PROTOTYPE PASSIVE SOLAR BUILDINGS IN LOUISIANA -- A HOT-HUMID CLIMATE

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ABSTRACT

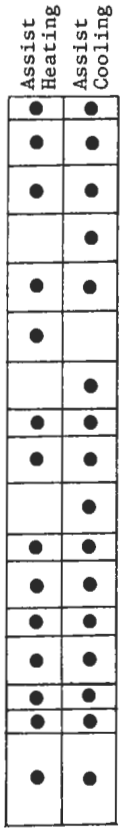
This paper on prototype passive solar buildings in Louisiana presents state of the art passive solar design. According to U.S. Department of Energy report, the annual energy consumption for a single family detached dwelling in Louisiana is from 31,000 to 51,000 Btu's/sq.ft./yr. with a mean at 38,000 Btu's/sq.ft./yr. and for an office building is from 39,000 to 58,000 Btu's/sq.ft./yr. Incorporation of passive solar design may provide a major percentage of the energy consumption with only 2 to 8 percent of additional construction cost. The projected savings as presented in this report are an approximate estimation. However, the actual savings will vary depending upon the occupancy, operation, and maintenance of the building.

At the same time, such design represents an increased involvement for the architect. The full potential of this passive solar design depends on a sensitive awareness of the relationship between climate, comfort and the thermal characteristics of buildings and building materials.

The primary purpose of this work is to offer a working definition and fundamental understanding of a number of practical applications of passive solar designs in Louisiana. Four new buildings and six existing retrofitted buildings are presented.

NEW RESIDENTIAL BUILDING

Type I -
-Building Description:
This one-story, three bedroom house has approximately 2,000 sq. ft. of living space. The exterior walls are wood frame with a 4 inch brick veneer.
-General Objectives:
The house is designed to have a minimum heat gain in the summer, solar assisted heating in the winter and to require a minimum amount of energy to operate on a year-round basis. A close relationship between interior and exterior spaces, ceiling fans, and the possibility of natural ventilation make this house comfortable as well as practical. The estimated energy savings of 50 percent over a conventional house of this style is achieved through the design features listed in the following summary. The additional construction cost of this type design is approximately 2-4%.



PASSIVE SOLAR DESIGN FEATURES

Orientation for proper solar exposure
Exposed brick pavers and brick feature walls for thermal mass
Roof overhang designed to shade windows & walls in summer but not in winter
Location of carport & storage to protect west wall of house
Earth berming on north side for temperature moderation
Attached greenhouse for winter heat collection
Window & door location designed for natural ventilation
Air lock door system
Exterior living spaces on north and south
Ventilated double roof on southern and northern slope* with foil radiant barrier
"Day and night use" zoning
"Heat producing/non heat producing" space zoning
"Lived-in/non lived-in" zoning
Tight shell construction, high insulation standards and double glazing
Careful landscape planning
Ceiling fans for air circulation*'
South facing clerestory designed for winter heat gain and year round natural lighting, but shaded by overhang to prevent summer heat gain

*Ratio of radiation exposure on south facing roof to radiation exposure on north facing roof is:

JULY	
30° N. Slope / 30° S. Slope	60° N. Slope / 30° S. Slope
0.90	0.52

*'Not a truly passive design feature

See Figure 1 and 2 for design description

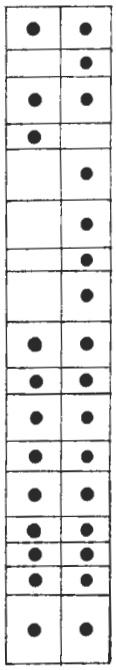
NEW RESIDENTIAL BUILDING

Type II-
-Building Description:
This two-story wood frame house with wood exterior siding has three bedrooms and two baths. The living space is approximately 1,600 sq. ft.

