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The Owner-Built Homestead

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THE OWNER-BUILT HOMESTEAD

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Introduction

It has been ten years since I first started writing *THE OWNER-BUILT HOME.* At the outset of writing this first book there was some suggestion to expand it to include home *food* production along with the central theme of home *shelter* production. At that time the "back to the land" sentiment was all but dead in this country. So I brushed off the suggestion and awaited with others an economic depression to revive the attitude of economic self-reliance. Theoretically, when great numbers of people lose their jobs and have only bread-lines and welfare handouts to look to for sustenance, they will then consider, perhaps, home food-production. So for all these years I've been waiting for the expected catastrophe: It would highlight a widespread social need and orient my research effort toward fulfilling this need.

The kind of economic depression we pictured never, as you know, came off. On the contrary, purchasing power and employment in this country reached an all time high. But something far more serious has occurred; the beginnings of a world revolution. The past ten years has witnessed a many-sided challenge to the whole military-financial-urban-real-estate complex. The student rebellion, the minority revolts, the break-down of urban America, and the mounting concern for the environment have led to an increasing exodus to the country-side.

More and more, retired and semi-retired people are looking to the small acreage. They are literally driven there by urban sprawl, noise, smog, high taxes, and inflation. The chaotic political state of the world stimulates many people to search for a more meaningful and natural value system.

There is another and more significant group of fresh recruits for rural living: The countless college students who have become disillusioned with their professional college training, shocked by our murderous war machine and alerted to the money-grabbing, life-negative forces within the establishment. I speak of the intelligent and able drop-outs, the turned-on, do-your-own-thing generation. It is chiefly for this dynamic and thoughtful generation, as well as for the mere refugees from the city, that I write this book on productive homesteading; an integral arrangement of earth, plants, animals, buildings and utilities.

In basic terms, I'm setting out here to promote the *post modern way of country living.* It is a life of self-reliance and at least partial economic self-sufficiency, but *in a social and ecological context.* Naturally, I'm attempting to sell these ideas to any and all. But the prospective buyer must have minimal emotional and technical potential and be in good position to leave the city. He must be fairly intelligent and have strong motivation and drive as well as ability to do manual work.

These requirements—especially being up to manual work—are, of course, seldom met by current youth. Their reaction against intellectualism is strong enough; but they just lack the manual skill and discipline-training necessary to satisfy their most basic needs. It is really tragic to observe so many mentally qualified young couples failing in their attempts to live on the land. In starting out they have no concept of step one—actual work—much less the whole complex of plant-animal-soil relationships, plus production-storage-processing, which takes the most knowledgeable and experienced farmer. Their failure disillusions them with the homestead scene, and they may react this time *against* the materials and tools and skills associated with living on the land. Thus the escapist talk nowadays about segregated tribal communes, primitive living, etc. They hate the computerized urban existence, and can't make it in the all-round homestead life; so the next step is to live isolated with fellow-failures.

This book, then, is an attempt to bridge the gap between primitive inability and a *wholesome* use of science, technique, and civilization. After answering the why and the where of homesteading, I intend to analyze into its components *a balanced homestead environment*—from human and animal shelter forms to crop production and utility functions.

I propose, next, a descriptive evaluation of sensible techniques and routines of productive homesteading.

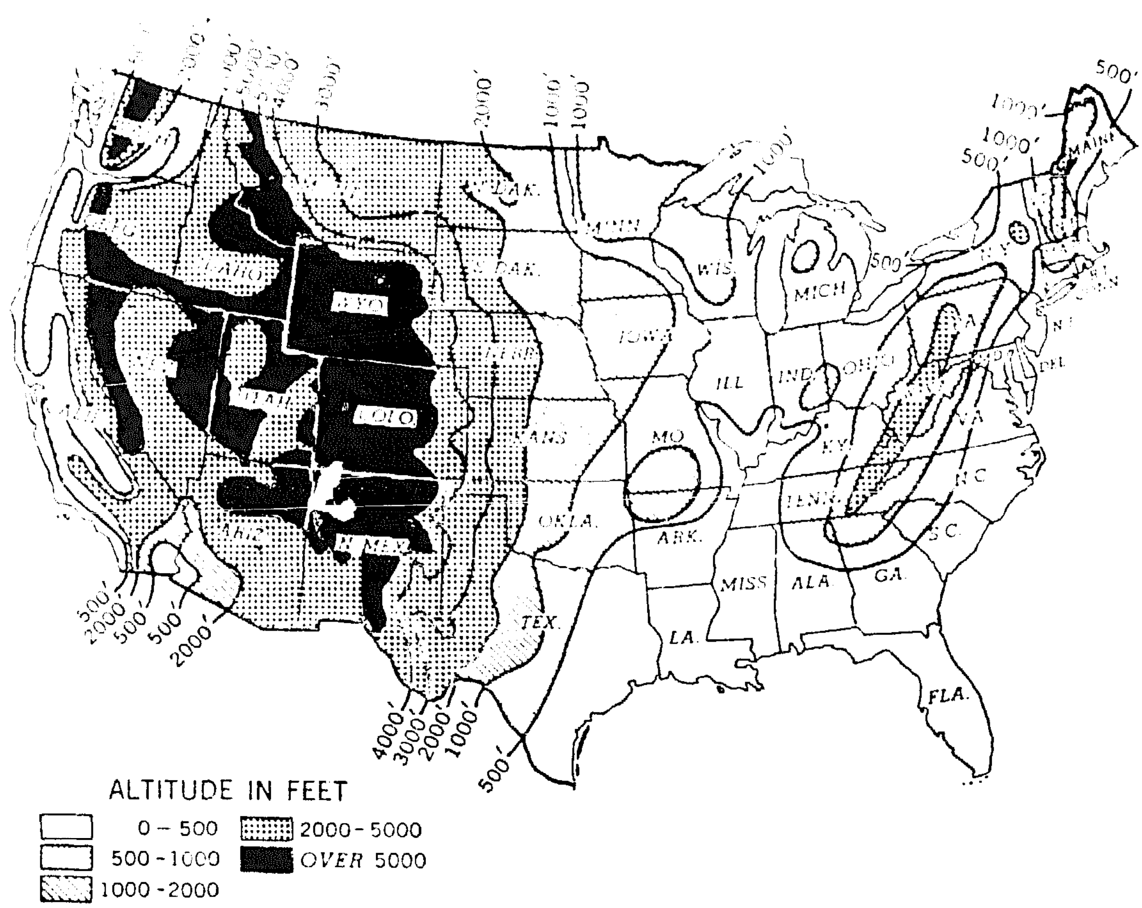
The tragedy of the homestead movement is having enthusiastic but ill-prepared people attempt a life on the land. To start with, the land they choose may not be adapted to the type of gardening or animal production they have in mind: They may innocently choose wrong soil and fertilizer types, insufficient or inefficient irrigation systems, inappropriate shelter forms, wrong tools and equipment. Efficient home production requires a concise what-to-do and how-to-do-it program.

At least in one small way a homesteader competes with his commercial farm neighbor, and yet how can a homesteader-come-lately ever expect to be as knowledgeable and efficient in his production as a full-time life-long experienced farmer? It is possible. He may be even more effective and advanced. Through proper design and planning practices, and through work simplification, an inexperienced homesteader can *become* more efficient in *living and livelihood* than a commercial farmer.

For one thing, today's ordinary farming practices are miserably *inefficient and wasteful.* The most famous study on this subject was made by Dr. Carter at the Vermont Experiment Station in 1943. For 4 months he studied the work practices of a 22-herd dairy farmer. Then with an investment of $50—which went mostly for a rearrangement of stables, tools and supplies—Carter reduced chore-time from 5 hours to 3 hours a day. Daily walking distance was reduced from 3 miles to 1 mile. In total, 760 man-hours and 730 miles of walking were saved in one year. This

Vermont study should encourage the prospective homesteader with an awareness of how his own food production program can be arranged with minimal chore labor and maximal personal satisfaction.

Yet I would not wish to close this Introduction by giving the impression that one develops a homestead merely through knowledge and efficient effort. In reality, the design-development concept must be *regained* rather than *acquired.* A first lesson of Zen tells us more: The concept can be regained only by *allowing things to happen.* In a very real sense the homestead that I intend to present is an ecological *happening.* Your brainy body is only one little organism in the big natural and social world. It cannot *command,* but it can, indeed, promote harmonious and creative adjustment.



—Approximate general altitudes in the United States.

STATE AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS

Alabama Polytechnic Institute, Auburn
University of Arizona, Tucson
University of Arkansas, Fayetteville
University of California, Berkeley
Colorado A & M College, Ft. Collins
University of Connecticut, Storrs
University of Delaware, Newark
University of Florida, Gainesville
University of Georgia, Athens
University of Idaho, Moscow
University of Illinois, Urbana
Purdue University, La Fayette Indiana
Iowa State College of Agriculture, Ames
Kansas State College of Agriculture Manhattan
University of Kentucky, Lexington
Louisiana State University, Baton Rouge
University of Maine, Orono
University of Maryland, College Park
University of Massachusetts, Amherst
Michigan State College of Agriculture East Lansing
University of Minnesota, University Farm, St. Paul
Mississippi State College, State College
University of Missouri, Columbia
Montana State College, Bozeman
University of Nebraska, Lincoln
University of Nevada, Reno
University of New Hampshire, Durham
Rutgers University, New Brunswick New Jersey
New Mexico College of Agriculture State College
Cornell University, Ithaca New York
North Carolina State College of Agriculture Raleigh
North Dakota Agricultural College, Fargo
Ohio State University, Columbus
Oklahoma A & M College, Stillwater
Oregon State College, Corvallis
Pennsylvania State College, State College
University of Rhode Island, Kingston
Clemson Agricultural College, Clemson South Ca
South Dakota State College of Agricul State College
University of Tennessee, Knoxville
Texas A & M College, College Station
Utah State Agricultural College, Logan
University of Vermont, Burlington
Virginia Polytechnic Institute, Blacksburg
State College of Washington, Pullman
West Virginia University, Morgantown
University of Wisconsin, Madison
University of Wyoming, Laramie

Selecting The Site

Will Rogers gave the advice: "Buy land . . . they ain't making any more of that stuff." And modern day population alarmists predict standing room only for the future. All the land will be occupied, they say, to feed and house and transport people. The population of the U.S. is estimated to be 700 million in one hundred years. Of the 2 billion acres of land in the U. S. only one-third is considered favorable to crop production. Alternative solutions appear to be (1) State socialism with overhead control of births, and (2) a strict limitation on population growth, keeping business (and private ownership and land speculation) as usual.

But there is now a Third World Front that is viewing the land and population issue in the new light of the *primacy of the home.* First of all, if we used only our prime cropland and cultivated it as intensively as the Japanese, and reduced bureaucratic wastage, and consumed more first-hand foodstuffs rather than processed trash and animal products, then we Americans could feed a tremendous population. (2 billion people, according to U. S. Department of Agriculture, 1958 Yearbook). The population explosion scare is overdrawn: It diverts concern from the *real* issue which is *the comfort and beauty of people,* versus (1) making money (capitalism) and (2) worship of the state (communism).

We must come to terms with this so-called land question before selecting or acquiring our homestead site. Understanding the issues will most definitely influence our choice of location. For one thing, anyone who has done any land shopping realizes that there is currently a strong demand for land. The same demand in the 1930's had its origins in unemployment and insecurity. Today's influence is more sophisticated: Industry is dispersing to the countryside . . . as is the suburban growth of population. An estimated million acres is taken up yearly by residential, industrial, highways and other nonfarm use. Farms are enlarging to make labor and machinery investments more efficient.

The amount of land now being withdrawn from the market for speculation is frightening. Traditionally, the investment in land is especially high during and immediately after a war. Land is considered a safe hedge against inflation. Speculative land is just not available . . . certainly not to the prospective one-horsepower homesteader. We must therefore outwit the carpetbagging speculators by finding attractive homesites that are not attractive to their investment dollars.

A brief study into rural appraisals indicates clearly the speculative value of various property features. Closeness to rail transport or a main road may be important to a commercial farmer but it is probably not worth the additional land cost to a small acreage homesteader.

Level ground is far more valuable to a land speculator than sloping ground. The speculator knows that level ground farming permits a more uniform type of vegetation. He knows that power equipment can be used to more advantage. But a small homesteader may find that drainage is poor on level ground, water accumulates and leaches nutrient materials down into deeper layers forming hardpan and poor aeration which becomes impervious to plant roots. A hilly site location may not be adapted to large scale farming operations but there are actually more advantages to the homesteader in choosing a hilly or mountainous location.

A level, protected valley receives much radiant energy from the surrounding slopes during the daytime, and is consequently warmer than the surrounding hillside. At the same time, wind movement in a hilly region provides better ventilation and therefore less heat build-up. At night, air drainage is accentuated in hilly regions and a process of temperature inversion takes place. Reservoirs of cold air drain from surrounding slopes to the low-lying basins.

The climatic comparisons of a valley and adjacent hilly regions was made in Ohio some years ago (Wolfe: Microclimate and Macroclimate of Neotome Valley: Ohio Biol. Survey; 1949). The hilly site consisted of a sort of grotto, weathered out of cliff-faces and located at the cove of a valley. The grotto had 276 frost-free days, while the valley frost pocket had only 124 frost-free days. Maximum-minimum temperatures for the grotto were 75 and 14; for the valley, 93 and 25.

A southern slope receives more insolation than a northern exposure. The degree of slope determines the amount of insolation received: According to the U. S Department of Agriculture Yearbook (1913) land in southern Idaho that slopes 5 degrees to the south is in the same solar climate as level land some 300 miles south in Utah. Also, ground sloping 1 degree to the north lies in the same solar climate as level land 70 miles further north. The warmest slope is the one most nearly perpendicular to the sun's rays during the growing season. Steepness should therefore increase with latitude.

The southwest slope is warmer than the southeast slope. Sunshine on the southeast slope occurs shortly after the prolonged cooling at night. Also, evaporation of the morning dew requires energy. The west slope of a hillside has the highest average air and soil temperature and the longest frost free season. Cold injury to plants is greatest on the east slope; heat injury greatest on the west slope. Slopes facing north tend to be more moist than slopes facing south.

Temperature considerations are different for the Eastern and Western regions of the U. S. A north-south distance is important for a frost-free difference in the Eastern half; elevation determines temperature differences in the Western half. Latitude and elevation are therefore essential considerations in determining the length of the growing season. Growing season is the main limiting factor in developing a homestead in Alaska. (It is the average period between the last killing frost in Spring and the first killing frost in Fall.) The duration of extreme temperatures . . . both heat and cold, the amount of sunlight, and the amount of rainfall, are further climatic considerations that should be considered when choosing a homestead site.

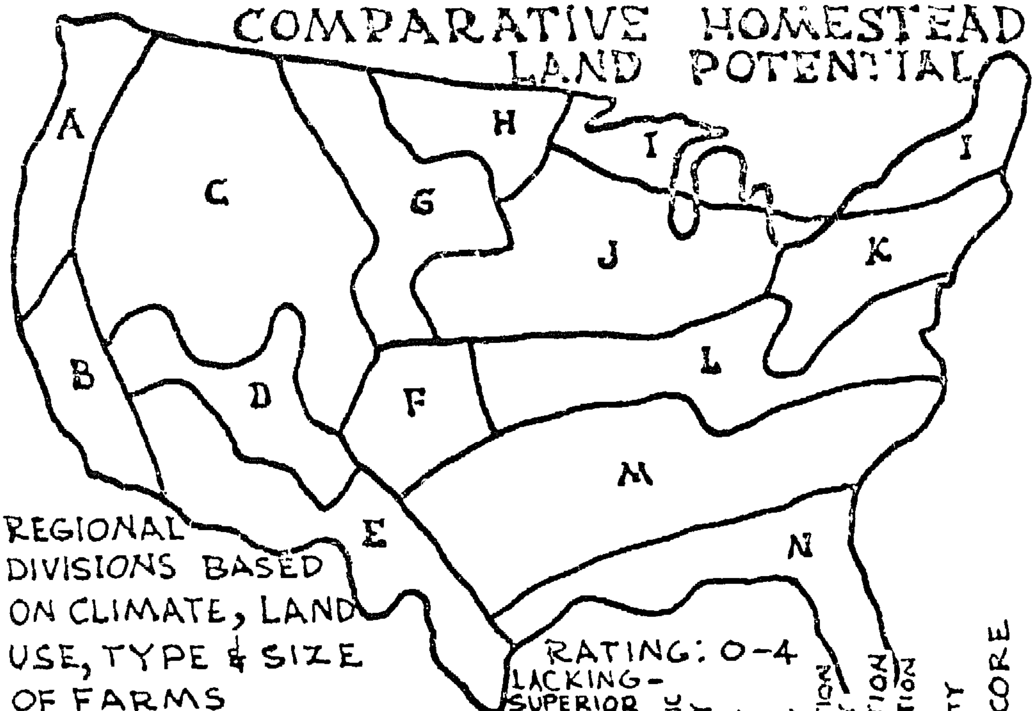
Next to climatic and topographic factors, soil type is of foremost importance. Soil classification is a very involved subject and will be dealt with later (there are 1000 types of soil in California, for instance). But a few general pointers about soil should assist one in land selection. A dark soil color usually indicates high fertility. Grey and yellow indicate poor drainage and light colored soil, low fertility. Look for medium-textured soils: Extremes of both sand and clay are usually low in productivity. Sandy soils thaw first and warm up faster in the spring than do clay soils. This is due to their lower heat capacity, lower thermal conductivity and reduced amount of evaporative chilling.

Soil fertility can also be determined by observing plant growth. Fast growing weeds like giant horseweed or cockleburr indicate good soil conditions; red sorrel grows in poor acid soil. If the plant has a deep color the soil in which it grows is probably fertile. Tree limbs that extend upward and do not droop also indicate fertile soil. Walnut, cypress, whiteoak and cottonwood trees are all good soil indicators; blackjack and pine grow in poor soil.

It may be profitable for evaluation purposes to list all the considerations–in order of importance–that go into choosing a homestead site. There are indeed many, and no one site could possibly be favorable in all respects. So we therefore learn how to adapt and how to compensate for shortcomings. If the latitude falls short of expectations, compensate by increasing elevation. Or one can pick a site that has a proper orientation and slope angle so that the angle of exposure to solar radiation compensates a high latitude that receives little radiation. A low annual rainfall can be supplemented by dew and fog, or by irrigation and water storage. Soil texture may be substituted for moisture: Asparagus thrives in sandy soils in areas where heavy soils would be much too wet for it.

When selecting a homestead site, start with a general evaluation of the region, state, county and community down to specific study of the actual site. The most important tool for this research is maps. They tell all. Start with a set of U. S. Geological Survey maps. They are accurate, show topographic features and cover about one-half of the U. S. The Soil Conservation Service can supply you with aerial photographs for most regions of the U. S. Soil maps are also available from this agency. The U. S. Bureau

COMPARATIVE HOMESTEAD LAND POTENTIAL



REGIONAL DIVISIONS BASED ON CLIMATE, LAND USE, TYPE & SIZE OF FARMS

RATING: 0-4
LACKING - SUPERIOR

REGION	CLIMATE C=COLD SEASON W=WARM SEASON	LAND USE	TOPOGRAPHIC SUITABILITY	SOIL ADEQUACY	WARMTH ADEQUACY	PRECIPITATION ADEQUACY	PRECIPITATION DISTRIBUTION	WEATHER RELIABILITY	TOTAL SCORE
A. N. PACIFIC	C-MUCH RAIN. COOL W. SHORT HEAT	FOREST. PASTURE FRUIT- ROOT	2	2	3	2	2	3	14
B. PACIFIC SUBTROPIC	C-MILD. SUN W-LONG HEAT	RANGE. FRUIT IRRIGATED	2	3	4	2	2	2	15
C. N. GRAZING	C-COLD- CLOUDY W- LITTLE RAIN	PASTURE. FRUIT	2	2	2	2	2	2	12
D. HIGH PLATEAU	C- COLD. SUN W. LONG HEAT	PASTURE. RANGE	2	2	3	1	2	1	11
E. ARID S.W S. VALLEYS	C-MILD. SUN W-LONG HEAT	RANGE. FRUIT SMALL GRAIN	3	2	3	2	2	2	14
F. S. GR. PLAINS	C-MILD. WIND. SUN W-LONG HEAT. SUN	RANGE - GRAIN	4	4	2	2	4	2	18
G. N. GR. PLAINS	C-COLD. LITTLE RAIN W. WIND	RANGE - CORN WHEAT	3	3	2	2	3	2	15
H. SPRING WHEAT BELT	C-COLD. WIND W- MILD. RAIN	PASTURE - GRAIN	3	3	2	2	3	2	15
I. N. DAIRY	C-COLD. SNOW W- RAIN.	PASTURE. FRUIT ROOT CROPS	2	2	3	3	3	4	17
J. N. CORN BELT S. DAIRY	C-COLD. SNOW W-LONG HEAT	CORN. TRUCK FRUIT - HAY	4	4	3	3	3	3	20
K. MID ATLANTIC E. DAIRY	C. MILD. CLOUDY W. WARM. RAIN	PASTURE. FRUIT TRUCK	2	2	3	3	3	3	16
L. MIDWEST S. CORN BELT	C. MILD. RAIN W. LONG HEAT	PASTURE. FRUIT TRUCK	3	3	3	3	3	3	18
M. UPPER SOUTH COTTON BELT	C - MILD. RAIN W - LONG HEAT	FRUIT. TRUCK ANNUAL LEGUME	2	2	3	2	3	3	15
N. GULF - FLORIDA	C - MILD. RAIN W. HUMID	GRAZING FRUIT TRUCK	3	2	4	2	2	2	16
W. CANADA MTS	C- COLD. RAIN W- MILD. SUN	PASTURE. FRUIT FOREST	1	2	2	2	2	2	11
ALASKA	C- COLD. SNOW W. CLOUDY	FOREST. PASTURE	1	1	1	1	1	1	6
HAWAII	C. MILD. RAIN W. MILD RAIN	FRUIT. TRUCK	2	3	4	2	3	3	17

of Public Roads and the U. S. Post Office Department have informative county highway maps and maps showing rural mail routes.

More specific site information is available on County record. The local Title Company oftentimes has more up-to-date land title information than County offices. But from County Plat Books record information can be found regarding assessed valuation, amount of taxes paid, special assessments for drainage etc., and dates and prices on sales of adjacent properties. Individual property owners names are indicated on County Plat Books; addresses can be found in the Assessor's Office.

On some remote properties it may be necessary to find site information from Government Township Plats. These are available from the U. S General Land Office or filed with the State Auditor. Individual counties may also have Government Township Plats on file—check with the County Surveyor.

Map study is one of the finer joys that go with locating a homestead site. Maps have a continual fascination: Nothing short of earth-contact can give one as much understanding and appreciation of the land. A roll of maps (folding maps is like cutting bread: Maps should be rolled and bread, broken) is the one best tool for site exploration.

Once a person narrows his land search to a specific county or community, he should move there and begin his quest for the actual site. For starters, inspect the tax rolls in the County Treasurer's office for properties on which taxes have remained unpaid for a number of years. Distressed or unwanted property can often be bought for unpaid taxes. Banks and trust companies are also engaged in liquidating property at bargain prices. Auctions are another good source, or one can advertise for property in the local newspaper. It is a good practice to get acquainted in the community: Ask around for available land and let it be known you are in the market. As a final, rather desperate resort, roll up your map and visit the friendly Real Estate Broker.

Something should be added to this subject of unwanted or distressed property. People—even professional land speculators—are unimaginative when it comes to developing "problem" sites. Their heads are too much into the money earning or commercial aspects and not into terracing, planting, excavating, filling, or the thousand other possibilities for adapting the land to fit one's needs. Also, homestead site requirements are flexible and adaptable—not specific as is the case with a housing development or a commercial farming enterprise. So it is good advice to capitalize on the fact that one can profitably utilize a piece of land that nobody else wants.

After the homestead site is located, start the land transfer proceedings by first making an appraisal map. This map is drawn mostly from on-the-ground site inspection. It should show an outline of the property according to the complete legal description. Important topographic and natural physical features should be shown (such as streams, fields, wood lot, etc.) Any improvements such as buildings, fences or roads should also be indicated. A tentative homestead layout and land-use sketch can also be suggested on this map.

At this point it would be prudent to confer with any county officials who may be involved in passing approval on the land transfer transaction. First check with the Planning Office for possible zoning restrictions. Find out too about building restrictions. The County Health Department may have something to say about sanitation requirements. At the County Recorders office you can determine if the property can be legally transferred. Most states have land-division regulations and many counties require a legal land survey before property can be sold.

At this stage in the land transfer transaction you probably know your way around the county offices: County clerks likely know you by your first name. You, therefore, may as well do the title search on your prospective land. Title insurance companies customarily perform this service—for a generous fee. They issue a mortgage policy that protects only the value of the land. If you build a $20,000 homestead on an insured $1000 site, and a missing heir later arrives to claim the property and cloud the title, you recover only the $1000 from the title insurance.

The whole operation is costly and ridiculous because with very little effort you can determine yourself the legitimacy of your land title. Merely check the Tract Index in the Recorder's office. Some counties keep an Abstract of Title on record. This is a condensed history of all recorded transactions for the parcel of land that you are buying. By examining the abstract, drawing up a simple deed, and preparing a closing (payment) statement, you keep several hundred dollars from reaching the sweaty palms of Title Officer, Escrow Agent and Real Estate Lawyer.

The simplest method of land transfer is to have the seller supply credit to the buyer (if the transaction is not a clean, cash deal). Either a deed is given to the buyer with the seller taking back a mortgage, or the sale is made under an installment purchase contract. In this latter case the legal title remains with the seller until all or a specified portion of the purchase price has been paid. The Contract of Sale is preferred over the mortgage contract. In cases of default, the mortgage contract requires an expensive foreclosure sale; a contract of sale is merely terminated.

Most stationary stores carry Deed of Conveyance forms. After the deed is made out have it signed before a Notary Public and recorded in the County Recorder's office. Then when you move onto the land, file a Homestead Exemption. Most state legislatures have adopted this statute to protect the value of the family home from creditor claim.

At some point in the land transfer procedure you will want to check out or establish property corners. Again, with a little knowledge on the subject, you can dispense with the services of yet another greedy professional. Land surveying was my occupation for 5 years, so I'm especially aware of how expendable the operation actually is.

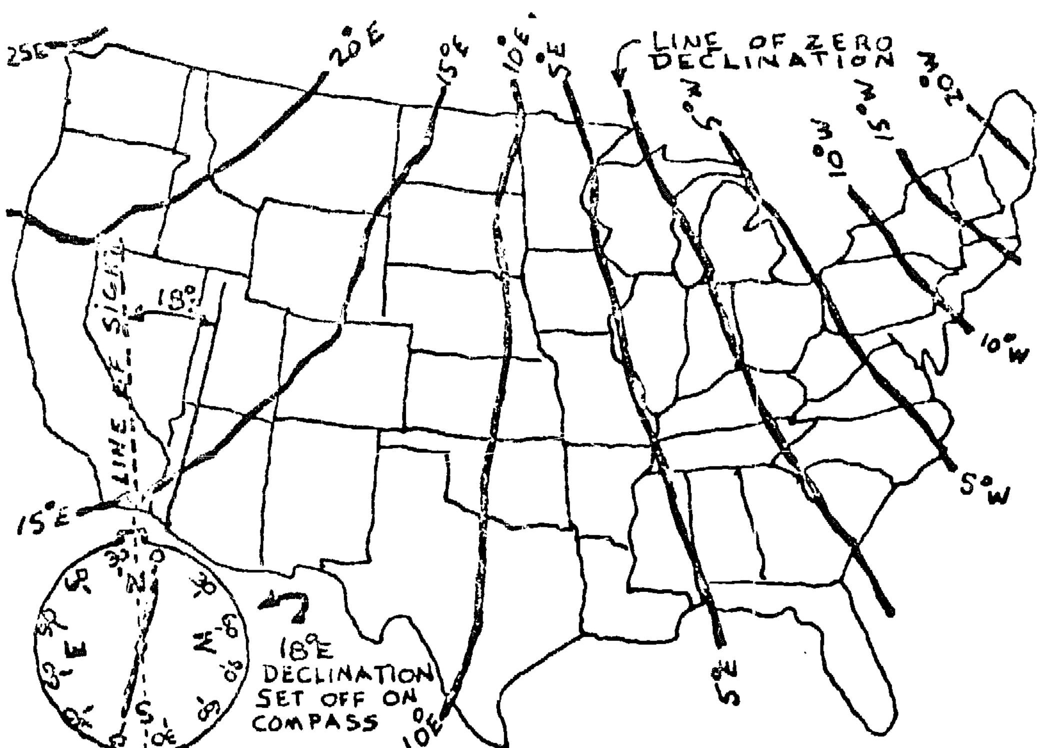
The 13 original colonies used a metes and bounds survey—the most simple to retrace, as it starts from a known point and goes a set distance and set bearing to the next point. In 1785 the government adopted the rectangular survey. This type applies to 29 states. In this land division a North-South meridian line and an East-West base line is first established. At the intersection of meridian and base an area is divided into 24 mile squares (called townships). Each township is divided into 36 squares (called sections). Section corners and half-section corners were originally set by the Government Land Office. The original survey notes for setting these corners are available to the public from the General Land Office. Missing corners can often be found or re-set by retracing the original notes. Land parcels can be surveyed out of sections by starting from known section corners and following the bearings and distances established in the original survey.

The only tools needed for this "homesteader survey" is a 100-foot steel tape and a pocket compass. The compass should be the type that rotates with respect to the box in which it is mounted. The circle can therefore be turned through an angle equal to the magnetic declination. The observed bearing will then be *true* and not magnetic. East of the line of zero declination (see drawing above) the North end of the compass points West of North; West of that line it points East of North.

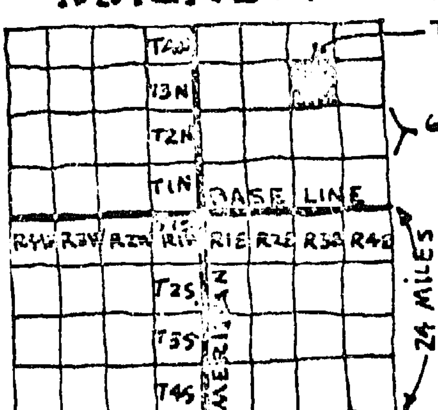
Selecting a site which best satisfies one's homestead needs should be done with care. Many factors should be considered. This chapter falls short in mentioning all the necessary considerations or the way they may vary with individual needs and circumstances. But the following check list does provide a start in evaluating those items considered most important for making a wise selection.

CHECK LIST FOR SELECTING A HOMESTEAD SITE (in order of importance to the author)

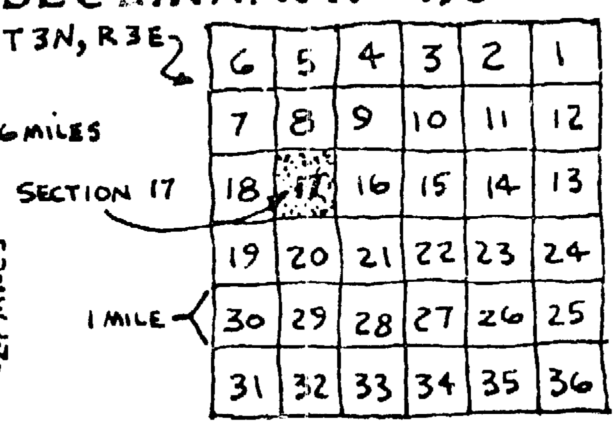
1. *Adequate domestic water supply*
2. *Proper solar exposure*
3. *Sufficient space*
4. *Adequate growing season*
5. *Air purity*
6. *Reasonable land costs and taxes*
7. *Favorable natural topography*
8. *Local employment opportunities*
9. *Good soil conditions*
10. *Availability of natural resources*
11. *Adequate precipitation and drainage*
12. *Neighbors and neighborhood nuisances*
13. *Zoning and building regulations*
14. *General cost of living*
15. *Natural beauty of area*
16. *Local and state political status*
17. *Electric power supply*
18. *Transportation and road access*
19. *Local medical facilities*
20. *Cultural and educational opportun*
21. *Recreational facilities*



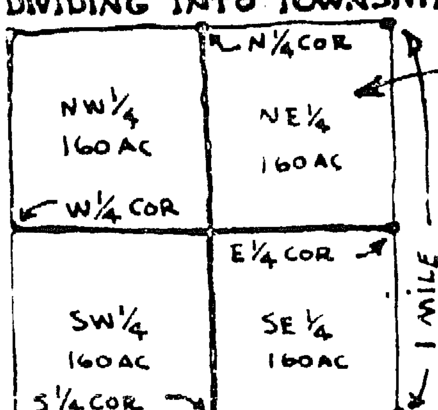
MAGNETIC DECLINATION 1950



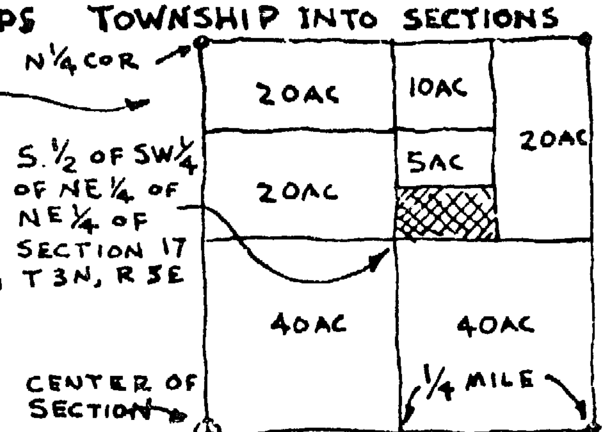
DIVIDING INTO TOWNSHIPS



TOWNSHIP INTO SECTIONS



SECTION INTO QUARTERS



QUARTER INTO PARCELS

The Homestead Plan

The total homestead layout–from structure design to soil and crop management practices–expresses more than any other single item, exactly where a homesteader is at in his viewing of lifestyle. A farm building lays open the thoughts and conceptions of its creator. The homestead layout and design that I am here proposing is therefore based on particular principles of life, deemed either self-evident or essential to my own thinking-through process. These principles make up the warp of this book–with individual homestead topics weaving consistently through the warp, like the welt that comprises the beauty and charm of finished tapestry.

