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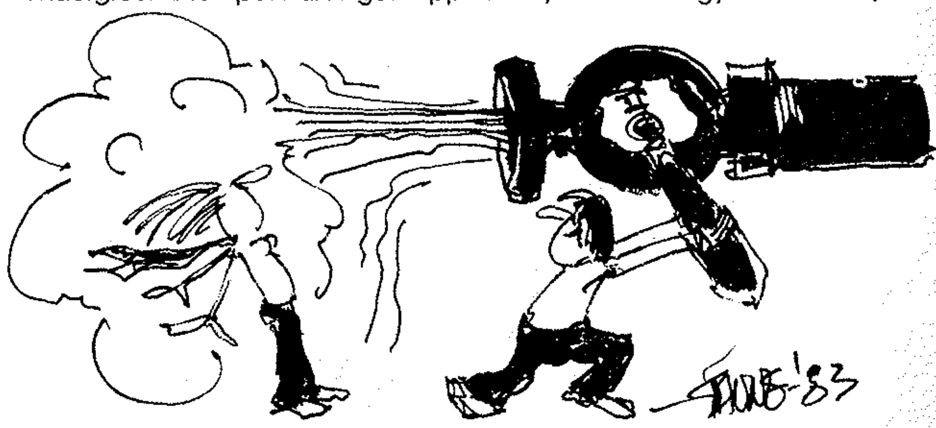
getting into it

earth pipes: preconditioning house air

Underground temperatures get tapped for passive energy use



Editor's Note: We have had many inquiries about the use of earth pipes to passively heat, cool, and ventilate earth shelters. Research information is now available, and it will be presented in the next two issues.

by C. Dale Elifrits and A.D.S. Gillies

One of the principal advantages claimed for living in or using earth sheltered buildings is that the environment is insulated from the temperature extremes. Advantage of tempered conditions of underground caves and tunnels have been used by animals and man through the ages.

Measurements taken at depths from the surface into soils or rock strata show that ground temperatures approach at shallow depth an annual average temperature for the geographic location. At a depth of only about 33 ft. a uniform temperature region will be reached.

Even at a shallow depth of only 6.5 ft. temperatures will only vary one or two degrees throughout the year. For instance, Rolla, Missouri, has a subsurface temperature of approximately 54-58 degrees F at 6 ft. based on research in the area of heat flow below grade undertaken by Boileau and Latta (1978), Lorentzen (1978), and Stauffer (1978).

People cannot live in the "natural" underground environment without movement of air occurring within the space and some exchange of fresh air occuring from outside. In winter, outside air is needed for respiration purposes, to remove odors and other contaminants and to keep interior humidity levels down, particularly in rooms where washing machines are in use, or in kitchens and bathrooms.

In summer, the situation can be exaggerated. When warm, humid outside air is passed quickly into a cooler underground interior, the relative humidity will rise to the point of saturation.

The sensible dry bulb (that is, the air temperature as you feel it) temperature of the air drops considerably. But with no change in the air moisture content, the humid conditions will be depressing and uncomfortable. Interior wet bulb temperatures (that is, what is read with a wet wick) above 72-76 degrees will be depressing unless positive airflow currents are generated in all parts of the house.

Airflow velocities of 1-1.5 ft. per second will be needed if a person plans to do hard work inside the house without feeling uncomfortable. Even with adequate airflow at high relative humidity levels, a person's ability to undertake sustained hard work decreases rapidly.

Conditions

Under difficult summer conditions, moisture in saturated air will condense on available surfaces and particularly, on cold surfaces. Problems with growth of mold and fungus in areas of low air movement will be experienced.

Exterior concrete walls, which are in contact with outside earth or rock materials and are good heat conductors, will be at a temperature approaching the outside substrata condition. They form an ideal condensing surface, because their temperature is below the dew point (condensation temperature) on the moist air.

In summary, the problems of harnessing the tempered underground environment to domestic living in hot summer conditions have often been over simplified. Positive ventilating currents, including some outside air, need to be passed through or ducted into every room.

Stagnant zones and corners should be avoided and cupboards should be "open" (louvre doors can be used) to encourage air flow. Exterior concrete walls should be insulated on the outside, so that the problem of interior "cold" condensing surfaces is not allowed to develop.

It may be impossible to overcome the problem of humidity completely without:

—Opening many outside windows or skylights, which negates much of the advantage of the tempered environment,

—Cooling outside air with a reduction of both temperature and humidity before air enters the underground space,

—Use of mechanical air conditioners or dehumidifiers to control interior conditions.

The use, installation costs, and operating costs of air conditioning plants are well known. Mechanical dehumidifiers also all expense using the vapor-compression refrigeration cycle with an arrray of cooled condensing cools to maximize moisture removal.

Alternative, passive methods which can precondition air at lower, long-term costs are available, although research into the system design and use are at an early stage.

Passive

One passive system for tempering air flow involves passing intake air through tunnels or buried pipes before it enters either the subsurface or conventional dwelling. Contact with rock or earth-pipe surfaces transfers heat and moisture to or from the surrounding rock mass and adjusts the air temperature to subsurface conditions.

In discussing passive ventilation, Wells (1977) states:

"... we think about earth pipes, about drawing fresh air into buildings through long, buried pipes that would warm the icy winds of winter and cool the hot air of summer, making air conditioning and heating far less expensive. . .we know that a straight buried pipe, even a 100-ft. long pipe, will not do the job very well. . .but if a whole maze of such pipes was laid in a buried bed of stones?"

In previous tests, Gillies and Aughenbaugh (1981) have experimentally measured the rate of tempering of an air flow which occurs along a rock-lined tunnel in Missouri. Tests were undertaken during three seasons. From these, it was observed that the dry bulb temperature of the air flowing through the passage changes sharply, initially, but decreases its rate of change in later sections when flowing air is at or close to the moisture saturation level.

In a later 10-day test in the same Missouri tunnel, it has been shown that the rate of wet bulb temperature change is constant along the airway.

Therefore, it is shown that as air moves through a subsurface opening, temperature changes take place as heat energy transfer occurs within the soil or rock adjacent to the airway and within air moving through the airway.

Figure 1 demonstrates results from these tests which are to be published by Gillies, Elifrits, Erten, and Aughenbaugh in the book of proceedings for the Sidney, Austrailia, conference, "Energy Efficient Building with Earth Sheltered Protection," August 1983.

The real problem is to establish the size airway required to provide an amount of energy necessary to heat or cool a structure.

Next: Sizing the Airway

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Figure 1. Graph of mean airway wet-bulb temperature at various distances along airway. Temperatures are averaged for the fourth day of study.