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BOZEMAN

RESEARCH:

AN ALTERNATIVE ENERGY "WOOD"

AND AN ARCHITECTURAL SOLUTION

PROJECT:

A RESIDENCE FOR BOZEMAN, MONTANA

PRESENTED BY:

GARY E. MESZ

MONTANA STATE UNIVERSITY

SCHOOL OF ARCHITECTURE

JUNE 1977

Bound By AMERICAN BINDERY, Topeka, Kansas.

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A THESIS PRESENTED TO:

THE SCHOOL OF ARCHITECTURE

MONTANA STATE UNIVERSITY

IN PARTIAL FULFILLMENT FOR

A BACHELOR OF ARCHITECTURE DEGREE

PRESENTED BY:

GARY E. MESZ

JUNE 1977

THESIS CONSULTANTS:

SCHOOL OF ARCHITECTURE

MONTANA STATE UNIVERSITY

GUYTON STUBBS

HUGO ECK

DAVID LEAVENGOOD

DAVID WESSEL

GORDON KELLY

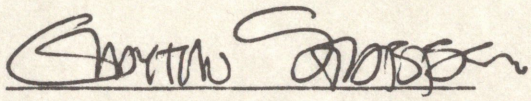
JAY CHAPMAN

SCHOOL OF INDUSTRIAL ARTS

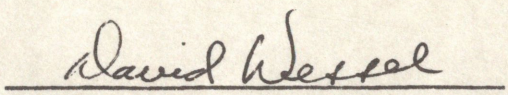
MONTANA STATE UNIVERSITY

DOUGLAS POLETTE

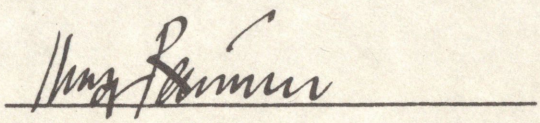
APPROVED:



GUYTON STUBBS, THESIS ADVISOR



DAVID WESSEL, THESIS CO-ORDINATOR



ILMAR REINVALD, DIRECTOR, SCHOOL OF ARCHITECTURE

I WOULD LIKE TO THANK MY WIFE, LINDA, WHO HELPED ME AND STAYED WITH ME THROUGH 5 DIFFICULT YEARS.

I WOULD LIKE TO THANK MY FATHER, TO WHOM I OWE VERY MUCH.

I WOULD LIKE TO THANK MY ADVISOR, GUYTON STUBBS, AND MY RESOURCE PEOPLE, HUGO ECK, DAVE LEAVENGOOD, & DOUG POLETTE WHO LISTENED AND TALKED TO ME.

I WOULD ALSO LIKE TO THANK A HIGH SCHOOL GUIDANCE COUNSELOR, ED GOTLIEB, FOR SAYING I COULD NEVER DO IT.

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INTRODUCTION

THE WRITINGS OF ABRAHAM MASLOW EXPLAIN ABOUT NEEDS AND THEIR HIERARCHICAL ORDER. THE MOST BASIC, PRIMARY NEEDS, DEAL WITH SURVIVAL, AND ARE COMMON TO ALL PEOPLE. SOME OF THESE PHYSICAL NEEDS ARE: AIR, FOOD, WATER AND HEAT. MASLOW SAYS THAT WHEN A BODY RUNS SHORT OF ONE OF THESE PHYSICAL NEEDS THERE BUILDS UP IN THE BODY A PRIMARY DRIVE THAT MOTIVATES YOU TO SATISFY THAT NEED. THIS IS RELEVANT TO MY PROJECT IN THAT THE PRIMARY NEEDS MUST BE MET IF WE ARE TO CONTINUE TO PROGRESS. MY THESIS DEALS WITH PROVIDING HEAT AND SHELTER FOR SURVIVAL. WHEN THERE WAS A THREAT OF ATOMIC WARFARE WE BUILT AIR-RAID SHELTERS. NOW, WITH THE THREAT ON AN ENERGY CRISIS, I WANT TO BUILD AN ENERGY SHELTER. I DON'T MEAN FOR THIS TO SOUND LIKE SOME FORM OF AUTONOMUS LIVING.

IN MY THESIS I AM PULLING TOGETHER LOW TECHNOLOGICAL WAYS OF CONSERVING ENERGY AND AM ATTEMPTING TO USE THEM MOST EFFICIENTLY. I WILL ALSO NAME ANY ALTERNATIVES I MAY FIND WHICH MIGHT EASE THE PRESSURE ON THE HOME OWNER BY REDUCING THE HIGH COST OF LIVING, I.E., UTILITIES. THIS IN TURN, ON A SMALL SCALE, WILL EASE THE PRESSURES ON OUR COUNTRY'S NATURAL RESOURCES AND OUR EVER INCREASING DEMANDS FOR FOREIGN OIL. I HOPE THAT WITHOUT RAISING THE COST OF A SMALL HOUSE I CAN DECREASE THE ENERGY CONSUMPTION BY AT LEAST ONE-HALF. MY DESIRE TO ACCOMPLISH THIS STEMS FROM MY INTEREST IN THE DESIGN-BUILD CONCEPT AND MY EXPERIENCE IN CARPENTRY AND CONSTRUCTION.

MY PLANS UPON GRADUATION ARE TO DESIGN AND BUILD A FEW HOUSES AND I'M USING MY THESIS TO GAIN AS MUCH UP-TO-DATE KNOWLEDGE AS I POSSIBLY CAN. AS I SEE IT, THESIS PROJECTS ARE NOT JUST THE FINAL REQUIREMENT FOR GRADUATION, BUT SHOULD BE INTERESTING, FUN, EXCITING, USEFUL AND WORTHWHILE FOR THE PERSON DOING THE PROJECT AND OTHERS AS WELL.

THE IMPORTANCE OF WHAT I AM DOING IS THE PRESENTING OR PULLING TOGETHER OF FACTS WHICH I HAVE FOUND IN MANY TEXTS, MAGAZINES, PERIODICALS AND INTERVIEWS. THINGS HAVE BEEN CHANGING VERY RAPIDLY DURING THE LAST FEW YEARS AND THE STANDARDS AND COMMONLY ACCEPTED METHODS THAT ARE USED TODAY IN THE BUILDING PROFESSION WERE VALID ONLY WHEN CHEAP ENERGY WAS AVAILABLE. THE ENERGY PICTURE NOW HAS NOT BEEN FIXED BUT IS CONSTANTLY CHANGING AND, AS OF YET, DOES NOT SHOW ANY SIGNS OF IMPROVING.

THESIS :

TO EXPLORE THE RELATIONSHIPS BETWEEN FUTURE ENERGY DE - MANDS & MY ARCHITECTURAL DESIGN SOLUTIONS.

PART - ONE

SINCE EARLY HISTORY MAN HAS DEALT WITH SURVIVAL. PRE-HISTORIC MAN FACED DAILY ENERGY CRISES IN HIS EFFORT TO STAY ALIVE. ALL HIS ENERGIES WERE SPENT TRYING TO SATISFY HIS MOST BASIC NEEDS FOR FOOD, WATER AND A SAFE SHELTER.

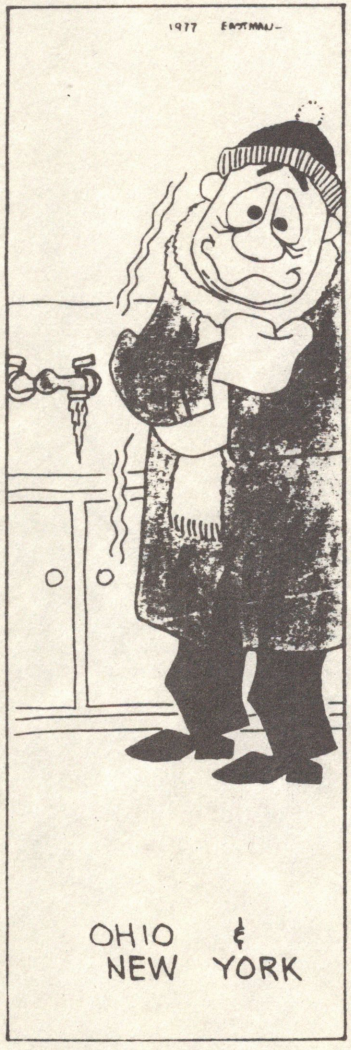
THROUGHOUT HISTORY MAN HAS INVENTED TOOLS TO MINIMIZE HIS LABOR AND INCREASE HIS LEISURE. HE TOOK SLAVES TO DO THE DIRTY, DEMEANING, TEDIOUS WORK. AFTER MANY CENTURIES OF SLAVERY CIVILIZED MAN DECIDED IT WAS NOT HUMANE TO CONTINUE HUMAN SLAVERY. THE ANSWER TO THE PROBLEM OF HOW TO CONTINUE PROGRESS WAS THE MACHINE- MECHANICAL SLAVERY.

AROUND THE 1840's A VALUABLE LESSON IN CONSERVATION AND MECHANICAL EFFICIENCY WAS DEMONSTRATED. COAL FIRED STEAM ENGINES WERE THE LATEST THING. VISIONS OF USING THIS ENGINE TO SAIL AROUND THE WORLD WERE MANIFESTED IN THE "FIRST GREAT IRON SHIP". THE ENGINE OF THIS SHIP WAS SO INEFFICIENT THAT IT WOULD REQUIRE THREE TIMES MORE COAL FOR FUEL THAN THE SHIP COULD CARRY TO SAIL FROM BRITAIN TO AUSTRAILIA. THIS STEAM POWERED IRON SHIP HAD EXCEEDED ITS "CARRYING CAPACITY". "CARRYING CAPACITY" CAN BE EQUATED TO AMERICA TODAY. HISTORY HAS SHOWN THAT WHEN A SOCIETY DOES NOT CONTAIN WITHIN IT THE ENERGY NECESSARY TO SUSTAIN IT THAT SOCIETY CANNOT SURVIVE.

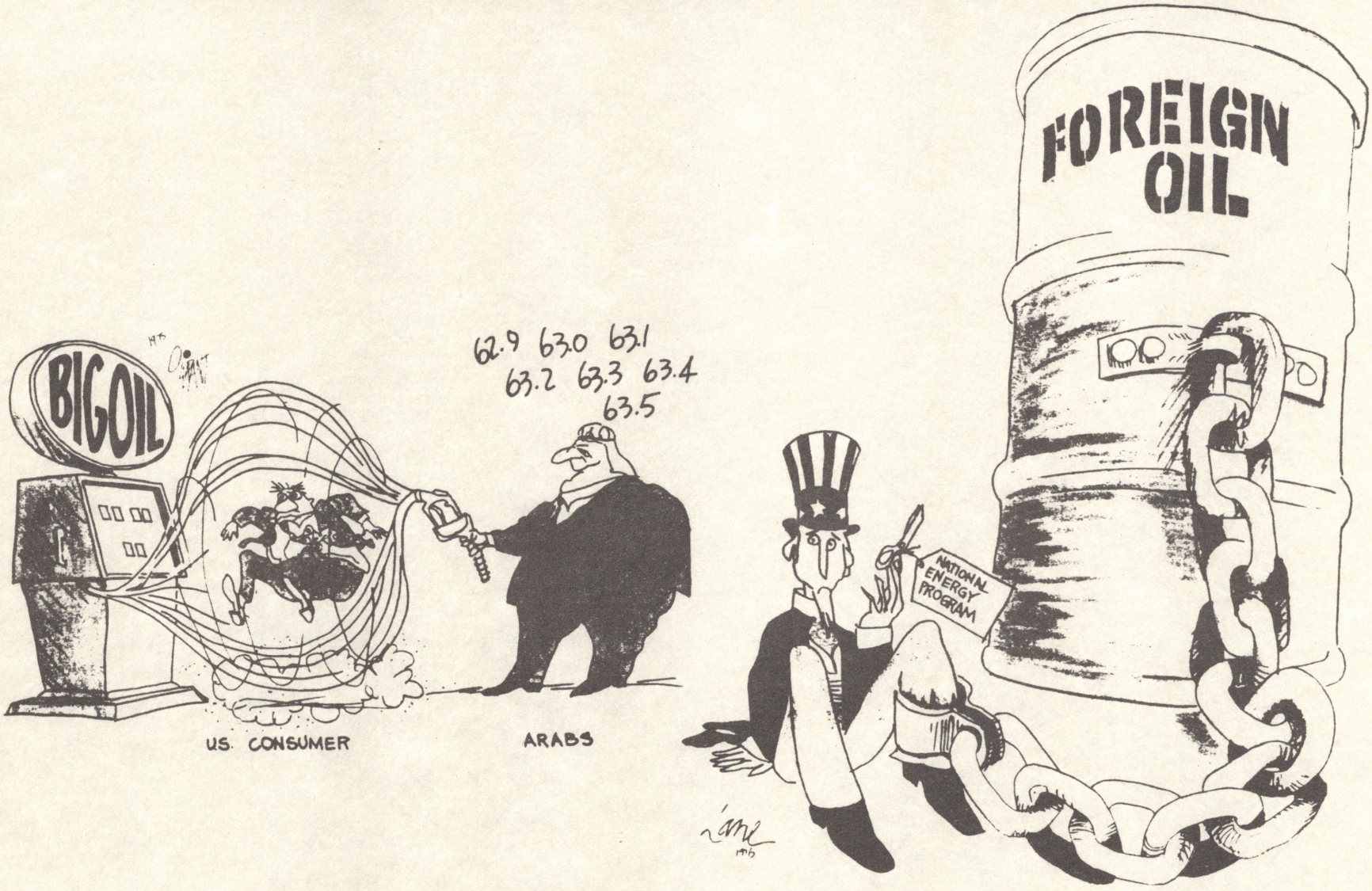
CARMICHAEL



CARMICHAEL

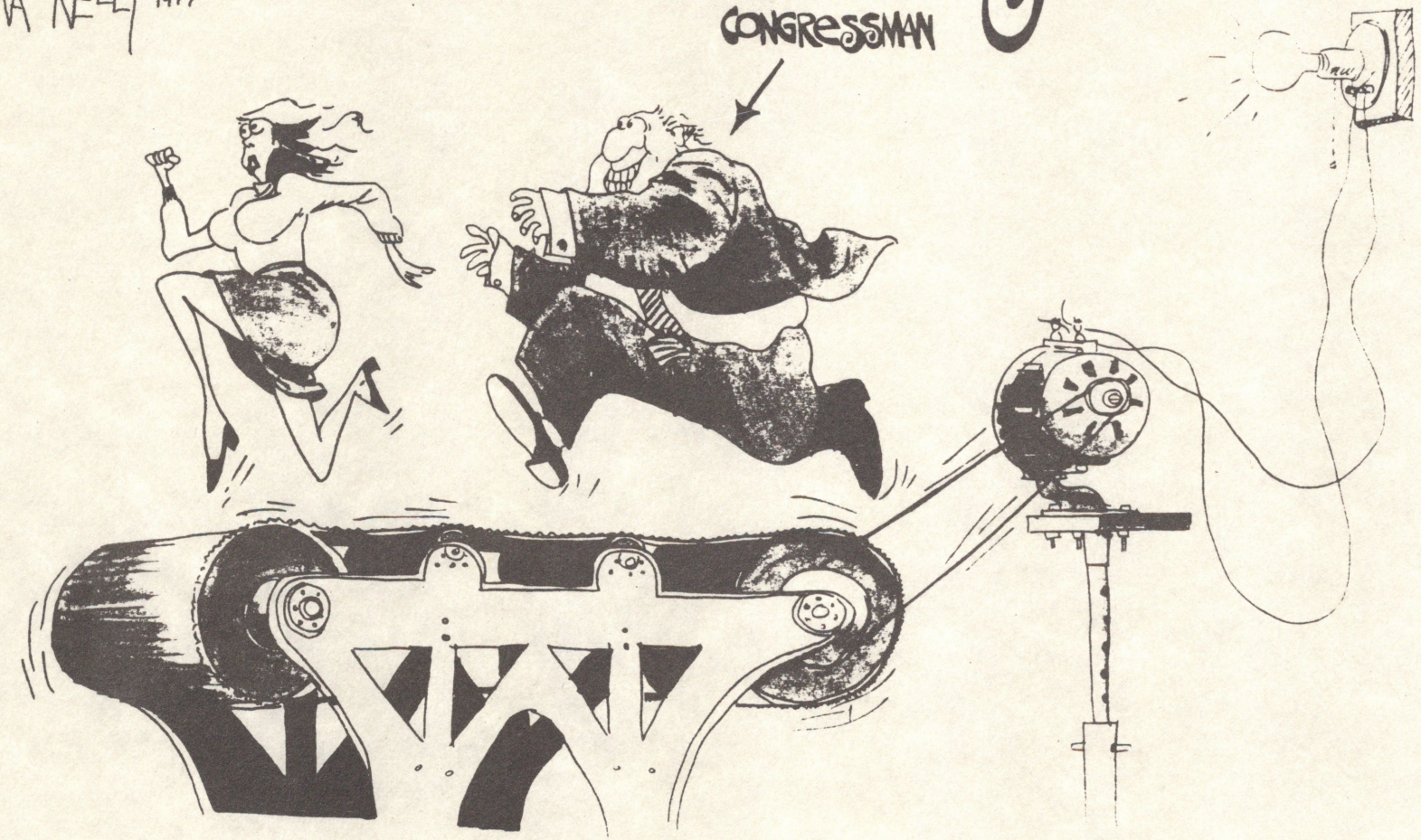





BIGOIL
62.9 63.0 63.1
63.2 63.3 63.4
63.5
US. CONSUMER
ARABS
FOREIGN OIL
NATIONAL ENERGY PROGRAM

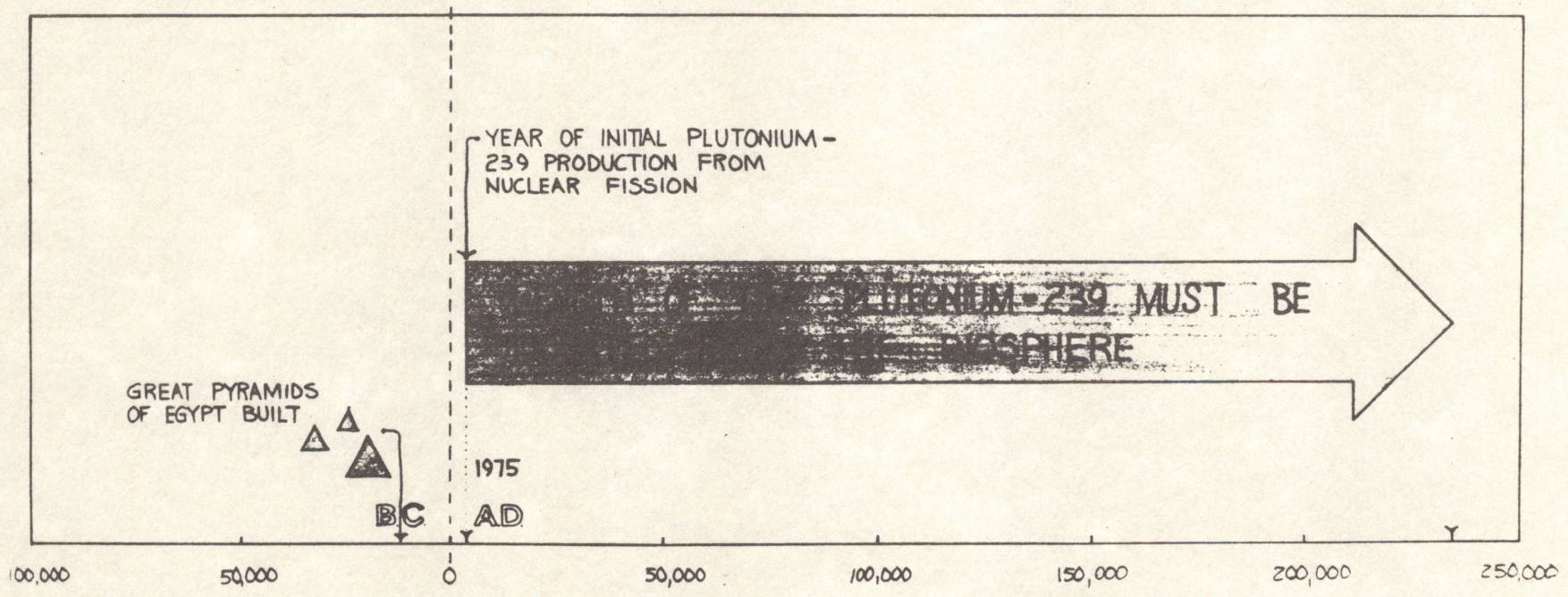
ALTERNATE ENERGY SOURCE:

MAC NELLY 1977



TODAY THE WORLD IS DEPENDENT UPON MACHINES. WE HAVE BECOME A HIGH ENERGY BASED SOCIETY AND WE NOW SUBSTITUTE MACHINES FOR THINKING AND DESIGN, I.E., WE CAN TURN ON MORE LIGHT, HEAT OR AIR CONDITIONING ANY TIME WE WANT TO. UNFORTUNATELY, THE MOST POWERFUL MOVING FORCE IN AMERICA HAS NOT BEEN INNER HUMAN SPIRIT BUT MECHANICAL POWER AND TECHNOLOGY. WE ARE NOW APPROACHING THE END OF THE FOSSIL FUEL ERA AND AGAIN WE LOOK AT THE NECESSITY FOR SURVIVAL. THE PEOPLE WHO EXPERIENCED THE NATURAL GAS SHORTAGE IN NEW YORK AND OHIO THIS WINTER DEFINATELY THOUGHT ABOUT ONE OF THE BASIC HUMAN NEEDS--HEAT--SURVIVAL. PROBABLY THE MOST CHALLENGING EXPERIENCE FOR AMERICAN PEOPLE WILL BE THE TRANSITION FROM A HIGH-ENERGY-BASED SOCIETY TO A RELATIVELY LOWER-ENERGY-BASED SOCIETY.

NUCLEAR FISSION



TO AVERT SOCIAL AND ECONOMIC DECLINES SOLUTIONS MUST BE FOUND. WE MAY FIND OURSELVES ADAPTING TO ENERGY SYSTEMS THAT TODAY SEEM NOVEL OR UNIMPORTANT. FOR EXAMPLE, WHO WOULD HAVE EXPECTED FIVE YEARS AGO THE IMPORTANCE THAT COAL WOULD PLAY IN AMERICA'S FUTURE?

PEOPLE TODAY ARE STILL SOMEWHAT SKEPTICAL THAT OUR FUTURE ENERGY DEMANDS ARE A PROBLEM. THEY THINK NUCLEAR ENERGY WILL PROVIDE THE POWER AND TECHNOLOGY WILL FIND THE SOLUTIONS. MOST PEOPLE ARE WILLING TO DISMISS THE MOST THREATENING PROBLEMS WITH THE SUGGESTION THAT SOMETHING WILL TURN UP. THERE ARE TWO MAIN PROBLEMS: TIME AND DANGER.

TIME: NUCLEAR ENERGY WILL NOT BE ABLE TO SUPPLY AMERICANS WITH THE POWER WE NEED WHEN WE NEED IT- NOW. IN 1970 NUCLEAR ENERGY SUPPLIED .1% OF OUR TOTAL ENERGY. BY 1990 IT IS HOPED NUCLEAR ENERGY WILL SUPPLY US WITH 12% OF OUR POWER. THAT IS NOT ENOUGH. WE WILL STILL NEED APPROXIMATELY 30% FROM OIL, (18% IMPORTED), 14% FROM COAL AND 12% FROM NATURAL GAS.

DANGER: NUCLEAR FISSION IS FAIL-SAFE ONLY IF IT WORKS PERFECTLY. NUCLEAR FUSION IS A THEORY THAT HAS NOT YET BEEN PROVEN TO WORK. THE WASTE PRODUCT OF FISSION REACTORS IS PLUTONIUM 239. THIS IS SO DEADLY THAT ONE TEN-THOUSANDTH OUNCE OF SMOKE WOULD KILL A PERSON THROUGH RADIOLOGICAL DESTRUCTION OF

LUNG TISSUE. I DON'T KNOW HOW MANY TONS OF DEADLY PLUTONIUM 239 THERE ARE BUT I HAVE BEEN TOLD THAT THERE ARE MANY. THE SKETCH SHOWS THE TIME FACTOR ATTACHED TO THIS POISON. ONE TON OF PLUTONIUM 239 HAS THE POTENTIAL OF KILLING 320 MILLION PEOPLE, MORE THAN THE CURRENT POPULATION OF THE UNITED STATES. THIS IS ONLY A HYPOTHETICAL SITUATION BECAUSE THE NUCLEAR PHYSICISTS TELL US THIS COULD NEVER HAPPEN.

