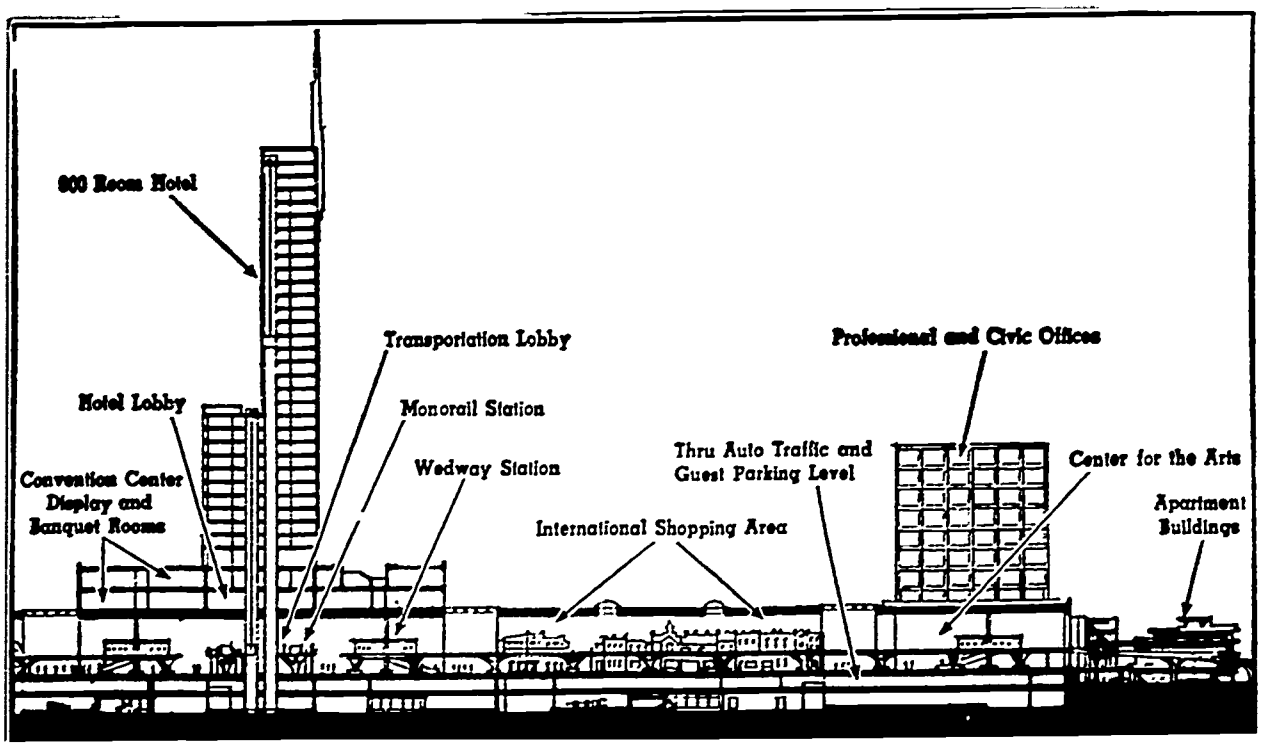


FIGURE 3

CROSS SECTION OF CITY OF TOMORROW

Proposed waterfront complex on the Hudson River, Manhattan. It is designed to be built of factory-fabricated units—about 24 x 60 feet, probably of aluminum, suspended from concrete towers that project from the central service core.

This is an example of a trend that will become increasingly important in urban redevelopment: horizontal, single plane zoning is replaced by vertical, multilevel zoning. Here, light industry is housed on the ground levels, adjacent to transportation, while apartments occupy the upper stories and are also built on the pier over the water. Photograph: Ezra Stoller

Paul Rudolf, architect, New York, 1967

FIGURE 4

PROPOSED WATERFRONT COMPLEX, NEW YORK CITY

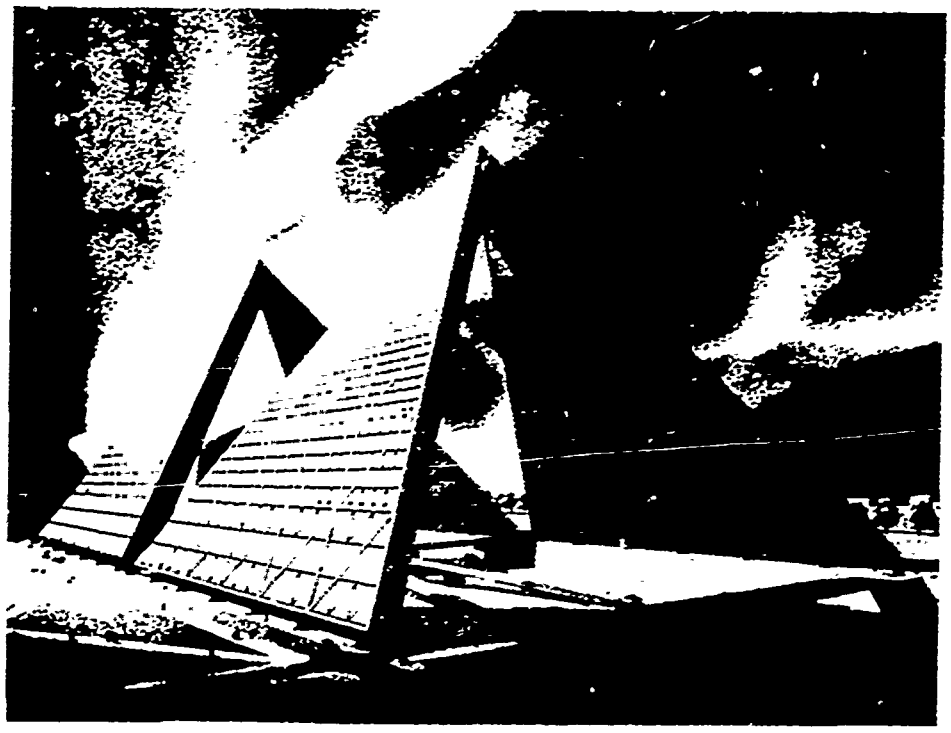


FIGURE 5

INSTANT CITY, 1966, STANLEY TIGERMAN

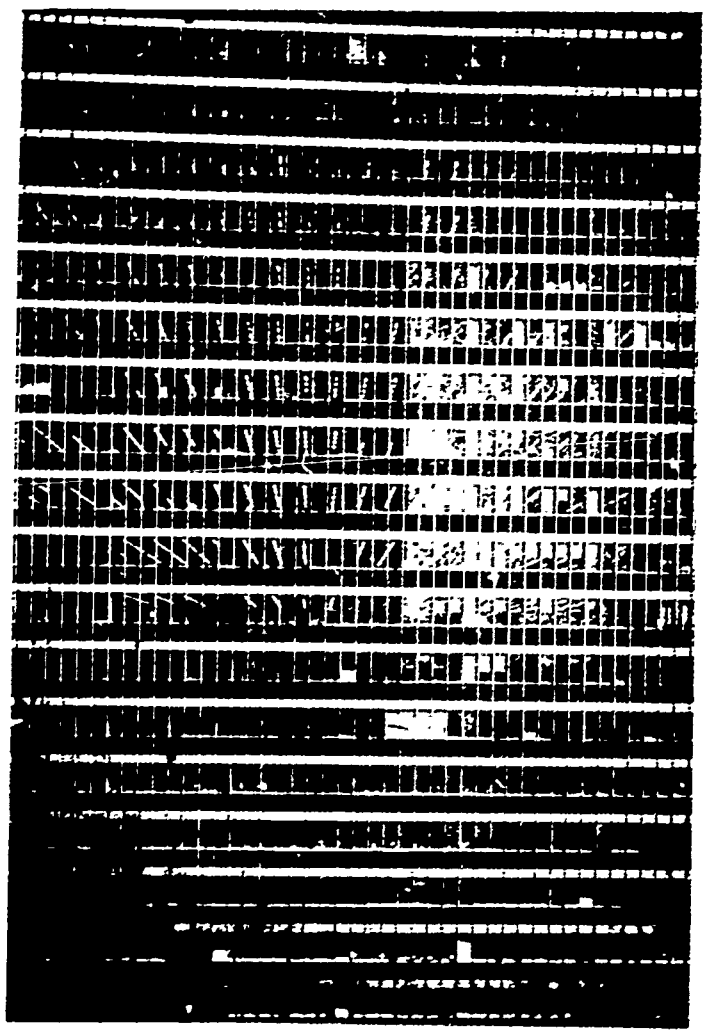


FIGURE 6

TOTAL HABITAT

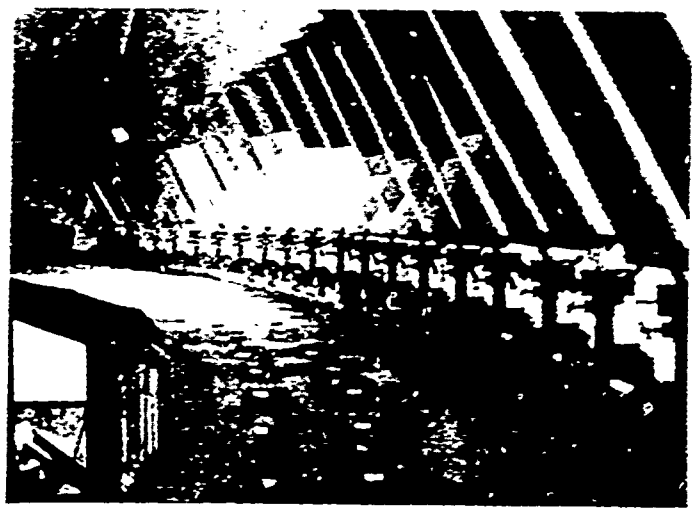


FIGURE 7

BIOLOGICAL SPECTROGRAPH

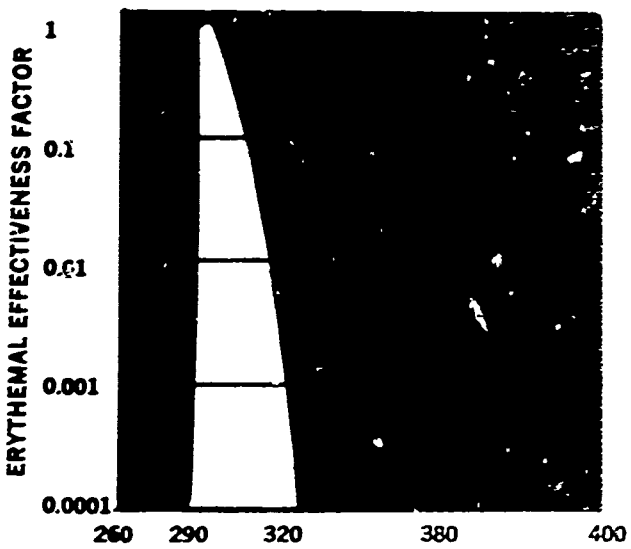


FIGURE 8

MIDDLE U.V.

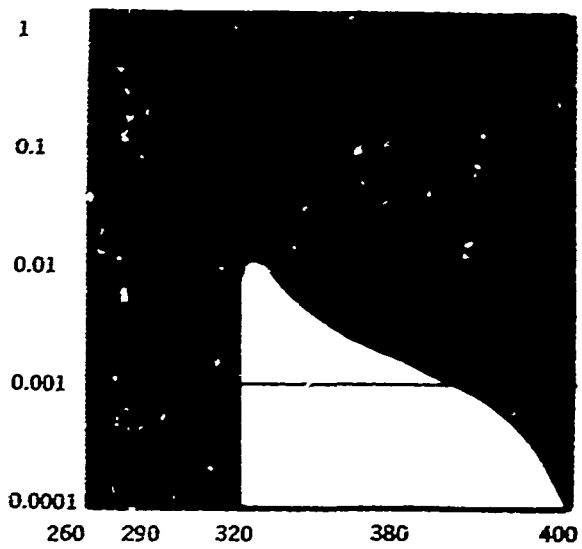


FIGURE 9

NEAR U.V.

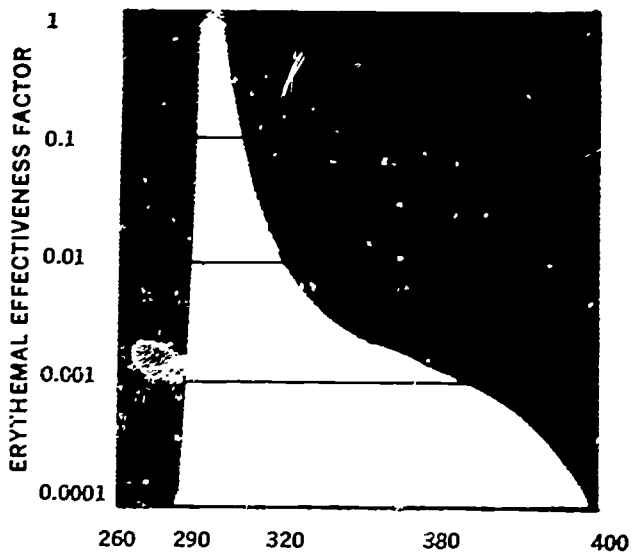


FIGURE 10

NEAR AND MIDDLE U.V. COMBINED

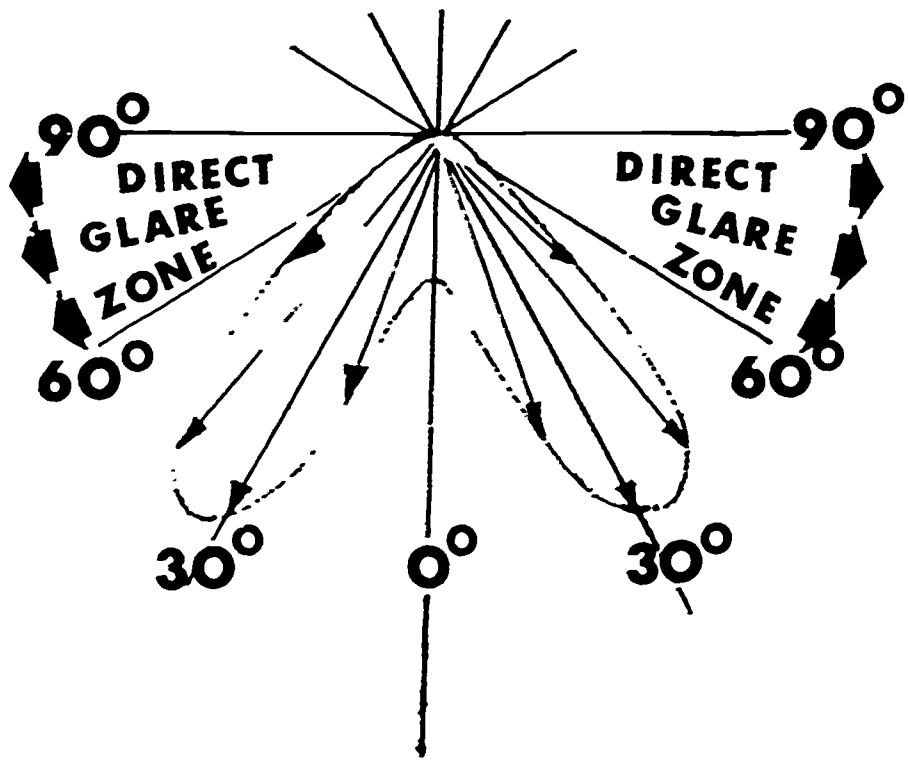


FIGURE 11

PHOTOMETRIC DISTRIBUTION

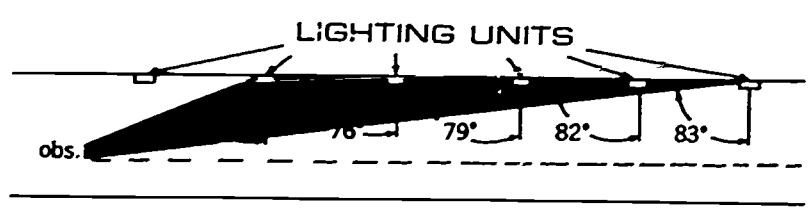


Diagram showing glare light directions in typical office. From positions of lights it is rays sent 60° to 90° from the vertical. These rays the observer receives 30° or less above his horizontal line of sight.