My clients oftentimes express the view that they wish, as a basis of their plan, an "organic" homestead. To me this is like saying the basis of their existence on the land is on the same level as the design and construction of a compost heap. Familiarity with the organic gardening and farming movement is possibly responsible for their move to the land; but the organics concept is very elementary–certainly not significant enough for one to use as a base of his homestead-life. People too often grasp or view the organic gardening concept as a universal panacea–in lieu of the necessary study and discipline that must precede a true understanding of land development and food production.

Let's start with these basics. The creation of a functioning homestead is a life-affirming endeavor. Plants, animals, and ourselves all live in *association* on the homestead. The homestead holds together (through the interdependence of its membership) a plant-animal-human organism. This dynamic outcome is formed by the interrelated organisms in *response* to the homestead habitat; living organisms and non-living environment. And the constant interraction of these organisms to the homestead environment can be called an *ecosystem.*

On the homestead, living in harmony with one's environment becomes a measure of maturity. Plants and animals also–and even soils grow, develop and mature. (A "climax" type vegetation–like a hardwood or redwood forest, or grass on the prairie–is an example of a mature plant growth). No "hunger signs" are evident; even scarce trace elements are recycled through the plant–from soil to roots, leaves, and back to the soil. All available nutrients are therefore utilized and conserved.

A young soil is made up primarily of parent rock material. It undergoes great change in adjustment to chemical and biological forces. A mature soil, on the other hand, reflects less of the "genetic" inheritance and more of the various environmental forces—like temperature, vegetation type, amount of rainfall, etc.

The homestead then becomes an organism where a maturing process is allowed to develop. The various homestead components adapt themselves through a process of natural selection. Adaptation involves the ability of each component to cope with its environment in the homestead. Plants, for instance, that are allowed to make full use of soil nutrients, water, temperature and light factors, can give protection against such diverse factors as temperature extremes, drought, harmful insects and disease.

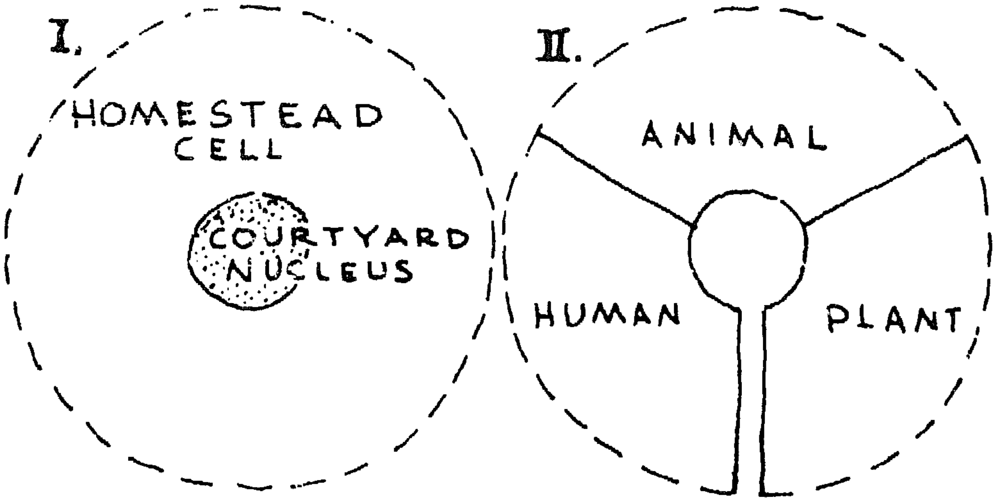
So in this chapter we will be thinking in terms of building an organic ecosystem rather than house-barn-shop-garden. The animal, plant, and human components will be situated in this homestead in harmonious and maturing juxtaposition. This harmonious maturation is the homestead's individuality. No other homestead—*no other place*—in the world is like it.

The success or failure of one's homesteading effort depends more on proper planning and layout arrangements than on any other single factor. Take a long view of your homestead property and imagine yourself creating a new life form on that plot of dirt. Start first with the courtyard, which is the hub, or center-point of a homestead complex. Like the nucleus in a cell structure, the *courtyard* is the central point of all activity. All traffic originates or terminates in the courtyard. The court should have a minimum diameter of 100 feet, as vehicles can turn around easily. Buildings located around the court should be directly accessible—without going through gates. Fields and pastures should be readily accessible from the court—in the shortest and most direct route possible.

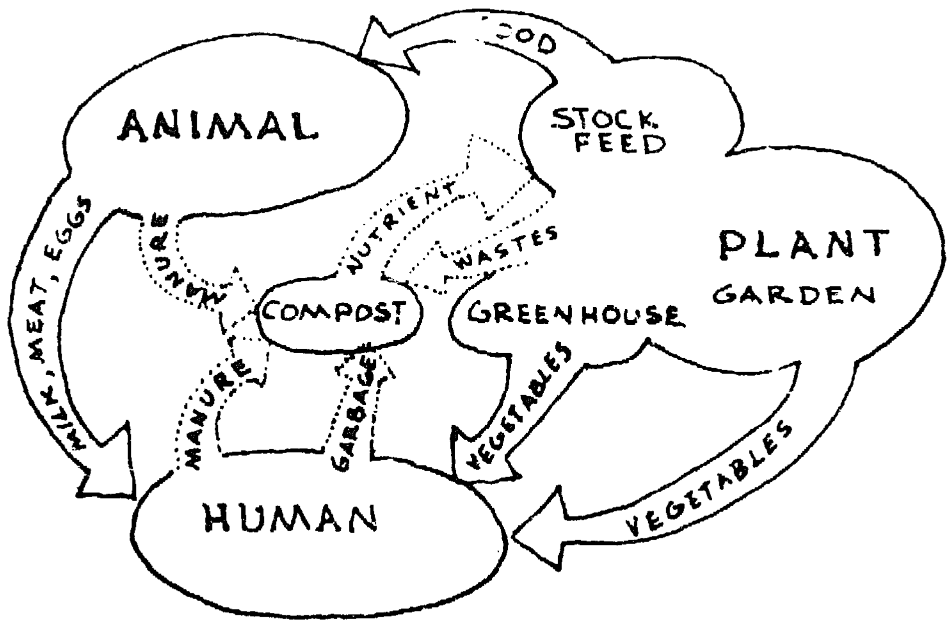
We now design arteries to connect the nucleus-courtyard to its extra-cellular and inter-cellular environment. A driveway, properly less than 200 feet in length, connects the courtyard with public access. The longer this entrance road the more expensive it is to build and maintain. Electric and telephone lines may cost more, too, with excessive length. Secondary artery-roads must be provided to connect the various plant-animal-human functions to the courtyard. A third access pattern must also be provided to connect the various animal-plant-human components to each other. A circular routing has been found most efficient from a chore performance point of view.

Traffic circulation patterns should be planned in detail. Buildings between which there is the most travel should be grouped together. The buildings, and adjacent yards, should be arranged so that they can be reached by truck. Ample size doors and gates—both in height and width—should be provided for easy access of equipment. Feed should be stored where it is used.

Flow diagrams should be made also to evaluate chore routes, storage areas, and work centers. Flow should be continuous, and not dead-



HOMESTEAD ECO-SYSTEM



ended. Keep distances between chore activities as short as possible. Make it feasible for livestock to self-feed. About 3/4 of the feed consumed by livestock becomes fertilizer. Livestock buildings and yards should be so planned to facilitate the movement of livestock through the homestead. This simplifies the fertilizer-handling chore as well as the feeding-grazing process.

Adequate concern should be given to this chore problem. A homestead can be thought of as a complex of food production. Raw materials are assembled, stored, processed and converted. The homestead is further complicated by interrelationships of buildings and equipment, climatic conditions and space-time factors as well as constant growth and change. An "engineered" homestead has an organization of work centers, with the work itself simplified and systemized.

Work-simplification studies indicate major advantages in handling larger amounts. Small batches should be eliminated. In handwork, it is always best to arrange jobs so that both hands can work.

Finally, due consideration must be given to safety and comfort. A healthful work environment must be provided for the homesteader as well as for animal housing. Inside, maximum winter protection should be provided for the homesteader as well as for animal housing. Inside, maximum winter protection should be provided with adequate provision for daylight and ventilation. Outside, one must protect against cold winters and drifting snow. Natural or planted windbreaks can be used to advantage in this regard. Downing, in 1860, pointed out the connection between animal environment and animal production:

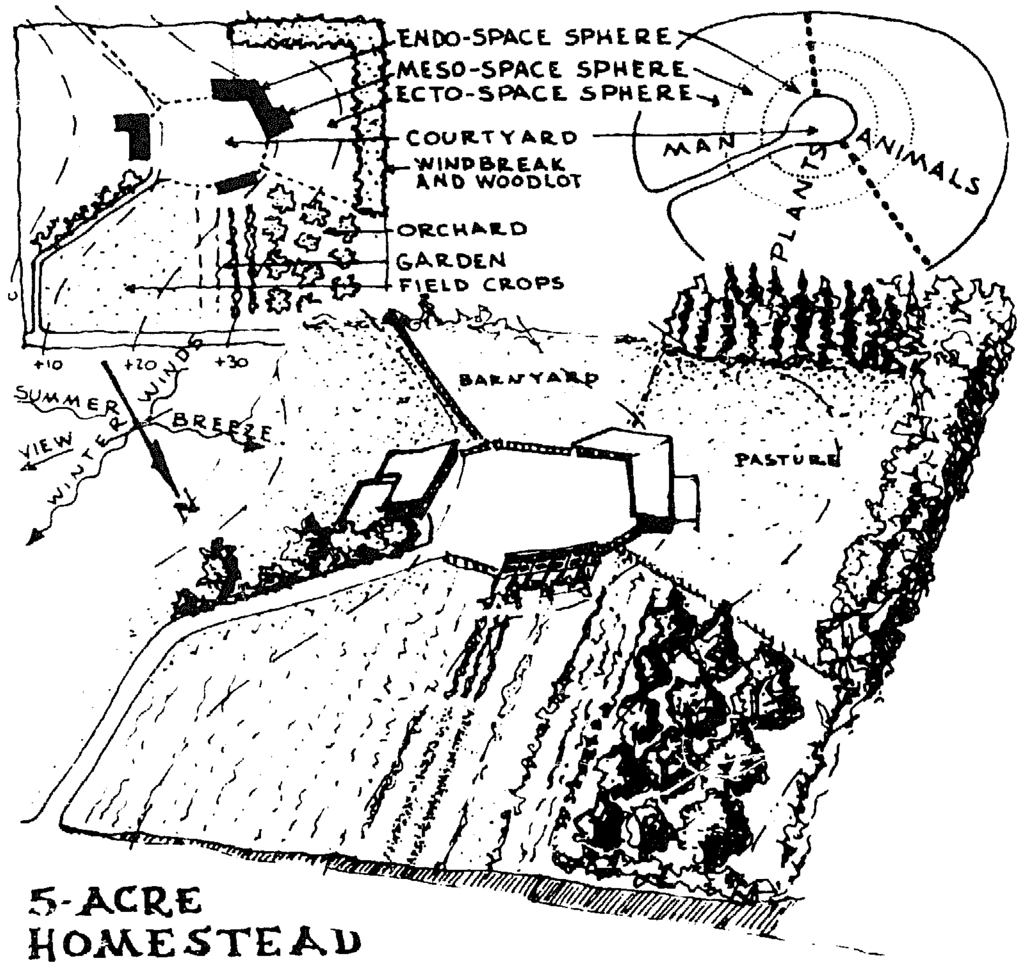
> As it is well known now that the extra supply of heat needful in the animal economy in cold weather, if not supplied by an extra consumption of food, with no increase of flesh or strength, but a great loss of comfort to the exposed animal, this extra consumption of food, in a few months, even where food is cheap, will more than balance all that can be saved by withholding a few feet of boards, and a few hours' labor. ARCHITECTURE OF COUNTRY HOUSE.

To this point in the discussion the homestead plan is based upon circulation-arteries and flow patterns for chore facilitation. But the actual *heart* of the homestead lies in open and enclosed spatial relationships of the animal-plant-human complex. I use the terms *endo, meso* and *ecto* to represent enclosed, partially open and open spaces. For instance, a greenhouse, barn, or house all express the enclosed, introverted endo-environment for plant, animal and man. An arbor, loafing shed, or covered patio satisfy partially enclosed meso-environment needs. A lawn, garden, field or pond area provide a completely open ecto-environment.

Integral to this inside-outside spatial relationship is the utility-nervous–system. The utility complex unifies the whole complex together. It is the maintenance center, shop and garage; it is the blood stream–the water system and sewage system. Utility includes also fences and walls and gates and culverts. It includes reservoirs, fuel storage and even a loading platform.

Again, as a living and maturing concept of the homestead, we find that a *vertical* development can take place from endo to meso to ecto spatial situations. A *horizontal* growth is possible within each sphere–endo, meso, and ecto. *An "open-ended" homestead plan is important: It allows for expansion and growth both vertically and horizontally.* Buildings and open yards should be adaptable to change and growth–functions should be flexible and multi-purpose.

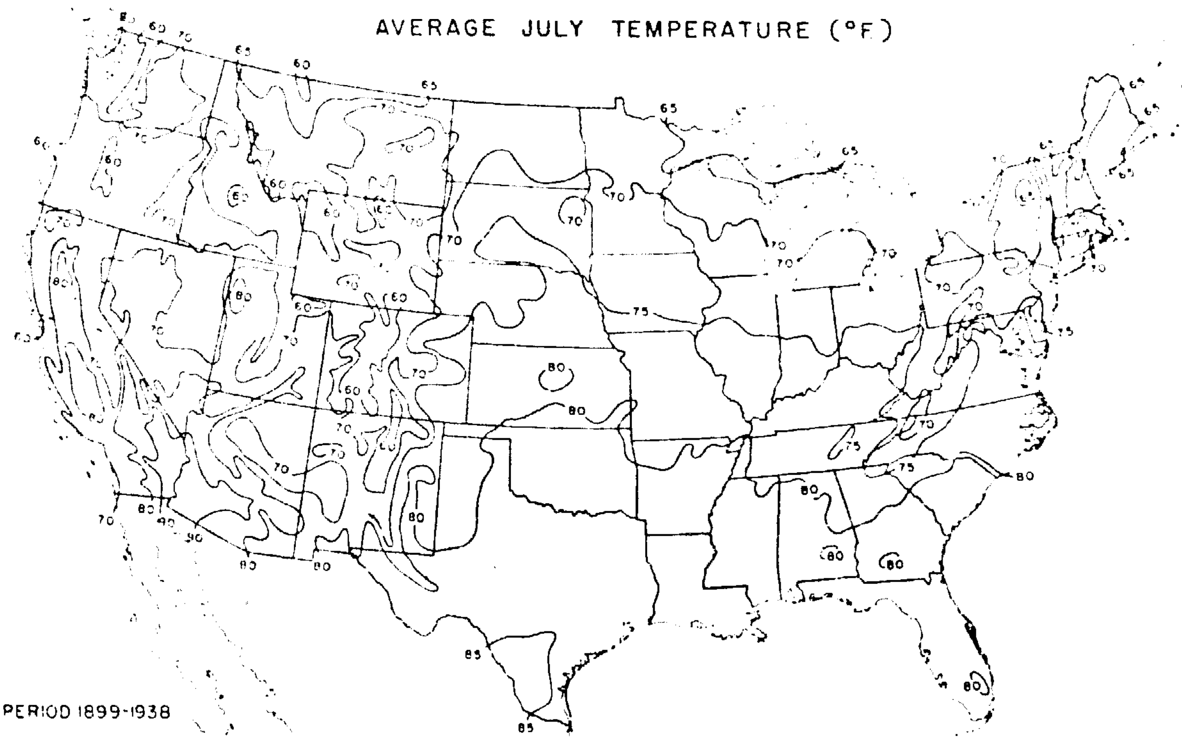
Most homesteads have a multiplicity of shapes, roof pitches, window sizes, and materials. These aspects can be kept consistently related and considerable variation maintained in plan, shape, complication in layout or change in height. A consistent design policy is to be desired: It maintains a unifying effect on the group as a whole.

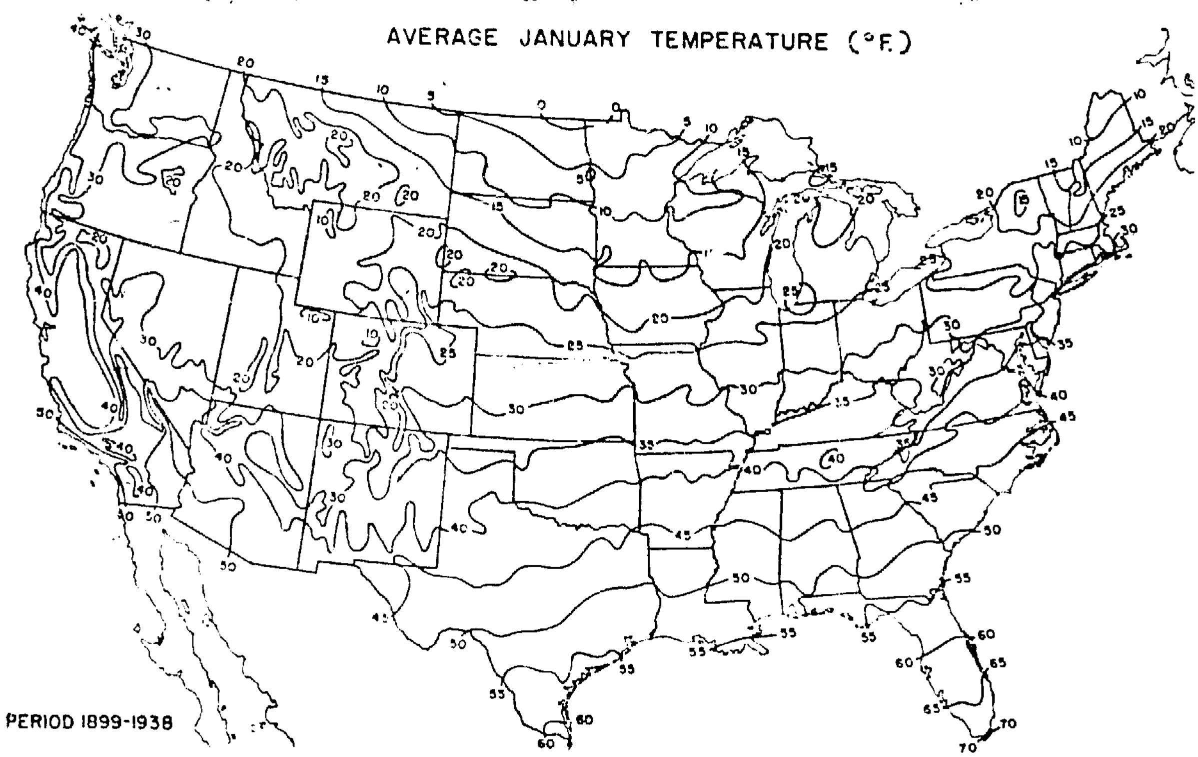


5-ACRE HOMESTEAD PLAN

The diagramatic endo-meso-ecto homestead layout represented here is only theoretically possible. Site conditions influence homestead design and arrangement. Solar orientation is perhaps the most important factor—getting sun and shade where each is needed, summer and winter. Wind direction determines the size and location of windbreaks and arrangement of buildings. Land contour determines water and air drainage, and thus farming or gardening location. Summer breezes and view direction further complicate planning.

It would be impossible to discuss in detail all the problems related to homestead planning in this one all-too-brief chapter. Specific information will be offered in following chapters; inspiration and interest in planning is intended here. It is hoped that sufficient has been included to give the potential homesteader an all-over view. This chapter, furthermore, appears early in the book (which is being published chapter by chapter) before too much development of the homestead takes place. Inspiration is not enough; fulfillment also requires planning. As an old German adage has it: *We get so soon old and so late smart.*





THE OWNER-BUILT HOMESTEAD, CHAPTER 3

Water Development

Water has come to be the most valuable resource to be found on the homestead. Its proper—or improper—development and use will make or break a homestead effort sooner than any other single factor. And yet for a rêsource of such import, there is a dearth of information!

Water is mankind's most wasted commodity. The water needs of a primitive savage—for drinking, cooking and occasional washing—have been estimated to be 1 gallon per day; the average modern city dweller uses 1,200 gallons per day. This includes his share of industrial and agricultural usage in the country and over the world. It takes, for instance, 65,000 gallons of water to produce one ton of steel; 225 gallons to produce an egg; and 550 gallons to grow the grain and produce a loaf of bread.

How the average homesteader sets out in search of water is more often than not the first indicator of ignorance on the subject. Despite knowledgeable scientific methods of water-well location, many people persist in the ancient superstitious belief in divining rods, or in the more modern electrical contrivance, to locate water. Water divining has long ago been proven to be nonsense, however honest water "witches" are in their belief that the working of the rod is influenced by electric currents following underground streams. An unconscious tightening of the grip on the divining rod (usually a simple forked willow branch) will always send the tip downward: the tighter one holds the branch the more it bends. Why the douser unconsciously tightens his grip can be explained by light muscular movements resulting from the unconscious adjustment of poise to compensate for the irregularities of the ground surface while walking.

Well location is best accomplished by *groundwater exploration*—in the library and on the ground. The U.S. is divided into 10 groundwater regions. Each region is further classified by the Water Resources Division of the U.S. Geological Survey (Department of the Interior). This department has amassed an impressive amount of information on groundwater supply. Most of it is based on geologic knowledge, but much public information on ground water resources comes from the actual well driller. Many states have laws pertaining to ground water, and require drillers to log every well, showing each layer of rock material penetrated. They also must show location and depth and quantity of water produced.

A water-seeking homesteader should acquaint himself with some of the geology of his region. Rocks are the most valuable clue for finding water aquifer (an aquifer is simply a layer of rock that carries the water). Geologic study is helpful for predicting the distribution, depth, and thickness of aquifers. The best aquifer is gravel, then followed by sand, sandstone, and limestone. In order for a well to be productive, it must penetrate materials saturated with usable water.

Much of this geologic exploration can be done from the ground surface. Topographic and geologic maps show general water features—from springs and streams to areas of outcrop and such structural features as geologic folds and faults. A rock body appearing at the surface can serve as either conduit or as barrier to water movement. An understanding of the geologic history of a region assists one in identifying such processes as weathering, erosion, sedimentation, compaction, volcanism and glaciation—all of which effect water storage.

In general, ground water follows precisely the same movement pattern as surface water. If the sides of an alluvial-filled valley are the same height, water is likely to be found in the middle; if one side is higher or steeper, water is more apt to be found near the steeper side. Artesian springs can be developed where primary and secondary valleys intersect. The head of a valley is a less likely location for an artesian spring. Remember, the average depth of all domestic wells in the U.S. is under 50 feet. About 90% of all ground water lies within 200 feet.

Plants and trees can also be reliable indicators of shallow-depth water, as illustrated in accompanying chart.

RESULTS OF WELL-SINKINGS AT ALL DIVINED AND NON-DIVINED SITES IN CENTRAL AUSTRALIA 1918-43

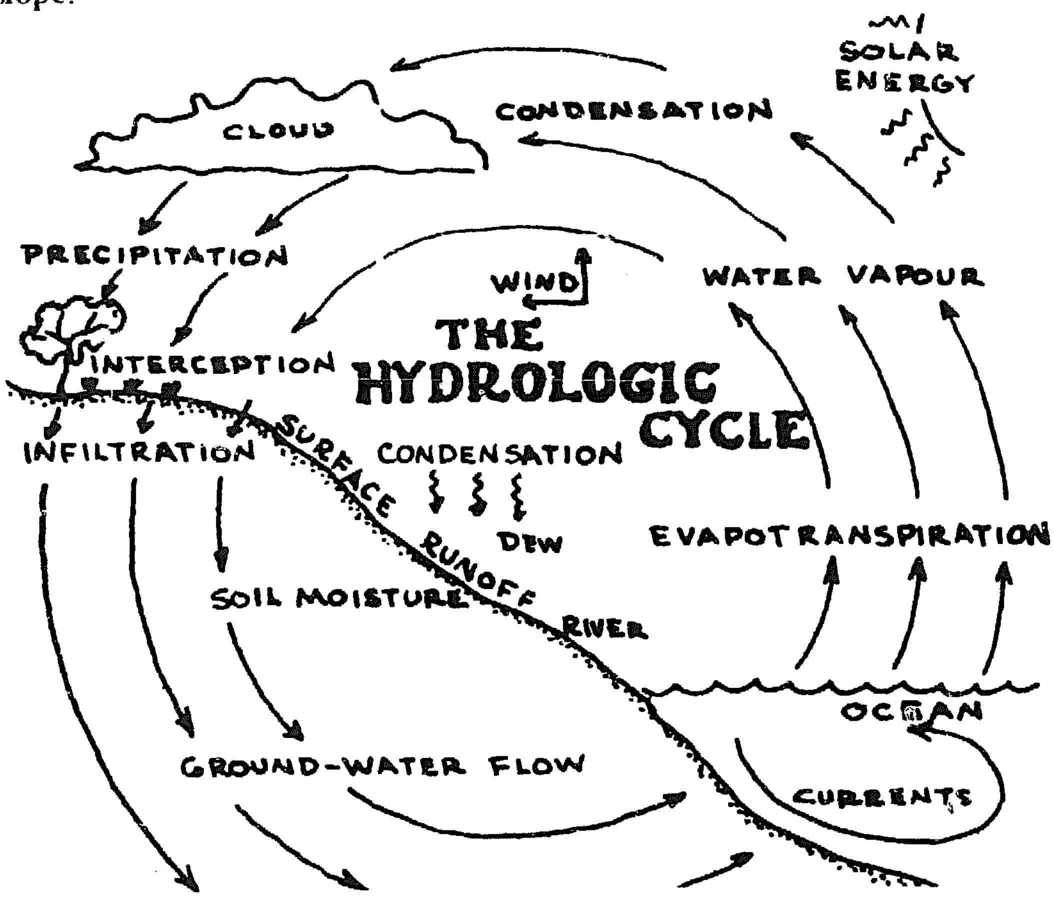
CLASSIFICATION OF WELL	DIVINED NUMBER	DIVINED PERCENT	NOT-DIVINED NUMBER	NOT-DIVINED PERCENT
100 G/H OR OVER	1284	70.4	1474	83.8
LESS THAN 100 G/H	184	10.1	93	5.3
UNSERVICEABLE WATER	87	4.7	60	3.5
ABSOLUTE FAILURE	268	14.7	131	7.4

FROM: WARD; DEPT. MINES, GEOLOGICAL SURVEY; S. AUSTRALIA; 1946

PLANTS THAT INDICATE PRESENCE OF GROUND WATER

SPECIES	HEIGHT	LOCATION	INDICATES WATER—
RUSHES, COTTONTAILS	GRASS	SWAMPS	NEAR SURFACE
REEDS, CANE	TO 10 FT	STREAMS	WITHIN 10 FT
GIANT WILD RYE	6-8 FT.	SUBHUMID	NEAR SURFACE
SALT GRASS	6-12 IN.	SALT FLATS	NEAR SURFACE
PICKLE WOOD	2 FT.	SALT FLATS	NEAR SURFACE
ARROW WEED	SHRUB	THICKETS	10-20 FT.
PALM TREES	50 FT.	ARID	NEAR SURFACE
WILLOW TREES	10-25 FT.	USA	NEAR SURFACE
RABBIT BRUSH	SHRUB	WESTERN US	WITHIN 15 FT.
GREASEWOOD	3-6 FT.	USA	10-40 FT.
MESQUITE	10-15 FT	USA	10-50 FT
COTTONWOOD	50 FT.	ARID REGION	WITHIN 20 FT.
ELDERBERRY	30 FT	USA	WITHIN 10 FT

There is a final method of determining water location and requirement. It comes with an understanding of one's climatic environment in respect to the Hydrologic Cycle. Altitude of one's homestead, for instance, affects water needs. The higher the altitude, the less water is required for growing things. Rain and cloudy days, which occur at the heights up to 3,000 feet, reduce the evapotranspiration process. Also, at these higher altitudes, most precipitation falls as snow. This is good. For snow is stored on the ground during winter months for use in spring and summer. A south-facing slope will lose its snow as much as 30 days sooner than a north slope.



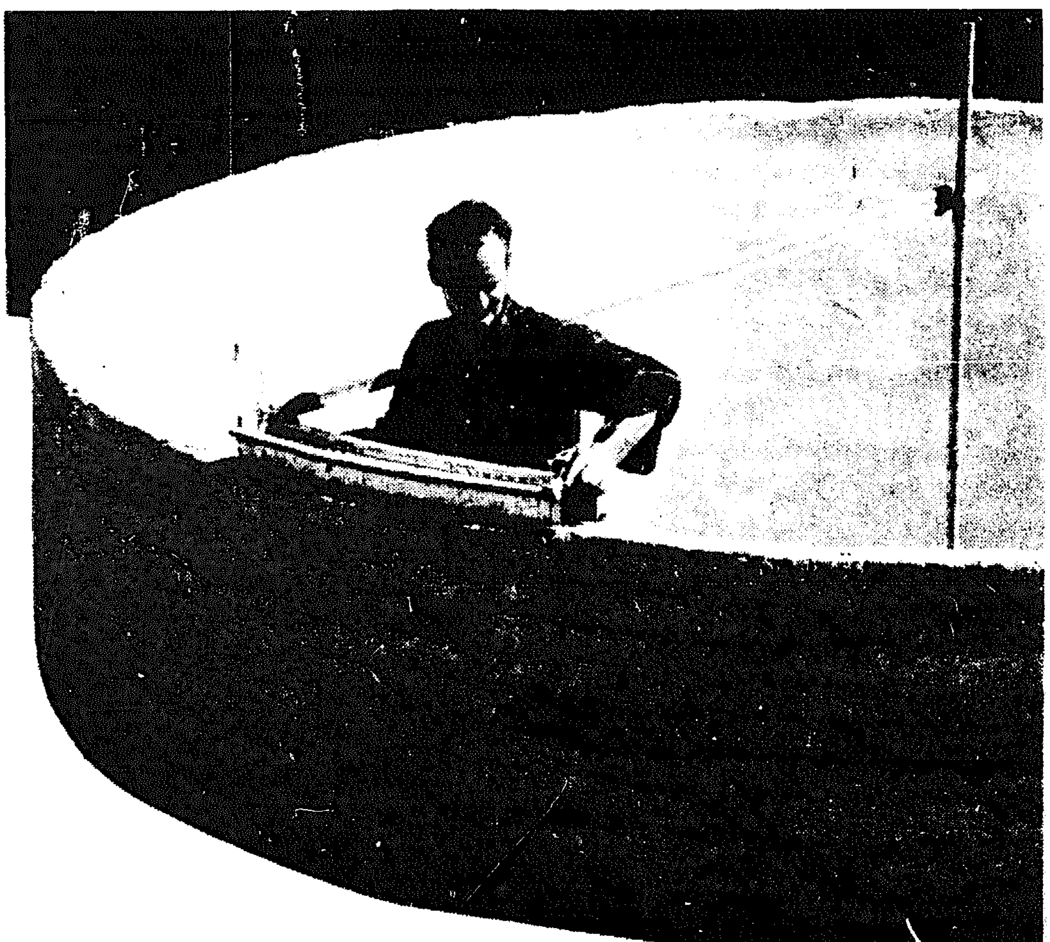
Topography can have a major effect on water distribution. Slopes facing the prevailing moisture-laden winds favor the lifting-cooling precipitation process. Slopes facing away from prevailing winds have drastically reduced precipitation. For example, a valley or slope on the leeward side of a mountain may be comparatively dry.

Without question, the first-choice homestead water facility is a gravity-fed spring or artesian well. If the spring can be located 20 or more feet in elevation above the homestead, moderate water pressure requirements can be met. Unfortunately, most springs are low producers—some sort of storage facility must be incorporated into the system.

Agricultural Engineer James Waller found that a spring emitting a trickle of water as little as 2 quarts per minute can be harnessed and stored to supply enough water for 35 head of cattle. This same amount is more than sufficient for average homestead requirements.

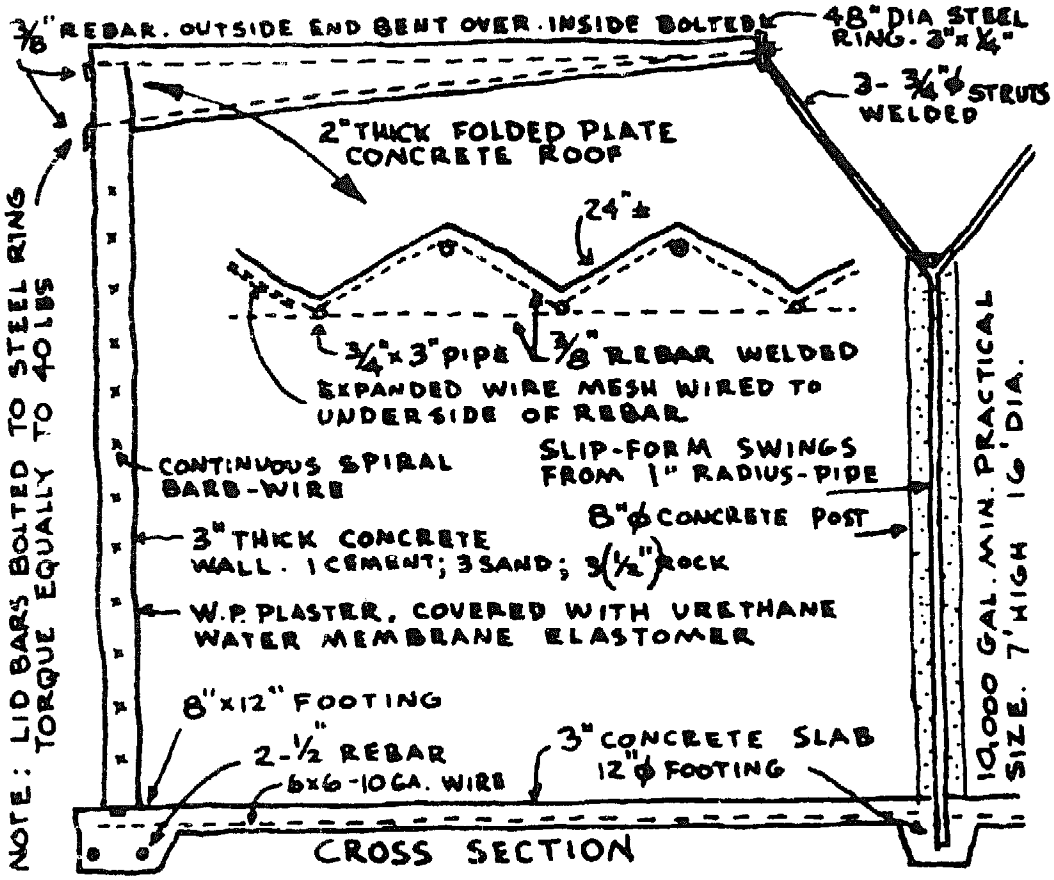
Traditional water storage facilities have proven to be expensive and inadequate. In a few years a metal tank will rust and a wood tank will deteriorate. Neither can be installed underground—which is essential for the prevention of temperature rise and evaporation. Concrete is the best material to use in building a water storage tank. An underground concrete tank undergoes minimal damage and evaporation.