END ENERGY (USE)

TRANSPORTATION (FUEL)	24.9
• SPACE HEATING (RESIDENTIAL & COM.)	17.9
PROCESS STEAM (INDUSTRIAL)	16.7
DIRECT HEAT (INDUSTRIAL)	11.5
ELECTRIC DRIVE (INDUSTRIL)	7.9
RAW MATERIALS (COM., IND., & TRANS)	5.5
• WATER HEATING (RESIDENTIAL & COM.)	4.0
• AIR CONDITIONING (RESIDENT. & COM.)	2.5
• REFRIGERATION (RESIDENTIAL & COM.)	2.2
• LIGHTING (RESIDENTIAL & COMMERCIAL)	1.5
• COOKING (RESIDENTIAL & COMMERICAL)	1.3
ELECTROLYTIC PROCESS (INDUSTRIAL)	1.2
• (RESIDENTIAL USE) TOTAL	97.1 %

RESIDENTIAL

SPACE HEATING	57.5
WATER HEATING	14.9
COOKING	5.5
REFRIGERATION	6.0
AIR CONDITIONING	3.7
OTHER	3.6
TOTAL	92.1 %

AIA TASK FORCE

ON ENERGY CONSERVATION MAY 1974

CONCLUSIONS:

1. ENERGY PROB. IS A LONG-TERM PROB. BUT RESOLVABLE THRU MULTIFACETED APPROACHES.
2. EVERY ONE IN THE BLDG. DESIGN & PLANNING PROF. WILL BE PROFOUNDLY AFFECTED.
3. THESE PEOPLE ARE IMPORTANT LINKS IN THE NATION'S SOLUTION.
4. POLICYMAKERS ULTIMATELY DETERMINE THE EXTENT OF THE CONTRIBUTION.
5. PUBLIC WILL DETERMINE IMPORTANCE OF SOLUTIONS BY POLITICAL DECISIONS

QUOTE:

PRESIDENT JIMMY CARTER 30 JAN. 1977

"IF WE CUT OUR GAS HEATING TO 65°F IT WOULD CUT OUR NATURAL GAS SHORTAGE IN ONE - HALF."

I BELIEVE WE ARE DOOMED ONLY IF WE CHOOSE TO BE. MY BELIEF IS THAT TO AVERT SOCIAL AND ECONOMIC DECLINE DUE TO AN ENERGY CRISIS IS TO ADAPT TO SCALED DOWN, RENEWABLE ENERGY SYSTEMS DESIGNED FOR LOCAL ENVIRONMENTS, APPROPRIATE LOCAL DESIGNS, DE-CENTRALIZED POWER, WASTE LESS, CONSERVE. IF WE ARE TO DO SOMETHING IT SHOULD BE DONE NOW WHILE WE CAN STILL AFFORD TO- NOT IN THE MIDDLE OF AN ECONOMIC DEPRESSION OR ENERGY CRISIS WHEN WE CANNOT. GOVERNMENT FUEL STAMPS FOR PERSONS IN HARD HIT AREAS DOES NOT CHANGE THE CAUSE OF THE PROBLEM. ECONOMIC INCENTIVE WOULD HELP CORRECT THE PROBLEM BUT LOWER FEES FOR SMALL, EFFICIENT CARS, LOWER UTILITY RATES FOR VERY CONSERVATIVE USERS AND TAX BREAKS FOR RENEWABLE ENERGY SYSTEMS WILL.

I SEE NEW HOMES BEING BUILT IN BOZEMAN, MONTANA THAT WINTER UTILITY BILLS OF $50/MONTH FOR 1200sq. ft. OF LIVING SPACE. I KNOW WE CAN DO BETTER THAN THIS. AS ARCHITECTS WE SHOULD BE LEADING THE WAY, BUT WE'RE NOT. I SEE THE SAME THING HAPPENING WITH COMMERCIAL DESIGN. AS I HAVE PREVIOUSLY STATED, IN THE INTRODUCTION, MY INTERESTS IN DESIGN-BUILD AND PLANS TO BUILD UPON GRADUATION HAVE LED ME TO MY GOAL STATEMENT.

GOAL: TO DESIGN AN EFFICIENT, CONSERVATIVE, ENERGY CONSCIOUS HOUSE.

ACHIEVE GOAL THRU:		OF:
SIMPLICITY	—	PLAN, CONSTRUCTION, HEATING SYS.
LOW TECHNOLOGY	—	CONSTRUCTION, HEATING SYS.
CONSERVATION	—	MATERIALS, HEATING SYS.
EFFICIENCY	—	PLAN, HEATING SYS.
MODIFY LIFESTYLE	—	PLAN, HEATING SYS.

EVALUATED LOOK AT:

MATERIALS	I
CONSTRUCTION	II
PLAN	III
HEATING SYS.	IIII ⇐ MOST IMPORTANT

A GOAL STATEMENT IS MADE TO HELP ONE CONCENTRATE ON REACHING A FEASIBLE, DESIRED END. IT IS LIKE A ROAD SIGN WHICH POINTS THE DIRECTION OF YOUR JOURNEY. FOR A STATEMENT TO QUALIFY AS A GOAL IT MUST SATISFY THESE FOUR CHARACTERISTICS:

1. IT MUST BE WRITTEN DOWN.

2. IT MUST BE SPECIFIC AND PERMIT OBJECTIVE INTERPRETATION AND EVALUATION.

3. IT MUST HAVE A TIME DIMENSION TO TELL WHEN THE GOAL IS REACHED.

4. IT MUST FOCUS ON A RECEIVING SYSTEM-HAVE A PURPOSE.

I HAVE BRIEFLY LISTED HOW THE GOAL MIGHT BE ACHIEVED. I HAVE FIVE ELEMENTS WHICH SEEMED ESSENTIAL TO ACHIEVE MY GOAL. OF THESE FIVE ELEMENTS I LISTED PHYSICAL PARTS OF THE DESIGN WHICH WERE DIRECTLY RELATED TO EACH ELEMENT. THEN EVALUATING THESE PHYSICAL PARTS, I FOUND THE HEATING SYSTEM TO BE DIRECTLY RELATED TO ALL FIVE ELEMENTS. THEREFORE, I DECIDED THE HEATING SYSTEM TO BE THE MOST IMPORTANT AND I BEGAN RESEARCH THAT WAS DIRECTLY RELATED TO MY THESIS PROJECT.

HEATING SYSTEM EVALUATION

1. MAN - ORGANIZED ENERGY SYS. FROM:

- SOLAR – THERMAL & ELECTRIC
- WATER – HYDROELECTRIC
- WIND
- BIOFUELS – WOOD
- GEOTHERMAL
- TIDAL

* POSSIBILITIES : SOLAR & WOOD

WHY WOOD VS. SOLAR ?

COMPARISON	WOOD	SOLAR
LOCATION	NAT. FOREST	CLOUDY
ECONOMICS	INEXPENSIVE	EXPENSIVE
COMPLEXITY	LOW TECH.	HIGH TECH.
KNOWLEDGE	KNOWN	PARTIAL
HEATING CAPACITY	100%	60% → ?

2. MAN - MADE ENERGY SYS. FROM:

- COAL
- PETROLEUM
- NATURAL GAS
- OIL SHALE
- TAR SANDS
- NUCLEAR

* ELECTRICITY : POWER FOR THE FUTURE

ELECTRICITY USED FOR HEATING

TYPE :	EFFICIENCY %
HOT WATER OR STEAM	80
HOT AIR - FAN	80
RADIANT PANEL	95
BASE BOARD	100 - 95
* HEAT PUMPS	260 → ?

THERE ARE TWO CLASSIFICATIONS OF FUEL: RENEWABLE AND NON-RENEWABLE. MY PLANS ARE TO USE A RENEWABLE RESOURCE FUEL AS MY PRIMARY HEAT SOURCE AND A NON-RENEWABLE RESOURCE FUEL FOR BACK-UP. OF THE MAN-ORGANIZING OF RENEWABLE FUELS WOOD AND SOLAR WERE THE ONLY TWO CHOICES. WOOD WAS CHOSEN OVER SOLAR FOR FIVE REASONS.

1. MY SITE IS LOCATED APPROXIMATELY FOUR MILES SOUTH OF BOZEMAN, CLOSE TO HYLITE MOUNTAINS WHICH HAS MORE CLOUD COVER THAN BOZEMAN AND IS CLOSE TO THE FOREST WOOD SUPPLY(APPROX. 2.5 MILES).

2. USING WOOD INITIALLY AND OVER A FIVE YEAR PERIOD IS LESS EXPENSIVE THAN A SOLAR MECHANICAL SYSTEM.

3. THE SIMPLICITY OF BURNING WOOD AS OPPOSED TO THE COMPLEXITY OF A SOLAR SYSTEM.

4. OUR KNOWLEDGE OF WOOD AND ITS HEATING PROPERTIES ARE KNOWN AND UNDERSTOOD AS OPPOSED TO SOLAR.

5. BY USING WOOD IT IS POSSIBLE TO RECEIVE ALMOST 100% OF THE HEAT REQUIRED. USING SOLAR THE BEST WE COULD DO TODAY IS ONLY 60%.

ELECTRICITY IS MY CHOICE FOR A BACK-UP FUEL. THROUGH EVALUATION OF THE DIFFERENT ELECTRICAL HEATING SYSTEMS I FOUND THAT THE HEAT PUMP WOULD BE THE MOST EFFICIENT. ALSO INTERESTING TO NOTE IS THE COST COMPARISON OF WOOD WITH FOSSIL FUELS IN BOZEMAN, MONTANA IN FEBRUARY 1977.

HEATING COST COMPARISON

FUEL TYPE	UNIT PRICE	COST PER MILL BTU.	EFF %	COST OF 1 MILL USEFUL BTU'S
ELECTRICY	1.55¢/KW.H	$4.54	100	$4.54 NAT. +N.Y. 14.64
FUEL OIL	.44¢/GAL.	3.13	65	4.81
NAT. GAS	$3.75/1000 CF.	3.95	75	5.26
SOFT WOOD	$30./CORD	2.25	60	3.75 NAT. PAST $3.30
SELF CUT SOFT WOOD	$5./CORD	.37	60	.62

WOOD



FACTS:

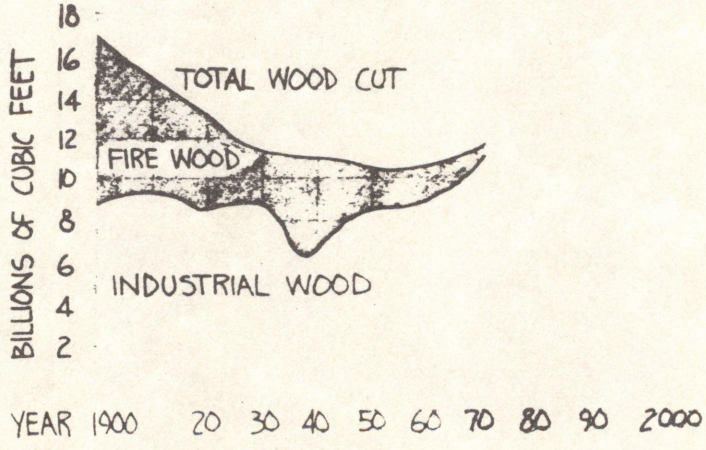
AVAILABILITY:

ABUNDANCE OF WOOD
500 MILLION ACRES - COMMERCIAL FOREST
350 MILLION CORDS ANNUAL GROWTH
150 MILLION CORDS COMMERCIAL HARVEST
250 MILLION ACRES - NON PRODUCTIVE FOREST

POLLUTION:

NO NET INCREASE OF CARBON DIOXIDE
NO NET SULFUR OR NITROGEN DIOXIDE
MINOR PARTICULATE MATER - RECYCLE

WOOD HARVESTED



THE AMOUNT OF WOOD HARVESTED ANNUALLY HAS BEEN DECREASING SINCE 1900 DUE TO LESS AND LESS FIREWOOD BEING BURNED. WE HAVE A MYTH ABOUT NOT HAVING ENOUGH WOOD FOR INDUSTRY. THERE ACTUALLY IS AN ABUNDANCE OF WOOD. THE FACT IS, THERE ARE 500 MILLION ACRES OF COMMERCIAL FOREST LAND IN THE CONTINENTAL UNITED STATES WITH AN ANNUAL GROWTH OF APPROXIMATELY 350 MILLION CORDS OF WOOD. RIGHT NOW, INDUSTRY IS USING 150 MILLION CORDS WHICH LEAVES 200 MILLION CORDS THAT HAVE THE POTENTIAL OF HEATING 2/3 OF ALL THE HOMES IN THE U.S., OR 40 MILLION HOMES(BASED ON AN AVERAGE OF 5 CORDS TO EVERY HOME). THIS COULD NEVER HAPPEN THOUGH BECAUSE MOST OF THESE HOMES ARE LOCATED TOO FAR FROM THE FOREST SUPPLIES, WHICH LEAVES EVEN MORE WOOD FOR THOSE WHO DO LIVE CLOSE ENOUGH TO FEASIBLY TRANSPORT THE WOOD, SUCH AS, THOSE WHO LIVE IN BOZEMAN. IN ADDITION, THERE ARE 250 MILLION ACRES OF NON-PRODUCTIVE FOREST.

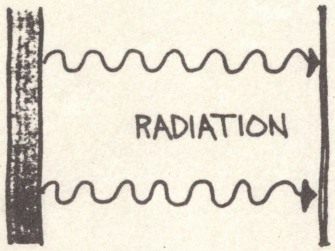
ANOTHER ISSUE TO BE CLARIFIED IS POLLUTION. THERE IS NO NET INCREASE OF POLLUTION (CARBON DIOXIDE) FROM BURNING WOOD. THIS IS BECAUSE TREES NATURALLY DECAY IN THE FOREST AND PRODUCE CARBON DIOXIDE WHICH SOMETIMES CAN BE SEEN AS A HAZE ABOVE THE FOREST. THIS HAZE IS SO PRONOUNCED THAT THIS IS HOW THE SMOKEY MOUNTAINS GOT THEIR NAME. THIS DECAYING PROCESS IS CALLED SLOW OXIDATION AND WHEN WOOD IS BURNED THE PROCESS IS KNOWN AS FAST OXIDATION. WHETHER THE WOOD DECAYS IN THE FOREST OR IS BURNED IN THE HOME

THERE IS NO NET INCREASE OF CARBON DIOXIDE. ALSO, WOOD DOES NOT RELEASE THE POISONOUS POLLUTANTS SULFUR OR NITROGEN DIOXIDE AS DO OIL AND COAL.

THE USE OF WOOD AS A PRIMARY HEATING SYSTEM DOES NOT APPEAL TO EVERYONE. I DON'T ADVOCATE THAT EVERYONE SHOULD BURN WOOD. WOOD MUST BE CUT, SPLIT, STACKED AND THE SUPPLY REPLENISHED, ALL OF WHICH TAKES AWAY FROM LEISURE TIME. IT IS ALSO SOMEWHAT MESSY IN THE HOUSE. THIS TYPE OF HEATING SYSTEM IS NOT FOR EVERYONE, BUT IT DOES APPEAL TO SOME PEOPLE, LIKE MYSELF, WHO KNOW OF ITS ADVANTAGES- THE MOST OBVIOUS BEING ECONOMICS. THE WASTE PRODUCT, WOOD ASH, CAN ALSO BE UTILIZED AROUND THE BASE OF TREES AND IN THE GARDEN.

WOOD STOVES ARE MORE EFFICIENT AND CHEAPER THAN FIREPLACES. LARRY GAY'S BOOK "HEATING WITH WOOD" EXPLAINS THE DIFFERENCES BETWEEN THE MODELS OF WOOD STOVES AVAILABLE TODAY. I PREFER THE NORWEGIAN BOX STOVES FOR THEIR EFFICIENCY AND SIMPLICITY. THE JØTUL BOX STOVE HAS AN EXTREMELY HIGH EFFICIENCY RATING BECAUSE IT IS AN AIR-TIGHT, CAST-IRON STOVE WITH A CONTROLLED INTAKE AIR SYSTEM WHICH BURNS THE GAS VIOLATES FROM THE WOOD. THIS STOVE BURNS FOR MANY HOURS (8-12) BECAUSE IT IS AIR TIGHT, HAS CONTROL-LABLE AIR INTAKE, AND BURNS WOOD FROM END TO END LIKE A CIGAR.

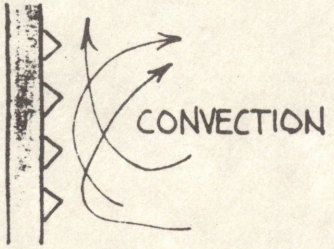
3 TYPES OF HEAT TRANSFER:



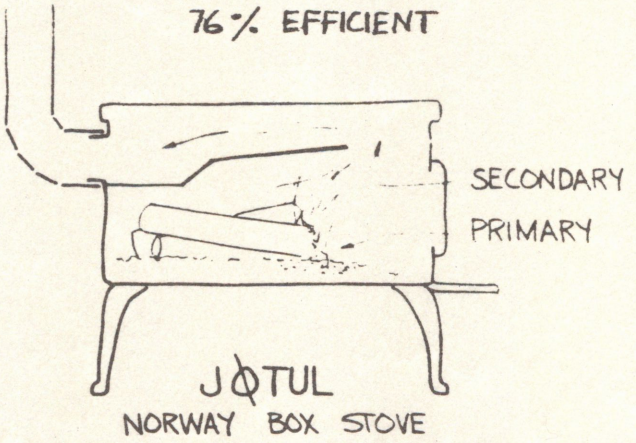
SURFACE TO SURFACE
NO CHANGE IN
AIR TEMPERATURE

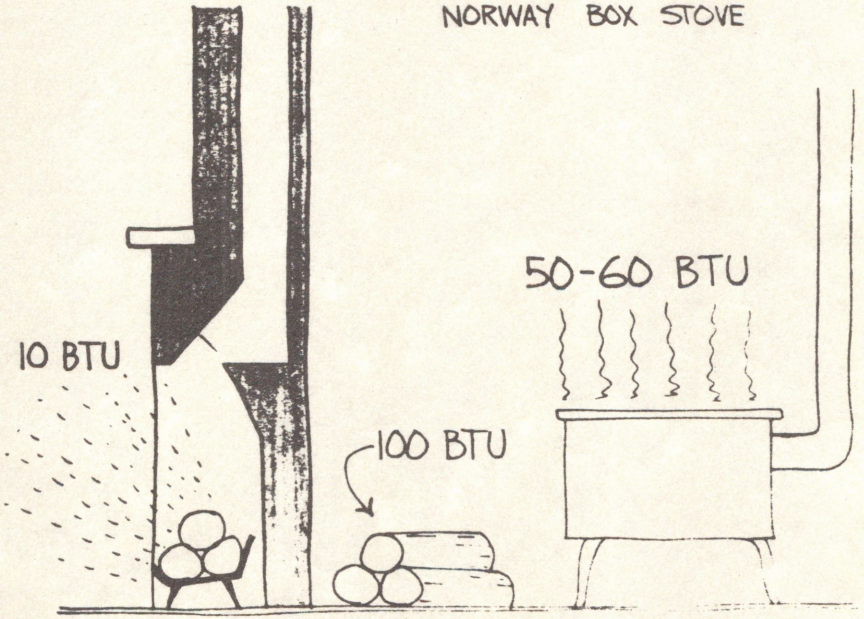


DIRECT CONTACT
THRU A MATERIAL

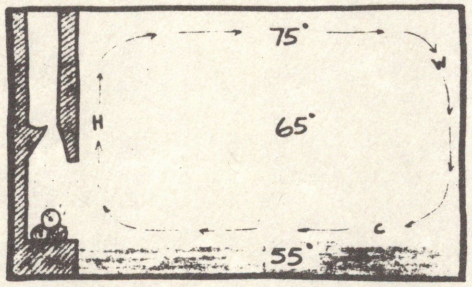


BY AIR OR WATER
MOVEMENT

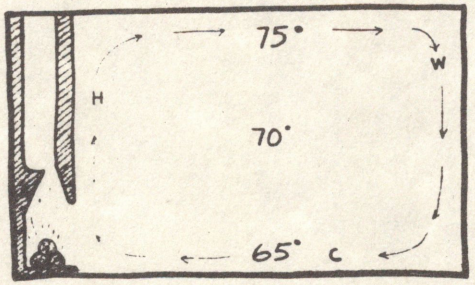




FIREPLACES :

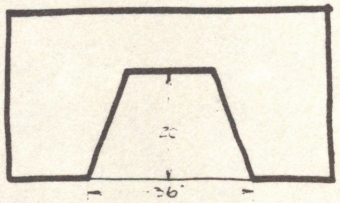


AIR CIRCULATION

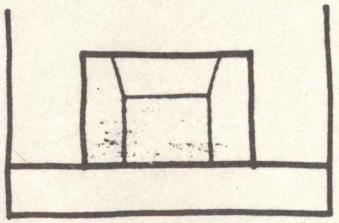


TEMPERATURE DIFFERENCES

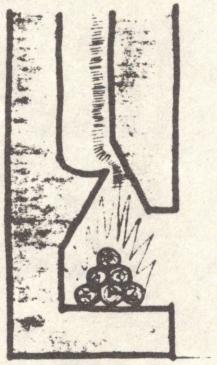
FIREPLACE TODAY



PLAN



ELEVATION



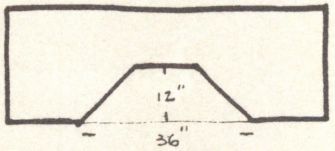
SECTION

RUMFORD FIREPLACE

DIFFERENCES

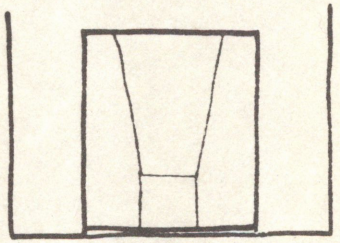
DEPTH

ANGLES



BACKWALLS

HEIGHT



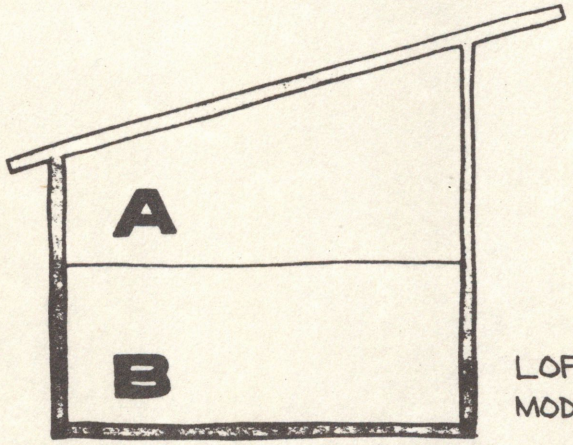
FLAME

SMOKE

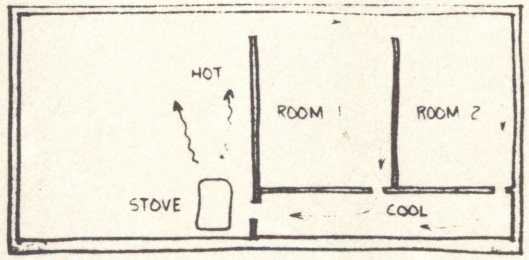


ALTHOUGH A FIREPLACE IS VERY INEFFICIENT THERE ARE CERTAIN QUALITIES THAT MAKE IT WORTHWHILE. FIREPLACES TODAY HAVE BEEN DECREASING IN EFFICIENCY SINCE THE EARLY DAYS WHEN THEY WERE USED AS THE HEATER FOR THE HOUSE. FIREPLACES TODAY ARE SYMBOLIC BUT NOT FUNCTIONAL. THERE ARE STANDARDS TODAY WHICH SPECIFY HOW A SAFE FIREPLACE THAT WON'T SMOKE CAN BE BUILT. THESE FIREPLACES WON'T HEAT EITHER. SOME WILL SUCK YOUR MECHANICALLY HEATED AIR OUT OF THE HOUSE AND THEREFORE, COST YOU MORE WHEN YOU USE THEM INSTEAD OF LESS. THIS DOES NOT HAVE TO BE SO IF YOU UNDERSTAND WHY THIS HAPPENS. TO MAKE THE FIREPLACE SAFE AND ALLOW YOU TO BURN LARGE FIRES STANDARD FIREPLACES ARE VERY DEEP. THIS IS WRONG BECAUSE IT DOES NOT ALLOW ANY OF THE RADIANT HEAT TO WARM YOU. IN THIS CASE, MOST OF THE HEAT GOES UP THE CHIMNEY. WHEN THIS HAPPENS, THE ONLY WAY TO CAPTURE SOME OF THE HEAT IS WITH A HEAT-A-LATOR OR OTHER SIMILAR DEVICE, BUT THIS IS AN AFTER-THE-FACT SOLUTION. IN ORDER TO RADIATE HEAT OUT INTO THE ROOM THE FIREPLACE SHOULD BE VERY SHALLOW AND THE SIDE WALLS SHOULD BE ANGLED. THE FRONT HEARTH SHOULD BE MASONRY AND BOTH WIDE AND DEEP ENOUGH IN CASE A LOG SHOULD ROLL OUT OF THE FIRE. STANDARD FIREPLACES OF TODAY LOWER THE FRONT OPENING IN ORDER TO REDUCE THE POSSIBILITY OF SMOKING. WHAT THIS ALSO DOES IS HIDES THE

FLAMES AND RESTRICTS THEM FROM HEATING THE ROOM. THIS SHOULD NOT BE DONE. THE OPENING SHOULD BE AS HIGH AS IT IS WIDE SO AS TO EXPOSE ALL OF THE FLAME TO THE ROOM. THE PROBLEM OF FIREPLACES SMOKING IS INCREASING TODAY WITH MODERN CONSTRUCTION. HOUSES TODAY ARE BUILT MUCH MORE TIGHTLY THAN 100-200 YEARS AGO AND THEY DON'T ALLOW ENOUGH AIR TO INFILTRATE AND FEED THE FIREPLACE WITH THE ENORMOUS AMOUNT OF OXYGEN WHICH IT NEEDS, THEREFORE, THE FIREPLACE SMOKES. THIS IS SOLVED BY LOCATING A FRESH AIR VENT FOR THE SINGLE PURPOSE OF FEEDING THE FIREPLACE. THERE ARE MANY MORE OLD RULES WHICH SHOULD BE FOLLOWED FOR THE CONSTRUCTION OF FIREPLACES. COUNT RUMFORD LISTS THEM ALL IN HIS BOOKS DATING BACK TO 1795. TWO MORE INTERESTING POINTS ABOUT FIREPLACES: THE HEARTH SHOULD BE LOCATED AT FLOOR LEVEL, NOT RAISED AND THE FIREPLACE SHOULD BE LOCATED NEAR THE CENTER OF THE HOUSE FOR BEST EFFICIENCY.