FIGURE 12

DIRECT GLARE ZONE

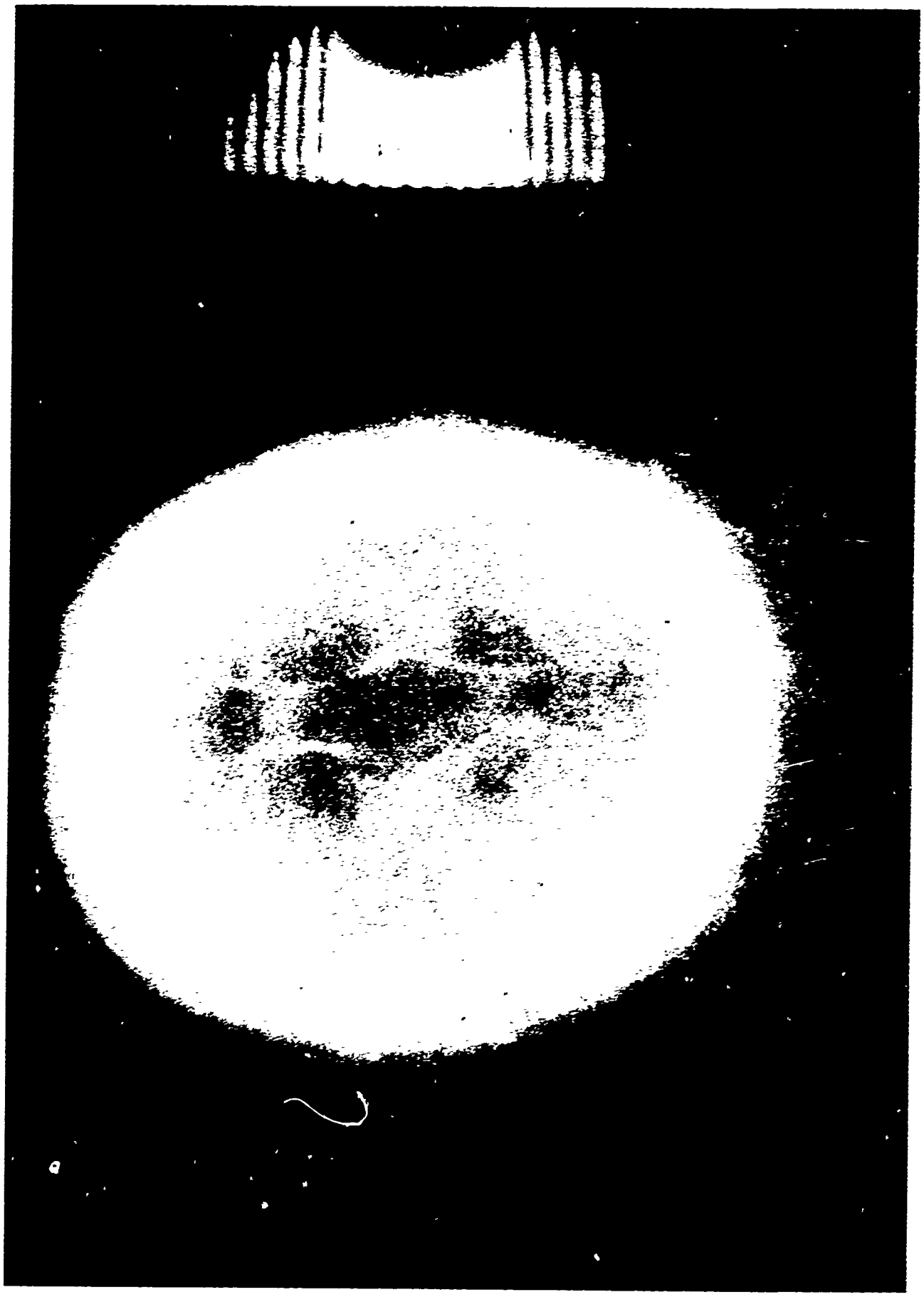


FIGURE 13

BASIC RAY STRUCTURE

Basic ray structure of a lens using accurately formed cones having the correct optical slope angles. Cone constructions vary greatly both in optical slopes and in ray patterns.

R + D + D

RESEARCH DEVELOPMENT AND DESIGN

Integration of All Three in One Office

By

CHRISTOPHER ARNOLD

Vice President
Building Systems Development, Inc.

BUILDING SYSTEMS DEVELOPMENT: THE PRACTICE OF RESEARCH, DEVELOPMENT AND DESIGN

Building Systems Development is an architectural firm with strong orientation towards research and development. As such, perhaps it represents a new kind of architectural firm, which is unusual in the profession at present.

Building Systems Development (BSD) began in 1965 as a means of keeping intact the small team which had worked with Ezra Ehrenkrantz on the School Construction Systems Development (SCSD) program in California. The apparent success of the SCSD program at that time led one to believe that there might be a substantial demand for the kind of services which the SCSD team could offer. Accordingly, BSD was formed as a corporation, amalgamated with Leefe and Ehrenkrantz, utilizing the premises of the latter firm. The first officers were Ezra Ehrenkrantz, James Leefe, and Christopher Arnold. These are the officers of the company today, with the addition of S. A. Musser in 1967. The first job of BSD was as a consultant to a team led by John Eberhard at the National Bureau of Standards, which was studying a systems program for a Department of Defense building.

The SCSD experience had developed a team with unique experience in working with industry and with innovative and yet well-tried experience in handling large-scale programs of building. This experience has provided the central core of work for BSD ever since SCSD. BSD believes that it is perhaps in the main stream as far as the future of the architectural profession is concerned. BSD has always felt that one of the major questions for the profession was not whether the practice of building will become industrialized, but rather when it does become industrialized, who will be in control. BSD has attempted to develop the talents and skills which would enable the architect to remain in a key position, perhaps by playing new roles. The

architect has a unique expertise in dealing daily with a multitude of variables. He moves freely between the technical, social, economic, political, and cultural worlds in a way that some professionals, who may be much more sophisticated technically, still find beyond their capabilities.

The efforts of BSD are related to research, development, and design. Typically, the work oriented around research and development is about 80 per cent of the total. Design, construed as more or less conventional architectural work, accounts for about 20 per cent. BSD is organized as a profit-making corporation and does not do basic research in areas that are more appropriate to the university or the non-profit research organization. BSD research must be closely applied to jobs which will provide visible benefits to the owner. The major area of research is with experiments in the manipulation of the building process as represented by the large system project such as SCSD or URBS (University Residential Building System). In these projects, the way in which the program is completely organized represents a form of research. The organization facilitates project completion in lieu of time and cost constraints and aims very definitely at producing a visible result.

BSD has been able to pursue limited specific research as a by-product of some of these large systems projects. For example, unique work has been done in costing as a result of needing component cost targets.

The development type project represents the core of BSD activity. The development program embraces a number of fairly specialized skills in which BSD regards itself still as a beginner. BSD now has experience in writing performance specifications for major subsystems. It has experience in dealing with industry and knows the strength and limitations of industry in relation to innovation.

BSD has worked on development programs in a number of ways and still finds itself inventing new ways or working out variants on existing ones. The large-scale systems program like SCSD or URBS, which uses the performance specifications route to obtain innovation, represents the most complex kind of building systems program. This kind of program is heavily dependent on a predictable volume market which will enable an owner to commit resources some years in advance. Such markets, and such owners, under present day economic and political conditions, are going to become increasingly difficult to find. Thus, new variations of this kind of program must be devised where such long-term commitments are not necessary.

In the full scale systems program, BSD tends to work as a direct consultant to the owner for the technical systems work. (See Figure 1.) In the Pittsburgh GHS program, BSD worked as a building system consultant to the Pittsburgh Board of Education. Instead of the systems being designed by industry to a performance specification, BSD's role was to act more as coordinator for a very strong design team which did direct design work on the building systems. (See Figures 2 and 3.) BSD believes that it will increasingly find itself playing a role as a member of a very strong team, which may embrace not only other professionals in the design fields but professionals from many outside fields. Close ties are maintained with the Organization for Social and Technical Innovation (OSTI) of Cambridge and San Francisco. Several projects have been done in various associations with them. BSD has discovered that it can be effective in a team situation and feels that it is extremely important to develop expertise in working in various forms of team organization.

In accordance with BSD desires to work in an applied, rather than a theoretical vein, the direct practice of architectural design is an important element in the firm. BSD was responsible

for an elementary school under the SCSD program and has just completed a high school in San Jose which fell just outside the SCSD program but which utilizes second generation SCSD-type components. Major work continues in the design of a number of buildings for the Claremont campus of Immaculate Heart College in Pomona, California. BSD has designed medium cost housing in Detroit, which is now under construction, and there are a number of housing projects of various kinds beginning to get underway, some of them as combined design and system problems.

BSD likes to treat design problems on their merits and does not attempt to force systems methods or components where they may not be appropriate. It has been surprisingly difficult to develop an effective working relationship between the design and systems areas of the office. In a time of intense growth, people tend to be extremely busy with their own projects and the mere proximity of different groups within the office is not effective enough as a means of spreading information and attitudes. This dissemination is extremely important; work must continue on it with increasing success. The practical needs of running an office, however, sometimes tend to cut across theoretical idealism of the cross-fertilization of ideas and techniques. With growth, the relationship of one project to another becomes of increasing importance. It also becomes a matter of concern that projects which may be fairly closely related in content do, in fact, make the best use of expertise within the office.

Much of BSD's work deals basically with information handling and innovation, so that the problem of cross-fertilization within the office is probably much more important than in a conventional architectural situation.

BSD's clients have tended to be people with large scale building programs. Typically, these are universities, large school districts,

or the Federal Government. In the housing area, there is involvement with large scale private developers. An increasing number of potential clients appear willing to pay for the kind of service that BSD offers. It is extremely important that owners recognize the skills that BSD has in relation to devising and managing a systems program as being extremely professional and relevant. BSD would never have come into existence at all without the sponsoring of systems projects in the educational area undertaken by Educational Facilities Laboratory (EFL). The debt which the now flourishing systems movement in the U. S. A. owes to EFL will probably only be fully understood by those who, like BSD, were involved at the beginning of it.

At present, BSD has its main office in San Francisco and another office in Washington, D. C. The current size of the staff is approximately 50. Ten staff members are in the Washington office. BSD believes that the methods used and the extent of its knowledge are still in their infancy. It believes that the work which it is doing is important both to the profession and to the society that it serves.