My earliest contribution to the owner-builder homestead technology has been the development of a low-cost, all-concrete circular reservoir. The foundation-floor of this tank consists of a single concrete slab. The roof is a 2-inch thick concrete folded-plate poured on expanded-metal lath, as illustrated in accompanying drawings. An owner-builder can fabricate this tank for about two cents a gallon of water stored.



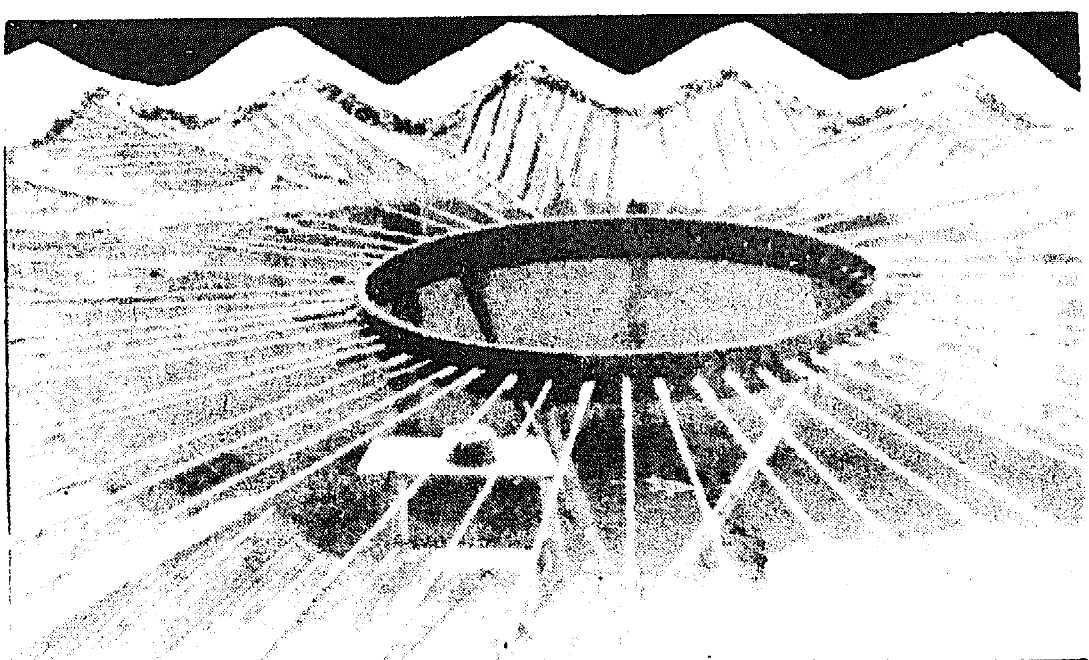
10 000 GAL TANK

AUTHOR SHOWING WALL-BUILDING TECHNIQUE USING HORIZONTAL (SPIRAL) SLIDING FORM



CONCRETE CYLINDRICAL TANK
USING A REVOLVING SLIP-FORM TO SPIRAL
A THIN-WALL MONOLITHIC CONCRETE WALL

DEVELOPED BY AUTHOR 1957



READY
FOR ROOF POUR
30,000 GAL TANK

If a natural spring or artesian well cannot be developed, a homesteader has the choice of *digging, boring, driving, jetting* or *drilling* into the ground for water. Each method, discussed briefly below, has its unique advantages, depending mostly upon the ease of penetration into the earth formation. One's State Geological Survey office will assist in determining what type of earth formation one is likely to encounter: just submit a legal description of your property.

Where the water table is fairly close to the ground surface, a well can be advantageously dug. Depths of from 10 to 40 feet are common. A circular hole, about 40-inches in diameter is usual: being round it is less apt to cave in. Except in cases of solid rock, dug wells require some form of permanent lining. Lining prevents collapse of the hole as well as supporting the pump platform and preventing entrance of contaminated surface water. One unique and practical method of digging deep wells (up to 200 feet) has been developed by the World Health Organization. The first 45 feet is cast-in-place concrete. A system of pre-cast concrete cylinders are then lowered into the well and assembled together. They act as caissons: as earth is removed, the caissons drop lower, guided by upper-level cast-in-place lining.

Bored wells can also be constructed by hand labor, using a simple earth auger. The maximum practical depth is 50 feet, using a 6-8 inch diameter auger. Boring with an auger involves simply forcing auger blades into the soil while turning the tool. When the space between the blades is full of earth the auger is removed from the hole and emptied. As greater depth is attained sections are added to the auger. A pully-equipped tripod is necessary as greater depths are reached, so that the extended auger rod can be inserted and removed from the hole without unscrewing all sections of the pipe.

An American Friends Service Committee team in India devised a simple hand-operated boring auger. In place of a tripod, they built a 10-foot high elevated platform. Pipe lengths of 20 feet could easily be handled by one man perched on the platform.

Whereas an earth auger functions best in heavy soils—like clay—in coarse sand it may be advantageous to *drive* a well. Driven wells are usually 2-inches in diameter and less than 30 feet deep. If driving conditions are good, a 4-inch diameter casing can be driven to as deep as 50 feet. A driven well consists of a drive point connected to the lower end of a tightly-connected section of pipe. The drive point consists of a perforated pipe with a steel point at its lower end to break through the earth. Five-foot sections of pipe are used for the pipe "string"; they serve as casing for the completed well.

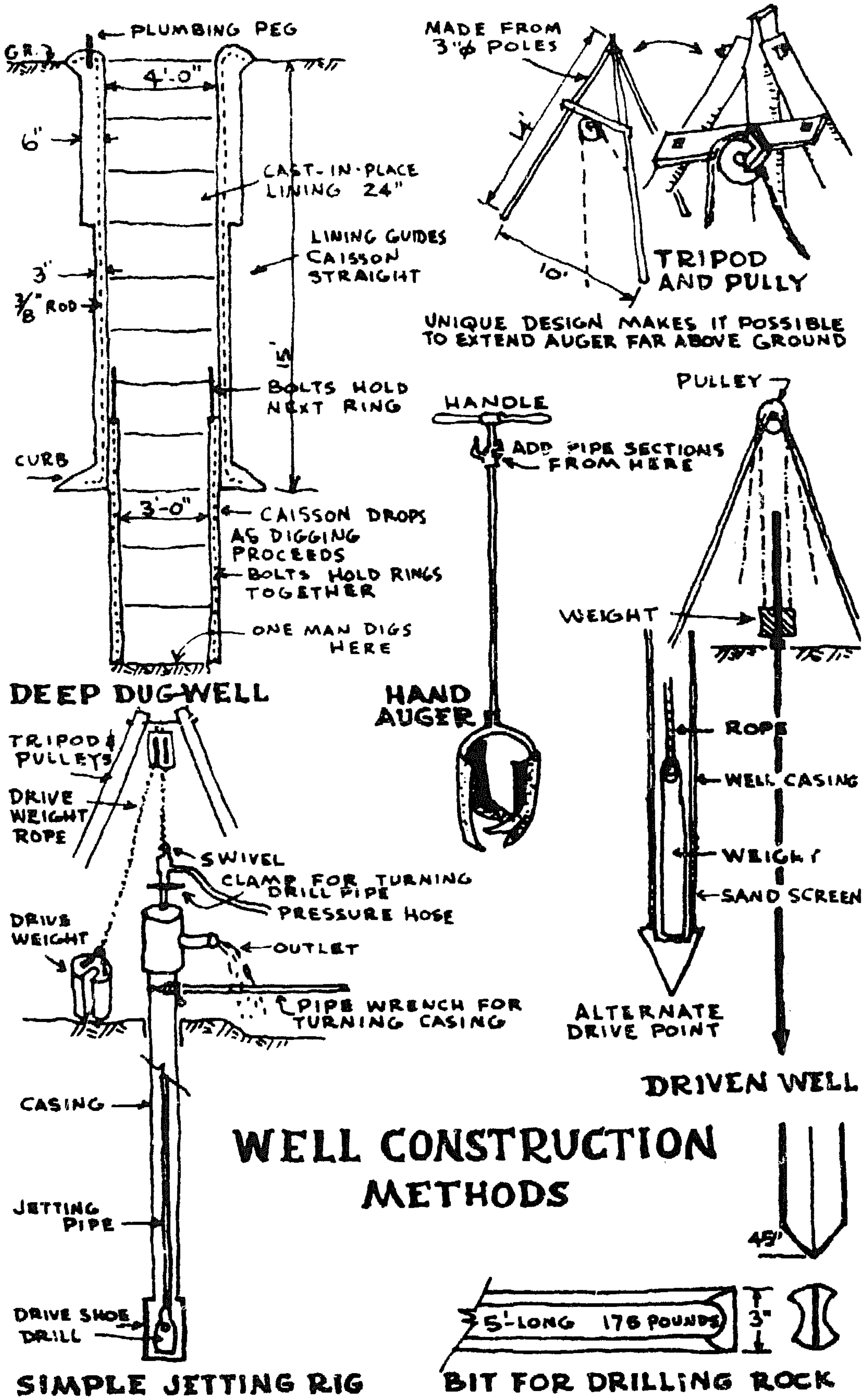
Driving may be done using a maul to strike a drive cap. A falling weight from a tripod, guided by the well pipe, can also be used. Another method is to use a steel driving bar attached to a rope, the bar falls freely inside the pipe and strikes the base of the drive point.

A jetted well involves the use of slightly more sophisticated equipment, yet it is a simple and dependable method accomplished entirely with hand tools. Simply stated, a well is drilled into the earth by the forces of a high-velocity stream of water. The stream washes fine particles of earth upward out of the hole, either by sinking a self-jetting well point or washing in a casing.

A tripod hoist must be installed to support the drill pipe and casing. It can also be used for dropping the drive weight on the pipe—which is done to penetrate clayey soil. A jetting pump capable of delivering 50-100 gallons per minute at 50 pounds pressure is used to fill the casing with water. The casing sinks by its own weight as the ground is washed out from beneath it. The casing is also rotated so that the teeth at the lower end will cut into the bottom of the hole. A straight bit is used to penetrate hard formations of earth that do not yield to the water jet.

A jetted well drilling operation can be mechanized by using a portable gasoline engine to rotate an earth or rock cutting bit. This rotary drill is especially useful for drilling horizontally into the side of a hill, for the development of artesian springs.

Where stone or hard formations are encountered wells must be drilled. Commercial well-drilling rigs are usually engaged for this work—either using a cable tool percussion or the hydraulic-rotary method. In the former case, the well is formed by the pounding and cutting action of a chisel-type drill bit alternatively raised and dropped. The bit is suspended from a cable. Water is added and the reciprocating motion of the drilling tool mixes the loosened material into a sludge that is then removed by a bailer tool.



WELL CONSTRUCTION METHODS

The hydraulic-rotary method uses a rotating drill bit that is perforated. Water is pumped through the bit, then up and out the opening between bit and casing, washing the drill cuttings out at the same time.

A rock-drilling bit can be shop-fabricated from a 3-inch, 5-foot long bar of mild steel. The 90-degree cutting edge is hard surfaced with stellite. A bailing bucket must also be fabricated to remove loose soil.

Well development is the next crucial stage of water well operation. In the process of developing the well, fine materials from formations near the well-point are removed. This opens passages so that more water can enter the well freely. Well yield may be increased by 50% as a result.

The increased yield depends much upon the type of well-point screen used, the spacing between screen openings, and the size of the screen opening. Openings should be large enough to allow finer materials to pass through, but in such a shape so they will not clog. In development, the direction of water flow is alternatively reversed, thereby forcing finer materials toward the screen and into the well. One device for this operation is a plunger-type block that is lowered into the casing. A surge action is created when this block is rapidly lowered and raised.

Back washing is also done to develop a well. A test pump is installed to stop and start at frequent intervals. A deep well turbine pump can be used to lift water rapidly to the surface and let it run back into the well through the pump column pipe. This action intermittently lowers and raises the water level through the screen opening.

Following well development procedures, well tests are made. Primarily the water yield test is made to determine proper pumping equipment. For this one needs to know the volume of water pumped per minute as well as the recovery of the water level after pumping is ceased. Where one has a source of flowing water—at least 3 gallons a minute with a minimum 3-foot fall in altitude—a Hydraulic Ram can be used to advantage. The principle of the hydraulic ram is little known, despite the fact that it has been in use since 1800. The hydraulic ram is about the most perfect pumping machine invented. It runs entirely from the energy generated by flowing water. It will lift water as much as 500 feet, depending on the height of the fall (about 25 feet lift for each 12 inches of fall in altitude). Once the ram is installed there is minimal need for maintenance during its 30 or more years of constant service. The water must fall through a valve to an air chamber. The flow of water closes the check-valve, which sets up a back-pressure, which *forces the water into the air chamber.* At the bottom of the chamber is the exit pipe leading upward to the storage tank.

Reduced to simplest terms water pumping is nothing more than a *suction* and *pressure* operation. Suction is created by a number of means, and theoretically will lift water 34 feet above sea level. Due to pump losses and pipe friction this suction lift is limited to more like 25 feet.

The oldest and most common of all shallow-well pumps is the cylinder and piston type. Suction is created by a piston or plunger working back and forth inside a cylinder. A shallow-well piston pump will deliver from 250 to 500 gallons per hour, so this type pump is especially applicable in low-producing wells.

Windmills can be used for the power source of piston pumps. Winds should average at least 5 miles per hour for more than half the time to warrant a windmill installation.

Suction can also be created by a high speed centrifugal–or throwing–action. Thus the Centrifugal Pump is used for pumping large quantities of water. Unlike the piston pump, the centrifugal pump is not positive acting: as the water level lowers in the well it pumps less and less water.

The most efficient positive action shallow-well pump is the Rotary Gear. It consists of two gears meshing together inside a housing. As the gears mesh, water becomes imprisoned between the gear teeth and housing. As the teeth continue to revolve, water is squeezed out and up through the delivery pipe. Water supply is thus continuous and steady without pulsations, and maximum pressure is delivered.

In cases where water depths exceed 25 feet one must employ some type of deep-well pump. Again, the simplest type is the piston and cylinder pump. Operating principles of the deep and shallow-well lift pump are the same. The only difference is in the placement of the cylinders. Instead of being part of the pump assembly it is lowered into the well to within 25 feet of the water level. The drop line holds the cylinder in position and acts as a water delivery pipe. A plunger inside the cylinder gets its motion through a sucker rod which is connected to the pump. This pump is especially suited to continuous low-production wells. It will deliver up to 6 gallons per minute.

Probably the most common deep-well pump found on modern homesteads is the centrifugal-jet. As the name implies, it is a simple centrifugal pump, with the addition of a nozzle. As water passes through the nozzle. water speed is greatly increased. A diffuser (or Venturi) changes the high speed stream back to high pressure for use by the centrifugal pump. The deep-well jet is located in the well below water level. Water level should not exceed 100 feet in depth. The centrifugal-jet pump is of high capacity under low pressure.

Water from a deeper than 100 foot well can be supplied with a *submersible* centrifugal pump. The pump and motor assembly is built as a unit and located below water level. This direct coupling gives greater pumping efficiency and the immersion is an effective motor coolant.

A final variety of deep-well pump under discussion here is the Turbine. Centrifugal pumps are called turbines when they are vertically mounted. Power is supplied through the drop pipe to the turbine assembly. The main feature of the turbine is the fact that it is a multi-stage pump: any number of impellers can be added to the drive shaft to provide enough pressure to raise water from any desired depth.

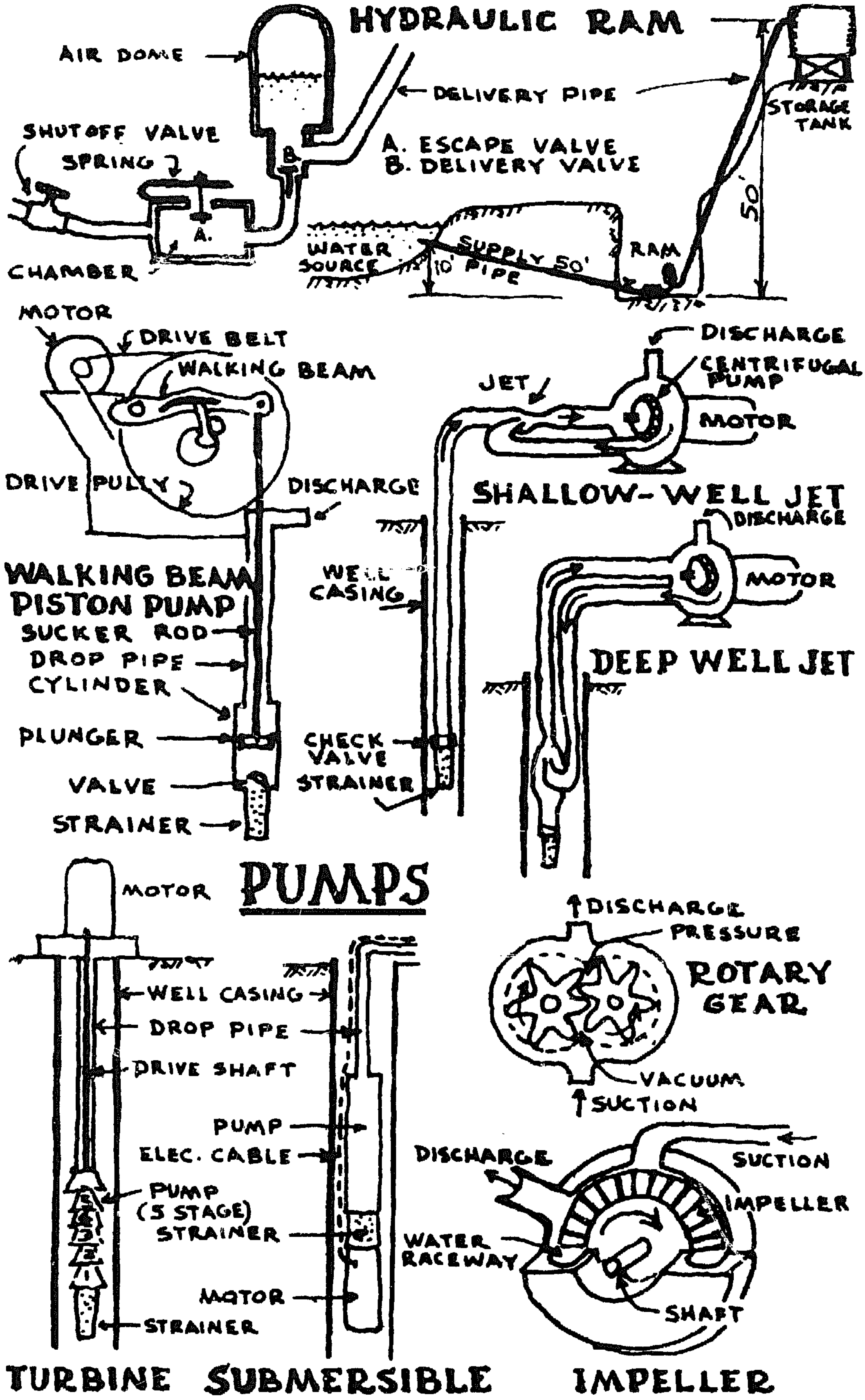
The following table shows some of the relative merits of various types of pumps. This is intended to aid the homesteader in his proper choice of pump to fit well to fit water needs. Water needs will be discussed next.

	PISTON	CENTRIFUGAL	JET	TURBINE
COST	LOW	REASONABLE	REASONABLE	HIGH
CAPACITY	10-25 G.P.M	2 GPM TO UNLIMITED	6 - 130 GPM	25-5000 GPM
HEAD	HIGH	2 - 150 FT.	LOW	7 - 150 FT.
OPERATION	SIMPLE	SIMPLE	SIMPLE	DIFFICULT
EFFICIENCY	LOW 25-50%	GOOD 50-85%	LOW 40-60%	GOOD 65-80%
MAINTENANCE	SIMPLE PLUNGER REQ. ATTENTION	SIMPLE	SIMPLE ATTENTION REQ.	DIFFICULT SKILL REQ.
ADVANTAGES	LOW-COST SIMPLE LOW SPEED	EFFICIENT WIDE CAPACITY	MOVING PARTS ON SURFACE	EASE OF OPERATION
DISADVANTAGES	LOW EFFICIENCY LIMITED USE	MOVING PARTS AND PACKING REQUIRE ATTENTION	LIMITED USE LOW EFFICIENCY MOVING PARTS REQ. ATTENTION	MOVING PARTS IN WELL. REQ. GOOD MAINTENANCE

FROM WORLD HEALTH ORGAN

SERVICE LIFE OF POWER UNIT

ELECTRIC MOTOR	50,000 HRS.	OR	25 YRS.
DIESEL ENGINE	28000 HRS.	OR	14 YRS.
GAS ENGINE			
AIR COOLED	8000 HRS	OR	4 YRS.
WATER COOLED	18000 HRS	OR	9 YRS.
PROPANE	28000 HRS	OR	14 YRS.


HYDRAULIC RAM
AIR DOME
DELIVERY PIPE
SHUTOFF VALVE
SPRING
A. ESCAPE VALVE
B. DELIVERY VALVE
B
A.
CHAMBER
WATER SOURCE
SUPPLY 50' PIPE
10'
RAM
50'
STORAGE TANK
MOTOR
DRIVE BELT
WALKING BEAM
DRIVE PULLY
DISCHARGE
WALKING BEAM PISTON PUMP
SUCKER ROD
DROP PIPE
CYLINDER
PLUNGER
VALVE
STRAINER
DISCHARGE
CENTRIFUGAL PUMP
JET
MOTOR
SHALLOW-WELL JET
CASING
CHECK VALVE
STRAINER
DISCHARGE
MOTOR
DEEP WELL JET
PUMPS
MOTOR
WELL CASING
DROP PIPE
DRIVE SHAFT
PUMP
ELEC. CABLE
PUMP (5 STAGE)
STRAINER
MOTOR
STRAINER
TURBINE
SUBMERSIBLE
DISCHARGE
PRESSURE
ROTARY GEAR
VACUUM
SUCTION
DISCHARGE
SUCTION
IMPELLER
WATER RACEWAY
SHAFT
IMPELLER

The spectrum of water development therefore extends from the simple gravity-flow artesian to the complex deep-well turbine. Naturally a homesteader's first choice would be the simple maintenance-free system: one that he might conceivably develop and install himself using minimal equipment and plumbing.

Such a system is now available. It is called the "horizontal" well and was developed only since the early 1950's. Equipment for horizontal drilling was originally engineered for highway drainage, but some innovative well developer altered the equipment to fit domestic water needs.

Two types of sites are especially suited to horizontal-well development: 1) a geologically tilted formation sometimes creates a rock dike or dam for underground water. In this case a horizontal well is drilled through this impervious barrier to the water laden aquifer. 2) a perched water table is sometimes found above an impervious layer. At the point where water seeps out, near the top of the impervious layer, a horizontal well is drilled to tap the aquifer.

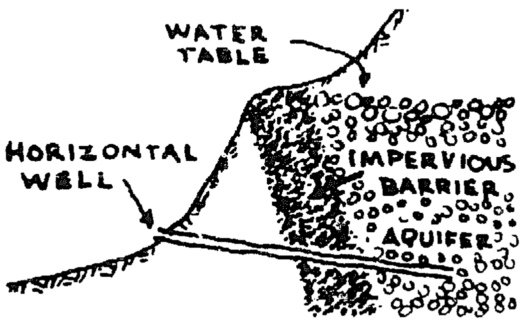
Horizontal drilling is the most sensible way to develop a natural seep or spring. Too often the digging or blasting of overburden to expose the aquifer destroys the natural barrier which serves as a dam for the underground reservoir. In a sense the horizontal well is a "cased spring": water is cased in a closed system from point of origin to point of use. For this reason the horizontal well provides a sanitary water supply, where contamination in a spring is common and difficult to control.

The process of horizontal well development involves a small rotary-jet rig with a pipe chuck powered by a 5 horse-power gas engine. Standard 1-1/4 diameter steel pipe is used as the drill stem: the drill bit has tungsten-carbide blanks welded into notches in the leading edge. As the drill rotates (at about 100 r.p.m.) the chuck and stem move forward on a carriage.

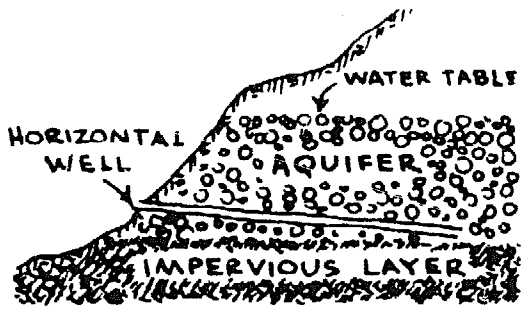
A minimum downward slope of 1/2-inch per foot is recommended to avoid vacuum problems in the casing. A water pump capable of delivering 3 gallons per minute at 120 pounds per square inch is used to circulate water through the drill stem. This cools the bit and at the same time removes cuttings.

Heavy clay, decomposed granite, and soft rock can be drilled at a rate of 3 to 9 inches per minute; hard rock is drilled at the rate of 1 inch per minute. A diamond drill bit is used in extremely hard rock. Horizontal well lengths up to 200 feet have been drilled successfully.

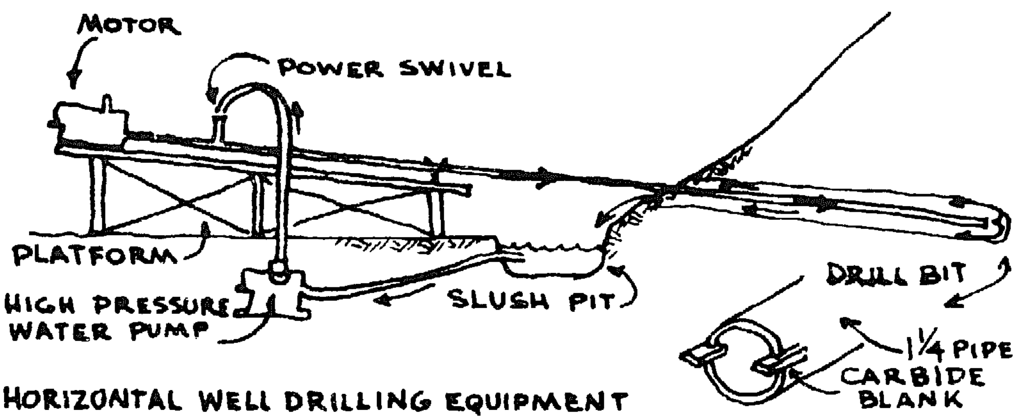
A low-cost simplified horizontal drilling operation is possible using an earth drill attachment mounted on a regular power chain saw. *Stihl* is one (West German) chain saw company which makes an earth drill attachment. This power arrangement makes for little waste or duplication as the chain saw can be used for other homestead functions.



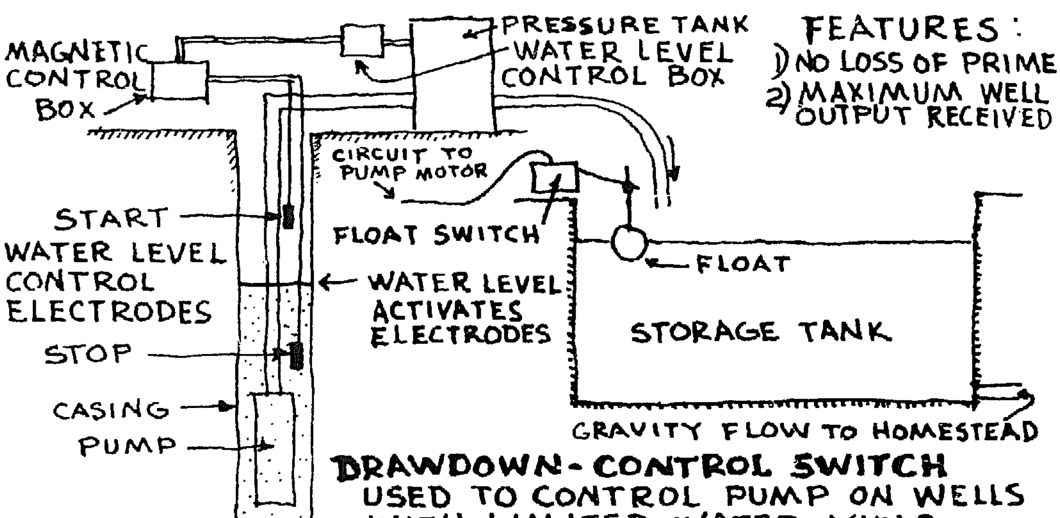
DIKE SPRING FORMATION



PERCHED WATER TABLE



HORIZONTAL WELL DRILLING EQUIPMENT



DRAWDOWN-CONTROL SWITCH USED TO CONTROL PUMP ON WELLS WITH LIMITED WATER YIELD

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THE OWNER-BUILT HOMESTEAD, CHAPTER 4

Water Management

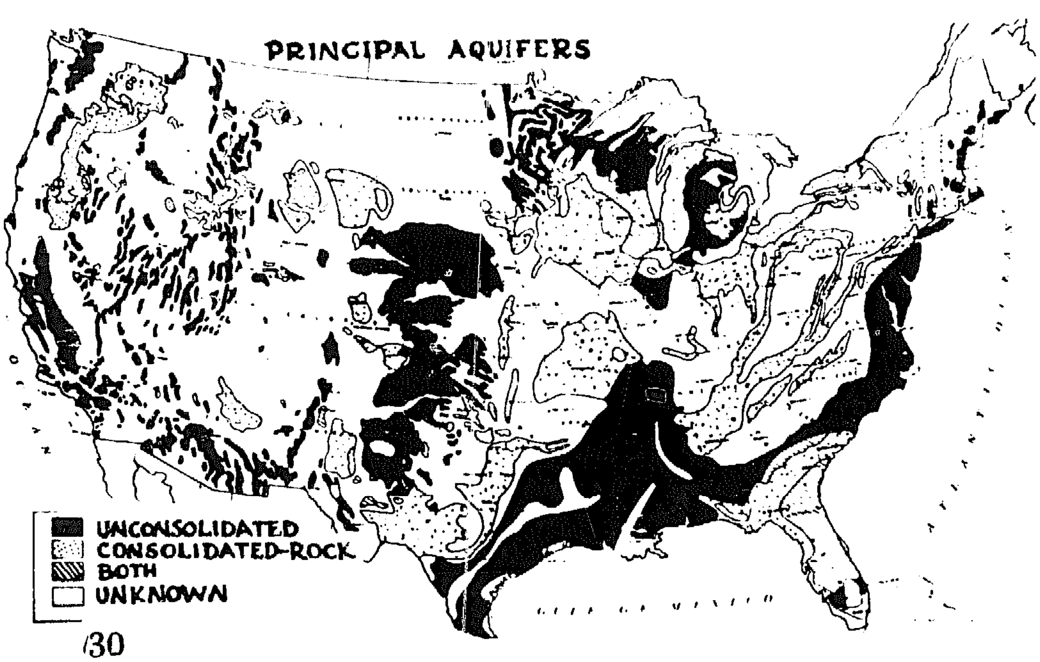
A brief presentation of the Hydrologic Cycle was included in the preceding chapter. My intention was to impress the reader with an important concept: *water is a function of the land.* Like the land, and things which grow on the land, water too has been badly misused. We may settle in arid regions where streams flow only during cold, non-growing seasons. So we have to divert water from stream channels or impound it behind dams. Then we over-irrigate, causing nitrate leaching and the establishment of pathogenic fungi. Commercial fertilizers and poisonous sprays are then used to counteract these evils. Or we may farm the rich bottom land--but must first drain the meadows and valleys of stored water. The tile drainage systems employed lower the water table and contribute to down-stream flooding. We may cut or burn forests and native grass to graze cattle or plow the land. Then soil-depleting cultivated plants replace native vegetation: tillage practices leave the land stirred up and exposed to the ravages of wind and rain. Agriculture then becomes, for the most part, an occupation dealing with floods and drought, erosion and infertility, insects and diseased plants.

Consequently, as a function of the land, water and water management become very closely interrelated to soil and the way in which soil is used. Organisms and plant roots living in the soil remove *oxygen* and respire *carbon dioxide.* This free movement of carbon dioxide out, and oxygen into the soil is a first criterion of healthy plant growth. Standing surface water, for instance, may contribute to crop damage by impeding this action. Flooded soil encourages undesirable bacterial transformations: when soil aeration is poor, plant roots have difficulty in excreting carbon dioxide, and beneficial aerobic (airborne) micro-organisms cannot function. Anerobic (waterborne) micro-organisms then take over and reduce valuable nitrates to toxic nitrite and gaseous nitrogen.

A leaching action–caused from excessive rainfall or irrigation–also contributes to an impoverished soil-condition by washing essential nitrates through the soil profile. The effect of percolating water on a soil's nutrient reserve depends a lot on the structure and texture of the soil. Heavy (clay type) soils will hold more water without nutrient leaching. The structural aggregates of heavy soils retain nutrients as they allow water to drain around them.