Proceedings of the Third Symposium on Improving Building Systems in Hot and Humid Climates, Arlington, TX, November 18-19, 1986

-General Objectives:
This house is designed to achieve a balance between the benefits of a compact two story home and the openness of a single level plan. It is also designed for a small site and is carefully oriented to receive maximum heat gain in winter with maximum shading in summer. Earth berms and a sloped roof provide an aerodynamic form to face the winter north winds. A thermally isolated open kitchen prevents internal loads from building up during the summer. The estimated average energy savings is approximately 45 percent. The extra cost for construction is between 2 and 4 percent.

PASSIVE SOLAR DESIGN FEATURES



Site orientation for correct solar exposure
Shaded and ventilated west wall
Roof overhang shades south windows and walls in summer
Compact plan
East windows shaded in summer by vertical shading fins
Windows & doors, located for natural ventilation
Shaded windows on east & west
Thermally isolated kitchen and laundry room
Zoning to locate heat-producing spaces on northern side
Earth berms on north side
Ventilated northern and southern sloped roof**
Exterior living spaces
Tight shell construction, high insulation standards and double glazing
Air lock door system on north side
Ceiling fans*
Exposed brick pavers for thermal mass
South facing clerestory for winter heat gain and natural lighting with overhang to prevent summer heat gain

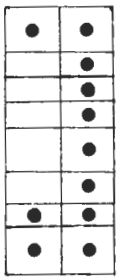
*Not a truly passive feature
**With foil radiant barrier

See Figure 3, 4 and 5 for design description

RESIDENTIAL RETROFIT

Type I-
-Building Description:
A simple one-story, slab-on grade structure of approximately 1,000 to 1,400 sq. ft. in floor area is typical of houses built throughout the state area in the 1950's. These houses have low levels of insulation, high levels of infiltration, and inadequate attic ventilation.
-General Objectives:
The goal is to ease the cooling load as listed in the following summary form. An estimated savings is approximately 25 percent when the suggested modifications are used. The payback period of the cost is less than 2 or 3 years.

ADDED PASSIVE SOLAR DESIGN FEATURES



New trellis with decidious vines on south wall
New ventilated double wall on west wall
Improved attic insulation
Air lock door system
Additional ventilation in kitchen and bathroom
New ceiling fans*
Additional control of infiltration levels
Ceiling insulation with foil radiant barrier facing up

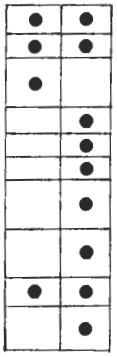
*Not a truly passive feature

See Figure 6 and 7 for design description

RESIDENTIAL RETROFIT

Type II-
-Building Description;
This example is an older, "large" two-story wood frame house common to this region. It has high ceilings, low levels of insulation, a front porch and an attic which are features that may respond to passive retrofit improvements.
-General Objectives:
The goals of this retrofit recommendation are to provide:
-An increase in natural ventilation
-Additional protection from summer heat gain and winter heat loss.
-Additional heat gain in winter
-Additional outdoor living spaces
The results of these modifications should amount to an approximate 35 percent savings in energy consumption.

ADDED PASSIVE SOLAR DESIGN FEATURES



Controlled infiltration levels
Added floor and ceiling insulation
New operable windows on front porches to provide sun spaces
Additional roof ventilation**
New north side screen patio
New floor grills for added ventilation
New ventilated double wall on west and east*
New overhangs on south side to protect from summer sun
New ceiling fans
Shading devices for east and west windows

*It is assumed that the east and west walls are both fully exposed to the summer sun (i.e., no shade from trees, etc.)

**With foil radiant barrier

See Figure 8, 9 and 10 for design description

RESIDENTIAL RETROFIT

Type III-
-Building Description:
This example is a 2,000 sq. ft. brick veneer house which contains a living room, dining room and kitchen. It is a one-story structure.
-General Objectives:
This structure has a high level of insulation and a tight shell. The goal, to reduce energy consumption, is achieved by controlling heat gain in the summer and in the winter. A 25 percent savings in energy cost is expected with the modifications indicated.