FIGURE 1
ORGANIZATION CHART

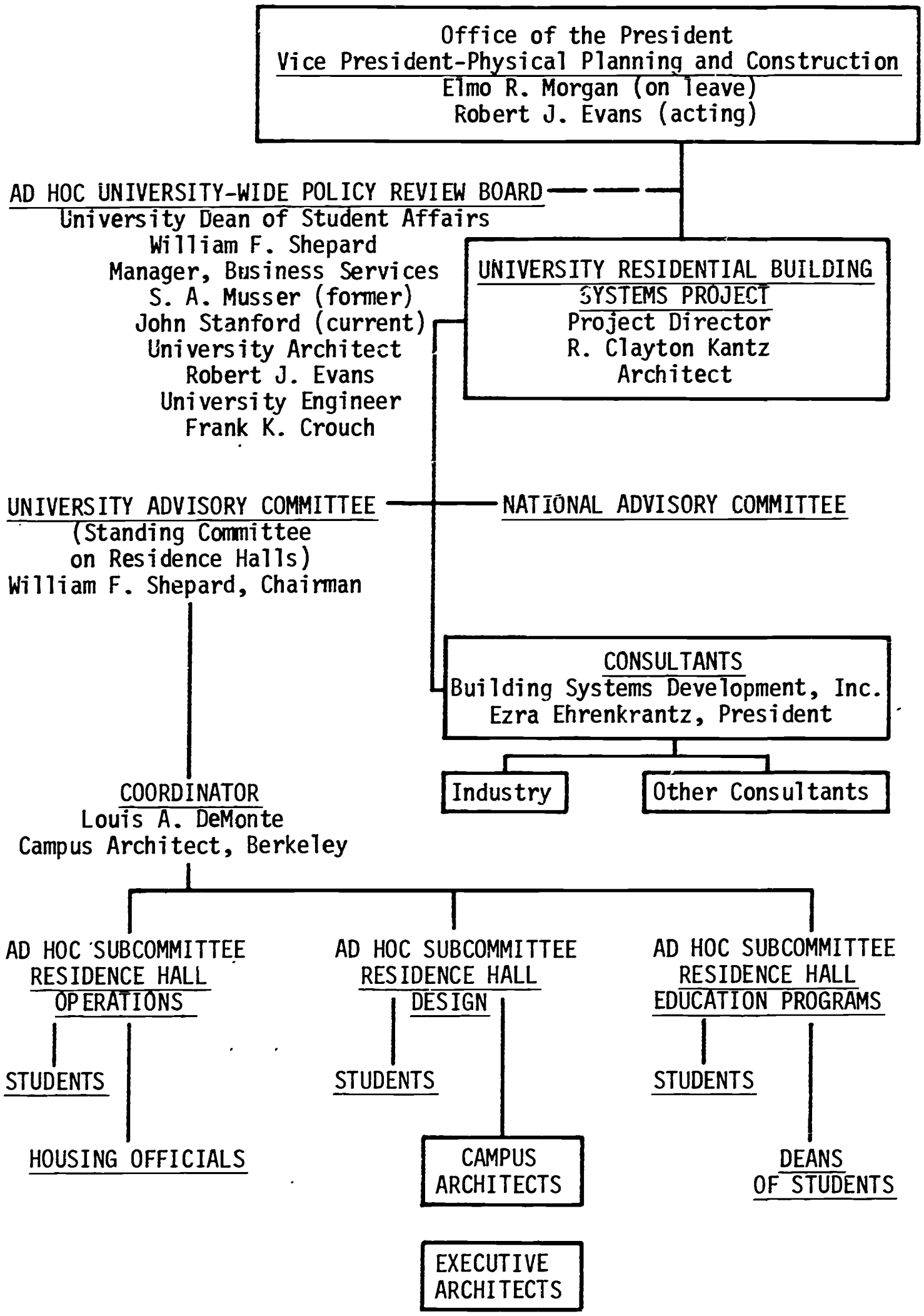


FIGURE 2

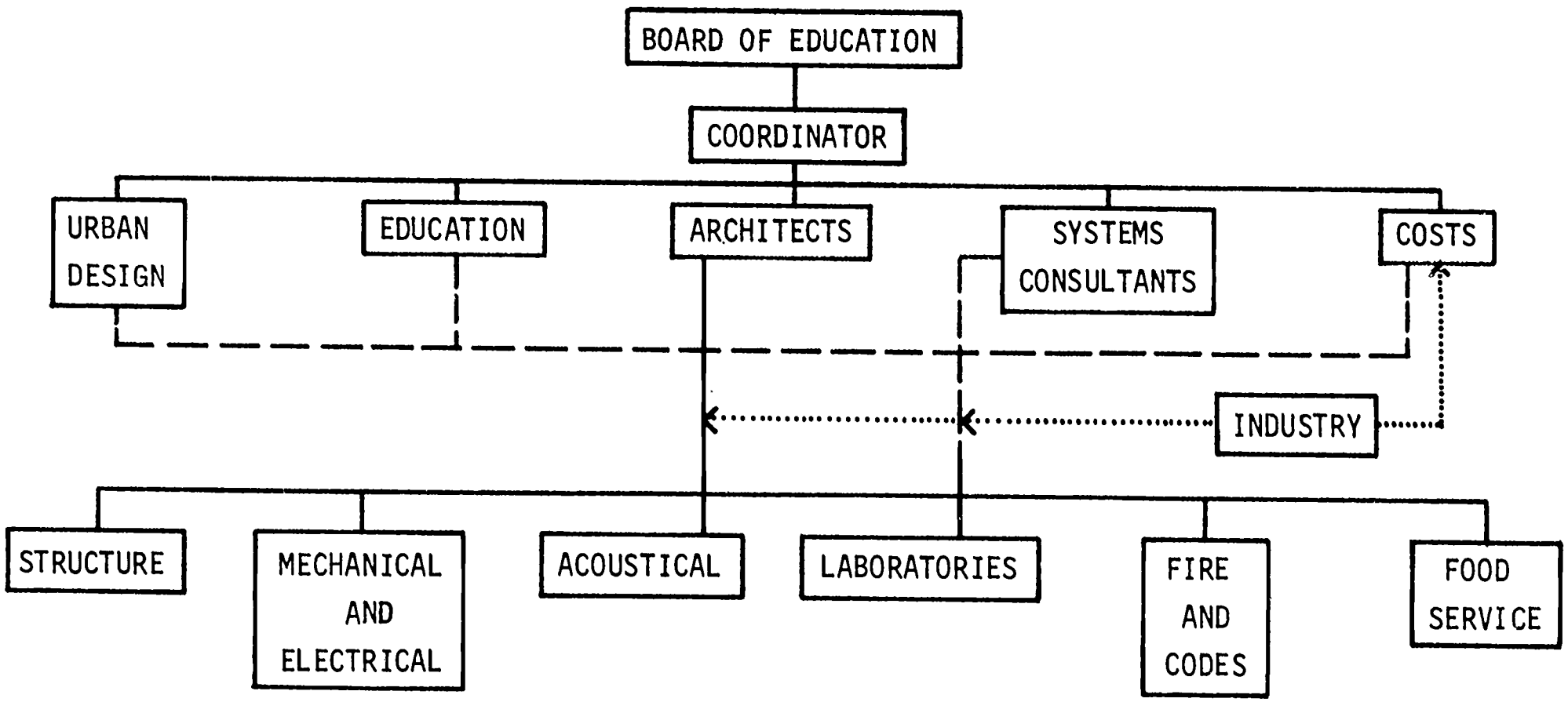
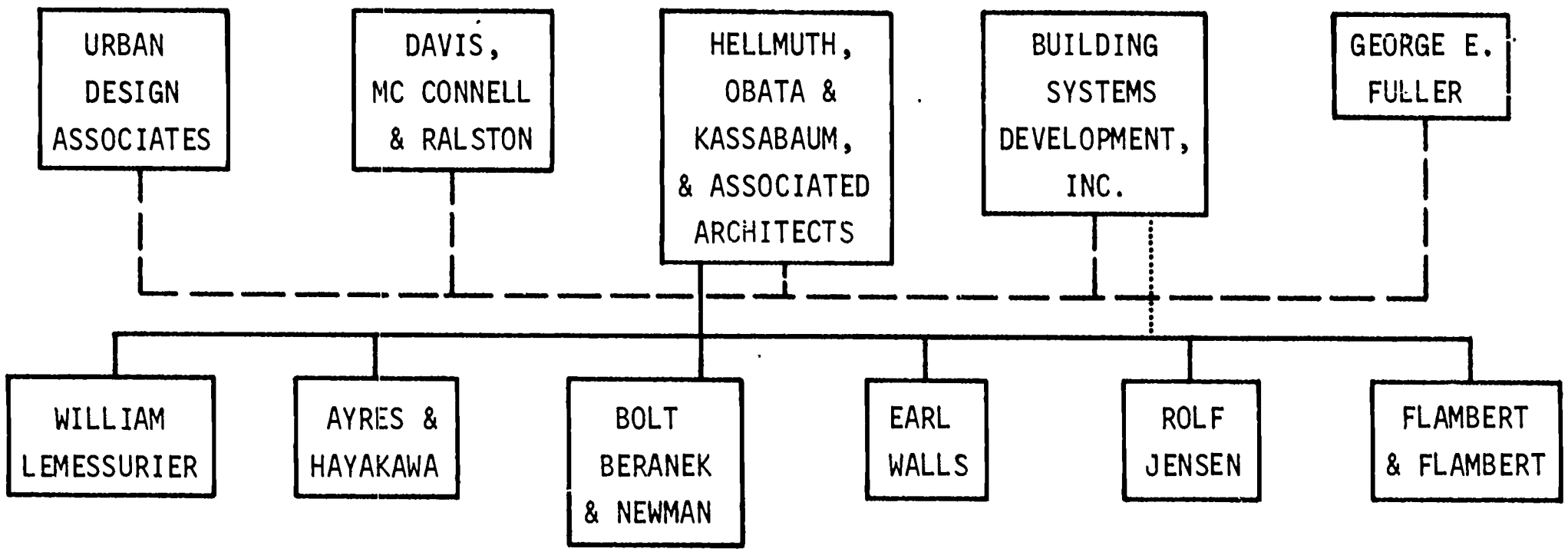

BOARD OF EDUCATION
COORDINATOR
URBAN DESIGN
EDUCATION
ARCHITECTS
SYSTEMS CONSULTANTS
COSTS
INDUSTRY
STRUCTURE
MECHANICAL AND ELECTRICAL
ACOUSTICAL
LABORATORIES
FIRE AND CODES
FOOD SERVICE

FIGURE 3


URBAN DESIGN ASSOCIATES
DAVIS, MC CONNELL & RALSTON
HELLMUTH, OBATA & KASSABAUM, & ASSOCIATED ARCHITECTS
BUILDING SYSTEMS DEVELOPMENT, INC.
GEORGE E. FULLER
WILLIAM LEMESSURIER
AYRES & HAYAKAWA
BOLT BERANEK & NEWMAN
EARL WALLS
ROLF JENSEN
FLAMBERT & FLAMBERT

THE SUZZALLO QUAD

A Computed Graphics Simulation

By

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Assistant Professor
College of Architecture and Urban Planning
University of Washington

This study was conducted at the University of Washington, College of Architecture and Urban Planning, with James Donnette, William Belshaw, and Christian Staub. The study was supported by a grant from the Agnes H. Anderson Fund of the Graduate School and is the third in a series of simulation studies. The principal goal of this study was to develop a computed graphics capability for simulation and to investigate the use of this tool in the design process.

DESCRIPTION OF RESEARCH

The University of Washington has, from its inception, demonstrated a continuing interest and concern for the form quality of the campus environment and has, over the years, attempted to guide development by careful consideration of each planning proposal. The proposed plan for the Suzzallo Quad, a key central space of the campus, has been carefully considered and much effort was given to picturing the qualities of the yet unbuilt quadrangle through use of sketches and modeling of space. The costs and time involved in such efforts have been such as to preclude extensive use of such methods except as finished presentations of a solution, and, moreover, to preclude their use during the design process itself as a tool or technique for making decisions.

There would appear to be three principal reasons for using a computed graphics capability to study definition of architectural space:

1. For complex shapes not readily constructed or shown by traditional methods,
2. For multiple views of sequential experience made time consuming by traditional methods,
3. For greater precision or sophistication of graphic means.

The design proposal for the Suzzallo Quad suggested this complexity of shape and the necessity of indicating the nature of the sequential experience to be gained in the daily use of this principal campus space. The Urban Data Center of this campus had developed a computed perspective program and work was predicated upon the availability of that program. This study proposed to compute, plot, and render sequential perspectives of the space so as to indicate in the form of a five minute filmed sequence the nature of the visual experience as one "walks through." To do this, it was necessary to study the simulation of percepted reality within the limitations of the computer program capabilities. The capacity of a computer for data storage and retrieval makes possible a design study of tentative proposals in that specific elements can be deleted and changes introduced without the necessity to re-enter all relevant data. The study, therefore, also attempted to investigate ways of organizing data so as to make the computed graphics technique useful both as a presentation device and as a design tool for simulation studies. It was intended that the filmed output be helpful in portraying the nature of the Suzzallo Quad to planners and staff concerned so as to provide a measure of effectiveness for consideration of this technique in future campus planning.

Previous studies had suggested that there were two principal elements to the problem:

1. Determination of the appropriate parameters and parameter values to achieve the degree of reality necessary to the simulation.
2. Determination of the mechanics of experiencing the environment in question so as to make possible a realistic appraisal by those involved as observers.

The intent has been to begin to build an operating model (a simulation model) of a process (visual perception) so as to replicate the experience of physical movement through space and give some indication of the qualities of this experience. The design process itself is a kind of simulation which begins with consideration of "schematics" as tentative patterns of use or character and extends to the ultimate reality of a building or urban space. The investigators had no illusions as to the degree of reality that could be achieved within the limitations of existing capability, and, therefore, emphasis was given to definition of parameters and mechanics of a system with which some degree of reality could be achieved.

PROCEDURE ADOPTED

Previous studies had been naturalistic simulations of an existing building by the use of photographs and closed-circuit television. This study was concerned with the preliminary design proposal for the addition of new buildings so as to reshape an existing quadrangle. Therefore, a first step was to consult with and obtain the cooperation of the design architects for the project. The Quad proposal had already received preliminary approval. Thus, the architects were asked to indicate the kinds of decisions that were made and the kinds of information they felt to be desirable during design studies. The architects thereafter were asked to review the kinds of graphic output investigated and to evaluate the usefulness for their work. Changes in the design continued to be made during the course of the study, but it was not possible to incorporate all of these changes in the final graphic output.

The second step was the determination of a data format for computation and the digitizing of building surfaces that would form the quadrangle space. In the course of the study, three data sets were prepared. The first set was used to test program capabilities. A second, more precise and complete, formed the basis

for much of the final output and was predicated upon economy of plotter use. A third partial set, more elaborate as to surface articulation than the second, was prepared to test conclusions based on earlier work and organized to facilitate usefulness to designers rather than provide for economy of machine time as in earlier sets. This latter set established 130 polygons in describing six buildings and associated towers, steps, etc., while the second set used only 62 polygons to describe the thirteen buildings and other elements that define a series of three campus spaces. A second data requirement is a series of plot commands which represent the path and view chosen in experiencing the spaces. This was initially prepared and then supplemented as useful during the course of the study to better replicate the kind and quality of experience to be visualized.

The only form of graphic output available for this study was a computer calculated line plot. Line itself is an artificiality and exists only as the percepted difference in brightness and texture gradient between adjoining surfaces. Although this form of line output proved useful and "legible" to designers, other more realistic output formats were thought necessary in communicating with lay persons. The reality of simulation involves both the content (graphic) and the mechanics of presentation. The original product had been proposed as an animated film in black and white, but slide animation techniques were also studied. Much of the time of the study was spent in the mechanics of presentation - to the detriment of other objectives. The study had expert technical guidance, but film-making techniques necessitate precise and elaborate equipment not available to the study.

During the course of the study, the computer program for sequential perspective was further refined so as to increase its capability for providing the kind of graphic output found to be necessary to simulation studies. An understanding of the characteristics and structure of the computer program proved helpful in

extending its usefulness as a simulation device. However, much of the final output was plotted before investigators were able to develop the computer program flexibility now possible.

The study began September 15, 1967, and ended June 15, 1968. Preparation of the third data set, program testing, and preparation of the final film and editing were not completed until July. At the same time, the computer program was under development, and a number of separate studies were made to test program capability. It was not possible to incorporate this material in the final film; it is only in slide presentations.

THE SUZZALLO QUADRANGLE

This area is the prime remaining open space on the original campus of the university. It was the site of the 1908 Pacific-Yukon Exposition and was indicated in the 1915 campus plan as the "University Quad." The space was seen to center on the intersection of the major axes of the two quadrangles adjoining and to be dominated by the form of the Suzzallo Library. In 1966 the removal of the remaining Exposition building, an auditorium which edged the space, made possible the reshaping of this central campus quadrangle. The projected addition of a large underground garage beneath the Quad itself and such new surrounding buildings as an undergraduate library, lecture-auditia complex, and performing arts center suggest the increased use and vital focal character of the area. The space, as presently envisioned, will be approximately 300 feet in width by 400 feet long and of an irregular shape. The pavement will slope upward from the Rainier Axis steps at the south in a bowl-shaped configuration with a rim some six to eight feet higher to the north and west edges. The President of the University has likened the resulting space to the great plaza at Sienna with arcades and an open environment. The comparison is interesting in that the historic

space cited is of a similar size and comparable slope but with a greater degree of enclosure and more pronounced slope which is further emphasized by the pattern of the pavement. The role of pavement pattern in defining the topography may be of importance to the projected quadrangle, but its nature was not known during the study. This is unfortunate as the graphic plot of irregular curving and/or non-parallel lines is a task for which computed graphics is well-suited and a kind of schematic study rarely carried out. The particular path chosen for this attempt at simulation is the most heavily traveled student route between upper and lower campus. The path begins in an existing space that focuses on Drumheller Fountain and proceeds upward (5-6 per cent gradient) to the northwest, entering the Suzzallo Quadrangle by a series of steps between the existing Administration and Library Buildings. At the intersection of quad axes, the path chosen turns to the northeast and proceeds slightly upwards (3 per cent grade approximately) past steps and into the Liberal Arts Quad. Thus, observers of the simulation would begin and end in existing spaces which they had previously experienced but pass through and visually pan the yet unbuilt quadrangle.

The choice of a university setting was a matter of convenience and not an attributation of uniqueness. The university is a micro-city of itself, and, perhaps, a more structural environment in which the variables of experience are more knowable. The methods used are intended to be directly translatable for use in urban settings or individual buildings.

SIMULATION OF THE PHYSICAL ENVIRONMENT

Previous studies had sought to simulate the visual characteristics of a real world situation through use of color slides projected on wide screens and by a monitor view of closed-circuit televised images of a model of the same existing museum gallery.

The user behavior of interest was gross physical movement - the path chosen by a subject as he moved through the space. Using slides had the advantage of presenting a realistically colored world with a nearly normal field of view, but the mechanics of "moving" through space by projector made it difficult to provide a smooth transition of image for viewers - as, for example, in turning about. The use of a dolly-mounted television camera provided a greater degree of mobility more under the control of the observing subject, but image presentation was a deliberately defocused black and white. In addition, the angle of view was less than previously used, being reduced to 45°, so that some subjects became disoriented in the space and backtracked. The ability to make changes in the environment under study was an advantage of this second study and freed the investigators from complete dependence on existing situations. Thus, these previous studies had moved from a visually realistic presentation of an existing environment which was completely beyond the control of the investigator towards a more incomplete presentation of an environmental abstraction more nearly under the control of the laboratory investigator as the "environmental designer." However, subject behavior in both studies was similar to that in the real space, thus suggesting an abstraction from reality was possible in study of behavior.

The present study sought to continue this research by studying the degree of abstraction of visual experience in terms of a tool for creating new environments or for recreating destroyed ones. It was hoped that with computed graphics it would be possible to recapture some of the realism of the first study by extending the visual field beyond the $45\text{-}60^{o}$ cone of vision used for mechanical perspective, even though the simulation would be limited to portrayal of experience of an observer rather than the totaled experience patterns of observers as previously measured.

These studies have sought only to characterize and simulate the visual scene and kinesthetic sense of movement through. The sense of movement through space for this study was to be induced by producing sequential views along a path. These views were to be plotted perspectives taken at specific intervals as might be the experience of an observer, together with such other glancing views or pans of a space as might serve to assist an observer in orienting himself or to explain the nature of a space. The simulation of the experience of a "pedestrian habitue" (student) was deliberately limited to these two aspects. On a university campus, perhaps the social environment might be at least as stimulating and memorable. Certainly a focal space such as the projected quadrangle should be peopled to indicate the experience of movement and human color. The investigators originally so intended but were unable to do so with the limited resources available. Realistic simulations should include all the sights, sounds, etc., that together constitute experience and by systematic deletion seek to determine the relative significance of kinds of experience.