Tillage operations also impede plant growth—mostly through compaction of the soil. Heavy equipment compaction reduces oxygen diffusion as well as obstructing root growth. Contrary to popular opinion, even light tillage wastes more soil moisture than it saves. As particles of soil are stirred up by tillage equipment, all sides are exposed to the air—which permits that much more moisture to evaporate. No more moisture is available to a crop which is cultivated than is available to a comparable crop uncultivated. One despairs at the wasted effort in "dust mulching": once a dry layer is formed on the surface of the soil, no amount of hoeing or cultivating can appreciably reduce the evaporation rate. And the common practice of lightly cultivating immediately after irrigation can be even more detrimental to a crop. Cultivated soils tend to cake and crust on wetting and drying: few empty pores remain where oxygen can diffuse, and water is held against drainage. Cultivation destroys surface "feeder" roots. And for other reasons, too, (which will be detailed in the following chapter) the Roto Tiller is seen as the most undesirable piece of equipment employed on most "organic" homesteads.

A proper water management program can be established once one understands the basic principles of water usage in relation to the growing plant and in relation to the soil. When it rains—or when one irrigates—old air is forced out and new air is pulled into the soil by the downward water movement. In its passage through the atmosphere, water absorbs traces of carbon dioxide which make it slightly acid. Certain minerals are thereby partially dissolved by this acidity: water acts as a solvent for the carbon dioxide and oxygen that the plant obtains from the atmosphere. Water is also the medium through which the plant obtains nitrogen and mineral nutrients from the soil to the plant and combines with nutrients entering plant leaves directly from the air.



In a "good" soil (as defined in the following chapter on Soil Management) water is quickly absorbed. A certain amount of reserve is held in the soil by a sponge effect (2/3 saturation is considered an optimum water content of most soils). Excess water is held in the water table. The minimum permissible depth of the water table depends upon the crop being grown: fruit trees, for instance, require a deeper water table than does grass.

The first principle, then, of proper water management is to increase the subsoil water storage capacity at depths where it will be free from evaporative losses. Water in subsoil depths should benefit the plant through a low "capillary" feeding of the root system. When one realizes that wheat, beans and peas, for instance, use about 200 pounds of water for every pound of dry matter produced, one can better appreciate the importance of this dynamic subsoil water storage. Again, the amount of water transpired for each pound of dry matter produced is much less on good soils than on poor ones.

As water transpires from a leaf, it has to absorb heat in order to vaporize. This is one way by which water regulates the temperature in a plant. During the middle part of a sunny day, the photosynthesis process can be reduced by sprinkling the plants during this hot, midday period. ...e cooling effect of midday sprinkling consequently reduces respiration ... increases net photosynthesis. The time-worn advice about sprinkling o... during the cool evening hours of the day is just one more old-wives' tale.

...oesn't take a very long farming experience in a semi-arid region to fully ...preciate some basic water management concepts. For one thing, one shou... ...ry to control as many environmental growth factors as possible—so th... ...vater becomes the *one* limiting factor. Someone found that the applica... ...f manure to unfertile soil reduced from 500 gallons to 300 gallons of wa... ...equired to produce 1 pound of corn. Proper fertilization is essential for ... extensive and vigorous root development—which is in turn necessary ... ...n effective exploitation of subsoil moisture. Surface evaporation can ... ...nificantly limited by *mulch planting*.

More will ... about mulch planting in ensuing chapters, but to the extent that mulch... ...es water and soil, it should be touched upon here. Mulch planting is the p... ...ting of new crops directly in the residue of the previous crop without pr... ...land preparation. Crop residues left on the soil through winter helps to ... ...rve water through absorption, and also in the form of accumulated snow ... ...would otherwise be blown off.

Contour farming is be... ...ing widely used on sloping land. Planting on the contour naturally re... ...s the velocity of water movement: more water is conserved through soil ... ...ltration and percolation.

Crop management practic... ...an become further methods of controlling environmental growth fact... The earliest safe planting date should find seed in the ground. This en... ...les the seedlings to utilize accumulated winter moisture and at the same time lowers the evapo-transpiration rate. Crop sequence is also important: shallow rooted row crops like corn do not fully utilize available soil moisture; deep rooted crops like grains do. So one is prudent to follow-up a corn crop with grain or alfalfa—which will benefit from the soil moisture untapped by the corn.

Fallowing is a common farming practice where the distribution of rainfall is uneven and sparse. The land is not cultivated, but allowed to store water for use by the next crop. That is, one crop is grown from moisture received in 2 years. Fallowing is an inefficient method of moisture conservation, but does illustrate the extent to which water can be stored in a heavy soil.

It is well-nigh impossible to indicate how much water a given plant requires during its growing season. For one thing, soil properties have a

EFFECT OF IRRIGATION ON INCREASING YIELD OF TRUCK CROPS — MacGillivary, U of Cal. 1945

CROP	ROOT DEPTH	% INCREASE IRRIG. OVER NON-IRRIG
Sweet corn	2	2,281
Cucumbers	4	547
Peppers	4	365
Late onions	2	245
Snap beans	4	206
White potatoes	2	200
Early onions	2	125
Tomatoes	6	60
Cantalopes	6	44
Pumpkin	6	27
Lima bean	6	25
Summer squash	4	17
Watermelon	6	7

NOTE: GREATEST INCREASES IN YIELD WERE OBTAINED FROM IRRIGATION OF CROPS HAVING SHALLOW ROOT SYSTEMS.

TONS OF WATER EVAPORATED FROM ACRE OF SOIL — WITH & WITHOUT MULCH - WISC. AG. EXP. STA.

MULCH DEPTH	CLAY LOAM	BLACK MARSH	SANDY LOAM
NONE	2414	588	741
1 - INCH	1260	355	373
2 -	979	270	339
3 -	889	256	287
4 -	883	252	315

great bearing on moisture retention: the coarser the particle, the less water it will hold. Sandy soils have a capacity of less than l-inch of available water for a foot depth, whereas clay soils retain more than 3 inches. For a vegetable garden, an equivalent of 1-inch of rain is considered adequate in a single downpour: a garden 1/10 acre in size requires 3000 gallons! Most vegetables require .10 to .20 inches of water a day or about 3 to 9 inches a month. Research at Kansas Experiment Station disclosed some interesting facts about irrigation: wheat seeded in dry soil yielded 5 bushels per acre; where the soil was wet 1 foot deep, the yield was 9 bushels; soil wet 2 feet deep yielded 15 bushels; soil wet 3 feet deep yielded 27 bushels.

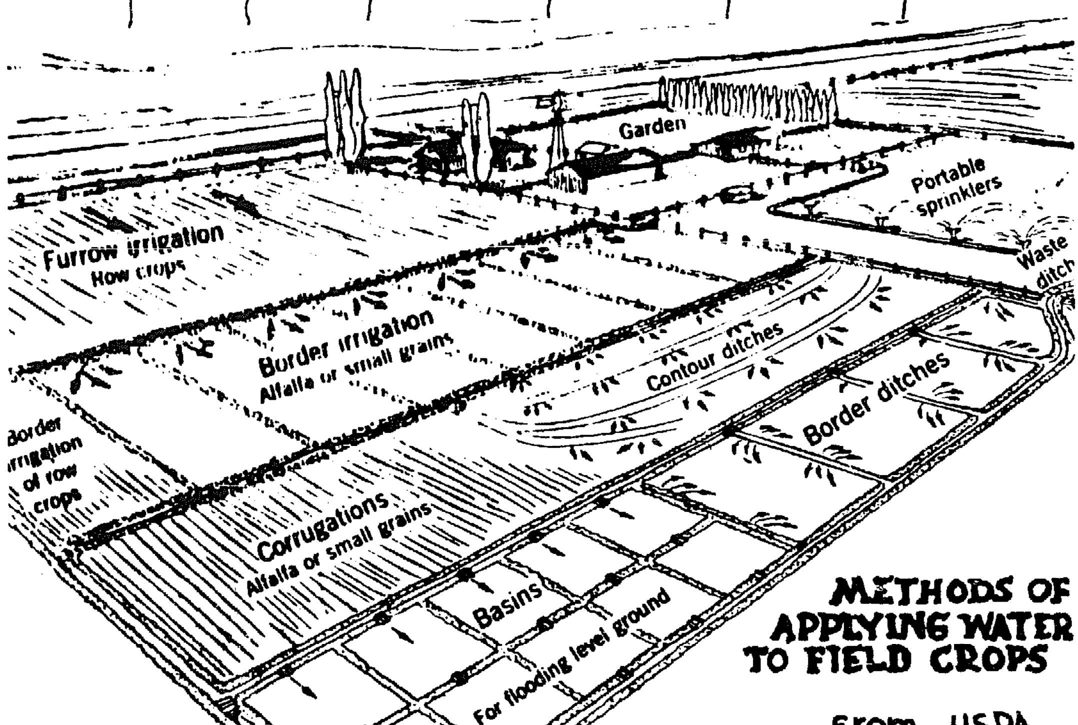
The competition between plants for available water is fierce. Small plants, for instance, have little chance for survival when they are within reach of tree roots. Crop yields can be increased in very dry seasons by increasing the distance between rows. This reduces the demand for water during the early part of the growing season, which therefore increases the amount of soil water available as the plant approaches maturity. In cases where land is plentiful and water scarce, it has been found to be more efficient to irrigate a large area with a small amount of water, than it is to irrigate a small area with a small amount of water. Seven inches of water on 4 acres produces three times the crop yield of 30 inches applied to 1 acre. Irrigation is a Pandora's box: its use raises the lid of many problems. These problems are associated mainly with soil management: drainage, soil structure, aeration, leveling, organic matter, mineral deficiency and toxicity, salt accumulation and general soil infertility. As pointed out in the previous chapter, water development has subtle but far-reaching influences: the hydrologic balance can be easily upset by man tampering with his environment. Introducing irrigation into a valley is an especially good example of how this balance can be upset. More particularly, one's homestead soil and plant population can be adversely affected—especially in arid regions. Irrigation water contains salt. Most of the water applied evaporates—either through the plant or on the soil surface. The salt remains, and must be washed away into the subsoil below the root zone, or into drainage canals. About one-fourth the amount of water used in irrigation is thus used to wash the salt out of the growing zone. And with the bath water goes the baby: most irrigated soils suffer severe nitrogen and phosphate deficiencies caused from the leaching of plant nutrients.

An accurate prediction of a soil's drainage requirements thus becomes the first element in selecting land for irrigation. As previously illustrated, water drainage through a sandy soil is more than twice as rapid as through a heavy, clay soil. Soil depth, degree of land slope, and regularity of topography also influence irrigation procedure. Any amount of land leveling can be very expensive. Sandy soils which erode readily should be limited to low slopes. Clay and gravelly soils can be irrigated on steeper slopes without so much danger from erosion.

Actual water supply is another, equally important consideration for the selection of an irrigation method. Supply should, of course, be adequate and reliable. A small, constant-flow stream is adaptable to sprinkler irrigation whereas a large intermittent stream is adaptable to surface irrigation. To achieve the maximum utilization of soil and water, deep rooting into the subsoil should be encouraged. Light irrigations applied frequently will restrict root penetration and increase the degree of drought damage when dry periods occur.

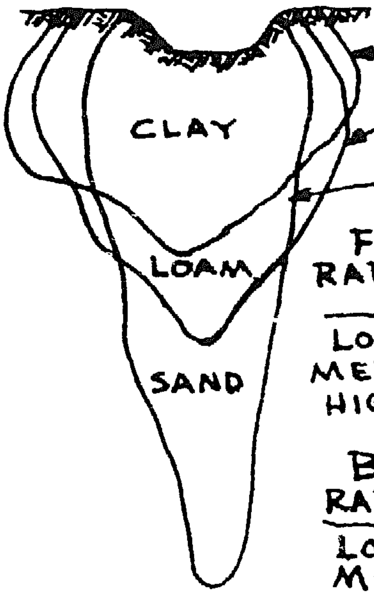
Soil and water factors favor one or another of six different methods of irrigation. These can be summarized in table form:

WATER HEAD	SOIL PERMEABILITY	SOIL EROSION	TOPOGRAPHY	ADAPTED TO:	DESCRIPTION	METHOD
LARGE	GOOD	LOW	IRREGULAR	PASTURE	FLOOD OVER LAND FROM HEAD DITCHES	**WILD FLOODING**
LARGE	HIGH AND LOW	HIGH	LEVEL	CLOSE GROWING CROPS - TREES RICE	FLOOD DIKED AREA TO DESIRED DEPTH 2"-6"	**BASIN**
LARGE	GOOD	MODERATE	LEVEL ONE WAY UNIFORM GRADE IN OTHER	CLOSE GROWING CROPS - TREES	CONTROLLED FLOOD W/ GRADUAL FLOW DIVIDED BY RIDGES	**BORDER**
SMALL	GOOD	LOW	MODERATELY IRREGULAR TO UNIFORM	ROW CROPS VINEYARDS ORCHARDS	RUNS DIRECTLY DOWN SLOPE	**FURROW**
SMALL	HIGH	HIGH	IRREGULAR	ALL CROPS	WATER APPLIED WITH SPRINKLER	**SPRINKLER**
INTERMED TO LARGE	LOW	LOW	LEVEL	TRUCK CROPS	TILE INSTALLED BELOW TOPSOIL	**SUBIRRIGATION**



METHODS OF APPLYING WATER TO FIELD CROPS

from USDA



LOW INFILTRATION - CLAY
.1 TO .5 IN./HR.
MEDIUM INFILTRATION - LOAM
.5 TO 1.5 IN./HR.
HIGH INFILTRATION - SAND
1.5 OR MORE IN./HR.

FURROW IRRIGATION

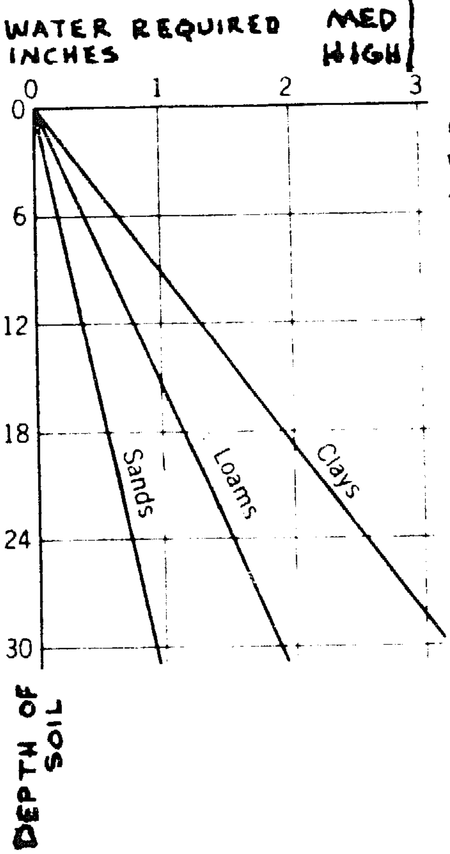
RATE	LENGTH	SLOPE OF LAND 0-.2%	.2-.5%	.5-1.0%
LOW	330 FT.	2 GPM	1.5 GPM	1 GPM
MED.	330 FT.	4 GPM	3 GPM	1.5 GPM
HIGH	330 FT.	9 GPM	4 GPM	3 GPM

BASIN IRRIGATION

RATE	450 GAL/MIN	900 GAL/MIN
LOW	.5 ACRE	1.0 ACRE
MED	.2 ACRE	.4 ACRE
HIGH	.1 ACRE	.2 ACRE

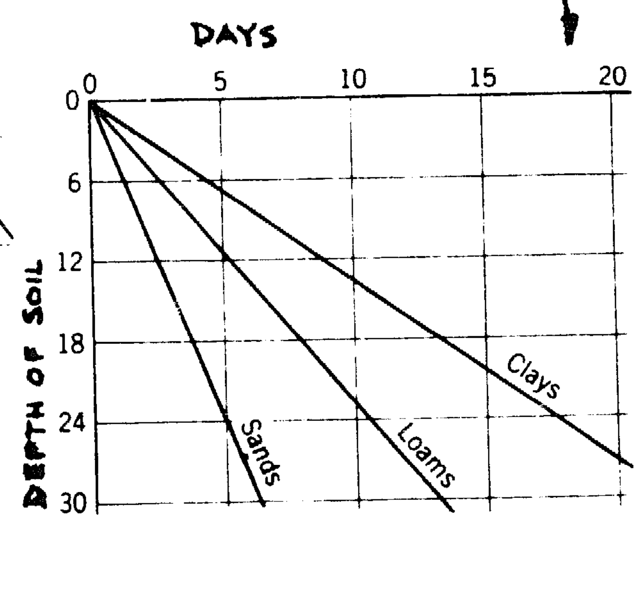
SPRINKLER IRRIGATION

RATE	SLOPE OF LAND 0-5%	5-12%
LOW	.2 IN/HR.	.15 IN/HR.
MED	.5 IN./HR.	.4 IN./HR.
HIGH	1.0 IN/HR	.75 IN/HR.



INCHES OF WATER REQUIRED TO WET VARIOUS DEPTHS OF SOIL

INTERVAL BETWEEN IRRIGATIONS



A small farm pond is practically an essential requirement of every owner-built homestead. As a reservoir, it becomes ideal for any type of crop-irrigation program. It can be used for livestock watering, for raising fish, ducks and geese. The fringe benefits of a farm pond are many: for recreational uses the pond can function for summer swimming and winter skating. It also serves as a convenient water source in case of fire.

Without question there have been more unsuccessful pond building attempts than successful ones. Reasons for failure are many and varied. There isn't space here to go into all the engineering details of small dam construction, but some of the obvious criteria should at least be mentioned.

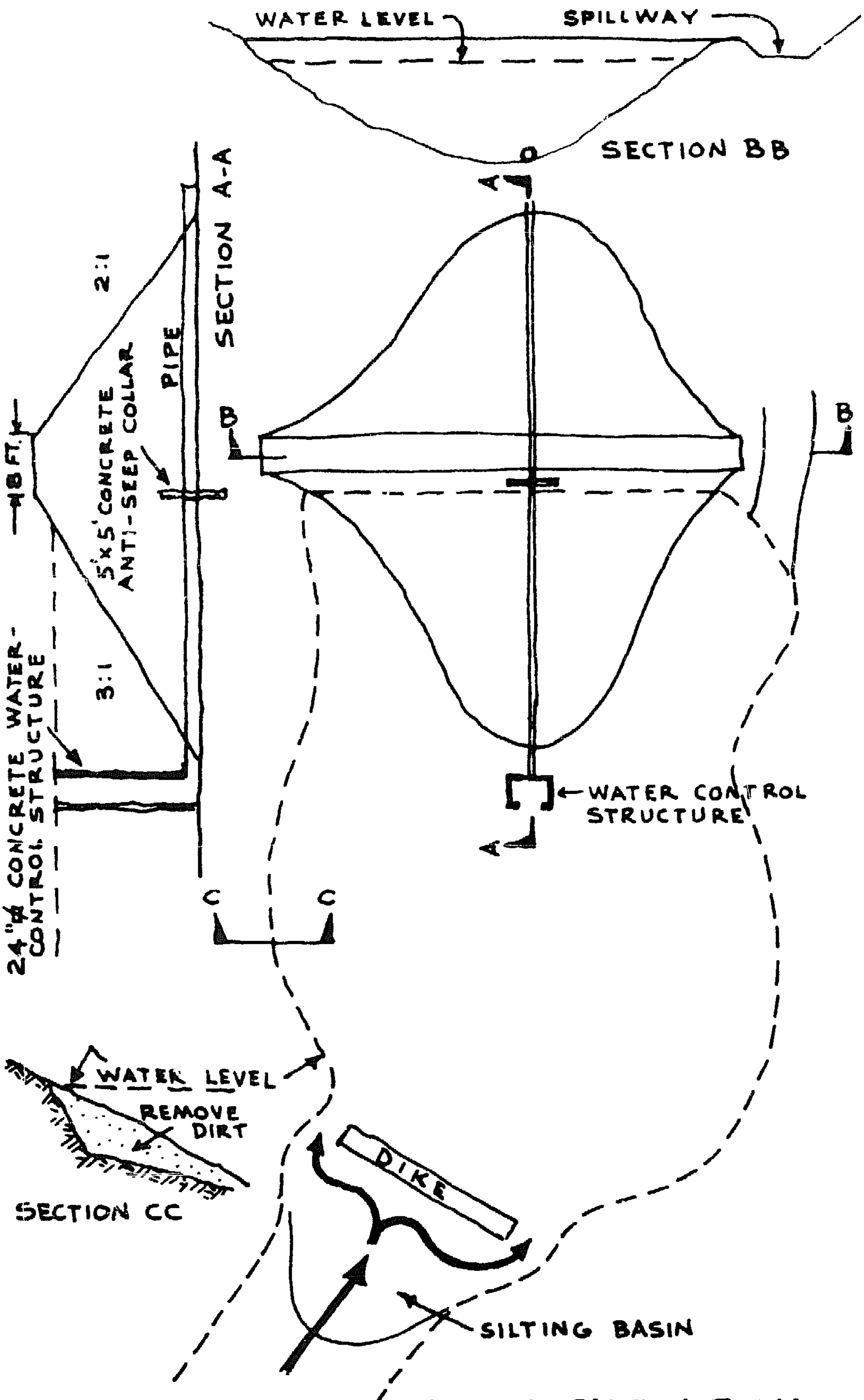
Keep several things in mind when choosing a pond site. First, seek a site that offers the maximum amount of storage area with smallest dam practicable. Ideally the site will be located at a point higher than the homestead–for possibilities of gravity-flow irrigation. A steep-sided valley where the stream runs slow is ideal: the greater cross sectional rise the shorter the dam; the flatter the longitudinal section the further upstream water will be impounded.

Second, investigate the geological strata closely. A concrete dam is a practical consideration where outcropping of granite or basalt extend across the valley or near the surface or where a good rock foundation is present. Other types of loose rock outcroppings along the banks should be avoided. Sometimes a shallow layer of soil will cover objectionable gravel and shattered rock. Ideally, for an earth fill dam, a site having a large percentage of clayey material with some silt or sand should be chosen. Too much clay causes cracks when dry and slippage when wet; too much sand causes seepage percolation.

An adequately designed spillway is most important in farm pond construction. The purpose of the spillway is to carry away surplus runoff: it may consist of a mechanical-type control or a drainage ditch planted to some protective ground cover. This latter type spillway should be clear of the dam and cut out of solid ground.

Farm pond management is another very much involved topic–and again will only be briefly touched upon here. A pond managed for wildlife, fish and recreation should be fenced. This will protect the spillway, fill and pond-edge from livestock trampling. A sharp bank should be maintained around the perimeter of the pond to avoid warm and stagnant water. Water less than 2 feet deep has little value for fish, and shallow water encourages mosquito and weed growth.

Tree, shrub, and deep-rooted legume growth should be discouraged from growing on the fill. Trees planted around the pond should be coniferous varieties–not broadleafed–to minimize evaporation. A row of correctly placed conifers will reduce evaporation losses by sheltering the pond [illegible]n winds which might otherwise ruffle the surface of the water. A wave actio[illegible]reases the evaporation manifold. Wave action and rain action are the [illegible] sources of erosion in a pond.



SMALL FARM POND

Erosion from rain may be a fitting subject on which to end this chapter. Erosion is like pollution: it suggests some grave mismanagement practice at some distant point of origin. With erosion, it is the whole system of agri-business which is at fault. Rains, for instance, are heaviest during that part of the growing season when row crops are least able to provide ground cover. This fact suggests a different practice, one that allows a ground cover *and* row crop growth simultaneously. Some far-sighted agriculturalists found that when *weeds* were grown with corn, the corn yield increased.

Weeds are not the water robbers that people once imagined them to be: they are actually conditioners of the soil. Weed growth can open up the soil and enlarge the feeding zone of other crops. Crop roots will follow weed roots deep into the subsoil in search of water.

A proper water management requires that the soil is used within its capacity. One's homestead may be sectioned into crop land, pasture, woodlot and wildlife refuge, depending upon soil structure and depth, movement of water and air through the soil, land slope, and susceptibility to water and wind erosion. A complete thesis on soil management is called for at this time. This will be presented in the following chapter.

Characteristic Rooting Depths of Various Vegetables When There Is No Barrier to Their Penetration

Shallow (To 18 to 24 inches)	Moderately Deep (To 36 to 48 inches)	Deep (To more than 48 inches)
Broccoli	Bean, bush and pole	Artichoke
Brussels sprouts	Beet	Asparagus
Cabbage	Carrot	Bean, lima
Cauliflower	Chard	Parsnip
Celery	Cucumber	Pumpkin
Chinese cabbage	Eggplant	Squash, winter
Corn	Muskmelon	Sweet potato
Endive	Mustard	Tomato
Garlic	Pea	Watermelon
Leek	Pepper	
Lettuce	Rutabaga	
Onion	Squash, summer	
Parsley	Turnip	
Potato		
Radish		
Spinach		

Soil Management

There comes a *moment of truth* in the life of every potential homesteader. That is, sooner or later one finds that he or she must come to grips with the purpose and motivation and inner feelings associated with desire to work the land. This chapter on soil management seems an appropriate juncture to qualify some of these subjective aspects. For one thing, soil is basic to the whole homesteading complex: the person who lacks some special feeling for the soil is not likely to have much feeling for plant or animal husbandry.

Soil management practices, moreover, can prove to be essential tests by which one can judge rapport with the growing process. What is your reaction, for instance, when giant machinery opens up soil furrows, denuding all vegetation for planting monoculture crops to be sprayed with deadly chemicals? Your moment of truth has arrived when you are able to correlate a plow-sliced furrow with a body slash; a denuding of ground cover with a peeling-off of one's skin; an application of commercial fertilizer with habitual injection of barbiturates.

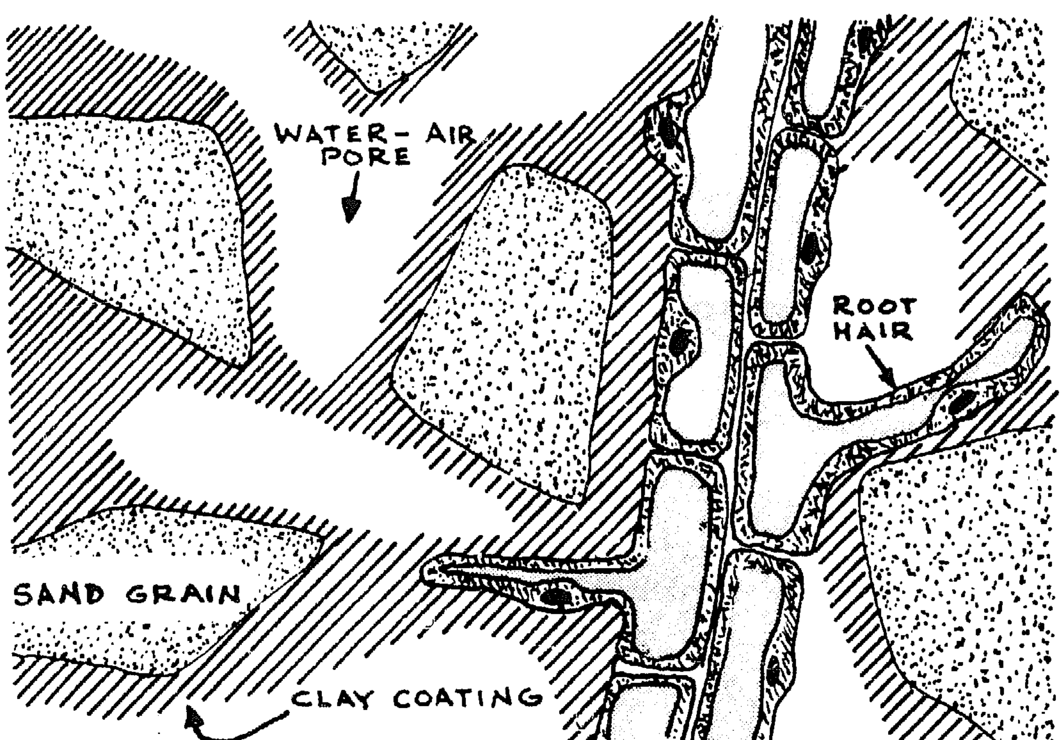
If such feelings for the soil are alien to the average homesteader, it is probably due to the fact that the average homesteader has no comprehension of the exceedingly bad soil management practices engaged in by modern farming. Nor, conversely, does he understand the principles inherent in *proper* soil management practices.

To achieve this understanding, the place to begin is with an investigation of a sample of good soil and a sample of poor soil. In the first instance, soil granules, or crumbs, are aggregated into a structural unity. A disaggregated soil, however, has no structure. Instead, pores are completely filled with water. The soil surface dissolves into mud after the first rain, and after the rain it dries to a powdery dust. When you become able to appreciate the intricacies of soil structure, you are well on the way to an appreciation of food production itself.

An ideal soil structure is one having large and stable pores which extend from the surface to the sub-soil strata. The size and arrangement of soil particles govern the flow and storage of water, the movement of air, and the ability of the soil to supply nutrients to the plants. A ready supply of air is especially necessary so that soil organic matter can be decomposed by aerobic bacteria. Spaces around soil particles also act as channels for conducting water through the soil. About one-half the volume of soil should consist of these soil pores and fissures. Many of these spaces are filled with micro-fauna: the gums and mucilages formed in the micro-fauna breakdown of organic matter helps to bind soil particles together.

Now observe the sample of earth that comes from the average farm. Tillage and clean cultivation drastically reduce the number of large pores available for the movement of air and water through the soil. Overcropping and monoculture also weaken soil structure. The cultivation of annual crops creates mechanical, chemical, and biological demands on the soil all of which cause the soil to lose its crumb structure.

A revolution against "farm implements"–great destroyers of soil structure–is long overdue. When Jethro Tull invented the moldboard plow, he said "tillage is manure". But we now know that soil tilth is created by decay, not by implements. The primary reason pioneer farmers plowed was to get rid of weeds: when weeds were plowed under the farmer had time to get his forage crop started before wild vegetation recovered from the plowing setback. Plowing cuts loose, then granulates, and finally inverts slices of earth on top of surface organic matter. As a result, bare soil is exposed to the direct eroding action of wind and rain (soil aggregates are badly destroyed through the beating action of rain). In this manner, plowing (as well as other forms of tillage) breaks down the soil structure and leaves the surface liable to crusting. The small pore size associated with surface crust increases the water runoff by restricting water intake, which thereby reduces the amount of moisture stored for future crop use.



FROM PHOTOMICROGRAPH OF SANDY SOIL SHOWING CLAY COATING OF SAND GRAINS AND ROOT HAIRS AS EXTENSIONS OF THE CELL ITSELF

As far as I am aware, there are *no* suitable tillage implements: all destroy soil aggregates—some more than others! For one thing, when surface moisture is just right for tillage, the subsoil moisture content (being higher) is in prime state for maximum compaction. Equipment compaction takes place throughout the whole process of crop production—from planting and cultivating to harvesting. Excessive compaction of moist soil limits water absorption by limiting the supply of highly essential oxygen. Compacted soils, like soggy-wet soils, hinder germination because much oxygen is required to digest the stored foods in seeds. In the germination process, carbon dioxide is given off and a maximum pore space is essential, as the gaseous interchange around the germinating seed must be maintained. Furthermore, the pore spaces must be contiguous—from subsoil to atmosphere. In this way the carbon dioxide can be dissolved with moisture in the surface layers (by capillary attraction) forming carbonic acid. This acid is the most efficient natural solvent of minerals, releasing (in particular) phosphorus and potash for the plant use.

Organic gardening magazines probably receive more revenue from hand-operated rotary plow, like the "Rototiller", ads than from the balance of all other advertisements. Ads that sell these machines to unsuspecting gardeners are just one more example of the innocence flawing the "organic" movement. No amount of organically-produced compost could even begin to compensate for the total destruction of soil structure which these machines deliver. Rototillers are the worst type of tillage implements: soil is not merely cut and turned over, it is *sheared to dust.* Powdery soils will cake and crust upon wetting and drying. Furthermore, the sharp tines completely destroy such essential soil microflora as algae—which keeps microbes supplied with greens through the production of chlorophyll.

In my judgment, *mulch planting* has been proven to be the best soil-building alternative to tillage. Practical mulch planting techniques will be discussed in following *PLANT MANAGEMENT* chapters; our only interest at this point is how mulch planting aids in the development of soil structure and fertility. Obviously, fiberizing the land with organic matter prevents surface compaction and crusting. Furthermore, this organic matter gradually decays, and in so doing releases carbon dioxide. As we have seen, the carbon dioxide combines with water-forming carbonic acid, which in turn releases essential nutrients from parent subsoil minerals. As the decay process continues, microbial activity leaves a residue of gelatinous and filamentous growth which acts as a collodial complex, drawing particles together into structural aggregations. Again, as we have seen, the aggregation structure acts as a conduit, connecting upper soil layers with the subsoil. Organic matter therefore acts as a regulator of air and water in the soil: *the foundation of productive land is based on the organic content of the soil.* Force roots, not tillage tools, through the soil.

ABOVE - SOD STRIP BETWEEN FENCE AND ROAD PROVIDES CONTINUOUS LITTER AND GRASS COVER. CULTIVATED CORN PROVIDES PLANT COVER ONLY IN SEASON. BELOW—SOIL SAMPLE FROM SOD STRIP AND CORNFIELD SHOWING EFFECTS OF TILLAGE ON SOIL TILTH. WATER PERMEABILITY 5"/HR. & .26"/HR.

BELOW- RESULT OF SATURATING SOIL SAMPLE. AGGREGATES REMAIN INTACT IN SOILS HAVING WELL DEVELOPED GRANULAR STRUCTURE

U.S.S.C.S. PHOTOS

Mulch planting does even more for soil structure: it sets the stage for the creation of humus. Humus is as important to soil as it is difficult for a person to understand. S. A. Waksman's major work on humus runs to over 500 pages! Farmers in past centuries believed that humus was directly utilized as basic plant-food by crops. Liebig, father of commercial fertilizer, disproved this, showing that plant growth was dependent upon inorganic compounds. Organic matter is fertile only after it is broken down into inorganic forms. However, to depart from Liebig's conclusion, inorganic compounds are made available by *microbes in a humus medium* and not, as he proposed, applied externally as plant-food!