Assist Heating	Assist Cooling	ADDED PASSIVE SOLAR DESIGN FEATURES
●	●	Increased insulation in attic
●	●	New air lock door system
●	●	New greenhouse for heat gain in winter
●	●	New landscaping and earth berming
●	●	Additional exterior living spaces
	●	New ventilated double wall on west and east sides
	●	Extension of roof overhangs
	●	Improvement of ventilation in kitchen, bathrooms and laundry
●	●	New ceiling fans*
	●	Shading on east and west windows
	●	Add foil radiant barrier in attic

*Not a truly passive feature

See Figure 11, 12, 13 and 14 for design description

NEW COMMERCIAL

Type I-
-Building Description;
This small, three-story office building has under 50,000 square feet of floor area. This building type covers a wide variety of construction types. Typically built on speculative basis, low initial and operating costs are essential. Low energy consumption is a significant factor in maintaining low operating costs.
-General Objectives;
This primary objective is to achieve low overall annual energy consumption while providing a building which satisfactorily meets the needs of the owners and building users. Since lighting and space conditioning account for over 90 percent of the total energy usage, conservation strategies should concentrate on temperature and insolation control, and the use of daylight.

A carefully designed office building may result in an approximate 50 percent energy savings as compared to similar buildings in which energy use has not been a consideration. This improvement can be achieved with only an approximate 3 to 5 percent increase in the construction cost.

Assist Heating	Assist Cooling	PASSIVE SOLAR DESIGN FEATURES
●	●	Orientation for solar control
	●	Building form to minimize solar gain
●	●	Increased still air film around building
	●	Use of unconditioned spaces
	●	Increased use of natural light and ventilation*
●	●	Efficient HVAC systems using economizer cycle
	●	Reduced levels of illumination, more efficient fixtures and switching techniques*

*Also reduces electrical energy consumption.

See Figure 15, 16 and 17 for design description

NEW COMMERCIAL CONSTRUCTION

Type II-
-Building Description:
This typical office tower is a multi-story, single use with only daytime occupancy and has minimum skin surface to volume ratio. The primary energy consumption factors are lighting and space conditioning. An important design consideration is the need for flexibility in office layouts.
-General Objectives:
The main goal of this design is to reduce the cooling loads which dominate buildings of this type. These heat gains are generated by both internal and external forces and are affected by the nature and characteristics of the occupancy. The heating load in tall office buildings in this climate can be dealt with by envelope design. The annual energy savings can reach 40 percent through the appropriate design considerations. The additional construction cost is about 2 to 4 percent more than conventional design.

Ast Heat	Ast Cool	PASSIVE SOLAR DESIGN FEATURES
●	●	Orientation for solar control
	●	Buffering heat gain with uninhabited spaces
	●	Use of unconditioned, naturally ventilated spaces
	●	Zoning office space for use of natural light
	●	Venting heat producing spaces
●	●	Efficient HVAC strategies (i.e., fresh air cooling, variable air volume systems, planned shut down for air systems
	●	Localized illumination controls*
	●	Reduced illumination levels*
	●	Use of natural light*
	●	Form to minimize heat gain
●	●	Building operation management training

*Also reduces electrical energy consumption

See Figure 18, 19 and 20 for design description

COMMERCIAL RETROFIT

Types I and II-
-Building Description:
Existing low rise and tower office buildings are often large consumers of energy when compared with their new or future counterparts. The problems with existing buildings are a result of lack of concern about energy conservation design. This is evident by buildings with improper site orientation, inefficient HVAC systems, limited use of natural light, and other factors. However, since these buildings may still be used over a long period of time and represent a large economic investment, energy conserving retrofit modifications are practical.
-General Objectives:
The goal of these retrofit designs is to reduce the cooling load and overall energy consumption by introducing sound economic modifications. The building form, orientation and internal organization can not be reasonably modified in existing structures; however, the incorporation of other passive features could result in an approximate 50 percent savings.