Of perhaps more value to a designer would be an indication of the sense of definition of space achieved and plotted views that would indicate the complex relationships of buildings one to another, or the changing relationships of parts of a single building as an observer approached and then passed by. To these ends, the designer's experience and training enable him to visualize relationships only incompletely indicated graphically. Thus, the portrayal of visual experience for a designer might be said to be less a replication of reality than that necessary to understanding by others not so trained. Furthermore, the designer manipulates particular functional elements of a building (stair tower, roof slope, etc.) in achieving the design changes desired. The totality of these physical elements then constitute the observer's experience, but they may be perceived as related by surface

brightness or material selection and not as differentiated by function.

Of some interest for simulation studies has been the proposed use of spatial notation systems such as that proposed by Philip Thiel. The graphic language suggested would systematize the preparation of data and, by its grammar, establish a set of experiential relationships that should be programmable for computer manipulation. This study sought only to systematize digitizing of surfaces by differentiating principal masses from subordinate details, solids from voids, and building masses from associated platforms, steps, retaining walls, etc. The development of simulation models for which no part is a physical reality but only a mathematical statement will be assisted by the development of notational systems. The project architects, however, had not used such a system; and, to the extent that the study process followed the design process, it would have been difficult to annotate design elements for retranslation into plotted views of significance to the designer.

Of usefulness to designers is the capacity of the simulation system to present multiple views of a set of objects on request. The initial costs of recording buildings as digitized data are such that multiple re-use is an economic necessity. Views can be drawn from any point in space and any number can be drawn from the original set of data. Changes can then be introduced without necessity to reprepare any but affected elements, and the revised whole then reproduced for study. With a library or data bank of recorded buildings, it is possible to study the effect of a single new project or approach by a previously untried path. If the city is, indeed, a network or grid, then not only is it possible to simulate the stately axial procession, but it is feasible to explore the cross-axes and back alleys.

ELEMENTS OF THE PROPOSED SIMULATION SYSTEM

This study proposed only to fit together items of existing equipment and techniques but not to design and build an entirely new device. The investigators believed that the potential usefulness of available elements remained largely undeveloped, particularly as related to simulation of sequential experience. The limitations of existing equipment were to be accepted for purposes of this study so as to better suggest the performance specifications of an improved system. Such a system was thought to be constituted of three separable elements:

1. The model environment - the computer program and script which become the mathematical model of observer experience.
2. The computer and plotter - the machine hardware for model manipulation.
3. The presentation medium - the device by which computed images would be displayed.

All three are interrelated. For this study, some visual tasks were accomplished mechanically by camera which might better be performed mathematically by the computer program. Graphic presentations, which can be automated by other equipment, were, for this study, done by hand. However, the computer program that calculates and plots multiple views is the principal element in the system and is the content of experience. The machine hardware for computation and plotting was more than adequate for the work assigned.

Less than adequate was the means of presentation adopted. Several choices are feasible at this time. The ultimate tool may well be the cathode ray tube which provides a monitored view for the observer-subject and acts as a surface upon which the designer may manipulate elements in apparent space with a light pen. Such system elements exist on the campus but were not available to the

investigators for experimentation. A second choice would be the use of a graphic plotter which prepares a 16 mm animated film directly from computations by photographing the face of a cathode ray tube. The camera is controlled by machine programs that execute the animation routines normally performed by a camera operator. Both these devices provide a degree of continuity in image that cannot be attained by slide projection although this method has the advantage of simplicity and economy. Continuity of image can be increased by use of tandem images which successively fade into one another, and this means was also used by the study. A greater degree of continuity can be achieved by non-automated animation of successive views so as to constitute a continuous film record. This was the method to be used and the presentation element of the simulation system.

Commercial films are sometimes animated frame by frame (24 frames per second) so that successive changes are not visually discriminated. The result is an apparent continuity of change. Greater economy with little loss of continuity can be achieved by careful study of the length of time that can be represented by a single image. This may necessitate using different image intervals, depending upon the visual cues that provide a sense of sequence. A building seen in the far distance as one approaches appears to change in size but slowly until, as the observer nears, the rate of change increases rapidly. Since all observers know that buildings do not "grow," the perceived image may be more dependent on the kinesthetic pace of observer movement. This study was unable to prepare frame-by-frame animation and sought only to present the effect of minimal animation in suggesting sequential procession.

An important factor in presentation is the size of image and observer position. To achieve reality, the observer must be at

the single point representing the original station point of the view. This is obviously impossible for all members of a large audience but can be minimized by wide screen techniques. When, as in this study, a cone of vision of 120^{0} is attempted, the apparent exaggeration of vanishing lines is unreal even though accurate when seen at the proper position. A sense of peripheral vision cannot be induced when the wide angle view encompasses only a 20^{0} visual task area.

Not only does film animation present the visual experience of an observer in motion along a path but the camera can seek to represent certain aspects of visual activity that might take place. In this study, the camera was used to execute a pan of the space much as an observer might rotate in one spot so as to experience the whole of the enclosure. The mechanics and effect of recording on film such technical devices as pans, dissolves, cuts, etc., are known. This study had technical assistance in filming and concentrated attention on development of computational methods.

DESCRIPTION OF COMPUTER PROGRAM AND USE OF PLOTTER

PERSPA is a variation on a perspective program developed by the Urban Data Center of the Department of Civil Engineering. The program is written in Fortran IV and is operational on the IBM 7094-4040 DCS machine used by the university. Plotting is done off-line on an EAI 3500 Tableplotter (plot area 60" by 45"). In contrast to some other perspective programs, this program is written so as to parallel traditional architectural perspective viewpoints and data requirements. Thus, it is readily accessible to those trained in perspective methods. The program requires the following data statements as input:

1. Plot commands
   Consist of x, y, z (z = height above ground plane) coordinates of SP (station point of observer),

6

FP (focal point of line of vision), and parameter value CV (cone of vision) desired.

2. Polygon data
   Successive x, y, z coordinates of points defining ends of line segments which are edges of closed polygons either two or three-dimensional in nature. These polygons represent surfaces of mass outlines of buildings to be studied.
3. Related calls that establish size of plotted view and move, delete, or reset data polygons before specific plot commands.

The plotted views are three-point perspectives and the picture plane is established perpendicular to the line of vision in each view. Time consumed by computer and plotter depends on the complexity of polygon data and number of plotted views so that no firm estimate is possible. A plot of 130 polygons (approximately 1000 line segments) plotted in 25 views, 7-1/2 inches square each, required a total of two minutes for computation execution plus five minutes for compiling and print-out on the computer. Plotter time was in excess of 90 minutes. In effect, the controlling economic factor is the speed of plotting and not the computation time required.

PERSPA is both the given name for the program of computed spatial perspectives and also the main control routine. This routine establishes common block areas for data of all sub-programs with limits of 1000 plotted views and 5000 points in terms of x, y, z coordinates, reads in and prints out plot instructions, and calls sub-programs. PERQ is the principal sub-program and accesses common so as to store, translate, and calculate data point arrays of line segments. These segments are translated into their picture plane projection and scaled to size of view specified. This sub-program calculates plot time for each view,

prints this with plot instructions, and calls EAI plotter routines for plotting. READ reads in polygon names and defining point coordinates and prints out polygon data. This sub-program also calls routines DELETE and RESET, which allow operator to omit specific polygons from consideration at any given plot and then reset polygons later. Thus, hidden lines can be minimized when polygons overlap, details can be added or subtracted, and plotting time is minimized. SIZE, the last sub-program of the deck, is designed to set up the EAI Tableplotter for graphic plotting of calculated views. Data origins, number of permissible plots, and various system calls are incorporated to control plotting.

Exhibits B1 and B2 illustrate the data format required and the information to be prepared for polygons describing the buildings and spaces. For this study, the plans and elevations of buildings were scaled and data coding forms handwritten for keypunching. This first step in the preparation of a data set describes architectural form in a machine-manipulable format. Decisions as to the number, extent, and composition of polygons affect both the economy of operation for machine and the clarity of plotted view for observer. This study based decisions as to polygon descriptions primarily on the economy of plotter operation even at the expense of clarity. In this way, more time was available for test plotting, but plotted views required more interpretation by observers. To conserve plotting time, some vertical edges were not plotted, being filled in later from traces of abrupt change in horizontal lines at top and bottom of surfaces. This study established certain rules for digitizing data, but much effort could be devoted in further investigations to this problem of organizing data for clarity of image.

A second set of data, that of plot commands, is familiar to all with perspective training. Selection of observer station points

involves the line of vision for view desired, the cone of vision to be used, and determination of a focal point. Fundamental to the use of this particular computer program is the freedom to select a particular cone of vision and determine the line of vision. The cone of vision parameter was fixed initially at 60° by the computer program and only in the last part of the study was it possible to vary the angle of view enclosed. The line of vision was selected to be straight ahead at an angle of five degrees below a horizontal line parallel to the ground plane. Experience in animating plotted views dictated that the focal point be fixed sufficiently ahead so that successive views all focused on a single point. Otherwise, the filmed output varied slightly, much as if the observer were wandering laterally between successive positions. A sobering experience.

Other data required establishes the size of plot and enables the operator to manipulate polygon data so as to obtain the exact plot content desired. To the extent that the precise visual extent of the experience can be established before plotting, it is then possible to input only those polygons that will appear and to eliminate confusing or overlapped surfaces. When there is a complexity of disposition of shapes, as in this study, this may not be possible nor a desirable prejudgment. Visual complexity has no meaning for the computer and is more a matter of human interpretation.

The size of the plot area has a direct influence on economic cost. For the same plotted lines, a plotter frame 7-1/2" square contains twice the area of a 5" frame, and the plotter will consume approximately 1-1/2 as much time in movement. The larger frame also represents a greater area to be "rendered" in reworking the plotter output, but shape areas are correspondingly increased so that this handwork is made easier. Thus, a number of trade-offs need to be considered. For this study, both a 5" and a 10" frame were used

in arriving at the final product. Other tests were carried out using a 7-1/2" frame, and this is suggested as possessing sufficient size for further presentation work and yet is reasonably economical of plotter time.

Another aspect of the use of frame size may be more important to the further development of simulation graphics. The choice of frame size in conjunction with the determination of the cone of vision enables the operator to vary the apparent closeness of a surface in a given view. Much as various camera lenses, wide angle to telephoto, vary the apparent spatial relationships in a photo, so can the computer be used to replicate visual experience. Given the same size of plotter output frame, a view of a building detail for a 2° cone of vision would appear one hundred times the relative size of a wide angle view of 125°. While this would be an exaggeration of the eye's focusing ability and adaptive power, some approximations can be established for further experimentation. The flexibility thus gained is of utmost importance as the subject-observer can thereby more naturally experience the totality of a space and then focus on a specific architectural detail.

PREPARATION AND USE OF INPUT-OUTPUT

During the course of the study, several data sets were prepared and computed for plotting. In order to assure the necessary accuracy of data for repeated uses, a transparent grid overlay was fixed to a campus map. The plan scale of this map was 1 inch equals fifty feet. The x-y coordinates of station points and corners of building polygons were established from this map. As the particular buildings and spaces under study are irregular in shape and non-parallel in disposition, some difficulty was experienced in locating corners with an accuracy greater than two feet. The particular computer program used allows five columns for each

x, y, or z. Thus, a location of 99999 feet is possible with accuracy to the nearest foot; but if accuracy to nearest six inches is desired, the greatest possible dimension is 999.5 feet. For plot commands and polygons, data coordinates were digitized to the nearest foot, but single building details were digitized in six inch increments. The x and y coordinates for each principal corner were transferred to eighth scale elevations and the x coordinate (height above sea level datum as established by the university) was scaled. Point coordinates were then entered onto coding forms for keypunching.

As data, the computer program accepts polygons as described by line segments. A polygon may contain any number of sides and be either a single plane or a three-dimensional surface. The plotter, in effect, draws a bent wire figure describing a closed surface. Each polygon may be named (for operator reference) and numbered as in a series. To systematize the work involved and to begin to approach the use of a notational system, this study adopted several conventions for data preparation:

1. Separate number series were assigned to buildings, steps and walls, trees and foliage, objects, pavement, and people. Buildings were differentiated from eachother by numbers within a series.
2. Each building was "polygonized" at several levels of detail:
   a. Principal massing - dimensional changes or breaks in surface greater than six feet in extent.
   b. Defining surfaces - dimensional changes greater than three feet but less than six.
   c. Surface contrast - openings such as windows or doors and/or marked changes in value contrast (brightness).
   d. Detail - single elements or changes in dimension less than three feet.

Thus, a building facade having no dimensional change greater than three feet and with no marked value change would be treated as one surface even if composed of seven materials. The conventions were empirically established to simplify data preparation and to test the effect of various levels of detail on the experience of spaces and buildings. As neither color nor texture were to be used in reworking of computed views, it was not necessary to consider these factors of visual experience.

Some form of organizing data at varied levels of abstraction is useful both to experimentation as well as to the mundane task of keeping track of data, particularly whenever changes in design elements are to be accommodated. A more explicit notational system might organize surfaces as by position, lateral or horizontal, but the investigators sought instead to organize data as a series of refinements on the definition of space and articulation of single buildings. Thus, a designer might first call for bulk studies of building cubage on the site, then successively study the shape, enclosure, and scale of open space by plotting defining surfaces, and finally "walk into" a single building, glancing at the window mullion detail in passing. Changes could be introduced at any point without necessarily affecting other levels of data.

In the course of this study, the project architects found the computer output to be of interest in studying the position and scale of the tower as seen from within the quadrangle and as seen in approaching the quadrangle entry. Also of interest was the visibility of a large roof surface as seen on the approach to the quadrangle. By examination of the plotted sequence, it was possible to determine that the least distance at which this roof could be seen was such that a more architectural treatment of the surface would not be necessary.

The second set of data and plot commands were prepared by digitizing coordinates of sequential positions as determined on campus map grid. The number of total views possible with funds available dictated a minimum interval of 50 feet to be desirable. This distance represents a time interval of fourteen seconds at a walking pace. With buildings only peripherally seen, this interval is not completely unreal, but as the observer approaches or passes close to a building, the rate of change is too rapid to be real. For that reason, a portion of the trip was plotted at twenty-five foot intervals. The sense of continuity between successive views was to be provided by fade-dissolve film techniques for overlaying successive images.

Observer eye height was fixed at five feet above ground plane with line of sight ahead and declined five degrees below a line parallel to slope of pavement. The normal line of regard for an observer is at angle of ten degree inclination in walking and, thus, the compromise adopted assumes a certain amount of glancing up and ahead in the normal course of passage. To better explain the nature of campus spaces, a sequence of views was computed at entrance to principal spaces and at center of new quad. This approximates a glancing about, or slow pan, and was accomplished by fixing successive focal points at 30° rotation intervals for a single station point.

A single data card is required for each station point view. Some form of script is desirable to describe the nature of the trip and as a check for the proper sequencing of views. The two separately prepared data sets of polygons and plot commands are related only to the extent that a specific polygon appears within the visual cone of a particular view. It is possible to require the computer to calculate the position and perspective plot of every polygon at each station point. It is more economical of plotter time and helpful to clarity of plotted output to

DELETE and/or RESET specific polygons by interspersing these commands between PLOT calls. Thus, a set of steps may be added as the observer approaches within normal viewing distance or a rear surface of a building deleted until observer turns the corner. All polygons are entered for each computer run and, therefore, careful preparation of PLOT sequences is necessary to achieve clarity of image.

Once all data have been recorded and keypunched into data cards, the data set is assembled with the program deck. Other special purpose data cards and operating system calls are also required and are shown on the computer program listing.