Humus is organic matter in its decomposed state. It contains the breakdown products and dead bodies of microorganisms—which give humus its characteristic dark color. It is these microorganisms, dying in the humus layer, which slowly decompose organic matter, thereby liberating and making soluble continuous streams of carbon dioxide, nitrogen (in the form of ammonia), phosphorus, and other elements. The gelatinous and filamentous residues give humus the property that binds soil particles into structural aggregations; and this structural aggregation of soil is the most favorable medium for the development of root systems and for the future growth of microbes. Aeration and water-holding capacity is increased: the soil is able to absorb more heat. Heat is also given off as a result of air circulation through humus—especially in light sandy soil where air moves freely as water drains away quickly. More organic matter must therefore be supplied to sandy soil than to clay or silt soils, to prevent this "burning up" of humus.

Humus is a veritable storehouse of nutrients. It is also a cementing agent, binding constituent soil aggregations together: one pound of soil colloidal particles is said to cover five acres of surface. Humus has functions and qualities unknown by modern science: Waksman mentions that when all extractions have been made by known processes there is still 30% of the humus unaccounted for. The most important adage that comes from a study of humus is that *growth equals decay*: the growing season must necessarily also be the decaying season.

There's another adage that every homesteader should memorize: *proper soil management is the care and feeding of bacteria.* Microbes are vital to the decomposition of organic and mineral wastes into basic plant nutrients. And, of the microbes that inhabit the soil, 99% are bacteria. The rest consist of fungi, protozoa, and algae. Bacteria are divided into aerobic—those which thrive under conditions of abundant oxygen—and anaerobic bacteria, which live in conditions where oxygen has been used up; that is, where pore spaces are filled up with carbonic acid and water.

Activities of soil bacteria populations are fantastic: one type produces antibiotics; one type digests proteins (most important of which is nitrogen);

other types gather nitrogen from the air. These latter bacteria live in nodules on the roots of certain legume plants. Nitrogen gas is extracted from the atmosphere and made available to the host plant in return for carbohydrates. Another, even more amazing, type of bacteria lives in association with the feeder roots of certain plants–for mutual benefit: the plant is able to assimilate mineral nutrients more readily.

Earthworms are always included, usually at top priority, in any discussion of soil microbe population. Actually, in comparison with the soil development accomplished by bacteria, earthworms are pikers! At best, earthworms are *indicators* of good soil fertility, not its cause. Darwin overstated the case for the ubiquitous worm: they have no mechanism for creating plant food, capturing solar energy, or fixing nitrogen from the air. Earthworm "aeration" of the soil is insignificant, and the "richness" of earthworm casting is just one more organic gardener myth. In reality, the earthworm reduces soil fertility to the extent that it burns up energy passed off as carbon dioxide. The leafy diet of earthworms is especially low in mineral nutrients.

Compost is another organic gardening myth worth exploring in this chapter on soil management. A massive literature on compost making has been compiled by ORGANIC GARDENING AND FARMING editor J. I. Rodale (*THE COMPLETE BOOK OF COMPOSTING*; 1971; 1,000 pages!), and compost making has traditionally been the farming criterion separating the good guys from the bad guys. In reality, mulch planting is a complete, integral process, requiring no further additives in the form of soil conditioners, amendments, or fertilizers. Organic matter applied in mulch planting is utilized in its entirety, without gaseous loss as is the case when making a separate compost pile. Mulch planting seems to call for a "sheet compost" program, where organic matter is spread directly on the ground surface. The only real advantage of centralized composting is where human excrement is utilized. More on this will appear in subsequent chapters.

Whether one adds compost, or any form of fertilizer, to a soil, the principle of *soil replenishment* remains the same, and has little to do with soil structure. Given an adequately based organic content, however, the soil microbe population can create its own nutrient demands in a soil structure that is compatible to the needs of these microbes. Experiments at the New Jersey Agricultural Experiment Station disclosed the fact that fresh residues applied on an equal organic matter basis produced as much as three times the soil aggregation as did composts prepared from the same material. Obviously an "applied" nutrient–whether it be humus-rich compost or commercial fertilizer–cannot have the same influence on soil structure as a more indigenous organic treatment.

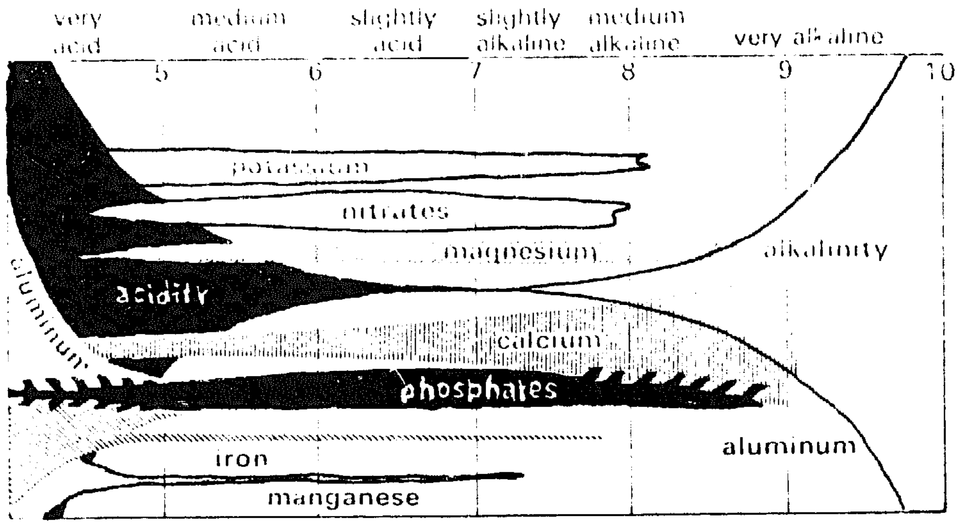
As a matter of fact, the indiscriminate application of fertilizers can have a *harmful* effect on crops: if a little nitrogen added to the soil is good, a whole lot added is not necessarily better! An excess of one fertilizing element in the soil may lead to a deficiency of another. Too much nitrogen leads to a deficiency of potassium; too much potash leads to a deficiency of magnesium. Excessive nitrogen added to the soil may over-stimulate the growth of leaves and stems and interfere with seed formation. There are good arguments against the use of commercial fertilizers which are applied at the time seed is planted: the fertilizer supplies soluble salts for plant nutrition at the very time when the seed is equipped with its own stored-up organic supply. The solubility of commercial fertilizers is much too high in most instances (phosphate rock is treated with sulfuric acid to make it even more available to plants). As soon as plant roots reach these soluble chemicals they go into a spasmodic growth spree, which in turn upsets the delicate soil balance.

Nitrogen is the most important of all fertilizer elements required for plant growth: it regulates directly a plant's ability to make *protein*. Large amounts of nitrogen are needed, especially at early stages of plant growth, and also because so much nitrogen is lost to the atmosphere as gas, or from the soil through leaching. Pre-agribusiness farmers used to leave their fields in rough-stubble throughout the winter months to facilitate rapid snow and rain penetration into the soil, thereby minimizing nitrogen loss from the sky. All nitrogen comes from the air: it is returned to the atmosphere at the same constant rate that it is removed from the air.

Other elements besides nitrogen can be recovered from the air. Field sorrel, for instance, is an extra-heavy user of phosphorous. It can supply itself even though a chemical analysis where it grows reveals no phosphorous present. Unlimited quantities of minerals are also present in the soil and these essential nutrients are made available to the crop in a properly structured soil aggregation.

Mineral nutrients can be "locked in"–made not available–when the soil structure is compacted, waterlogged, or where insufficient moisture prevails. Raising or lowering the acidity of a soil can have a major influence on soil nutrients. Raising the pH of an acid soil from 5.5 to 6.4 (making it more alkaline) increases the availability of phosphorous about ten times. And reducing the pH of alkaline soil from 8.3 to 6.9 (making it less alkaline) increases phosphorous availability 500%. The pH (literally, parts-of-hydrogen) refers to the balance of acidity alkalinity. The scale extends from 10 (high alkalinity) to 4 (high acidity). Most plants thrive at a pH range of 6.0 to 6.9. At this range bacteria seem to thrive, thereby speeding the decay of organic matter and the liberation of nitrogen. At a pH below 6.0 only those bacteria which break organic matter into an inferior ammonia are active; at higher pH the breakdown produces more valuable nitrate nitrogen.

A quartz, granite, sandstone, or shale parent soil usually produces an acid topsoil, whereas marble and limestone produce alkaline soil. Ground limestone is traditionally applied to reduce soil acidity. If available, use dolomite limestone as it contains magnesium carbonate as well as calcium carbonate. Magnesium is an important soil amendment. If a soil is too alkaline, apply sulfur or gypsum. It is the *oxidation* of sulfur that reduces alkalinity. And organic matter encourages sulfur oxidation, which further illustrates the importance organic matter plays in soil management practices. A light, sandy soil—or one highly weathered—requires less amounts of soil amendment to lower or raise pH than heavy clay soils or soils high in organic content. Usually gardeners use either too much or too little lime: at Cornell University several hundred home gardens were analyzed: one-third had too much lime, one-third had too little, and one-third were just right.



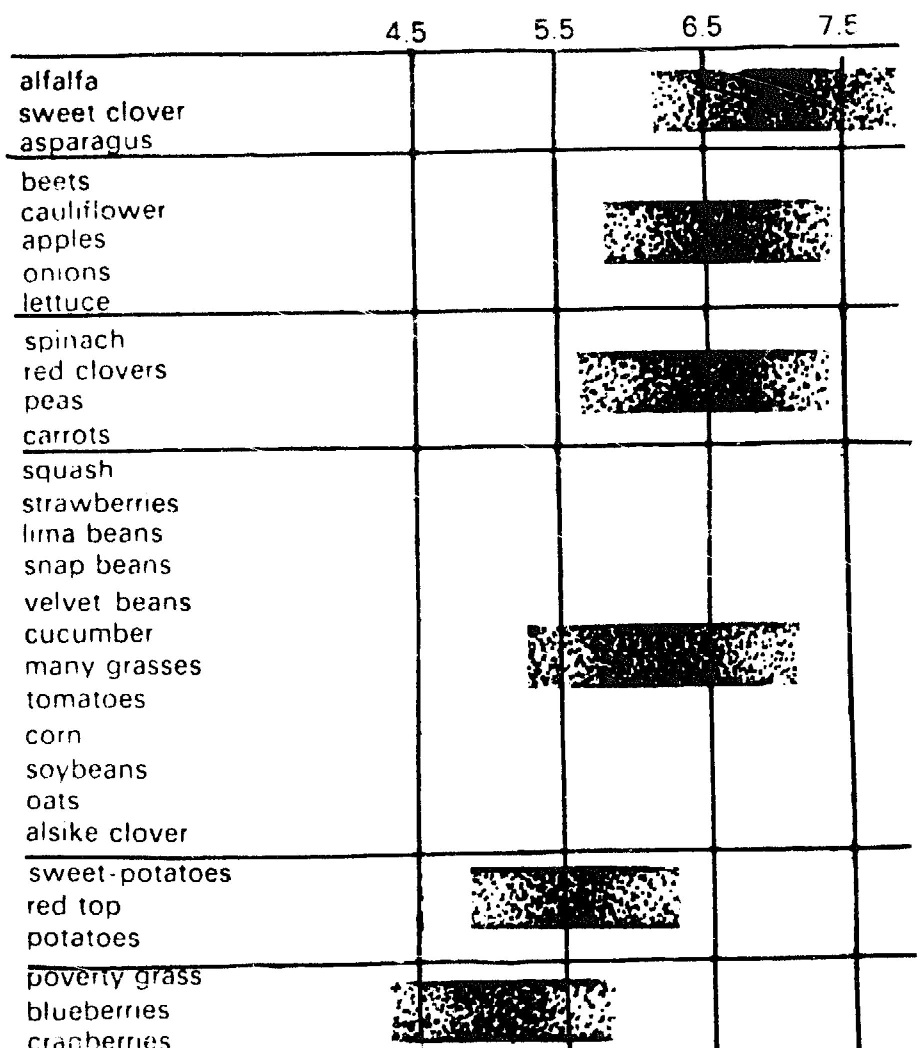
NUTRIENT AVAILABILITY AT VARIOUS pH RANGES
(FROM STUDY MADE AT VIRGINIA POLYTECHNIC INST.)

Most states have agricultural experiment stations and extension services which will test one's soil for lime and fertilizer requirements. Or one may prefer to do his own testing, using an inexpensive soil-test kit. Purdue University makes the best deal for a soil and plant tissue test kit: a complete setup for $13.75.

Soil for testing should be taken 6 inches deep, where most crop roots live. It is important to keep soil moist several days before testing as drought affects pH by killing bacteria. Also a cold soil inactivates bacteria: so, in order to get a fair pH reading, test warm, moist soil. When using the kit to test for mineral requirements, remember that the availability of soil nutrients varies from day to day and from season to season. In the early spring, for instance, nitrogen is taken up by soil organisms, so on this basis a false reading will be made. Also a single soil sample would not necessarily be typical of the whole homestead. A farm usually has from 3 to 6 types of soils—there are tens of thousands different soil types in the U.S.

Actually, to classify soils into "types"—like Chernogen, Podzol, Prairie, etc.—is rather misleading as well as being unimportant. In the early farming days, before the destruction of topsoil and humus by bad farm practices, soils were made up of thick, black layers of organic matter. And in this respect the part of the soil that was important was the same as any other soil. It is only since denuding the soil of this black mantle that the underlying sandwich layers became discernible and classifiable.

The most important thing that one should know about the soil he works with is the *texture* of the soil aggregations. That is, whether it is of clay, silt, sand, or gravel texture. As noted in the previous chapter on water management, water percolates rapidly through light sandy soils. Clay soils have greater water storage capacity. Also, and more to our interests here, the finer the texture a soil possesses the more nutrients are available. Fine clay aggregations provide more clinging surfaces whereas in sandy soils water and nutrients are easily leached away. The sandier the soil, the less organic matter it contains. On this type of soil it is imperative to build up humus content so that the filamentous and gelatinous residues of crop refuse will fill up spaces around sand particles and thereby overcome excessive drainage and leaching—and the rapid conversion of organic matter into carbon dioxide and water.



SUITABLE pH RANGE FOR CERTAIN PLANTS

Inasmuch as soil is created primarily by the growth of plants, the best soil improvement method is to *grow crops.* A soil aggregation of heavy clay or silt particles can therefore best be lightened or made more friable by growing weeds or green manures. A green manure is a crop grown and returned to the soil for purposes of improving the soil. Besides the surface mulch that is made available, roots from green manure crops penetrate deep. When they die and decompose a water conduit is provided through which excess water can drain from the clay subsoil, and down which the roots of the next crop can grow more easily.

Extremely poor, eroded, and structureless soil can be made productive by using green manuring principles: first apply necessary lime; then commercial nitrate fertilizer; then turn the land to weeds. The weeds will thrive on the applied nutrients and penetrate the subsoil with their highly developed root systems. Mineral nutrients will be brought to the surface through the roots of these weeds. Some grasses and legumes will thrive on poor soils; for instance, buckwheat, rye, lespedeza, and sweet clover.

There are other farming practices, crop rotation for instance, which improve soil structure. A discussion of these principles brings us to the subject content of the next three chapters on Plant Management, so basic concepts only will be listed:

1) Legume crops are grown to promote the fixation of nitrogen from the air.

2) Perennial grasses, in a grass arable pasture system, are grown to supply a constant source of humus.

3) The alternation of deep and shallow rooted crops prevents continual absorption of nutrients from the same zone.

4) Deep rooted plants (like alfalfa) improve subsoil structure when roots decay.

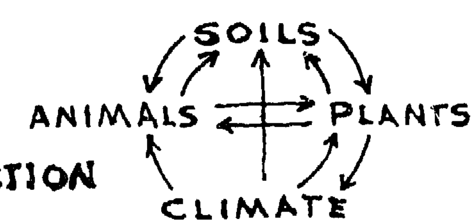
5) Keep a cover crop growing during winter months for protection against wind and rain. Always remember: let the surface of the soil wear a beard.

6) Grow green manure crops between regular growing seasons for producing organic matter.

Admittedly, this chapter on soil management fails to even mention some of the issues which are considered paramount in most textbook treatments on the subject. This is not an oversight on the part of the author: only that material which is pertinent to the development and maintenance of soil structure has been considered at this time

	SOIL	PROFILE	NATIVE VEGETATION	CLIMATE	NATURAL FERTILITY	DOMINANT AGRICULTURE
PEDOCAL (ARID REGIONS)	CHERNOZEM	2-4 FT. BLACK-SOIL TO WHITISH CALCAREOUS HORIZON	TALL-GRASS PRAIRIE	TEMPERATE TO SUB-HUMID	VERY HIGH	WHEAT - CORN
	CHESTNUT	1-3 FT. DARK BROWN TO WHITISH CALCAREOUS HORIZON	MIXED TALL & SHORT-GRASS PRAIRIE	TEMPERATE ARID	HIGH	WHEAT - GRAZING
	BROWN	1-2 FT. BROWN TO WHITISH CALCAREOUS HORIZON	SHORT-GRASS PRAIRIE	TEMPERATE ARID	HIGH	WHEAT - EXTENSIVE DRY-LAND FARMS LIMITED CROPS
	SIEROZEM	1 FT GRAYISH GRADING INTO LIGHT COLORED CALCAREOUS HORIZON	SHORT-GRASS & DESERT PLANTS	TEMPERATE ARID	MEDIUM	GRAZING
	DESERT	GRAYISH SOIL	DESERT PLANTS	TEMPERATE ARID	MEDIUM	GRAZING
PEDALFER (HUMID REGIONS)	PODSOL	GRAY LEACHED SOIL OVER DARK-BROWN HORIZON	CONIFEROUS FOREST	COOL MOIST	LOW	SMALL FARMS WIDE VARIETY CROPS & LIVESTOCK HAY & PASTURE
	GREY-BROWN	GRAY-BROWN LEACHED OVER BROWN HORIZON	DECIDUOUS FOREST	COOL MOIST	MEDIUM	SMALL FARMS WIDE VARIETY CROPS & LIVESTOCK CORN - WHEAT - SOY BEANS
	PRAIRIE	3-5 FT VERY DARK BROWN TO LIGHT PARENT HORIZON	TALL-GRASS PRAIRIE	TEMPERATE MOIST	HIGH	SMALL FARMS MUCH LIVESTOCK CORN - WHEAT SOYBEANS
	YELLOW	GRAY - YELLOW SOIL OVER YELLOW HORIZON	FOREST (CONIFEROUS)	WARM MOIST	LOW	SMALL FARMS TRUCK & FRUIT TOBACCO - COTTON
	RED	YELLOW - BROWN SOIL OVER DEEP-RED HORIZON	FOREST (DECIDUOUS)	WARM MOIST	MEDIUM	SMALL FARMS WIDE CHOICE CROPS

ENVIRONMENTAL INTERACTION

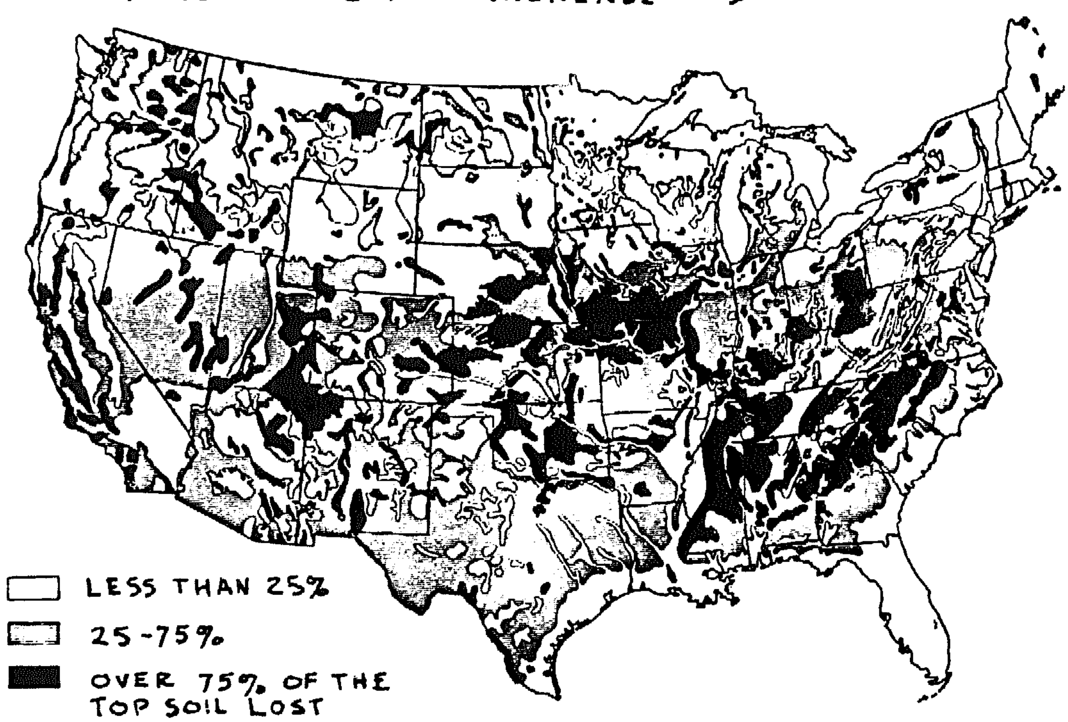


CORRELATION BETWEEN CLIMATE - VEGETATION - SOILS

ARID DESERT SHRUBS AND GRASSES			
TROPICAL DRY	WARM DRY		COOL DRY
LIGHT COLORED DESERT SOILS			
SEMI-ARID SHORT GRASSLANDS			
TROPICAL DRY	WARM DRY		COOL DRY
	BROWN SOILS		
SUB-HUMID TALL GRASSLANDS			
TROPICAL	WARM		COOL
BLACK PRAIRIE & CHERNOZEM SOILS			
HUMID FORESTS			
TROPICAL WET	WARM HUMID		COOL HUMID
RED SOILS	YELLOW	GREY-BROWN	PODSOLS
WET RAIN FORESTS			
TROPICAL WET	WARM HUMID		COOL HUMID
RED SOILS	YELLOW	GREY-BROWN	PODSOLS

TEMPERATURE INCREASE →

PRECIPITATION INCREASE →



GENERAL SOIL EROSION

Plant Management – Sod Crop

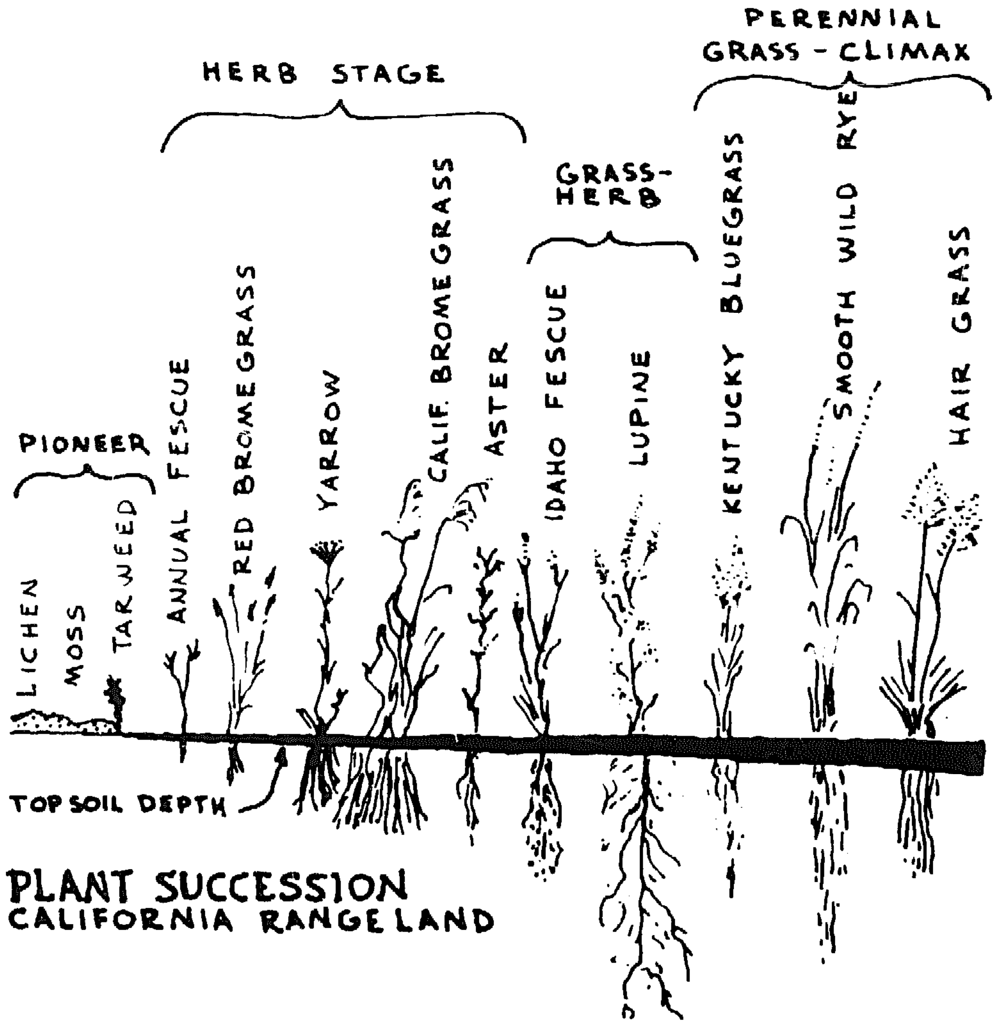
Sod cropping as defined in this chapter is a *balanced* method of farming which permits maximum output of soil resources while at the same time maintaining and improving them. It is a method that contrasts with *Row Cropping* (the subject content of the following chapter) in that sod cropping is basic to water and soil conservation, and essential–in rotation–for the maintenance of high level row crop production.

Without question, sod crops are the most important underdeveloped agricultural resource in the world today. This is true in spite of the fact that they have been around a long time: improved varieties such as alfalfa were known to the Persians and Romans before the time of Christ; clovers were grown in northern Europe in A.D. 800. There are at present 5,000 species of sod grasses in the world, and 1,500 of these are found in the U.S. This number does not include the hundreds of "natives" and weed varieties which agriculturalists refuse to include as economic to American farming practice.

Due to the numbers involved, it is with some difficulty that we attempt a classification of sod cropping. Some crops are grown annually, some in rotation, and some permanently. Of the annuals, there are warm season and cool season varieties. Grasses are grown in companionship with other grasses or with legumes. And every plant species has an optimum soil and climate requirement. A high-producing sod crop may prove to be valueless on poor soil. And conversely, a sod crop considered undesirable in a productive soil-and-climatic-environment, may be highly regarded on a less desirable site: palatable short grasses like buffalo blue grama, silver bluestem, and sand dropseed are not grown to advantage on fertile sites.

Plant ecologists present the clearest perception of optimum plant development in the presentation of the *Climax Growth* concept. We are told that there is a subtle response between plants and changes in the environment. Individual plants become more abundant or less abundant in a community, depending upon soil and climate factors. One species is gradually replaced by another higher and more adapted variety, until finally vegetation attains the climax form characteristic of the soil and climate. This is a good explanation of why a climax sod crop is the only important soil builder of any consequence. When a native sod is plowed and put into row-crop production, a climax has been destroyed but the soil remains productive for many years. When this happens in a humid forest situation the soil becomes unproductive after a few short years of cultivation; the wider spacing of trees offers little root development and soil-aggregation buildup.

A sod growth, however, reaches climax as more and more topsoil is formed and accumulated. Each succession contributes to the next higher plant development. An example of California rangeland climax is illustrated below.



PLANT SUCCESSION
CALIFORNIA RANGELAND

Climax succession is also apparent when overgrazed or cultivated land is abandoned and sod crops allowed to return: first, *annual weeds* (crab grass, pigweed, Russian thistle) appear; then so-called *poverty grasses* (wire grass, broom sedge) replace the native weeds; as the organic content of the soil increases, poverty grasses get so thick they cannot withstand their own competition. Thus, *short-lived perennials* like bunch grass appear and progress, finally, to semi-climax and climax grasses native to the region.

The importance that weeds play in this succession cannot be overstated. Weeds condition the soil; their vigorous root system opens up the soil, fiberizes it, and enlarges the feeding zone for the benefit of succeeding plants. Grass will return and thrive in a pasture situation only when weeds have first prepared the way; grass has the power to disperse the weeds once the environmental conditions are right.

The director of the Rocky Mountain Forest and Range Experiment Station, Dr. David Costello, studied the value of weeds on the western range. He found that weeds, surprisingly, made up the greater portion of cattle diet. Furthermore, perennial weeds and shrubs were found to have a higher crude protein content than native grasses. From Dr. Costello's research we deduce that low-protein grass pastures would best be grazed in summer when food values are highest. Superior pasture–containing abundant weeds and shrubs–should be grazed in late summer, fall and winter when the food value of grass is low. The nutrient value of standing grass herbage drops during fall and winter, because at that time nutrients drain back into the root zone, whereas the food value of browse plants remains high.

It was the Swiss dairymen who first demonstrated the value of harvesting *immature* forage. Alfalfa cut at a pre-bloom state has 28% protein and 12% mineral content; at full bloom it contains only 13% protein and 8% mineral. The Swiss also showed that grass under continuously heavy grazing is more nutritious than under light grazing. Frequent cutting promotes a continuous production of young, nutritious shoots. Young forage is more digestible and palatable as well.

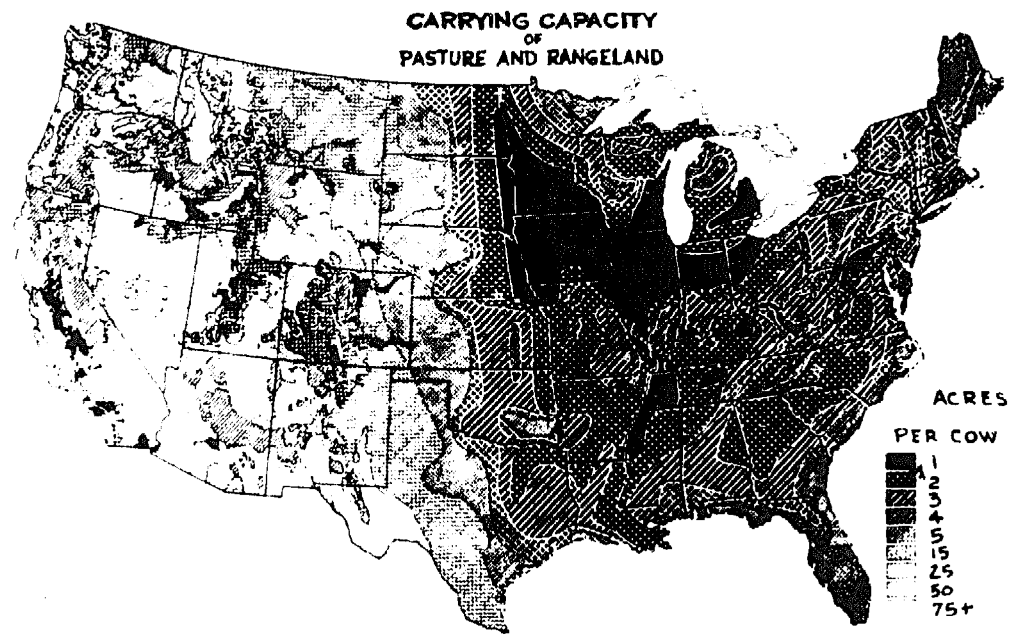
I will show in the following chapter on row crops how their value depends primarily upon nitrogen and vitamin content. Now, except for the legume family, sod crops cannot accumulate large quantities of nitrogen. So it makes good agricultural sense to follow a sod crop (grass-legume mixture) with row crops (vegetables). This form of alternate husbandry is called *Ley Farming,* and it involves the full fertility cycle of crop-soil-animal relationship. A three-year sod cropping program rotates with a three-year row cropping. Ley farming becomes a rather good substitute for *green manuring* which may require a plowing under of the sod culture for possible soil enrichment.

Although it takes about seven acres of sod crops to equal the production of one acre of row crops, the nutrients supplied cost a fraction of the amount as that of row crops. The Bureau of Dairy Industry (USDA) made a four-year study of the relative cost of producing 100 pounds of totally digestible nutrients. It was found that the return from pasture crops per man-hour-labor is six times more than from corn, and ten times more than from barley.

And there is one other important sod-cropping statistic–this time provided by the Missouri Agricultural Research Station: on a land slope of three degrees, continuously cultivated soil erodes seven inches in 24 years; seven inches of continuously grown corn soil is eroded in 50 years; seven inches of continuously grown wheat soil is eroded in 100 years. But under continuously grown sod pasture it would take 3,000 years to erode seven inches of soil! It is little wonder that advocates of *permanent pasture* are so enthusiastic. Certainly every homestead would do well to include at least one permanent pasture. This pasture may be grown in companion with scattered tree crops as is often the case in southern forests of longleaf pine growing in open stands with an understory of sod crops. Most sod crops grow best and produce a higher protein level when grown in partial shade.

Although the major portion of permanent sod crops consists of perennial (self-seeding), and long-lived annuals, it may also include short-lived, aggressive and rapidly establishing species as Italian ryegrass. There is no hard-and-fast rule for determining optimum sod mixtures. Agriculturalists at one extreme favor "shotgun mixtures", the indiscriminate mixture of up to a dozen different species. Other experts advocate a two-seed, grass/legume mix. Somewhere between these extremes lies essential, sod-growing knowledge usable by the small homesteader.

A well-balanced pasture community is analogous to well-made concrete: various plants combine to form a dense ground cover in the same way that sand and cement fill porous spaces around coarse aggregates. An example is the way broomgrass fills in around alfalfa, and ladino clover fills in around orchardgrass.