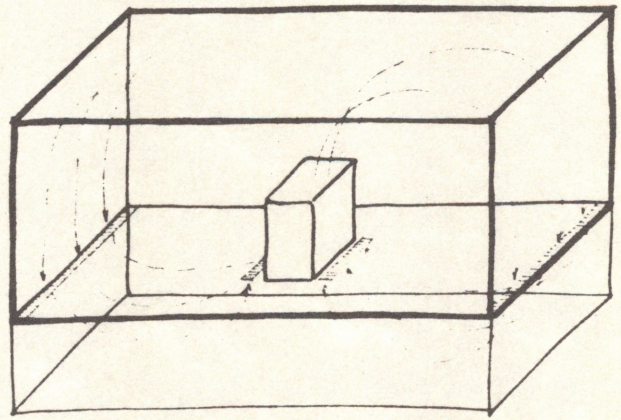


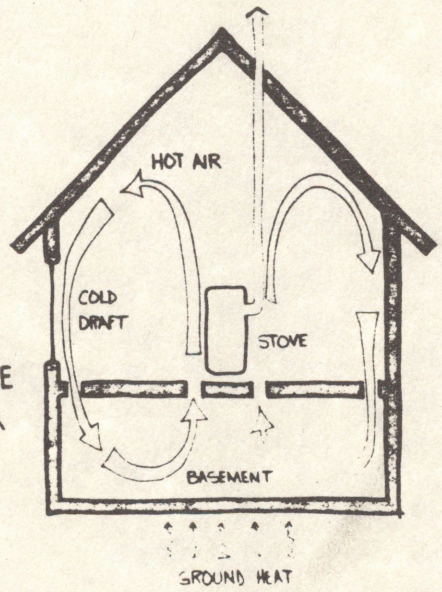
LOFT
MODEL



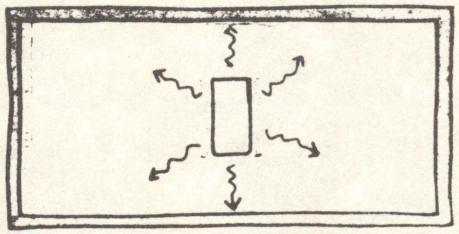
RAISED FLOOR
AIR MOVEMENT

CONVECTION
AIR MOVEMENT





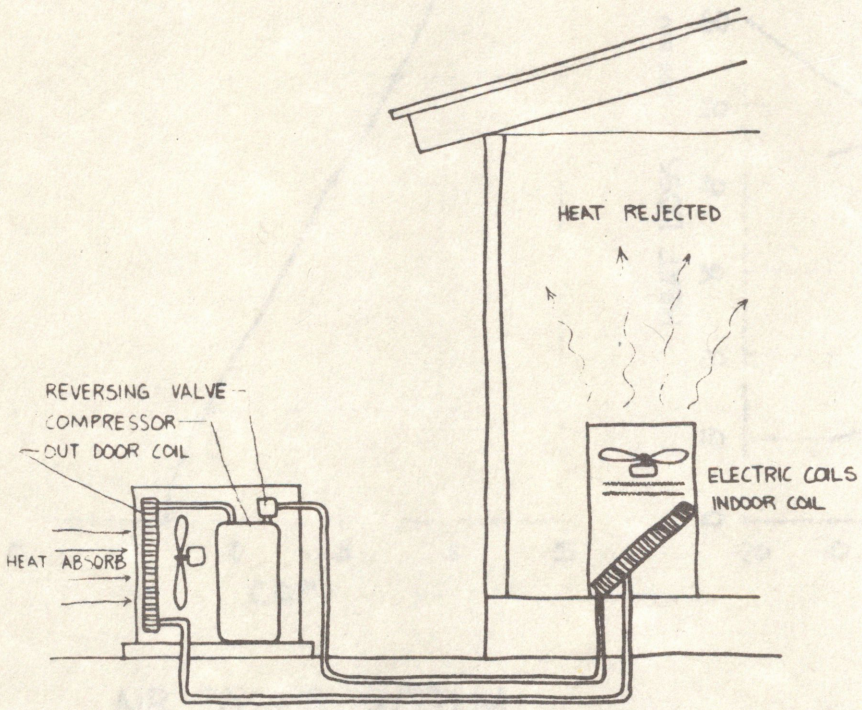
DRAFT - FREE
LIVING AREA



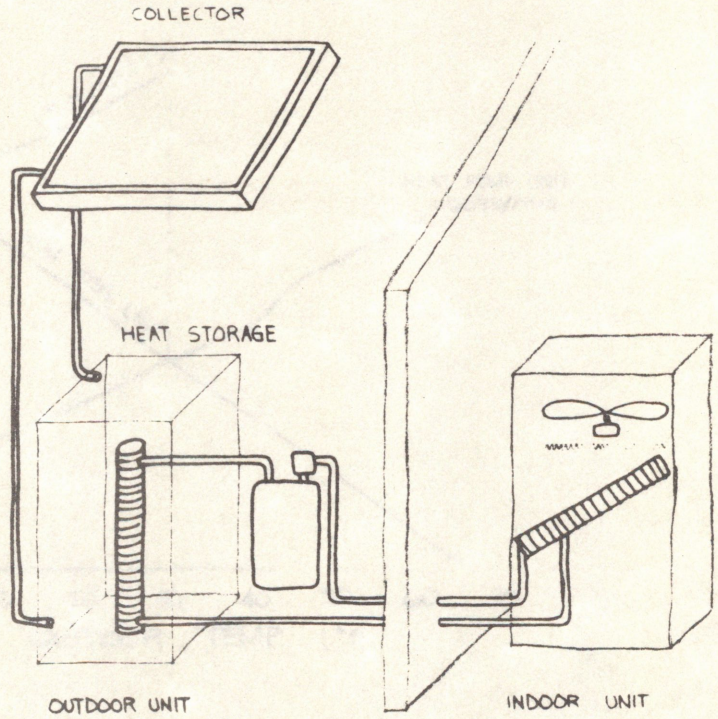
RADIANT HEAT
DISTANCE

IN COMPARISON, THE WOOD STOVE CAN ONLY TRANSFER HEAT TWO WAYS: RADIATION, THE INTENSITY DECREASES WITH DISTANCE, AND BY CONVECTION OF AIR MOVEMENT. THE SKETCHES SHOW HOW AIR CAN BE MOVED OTHER THAN BY DRAWING IT ACROSS THE FLOOR. LOCATION IS ALSO IMPORTANT. IT IS BEST IF THE STOVE IS LOCATED IN THE CENTER OF THE PLAN AND ATTENTION GIVEN TO HOW THE HEAT IS MOVED VERTICALLY. IF IN THE "LOFT MODEL" A STOVE WERE LOCATED AT LEVEL "A" THE SAME TEMPERATURE THROUGHOUT WOULD BE EXPERIENCED. IF THE STOVE WERE LOCATED AT "B" THE LOFT AREA WOULD BE 10-15 DEGREES F. WARMER THAN THE DOWNSTAIRS. OBVIOUSLY, THE PLAN OF THE BUILDING IS AN IMPORTANT ELEMENT IN HOW SUCCESSFUL THE HEATING SYSTEM IS. THOUGHT MUST BE GIVEN TO HOW THE HOT AIR WILL NATURALLY FLOW BOTH HORIZONTALLY AND VERTICALLY.

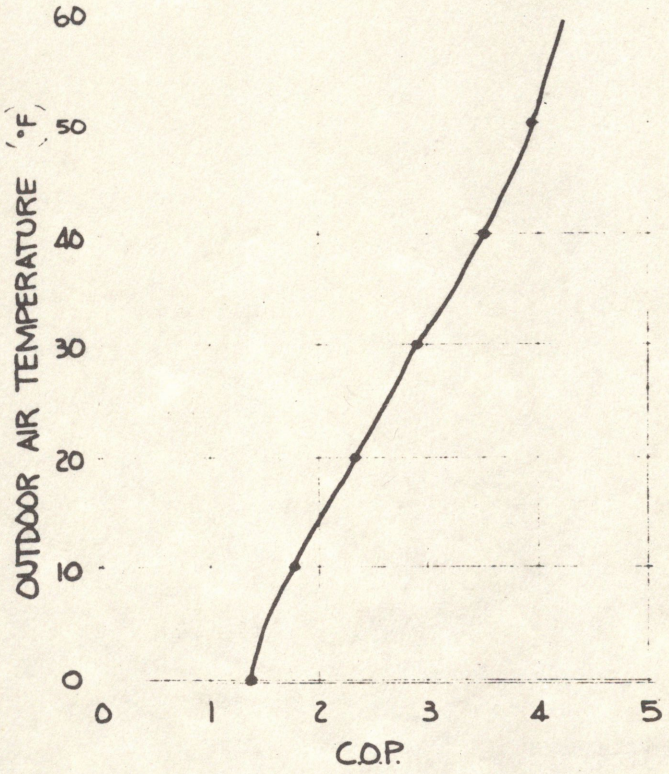
HEAT PUMPS



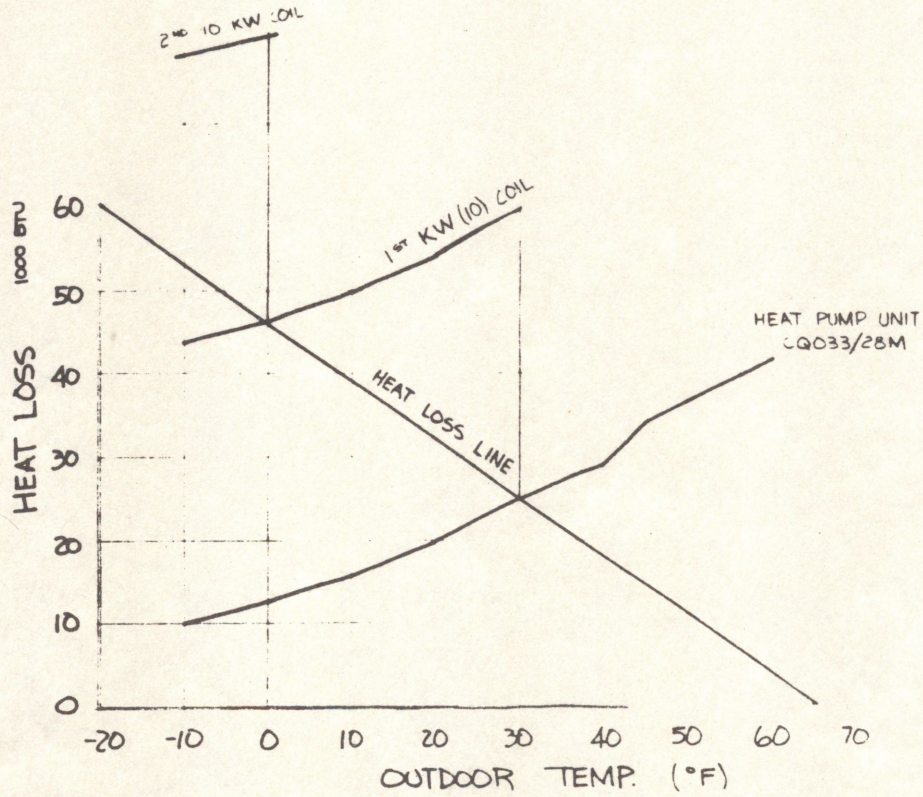
HEAT PUMP (AIR)



SOLAR HEAT PUMP (AIR)



AIR TO AIR SYSTEM
CONSTANT INDOOR TEMP. 70°F



BALANCE POINT
WORK SHEET

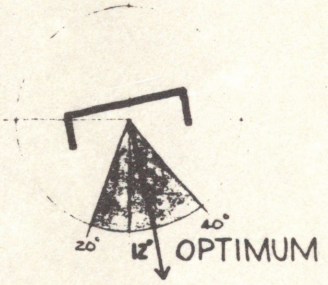
ELECTRICITY WILL BE THE FUEL FOR THE FUTURE AND THE HEAT PUMP IS THE MOST EFFICIENT WAY TO USE ELECTRICITY TODAY FOR HEATING. THE HEAT PUMP WORKS LIKE A REFRIGERATOR IN REVERSE. THE HEAT PUMP HAS A C.O.P. OF 2.6. THIS MEANS THAT IT PRODUCES APPROXIMATELY 2½ TIMES MORE HEAT THAN IT TAKES TO RUN IT. THIS IS BECAUSE THE HEAT PUMP IS CAPABLE OF DRAWING HEAT FROM OUTSIDE AIR. THE HEAT PUMP USES FREON GAS WHICH, WHEN COMPRESSED, WILL INCREASE THE TEMPERATURE OF HEAT IT HAS COLLECTED FROM OUTDOORS. IN MONTANA OUR WINTER NIGHT AIR CAN BECOME SO COLD THAT THE HEAT PUMP CANNOT COLLECT ANY HEAT FROM IT SO IN THE HEAT PUMP UNIT THERE ARE ONE OR TWO ELECTRICAL COILS WHICH WILL ADD HEAT WHEN IT IS NEEDED. ADAPTIONS HAVE BEEN MADE TO INCREASE THE C.O.P. OF THE HEAT PUMP. THE SOLAR HEAT PUMP HAS HAD C.O.P. RATINGS OF BETWEEN 6&8. THIS IS POSSIBLE BECAUSE THE SOLAR ADDITION INCREASES THE STORAGE TEMPERATURE WHERE THE HEAT PUMP COLLECTS ITS LOW GRADE HEAT (50 DEGREES) TO PRODUCE A HIGH GRADE HEAT (70 DEGREES). IT STANDS TO REASON THAT THE HIGHER THIS COLLECTED HEAT IS THE EASIER IT IS TO PRODUCE HIGH GRADE HEAT. IT IS MY INTENTION TO USE THE HEAT PUMP AS A SECONDARY HEATING SYSTEM, THE PRIMARY BEING FROM BURNING WOOD.

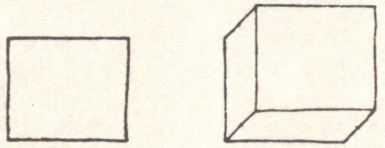
SOLAR GAINS

— FOR COOL REGIONS —
VICTOR OLGYAY

CLIMATE BALANCE BEGINS AT THE SITE

ORIENTATION AND SHAPE





1:1.1 OPTIMUM

RADIATION BTU/FT²/DAY

	WINTER	SUMMER
E	416	→ 1314
S	→ 1374	979
W	416	→ 1314
N	83	432
ROOF	654	→ 2536

SOLAR RADIATION IS ONE OF THE MOST IMPORTANT NATURAL CONTRIBUTORS TO HEAT GAIN IN DWELLINGS.

CRITERION FOR SHAPE:

MIN. HEAT LOSS IN WINTER
LEAST HEAT GAIN IN SUMMER
∴ A SQUARE BLDG. W/ SMALLEST EXT. SURFACE & LARGEST INT. VOLUME

* WITH LARGE CONTEMPORARY WINDOWS THIS CONCEPT BECOMES A FALLACY.

TEST HOUSE

1000 FT²
R = 7.7 U = .13
WINDOWS
SINGLE PANE GLASS
LOCATION
40% SOUTH SIDE
20% E, W, & N SIDES
ASSUME 10% FLOOR AREA = WINDOW AREA
∴ ≈ 40 FT² SO. WINDOWS

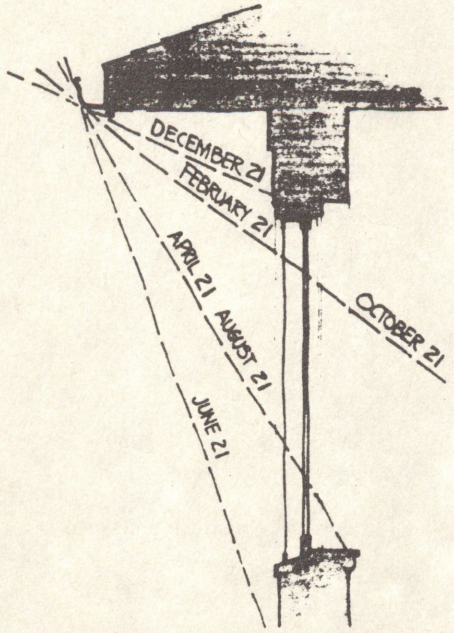
IN COLD CLIMATES HEAT CONSERVATION IS ESSENTIAL — PRIMARY OBJECTIVES: SITE PROTECTION OR SIMULATION OF

THE AMOUNT OF HEAT THAT CAN BE GAINED FROM THE SUN HAS IN THE PAST ONLY BEEN CONSIDERED FOR SUMMER CONDITIONS WHEN IT IS UNDESIRABLE. DURING THE WINTER MINIMIZING HEAT LOSSES WERE AND STILL ARE PRIMARY CONCERNS. HEAT CAN BE GAINED FROM THE SUN EVEN ON VERY COLD DAYS. THE RADIATION CHART SHOWS THAT HEAT CAN BE GAINED IN THE WINTER FROM SOUTHERN SUNSHINE. IT ALSO SHOWS WHERE THE GREATEST AMOUNTS OF SUMMER SUN COME FROM. VICTOR OLGYAY HAS STUDIED ALL TYPES OF CLIMATE DATA AND MAKES SUGGESTIONS FOR OPTIMUM ORIENTATIONS AND SHAPES FOR A HOUSE IN VARIOUS CLIMATES. ALTHOUGH VICTOR OLGYAY DID A VERY FINE JOB, HIS CRITERION DID NOT INCLUDE POSSIBLE WINTER SOLAR GAINS NOR DID HE USE THE BEST EXAMPLE SHAPE HOUSE FOR TESTING. TODAY WE WOULD NOT CONSIDER A HOUSE VERY ENERGY CONSERVATIVE IF IT USED SINGLE PANE GLASS AND HAD AN AVERAGE INSULATION "R" VALUE OF 7.7 WHICH IS APPROXIMATELY EQUAL TO 2½ INCHES OF FIBERGLASS. A SQUARE HOUSE FOR THIS COLD CLIMATE MAY NOT BE OPTIMUM AS VICTOR OLGYAY SUGGESTS. I FEEL THAT A HOUSE WHICH IS LONGER ON AN EAST-WEST AXIS WITH DOUBLE OR TRIPLE PANE GLASS ON THE SOUTH SIDE FOR COLLECTING HEAT FROM THE SUN WOULD BE A BETTER EXAMPLE HOUSE. THERE IS PROBABLY AN OPTIMUM PROPORTIONAL RELATIONSHIP BETWEEN GLASS AND INTERIOR SPACE, BUT AS OF THIS TIME I AM NOT AWARE OF ONE. I DID A HYPOTHETICAL CALCULATION FOR THIS COLD CLIMATE

AND FOUND THAT WE COULD RECEIVE TWO TIMES MORE B.T.U.'S IN 9 HOURS OF SUNSHINE THAN WOULD BE LOST OVER 24 HOURS THROUGH TRIPLE PANE GLASS WINDOWS WITH A SOUTHERN EXPOSURE.

SOLAR CONTROL

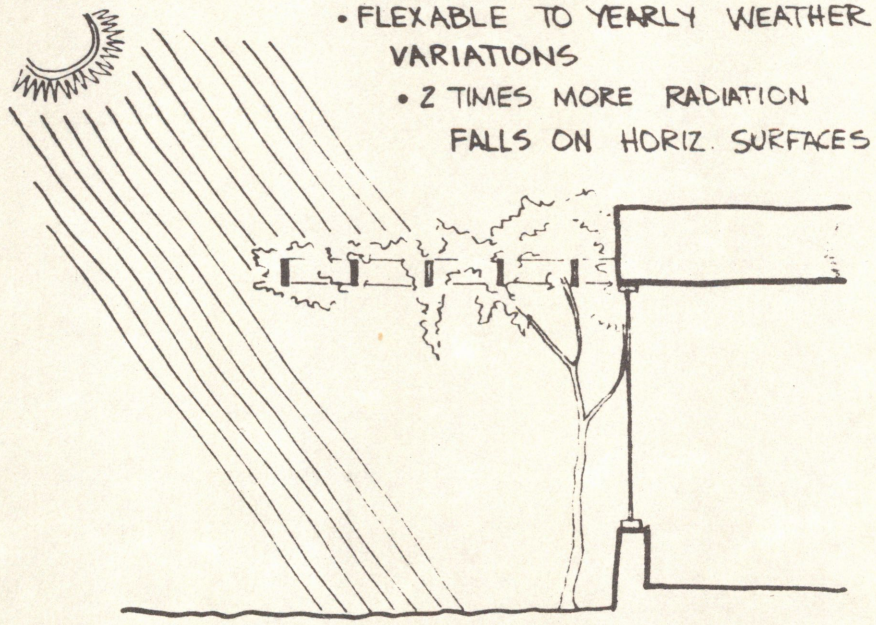
OVERHANGS



BASIC - MOST OBVIOUS
PHYSICAL LIMITATIONS

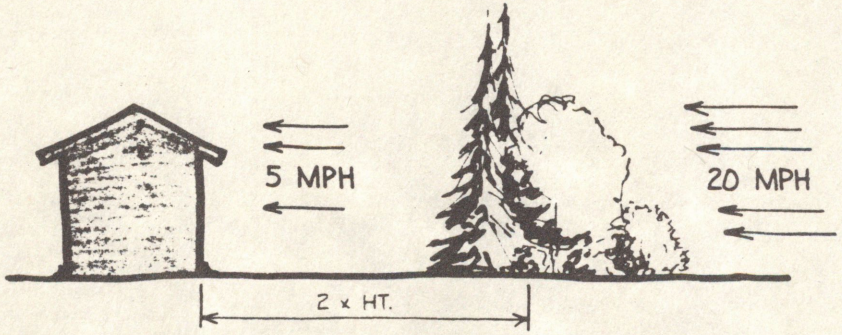
VINES

- EXCELLENT USE OF PLANTS FOR SHADE CONTROL.
- FLEXABLE TO YEARLY WEATHER VARIATIONS
- 2 TIMES MORE RADIATION FALLS ON HORIZ. SURFACES



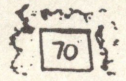
PLANTS

PLANTS CAN INTERCEPT, DIVERT, OR DECREASE WIND
BARRIERS SHOULD BE PLACED ⊥ TO WIND
EFFECTIVNESS: PRIMARY - HEIGHT & DENSITY
SECONDARY - WIDTH
INCREASE SPEED NEAR TOPS & EDGES
CUT VELOCITY 75-85% W/ DENSE SPRUCE & FIR SCREEN

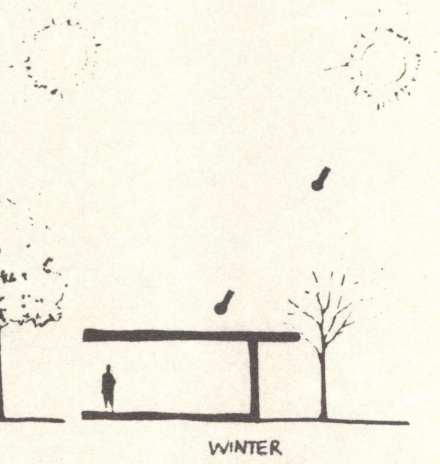


WIND PROTECTION

EX. HOUSE USE 2.4 TIMES AS MANY BTU/HR
IN A 20MPH WIND THAN IN A 5 MPH WIND
THIS COULD AMOUNT TO A $90 - $100 SAVING/YEAR

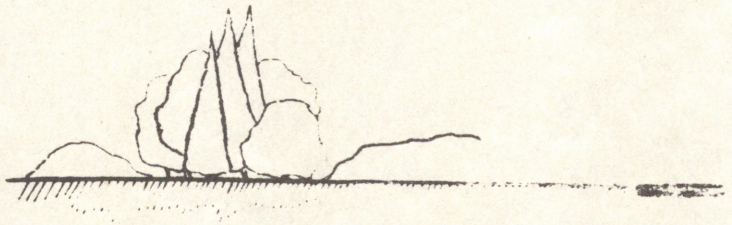


30%



TEMPERATURE VARIATION

DUE TO RADIATION, WIND, & PRECIPITATION
PLANTS ABSORB SUN'S HEAT IN DAY &
RELEASE AT NITE ∴ COOLER DAYS &
WARMER NITES

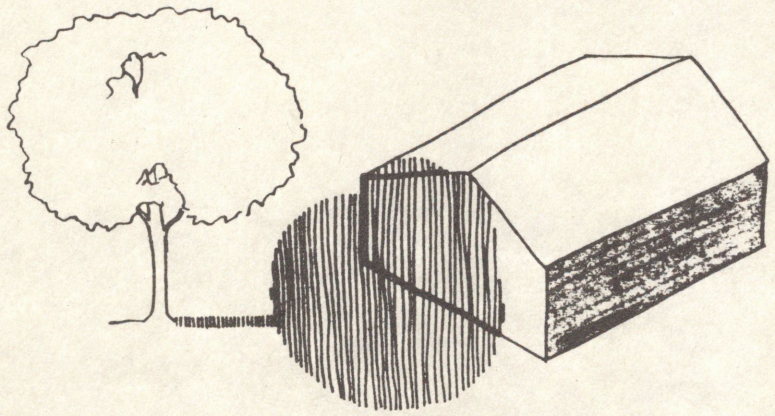


SNOW CONTROL

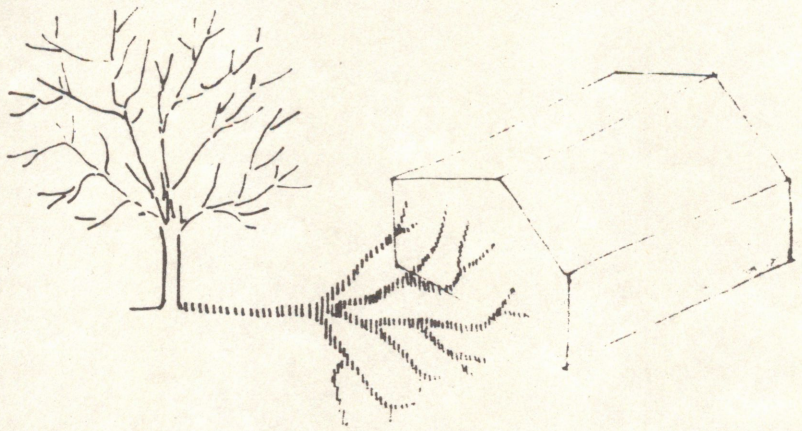
SWEEP CLEAN OR LOCATE DRIFT

TREES - SHADING

BROAD LEAF PLANTS GIVE BEST SOLAR RADIATION CONTROL.
VERY LITTLE RADIATION WILL PENETRATE THEM.
PRIMARILY EFFECTIVE FOR SHADING LOW SUN ANGLES.