Assist Heating	Assist Cooling	ADDED PASSIVE SOLAR DESIGN FEATURES
	●	New shading devices on east, west and south walls
	●	Rewiring of existing lighting fixtures to allow local switching and the use of daylight
	●	The clustering and venting of internal heat sources
	●	The reorganizing of office space to buffer heat gain with uninhabited or service spaces
●	●	The use of economizer cycle in HVAC equipment
●	●	Additional use of unconditioned spaces (halls, lobbies, etc.)
●	●	Building operation and management training
●	●	Planned shut down for air systems

See Figure 21, 22 and 23 for design description

COMMERCIAL RETROFIT

Type III-
-Building Description:
This building is a pre-fabricated metal building. These structures are typically constructed with a lack of natural ventilation, daylighting, and adequate insulation.
-General Objective:
The goal of this energy remodel is to improve occupancy comfort conditions in the structure. The existing conditions, resulting from the design and construction of the building, limit the ability to make large improvements. It should be noted, however, that any existing structure that was designed with little concern for energy conservation may be more energy efficient by certain types of modifications, as listed in the following summary form. The energy conservation is projected about 35 percent.

Assist Heating	Assist Cooling	ADDED PASSIVE SOLAR DESIGN FEATURES
	●	New doors placed for cross ventilation
	●	New continous ridge vent
	●	New roof spray system
	●	Installation of new shading devices on existing improperly placed skylights
●	●	New north facing roof monitors
●	●	New solar domestic hot water system if needed*
●	●	New ceiling fans*

*Not a truly passive design feature

See Figure 24, 25 and 26 for design description

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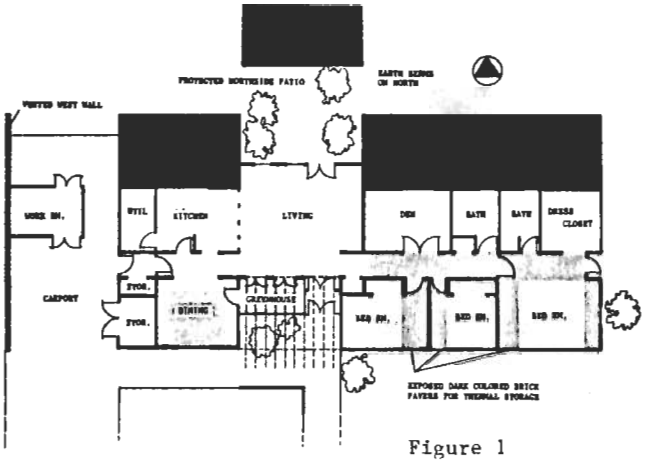
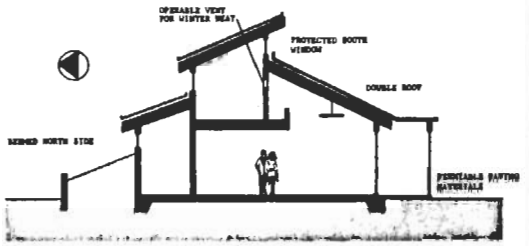


Figure 1



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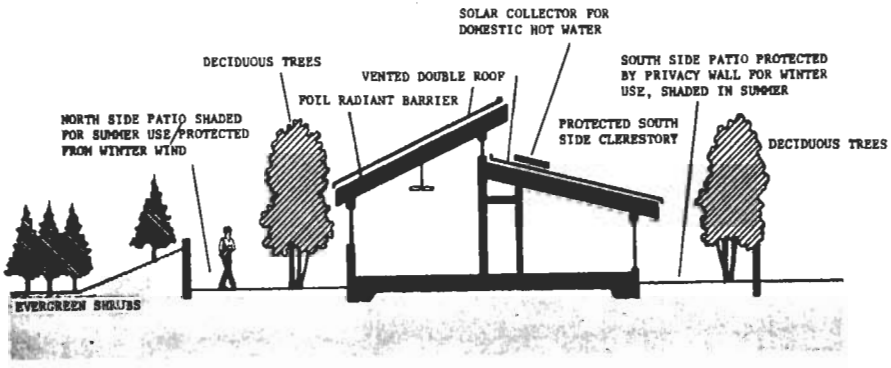