Since the time of George Washington ("Orchardgrass of all others is in my opinion the best mixture with clover") farmers knew that grass and legumes should be grown together. If grass is grown without a legume companion, nitrogen soil deficiency is likely and the crop will contain excessive energy-giving carbohydrates at the expense of mineral and protein content. If a legume pasture is seeded without a grass companion, more nitrogen becomes available than required; volunteer grasses and weeds will soon invade the legume. So in general it is prudent to sow half grass and half legume in a sod crop mixture. As mentioned in the previous chapter, legumes alone are able to obtain nitrogen from the atmosphere. Nitrogen is "fixed" by symbiotic bacteria which live in nodules on their roots. This is the reason why legumes are less sensitive than grasses to the level of nitrogen *in the soil.*

It has been found that the presence of a legume in a sod culture increases the protein content of the companion grass. Corn, for instance, that is grown with soybeans has twice the nitrogen content. The protein content of timothy hay can be increased by growing it with alfalfa. Grass also grows at a *faster rate* when a companion crop of legume is present. The yield of a grass crop can be doubled when red clover is included in the sod mixture.

Seed mixtures and proportions must be determined with great care. A choice is influenced more by soil and climate than any other factor. Temperature, soil moisture, latitude, altitude, soil pH and rainfall are main considerations. Alfalfa does poorly on wet undrained soils where alsike clover thrives. Studies at the Wisconsin Experiment Station show that an acre of bromegrass/alfalfa mixture provides as much pasturage as 2½ acres of bluegrass. With an oat/soybean mixture, only the oats germinate and grow; an oat/field pea mixture, however, gives a balanced crop. Bromegrass matures early and crowds out red clover; timothy matures too late to make a satisfactory stand with alfalfa. But bromegrass/alfalfa and timothy/red clover are excellent mixtures.

The best companion crop is the one that gives the least competition . . . grass and legume mixtures should produce together for best results. One naturally wishes to extend the grazing season to as much of a year-round program as possible. To do this it may be necessary to have two or more separate pastures—one for cool season sod crops, and one for warm season sod crops. Warm season crops begin growth in late spring, with most growth during the summer. Cool season crops are seeded in the winter and start growth early the following spring. A dormant period occurs here in midsummer, but growth resumes in early fall.

For some unexplainable reason sod crop seeds give greater yields when they have undergone a freezing action to break their dormancy period. So it is preferable to broadcast seed by hand or with the use of a hand-operated whirlwind seeder (e.g., Cyclone Seeder) in the early winter . . . seed that falls on the ground will be covered by the freezing and thawing action throughout the winter months. This dispenses with expensive seed-drilling equipment and springtime tractor compaction of the soil.

Mulch planting is as important to sod cropping as it is to tree and row cropping. Nothing will do more to insure a successful sod crop than a light mulch applied at the time of seeding. Mulch conserves surface moisture and delays seed germination until the soil is sufficiently warm. It also protects seedlings from excessive wind and sun and unwanted plant competition.

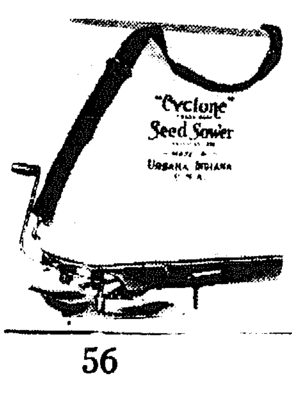
A properly managed sod crop program requires no tillage, no fertilization, no burning. One can begin his pasture operation with a luxurious stand of tall weeds and brush. A mowing machine or stalk shredder is first used to cut or beat up and scatter top growth. Sod crop seeding is done directly in the remaining stubble. The heavy trash covering on the ground is highly desirable, and the tall stubble helps to protect young seedlings. Stubble offers no competition to young sod crops for moisture and soil nutrients.

Mowing is the one *essential* management practice for successful sod cropping. It satisfies a number of necessary sod culture practices by (1) allowing tough parts of the plant to decompose, thereby improving soil structure; (2) making hay or silage from clippings; (3) providing uniformity of grazing and consequently greater total production and (4) maintaining an immature and more nutritious stage of growth. Cease mowing activities in early fall so good ground cover can grow for fall and early winter grazing, and so that the sod crop can be into the winter dormant season with plenty of growth left.

There is one important rule to remember when mowing or grazing sod crops: TAKE HALF AND LEAVE HALF. Overgrazing is to be deplored. A plant's food manufacturing ability should be constantly maintained.

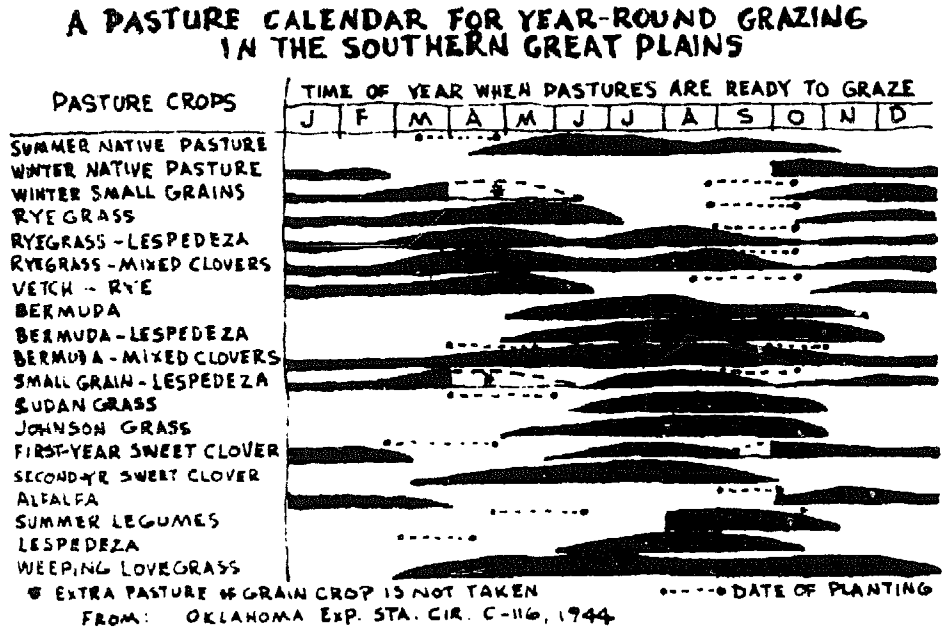
The goal of any serious pasture program is one of providing for year-round grazing. This is obviously possible in milder or moister climates, but requires concentrated planning in places where the ground remains frozen or covered with snow much of the winter. Pastures are rarely productive for more than a few months at a time, so in northern climates two or more permanent pastures and perhaps several fields for raising supplementary feeds are required to "weather through" grazing stock. In some cases it may be advisable to incorporate *ration grazing:* a small strip of pasture is cut off from the main field each day. A movable electric fence is customarily used to ration the food.

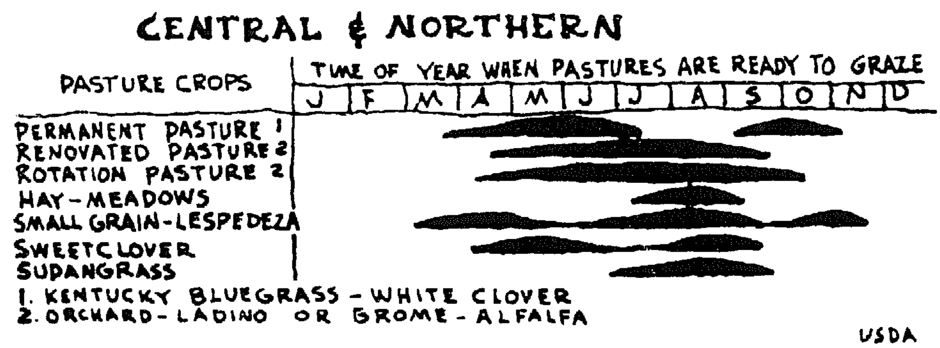
MULCH PLANTING WITH HOWARD ROTACASTER
HOWARD ROTAVATOR CO. BOX 100 HARVARD, ILL.

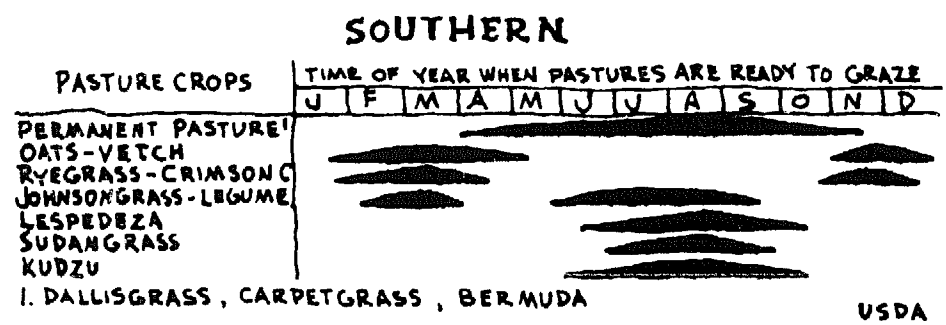


- DIRECT SEEDING (MADE IN FRANCE & ENGLAND)
- MINIMUM COMPACTION
- MINIMUM MOISTURE LOSS
- 2½ ACRES/HR W/ 65 H.P. TRACTOR

CYCLONE BROADCAST SEED SOWER
ACCURATE DISTRIBUTION – ½ BU. CAP.
FROM: FORESTRY SUPPLY, JACKSON, MISS.







Modern agribusiness methods for animal feeding limit the animal to a "dry lot" situation, with sod crops harvested and brought to the animals throughout the year. It makes little sense for the small homesteader to grow, harvest, haul, process, store and then ration feed for his animals when the animal can provide these functions in a more comfortable and sanitary manner out in the pasture. And it has already been pointed out that the dry matter or immature sod crops are higher in protein and nutrients and more palatable than dry matter from mature crops harvested for hay or silage. Research at the Virginia Agricultural Experiment Station shows that the nutrient yield of pasture is 50% greater than for the same crops that were allowed to mature and then cut for hay. Let the animal harvest its own food—and let it spread its own manure.

DEPTH OF SEEDING SOD CROPS IN RELATION TO EMERGENCE OF SEEDLINGS – J. AM. SOC. AGROM. '43

PERCENTAGE EMERGENCE OF VIABLE SEED AFTER 25 DAYS WHEN PLACED AT DEPTHS OF:

CROP	0	1/4"	1/2"	1"	0	1/4"	1/2"	1"
	NOT MULCHED				MULCHED 1T./ACRE			
ALFALFA	42	75	63	48	76	85	82	73
RED CLOVER	40	44	39	25	74	85	86	70
ALSIKE "	39	21	22	7	70	91	91	46
LESPEDEZA	48	88	82	33	70	96	92	66
ORCHARDGRASS	37	58	59	40	78	95	86	69
TIMOTHY	30	46	27	3	49	70	68	23

AVERAGE AMOUNT OF NITROGEN FIXED/ACRE

ALFALFA	194#
SWEET CLOVER	119
KUDZU	107
LESPEDEZA	85
VETCH	80
PEAS	72
SOYBEANS	58
PEANUTS	42
BEANS	40

COST OF PRODUCING 100# TOTAL DIGESTIBLE NUTRIENTS

PASTURE	250 DAYS	.29
ALFALFA HAY	4.7 TON	.49
CORN SILAGE	13.7 T.	.91
GRASS SILAGE	13. T.	1.17
OATS	66 BU.	1.19
CORN	63 BU.	1.29
BARLEY	40 BU	1.40

U.S.D.A.

FOOD VALUES

	IN PERCENT CALCIUM	PROTEIN	FAT
PERENNIAL NATIVE GRASSES			
SUMMER	.394	9.01	2.67
WINTER	.363	3.71	2.04
ANNUAL	.381	6.36	2.35
PALATABLE WEEDS			
SUMMER	.480	9.82	2.89
WINTER	.499	6.22	2.34
ANNUAL	.490	8.02	2.62
SHRUBS			
SUMMER	.848	12.08	7.36
WINTER	.956	6.75	4.81
ANNUAL	.952	9.42	6.09

OKLA. EXP. STA. 1947

There is a final consideration in increasing the productiveness of sod crop pasturage: graze several combinations of animals on it simultaneously. Sheep and dairy cows do well on a pasture together; sheep will eat weeds and other plants refused by cows, and plants not required for high milk production. Goats tend to favor types of woody vegetation and are valuable in keeping brush from overtaking a pasture. It is a good practice to let beef cattle and hogs pasture together; hogs eat much of the vegetation overlooked or wasted by cattle.

At these northern regions where some form of winter feed supplement must be provided for, one has the choice of storing feed by drying or by silage. Each process has its pros and cons, so the best approach here is merely to acquaint the homesteader with some of the problems and prospects inherent in each method.

Hay-making involves mowing the crop, raking it into windrows, bailing or bunching, curing, loading, transporting and storing. As mentioned earlier, these processes exact about 50% of the nutrient value from the original crop. And if it rains during the haymaking process, molds may develop and plant nutrients may leach to lower the nutrient value even more. If the moisture content of hay is high at the time of storage (above 30%) heat will be generated during the time of storage. This heat destroys carotene and sometimes causes spontaneous ignition.

The loss of carotene in field-cured hay has stimulated agricultural research toward improved curing processes. One such method of "barn curing" has been developed by the Virginia Experiment Station, with similar solutions proposed by the Tennessee Agricultural Experiment Station and T.V.A. Partially dried hay is placed over a duct system and hot air is forced out through the hay. Three to four times the amount of carotene is retained using this system of barn curing.

Despite the nutrient losses associated with hay-making, the small homesteader may still find it the most practical method for providing supplemental feed. For one thing the investment in equipment required to process loose hay is minimal. With a full mechanized setup, a ton of hay can be processed and stored by one man in two hours; with hand labor the same man can process and store a ton of hay in six hours. A mowing machine need be the only mechanical equipment required. Hand pitching hay onto a four-wheel trailer is fast and gratifying work. And unloading into a hay loft can be done with a small investment in power forks or slings.

Ensiling sod crops requires much more equipment and expensive storage facilities, though the storage size can be reduced considerably. Loose hay takes four times and baled hay two times as much space as an equivalent amount of dry matter in silage. Silage is not a new process: the Romans knew that crops could be preserved by excluding air. As chopped sod crops are placed in airtight silos, air is driven out by the settling and compaction of the crop. Fermentation takes place as oxygen is replaced by carbon dioxide. Natural carbohydrates are reduced to acids (lactic and acetic) by microbial action. After the oxygen is eliminated silage will keep almost indefinitely. For this reason it is important to force all air pockets out as the silo becomes filled.

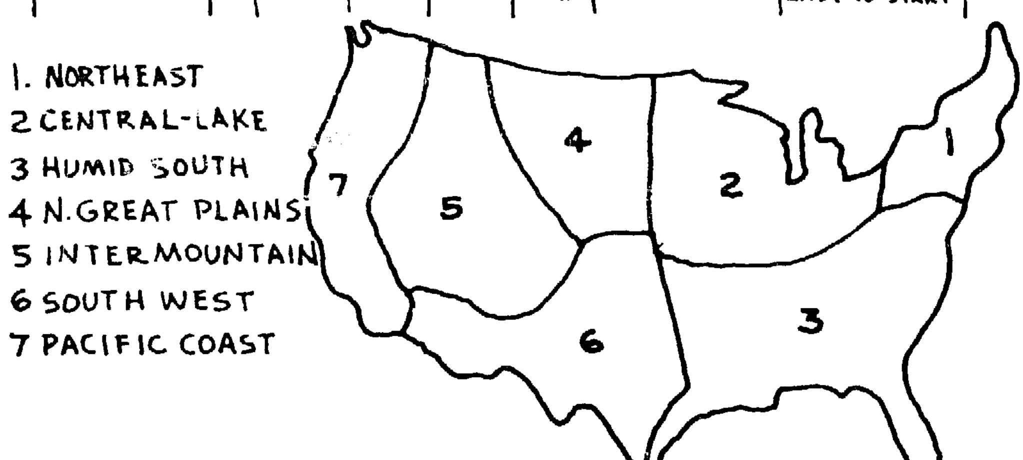
A final understanding of sod cropping can be gained from a thorough study of the chart with this section.

SOD CROP INFORMATION

A = ANNUAL
P = PERENNIAL

H = HAY P = PASTURE
S = SOIL BUILDING

	NAME	TYPE	REGION	VALUE	SEED	GRAZE	SOIL	REMARKS	USE
P	ALFALFA	LG.	1234567	VERY HIGH	FALL-SPRING	SPRING FALL	NOT WET OR ACID	DANGER OF BLOAT	H.P.
P	ALSIKE CL.	LG	12345	VERY HIGH	FALL-E. SPG.	E. SPG & FALL	WET, ACID, HEAVY O.K.	SEED TOP FROZEN GR.	HP
P	BAHIA	GR.	3	HIGH	E. SPG.	E. SPG L. FALL	SANDY SLOPING OK	SEED EXPENSIVE LOW GERM.	PS
P	BERMUDA	GR.	36	AVER.	E. SPG	L. SPG E. FALL	LOAM, CLAY SILT	SOD TRANSPLANT	PS
P	BROME	GR	12345	HIGH	E. SPG L. FALL	E. SPG L. FALL	ANY TYPE	ORCHARD, VINES DROUGHT RES.	HP S
P	BLUE STEM	GR	45	HIGH	E. SPG	SPRING	ANY TYPE	DRY LAND RANGE	HP S
A	BUR CLOVER	LG	37	HIGH	LATE SUMMER	FALL-SPG	WELL DRAIN ANY TYPE	RESEEDS	PS
P	CARPET	GR	3	AVER.	E. SPG	SPRING-FALL	MOIST-SANDY	TIGHT TURF	PS
P	GRAMA	GR	45	HIGH	SPRING	LA. SPG-SUM.	DROUGHT RES. ANY TYPE	ERODED RANGE ALKALINE	PS
P	JOHNSON	GR	3	HIGH	E. SPG	SPRING-FALL	LOAM-CLAY	DROUGHT RES.	PH
P	KEN. BLUE G.	GR	12	HIGH	E. FALL	SPRING L. FALL	SANDY LOAM-CLAY	LEADING PASTURE GR.	PS
P	KUDZU	LG	3	HIGH	SPRING	L. FALL	NEEDS GOOD SOIL	GULLY, SLOPE WOODS	PS H
P	LADINO	LG	123	VERY HIGH	FALL	SPRING-FALL	WELL-DRAINED	PREVENT HEAVY GRAZING	P
A	LESPEDEZA	LG	3	HIGH	E. SPG	E. SUM TO FALL	WELL-DRAINED	FATTENING PASTURE	HP
P	MEADOW FES.	GR	1	HIGH	E. FALL	E. SPG L. FALL	LOAMS TO HEAVY CLAY	DISAPPEARS RAPIDLY	P
P	ORCHARD	GR	123456	AVER	E. FALL E. SPG	E. SPG FALL	ANY TYPE	GROWS IN BUNCHES	P
A	SUDAN	GR	1234567	HIGH	L. SPG	SPRING	ANY TYPE	DROUGHT RES	PH
A	SOYBEANS	LG	23	HIGH	SPRING		ANY TYPE	GOOD HAY	HP
P	TIMOTHY	GR	124	HIGH	E. FALL E. SPG	E. SPG L. FALL	ANY TYPE EXCEPT SAND	QUICK GROW NOT PERM.	PH
BA	RED CLOVER	LG	12345	VERY HIGH	E SPG L. WIN	E. SPG FALL	ACID OK. ANY TYPE		HP
P	TREFOIL	LG	13	VERY HIGH	E. SPG	E. SPG L. FALL	WET OK.	GOOD WITH KEN. BLUE GR.	HP
P	RYE	GR	1245	HIGH	E. FALL	E SPG L. FALL	SANDY LOAM TO CLAY	LITTLE USED	HP
A	VETCH	LG	3	HIGH	FALL SPRING	E. SPG	LIGHT SOILS		PS
P	WHEAT	GR	45	HIGH	E. SPG	E. SPG L. FALL	ANY TYPE	DROUGHT RES EASY TO START	P



Plant Management - Row Crop

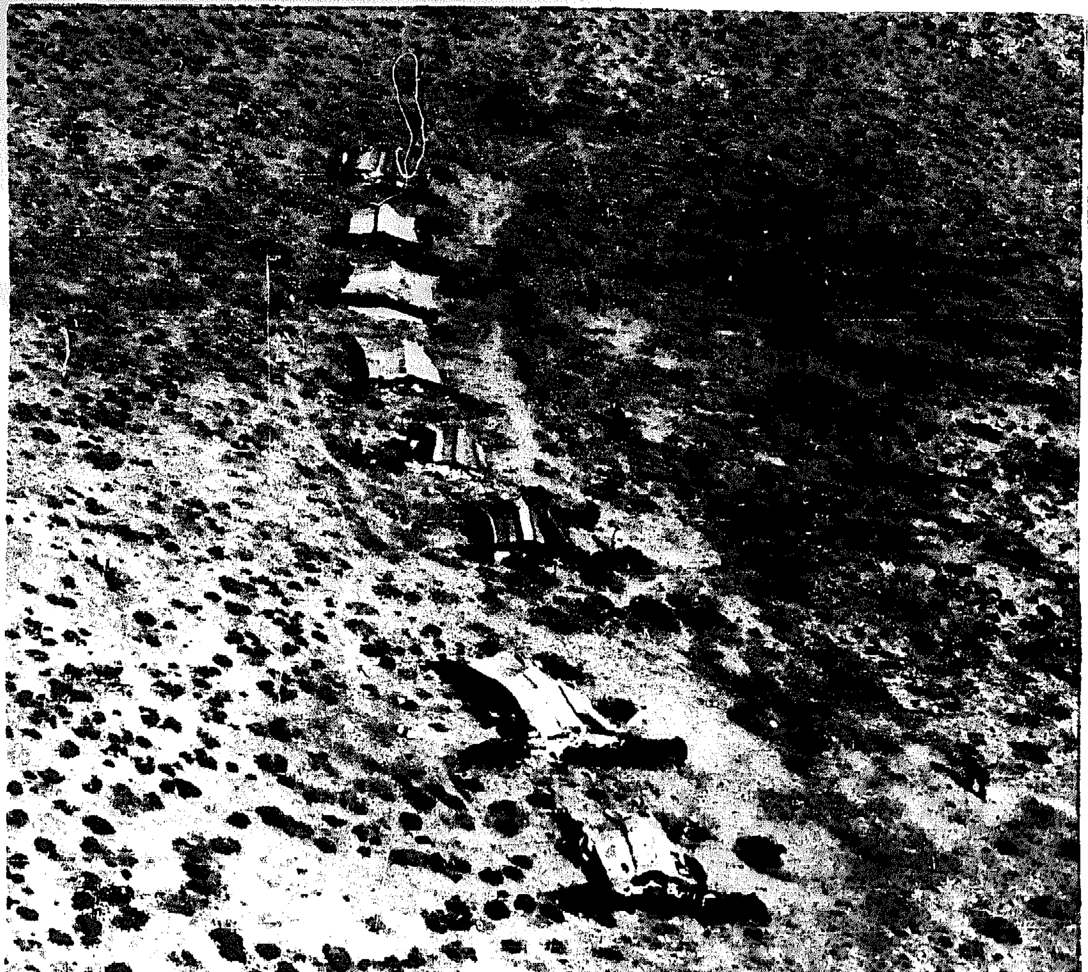
You ask me to plough the ground. Shall I take a knife and tear my mother's bosom? Then when I die she will not take me to her bosom to rest. You ask me to dig for stones! Shall I dig under her skin for bones? Then when I die I cannot enter her body to be born again. You ask me to cut grass and make hay and sell it and be rich like white men. But how dare I cut my mother's hair?

Nevada Chief Smohalla's reply to agricultural directives from Washington

The photo on the following page was taken by Richard St. Barbe Baker, leader of the 1952 Sahara University Expedition. It is an aerial view of a Bedouin encampment in the Libyan Desert. In better times this land was heavily forested, later to be cleared and tilled to provide grain for Rome. As Mr. Baker observes, "An iron plow is a dangerous implement, because it loosens the earth to a considerable depth, allowing the soil to be washed away in the first torrential downpour." In equatorial regions, especially, the clearing away of extensive areas for the production of row crops, such as corn or cotton, leads to certain disaster . . . even to the decline and fall of otherwise thriving civilizations.

Actually there is only *one* remaining ancient row-crop-based civilization: the Chinese. This fact rather impressed a University of Wisconsin soil scientist. In 1910 Professor F.H. King determined to study firsthand the row crop farming methods of the Chinese. His delightful travel book, *FARMERS OF FORTY CENTURIES*, appeared the following year. In it King describes the tilling, fertilizing and planting techniques that have enabled survival (and even improvements in soil structure and fertility) throughout these many centuries. Even before his trip to the Orient, maverick King found little acceptance to his theories of *minimum tillage* . . . which he pronounced in 1890. When he later gave credence to the use of human excrement as a row crop fertilizer, his colleagues discredited him completely. Professor King was perhaps the foremost soil scientist of his time, and *FARMERS OF FORTY CENTURIES* is the most important book on food production . . . yet it is not even listed in the Department of Agriculture's bibliography of 500 important books on soil management (*SOILS AND MEN*, Yearbook, 1938).

Chinese row crop production methods are not presented here as the final word. Rather, their sensitive regard for *fertilizing, tillage* and *planting* establishes a neat basis for discussing pre-modern and post-modern row cropping techniques.

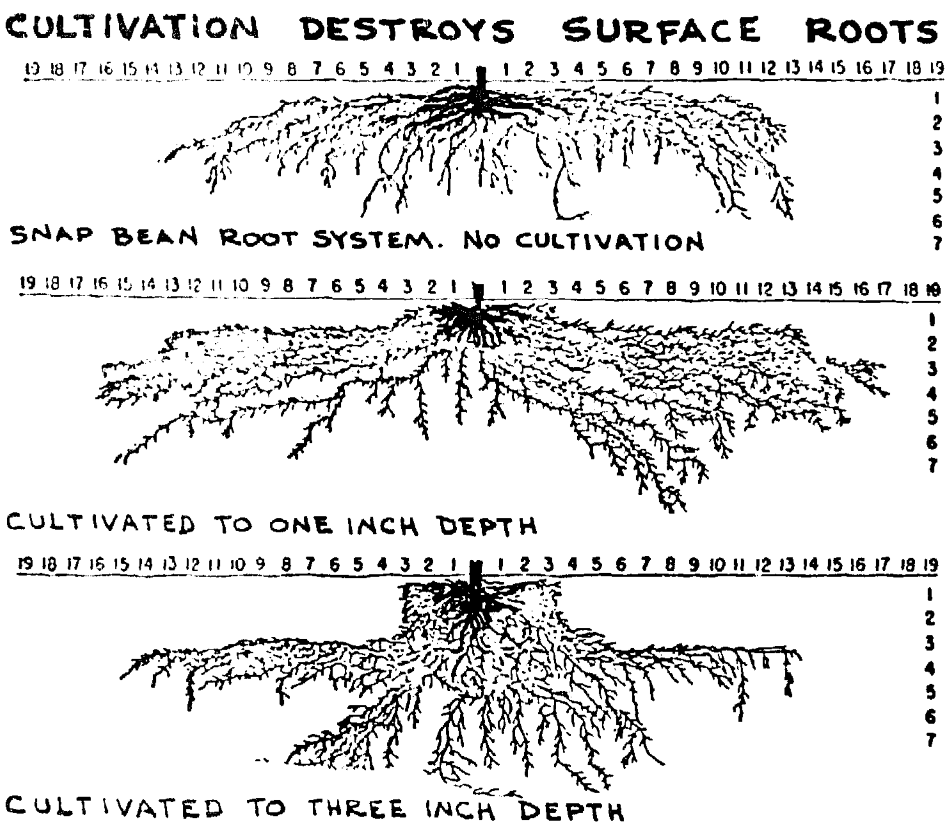


Traditionally, the Chinese till their row crops to a very minor extent. Mainly, they broadcast legumes such as soybeans or cereals among row crops . . . when the plants reach a few inches tall they are worked into the soil with a hoe. The Chinese realize that *young* green manures are best for feeding microbe populations. Soil will soon lose its crumb structure following the cultivation of annual crops, and must be replenished by a system which permits an accumulation in the soil of active humus capable of cementing the soil into crumbs. Instinctively, the Chinese had a concept of growing *space* which we would do well to understand and appreciate . . . one might call this space the *humosphere*, the vital, most active upper six-inches of the soil. It is in this zone that 80% of the organic matter is concentrated. Antibiotics are also produced in the humosphere by aerobiotic microorganisms, and tillage buries and asphyxiates these sensitive microbe populations.

There is also a substantial loss of nitrogen when the soil is tilled. The tillage process suffocates organic matter and at the same time introduces excessive oxidation into the soil structure. Ordinarily the oxidation process is slow . . . which allows the ammonium salts to produce an intermediate ammonium nitrate stage before finally breaking up into nitrogen and water. Ammonium nitrate is an unstable (even explosive!) substance and readily dissipated wasted to the atmosphere in conditions of excessive oxidation.

Professor Yarwood, plant pathologist at University of California, points out that the food production per unit area of land increases 6,000 times as a result of tillage. This is of course good news to agribusiness mentalities, who select crops specifically for big yields. But big yield production reduces the power of the plant to manufacture protein. Also, big crop yields reduce the protection against microbe and virus invasion. Yarwood mentions that of 20 fungal pathogens, 12 were more severe on tilled plants. Concurrent with increase in crop production since 1926, the number of recorded diseases of principal crops increased threefold. Yarwood counted 659 different diseases found in conventionally tilled crops, and 374 in untilled "native" plants.

In a few years, perhaps the concept of "zero tillage" will be more widely circulated throughout agricultural circles. Major advancements are now coming from England and Germany, for the development of new machinery and mulch-planting techniques. At the agricultural university in the Netherlands, a special "Tillage Department" has been formed to do research on herbicides and non-soil-compactive machinery. The Dutch reason that herbicides can very readily replace tillage, as the traditional purpose of plowing and cultivating is to eliminate competitive weed growth.



Most of the significant progress in zero tillage has been done during wartime . . . when power sources are low and food requirements high. The Spanish-American War no doubt influenced Professor King's minimum tillage approach. At the time of the First World War, Professor Hollack in Germany published his no-plow arguments the same way that Faulkner did in 1943 *(PLOWMAN'S FOLLY)*. A three-year research on minimum tillage was conducted during the early years of World War II at Rothansted Agricultural Station in England. And in Vienna, Viktor Schauberger made his claims against the plow that is moved at a fast rate through the soil. Electrical disturbances supposedly occur which destroy essential trace elements. The modern–peacetime–exponent of zero tillage is, of course, Ruth Stout. As with Faulkner, none of her books are even hinted at in scientific publications, due possibly to the frivolity of her presentation.

Ruth Stout has successfully popularized mulch planting among organic gardener circles. She also represents a viable–though nonscientific–position against the use of fertilizers and manures. Fertilization with mineral nutrients (NPK) is of course responsible for tremendous crop yields. But as Professor Yarwood reminds us, increased crop yields bring increased disease. A concentration of fertilizer is far less desirable than a minimum *balance* of nutrients. Excessive quantities of nitrogen, for instance, promote wilt disease by providing better nourishment for the parasite.

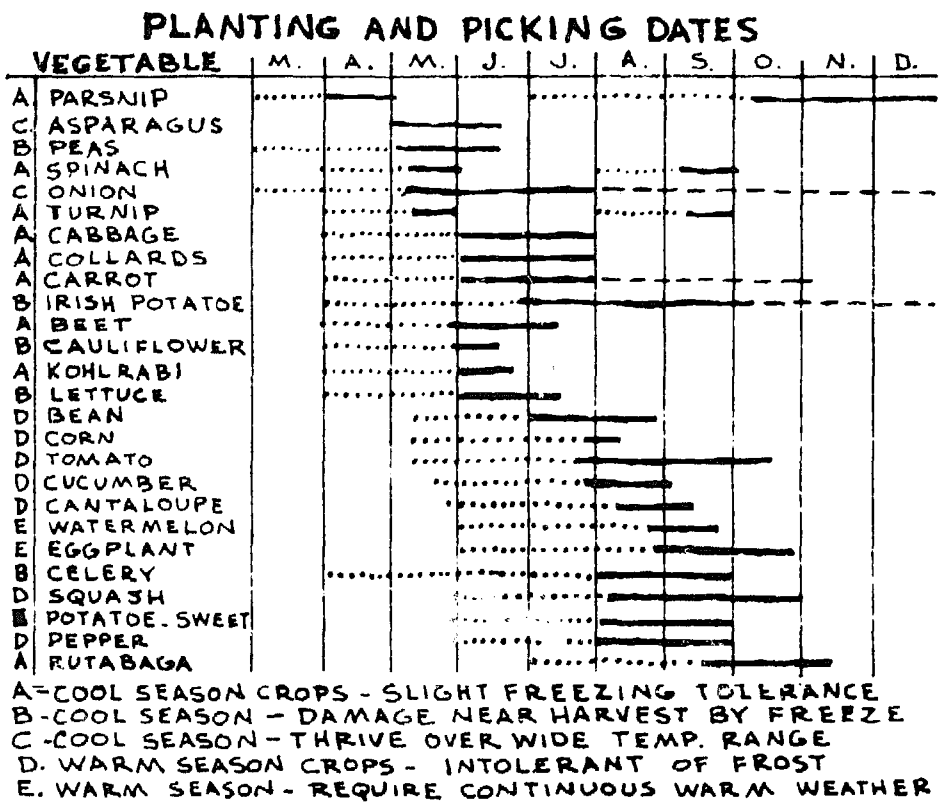
The value of manure as a mulch is far greater than as a fertilizer. The humus that manure supplies improves soil structure by increasing its capacity to take in and hold water. Soil moisture is retained by shading, the evaporation is minimized, aeration increased and the biological activities of microorganisms are augmented.

Professor King reports that the Chinese *manufacture* their fertilizers in the form of earth composts. Dwelling walls and floors and village walks are periodically dug up and composted for use in their fields and gardens. And, of course, the use of night soil is common throughout the Orient.

Intensive row crop planting techniques developed by the Chinese would be difficult to improve upon. They hold advanced concepts of intercropping, successive planting, rotation planting and companion growing. Basically, the Chinese believe that *diversification is fundamental.* Different crops are grown together, to permit the different root systems to thrive . . . the shallow feeders, deep feeders and intermediate-level feeders. Professor King noted that as many as three crops occupy the same field in successive rows, all in different stages of maturity. One field has a crop of winter wheat nearly mature, a crop of beans about two-thirds mature and a crop of cotton newly planted.