SUMMER



WINTER

STUDY – (TROPIC'S) TREES 95' HT. ADMIT 1% LIGHT 6' ABOVE GROUND AND ONLY .04 – .05% REACHES THE FOREST FLOOR

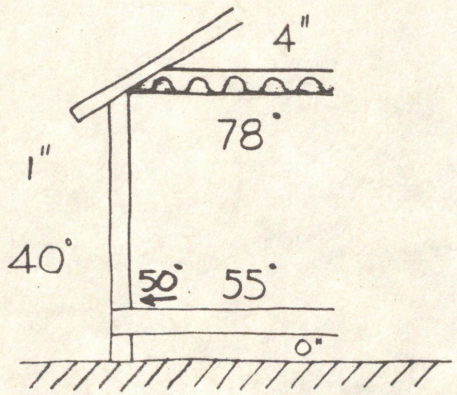
IN TERMS OF ENERGY CONSERVATION IT IS EQUALLY IMPORTANT TO CONTROL THE HEAT GAIN IN SUMMER WHEN IT IS UNDESIRABLE, EVEN IN COLD CLIMATES LIKE MONTANA. ROOF OVERHANGS WORK VERY WELL ON SOUTH EXPOSURES AND EFFECTIVELY CONTROL SOLAR GAINS ON VARYING PROPORTIONS OF THE HOUSE. ROOF OVERHANGS DO HAVE LIMITATIONS AS TO THE AMOUNT THEY CAN SHADE. THEIR EFFECTIVENESS CAN BE INCREASED WITH THE ADDITION OF VINES AND TRELLISES. VINES CAN BE USED TO BOTH ADMIT SUN WHEN DESIRED AND FILTER IT OUT WHEN DESIRED. VINES CAN BE EXTENDED OUT FROM BUILDINGS SO THAT THE HORIZONTAL SURFACE IN FRONT OF THE BUILDINGS CAN ALSO BE SHADED. THIS HELPS TO LOWER TEMPERATURES TREMENDOUSLY BECAUSE TWO TIMES MORE RADIATION FALLS ON HORIZONTAL SURFACES THAN ON VERTICAL ONES.

TREES ARE PRIMARILY IMPORTANT FOR CONTROLLING LOW SUN ANGLES AND THEREFORE, SHOULD BE PLACED EAST TO SOUTHEAST AND WEST TO SOUTHWEST.

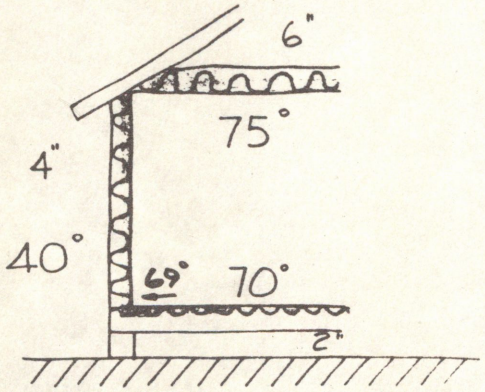
PLANTS, IN GENERAL, ARE GOOD SOLAR CONTROL DEVICES BECAUSE THEY ARE FLEXIBLE TO SEASONAL WEATHER VARIATIONS. PLANTS SERVE THREE FUNCTIONS IN TERMS OF ENERGY: SNOW CONTROL, TEMPERATURE VARIATION AND WIND PROTECTION. IN COLD CLIMATES WIND PROTECTION IS PROBABLY THE MOST IMPORTANT OF THESE FUNCTIONS. EXAMPLES OF SHELTERBELT DESIGNS CAN BE FOUND IN "PLANTS, PEOPLE AND ENVIRONMENTAL QUALITY" BY G.O. ROBINETTE.

ABOUT INSULATION :

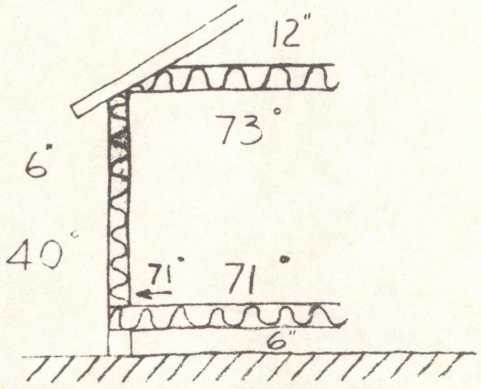
AVERAGE EFFECTIVE TEMPERATURE 66.5°
AVERAGE MONTHLY HEATING & COOLING COST # 26.57



TEMPERATURE 72°
COST # 22.86



TEMPERATURE 72°
COST # 14.25



AIR TEMPERATURE AND WALL TEMPERATURE

ENERGY SAVED

ANNUAL ENERGY

ROOF U-COEF. FROM .2 TO .06 — 3.5%

WALL U-COEF. FROM .3 TO .06 — 8.5%

FLOOR U-COEF. FROM .25 TO .06 — 6.0%

WINDOW FROM SINGLE PANE TO TRIPLE PANE — 13.5%

WINDOW AREA FROM 50% OF EXPOSED WALL AREA TO 10% — 10.5%

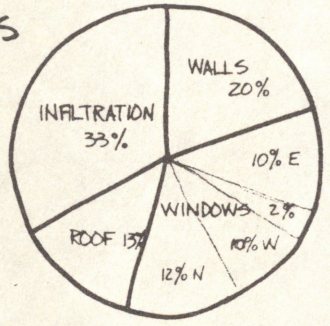
HEAT LOSS COMPARISON CHART

	CONSERVE CONSTRUCTION	FHA MINIMUM
FLOOR	3,179	8,722
WALLS	4,411	6,757
CEILING	2,041	4,320
WINDOWS & DOORS	3,050	13,131
INFILTRATION	3,007	7,548
SUB TOTAL	15,688	40,478
DUCT LOSS	3% 471	15% 6,072
TOTAL BTU HEAT LOSS	16,159	46,550

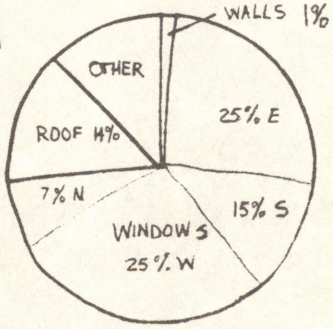
TOTAL HEAT LOSS REDUCTION = 65%

WHERE DOES THE HEAT GO?
THE ORTHODOX HOUSE →

LOSS



GAIN



THE SINGLE MOST IMPORTANT ELEMENT IS INSULATION. THE AMOUNTS OF INSULATION USED TODAY ARE HIGHLY INADEQUATE AS ARE THE CODES WHICH GOVERN THEIR INSTALLATION. NOT ONLY WILL THE USE OF MORE INSULATION LOWER THE AMOUNT OF ENERGY USED FOR SPACE HEATING AND COOLING BUT IT WILL PROVIDE A MORE COMFORTABLE INTERIOR LIVING SPACE, WARMER IN WINTER, COOLER IN SUMMER. BRIEFLY, THIS IS ACHIEVED BY LESS VARIATION OF AIR TEMPERATURE BETWEEN FLOOR AND CEILING AND WARMER WALL SURFACE TEMPERATURES WHICH WILL NOT CONDUCT BODY HEAT THE WAY THAT COOLER WALLS DO.

MOST HEAT LOST IN STANDARD HOUSES DURING THE WINTER IS LOST THROUGH WINDOWS, NORTH, EAST AND WEST RESPECTIVELY. THE NEXT LARGEST PROPORTION OF HEAT LOSS IS DUE TO INFILTRATION OF COLD AIR. IN SUMMER MOST HEAT IS GAINED THROUGH WINDOWS, WEST, EAST & SOUTH, RESPECTIVELY. THIS SHOWS THE EFFECTS OF LOCATING WINDOWS ON SPECIFIC SIDES OF THE HOUSE, THE IMPORTANCE OF PREVENTING DRAFTS AND THAT USING STANDARD SINGLE PANE GLASS WINDOWS IS NOT GOOD ENOUGH. ALSO IMPORTANT TO NOTE ABOUT SAVING ENERGY, IS THE DIFFERENCE BETWEEN THE PERFORMANCE OF A MINIMUM STANDARD F.H.A. CODE HOUSE AS OPPOSED TO ONE THAT IS BUILT WITH ENERGY CONSERVATION IN MIND, USING MUCH MORE INSULATION AND DOUBLE GLAZED WINDOWS.

TO CLARIFY THE DIRECTION WHICH THIS RESEARCH IS LEADING, I'LL LIST BRIEFLY THE KEY ELEMENTS:

1. THE AMOUNTS OF INSULATION USED ARE VERY IMPORTANT.

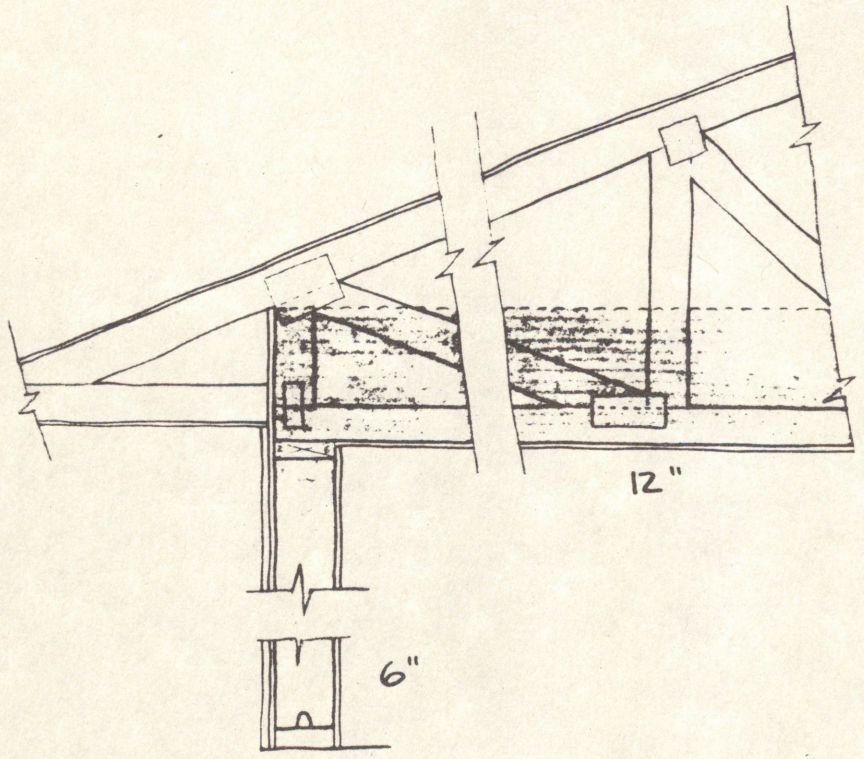
2. DOUBLE PANE WINDOWS ARE MINIMUM AND TRIPLE PANE SHOULD BE STANDARD.

3. THE ORIENTATION OF THE HOUSE AND THE LIVING SPACES WITHIN ARE VERY IMPORTANT.

4. LOCATING WINDOWS ONLY WHERE THEY DO THE MOST GOOD AND OTHERWISE OMITTING THEM, WHEN FEASIBLE, SHOULD BE A GUIDELINE.

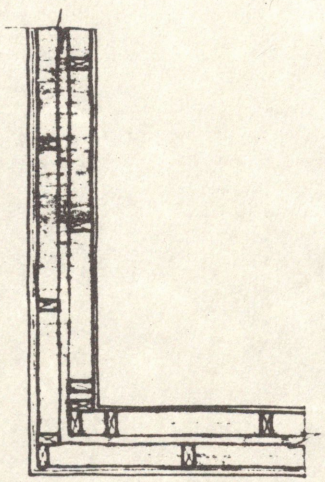
ENERGY CONSCIOUS EXAMPLES :

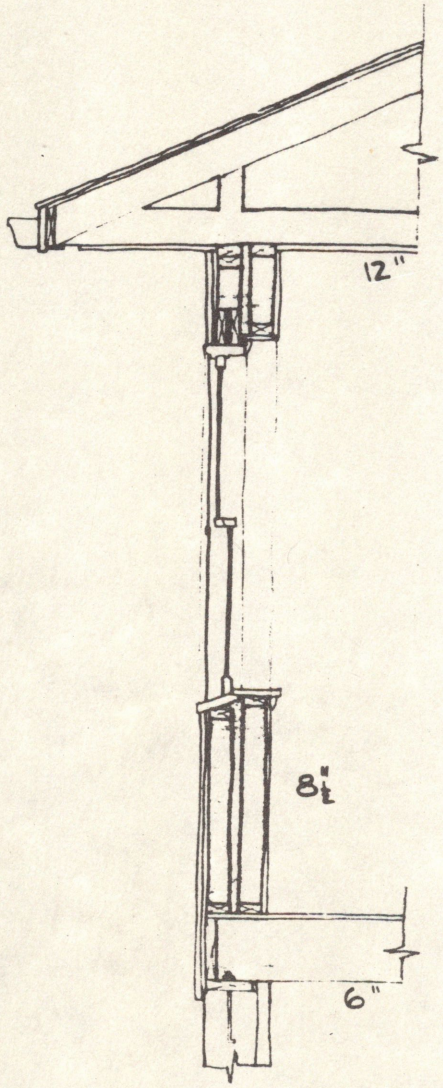
"THE ARKANSAS STORY"



1975
1040 - 1200 FT.²
WALLS 2x6 24" O.C.
INSULATION: WALLS 6" R=19 U=.052
CEILING 12" R=38 U=.026
FLOOR 6" R=19 U=.052
WINDOWS: DOUBLE GLAZING
8% OF FLOOR AREA.
80-95 FT.² OF SOUTH WINDOWS
NO EAST OR WEST
OTHER: CEILING INSU. EXTENDS OVER EXTERIOR WALLS
HEATING WAS REDUCED BY 1/3

ILLINOIS

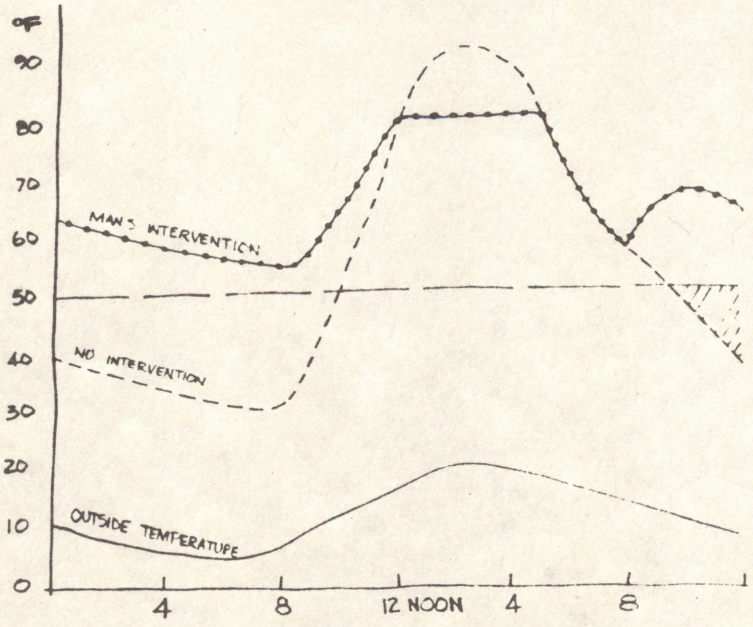




"LO-CAL HOUSE"

1976
1560 FT.²
WALLS STAGGERED 2×4 24" O.C.
INSULATION: WALLS: 8½" R=33 U=.03
CEILING: 12" R=38 U=.02
FLOOR: 6" R=19 U=.05
WINDOWS: TRIPPLE GLAZING
8% OF FLOOR AREA
85% LOCATED ON SOUTH
NO EAST OR WEST
122 FT² SOUTH WINDOWS
OTHER: CEILING INSU. EXTENDS OVER EXTERIOR WALLS
HEATING WAS REDUCED BY ²/₃
80% DUE TO SUPERIOR INSU.
SOLAR ORIENTATION ALSO IMPORTANT
WINDOWS AVERAGE 200-400 BTU/FT²/DAY
MORE GAIN THAN THE 24 HR HEAT
LOSS THRU THE WINDOWS.

MAINE



"CHARLES WING HOUSE"

1975 - 1976
1700 FT.²
CONSTRUCTION ?
INSULATION ?
WINDOWS: PASSIVE SOLAR
600 FT.² OF GLASS ON SOUTH-EAST, SOUTH, & SOUTH WEST
8 FT.² ON NORTH
OTHER: AUXILIARY HEAT FROM ONE MODEL 118 JØTUL WOOD STOVE

WE AS A CULTURE HAVE COMPLETELY ISOLATED OURSELVES FROM CLIMATE.

STUDIES SHOW SPENDING 8 HR / DAY AT 30°F & 16 HR/DAY AT 65°F PERSONS HAVE NOT MORE BUT FEWER COLDS THAN AT 72°F FOR 24 HR/ DAY.

THE PREVIOUS EXAMPLES SHOW IMPORTANT ENERGY CONSERVING FACTORS. TO ILLUSTRATE THIS, "THE ARKANSAS HOUSE" USES 2X6 CONSTRUCTION WITH 6 INCHES OF INSULATION IN THE WALL AND FLOOR, AND 12 INCHES IN THE CEILING. AN ALTERED TRUSS WAS USED SO THAT THE CEILING INSULATION DOES NOT HAVE TO BE COMPRESSED OVER THE WALLS TO ALLOW FOR ROOF VENTILATION. DOUBLE PANE WINDOWS WERE USED AND NONE WERE LOCATED ON EITHER THE EAST OR WEST ENDS OF THE HOUSE. HEATING AND COOLING CONSUMPTION WAS REDUCED BY 1/3 AND THE CONSTRUCTION COST WAS VERY LITTLE MORE THAN AN AVERAGE HOUSE.

"THE LO-CAL HOUSE" WENT A FEW STEPS FURTHER AND USED A STAGGERED STUD WALL WHICH ALLOWED FOR 8½ INCHES OF INSULATION IN THE WALLS. TRIPLE PANE WINDOWS WERE USED AND 85% OF THEM LOCATED ON THE SOUTH WALLS. HEATING CONSUMPTION WAS REDUCED BY 2/3 AND THEIR CALCULATIONS SHOWED THAT 80% OF THIS SAVING WAS DUE TO THE SUPERIOR INSULATION AND THE REST DUE TO ORIENTATION AND WINDOW LOCATION.

"THE CHARLES WING HOUSE" SHOWS WHAT CAN HAPPEN WHEN MASSIVE AMOUNTS OF SOUTH FACING WINDOWS ARE USED. DUE TO THE LARGE AMOUNT OF SOLAR GAIN THROUGH THE WINDOWS HE MUST VENTILATE HIS HOUSE FROM NOON TO 2 P.M. AT TIMES DURING THE WINTER. THE HOUSE ALSO USES A WOOD BOX STOVE TO HEAT IT OVER-NIGHT.

SUMMARY :

1. WE CAN NOT GO ON LIVING THE WAY WE ARE NOW ACCUSTOMED.
2. WE MUST LOOK AT ALTERNATIVE WAYS OF CONSERVING ENERGY AND LIVING.
3. WE MUST CONSIDER THE IMPORTANCE OF PROPER ORIENTATION AND PLANNING.
4. PLANTS CAN HELP US ACHIEVE CLIMATIC COMFORT NATURALLY.
5. OLD CONCEPTS DERIVED FROM CHEAP FUELS MUST BE RE-EVALUATED.

PART - TWO

PEOPLE WOULD ASK ME WHAT I WAS DEALING WITH IN MY THESIS- MY ANSWER: "AN ALTERNATE ENERGY SOLUTION". BY ALTERNATE I MEAN DIFFERENT OR A VARIATION OF THE WAY WE LIVE, BUILD AND USE ENERGY TODAY. MY SOLUTION DEALS WITH NOT ONE BUT MANY ENERGY SAVING IDEAS. I AM INCORPORATING AS MANY IDEAS AS POSSIBLE, WITHIN REASON. MY HEAT SOURCE IS A WOOD STOVE, WHICH WILL SUPPLY THE ENTIRE HOUSE WITH HEAT. AT THIS POINT I AM NOT SURE IF ONE OR MORE STOVES ARE NEEDED. MY OTHER SOURCE OF HEAT WILL BE THE SUN. I PLAN TO USE THE SUN'S HEAT WHEN IT IS AVAILABLE DURING THE DAY. MY INTENTIONS ARE NOT TO COLLECT THE SUN WITH FLAT PLATE COLLECTORS OR OTHER DEVICES AND STORE HEAT, BUT TO USE MY WINDOWS FOR MAXIMUM HEAT GAIN AND MINIMUM HEAT LOSS AND THEREFORE, ORIENTATION AND WINDOW PLACEMENT ARE VERY IMPORTANT.

THE PROGRAM I AM WORKING ON IS FOR A SMALL HOUSE: 2 BEDROOM, 1 BATH, KITCHEN, EATTING AND LIVING AREAS, APPROXIMATELY 1000 SQ. FT, WITH A DETACHED GARAGE AND GREENHOUSE. THERE IS NO BASEMENT BUT USEABLE ATTIC SPACE SHOULD BE PROVIDED.

MY FIRST DESIGN WAS ONE WHICH HAD THE ENTIRE SOUTH FACING WALL COVERED WITH WINDOWS AND ONE WOOD STOVE FOR HEATING. I WAS ALSO TRYING TO INCORPORATE THIS STOVE FOR COOKING AND HOT WATER HEATING. AFTER I BUILT A STUDY MODEL TO SEE IF ONE STOVE WOULD

BE ENOUGH AND HOW MUCH GAIN THE WINDOWS PROVIDED, IT WAS FOUND THAT ON CLEAR WINTER DAYS I HAD A GREAT DEAL OF HEAT GAIN FROM THE WINDOWS BUT ON CLOUDY WINTER DAYS WHICH IS ABOUT 50% OF THE TIME, FOR THIS AREA, THE HEAT LOSS EQUALLED THE GAIN. THE ONE STOVE DID A GOOD JOB OF HEATING THE ENTIRE HOUSE. THIS IS POSSIBLE BECAUSE IT IS A SMALL HOUSE AND I AM USING LARGE AMOUNTS OF INSULATION. IN TERMS OF A PLEASING SPATIAL SOLUTION THIS DESIGN LEFT SOMETHING TO BE DESIRED. SINCE THE IDEA OF THE WINDOWS AND THE SPACE PROVIDED DID NOT WORK VERY WELL I DROPPED THIS APPROACH.

WORKING WITH ENERGY CONSERVATION SEEMED TO DEMAND CERTAIN THINGS WHICH WERE NOT SPATIALLY RICH. I DECIDED THAT THE GOAL I HAVE SET AND OTHER IMPORTANT THINGS LIKE THE SPACE CREATED WERE OPPOSITES AND SEEMED TO CONTRADICT ONE ANOTHER. I MIGHT FIND A BETTER SOLUTION IF I WERE TO DO THE TWO OPPOSITES SEPARATELY AND THEN COMBINE THE IMPORTANT ELEMENTS OF BOTH.

MY SECOND ENERGY CONSERVING DESIGN WAS MORE OR LESS BUILT AROUND A WOOD STOVE AND ALONG THE SOUTH WALL OF THE DESIGN WAS PLACED A GREENHOUSE FOR HEAT COLLECTION. THE GREENHOUSE WAS SEPARATE FROM THE HOUSE SO THAT WHEN IT WAS NOT GAINING HEAT IT COULD BE CLOSED OFF SO AS NOT TO DRAW HEAT FROM THE HOUSE.

THIS DESIGN HAD DOORS WHICH COULD BE OPENED OR CLOSED TO ALLOW THE HEAT TO MOVE INTO DIFFERENT AREAS. AGAIN ONE STOVE WAS USED AND WAS CENTRALLY LOCATED.