The assembled deck is then submitted for computer run. Several runs may be necessary if data errors occur as the program will not execute (compute plots and record on magnetic tape) until all data are complete and correct as to format. Data coordinates may actually be incorrect, but if recorded in proper columns, inaccuracy will be calculated and plotted. The magnetic tape containing machine-coded plotter instructions is then transferred to the off-line plotter and played back. A single sheet 60" by 45" will contain more than sixty 5" by 5" plots.

This study used two different methods for reworking and presentation of plotter output. With the exception of the production of a film as a final product, the study prepared photographic slide series of individual views. These were then projected with the use of two slide projectors in tandem. Both the Tandemmatic projector and Kodak Carousel Dissolve Unit were tried. When the images are properly superimposed, a sense of continuity can be achieved as each image in sequence brightens and then fades into succeeding image. One difficulty of every presentation method used is found in size of image. For a realistic simulation, the observer should be at the proper viewing distance as

determined by the cone of vision used, and neither screen size nor image brightness of most projectors is sufficient to the task.

The research proposal envisioned preparation of a five-minute film as a final product. For this film, it was decided to prepare value renderings of each view and then film animate the sequence. An overall size of ten inches square was found necessary for proper rendering of small polygon areas in a particular view. Various rendering media were experimented with and felt pens of a graded value range appeared to be most satisfactory. Black and white photographs of the buildings in question provided information as to the specific tones to be used. Once these individual views were rendered and pan sequences assembled in strips, a Bolex 16 mm camera was affixed to a copy stand and each view photographed as indicated by script prepared for this purpose. Pans were executed by pulling a strip sequence horizontally past the camera lens. Fade-dissolves were executed mechanically by timing the opening and closing of lens. The pace of movement simulated is more rapid than would be time of observer in actual space. Partially, this was done to conserve film, but, principally, the degree of abstraction and lack of visual content in each successive view is such that a normal pace of 2-1/2 mph seems too slow. The timing of intervals used is such that the observer is proceeding at a speed of 5 mph for portions of the trip, with the remainder timed at 3 mph.

FINDINGS AND FURTHER DEVELOPMENT

This study had limited goals and limited achievements. The principal emphasis of the study was given to development of a computed graphics capability that had not previously existed. The program is now sufficiently documented that it can be used by students for their design studio work. One application has been

made to explain the nature of the spaces proposed for an urban renewal project. The study has demonstrated the feasibility of a simulation system based on computed graphics. In the course of the investigations, several problems arose which are as yet unresolved and can be stated as questions:

1. What is the "natural" experience of an observer for a realistic appraisal of the effect of architectural space? A consideration of the pace, continuity, visual field, and actions that will enable appraisal but not prejudice attitudes.
2. What is the content of the simulation - what are the significant units of the "environmental display"? A consideration of orienting cues, space defining elements, furnishings, and sense of activity.
3. When used as a design tool, what does the designer want to know? What form of data organization or notational system will be most useful? What are the criteria and what are the levels of abstraction necessary to each phase of the design process?

Most of these points have been touched on previously. For the sake of convenience, the study made assumptions and adopted conventions that should now be tested. This is particularly true of data organization and of film animation techniques.

Several advantages are seen to accrue to the use of this system:

1. The graphic capability of the system is such that complex relationships difficult to picture accurately by traditional perspective methods can be readily executed by machine.
2. With multiple re-use of data, it is possible to study alternative solutions economically or to prepare a number of views of a single solution.

Economy of use and generation of alternatives are two levels of successful use achieved. The highest level of use, purposeful insight, is a value to be sought for computer use in the design process.

3. With the use of computed graphics, there is now a way to study percepted differences in environmental images by making small incremental changes successively over a broad range of parameter values.

Disadvantages would appear to be:

1. At present, the computer output of single line plots is a form of abstraction requiring reworking to achieve a level of reality sufficient for ready comprehension of the visual form of architectural space.
2. The hidden line problem can only be minimized and a sense of surface texture and brightness (Gibson's "texture gradient") can be achieved only at great cost in machine time.
3. Mechanical animation methods and film techniques require a technical competence not readily achieved.

In the system presented, this last disadvantage had the most effect. A great deal of time was given over to the preparation of film to the detriment of the remainder of the study objectives. Others would be advised to seek professional guidance and to have film properly executed by commercial studios which are equipped for this purpose. Slide presentations are more easily prepared and can suffice for most uses.

Further development is both necessary and proper. Limitations of the present system and new knowledge resulting from its use

indicate possible directions for further study. The possibilities inherent in the computer program have not been fully realized, and the graphic capabilities of kinds of perspective output were not fully explored. Nor at present does the system operate in real time. Thus, the designer can only react to a completed sequence and has no means of interacting with plotter as successive details are plotted. Such interaction is possible for the plotter operator, and computer program changes could provide a degree of immediate accessibility. These and many other refinements are possible only to the extent that potential users can become knowledgeable of limitations and implications by direct application. In this way, the capacities of the present system can be extended. Only in this way can the performance characteristics of superior systems be determined.

THE SUZZALLO QUAD:
A COMPUTED GRAPHICS SUPPLEMENT

The principal graphic output of this study is an eight minute black and white film depicting the character of plotted output and the animated simulation of a "walk through" the Suzzallo Quad. A number of slides were also prepared in the course of the study, and the accompanying diagrams are drawn from this illustrative material and keyed to the text of the paper.

EXHIBIT A1 - SUZZALLO QUAD PATH

Photo of Suzzallo Quad path - begin bottom center. Proposed buildings in light gray.

EXHIBIT A2 - FRAME CONTENT FOR VARIED CONES OF VISION

Illustration of visual field for visual cones ranging from 45° to 125° (exceeded area of plot data). Note that the frame size remains constant so that apparent closeness of object changes as a smaller image area (cone of vision) is scaled to fill frame area.

EXHIBITS B1 AND B2 - PREPARATION OF PROGRAM DATA

Exhibit B1 shows the organization of data and program for submittal to computer. The "$" are system calls of the particular computing system used. Exhibit B2 defines the data requirements and format for data decks where each line on the coding sheet represents one data card.

EXHIBIT C - EFFECT OF VARIED ANGLES OF DECLINATION

The angle of declination of line of sight, measured from a line parallel to ground surface, varied from straight ahead (top) to

10° down (bottom view). The study selected a 5° declination (middle view) here shown for a surface grade of 5 per cent upwards.

EXHIBIT D - RELATIONSHIP OF FRAME AND CONE OF VISION

Apparent image from the same point for varied cones of vision, ranging from 20° task vision (top), 60° and 125° (middle), and 175° peripheral vision (bottom). Top right is weathervane, 2° detail cone of vision, of pinnacle of tower to left in middle photo. Note the extent to which sense of architectural space is defined, or lost, by various cones of vision.

EXHIBIT E - PROGRAM PRINT-OUT

Partial print-out from computer of polygon data and plot sequence. Figure to right of "PLOT" is plotting time in minutes of a specific frame.

EXHIBIT F - CONE OF VISION DIAGRAM

Comparison of cones of vision for two positions on walk through quadrangle. Note that in both cases, a 60° cone (traditional limit for perspective views) fails to include adjacent edges defining limits of space. The observer is projected into a space before actually entering.

EXHIBITS G1, G2, and G3 - SELECTED VIEWS FROM PATH

Comparison of frame content between 60° cone of vision (left series) and 125° cone (right series). Top and middle views of sheet G3 are for positions shown bottom and top of Exhibit F.

THE SUZZALLO QUADRANGLE PATH

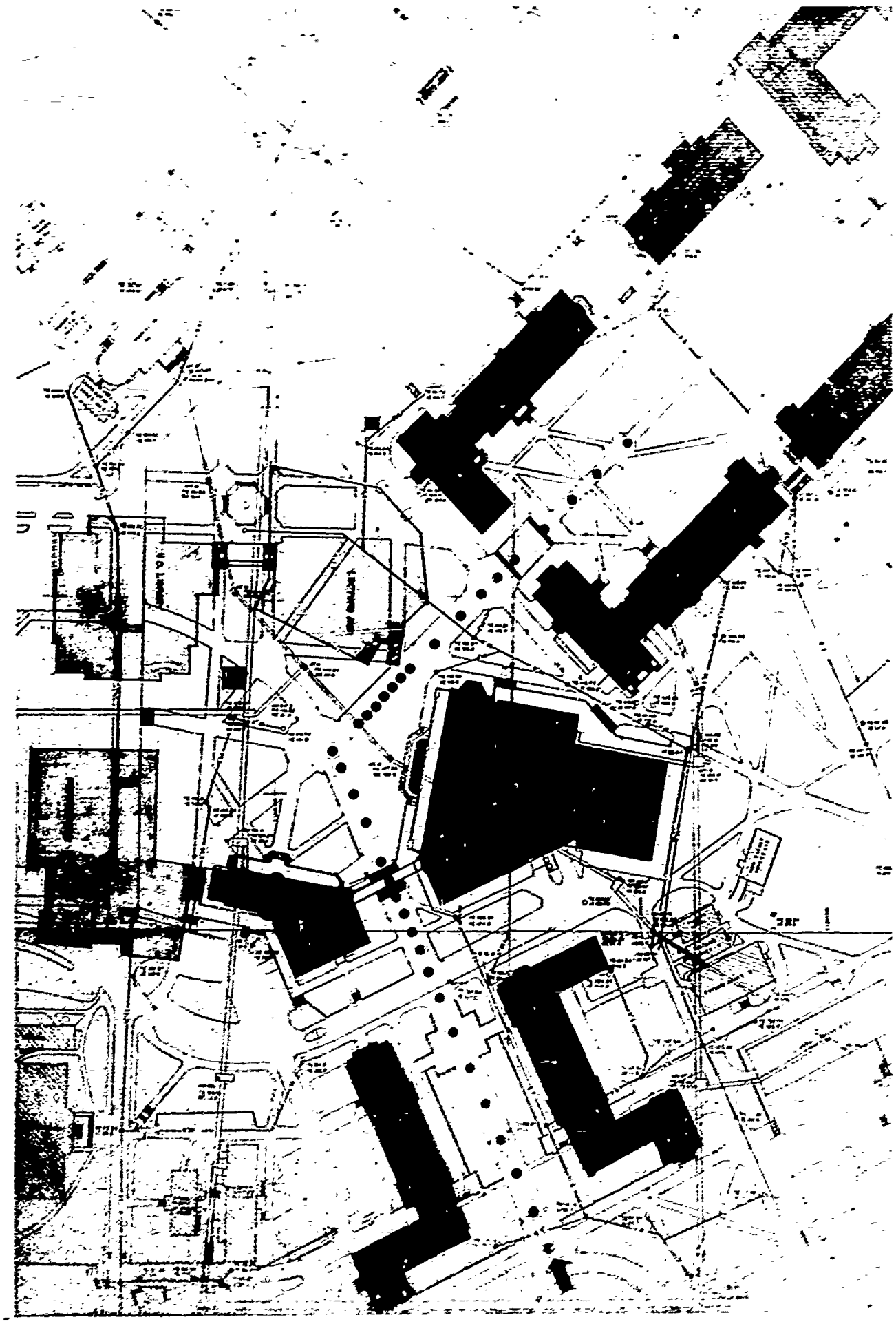
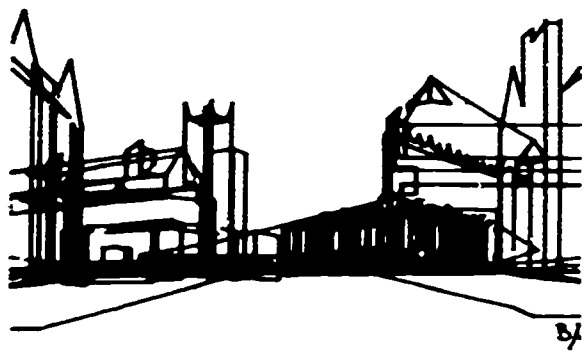
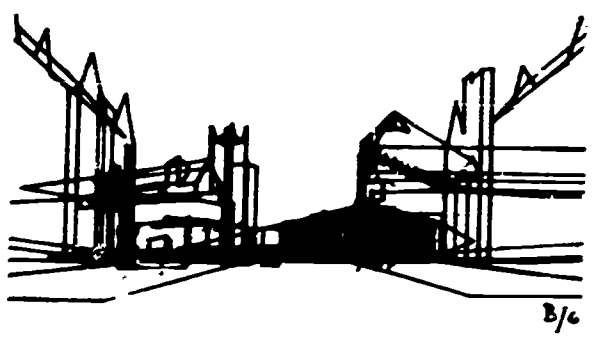
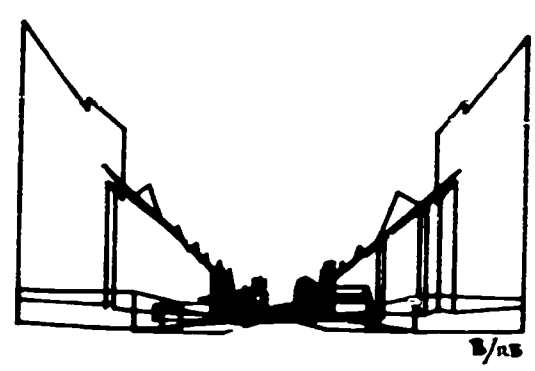


EXHIBIT A1

FRAME CONTENT FOR VARIED CONES OF VISION







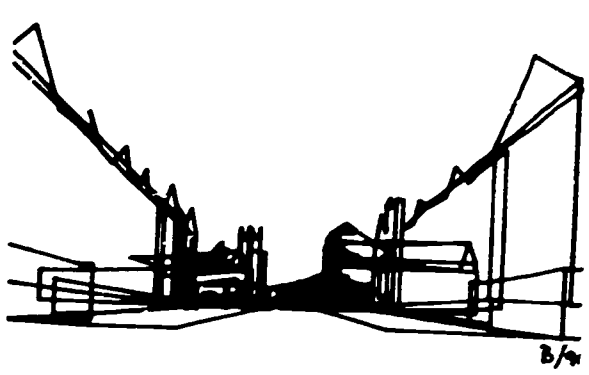


EXHIBIT A2

PREPARATION OF PROGRAM DATA

FORTRAN CODING FORM

Program PERSPA
Coded By
Checked By EAI PLOTTER

Date 6-16-68
Page of

Identification 73 80

1 5	6 7	FORTRAN STATEMENT 72
		PLOTTER REQUEST CARD
$JOB		0,3,1000 ,, NAME
$ID		
$SETUP		87 EAI
$EXECUTE		IBJOB
$IBJOB		PLOT
		(PERSPA PROGRAM DECK)
$DATA		
DATA		
		(POLYGON DESCRIPTION DATA DECK)
99999999		
SIZE		
		(PLOT COMMAND DATA DECK)
END		
$EOF		