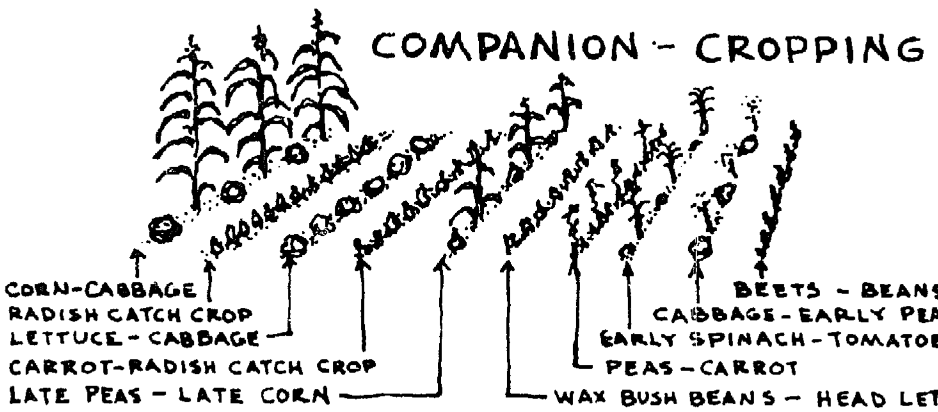
In some instances, intercropping is used when one crop is grown and cleared off the ground before the main crop requires the room to itself. Radishes or lettuce are often intercropped with carrots . . . the latter being the main crop. Endive can be sown three weeks prior to the main crop of cauliflower. An early, or incidental, crop is often referred to as a *catch crop.*

There are both "early" and "late" *varieties* of the same *species* of crop. Early means the crop matures in fewer days. And of course individual species of row crops mature at different times. Cabbage, for instance, requires 90 days where lettuce needs 50 days and radishes only 30 days. Many combinations of early-late plantings have been worked out: spring spinach followed by Brussels sprouts, beans or tomatoes; late peas followed by a late planting of corn; early peas followed by cabbage, tomatoes or by a planting of strawberries for next year's bed.



Chinese row crop production maintains a constant and even growth. Crops are sown successively, so they ripen as they are needed; and when a crop is harvested, another one is transplanted to take its place . . . a plant is never allowed to stop growing. The Chinese make good use of nursery beds . . . where winter and spring crops can be started a month or so earlier. Also, stronger and more uniform plants can be grown in a controlled nursery bed situation. A suggested companion cropping sequence is illustrated on the following page.

Rudolf-Steiner, founder of the bio-dynamic gardening approach, maintained that permanent *raised* beds increased the growth activity on their surface. His esoteric arguments for raised beds are not clear to me, but there are obvious practical advantages: such beds insure maximum use of the planting space. The first principle of intensive gardening is *uniformity of space.* Flats and frames should be built to an interchangeable module, so that they can be moved from any one part of the garden to any other part when needed. A four-foot-wide module with bed length of 16 feet seems to be the most practical size. Paths have to be provided between the six-inch-high beds.



In medieval Europe, monks grew vegetables, herbs, flowers, berries and fruit trees all together, for mutual benefit. The Chinese hold a near-religious sentiment against sameness and uniformity. They feel that monoculture is a wrong row crop gardening approach because pure stands are not found in nature. Monoculture makes for an efficient truck-gardening operation, but it favors disease. The greater the variety of planting, the less likelihood of insect infestation buildup. Where a rich variety of plants make up a biological community, that community has a better chance of remaining stable. Crop rotation and crop combinations are the best ways to achieve a balanced plant community. It is based on variations in species . . . plants of the cabbage family (cabbage, cauliflower, broccoli, radish, turnip, etc.), for instance, should not be grown in the same location.

Plants should also be grown relative to the root level they occupy in the soil, as well as to the nutrient feeding capacity of the plant itself. Heavy feeders like the cabbage family, tomatoes and leafy vegetables should be followed with light feeders like carrots and beets. An ideal rotation might be: light feeder plants, selected from the legume family—peas or beans—would prepare the soil for following heavy feeder rotation. Bacterial blight can be controlled by rotating peas and beans with cabbage. Tomatoes and potatoes are both attacked by the same organism, so they should never be grown in the same location each year (bio-dynamic theories notwithstanding) as the verticillium-wilt organism which attacks tomatoes is carried over in the soil. The sugar beet nematode builds up a dense population when beets are planted in the same location for several consecutive years.

Row crop rotation principles should be extended to include sod crops, cover crops and animal grazing. And during the late summer dormancy periods, one would do well to encourage a healthy crop of *weeds.* Domesticated animals, as well as wild animals such as birds, frogs and moles, should be allowed controlled access to the garden and field crops. No better method of insect control exists.

Sir Albert Howard said that insect pests and plant disease are mere *indicators* that farming methods are wrong. Insects attack the weaker plants because the plants are not suited to their environment . . . they are less healthy in terms of their own internal protection against microbial attack. And of course first causes of an unhealthy plant can be traced to the unhealthy soil in which it is grown. This fact is succinctly illustrated by the Missouri Experiment Station:

> *With some of our most troublesome crop pests, there is a direct relation between insect numbers and soil fertility. The less fertility, the more insects. Our experience and studies over the last several years have proved this. In other words, as we over-crop, single-crop and permit the damage of soil erosion, we grow more crops of harmful troublesome pests than we need to have.*

Soil fertility is of course a prime consideration when establishing a row crop garden location. A good rule is to plant where weeds flourish. One should also consider wind and frost protection, drainage and land slope, and degree of available sunshine. Some plants, like tomatoes, will thrive in one-half the normal sunshine. The dead shade of a building is of course more harmful than the moving shade of a tree.

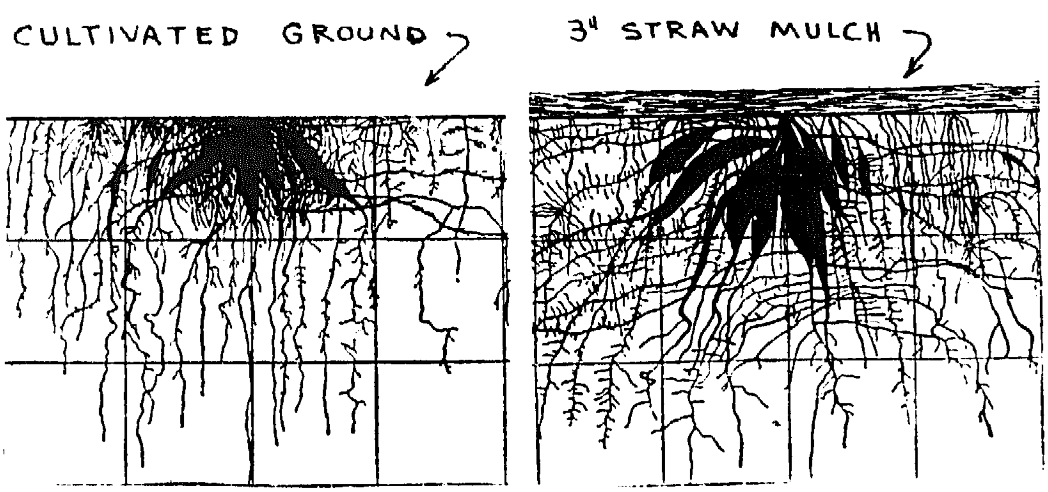
Row crops should be located at a point immediately accessible to the homestead cooking area. Experience in a wide range of gardening situations have proven this to be a very important factor . . . both from the standpoint of occasional harvesting and occasional maintenance, home and garden must be contiguous.

There are possibly a hundred published row crop garden plans . . . each purporting to be the most optimum, well-thought-out scheme. Actually it is impossible to design a garden plan for someone else . . . site conditions, regional climatic variations and personal food tastes and dislikes are far too variable.

A few rules, however, may prove helpful. First, keep the space as *small* as possible, relative to family food need, available space and amount of time and help for work. As an old adage has it, *never plow up(!) more space than your wife can take care of.* Second, grow plants of the very finest quality. Every homestead family should make a *row crop rating chart*, with each crop chosen on the basis of season, adaptability to site, nutrition value, taste and growing efficiency. I am including a vegetable efficiency rating chart below. It was originally prepared to assist my wife in the family homestead garden planning and planting chore.

VEGETABLE EFFICIENCY RATING

RATING	CROP	YIELD/ACRE 100 POUNDS	MAN HOURS PER ACRE	AV. DAYS TO PRODUCE	PROTEIN LBS/ACRE	CALORIES 1000#/ACRE	VITAMIN B GRAMS	VITAMIN C GRAMS	VITAMIN G GRAMS	VITAMIN A MILLIONS
1	SPINACH	117	117	50	221	1058	5.5	1443	15.3	873
2	CARROT	194	243	80	210	3587	7.9	315	7.2	246
3	ONION	198	239	110	261	4103	5.3	765	3.8	c
4	SQUASH-WIN.	170	58	120	189	2516	2.7	176	4.6	171
5	POTATOE-IRISH	152	130	120	255	4909	7.5	638	3.5	2
6	CELERY	320	300	120	263	2019	3.2	646	3.9	3
7	CABBAGE	137	111	90	140	1298	4.8	3180	4.5	3
8	TOMATO	110	108	180	108	1130	4.5	1119	2.4	42
9	BEAN-SNAP	46	133	55	99	787	1.4	282	2.0	23
10	LETTUCE	91	109	80	75	531	2.5	400	4.8	11
11	TURNIP	120	165	60	115	1618	3.8	1190	3.6	1
12	BROCCOLI	73	176	150	114	587	1.4	1411	5.5	74
13	CAULIFLOWER	108	151	75	148	865	4.6	1990	5.2	1
14	BELL PEPPER	69	144	150	70	786	.7	3171	1.0	13.
15	POTATO-SWEET	60	127	170	94	2940	2.7	266	2.0	59
16	CORN	62	80	90	87	1154	1.4	106	.6	6
17	SQUASH-SUM.	97	147	60	57	804	2.0	132	3.5	129
18	BEET	108	218	70	97	1256	2.2	146	3.5	4
19	CANTALOUPE	98	195	160	35	734	1.3	798	2.0	37
20	ASPARAGUS	44	188	365	73	400	2.5	423	1.5.	8.
21	PEA	22	143	85	72	476	1.9	101	1.3	6
22	CUCUMBER	84	190	100	41	383	2.4	212	4.0	1
23	RADISH	120	273	30	70	588	2.0	429	.8	0
24	WATER MELON	103	110	160	24	670	.7	153	.7	2
25	BEAN-LIMA	14	140	80	41	324	.7	62	.6	1



ROOT SYSTEM OF SWEET POTATO

Plant Management - Tree Crop

Trees full of soft foliage; blossoms fresh with spring beauty; and, finally–fruit, rich, bloom-dusted, melting, and luscious–such are the treasures of the orchard and the garden, temptingly offered to every landholder in this bright and sunny, though temperate climate.

A.J. Downing 1845

Whenever the subject of Homestead Orchard is discussed, two things flash to mind: First, I am reminded of the many agricultural Titans who have devoted major segments of their lives to the furtherance of tree crops. There are hard-working devotees in every field of plant and animal husbandry . . . but pomologists appear somewhat different. They seem to be a more dedicated and intense breed . . . to them tree crops offer philosophical substance as well as taste and nutrition.

Professor John Gifford was one of these Titans who saw social and economic implications in tree crops. In 1934 he wrote a small book on diversified tree crop farming for the tropical homestead. In it he showed how annual crops are unsuitable to tropical climates, where deep-rooted trees thrive. The Mayans failed to survive because they planted corn and cut down forests. For the most part tree-men consider corn the killer of continents, and regard corn as one of the worst enemies of the human future. Annuals are the crop of primitive man . . . food needed in a hurry, Promethean man supposedly has the culture and the leisure and intelligence to subsist on tree crops!

This is my favorite passage from Gifford's book:

The furtherance of the tropical forest subsistence homestead has been and I hope always will be uppermost in my mind. For 40 years my life has been shaping itself to this very end because it seems to me about the most essential thing that can give life and comfort to the majority of our people, in fact, the only permanent way out of the difficulties which beset the world. The small farm home is the essential basic unit of society. The prosperity and strength of any country can be measured by the number of small self-supporting homesteads which it contains. The best nations of the world are not those with the greatest natural resources but with the largest number of small, self-supportive, free-of-debt homesites. THE TROPICAL SUBSISTENCE HOMESTEAD.

The second thing that comes to mind in a tree crop discussion is disheartening: A tremendous knowledge of tree crops has been amassed by many at great cost in time and energy . . . but is virtually unknown or unaccepted by contemporary farmers. There is no better example of this unfortunate situation than exists in a review of the life work of J. Russell Smith, tree-man par excellence. Smith launched his study of commercially useless trees in 1910, with a worldwide quest for new varieties. In 1929 he published *TREE CROPS–A PERMANENT AGRICULTURE.* His valuable tree discoveries were then intensified with more worldwide travel followed by a revised edition of his book in 1954.

As a loyal tree-man, Smith (who, incidentally was professor of economic geography at Columbia University) spoke vehemently against annual row crops. Crops that must build themselves from scratch for each harvest are victims of the climatic uncertainty of short seasons. Tree crops, on the other hand, are not affected by drought to the same degree . . . deep roots enable a tree to accumulate and store moisture.

Smith was repulsed by the fact that four-fifths of everything raised by the American farmer goes to feed animals. He made a good case for a tree crop diet instead, realizing that meat contains 800 calories as compared to nuts which contain 3,200 calories. If animals are to be raised, Smith maintained that they should be allowed to harvest their own crops. This "hogging down" principle is nowadays a major agricultural innovation . . . as when hogs are permitted to harvest corn, soybeans, peanuts, etc. Smith maintained that tree crops can also be harvested directly by animals . . . mulberry, persimmon, oak, chestnut, honey locust, and carob are all excellent stock-food trees.

Andrew Jackson Downing continues to be the tree-crop giant of them all. One of his major works, *FRUITS AND FRUIT TREES OF AMERICA,* published in 1845, remains today an essential tree crop reference. Resulting from the publication of a number of his important books, Downing's influence on American fruit tree culture is apparent to this day. He fully remodeled western European fruit growing practices to fit American site and climatic conditions. One contemporary tree crop author found that fruit trees planted in Massachusetts and Michigan during the height of Downing's influence (1870-1890) are still standing and bearing fruit. Yet thousands of trees planted in subsequent years (1890-1920) have broken down or died. There is a refreshing simplicity in Downing's basic principles:

> *A judicious pruning to modify the form of our standard trees is nearly all that is required in ordinary practice. Every fruit tree, grown in the open orchard or garden as a common standard, should be allowed to take its natural form, the whole efforts of the pruner going no further than to take out all weak and crowded branches.*

The tree-men who have qualified the science of pomology are in unanimous agreement on one important aspect: *interplanting* is a desirable practice. Interplanting makes good sense to the homesteader from a purely economic standpoint. Where peaches, pears and plums are interplanted in apple orchards, revenue from their yields subsidize the apples to production. Rapidly maturing tree crops (like dwarfed varieties) can be alternated with slowly maturing species. Mulberry trees are an excellent choice to interplant in a nut tree orchard . . . they grow rapidly, bear young and are resistant to shade.

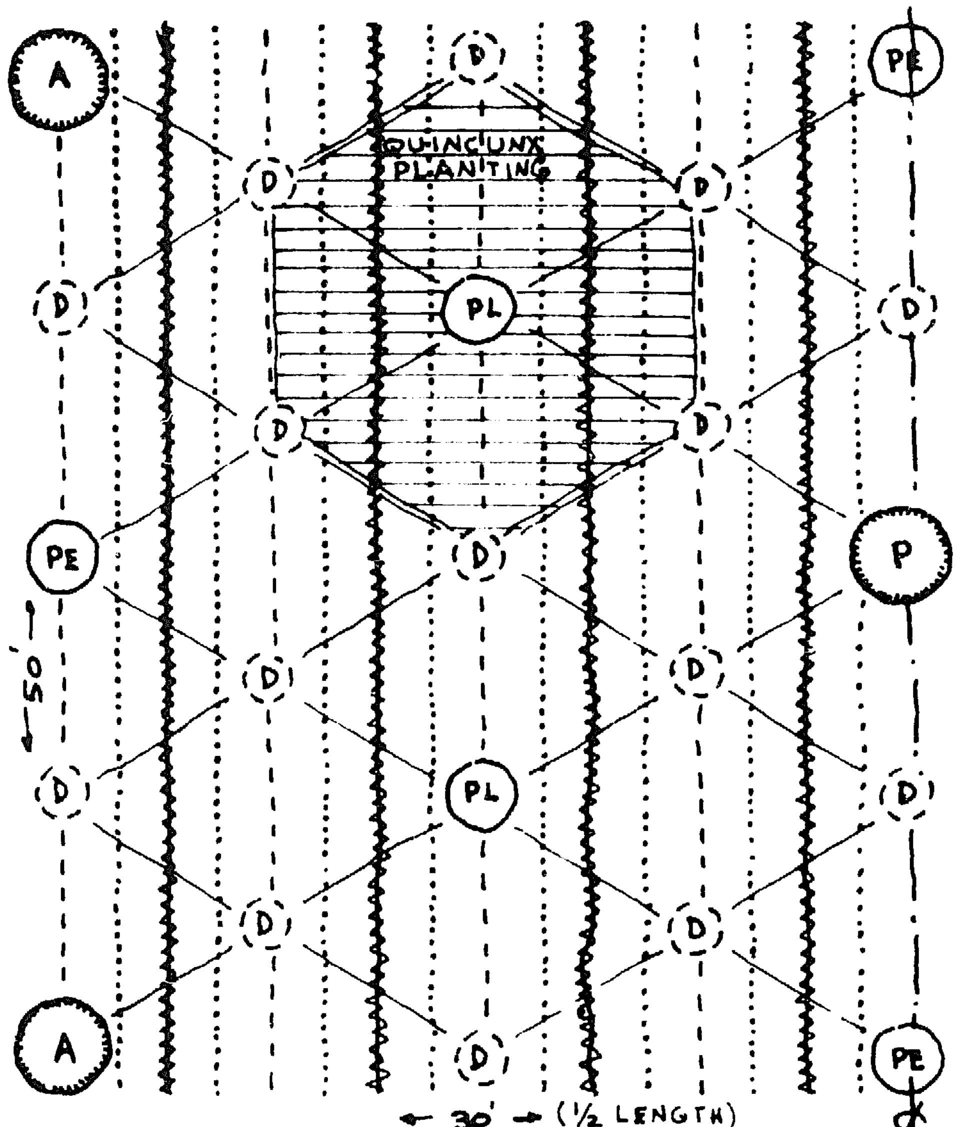
One type of interplanting is known as "two-story agriculture". Here, trees are grown on land that is cropped or pastured for mutual benefit. There has already been some discussion (see chapter 7,) of how sod crops benefit by the companionship of tree crops. About 10 black walnut trees in an acre of permanent pasture improves the pasture considerably. The deep roots and thin open foliage characteristic of walnut trees do not interfere with a lower-story sod crop. The leaf-filtered sunlight makes it possible for a sod crop to continue growth throughout summer months. Walnut trees give grass more time to get established before the summer warm season, because their growth is primarily in the late spring.

There are numerous advantages in planting a two-story fruit and vegetable garden. Fruit trees bear in the upper story while brambles, grapes, bush fruit, or vegetables grow below. Long-lived fruit trees continue to bear when short-lived lower-story plants are removed. "Filler" trees are located between standard varieties, to provide early bearing on short-lived fruit. Dwarfed trees can be used as fillers in a standard bearing orchard. They can be chosen as early bearing varieties of the same fruit, as when a wealthy apple is set between a northern spy or McIntosh apple.

In terms of intensive gardening, planting trees in "square" patterns is wasteful of space. When a tree is planted in the *center* of each square (creating a quincunx arrangement), nearly twice as many trees can be located in the same area.

The gardening program for an intensively planted, heavily mulched 60 by 50-foot plot might be as follows: Vegetables and ever-bearing strawberries harvested the first season, a partial crop of brambleberries harvested from the second to tenth year, and then removed; from the third to the tenth year dwarfed fruit varieties bear, then removed to allow more room for semi-permanent trees; peaches and plums produce until the fifteenth year, then removed to allow maximum space for the remaining four apples and pear—with appropiate sod crop—which continue to bear indefinitely.

There are a number of conditions that influence the choice of a sod crop in an orchard. The ideal sod crop is one which grows slowly at first, when trees need the ground moisture, and more rapidly later in the season when trees require less moisture. Soybeans and cowpeas have this quality. Alfalfa and small grains are poor choices because their extensive root systems may rob the tree of moisture. Leguminous sod crops—such as hairy vetch—are especially valuable for maintaining soil fertility in a nut tree orchard.



60'x50' TWO STORIED FRUIT GARDEN

A - 4 STANDARD APPLE — BASED ON QUINCUNX

P - 1 STANDARD PEAR

PL - 4 PLUM — PERMANENT — SEMI-PERMANENT — FILLER

PE - 4 PEACH

D - 28 DWARFTED (APPLE, PEACH, APRICOT, CHERRY, PEAR)

- - - - STRAWBERRY - 3 ROWS BETWEEN TREES

.... VEGETABLES - EARLY MATURING VARIETIES

~~~~ BRAMBLEBERRY (AND GRAPES)

INTENSIVE • MULCH PLANTED • ZERO-TILLAGE
~~~~

Tree crops planted in a heavy and poorly drained soil will benefit from a lower-story permanent sod crop such as bluegrass or orchard grass (*orchard* grass is aptly named!). Grass roots help to use up soil moisture and increase the size of air-filled pores and fractures. Aeration is thus improved, and if cultivation can be avoided, the tree's surface root growth will be encouraged at the one place where aeration is best attained . . . the surface.

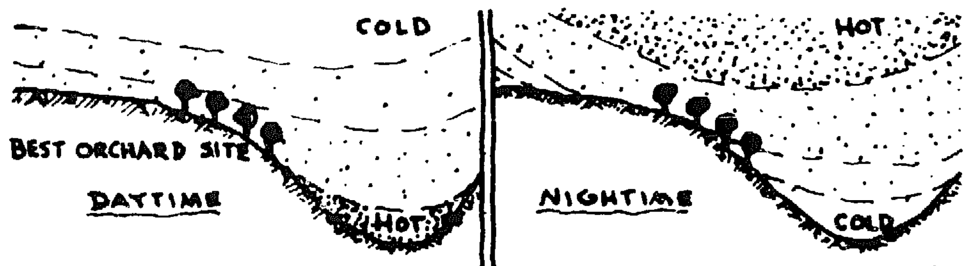
Plowing, discing, rototilling, and cultivating around trees is a ghastly practice, to be avoided at all costs. A homesteader should realize that the greater majority of all feeder roots are located within one foot of the surface. This is the zone where the soil is most fertile and where aeration is greatest. Mulch planting is a much preferred practice. Besides nutrient and moisture conservation, mulch gives excellent protection against winter root damage. Tests at the University of Kansas show freezing soil penetration to 26 inches on bare ground; snow cover reduces this danger area to 12 inches; straw mulch plus the snow coverage reduces it even more . . . to 6 inches.

A mulch cover tends to retard spring blossoming . . . which can be a desirable feature in areas where late frosts present a danger (as in eastern Oregon, where it may freeze *any time* during the growing season). Another protection against early blossoming is to plant on the north slope. The accompanying diagram illustrates how this retardation principle operates. Some tree crops, like apricot, plum, sweet cherry, and almond naturally blossom early; some apple varieties like Rome beauty and northern spy blossom late. As a general rule the blossoming of fruit begins early in the south and moves north at about five days for each degree of latitude. Altitude will influence these figures somewhat.

Charts showing "average date of last killing frost" should not be entirely adhered to, because *average* means that 50% of the frost occurs before and 50% after the specified date. The odds are just too great to follow.

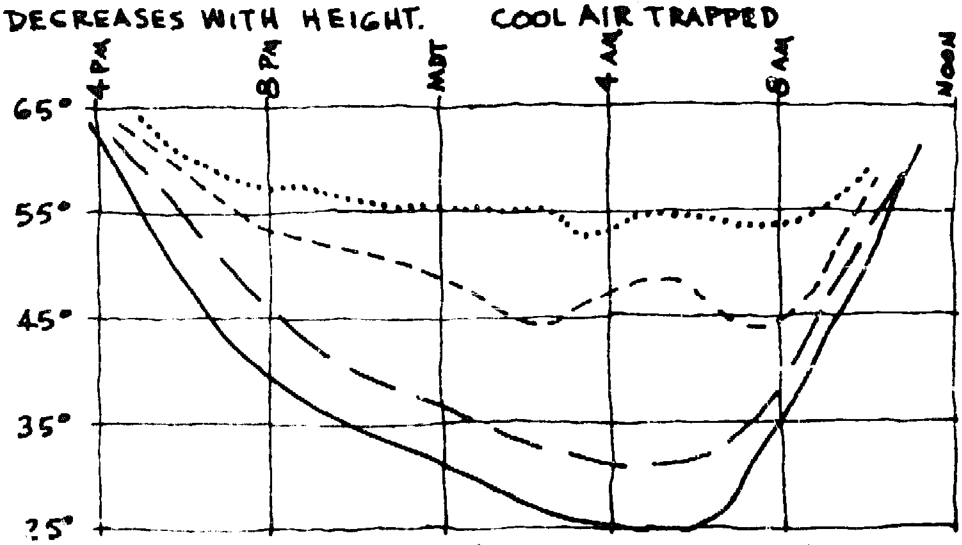
An injurious winter temperature can also be influenced by a water-tempering effect. There is more danger of winter injury to tree crops in the Mississippi Valley (latitude 38 degrees) than in Nova Scotia (latitude 45 degrees). An orchard planted on the leeward shore (usually south or east) of water gains significant temperature advantage. This assumes, of course, that the water remains unfrozen . . . no protection is offered from frozen water. Water-filled soil supplies more latent heat on a frosty night than dry soil.

An ideal tree crop site is one that lies higher than surrounding land. Trees planted in a natural draw receive cold air drainage. Even on a gradual slope, when cold air drainage meets a tree crop obstacle, it may engulf it and cause frost damage. Air drainage can be facilitated by correct planting practice, as accompanying sketches depict. Trees planted on the contour or in rows across a slope may also impede essential air drainage.



AIR TEMPERATURE DECREASES WITH HEIGHT.

TEMPERATURE INVERSION. COOL AIR TRAPPED

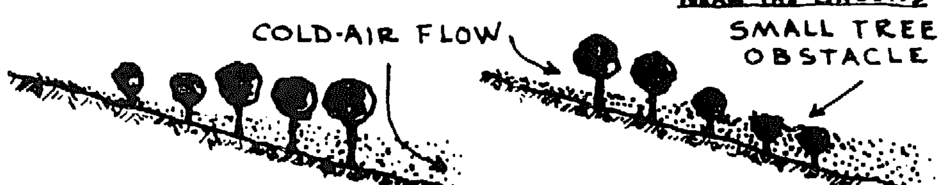


DIFFERENCES IN TEMPERATURE AT VARIOUS HEIGHTS

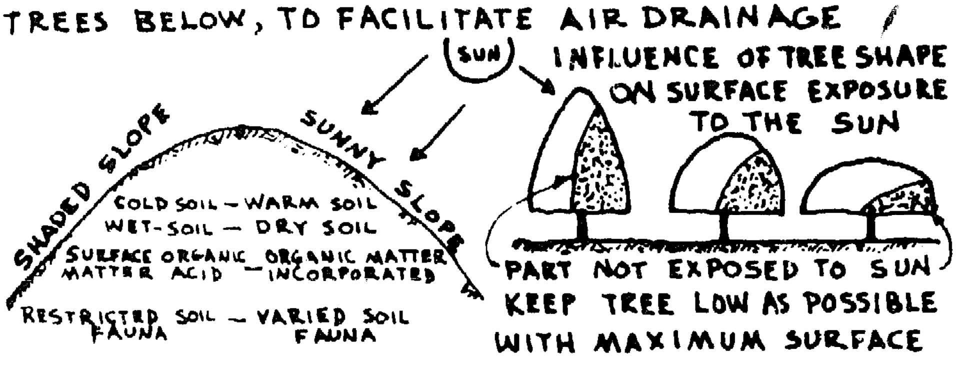
——— BASE OF SLOPE ---- 50 FT. ABOVE

— — 25 FT ABOVE .... 225 FT. ABOVE

REFERENCE: J. RUSSELL SMITH; MEN & RESOURCES - GEIGER; CLIMATE NEAR THE GROUND



SMALLER TREES PLANTED TOP OF SLOPE AND LARGE TREES BELOW, TO FACILITATE AIR DRAINAGE



Wind protection is an essential consideration in any homestead tree crop program. A following chapter will give ample consideration to windbreak planning. Mainly, the fact that winds are usually accompanied by heavy ground-saturating rains make trees vulnerable to toppling over.

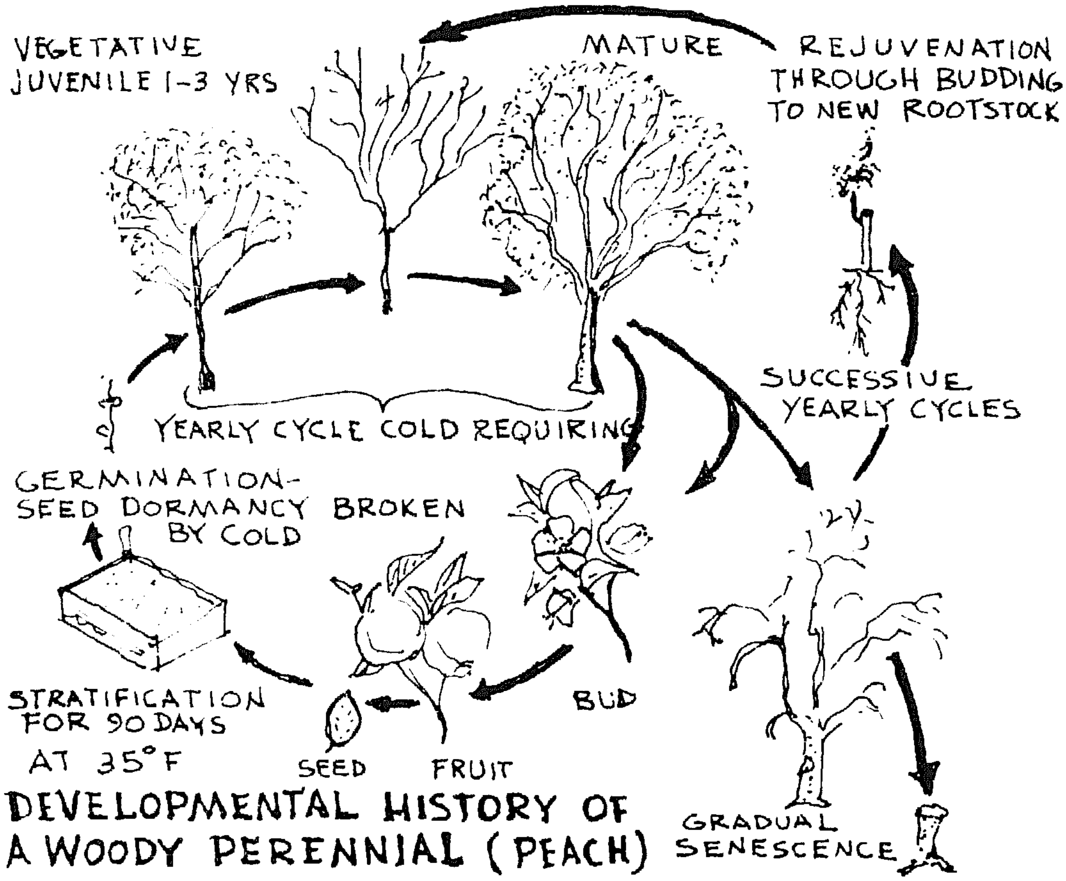
There are various reasons for choosing dwarf varieties of fruit trees in preference to standard varieties. For one thing, site and climate problems can be tolerated better with dwarf varieties. The ground-hugging feature of closely planted dwarf trees permits them to receive more warming radiation from ground heat. There is a type of "creeper" dwarf apple tree that grows as far north as Siberia. Having little height it can stand the cold better and be protected in the wintertime by a snow cover.

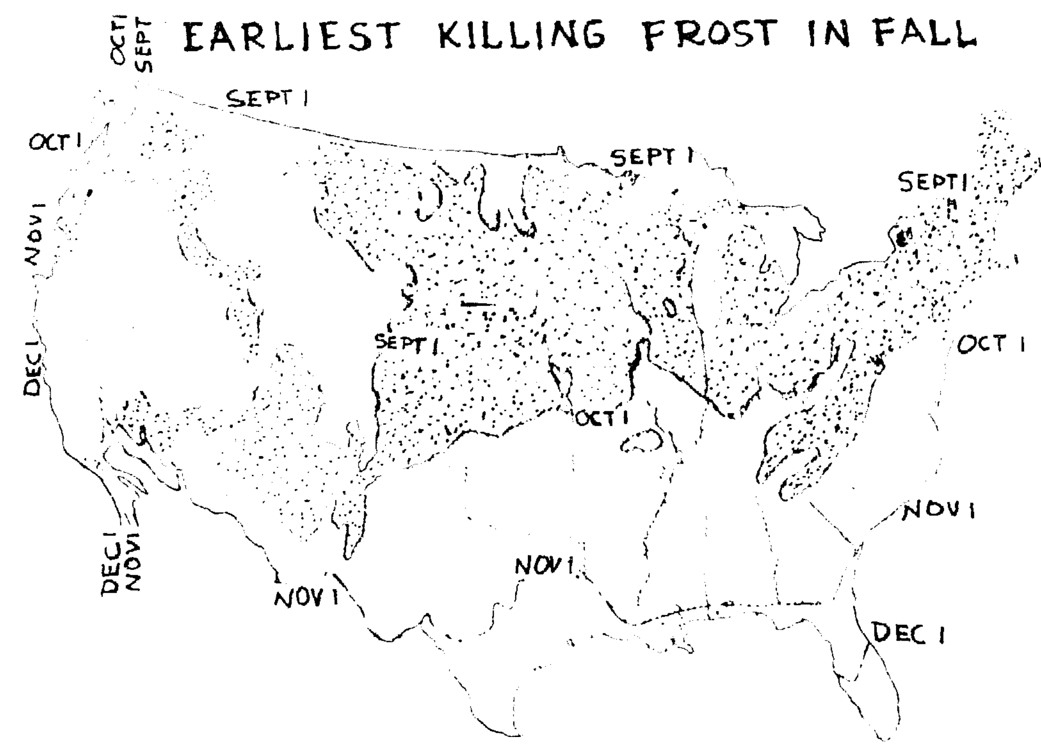
Other considerations for tree choice besides site and climate should be mentioned: *hardiness* is certainly one. A tree that is hardy in its environment is certainly more resistant to disease. In California, for instance, English walnut trees are customarily grafted onto black walnut root stock. As a result of long years of experience it was found that black walnut roots are less susceptible to fungus attack and survive California temperature extremes better. Rootstock grafting is also done to attain a deeper root system . . . a valuable consideration in areas of limited irrigation or rainfall.