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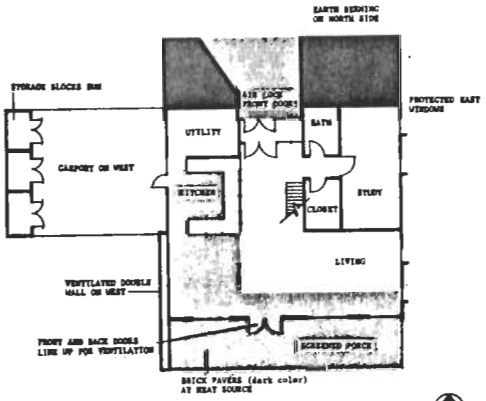

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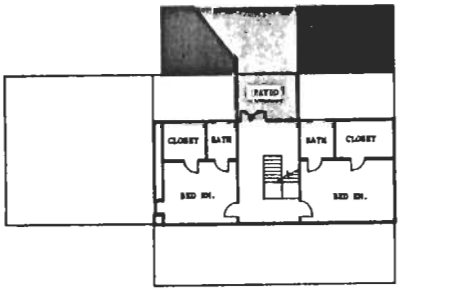

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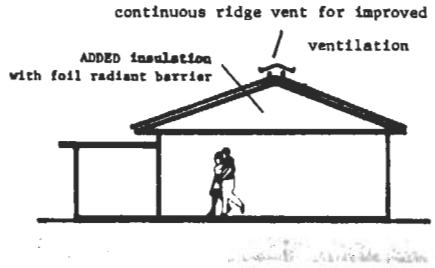

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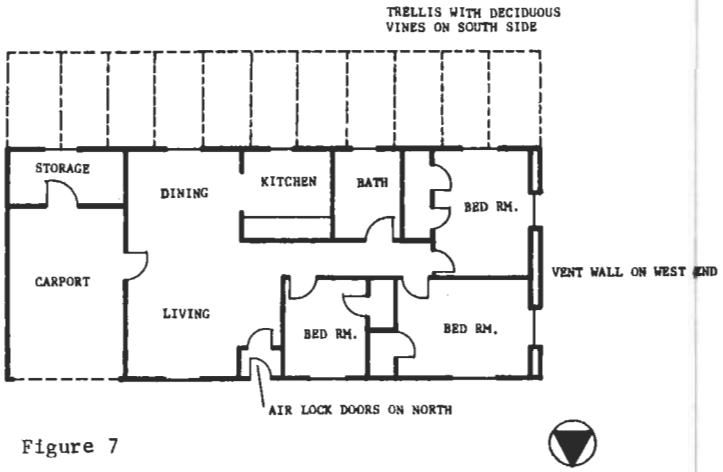

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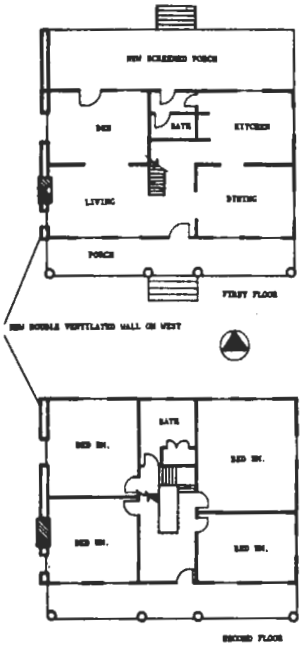