EXHIBIT B1

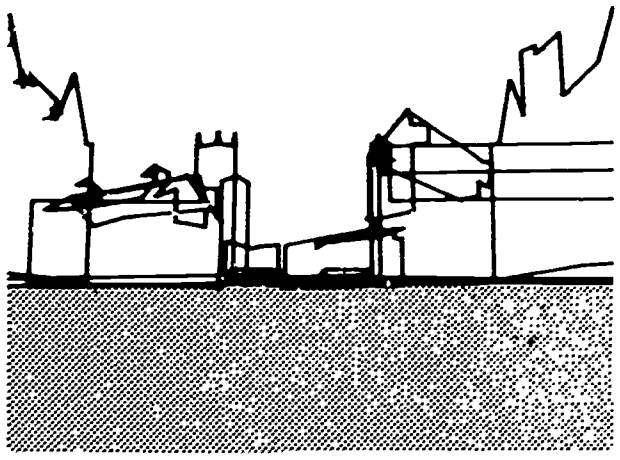
80 COLUMN ENTRY

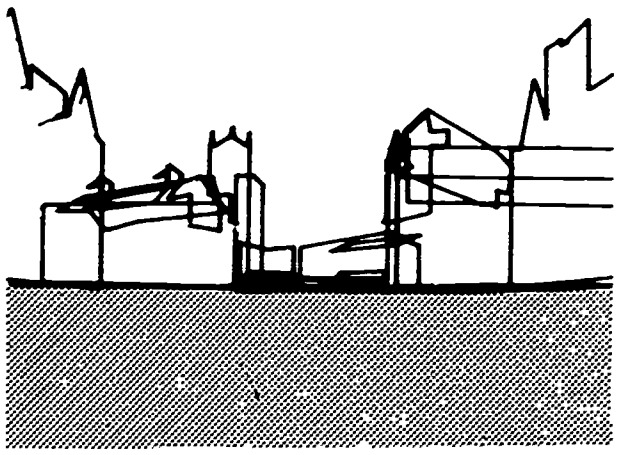
PROGRAMMER PROBLEM DATE 6-16-68 PAGE OF

1 5	6 10	11 15	16 20	21 25	26 30	31 35	36 40	41 45	46 50	51 55	56 60	61 65	66 70	71 73	74 80
			(POLYGON DESCRIPTION CARDS)												
NO.	NAME					[POLYGON TITLE CARD									
	X^0	Y^0	Z^0	X^1	Y^1	[X,Y,Z COORDINATES OF ABOVE POLYGON							Y^4	Z^4	
	X^5	Y^5	Z^5	X^6	Y^6	BEGINNING X^0,Y^0,Z^0, AND CONTINUING									
						ON SUCCESSIVE CARDS UNTIL CLOSE									
						POLYGON AT X^0,Y^0,Z^0									
			[ANY NUMBER OF POLYGONS MAY BE DESCRIBED - EACH												
			CONSISTS OF: TITLE CARD												
						X,Y,Z COORDINATE CARDS FOR POLYGON									
			(PLOT COMMAND CARDS)												
SIZE			S			[OR 7.5 OR 10., ETC., TO SET FRAME SIZE									
PLOT			X		Y		Z		X		Y		Z		CV
			STATION POINT, EA. VIEW						FOCAL POINT, EA. VIEW						
			[ANY NO. OF PLOT COMMAND CARDS FOLLOW - PREFERABLE ORDER												
			IS ORDER OF VIEWING SEQUENCE												
			[CV IS VALUE DEFINING CONE OF VISION - 60° = 1. IS, 120° = 3.50 ETC.												
DELETE			A		B		C		D		E				
			[A=NUMBER OF POLYGON TO BE DELETED FROM VIEW COMPUTATION												
			IN ORDER OF PLACEMENT IN POLYGON DESCRIPTION DECK												
RESET			A		B		C								
			[A=NUMBER OF POLYGON, AS ABOVE, TO BE RESET FOR COMPUTATION												

EXHIBIT B2

EFFECT OF VARIED ANGLES OF DECLINATION





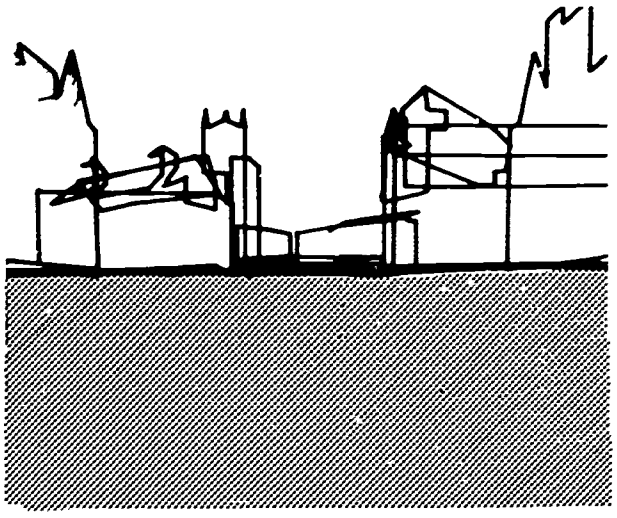
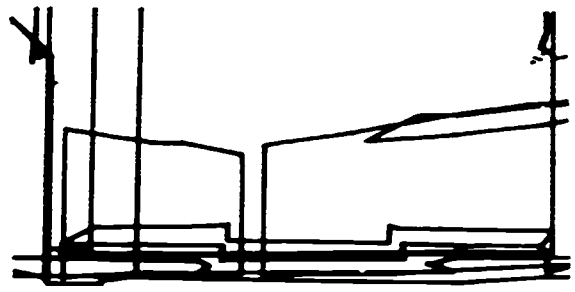
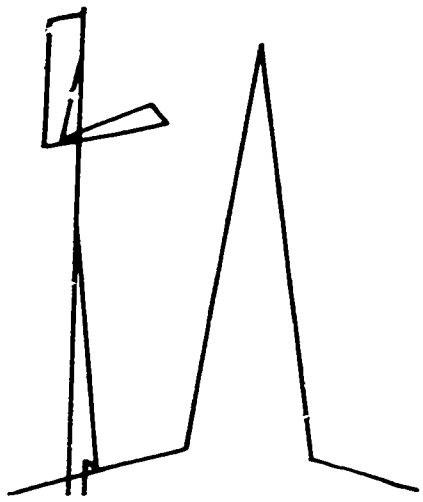
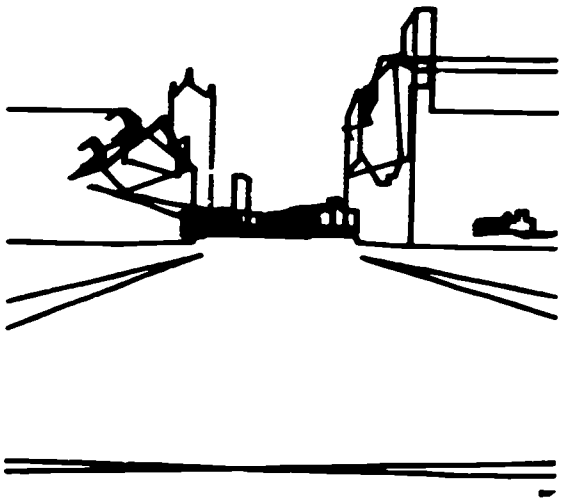


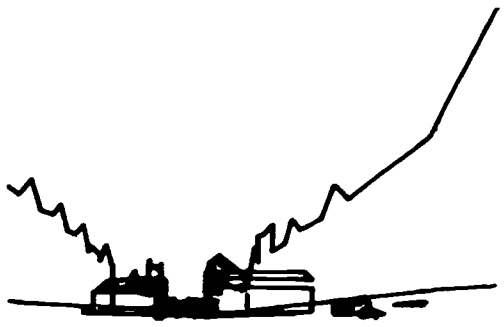
EXHIBIT C

RELATIONSHIP OF FRAME AND CONE OF VISION









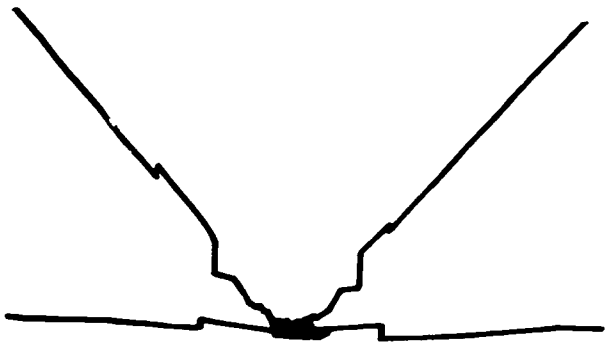


EXHIBIT D

PROGRAM PRINT-OUT

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EXHIBIT E

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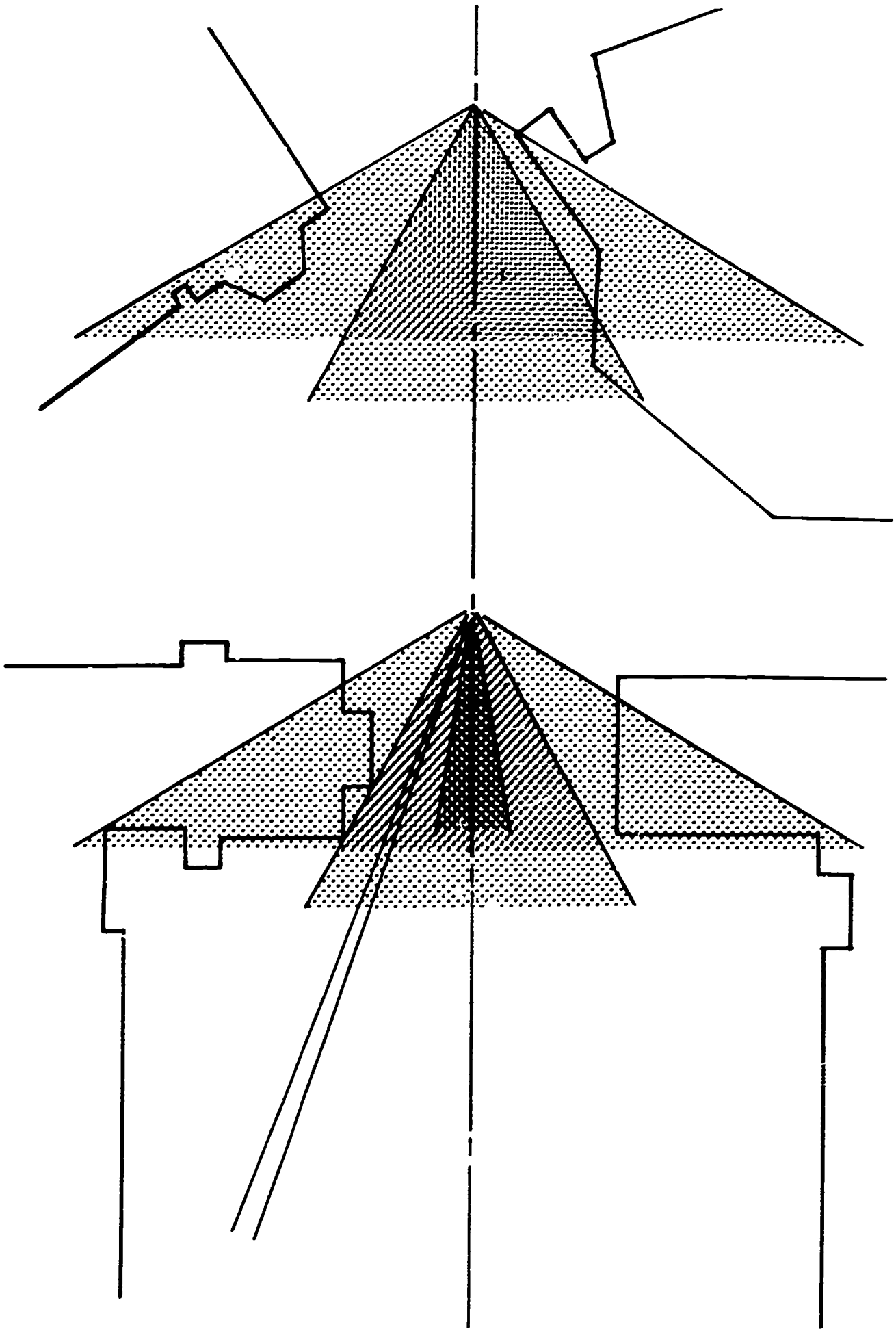

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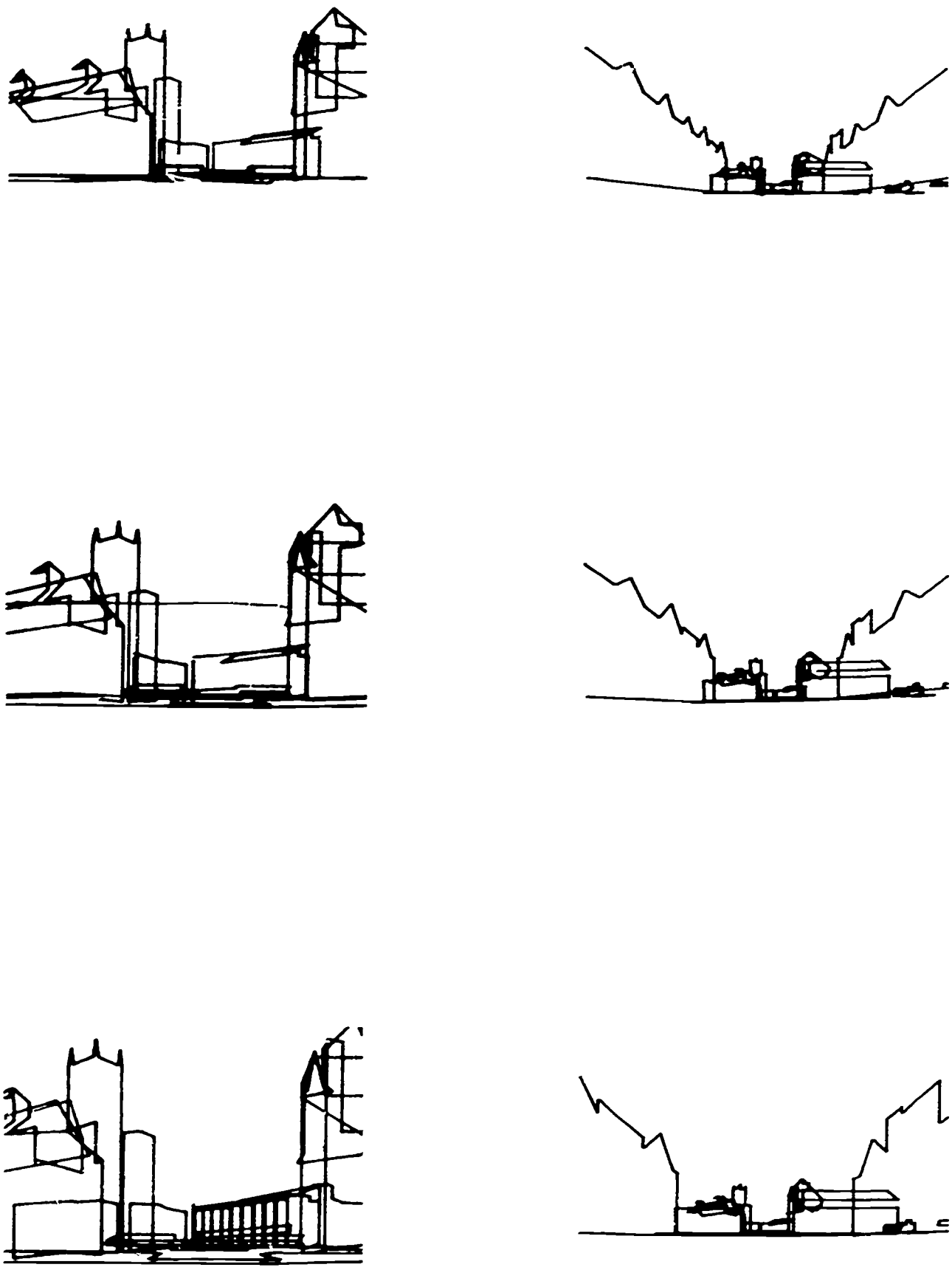

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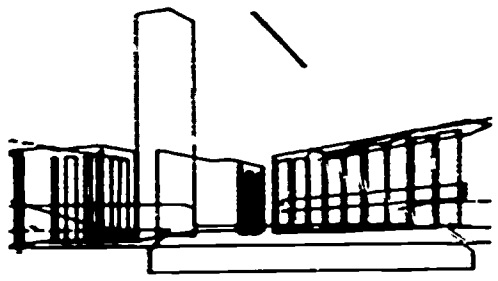