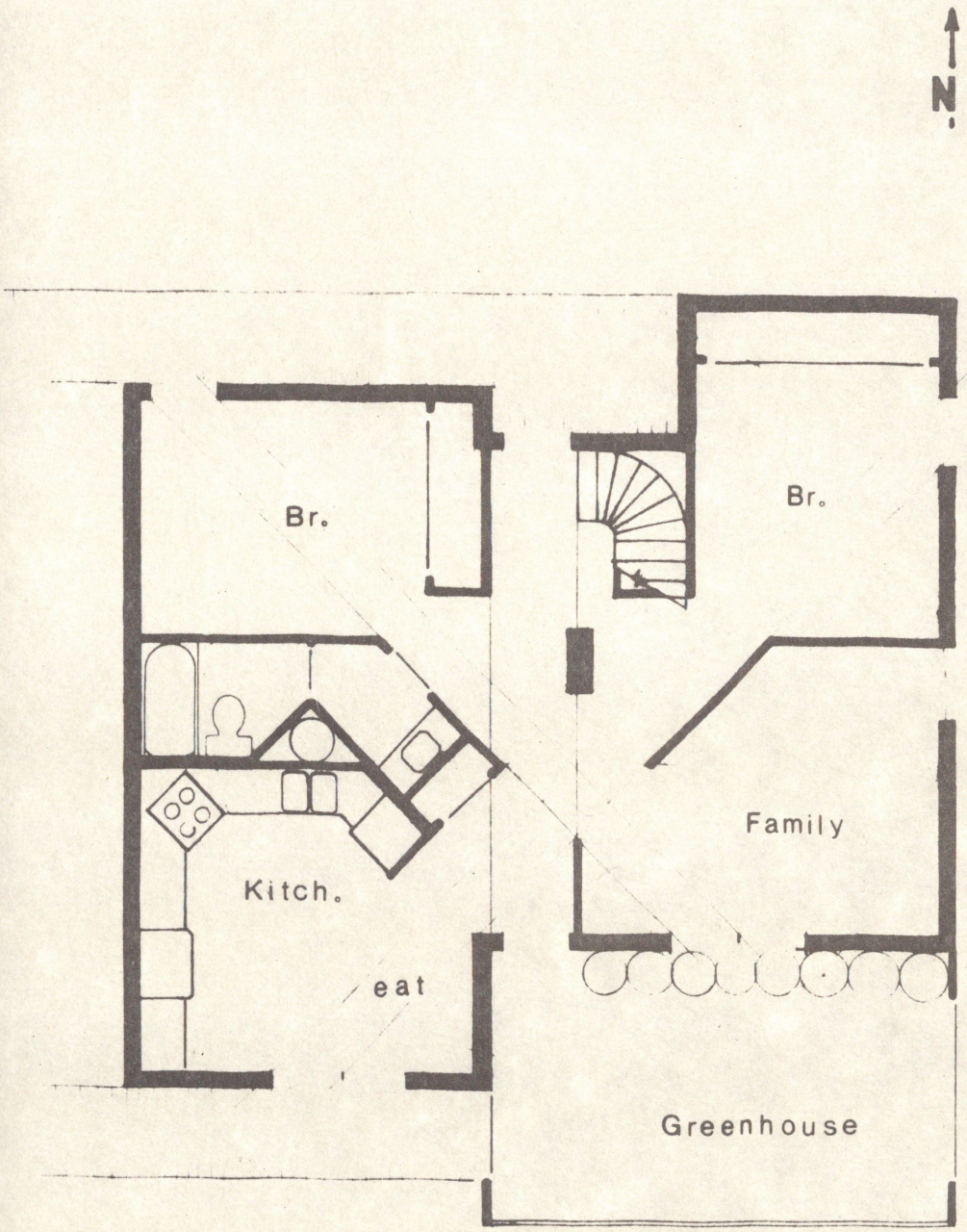
IN MY THIRD AND MORE SPATIAL HOUSE DESIGN I WAS CONCERNED WITH PLANNING SPACES SO THAT THEY COULD BE CONNECTED OR SHARED PHYSICALLY OR VISUALLY BOTH HORIZONTALLY AND VERTICALLY. THE DESIGN WAS MUCH MORE INTERESTING. THE EXTERIOR WAS SIMILAR IN CHARACTER TO THE FIRST BUT THE INTERIOR WAS VERY MUCH DIFFERENT: BALCONYS, HALF-WALLS, 2 STORY SPACES, PATIO DOORS, OUTSIDE UPPER DECK AND WALK THROUGH GREENHOUSE WERE INCLUDED. ALSO, A DISSECTING GRID OR INTERSECTING AXISES WERE USED.

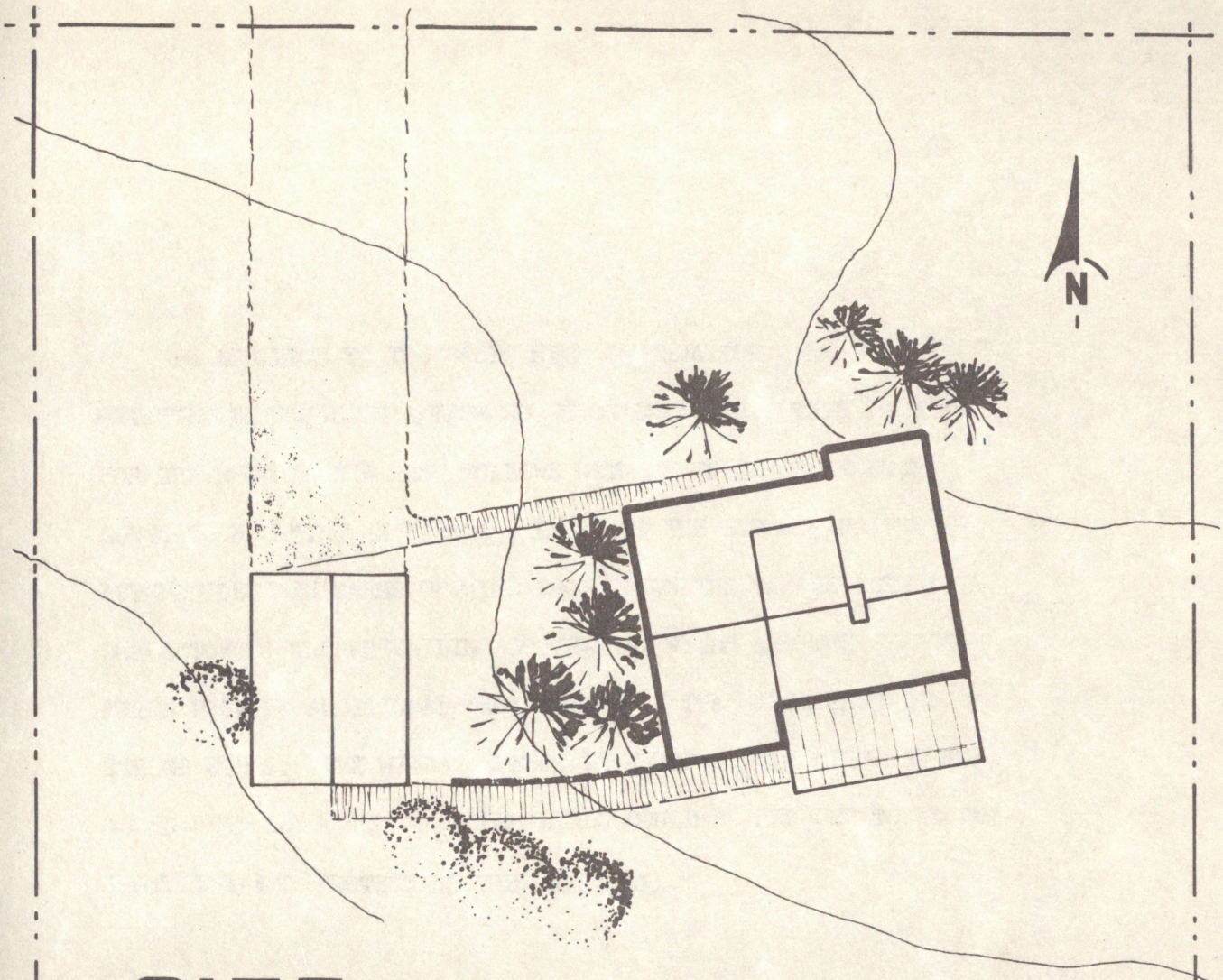
AFTER THESE STUDY MODELS WERE BUILT AND COMPARED MY EVAL-UATION WAS THAT THE SPATIAL DESIGN WAS SO MUCH MORE SATISFYING THAT IT WOULD BE NECESSARY TO KNOW ITS PERFORMANCE BEFORE RATIONAL DECISIONS COULD BE MADE. IT WAS FOUND THAT WITH MINOR ADJUSTMENTS THE HOUSE WOULD FUNCTION REMARKABLY WELL. THE STOVE WOULD BE PLACED IN THE CENTER AT THE INTERSECTION OF THE 3 AXISES.

THE ADJUSTMENTS WHICH WERE MADE FOR THE FINAL DESIGN WERE THE REMOVAL OF PATIO DOORS AND THE OUTSIDE UPPER DECK. THINGS ADDED WERE DOORS FOR HEAT CONTROL, WINDOWS INSTEAD OF A BALCONY, AND WATER BARRELS FOR HEAT STORAGE IN THE GREENHOUSE.

THE 3 CROSS AXISES MENTIONED BEFORE ARE SHOWN DRAWN ON THE PLAN. ABOVE IS USABLE ATTIC SPACE. A RECTANGULAR BOX STOVE IS LOCATED APPROXIMATELY IN THE CENTER OF THE PLAN.

MY DESIGN





SITE

RURAL SITE APPROX. 5 MILES FROM TOWN

SIZE APPROX. 1 ACRE

BURIED UTILITIES - PHONE & ELECT. NO GAS

WELLS 40'-45' DEEP

SEPTIC TANKS & DRAIN FIELDS

NO BAD SOIL CONDITIONS

WATER TABLE APPROX. 10' DEEP

GRAVELY ROCK BED 3' DEEP

PREVAILING WINDS FROM S.W.

SOME WIND FROM N. IN WINTER

TREES LOCATED FOR WIND PROTECTION

HOUSE TURNED TO FACE TRUE SOUTH.

IN ADDITION TO THE BASIC SITE INFORMATION COLLECTED I HAVE ORIENTED MY HOUSE TO A TRUE SOUTH ORIENTATION. THIS IS BEST FOR GREENHOUSES AND ALSO FOLLOWS WITH MY THEME OF "ENERGY CONSCIOUSNESS". THE GARAGE RELATES TO THE STREET AND THE AUTOMOBILE. IN TERMS OF WIND PROTECTION THE GARAGE ACTS AS A DEFLECTOR TO THE PREVAILING SOUTH-WEST WINDS AND THE SPRUCE TREES PROVIDE ADDITIONAL PROTECTION FOR THE HOUSE FROM THE STRONG WINDS. THE WIND'S EFFECT IS WORTH CONSIDERING AND THE ADDED HEAT LOSS DUE TO STRONG WINDS COULD BE REDUCED TO APPROX-IMATELY 1/3 BY PROTECTING THE BUILDING.

WIND EFFECT



DURING A 35 MPH WIND IN AN UNPROTECTED LOCATION AN AVERAGE HOUSE MIGHT REQUIRE 926.12 BTU'S/HR. MORE DUE TO THE WIND. WHILE A PROTECTED HOUSE MIGHT ONLY REQUIRE 369.95 BTU'S/HR.

THESE FIGURES WERE DERIVED FROM:

$Q = \Delta T\,(1.3)\,10^{\frac{.025\,U}{}}$ UNPROTECTED

AND

$Q = \Delta T\,(1.3)\,10^{\frac{.018\,L\,.07\,U}{}}$ PROTECTED

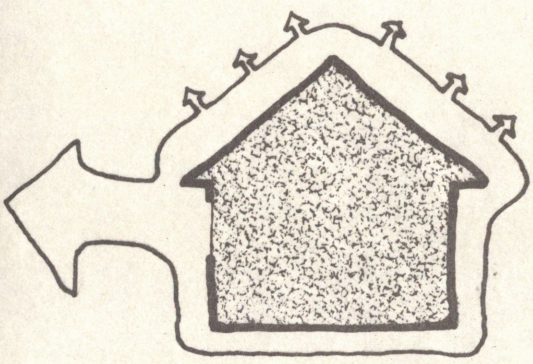
WHICH WERE FOUND IN; TECH. BUL# 77, " SHELTERBELTS & SURFACE BARRIER EFFECTS "

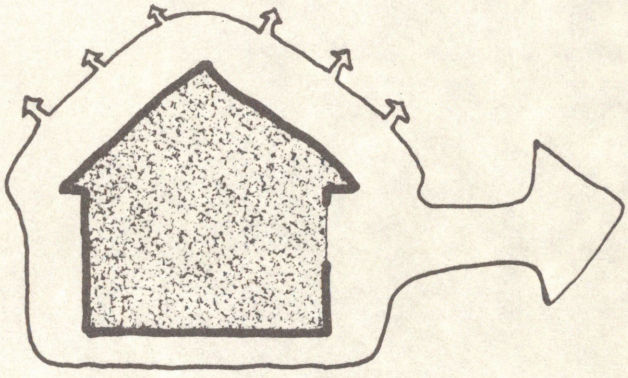
IN ADDITION TO GARAGE AND TREE PLACEMENT I HAVE A FENCE THAT FUNCTIONS SIMILARLY TO A SNOW FENCE WHICH DEFLECTS THE WIND SLIGHTLY AND COLLECTS SNOW ON THE LEEWARD SIDE (IN THE TREES). THE FENCE ALONG WITH THE WALK RAISES THE SURROUNDING TEMPERATURE IN THE WINTER THROUGH RADIATION.

OVERHANGS WERE DESIGNED TO PROVIDE CONTROL THE DIRECTION OF ADMISSION OF THE SUN'S RAYS.

WINDOW PLACEMENT PROVIDES FLOOR TO WINDOW RATIOS OF 8% IN BEDROOMS AND 15% IN LIVING AREAS RATHER THAN THE STANDARD 10%. CONSCIOUS WINDOW PLACEMENT CAN RESULT IN LESS HEAT LOSS AND MORE OR LESS HEAT GAIN, AS DESIRED. (SEE PAGE 50).

HEAT LOSS



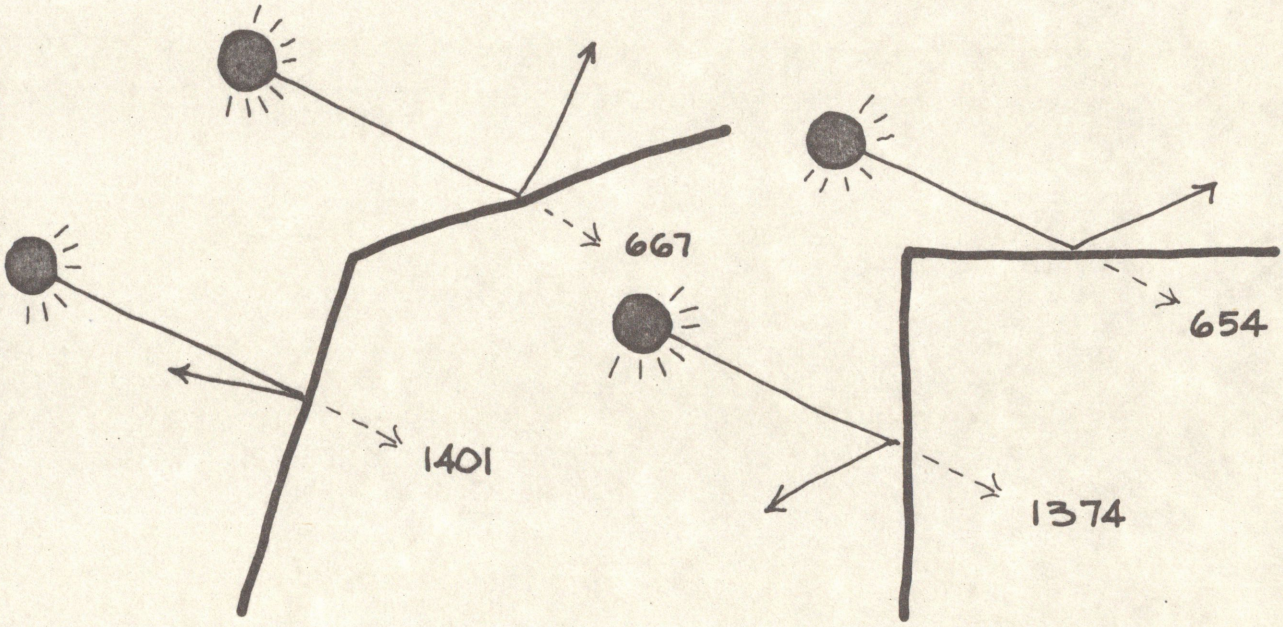


WINTER DAY		WINTER NIGHT	
OUTSIDE TEMP.		OUTSIDE TEMP.	
	20°F		-10° F
INSIDE TEMP.		INSIDE TEMP.	
	65°F		65° F
* APROX. BTU'S/ FT²/HR.		APROX. BTU'S/ FT²/HR.	*
WINDOWS	5.0	WINDOWS	7.8
ROOF	1.2	ROOF	2.2
WALLS	1.1	WALLS	2.0
FLOOR	0.9	FLOOR	1.5

NOTE : AN AVERAGE DAYTIME GAIN AT 10:00 AM IN DECEMBER WITH 50% CLOUD COVER WOULD BE 76 BTU'S/FT²/HR. ON A VERTICAL WINDOW.

HEAT GAIN

GREENHOUSE :



MY DESIGN

BOOK VALUES

BOOK VALUES WERE USED TO COMPUTE GAINS. MY DESIGN FOR THE GREENHOUSE GIVES ABOUT 2% BETTER TRANSMITTANCE OF SOLAR RADIATION.

TOTAL HEAT GAIN IS 44,044 BTU/HR. CLEAR SKY

* WITH 50% CLOUD COVER 22,022 BTU/HR.

TOTAL HEAT LOSS IS 18,792 BTU/HR.

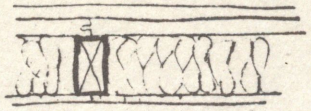
LEAVING 3,230 BTU/HR. EXTRA

THE SOUTH SIDE ROOMS (FAMILY & KITCHEN) NEED 3,230 BTU/HR WITH TEMPERATURES OF 0° OUTSIDE AND 70° INSIDE.

HEAT LOSS CALCULATIONS WERE DONE AND VERY GOOD RESULTS WERE OBTAINED. THIS, I FEEL, IS DUE TO BETTER INSULATION, GOOD WINDOW TREATMENT AND SMALLER HOUSE AREA IN BOTH PLAN AND VOLUME,I.E., 7'-3" CEILINGS WERE USED. THE PREVIOUS SKETCH SHOWS THE PROPORTIONAL RELATIONSHIPS BETWEEN THE FLOOR, WALL, ROOF AND WINDOWS OF MY DESIGN. THE GREENHOUSE HEAT GAIN WAS ALSO CALCULATED. ON CLEAR DAYS THE HEAT GAIN IS ENORMOUS BUT ON CLOUDY DAYS THE GAIN IS MUCH LESS. EVEN AFTER LOSSES THERE IS STILL ENOUGH HEAT FROM THE GREENHOUSE TO SUPPLY APPROXIMATELY 1/2 THE HEATING NEEDS FOR THE HOUSE.

INSULATION STANDARDS HAVE RECENTLY BEEN INCREASED. F.H.A. NOW REQUIRES "R" VALUES OF 38, 19 & 22 IN THE CEILING, WALL, AND FLOOR, RESPECTIVELY, OF NEW HOUSES. THIS IS VERY WISE AS IT SAVES MUCH ENERGY AND PROVIDES A MORE EVEN TEMPERATURE COMFORT ZONE.

WALL SECTION ANALYSIS



2X4 STUDS

3½" FIBER GLASS
R-11
1" STYRAFOAM
R-8

19



2X6 STUDS

5½" FIBERGLASS
R-19

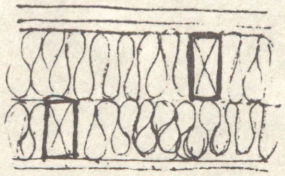
19



2X6 STUDS

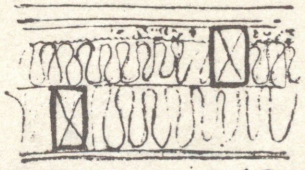
3⅝" FBERGLASS
R-13
1" POLY FOAM
R-9

22



3½" FIBERGLASS
R-11
TIMES 2 =

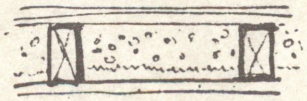
22



DOUBLE 2X4 STUDS

1" POLY FOAM
R-9
2¼" FIBER GLASS
3½" FIBER GLASS
R-18

27



2X4 STUDS

3" POLY FOAM
R-27

27

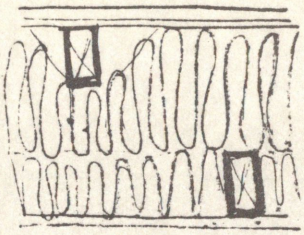


DOUBLE 2X4 STUDS

3½" FIBER GLASS
R-11
TIMES 3

33

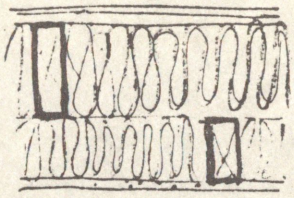
WALL SECTION'S CONT'D



DOUBLE 2X4 STUDS

6" FIBERGLASS R-19
3½" FIBERGLASS R-11

30

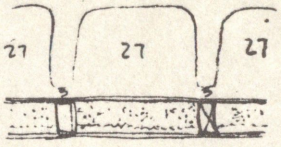


2X6 STUDS & 2X4 STUDS

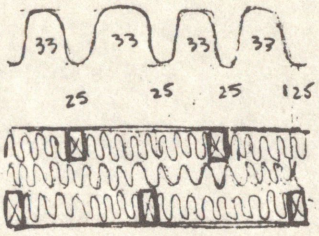
6" FIBER R-19
3½" FIBER R-11

30

THERMAL BRIDGES.



3" POLY WALL



10½" GLASS WALL

COST # MAY 1977

9 R
1" POLY INSU = 6.88
1 2X4 STUD = 1.18
6' 2X4 PLATE = .84
3.65

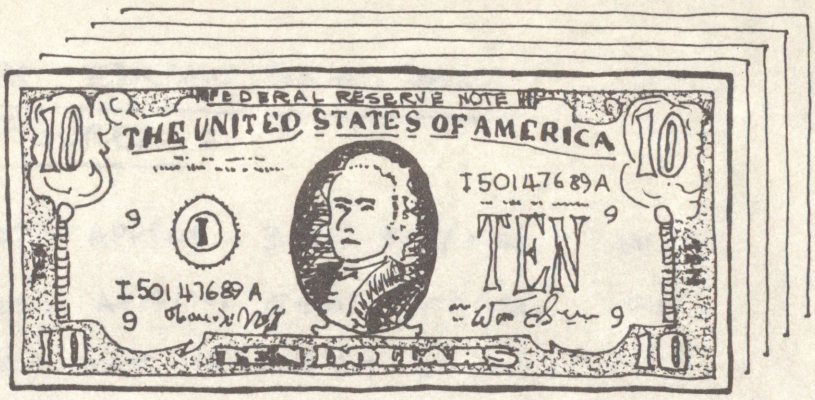
11 R
3½" GLASS = 1.63
1 2X4 STUD = 1.18
6' - 2X4 PLATE = .84
3.65

27 R
3" POLY INSU = 20.64
1 2X4 STUD = 1.18
6' - 2X4 PLATE = .84
22.66

33R
10½" GLASS = 4.89
2 - 2X6 STUDS = 2.36
10' - 2X4 PLATE = 1.39
8.64

19 R
6" GLASS = 2.88
1 2X6 STUD = 1.38
6' 2X6 PLATE = 1.03
5.29

30 R
9½" GLASS = 4.51
1 2X6 STUD = 1.38
1 2X4 STUD = 1.18
4' 2X6 PLATE = .68
4' 2X4 PLATE = .56
8.31



EXTRA COST

COMPARED WITH NEW FHA STANDARDS (MAY 1977)
12" OF INSULATION IN THE CEILING,
6" IN THE WALL & 6½" IN THE FLOOR.
MY DESIGN USES 9½" OF INSULATION IN THE WALL.

LIFE-CYCLE COSTING STUDYS EVALUATE:

1. OPERATION & MAINTENANCE
2. DEBT & INTEREST RATE
3. ENERGY SAVED
4. LIFE EXPECTANCY

IN MY STUDY I ONLY EVALUATED PART 3.
ENERGY SAVED:

WITH ADDITIONAL INSULATION APPROX.
2,347 BTU'S / HOUR ARE SAVED.
USING DEGREE-DAYS IT IS FOUND:
6,758,935 BTU'S / YEAR CAN BE SAVED.

AT TODAYS ELECT. RATES THIS WOULD COST ONLY #31.81 A YEAR BUT AT PROSPECTED 1980 RATES THIS WOULD COST $111.13
WITH EXPECTED ELECTRIC RATE INCREASES IT WOULD TAKE 4½ YEARS TO PAY FOR THE EXTRA INSULATION.

HOW THE ENERGY SAVED WAS FIGURED :

WALL R-33 LOSS APPROX. 3115 BTU/HR. MINE

WALL R-19 LOSS APPROX. 5462 BTU/HR.. FHA

DIFF. = 5462 − 3115 = 2347 BTU/HR.