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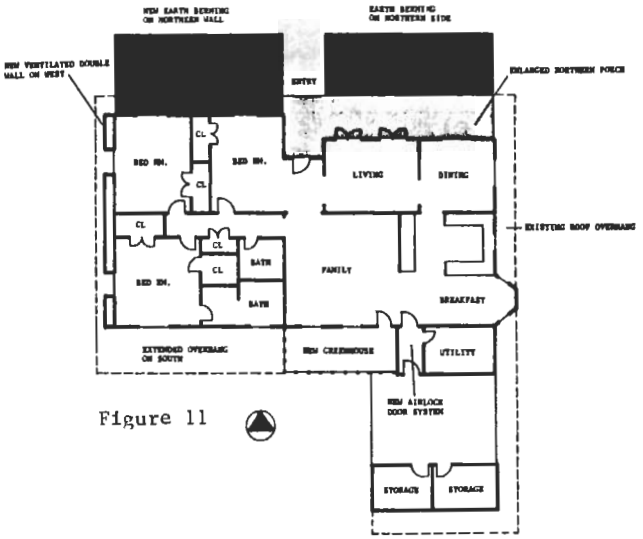

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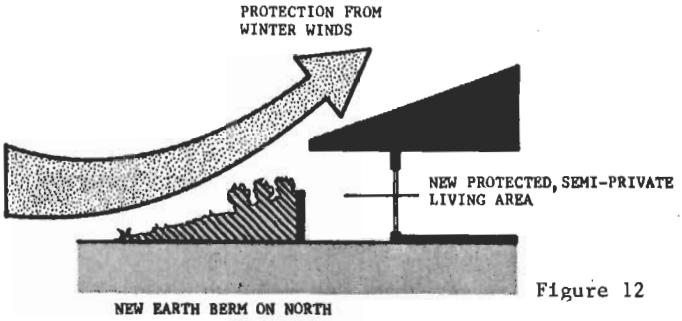

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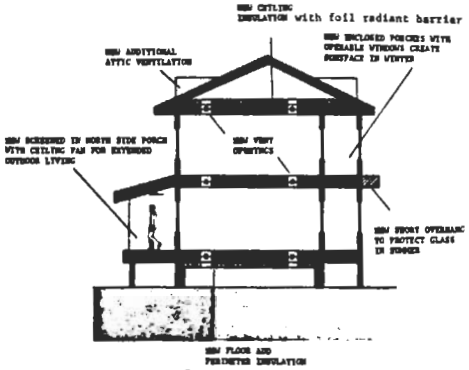

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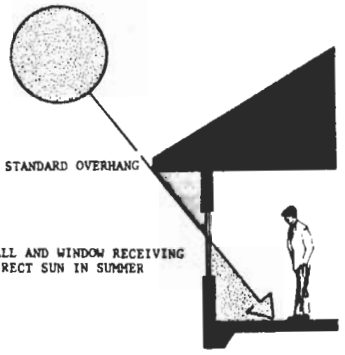

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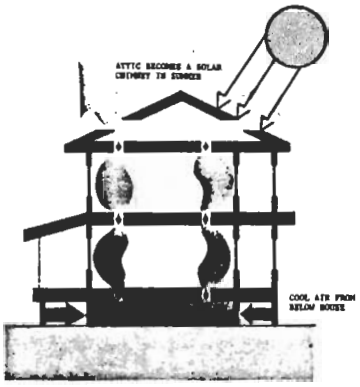

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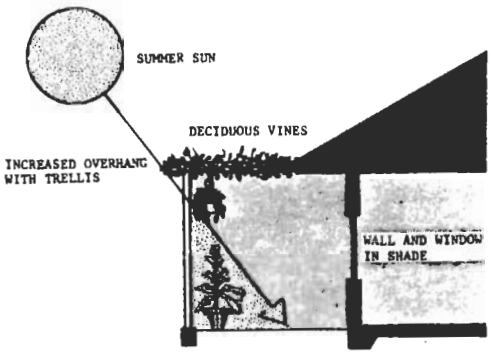

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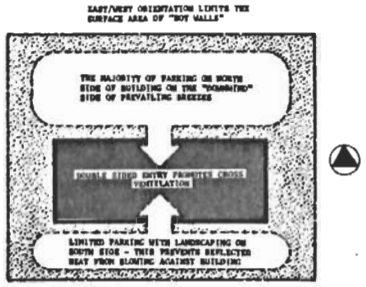