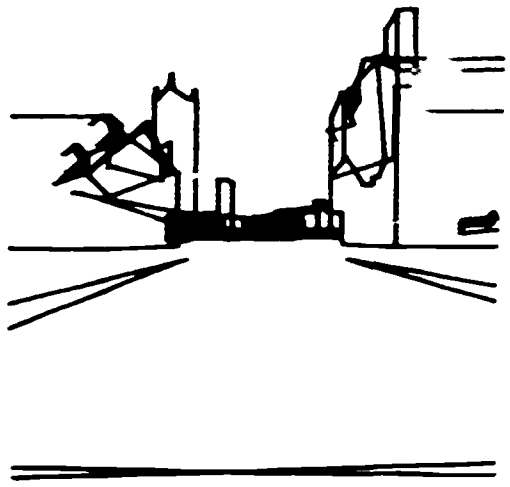

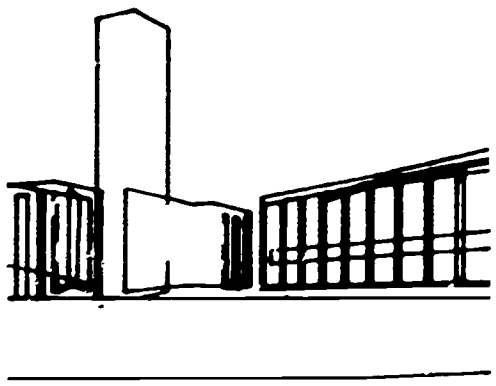

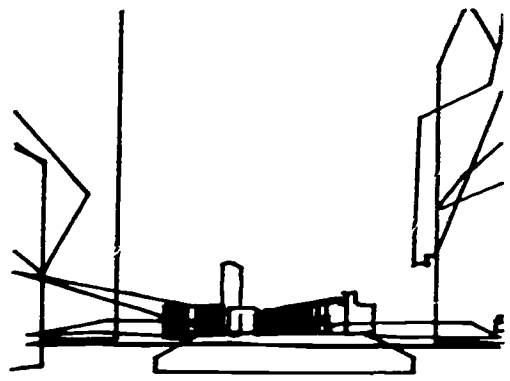

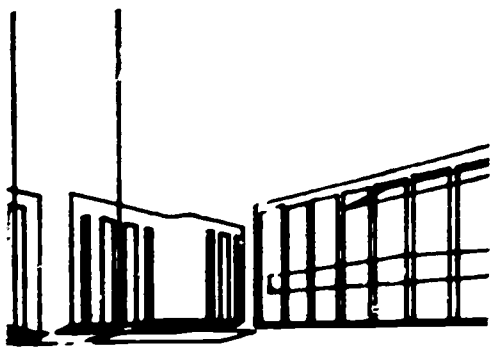

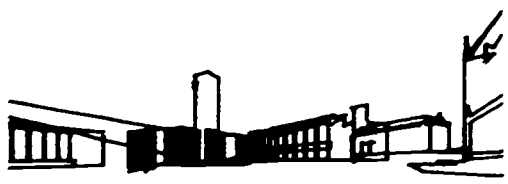

EXHIBIT G2

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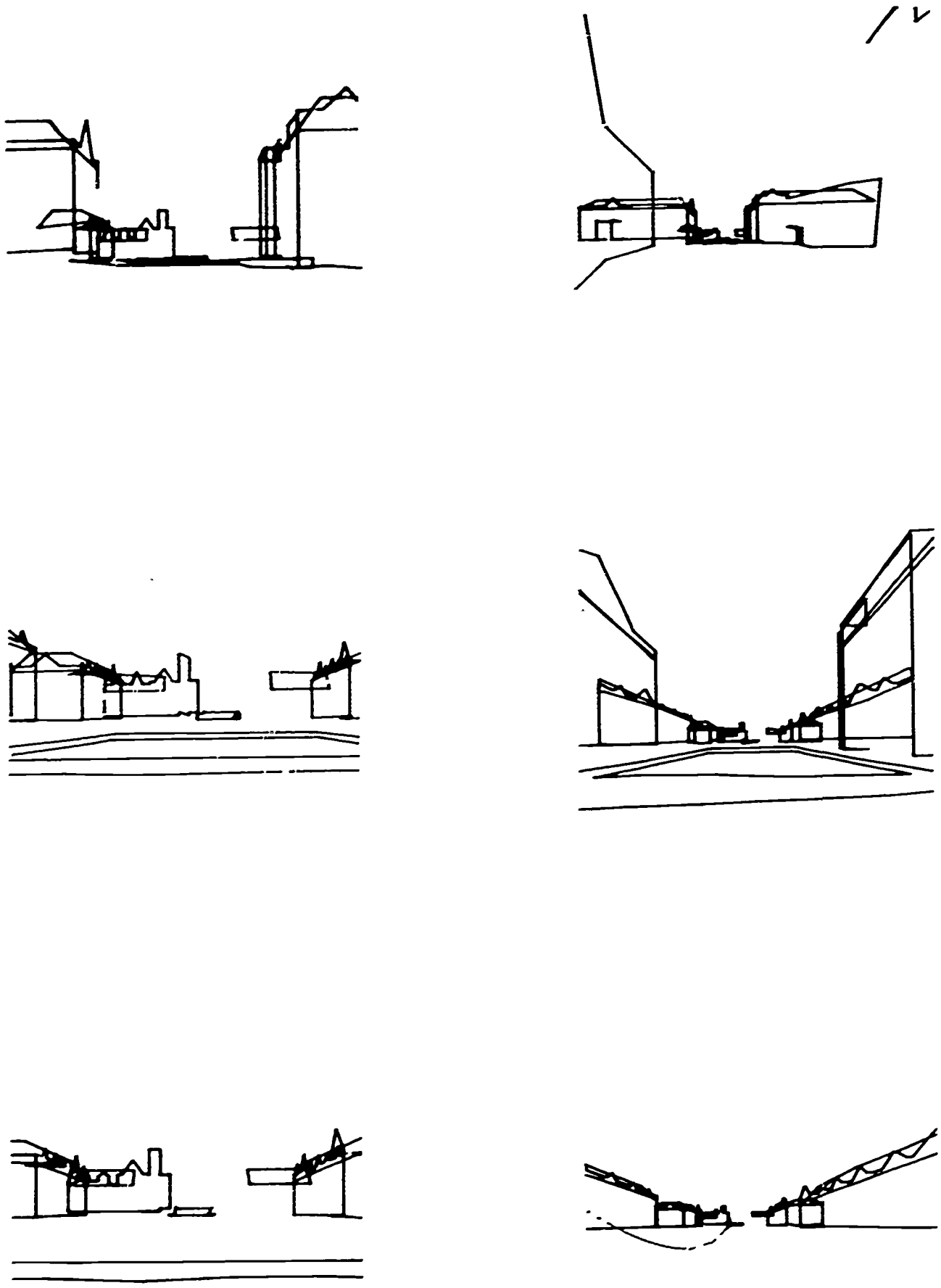

EXHIBIT G3

TRANSPORTATION EFFECTS

ON

NATIONAL PARK ENVIRONMENTS

By

KENNETH C. ANDERSON

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Division of Environmental Design
National Park Service
U. S. Department of the Interior

The National Park Service was legislatively created to preserve the great environments and present them to the visitors. A national park is one of those great environments with its pattern of use. Transportation is that pattern of use. In 1966, the National Park Service set up a Design and Construction Research Office, the Division of Environmental Design, to study factors affecting the whole park environment. Transportation is such a major factor.

Slides were shown of great environments in the following national parks: Glacier, Grand Teton, Rocky Mountain, Canyonlands, Everglades, Yellowstone, Great Smoky Mountains, Dinosaur, and Blue Ridge Parkway, showing how transportation has affected and/or can affect those environments. These effects are the effects of automobiles and roads, ranging from pleasant and well-integrated access to congestion and loss of natural values.

Slides were shown of sketches depicting possible monorail and tramway visitor access in the scenic parks. These types of transportation would avoid the congestion and wide corridor of despoilation associated with the automobile.

The concept of the ecological barrier is valuable in assessing the intrusiveness of transportation facilities in natural environments. Any man-made linear element in a park may be considered as a barrier of from 0 to 100 percent effectiveness. A seldom used forest trail would hardly inhibit at all the crossing of wildlife and migration of plantlife across it. It would almost be a zero barrier. A road congested with cars, with resultant noise, fumes, and motion would constitute almost a 100 percent ecological barrier. Even a road at quiescent periods is a considerable barrier because of its ribbon of pavement and particularly because of its cuts and fills, altered topography, and altered drainage. But, an aerial tramway with cabins

at long intervals going overhead on cables, remotely powered and quiet, would be like the trail, almost a zero ecological barrier, with only far-separated towers and an occasional moving cabin shadow disturbing the ground conditions.

Transportation affects natural parks in three inter-related ways: (1) It provides more or less convenient and pleasant means of access within the park for visitors, (2) it establishes channels of use and, when properly designed and located, helps to preserve the environment, and (3) it makes possible new types of parks, roadless - reached only by helicopter, boat, hydrofoil, tramway, etc.

Slides were shown of transportation types in the United States and Europe: trails for hiking, for horseback riding and for bicycling, a park road, jigback tramway, gondola tramway, funicular railway, suspended monorail, top riding monorail, minirail, cog railway, sky bus, dashaveyor, hydrofoil, helicopter, and incline. Comments were made on their attributes and their relative usefulness in various park situations.

Slides were also shown of structures related to transportation facilities, tramways, minirails, marinas, etc. These ranging from make-shift constructions to the most sophisticated buildings indicate the range of possibility and the challenge to architects to design suitably for people and transportation equipment, the sense of access and the environment itself.

The Division of Environmental Design in the National Park Service is studying these transportation modes and their effects on national park environments. It is a process of familiarization and research. The division is providing transportation planning consultancy to the Service's master planners. It is establishing parameters and preparing rough estimates for various types of

transportation systems in parks and portions of parks. It is sharing the data that it has assembled, together with its convictions and recommendations, by speaking and by data sheet dissemination to the Service's planners, administrators, and park superintendents.

THE MINNESOTA EXPERIMENTAL CITY PROJECT

By

WALTER K. VIVRETT

Project Director
Experimental City Project
University of Minnesota

An overleap in the ability to mould and shape man's environment - and thereby to improve the quality of his life - that is the goal of the Minnesota Experimental City Project. As the vehicle for achieving such an overleap, a new city is proposed, one in which technological innovations could be demonstrated and tested. This paper outlines, in general terms, the basic philosophy and objectives of the proposal.

At the outset, perhaps it would be helpful to you if I stated the scenario assumed for the purposes of project study and workshop discussions:

1. Joint private and public intervention in northern Minnesota;
2. To build a new city of 1/4 million population or more;
3. A city to be located at a distance of 100 miles or more from any existing major urban center;
4. A city in which technological innovations might be demonstrated and tested;
5. A city which, after a reasonable take-off period, would become economically viable (in the sense that we use that term in America today).

Along with this scenario, the following human goals were assumed as essential in the proposed new City:

To meet the common needs of individuals and groups, and the special needs of sub-groups such as the very old and the very young; to provide protection and security; to support personal integrity, individuality and choice; to permit social interaction between people of all ages and persuasions; to foster creative and renewing experiences; to encourage evaluation by citizens and to provide mechanisms for adjustment.

A word about the origin of the project and the present stage of work: Originating in a concern over the lag between technological development and the application of technology to the social and physical problems of our cities, the Minnesota study project is a cooperative venture of the Federal Government, the business and industrial community, the State of Minnesota, and the University of Minnesota. During the 16 months just past, more than 150 experts from a variety of disciplines participated with the project Steering Committee and Staff in workshop discussions embracing the state-of-the-arts in selected fields, the critical problems being encountered, and potential areas of innovation. These discussions have led to the formulation of a tentative concept of the Experimental City. They have also made a first cut at the myriad considerations which will be involved in bringing the City into being.

The Minnesota Experimental City is conceived as a proving ground to demonstrate what America is capable of, socially and physically. It is conceived as a symbol for 1976 of 200 years of evolving democratic society.

An open society in an open city is envisioned as one in which freedom of movement within the economic range of the community can become a reality for a significant number of minority and disadvantaged persons. A similar concern for people is embodied in two other specific objectives:

1. To apply new technologies - social, economic, and physical - in the service of people, and
2. To promote continuing experimentation structured to enhance the growth and development of man and his institutions.

The Experimental City should be regarded (and perhaps is only possible) as an <u>instant</u>, <u>new city</u> in which a coordinated

application of social, economic, and physical know-how can be brought to bear to the end that the City is realized as a living demonstration. The instant aspect of the effort is important, otherwise the overleap of today may turn out to be no leap day after tomorrow. With formal planning of the City to be initiated in 1970 and with a construction start in 1972, the goal for 1982 is a functioning city with a resident population of 1/4 million.

A new city is essential because only there would a total systems experiment be possible, for urban systems are complex and interacting. The bits and pieces of experiments possible in existing communities can be no substitute for one of life scale since their citizens and their institutions are deeply committed to the economic, social, and political status quo. Thus, a new city is sought beyond most of these troublesome commitments, yet with the usual cultural, social, and economic ties to other urban communities provided through communication and transportation linkages.

INTERVENTION

Now the obligations implicit in the above objectives are formidable. Except for a national emergency, Oak Ridge or a Los Alamos, the course for building a city de novo in unchartered. Further, no earlier day river-rail-and-turnpike juncture is going to assure the launching of the Experimental City. Rather, only through intervention of the highest order is it likely to be achieved. Thus, a basic premise of the proposal is that a cooperative intervention will be brought to bear, an intervention which includes business and industry, academic institutions, and state and Federal governments.

To intervene effectively, that is, to trigger not only a start but an on-going urban community, a highly coordinated effort is required. A unique partnership involving both the private and the public sector is envisioned - a partnership in which the principal interveners assume active roles in the initial city programming-planning process. Thus, interested parties from private industry would be encouraged to phase their 5- to 15-year development plans with those of the City. In addition to increased efficiencies which might accrue through such joint planning, some industries might elect to relate their experimental projects to those of the City; indeed, they might wish to make their image synonymous with that of the high-technology City.

In the public sector, state and Federal government participation will relate to traditional roles though acted out in slightly different ways. A clue perhaps to their roles in the partnership can be found in the modus operandi of the coordinative efforts in the Model Cities program or as embodied in the concept of the New Federalism.

SOCIAL COMPONENTS OF THE CITY

The heartbeat of a city is its people. And it is the people, residents of the City, who will play key roles in finally shaping the City's destiny. However the City may be popularly characterized in the years ahead - by its technological innovations, its experimentally tempered climate, its attractive tangible structures - those years cannot occur without individual and community effort. Consequently, consideration of the people and their social systems will be basic to all planning efforts.

Woven into all the City's objectives is a commitment to achieve a higher excellence of life than now exists in urban America,

and an assumption that improvement can be wrought if every man's capacities are more fully activated. To pinpoint obstacles to human resource development now and in the future is difficult enough, but to elaborate the social systems and institutions needed in a new environment to assure the full development and release of human resources is infinitely more difficult. Nonetheless, these two tasks confront the Minnesota Experimental City.

Much of the discussion at workshops revolved around social issues. Commanding the attention of all participants, regardless of their particular areas of expertise, were questions centered around:

1. The relationship of social and physical environmental characteristics on the quality of life,
2. The impact upon the consumer of various organizational forms and delivery systems,
3. The pattern of economic colonization in existing cities, and
4. The desirable professional-consumer relationship in the city.

Recent urban renewal and intra-city transportation systems reveal the weakness of implementing new plans without adequate consideration of ramifications for all of the people rather than isolated segments of the population. These efforts have often produced unanticipated consequences more dire than the original improvement target. They have also made significant segments of the population suspicious of public intervention. The lesson to emerge from this is that all segments of the population must be permitted to participate in the planning process. Another lesson is that physical and social planning must move hand-in-glove if the potential of the new city is to be realized.