Q = HEAT LOSS / DEGREE OF TEMP. DIFF.

$$= \frac{\text{HEAT LOSS}}{T_i - T_o} = \frac{2347}{65-(-10)}$$

= 31.3 BTU

S = SEASONAL HEATING REQUIRED

= 24 Q (DEGREE DAYS?) BOZ. ≈ 9000

= 24 (31.3) 9000

= 6,758,935 BTU / YEAR ⇐ DIFFERENCE

1 KWH = 3,400 BTU

∴ 6,758,935 = 1,987.9 KWH.

ELECTRIC RATES :

MAY 77	.016	=	$31.81
NOV. 77	.026	=	51.69
78	.036	=	71.57
79	.046	=	91.44
1980	.056	=	111.13 ← NEW YORK RATE — NOW —
			— ETC. —

ESTIMATES →

DIFF. BETWEEN 2 WALL SECTIONS :

$8.31 − 5.29 = $3.02 / 2 LINEAL FEET

WITH APPROX. 159 LINEAL FEET

TOTAL PRICE DIFF. = $240.09

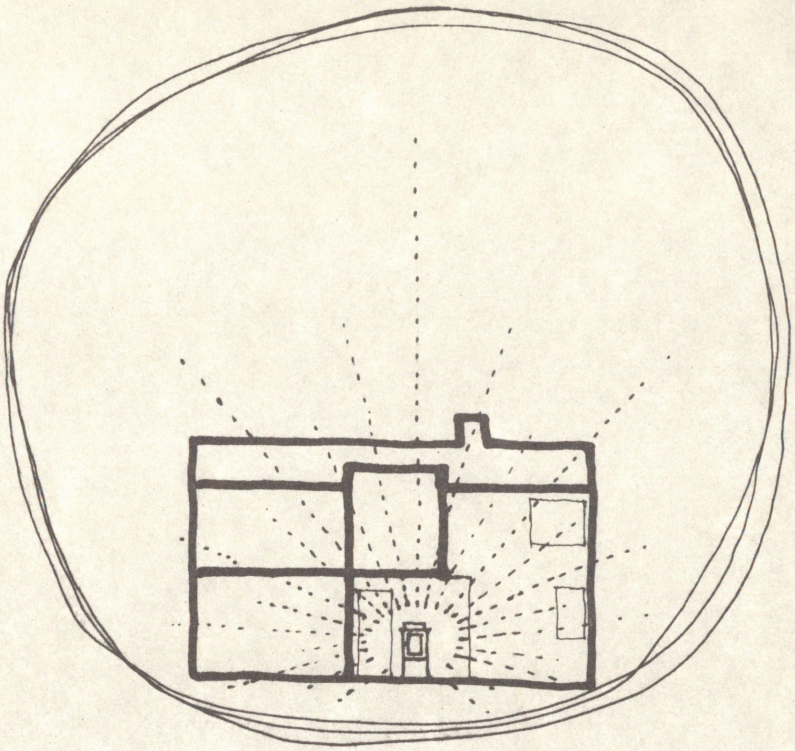
LABOR = APPROX 1/2 OF MATERIALS

∴ 240.09 + 120.04 = $360.13

AT ESTIMATED RATES IT WOULD TAKE 4½ YEARS TO PAY OFF.

AT THIS POINT I DID A WALL SECTION ANALYSIS TO DETERMINE WHICH SECTION TO USE. I CHOSE A DOUBLE WALL BUILT OF 2x4 AND 2x6 STUDS WITH 9 1/2" OF FIBERGLASS INSULATION WHICH HAS A 30 "R" VALUE. USING THE "R" VALUE FROM NEW TABLES (3.85/INCH) 36.5 "R" (.027 "U" COEFFICIENT) IS ACHIEVED. I CHOSE THIS SECTION BECAUSE IT IS THE BEST VALUE ECONOMICALLY WITH A HIGH "R" VALUE.

TO SHOW PEOPLE THAT IT IS WORTHWHILE TO INVEST MONEY TODAY ON BUYING EXTRA INSULATION I DID A COMPARATIVE COST ANALYSIS WHICH SHOWED THAT IN 4 1/2 YEARS THEIR ENERGY SAVINGS WOULD PAY FOR THE EXTRA INSULATION COSTS. THIS COST ANALYSIS WAS FOR MONTANA WITH ESTIMATED PRICE INCREASES. FOR NEW YORK OR OTHER PLACES WITH HIGHER UTILITY RATES THE SAVINGS WOULD PAY FOR THE INSULATION IN APPROXIMATELY 2 YEARS. I DID NOT FIGURE COST ANALYSIS FOR THE 13" OF INSULATION IN THE CEILING AND THE 6 1/2" IN THE FLOOR BECAUSE THEY DO NOT EXCEED THE NEWLY ADOPTED STANDARD (MAY 1977).



WOOD STOVE

ONE WOOD STOVE, MODEL 118 JØTUL
TESTED IN NORWAY PRODUCED:

44,500 BTU'S/HR. MAXIMUM

22,500 BTU'S/HR. PEAK EFFICIENCY

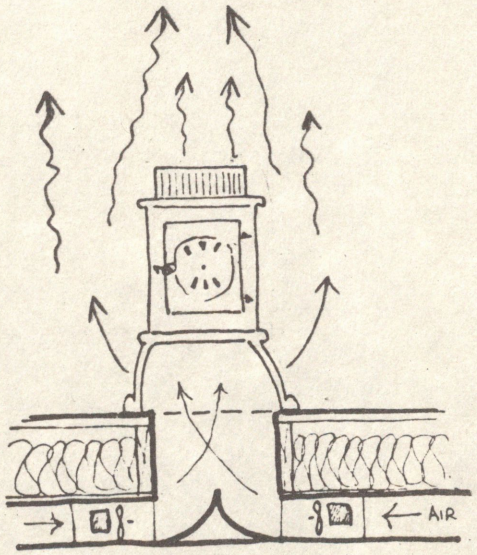
* ASSUMED BIRCH WOOD WAS USED
∴ RESULTS WICH EASTERN WHITE PINE
WOULD BE APROX:

27,786 BTU'S/HR. MAXIMUM

14,049 BTU'S/HR. PEAK EFFICIENCY

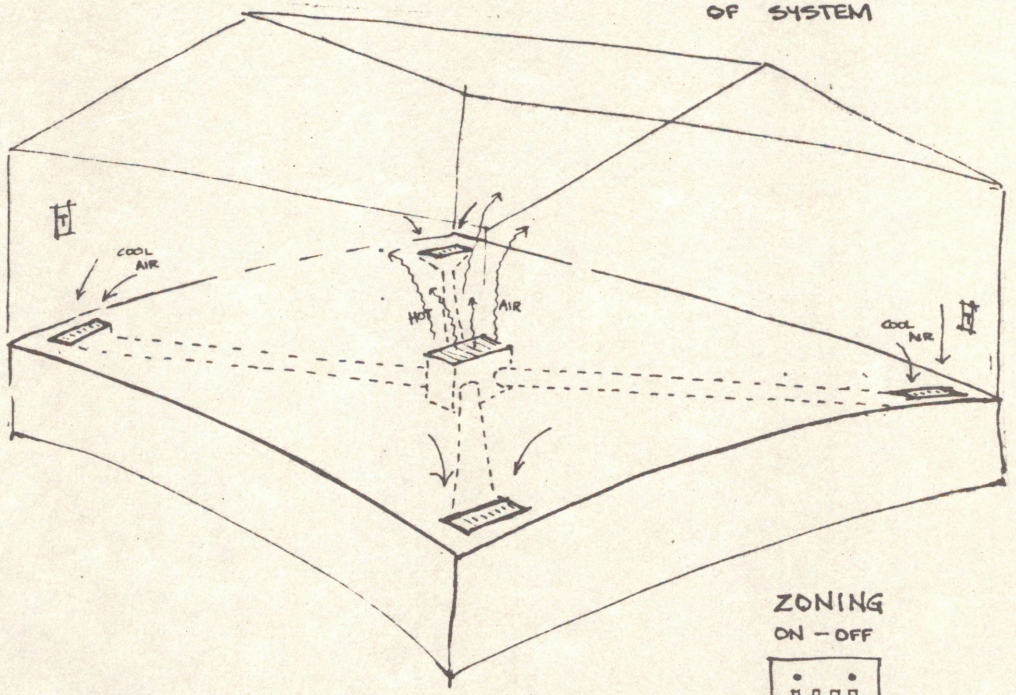
THIS HOUSE AT -30°F REQUIRES APROX.
10,000 BTU'S/HR. TO MAINTAIN 65°F.

CIRCULATION SYS.

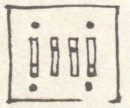


AIR CIRCULATION SYSTEM DRAWS COOL AIR FROM PERIMETER FLOOR VENTS THEN PUSHES THE AIR PAST THE STOVE. THE INDIVIDUAL FANS ARE THERMOSTAT OPERATED.

SIMPLIFIED DIAGRAM OF SYSTEM



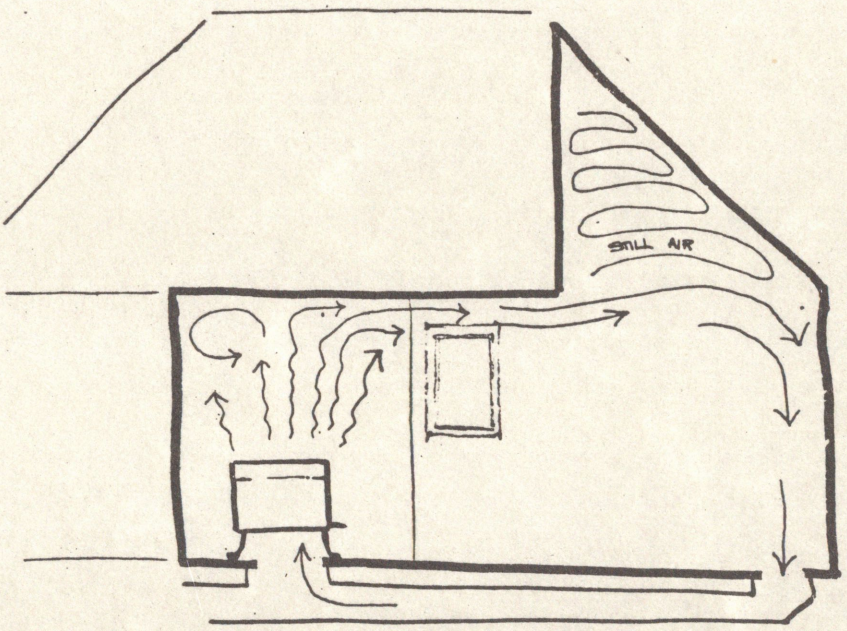
ZONING
ON – OFF



SWITCHES FOR THERMOSTATS

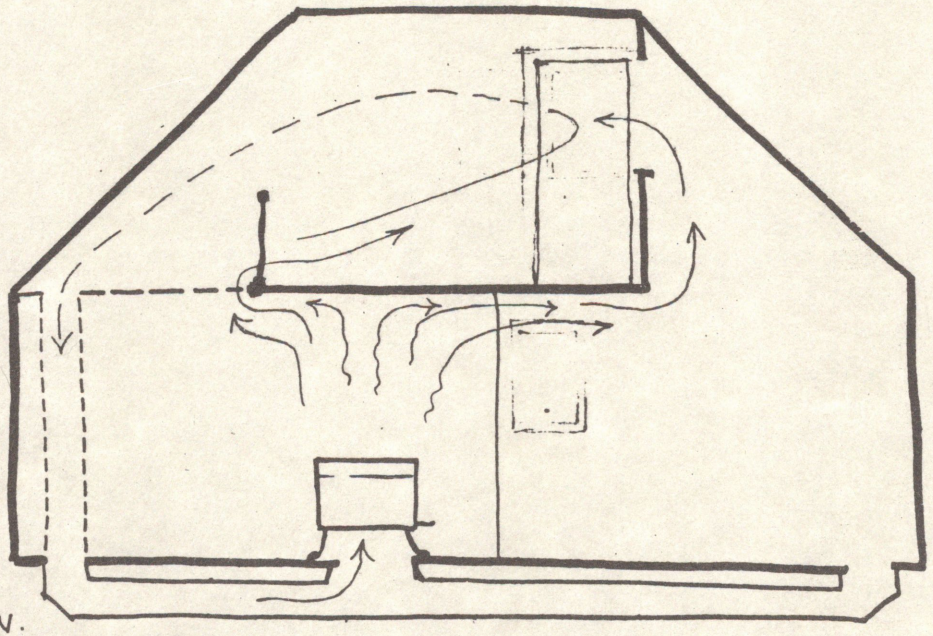
I CHOSE TO USE A JØTUL MODEL 118 WOOD STOVE FOR MY DESIGN. THE JØTUL PEOPLE PRODUCE A VERY FINE LOOKING AND PERFORMING CAST IRON BOX STOVE, WITH THE POTENTIAL TO HEAT A LARGER VOLUME THAN I HAVE, BUT FOR PEACE OF MIND I PREFER A SLIGHTLY OVERSIZED STOVE. THIS IS THE ONLY HEATING ELEMENT INITIALLY PROVIDED IN THE HOUSE WHICH WILL ALLOW FOR TESTING WOOD STOVE HEATING. TO INCREASE THE BURNING EFFICIENCY OF A WOOD STOVE I AM PROVIDING AN AIR CIRCULATION SYSTEM CONSISTING OF NOTHING MORE THAN FLOOR VENTS THAT COLLECT COOL AIR AT THE PERIMETER OF THE HOUSE AND PULL IT TOWARD THE STOVE TO BE RE-HEATED. AIR IS MOVED BY SMALL FANS INSIDE THE DUCT WHICH OPERATE ONLY WHEN THE THERMOSTATS CALL FOR MORE HEAT TO THAT SPACE. THE THERM-OSTATS CAN BE DEACTIVATED BY TURNING THEIR POWER OFF AT A CENTRAL LOCATION.

MODEL EXPERIMENT



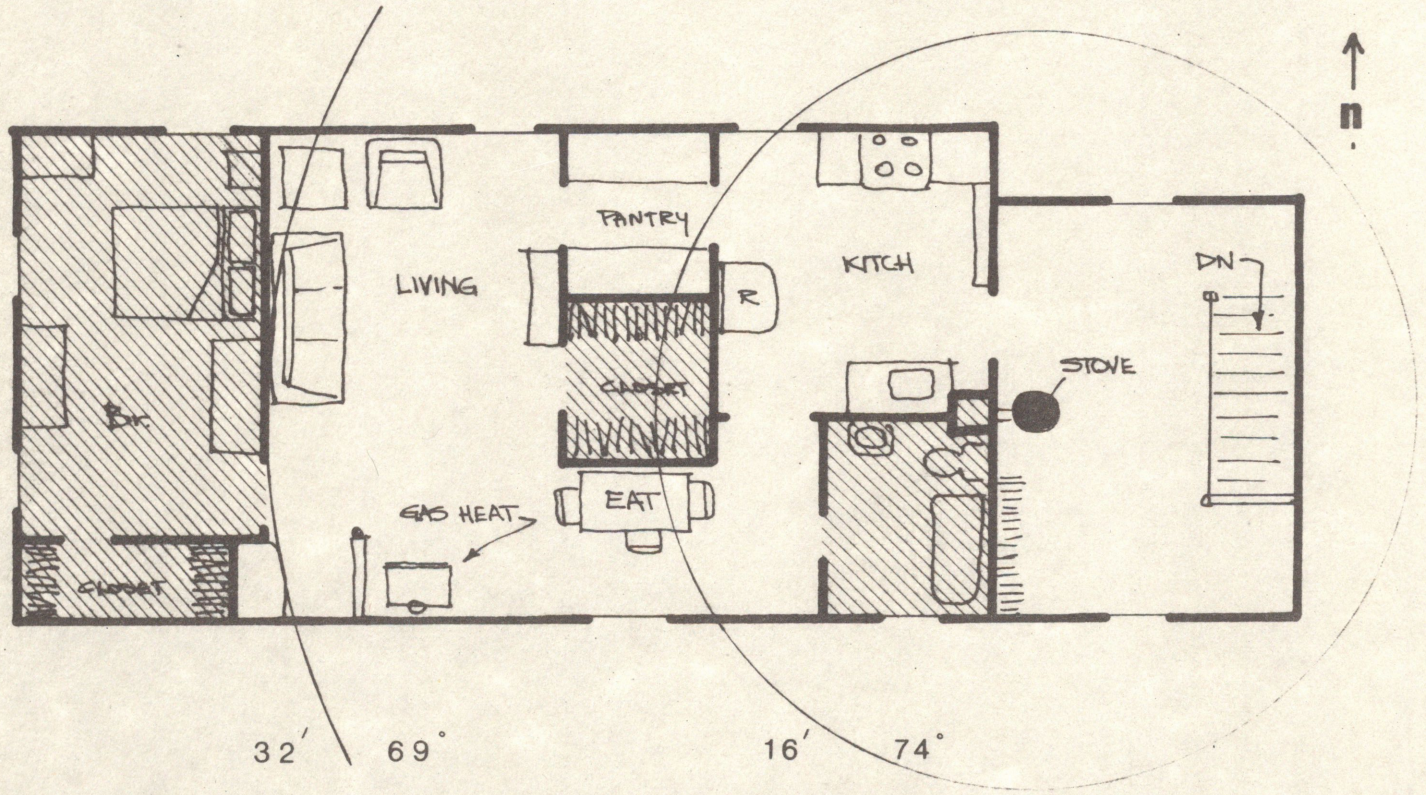
THE MODEL SHOWED AIR CIRCULATION. THIS WAS DEMONSTRATED BY WARMING OIL UNTIL IT SMOKED. THE SMOKE ROSE SIMILAR TO THE WAY HEAT WOULD. SEVERAL DIFF. PATTERNS DEVELOPED BASED UPON DIFF. CONDITIONS. THIS PATTERN SHOWS A BLANKET OF STILL AIR IN THE HIGH CEILING SPACE. THIS BLANKET ACTED LIKE A CUSHION WHEN THE AIR WAS CIRCULATED BY THE FAN THRU THE FLOOR VENT.

THIS IS THE PATTERN OF AIR MOVEMENT THAT FORMED WHEN THE UP-STAIRS VENT WAS USED. SMOKE OR WARM AIR COULD ENTER THE ROOM THRU THE DOOR OR WINDOW.



IN ORDER TO CHECK THE CIRCULATION SYSTEM I BUILT A LARGE MODEL OF MY HOUSE DESIGN. I HAD A SCALED, ELECTRICALLY HEATED WOOD STOVE, FLOOR VENT, DUCT WORK AND A SCALED ELECTRIC FAN TO MOVE THE AIR. THE MODEL WAS AS AIR TIGHT AS POSSIBLE. I PLACE OIL IN THE STOVE, WHICH, WHEN HEATED ENOUGH WILL SMOKE. THIS SMOKE RISES AND MOVES THROUGH THE INTERIOR SPACES IN MUCH THE SAME WAY THAT HEAT FROM A STOVE WOULD. BY INTRODUCING SMOKE INTO THE HEATED AIR ONE IS ABLE TO WATCH THE HEAT MOVEMENT. I HAD PLACED FLOOR VENTS IN TWO LOWER AND ONE UPPER SPACE. THE DIAGRAMS SHOW MY OBSERVATIONS, FOR DIFFERENT CONDITIONS. I FEEL THAT THE MODEL EXPERIMENT SHOWED THAT THE SYSTEM DOES WORK. THE NEXT STEP WOULD BE TO SIZE FANS THAT WOULD MOVE THE AIR AT THE CORRECT RATE.

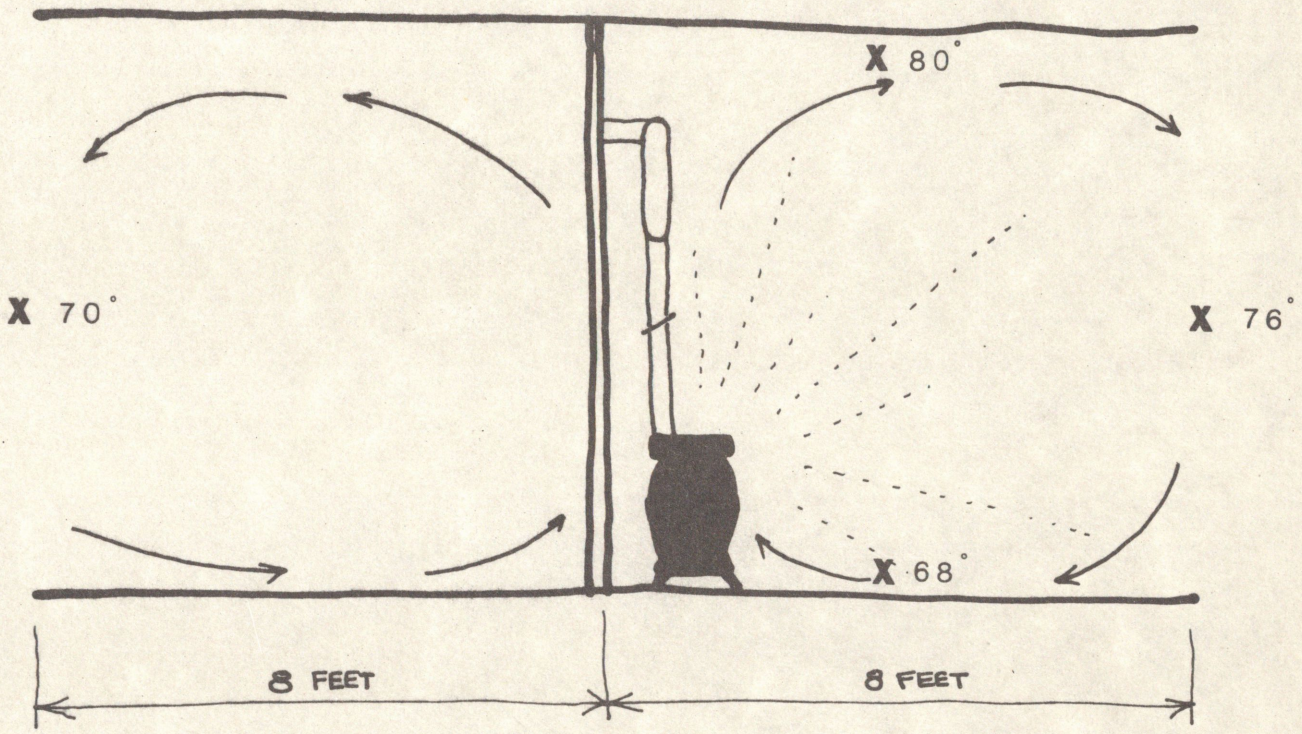
CASE STUDY



AN OLD HOUSE WITH POOR INSULATION APPROX. 900 FT^2
WOOD STOVE POT BELLY 18" DIA. 36" HT.
HEATING DISTANCES:

NEXT TO STOVE	79°-80°
WITHIN 16 FEET	74° AVER.
UP TO 32 FEET	69° AVER.

TEST RESULTS



CONVECTION

RADIATION & CONVECTION

THE HEAT IS MOVED TO THE LEFT BY CONVECTION — AIR MOVEMENT. THIS IS AN EVEN HEAT.

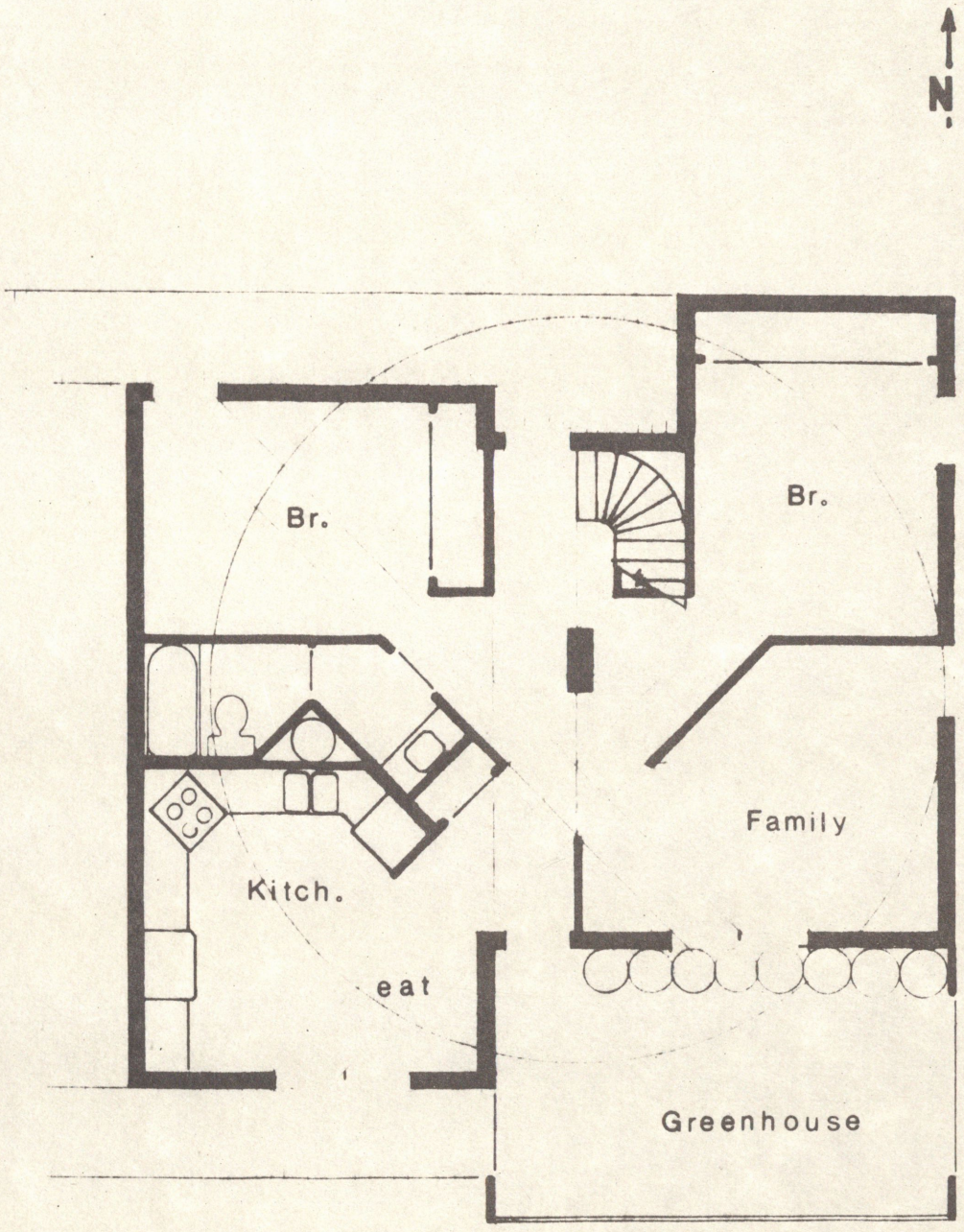
THE HEAT IS MOVED TO THE RIGHT MAINLY BY RADIATION BUT ALSO BY CONVECTION. THIS IS AN UNEVEN HEAT, YOU WOULD BE WARM ON THE FRONT & COLD ON THE BACK.