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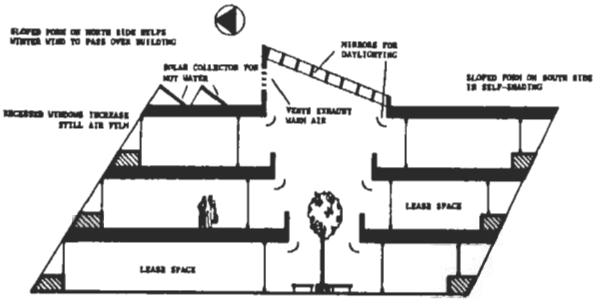

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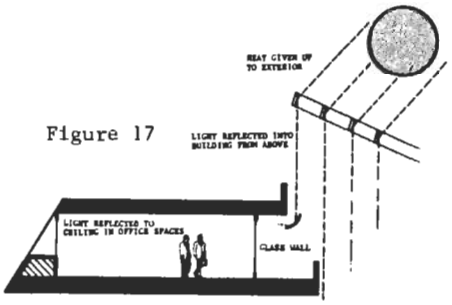

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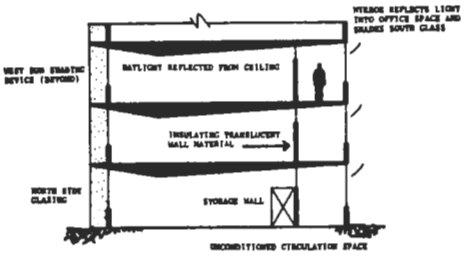

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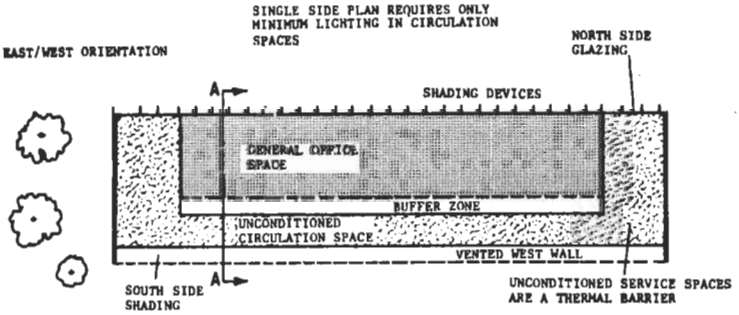

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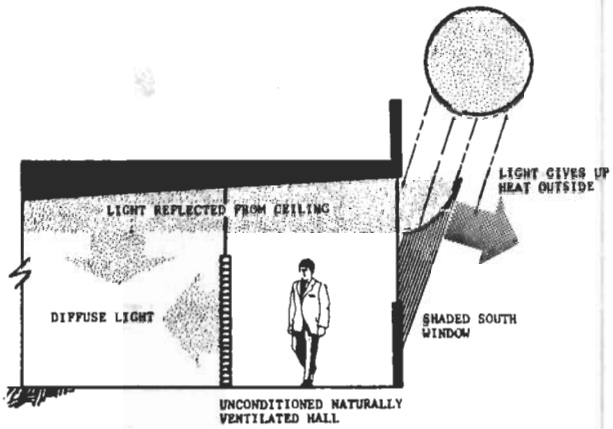

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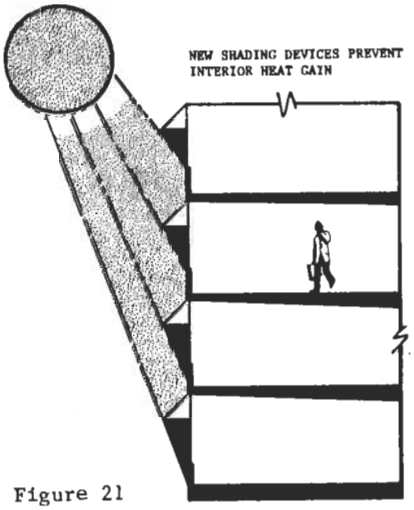