New avenues for growth and development may be opened if the influences leading to current social and economic colonizations are removed. By reorienting and reorganizing services along lines consistent with development over the life cycle, new education, health, and welfare programs might be indicated. For example: educational programs for all age groups, geared to meaningful living rather than training for specific roles or occupations; health and welfare programs incorporating new organization and delivery forms, overcoming the fragmentation, rigidity, inaccessibility, and uncertain quality of some of the present systems. More complete specifications will emerge from future investigative efforts.

PHYSICAL COMPONENTS

Establishing the link between desired social outcomes and the physical hardware to be installed in the City is one of the major problems. Throughout the workshop discussions, the recurring statement of participants from industry was: "Tell us what you want; we will do it for you." This obviously does not imply that urban physical systems have been perfected and appropriately catalogued. It does mean, however, that building the Experimental City and its physical systems will not be an excessively complicated job for U. S. business and industry, if given instructions to proceed.

Within the time constraints proposed, several major advances in city-building would be possible. A major concern is in developing criteria for the acceptance or rejection of new systems. Obviously, many new systems would be rejected if profitability were the chief requirement. At the least, social costs would have to enter any profitability calculus. Beyond this, some value should be placed on being able to test an innovative new system in a life setting.

A new physical pattern of the City might emerge from future investigations, one in which micro-and macro-community features are better integrated. Out of this, a basis for ordering both housing and major services might be derived.

At the micro-community level, new research findings would be invaluable in the definition of the problem for movement systems. Instead of the usual myopic approach, a total, coordinated movement system would be possible in which one might give more than lip service to the call for transportation suitable to the needs of the old, the adolescents, and the very young.

Along with the highly optimistic attitudes toward promising innovations in the City comes a recurrent caution: A two-fold hazard to success exists in (1) man's reaction to innovations, and (2) man's interaction with the change - the inputs of which he is capable and which he is willing to make. Required, of course, is investigation of these considerations in any systems design as well as in the follow-through which might assure a fair trial of the system proposed.

FUTURE WORK

Study and investigation are continuing. Indeed, concept formulation has only begun and will continue up into the development years. Only exploratory efforts have been made at understanding the complexities of, or in considering policies for, such items as: site selection and regional impact; land ownership and development controls; programming and planning; economic base and investment opportunities; manpower recruitment and population estimates; and the interfaces of development and marketing. These and other studies, a part of the first phase of the work, will continue in greater specificity and depth and with sharpened focus upon the long range goal of achievement of the Minnesota Experimental City.

Tentative plans call for future work to be phased according to the following schedule:

	Date of Initiation	Nature of Work
Phase 1	1967	Concept formulation and background studies
Phase 2	1968	Experimental and developmental projects
Phase 3	1970	Planning, performance specifications, and design of the city
Phase 4	1972	Construction
Phase 5	1974	Feedback and continuing evaluation of the City and the process

For the second phase of the work, a program of experimental and developmental projects is being structured around alternative concepts and functions of the City. Organized under a series of umbrellas, these projects would be particularly concerned with areas of innovation and potential overleap in the Minnesota Experimental City.

Let me speak briefly about one of these umbrella projects, that of a coordinated social and physical design for community structure and growth. Our present notions about community structure are largely 19th century in origin. While urban problems have mounted and urban crisis in the 60's have heightened, we have clung to the pastoral village life concept and to the small town. As a consequence, a small town social order is defined and physically supported which focuses upon promotion of close interpersonal relationships through mutual interests: the neighborhood with its own school, church, recreational area, social and civic organizations; or a homogeneous, middle-class residential suburbia, removed from problems of the central city. Yet the urbanization process suggests that man may have been

seeking something other than this sheltered existence and growth opportunities of the small town by the very fact of his leaving that setting. The routes, the events through which this occurred, are known to us all.

Despite a growing literature by social scientists as well as the observations of a concerned citizenry in and out of government which decry the small town social order as a model for the city, few alternatives have been delineated. The colonization which it fosters seems universal - accepted in the belief that it represents the preferences of the people. Further, our efforts at remedial action in existing cities have brought only the most meager changes.

The objective of this project would be a basis, a theory for ordering individual and institutional functioning at the micro and at the macro level and, thereby, a new theory of community structure and growth. Such a research effort would involve not only the full range of social subsystems, but also the full range of physical components and subsystems - particularly those innovations which might be contributive to an improved environment for urban life.

If individuality, integrity, and choice are to be supported, social criteria, developed from human expectations and realities, must be relevant to the urban environment of the future. Development of such a social design, I am sure you would agree, could be of enormous importance to the entire urban planning field.

A recurring question is whether or not time constraints would permit an overhauling of this magnitude. The horseback guess of the staff is that in-depth research in this area would require five to seven years. On the other hand, it is believed that a two year period of research could produce significant criteria for the social design.

A promising early return might be provided by the identification of an age-related continuum of human needs and aspirations, pulling together the existing literature on human growth and development and the aging processes. The continuum should include, for example, age-linked needs characteristic of the major stages of the life cycle, needs which continue throughout life, and age-related needs which are common and those which are unique to members of specific population groupings.

From this and related constructs, we would hope to achieve new insights which would suggest guidelines for new social policies and their physical counterpoints.

In conclusion, physical and social innovations will give form and substance to the new city. But the real test will be the extent to which such innovations enrich the lives of residents, for it is its people who are the essential ingredient of a city.

PROBLEMS AND OPPORTUNITIES IN THE DEVELOPMENT AND MARKETING OF UTILITY CORES

By

NICHOLAS L. MACZKOV

Manager
Major Account Sales
American Standard, Inc.

I think we are well aware of the history of our quest for a sub-system of manufactured mechanical components and utility cores that would reduce on-site labor and reduce on-site skill, as well as reduce weight and shorten construction time, at a reasonable cost.

The opportunities seem endless, but, judging by the absence of an acceptable total utility core in the construction and design market-place today, we can assume that perhaps the problems outweigh the opportunities.

The pressures of immediate and near-future mass housing demands directed towards the utilization of innovative building systems have again spotlighted the need for a utility core concept. A rather comprehensive study of building systems has been undertaken in recent months related to the H. U. D. "In-City Experimental Housing Research and Development Program" for model cities. The studies and investigations of the groups working in this program, as well as the Department of Defense Housing Program, have provided the researcher with his first significant opportunity.

Since innovations are a requisite within the building systems to be employed, all groups have a prime interest in bathroom components, unitized bathrooms and utility cores, manufactured or site pre-assembled.

This is the first time that the researcher of utility or mechanical cores has had "prime time" with the total design and disciplines group involved in housing. It is also the first opportunity the researcher has had to relate the utility and mechanical requirements and core feasibility in varied housing market categories with the same design and disciplines group.

The configuration of the core concept varies in the categories of single family detached housing as compared to rehabilitation, self-help housing, low-rise, medium-rise, and high-rise units.

The so-called "low cost" single family, one story, one bathroom house can utilize a simple bathroom-kitchen core configuration comprised of pre-assembled components; the two story living unit would require a modified version where the bath was on the second floor. In neither case can a "fixed" type of total core be justified if volume is to be gained.

The low-rise/high-rise multiple living unit complex offers the greatest opportunity since the "stack-on" economies can be realized. But, even in this instance, wide usage of a fixed or unitized core complex is highly questionable since the various mixes of bedroom requirements and user needs dictate variations of core configurations.

Obviously, the rehabilitation and "self-help" housing markets require different component applications as well, from the simple wet wall and tub component to possibly a fixed manufactured box unit.

What feasible core solutions will be arrived at within the scope of the experimental In-City Housing Program that prove the innovative concepts acceptable cannot be anticipated. However, the researcher should be in a far better position to measure the opportunities for mass use of the utility core or component concepts as the result of these experiments.

For the researcher, the time is seemingly right, the markets have been generally delineated, the building systems will soon be in the experimental stages, and the local codes and labor attitudes, as well as consumer acceptance, may soon be measurable. Within

a reasonably short time, the criteria for the sub-systems of mechanical equipment may be more accurately determined. We must, however, re-assess our direction in component core development to keep it as flexible as possible until the precise conditions are established.

If I were to delineate suggested parameters of a mechanical-utility core components concept to best meet the varied requirements of the categories of housing involved in the mass housing program, they would be as follows:

1. The various housing systems involved, as well as the living plan arrangements of the categories of single family, rehabilitation, self-help, low-rise, medium-rise, and high-rise, cannot employ a fixed manufactured utility core unit in volume application.
2. Accordingly, a sub-system of component units inter-related to afford different total core configurations, as well as single bath-kitchen combinations, would best serve the desired flexibility of living unit planning.
3. With the status of numerous producers of plumbing fixtures, appliances, heating and air conditioning, and electrical equipment, it is very questionable that any single producer or manufacturer can successfully and competitively mass-produce the core configuration requirements of this mass housing market.
4. Flexibility of core configurations is mandatory for the architect, engineer, and designer if the user needs are to be met within the housing construction systems employed.

I would like to visually demonstrate a realistic application of the component concept in a medium high-rise building utilizing Carl Koch's Techcrete system, which evolved initially from the development of a component unit bathroom concept and further integrated into a variable core concept within the building system.

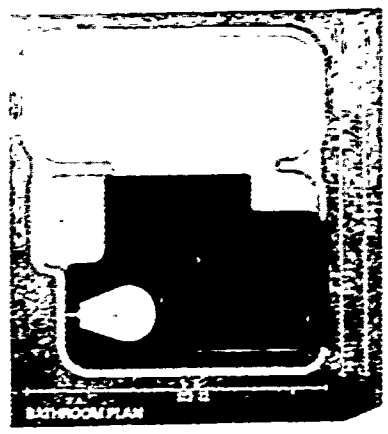
Slide 1 - Ideal-Standard Ltd.
Rollosrank glass fibre bathroom unit
Slide 2 - Component bathroom unit
Slide 3 - Interior view of bath and wall surround
Slide 4 - Interior view of the Lav-WC component
Slide 5 - Component bath unit - back to back arrangement
Slide 6 - Component bath unit - four way with core housing
Slide 7 - Alternate core configuration with kitchen and laundry components
Slide 8 - Core configuration in relation to living unit - first floor
Slide 9 - Core configuration in relation to living unit - second floor

In closing, I would like to present a few "abilities" which the researcher must consider in the problem areas of the component utility core concept.

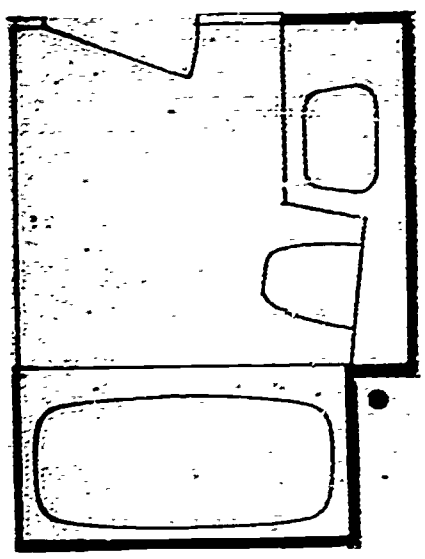
Never, in the past thirty-odd years, has the timing, environment, interest, and demand of the housing market-place been so receptive to the component utility core concept. The opportunities seem rewarding, but the gloom of the inherent problems and obstacles which the researcher must face in the total development and marketing process are still with us.

As you know, the name of the game is acceptability, low-cost ability, flexibility, reliability, accessibility, and, of most importance to the producer, profitability.

Only through a continuous over-all mutual effort of the researcher and design-disciplines group can we hope to bring to the market-place the industrialized mechanical components to meet the over-all requirements of the mass housing market. In addition to this effort, we must have the proper acceptance environment at the local project levels as well. This is our challenge; this is our quest.



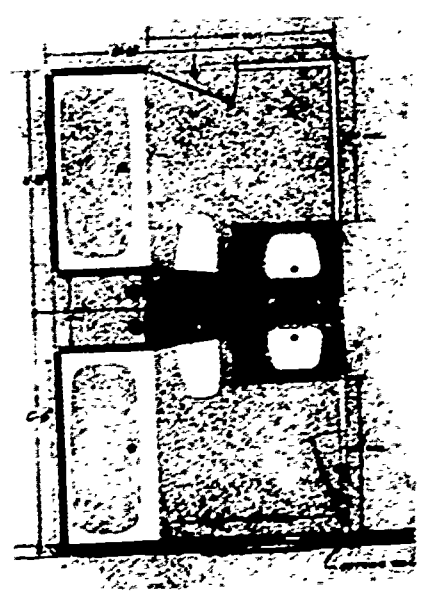
SLIDE 1



SLIDE 2

SLIDE 3

SLIDE 4



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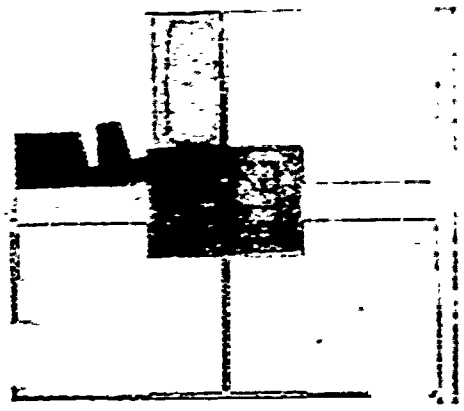

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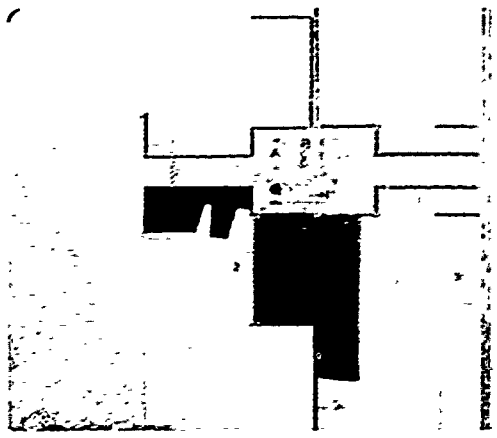
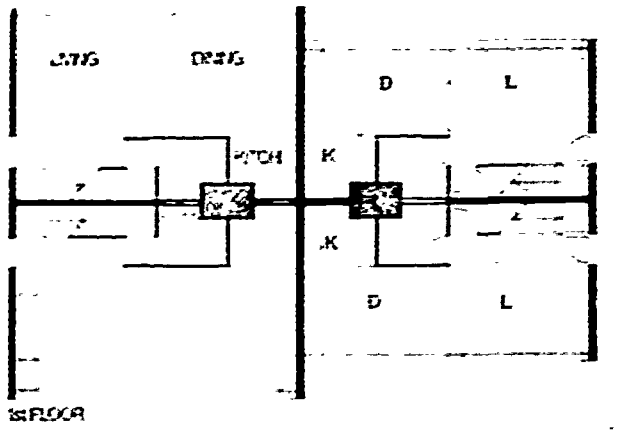
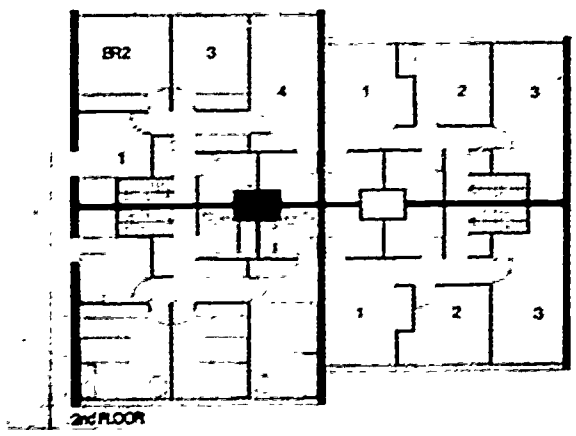


SLIDE 7



SLIDE 8



SLIDE 9

APPENDIX A

A I A C O M M I T T E E
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APPENDIX D

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MURTHA, D. Michael
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SLATER, Gerald
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STOLPER, Jane H.
Interior Design

S T A F F

BATTEEN, Carol M.
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