IN POORLY INSULATED HOUSES FLOOR TO CEILING TEMPERATURES VARY GREATLY.

I PERFORMED A CASE STUDY THIS WINTER OF THE HOUSE WHERE I AM NOW LIVING. MY ONE BEDROOM LIVING QUARTERS OF APPROXIMATELY 900 SQ. FT. WAS HEATED ALMOST ENTIRELY BY ONE WOOD BURNING STOVE. THE OLD HOUSE IS VERY POORLY INSULATED AND BADLY PLANNED FOR A WOOD STOVE DESIGN BUT BECAUSE OF A MILD WINTER AND OUR MODIFIED LIFESTYLE WE ROUGHED IT THROUGH. BY ROUGHING IT I MEAN WE WORE SWEATERS AROUND THE HOUSE,LAID A BLANKET ACROSS OUR LAPS WHEN SITTING IN THE LIVING ROOM, SLEPT IN A COOL BEDROOM (WOULD BRING GOOSE BUMPS TO BARE SKIN) AND SAT ON COLD TOILET SEATS. ALL IN ALL WE FOUND IT NOT HARD TO GET INTO THE SPIRIT OF THE SITUATION AND WERE VERY SATISFIED WITH THE RESULTS AND SAVINGS.

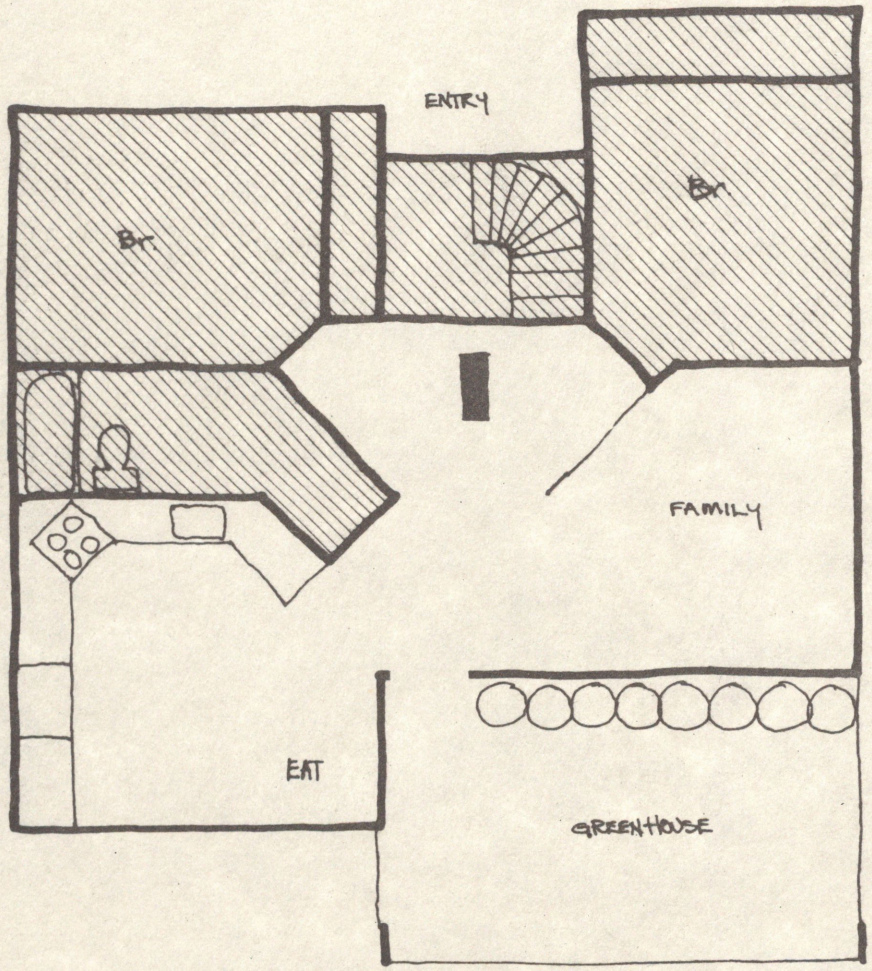
OUR EFFORTS PRODUCED VERY LOW GAS AND ELECTRICITY BILLS WHICH AVERAGED AROUND $11.50/MONTH, THE HIGHEST BEING $13.00. DUE TO THE POOR INSULATION THE FLOOR TO CEILING TEMPERATURE DIFFERED 12 DEGREES (80-68 DEGREES). DUE TO THE PLAN OF THE HOUSE AND LOCATION OF THE WOOD STOVE ALMOST NO RADIANT HEAT ENTERS THE HOUSE WHICH IS HEATED BY NATURAL CONVECTION OF WARM AIR CIRCULATION. THIS METHOD OF HEAT TRANSFER (CONVECTION) IS MORE COMFORTABLE THAN RADIANT TRANSFER AND PRODUCES MORE EVEN TEMPERATURES.

MY DESIGN

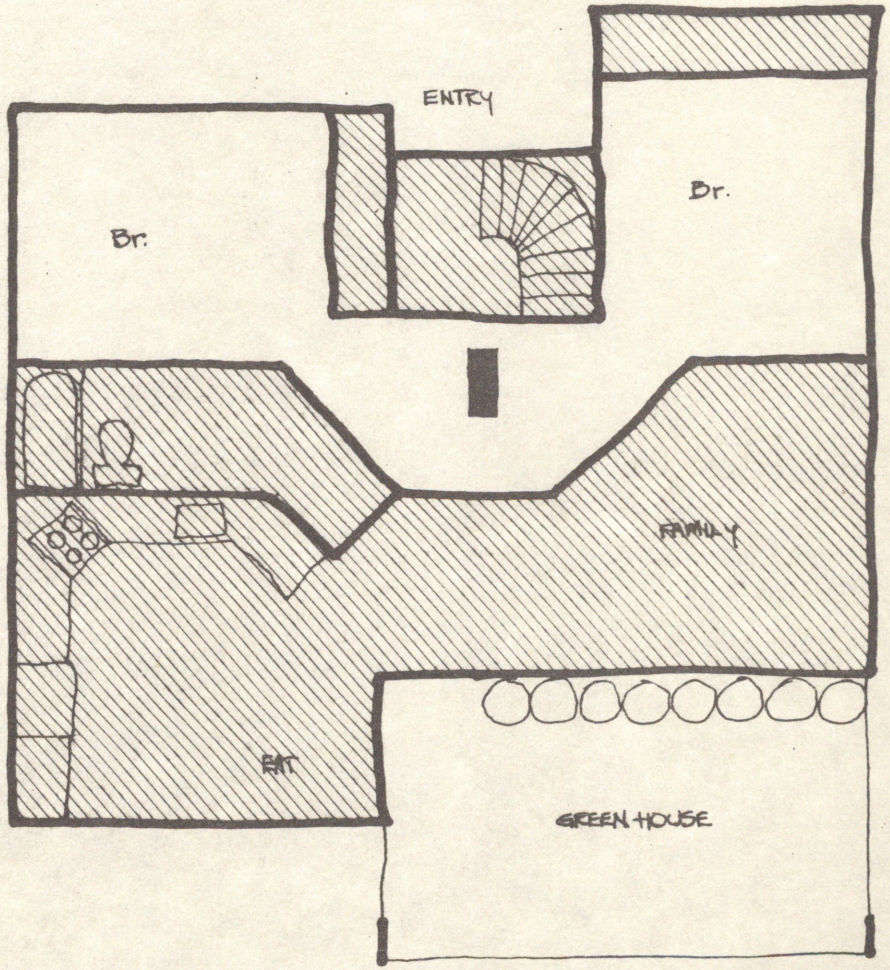


16 FT. RAD. HEATING CIRCLE

ZONING



2,076. btu/hr **day**

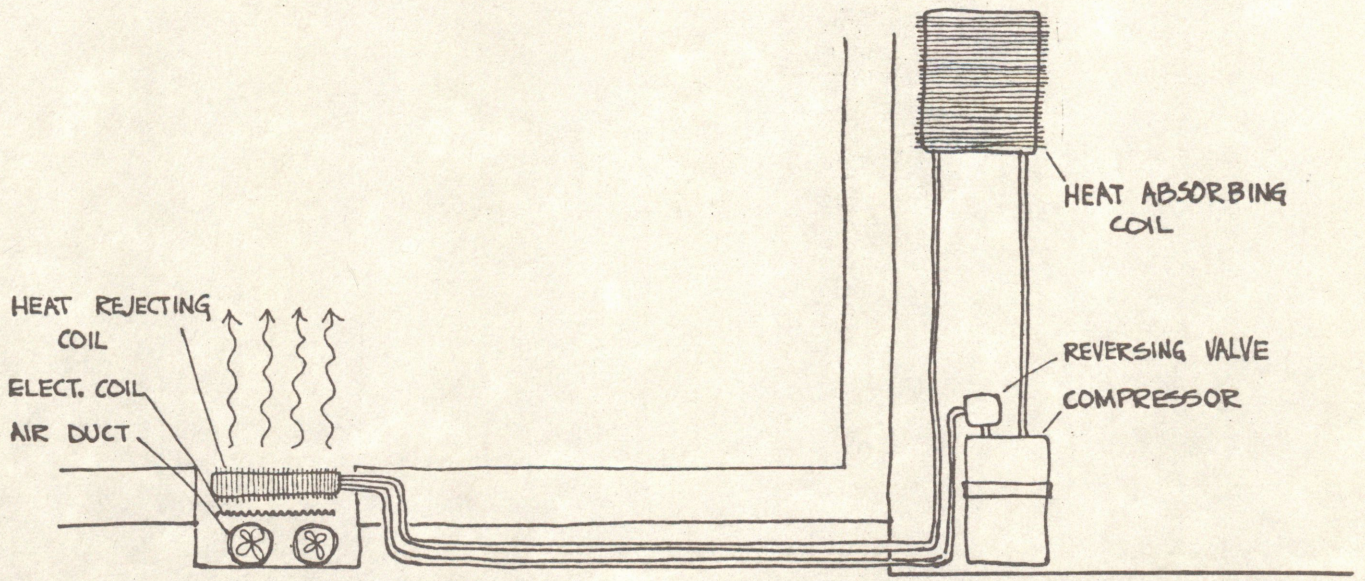


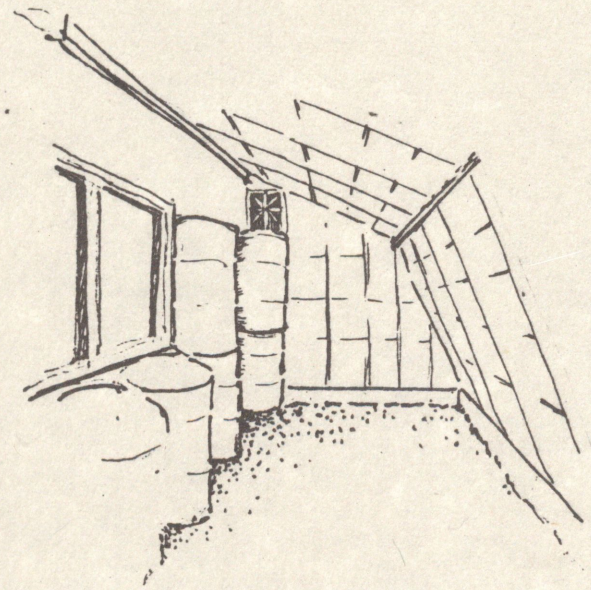
night 2,911. btu/hr

ON THE CASE STUDY ILLUSTRATION (PAGE 69) I HAVE DRAWN A HEATING RADIUS AND AVERAGE TEMPERATURE AT THAT DISTANCE. WITHIN THE 16' RADIUS I MAINTAINED 74 DEGREES F. MY DESIGN HAS A CIRCLE DRAWN ON IT WITH A 16' RADIUS TO SHOW HOW MUCH BETTER THE PLAN IS ADAPTED TO HEATING WITH A WOOD STOVE.

ANOTHER IMPORTANT WAY TO SAVE HEAT IS BY ZONING: THAT IS, CLOSING OFF PARTS OF THE HOUSE THAT ARE NOT BEING USED AT THAT TIME. MY THESIS DESIGN HOUSE DOES EVEN BETTER THAN MY CASE STUDY HOUSE BECAUSE IT ALLOWS FOR LARGER AREAS TO BE CLOSED OFF WHICH CUT DOWN THE HEATING NEEDS BY ABOUT 1/3.

HEAT PUMP

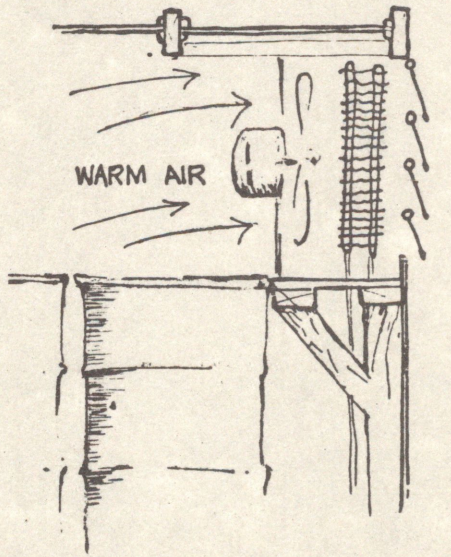

HEAT ABSORBING COIL
HEAT REJECTING COIL
ELECT. COIL
AIR DUCT
REVERSING VALVE
COMPRESSOR
HOUSE
GREENHOUSE



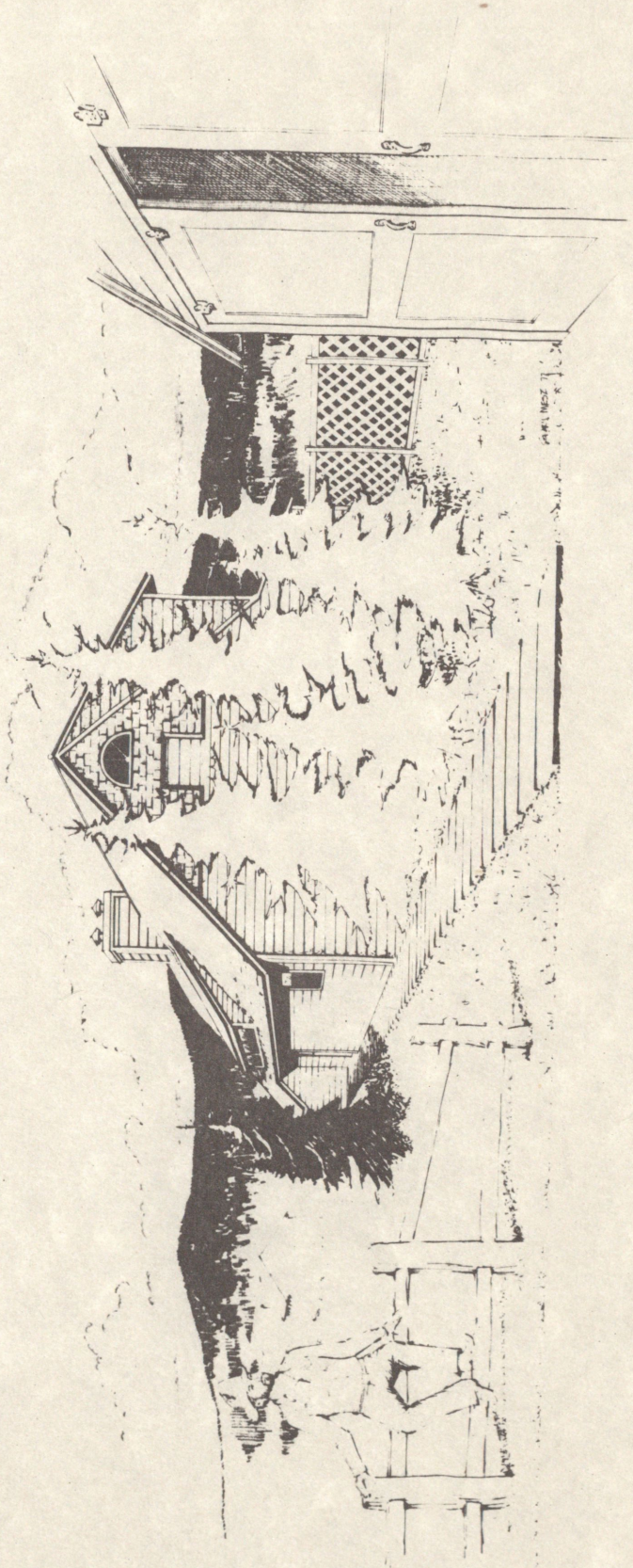
EXHAUST FAN IN GREENHOUSE

THE EXHAUST FAN MOVES THE WARM AIR PAST THE HEAT-PUMP COLLECTION COILS. THE COMPRESSOR & REVERSING VALVE ARE LOCATED ON THE GREENHOUSE FLOOR UNDER THE FAN.

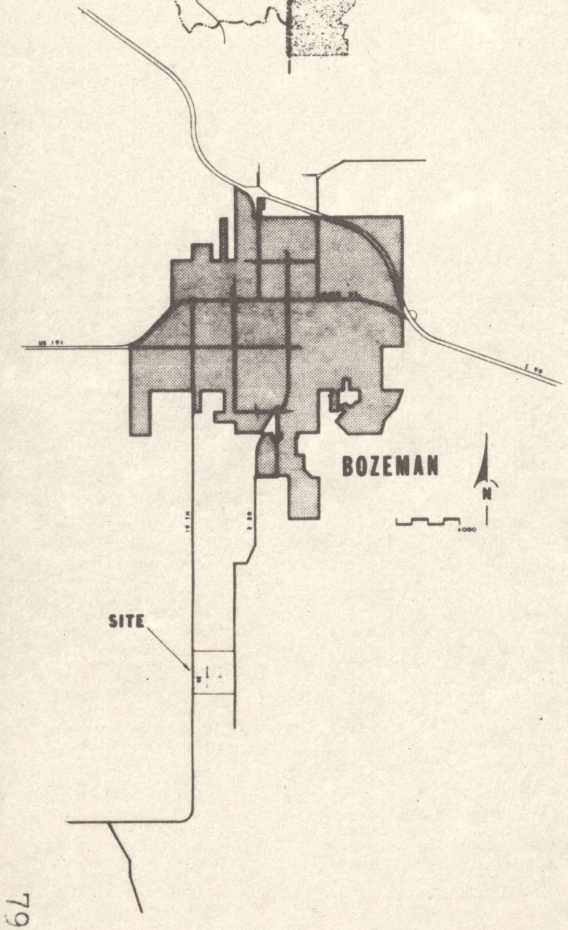
HEAT PUMP COLLECTION COILS IN TOP CORNER OF GREEN-HOUSE.

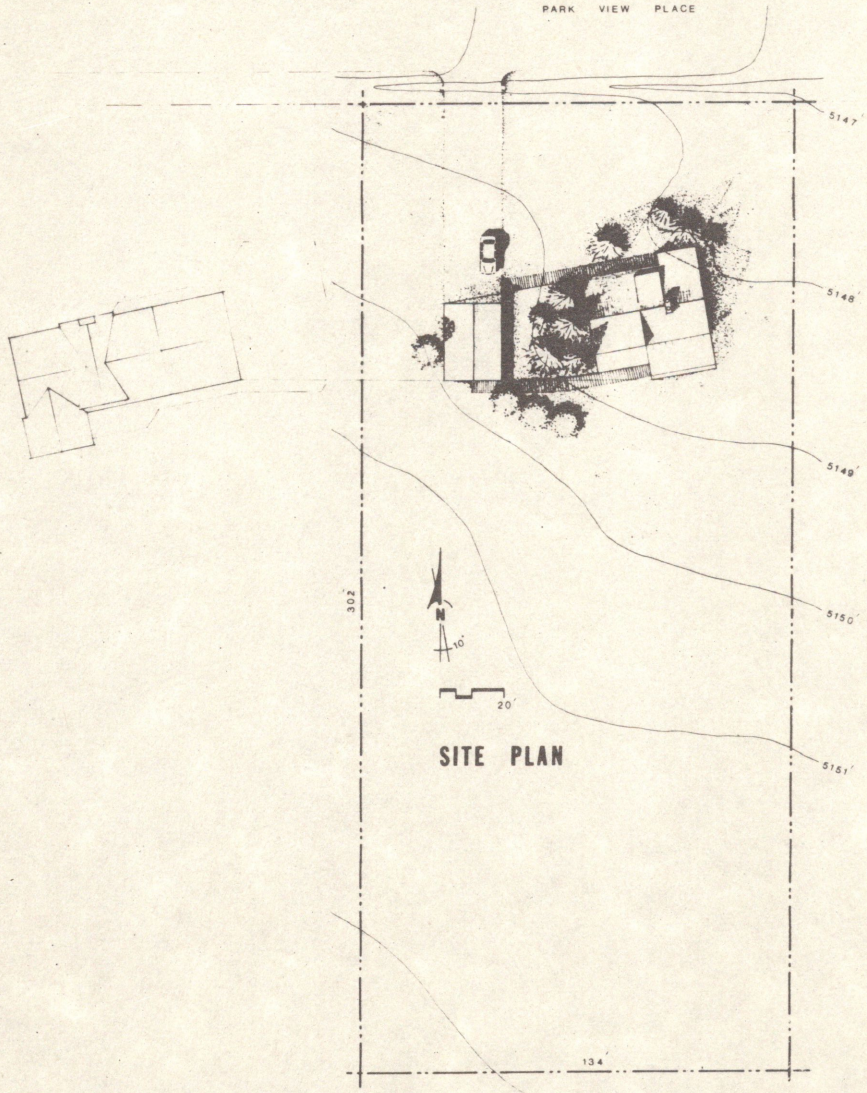


AS WAS STATED EARLIER A HEAT PUMP SYSTEM WOULD BE ADDED LATER TO BE USED AS A BACK-UP OR PRIMARY SYSTEM, IF DESIRED. THE ABSORBING COILS OF THE HEAT PUMP ARE LOCATED IN THE GREEN-HOUSE NEAR THE CEILING WHERE THEY WILL COLLECT THE MOST HEAT. THE HEAT IS THEN PUMPED TO THE CHAMBER UNDER THE STOVE WHERE IT IS RELEASED UPWARD AND THE HEAT CIRCULATES THE SAME WAY THAT THE HEAT FROM THE STOVE DID.