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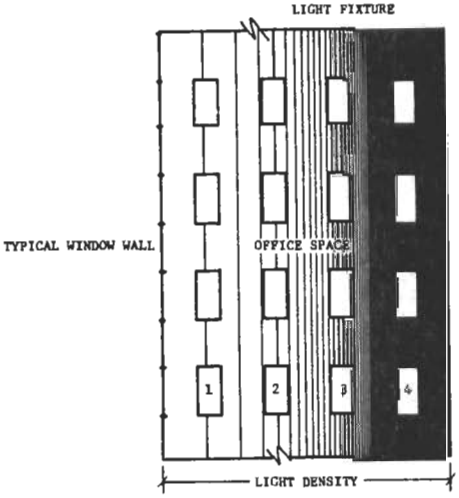
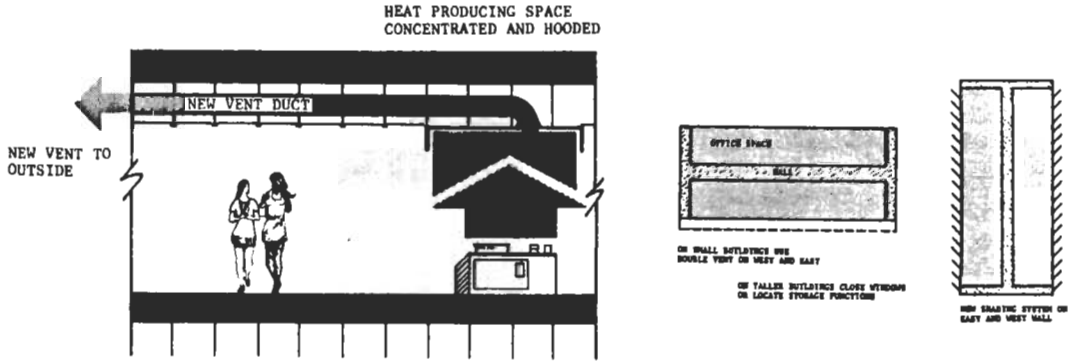


THE USE OF DAYLIGHT IN OFFICES REQUIRES THAT THEY BE WIRED SO THAT ROWS OF LIGHTS RUN PARALLEL TO WINDOWS - A POSSIBLE RETROFIT

CONDITIONS	# ROW ON
BRIGHT DAY	4
CLOUDY	3 & 4
NIGHT	1,2,3 & 4

Figure 22



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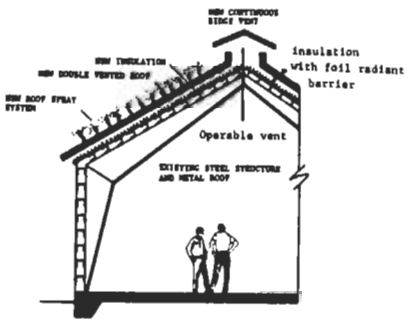

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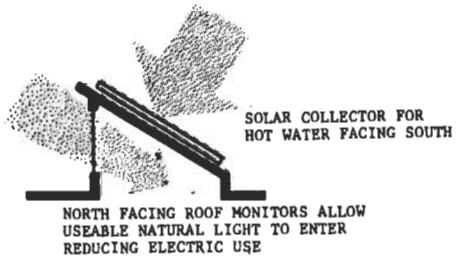

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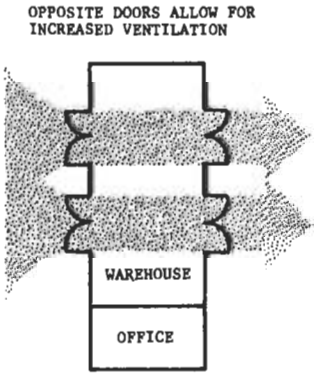

Figure 26