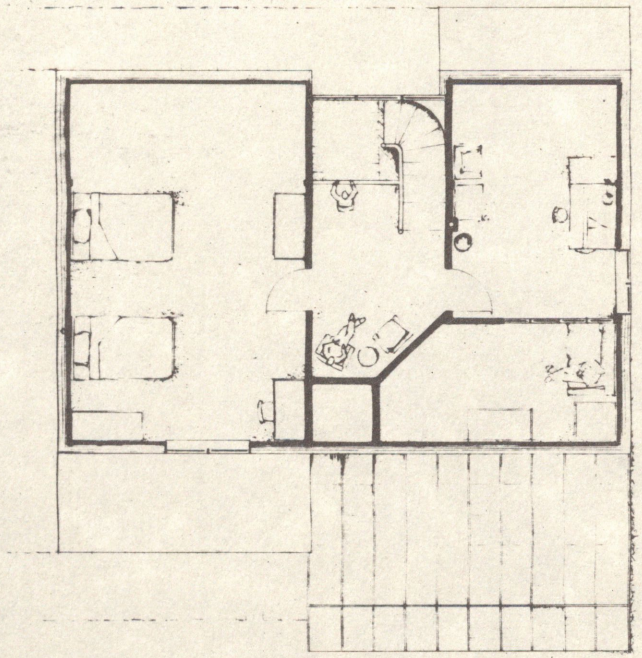



GREAT FALLS
MISSOULA
MONTANA
HELENA
BUTTE
BOZEMAN
BILLINGS

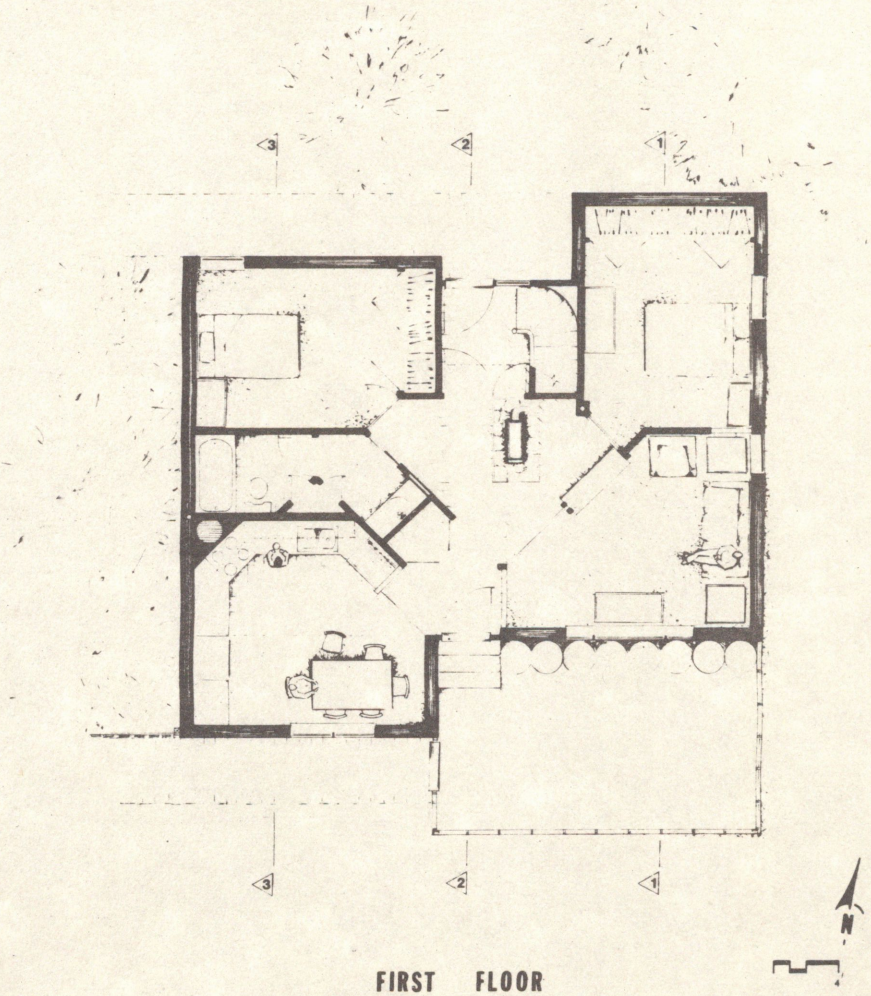

BOZEMAN
N
SITE


PARK VIEW PLACE
5147'
5148'
5149'
5150'
5151'
302'
N
10'
20'
134'

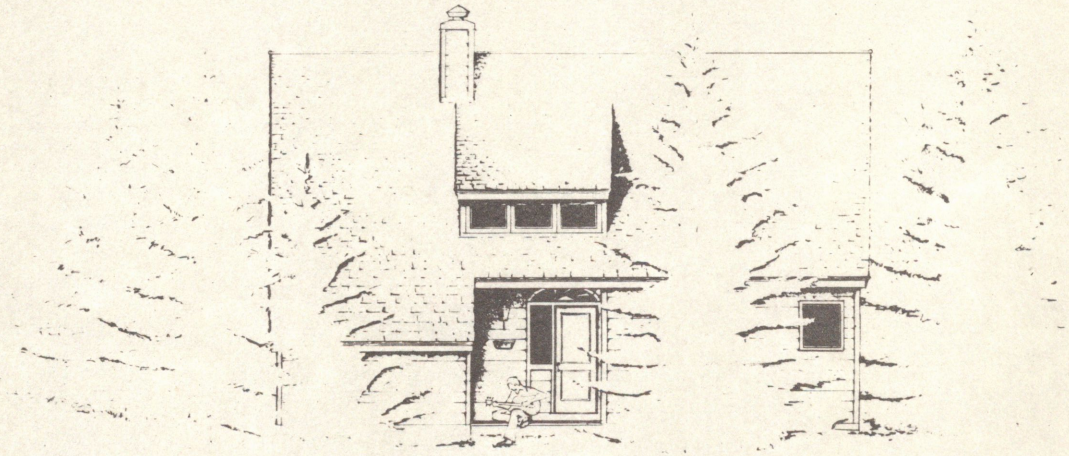
SITE PLAN



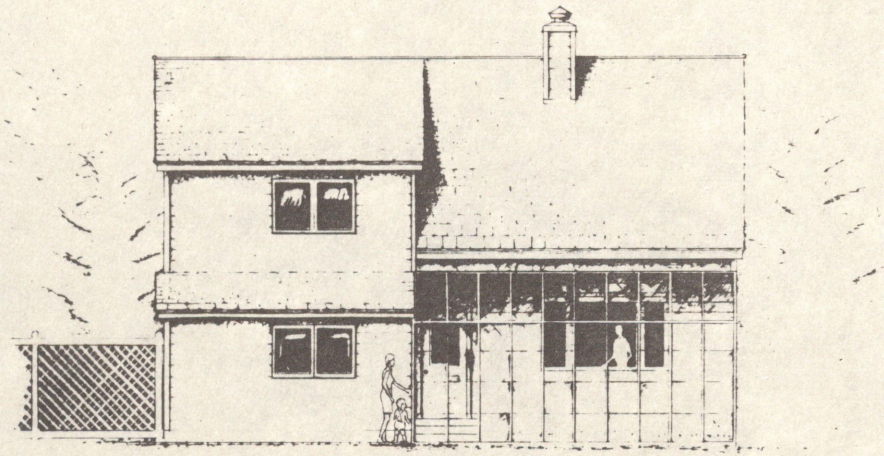
SECOND FLOOR



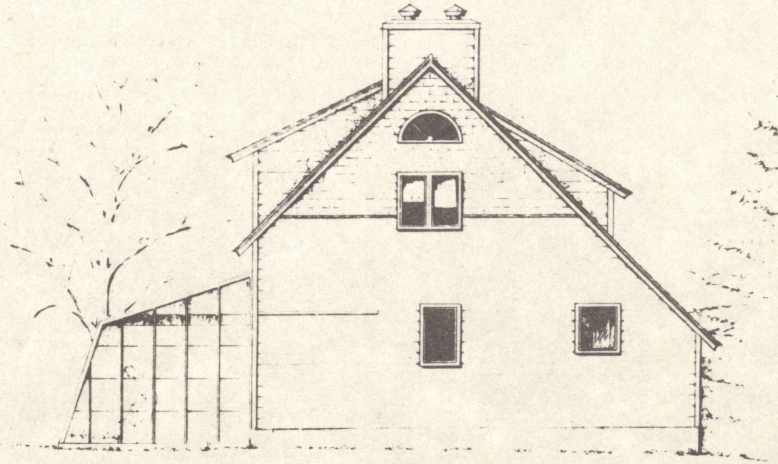
FIRST FLOOR



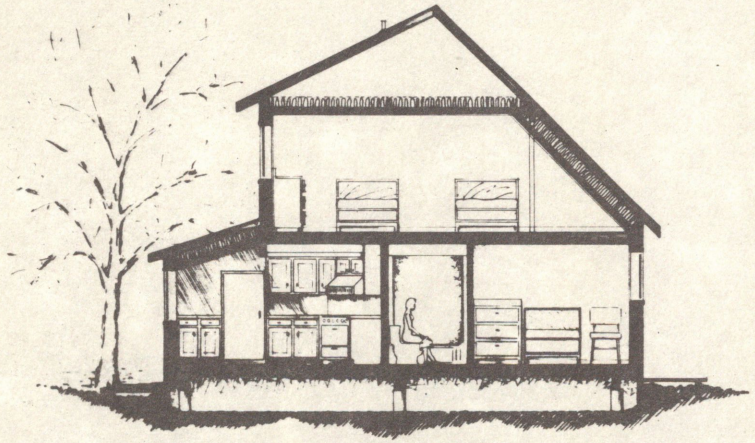
NORTH



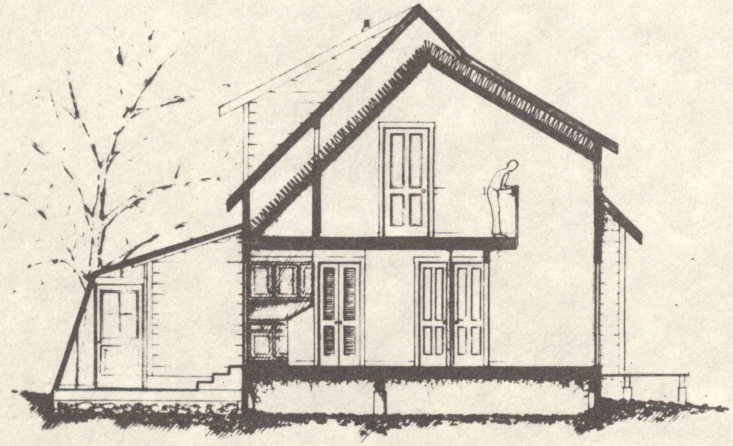
SOUTH



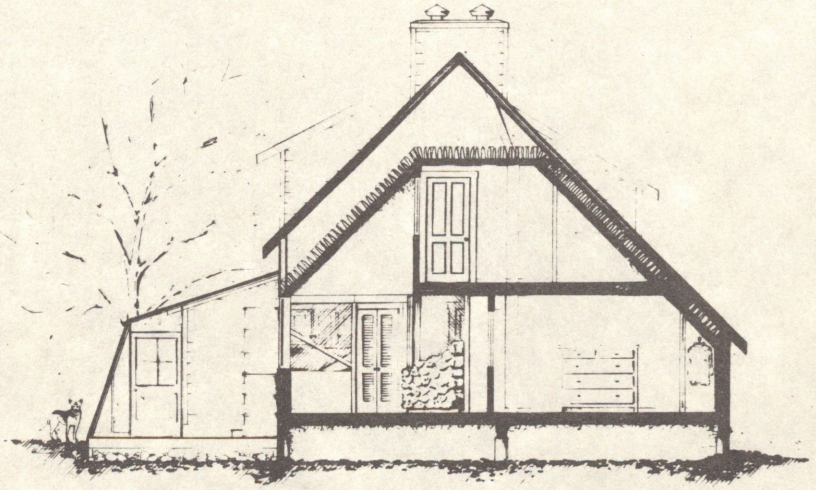
EAST



SECTION 3



SECTION 2



SECTION 1

MY DESIGNS ARE PRODUCTS OF EARLY IMAGES AND IDEAS THAT ARE RESPONDANT TO MY OWN BACKGROUND REFERENCES. INCLUDED IN THOSE BACKGROUND REFERENCES FOR THIS PROJECT WAS THE KNOWLEDGE THAT THIS HOUSE WAS TO BE DESIGNED WITH A WOOD BURNING HEATING SYSTEM. ALSO, THE DESIGN WOULD REFLECT MY CAPABILITIES AND LIMITATIONS AS A BUILDER AT THIS TIME. THE EXTERIOR CHARACTER ACHIEVED SHOWS A MIXTURE OF MY NEW ENGLAND INFLUENCES AND MY INTERPRETATION OF SOME BOZEMAN HOUSES, I.E., ROOFS, SHAPES, DETAILS.

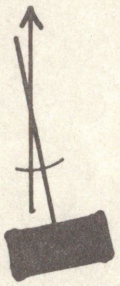
THE THEME OF THIS HOUSE IS BURNING WOOD, AND THE WHOLE IDEA AROUND THAT TYPE OF LIFESTYLE. IT IS A STEP BACKWARD, IN A SENSE, WHICH THE CHARACTER OF MY BUILDING EXPRESSES.

REFLECTING BACK TO MY THESIS STATEMENT "EXPLORING RELATIONSHIPS..." I FEEL I HAVE LEARNED A GREAT DEAL. I HAVE A MUCH MORE ACCURATE PICTURE OF WHAT RESULTS FROM THE DECISIONS I MAKE IN MY DESIGNS, BUT PERHAPS THE MOST IMPORTANT LESSON I HAVE RELEARNED IS THAT I, AS A DESIGNER, MUST START WITH CREATIVITY, NOT FUNCTION, TO BE SATISFIED WITH MY ARCHITECTURAL DESIGN SOLUTIONS---- FOR I AM A PRACTICAL FUNCTIONING PERSON.

THE PAGES THAT FOLLOW ARE MEANT TO BE A HELPFUL GUIDE THAT COULD BE APPLIED TO DIFFERENT DESIGN PROGRAMS. IT HAS TAKEN ME MUCH TIME TO COME TO THESE UNDERSTANDINGS.

ORIENTATION

VICTOR OLGYAY



12° E. OF SOUTH
OPTIMUM

GRAPHIC STANDARDS



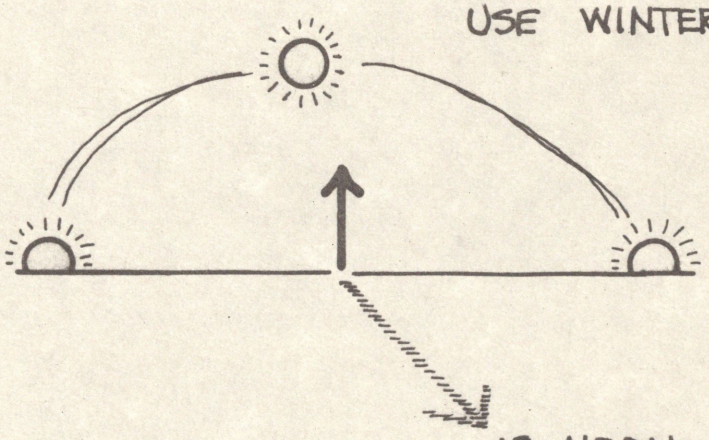
MAGNETIC NORTH

18° E. OF SOUTH
FOR BOZEMAN

TRUE SOUTH

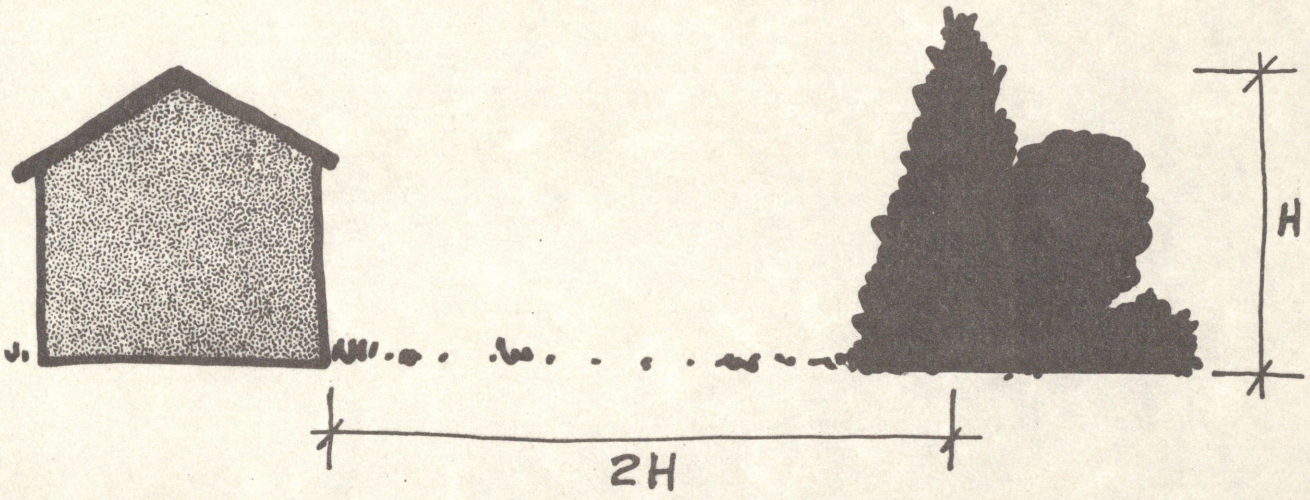
TRUE NORTH - SOUTH

USE WINTER SUN



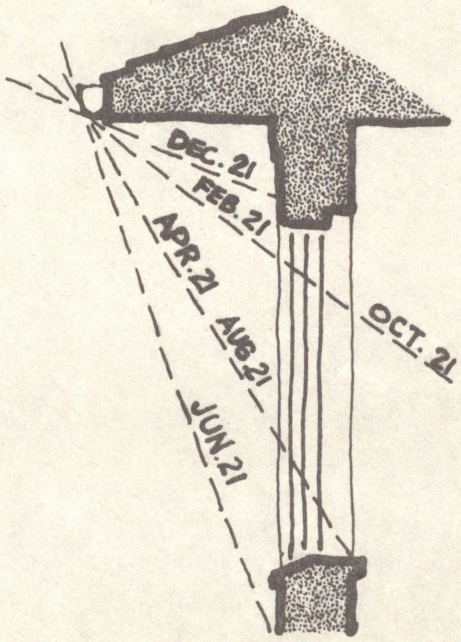
12 NOON

WIND



PLACE BARRIER ⊥ TO COLD WINDS
BARRIER DENSITY VERY IMPORTANT
ALSO CONSIDER SOLID BARRIERS IE:
FENCES, WALLS, & BUILDINGS

SOLAR CONTROL



CALCULATE SUN ANGLES AND USE PROPER OVERHANGS

ALLOWS FOR LESS HEAT IN SUMMER AND MORE HEAT IN WINTER

WINDOWS

RADIATION CHART BTU/FT²/DAY

	WINTER	SUMMER
EAST	416	1314 ←
SOUTH →	1374	979
WEST	416	1314 ←
NORTH	83	432
ROOF	654	2536 ←

PLACE WINDOWS :

MAINLY ON SOUTH SIDE LIVING SPACES
USE 15% OF FLOOR AREA

SOME ON EAST SIDE LIVING SPACES

FEW TON EAST SIDE INACTIVE SPACES

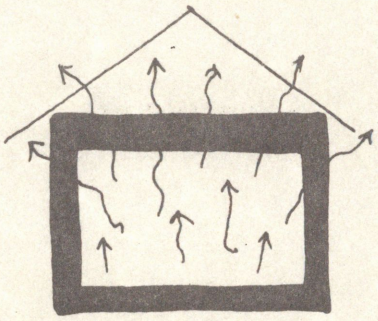
FEW TO NONE ON NORTH SIDE INACTIVE SPACES USE 8% OF FLOOR AREA FOR IN ACTIVE SPACES IE. BEDROOMS

NONE ON WEST SIDE IF POSSIBLE

REMEMBER DURING CLEAR WINTER DAYS 4 TIMES MORE HEAT IS RECEIVED THAN IS LOST THRU WINDOWS

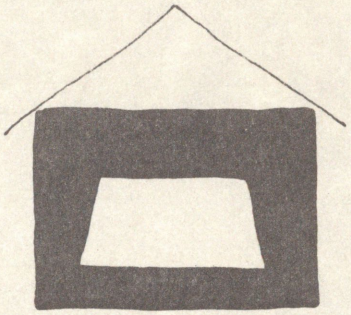
BUT ON CLOUDY DAYS THE PROPORTION IS 1 TO 1

INSULATION



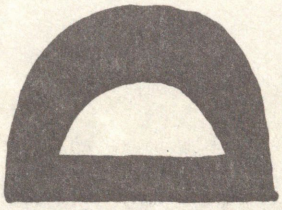
HEAT MOVEMENT

MOVEMENT IS UPWARD BARRIERS WILL FORCE THE HEAT TO MOVE OUTWARD ALSO.



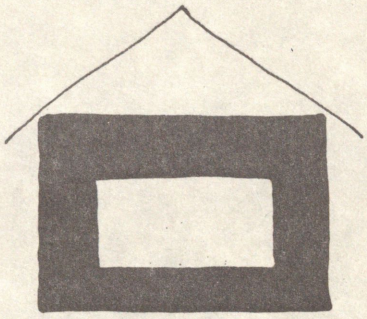
GOOD CONDITION

THIS IS HOW INSULATION SHOULD BE PLACED FOR A BALANCED CONDITION. (MY OPINION)



IDEAL

THIS IS PROBABLY AN IDEAL CONDITION BUT MAY NOT BE A DESIRABLE SHAPE.

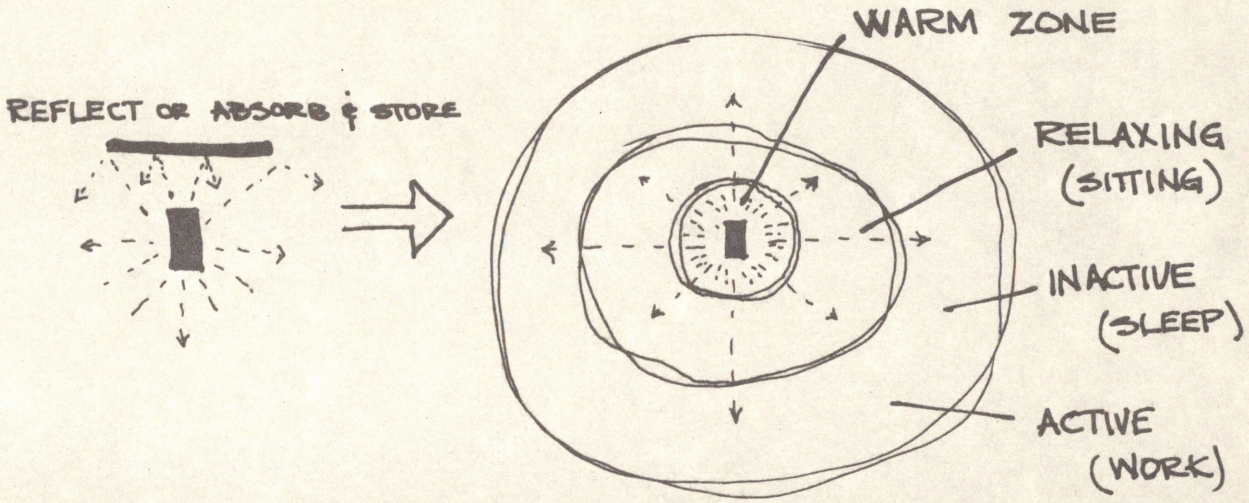


MY DESIGN

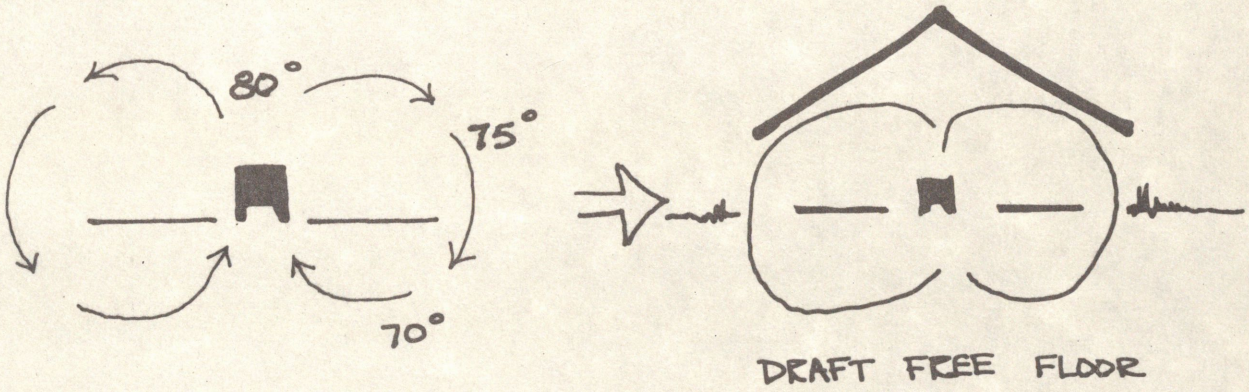
THIS IS WHAT I HAVE DONE.

WOOD STOVE HEAT

RADIANT



CONVECTION



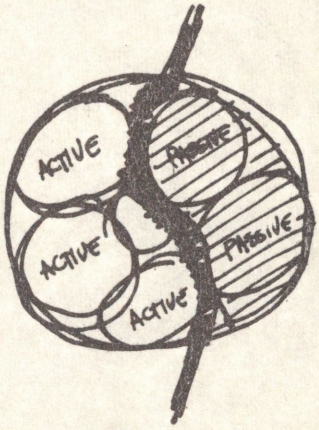
ZONING

DESIGN WITH ZONING IN MIND
IN ORDER TO CLOSE OFF
AREAS WHEN NOT NEEDED
SIMILAR TO ELECT.



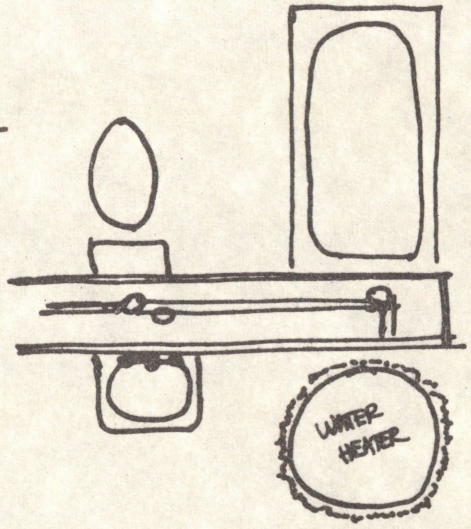


TURN OFF
WHEN NOT USING



PLUMBING

USE COMMON WET WALLS
CENTRALIZE FIXTURES
SAVE MONEY & HOT WATER



SPRAY FOAM
HOT WATER PIPES



SPRAY FOAM WATER HEATER
WITH EXTRA INSULATION

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