Proper tree choice is also essential in moisture-scarce regions. Cherries, grapes and olives require less moisture than oranges, apples and pears. In Tunisia, olive trees are planted as much as 100 feet apart in order to gain the extra moisture advantage that comes with increased spacing.

Commercial, monoculture orchards are invariably overcrowded, overtilled, overfertilized, overpruned, and of course, overdiseased. But to be commercially "economic" a money-based orchard could hardly be operated otherwise! Tree crop food production is one area where a homesteader can maintain major advantages over the commercial farmer. The homesteader can engage in all the "uneconomic" practices, like two-story, intercropped, mulch-planted varieties, and produce better tasting, nutritious, disease-free crops.

To remain competitive, a commercial orchardist must stimulate large-and-early, colorful crops. Of the numerous shot-in-the-arm methods for attaining these ends, *fertilization* is probably the most used . . . and misused. Darwin was one of the first to point out the dangers of fertilization. In his *VARIATIONS OF ANIMALS AND PLANTS UNDER DOMESTICATION* he quotes Gartner in the statement that sterility from soil fertilization is especially common with cereals, cabbage, peas and beans. The concentration of salts found in farmyard manure as well as chemical fertilizer will *destroy* tender feeder roots. Many newly planted trees die because the grower was too eager to "give the tree a good start" by filling massive amounts of fertilizer around the root zone. A mixture of damp peat moss and loamy soil around newly planted roots would be better than fertilizer in any form.


VEGETATIVE
JUVENILE 1-3 YRS
MATURE
REJUVENATION
THROUGH BUDDING
TO NEW ROOTSTOCK
YEARLY CYCLE COLD REQUIRING
SUCCESSIVE
YEARLY CYCLES
GERMINATION-
SEED DORMANCY BROKEN
BY COLD
STRATIFICATION
FOR 90 DAYS
AT 35°F
SEED
FRUIT
BUD
GRADUAL
SENESCENCE
DEVELOPMENTAL HISTORY OF
A WOODY PERENNIAL (PEACH)


EARLIEST KILLING FROST IN FALL
OCT 1
SEPT
SEPT 1
OCT 1
NOV 1
DEC 1
DEC 1
NOV 1
NOV 1
SEPT 1
SEPT 1
SEPT 1
OCT 1
OCT 1
NOV 1
NOV 1
DEC 1

Also, the planting hole should not be water-saturated as the tree is planted. Moisten the soil *after* the tree is planted, to prevent the formation of clods and to facilitate tamping.

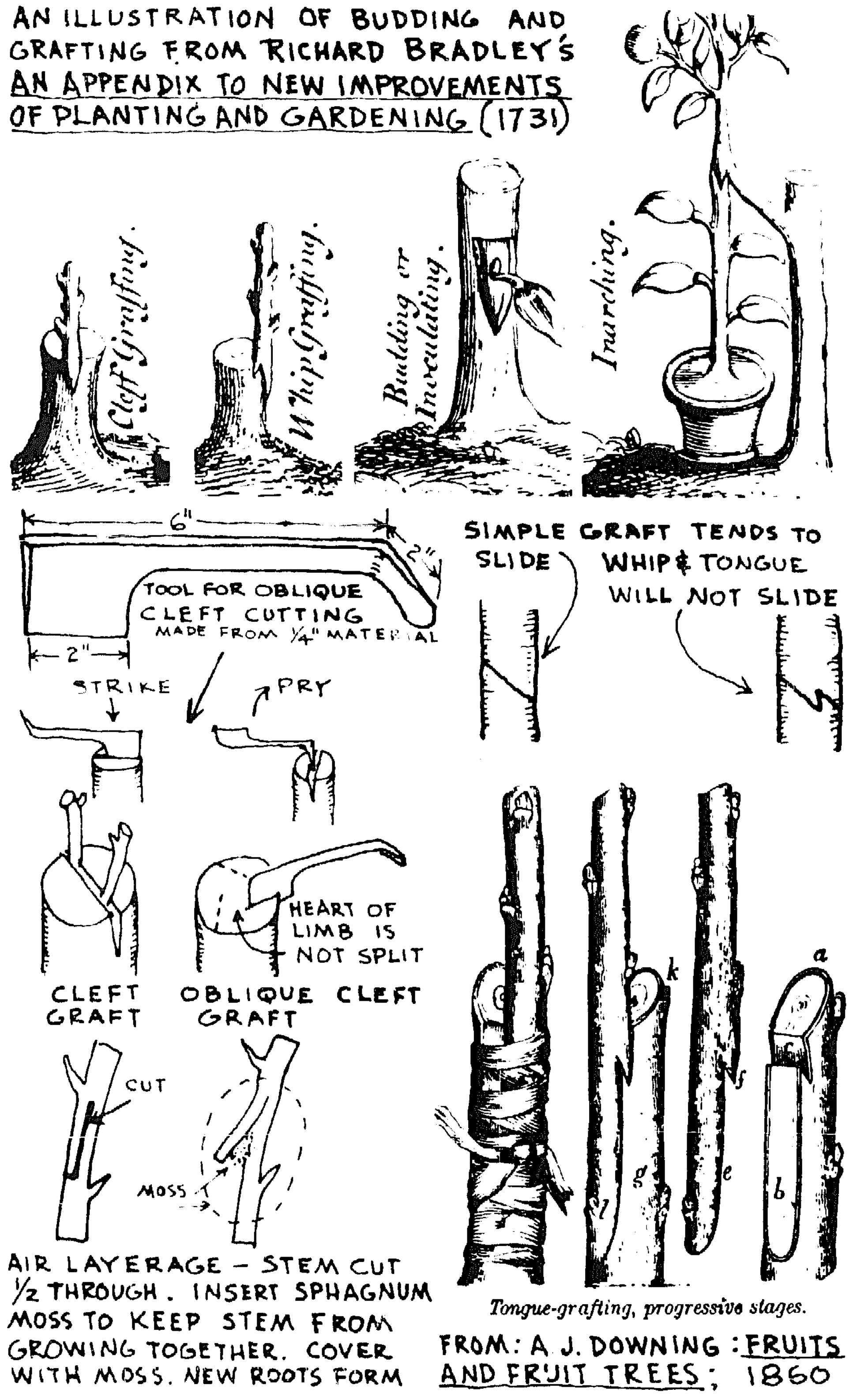
Fall planting is considered best for tree crops. However, where severe winters prevail, spring planting is preferred. With a fall-planted tree, some root growth will take place through the winter months if the tree is heavily mulched. Be sure to direct the newly planted tree slightly into the prevailing wind. This encourages root development on the windward side, as the most vigorous branch always lies directly over the most vigorous root. Dioecious trees—those having male and female organs borne by different individuals—should be grown as one would raise a herd of animals . . . one male tree (staminate) planted with a group of female trees (pistillate).

Commercial nurseries charge exorbitant prices for grafted tree stock. Traffic bears this cost mostly because of the mystique associated with "grafting". Actually, as tree-crop writers like Downing point out, grafting is a simple, basic skill that can be mastered by anyone who takes the trouble to understand a few basic principles.

First, the seedling must be raised. Smith describes one interesting method: four plaster laths are nailed together to form a tube of earth one inch square and three feet long. The seed is placed near the surface of this tube, and as the plant grows, roots cling to one lath previously soaked in a nitrate of soda solution. The four-inch-high seedling with three feet of roots can thus be planted deep into the ground using nothing more than a crowbar to prepare the hole. Before germination is possible, some seed (notably nut trees) must undergo a certain amount of freezing.

The tree raised from seed is not apt to develop true to the character of the tree it came from. For this reason a scion—or branch of the producing tree—is grafted onto the root stock. Both scion and stock should be about the same diameter, about 1/2 inch. Grafting should be done early in the spring so that the wound will not be exposed long before growth resumes.

Budding and *layering* are other methods of multiplying the progeny of an especially desirable tree. In layering, a part of the parent plant is induced to grow roots or shoots before separation from the plant. All of these grafting processes (grafting is the healing in common of two wounds) are best accomplished by the homesteader on trees and seedlings *already planted* in their final location on the homestead. Even dwarf fruit varieties can be started in this manner. A dwarfed tree is nothing more than a strong-growing scion grafted onto a weak-growing root stock. A quince rootstock will dwarf a pear scion; but a pear that is thus grafted on a quince root will tend to grow larger and faster than the quince tree. The weak-growing quince rootstock takes a little from the soil and requires small amounts of carbohydrates for growth, whereas the standard-size scion will accumulate carbohydrate at the cost of protein assimilation. The high proportion of carbohydrates to protein results in dwarfing and early fruitation. The northern spy dwarf apple bears in 4 years as against 15 years for standard varieties. Apple, pear, cherry, peach, plum and apricot trees can all be successfully dwarfed, and they all certainly have a place on the homestead.



Tongue-grafting, progressive stages.

As mentioned earlier, due to their low profile, dwarf "creeper" apple trees can be grown in a Siberian weather zone. In general, a low, spreading tree form should be encouraged . . . it maintains maximum sun exposure and offers least resistance to wind. Shade over the immediate soil area helps to conserve soil moisture. Some tree experts even claim that a low-growing tree offers less drain on soil fertility. The greatest vigor in a tree is located near its top, so by pruning the top this vigor is spread to other parts of the tree.

Of pruning, someone once said: "There is no horticultural practice concerning which there is a greater diversity of opinion or in the application of which there is a greater diversity of procedure." According to the Illinois Experimentation Station (Bulletin 376) pruning contributes to the death of more trees mistakenly attributed to "mishandling" than to any other single factor.

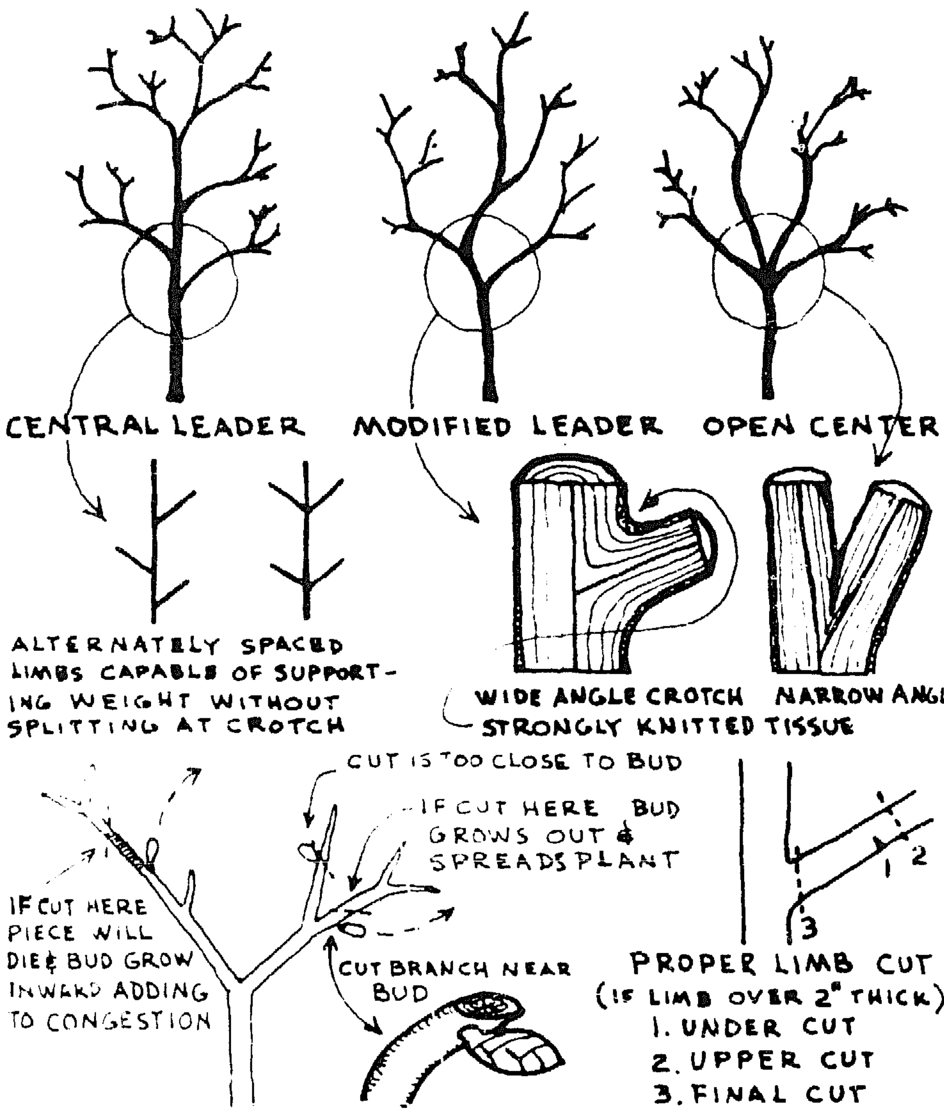
The main purpose of pruning is to remove injured and diseased growth. Without the protective outer cover that bark offers, dead limbs are attractive to parasites and saprophytic fungi. Another equally purposeful reason for pruning is to train the young tree structurally . . . so it might better resist wind, snow and ice damage at a later, more mature stage. The "central leader" and "modified leader" patterns are in common usage, along with the somewhat less popular "open center" pattern. An open center tree has a structural defect, but does receive more interior sunlight.

As the tree matures, so too does the purpose of pruning. On a mature tree one finally limits pruning activities to maintaining a balance between vegetation and fruiting, and between the root system and the vegetation system . . . mostly by thinning out top growth. When transplanting, top growth should be removed to balance the remaining root system.

Downing recommends summer pruning in preference to winter pruning, as wounds heal more rapidly while the tree remains in active growth. The old adage that advises pruning during the dormant period, "when the sap is down", is rather foolish, as wood is just as sap-laden in winter as it is in spring. In spring, mineral saturated water from the soil travels *upward* through sapwood to the leaves. In the leaf the water is converted into starches and sugars and then travels *downward* through the inner bark, feeding the tree en route.

With practice and clear advice grafting can soon become one of the rewarding "fun things" that one can do on the homestead. The art of plant propagation is never really learned or mastered . . . but at the outset one receives a satisfaction that comes from cooperation with plant growth processes.

Super-trained tree specimens–like espalier–can be created, not without great patience and skill. Or exotic conversation pieces can be displayed . . . as with the five-variety apple tree or tomato-producing potato plant. Some have even chosen to deal in an illicit grafting practice . . . one that in current legal cases has even **jurisprudence** bemuddled: a hop (Humulus lupulus) scion grafted onto a marijuana (Cannabis sativa) rootstock will produce a hop leaf suitable for psychedelic usage. Peace.



The Pit Greenhouse

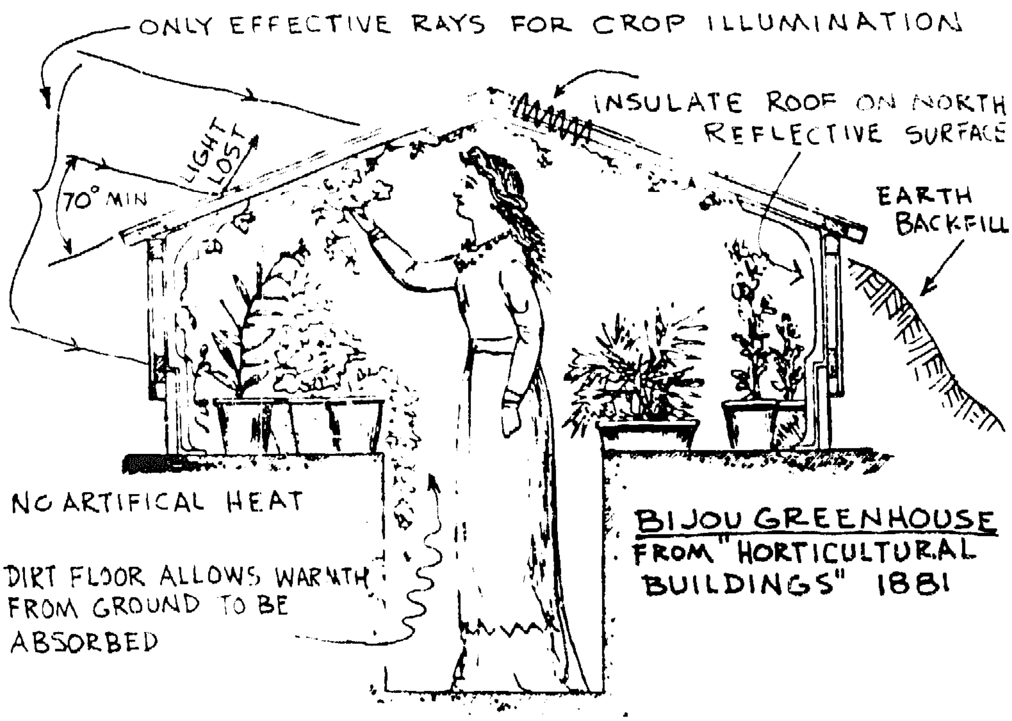
There's an ancient Persian proverb that says, "When you understand how to do a thing, the doing is easy; if you find it difficult you do not understand it." There are of course numerous homestead activities where a basic understanding can make the difference - not only between making a thing simple or difficult, but between a gratifying success or disheartening failure. And nowhere on the homestead is this dichotomy more evident than when one attempts to modify plant environment by the use of a forcing structure.

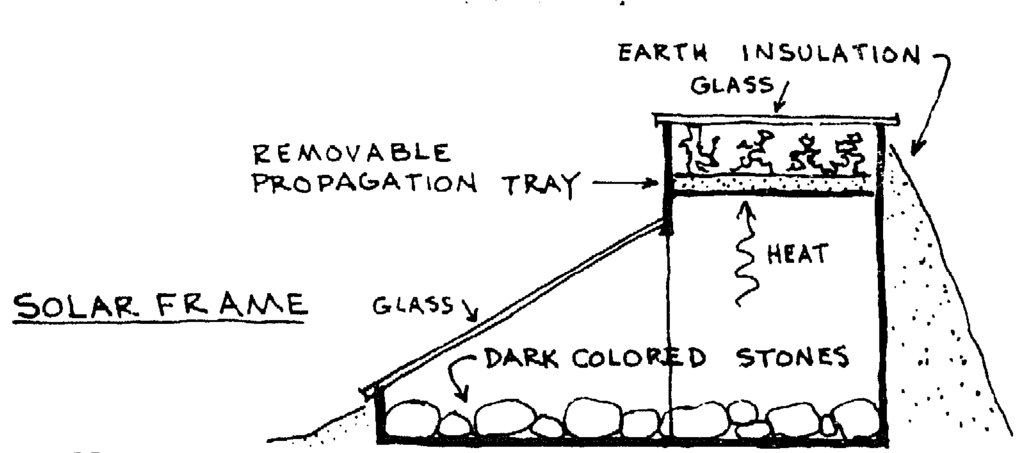
Some types of plant shelter are simple and easily understood; a shade or windbreak screen, an arbor or even a cold frame are rational structures requiring minimum knowledge to construct and manage. But it's a different ball game when a homesteader attempts to modify plant environment in a *greenhouse* situation.

A greenhouse is something more than a sun trap and a light trap for the benefit of plant growth; it's complexity lies in the fact that plant forcing, itself, is a highly complicated affair. In a greenhouse there exists a so-called *trinity of plant ecology*, which necessitates a balance between light (heat), moving air, and controlled humidity. Temperature, first of all, affects plant growth because it directly influences such internal processes as photosynthesis (food manufacture). Plant growth also requires respiration--which is energy generated by the breaking down of foods manufactured by the plant. Now to illustrate how this trinity principle works: during the day, sunlight promotes plant growth through photosynthesis; plants absorb light energy to reduce carbon dioxide in the air to sugar. High daytime temperatures require high relative humidity and high soil moisture to balance the increased water loss through the plant. We see here that the plant environment includes not only the vegetative- above ground- considerations such as temperature, humidity, radiation, air movement and gas content of the air. There is also the root environment to consider: root temperature, soil moisture, plant nutrients, and soil structure. And there is yet another complication: not only do different plants require different environments, but the nighttime factors are different from the daytime. At night photosynthesis stops and reactions associated with reproduction occur. A low temperature at night produces growth, flowers and fruit.

Much of my understanding and appreciation of greenhouse functions grew out of a brief 1957 visit with F.W. Went, then director of the Earhart Plant Research Laboratory in Pasadena. Through lengthy and painstaking experiments, Went found optimal temperature and humidity requirements. Tomatoes, for instance, require an optimal daytime temperature of 80 to 90 degrees Fahrenheit, nighttime 65 degrees F. The optimal daytime humidity was found to be 50 to 80%, nighttime 95%. Went's findings proved important to the furtherance of plant growth knowledge–it also pointed to some obvious inefficiencies of conventional greenhouse design.

The "greenhouse effect" is an expression which applies to a building having excessive radiation buildup. As one would suspect, greenhouses are troubled with "greenhouse effect" . . . so is our atmosphere. Atmospheric vapor filters shortwave solar radiation (ultraviolet). Water vapor, however,





is transparent to visible light, which warms the earth and re-radiates longwave (infrared) rays back to the atmosphere. Some of this infrared heat is absorbed by the atmosphere, and some is reflected back to earth. The earth's atmosphere acts like glass in a greenhouse: opaque to longwave but transparent to shortwave radiation. In a greenhouse situation this effect works in much the same fashion: the ground and vegetation inside are heated by the transmission of ultraviolet rays from the sun. These contents then give off heat in the form of infrared radiation. Window glass, however, will not allow these longwave radiations to escape so they are retained (to the actual detriment of the vegetation inside).

Heating from strong radiation reduces the nighttime humidity of the air when a high water-saturation is especially needed. Artificial heating also tends to lower the relative humidity. Went overcame these obstacles in his experimental greenhouses by employing elaborate, highly sophisticated, artificial conditioning devices. These methods are of course not available–not even desirable–for homestead greenhouse production. A better home-grown solution is to design a greenhouse structure that provides optimum growing conditions.

A little greenhouse research reveals the fact that, although Washington and Jefferson both had greenhouses, the oldest reported forcing structure in the U.S. was not a greenhouse as we know it today. It was, rather, a pit covered with glass on the south side, and earth insulation on the north. This so-called *pit greenhouse* was built into the side of a Waltham, Massachusetts hill about 1800. I found that the pit greenhouse is practically unknown among horticultural circles, yet it proves to be a far more sensible, economical, and efficient forcing structure.

In principle the sun pit is an "unheated" greenhouse. That is, it relies entirely upon solar and ground heat rather than auxiliary furnaces–which are always required in conventional greenhouses.

Soon after learning of Went's greenhouse research I had occasion to include an unheated pit greenhouse into a rambling, adobe ranch house designed for the Morgan Washburn family in Oakhurst. About the only unique feature of this greenhouse (besides the obvious pit-heating effect) was its incorporation as an important annex to the house; one could stand in the kitchen and pick salads from the greenhouse bench.

Tom Powell featured the Washburn greenhouse in an article for *ORGANIC GARDENING AND FARMING* magazine (January 1959), and notoriety from this item helped to initiate me into an expanding fraternity of greenhouse freaks–designers, builders and growers. For the next ten years I amassed an impressive working knowledge and greenhouse construction experience. I found greenhouse enthusiasts to be, on the most part, exciting and imaginative people. Witness the Nearing 9 by 18 sun pit, which Helen and Scott kept active all year in Vermont: tomatoes and peppers were grown through the summer months; Chinese cabbage, celery, parsley and chives all winter–with no supplemental heat!

There are both ephemeral cranks and foremost representatives of science involved in the study of forcing plants in artificial structure. Sometimes the sifting out of the true and beautiful is not all that easy; even the scientific opinion raises questions and problems that seem unanswerable in our lifetime. But there is much of this information that can be used to advantage by today's homestead builder. Are you ready?

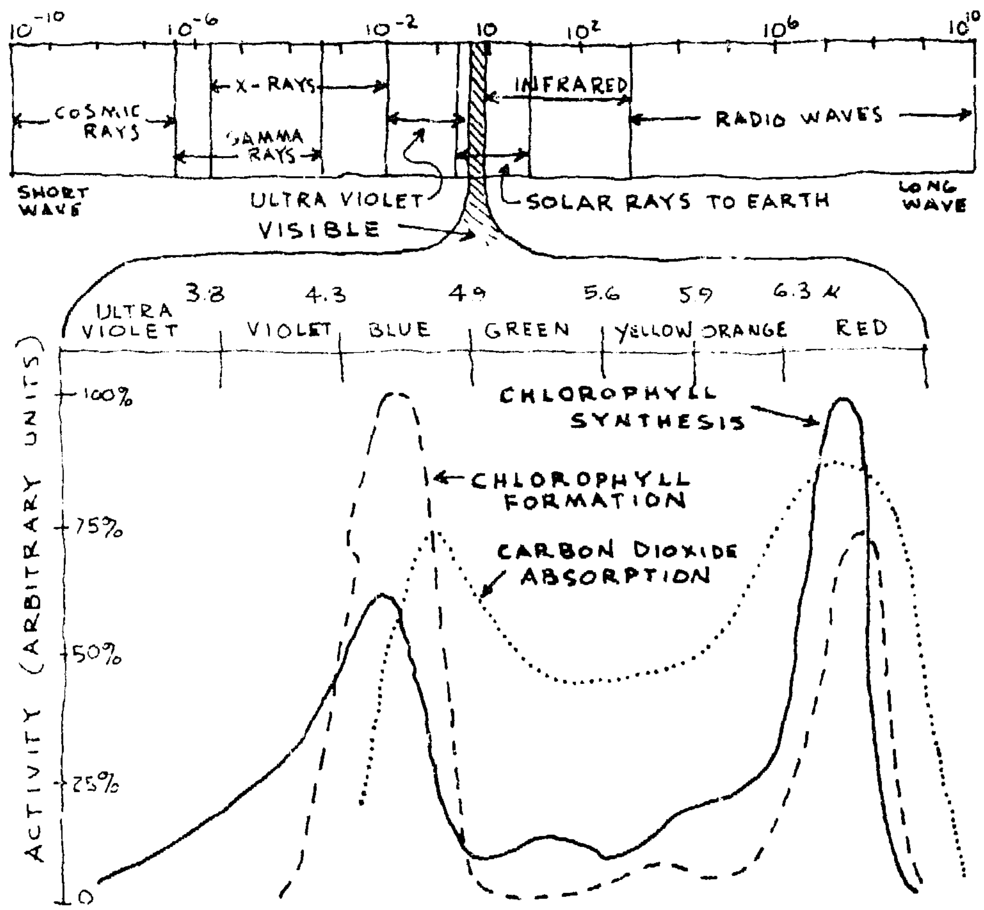
Let's begin again with light and heat. To function properly, a greenhouse requires maximum light. But admitting desirable light also admits a possibly excessive and undesirable temperature buildup. High temperature causes plant respiration which tends to disturb the metabolic process. It is the infrared–the heat–region of the solar spectrum that causes this temperature increase. The greenhouse operator who customarily paints whitewash on the glass for shade, thereby reducing entry of shortwave rays, is sensitive to plant respiration. Opaque shading is a shortsighted solution, however, because the balance of light rays (fully one-half of the rays) is thereby inhibited on the other end of the spectrum, restricting the narrow ultraviolet (shortwave) rays.

The "greenhouse effect" also takes place as a result of faulty (e.g., standard) greenhouse design. As the contents of a greenhouse are heated, this interior heat is given off in the form of infrared radiation. Though given off, the heat never leaves the greenhouse: *window glass* does not transmit longwave infrared radiation. Heat consequently builds up inside, and plants "burn". Furthermore, window glass admits only about 5% of the ultraviolet rays, which really makes glass a health hazard for man as well as for plants. Ultraviolet radiation controls bacterial and viral populations, and when the rays are filtered out upper respiratory troubles are apt to occur, especially during winter months in cold climates.

The obvious solution here is to use a type of translucent material which admits the maximum amount of light, and maximum quantity of ultraviolet radiation and the minimum degree of infrared intensification. *Fiberglass* plastics meet these specifications: as much as 95% of the ultraviolet rays are admitted (as against 5% for window glass). Glass fibers and crinkled surfaces diffuse infrared heat rays, making this material almost a perfect solution for greenhouse coverings.

Light, as we have seen above, is the energizer for the primary growing process known as photosynthesis. The "white" light visible in the ultraviolet range of wavelength is actually made up of tones of violet, blue, green, yellow, orange and red; light projected through a prism will demonstrate this range of color. Scientists have for a long time been interested in the ultraviolet waves, known also as *actinic rays*. In fact, early Egyptians treated various diseases by exposing patients to the sun rays filtered through a blue quartz lens. Actinic rays are known as decomposing, or chemical rays, of the sun. They penetrate through solid matter and are thought to have the power of setting up a vibration, which, in matter that is susceptible to it, sets up a counter vibration.

Some of the actinic rays that shine through chlorophyll are absorbed. From plant-growing research that extends to 1880, we know that in photosynthesis, plants use more light from the blue and red parts of the spectrum. Little use is made of green, yellow, or other actinic rays . . . in fact, violet rays actually inhibit plant growth.



ACTION SPECTRA OF CERTAIN PLANT PROCESSES

The accompanying graph was compiled from research data supplied in part by the Philips Research Laboratory, Eindhoven, Netherlands. Three processes are illustrated: carbon dioxide absorption, chlorophyll formation, and chlorophyll synthesis (photosynthesis). Carbon dioxide is absorbed into the plant through the stomata, located in the epidermis of leaves (oxygen is also transpired through the stomata). Stomata open under the influence of light, and are more widely open in the presence of blue light than either red or green. Evaporation and photosynthesis are intensified and chlorophyll production is accelerated when exposed to blue light.

Those of us living in mountainous apple country can testify to the effect that light plays in producing red pigment (anthocyanin) in apples. Ample amounts of late summer sunshine produce redder apples. A simple experiment can be performed to demonstrate the effect blue light has in producing anthocyanin: using a simple prism, project a solar spectrum on a green apple. The only part of the apple that will turn red is that in the blue and nearly ultraviolet end of the spectrum.

One greenhouse manufacturer (Lifelite Corporation, Concord, Calif.) promotes a bluish-red film colorant to absorb ultraviolet and green wavelengths. Red wavelengths are shifted and intensified. These self-adhering sheets can be used as reflectors from indoor fluorescent units, or on outdoor greenhouse panels. The degree of chlorophyll absorption under the influence of red light is significant, as illustrated in accompanying graph.

I have yet to find a viable explanation of what actually takes place when actinic rays are absorbed in chlorophyll. It must certainly have something to do with cellular decomposition. Growth equals decay, remember?

Physicians who employ color therapy explain the principles as far as the human body is concerned: the absorptive quality of actinic rays has the faculty of starting every nerve cell in the body into active vibration. This vibration stimulates into action the proper interchange of fluids in the cells of the muscular structure, thus promoting cellular subdivision and new formation. Actinic rays affect chemical blood composition more than anything else. Blood, of course, repairs all illness; all waste matter is swept out through blood circulation. Color, supposedly, has a definite oscillatory frequency which corresponds to a similar oscillation in one or more of our body organs.

Dr. Dinshah Ghadiali, founder of the Spectro-Chrome Institute, Malaga, New Jersey, and inventor of the one-time controversial "Spectro-Chrome Metry" equipment for localized color treatment, claims that all fevers are caused by an excess of the chemical elements hydrogen and carbon. These elements are localized by the use of his special equipment: red and yellow attuned color waves seem to be present. Oxygen is necessary to eliminate the hydrogen and carbon elements. In fever, the respiration does increase, giving a larger intake of oxygen, which converts the hydrogen into water and the carbon into carbon dioxide, both of which are excreted. Oxygen "burns" out the hydrogen and carbon. It is made more available to the body through the single attuned color wave of *blue*.

Kate Baldwin, M.D., F.A.C.S., former Senior Surgeon, Woman's Hospital, Philadelphia, says the following about the therapeutic value of light and color (as quoted from Atlantic Medical Journal, April 1927):

> For about six years I have given close attention to the action of colors in restoring the body functions, and I am perfectly honest in saying that, after nearly thirty-six years of active hospital and private practice in medicine and surgery, I can produce quicker and more accurate results with colors than with any or all other methods combined . . . and with less strain on the patient. In many cases, the functions have been restored after the classical remedies have failed.

In about 1900, Arthur Schuster, Professor of Physics at the University of Manchester, worked on a lamp that would simulate actinic rays for the treatment of human disease. It took 12 years for him to perfect the quartz lamp with a side band of the actinic ray sufficient for therapeutic use. The quartz lamp is used today by some physicians. Treatment is not pleasant but results are said to be outstanding.

Several years ago I had occasion to build an experimental greenhouse for the McCoy family in Oakhurst. In one section of the greenhouse we used blue-tint fiberglass panels. Results from the use of blue fiberglass were immediately apparent: the growth rate increased, the plant fiber strengthened, yields were greater and the taste of vegetables improved. The McCoy experience fully substantiated the blue-glass theories postulated a hundred years ago by General A.J. Pleasonton. In 1861, this inventive genius built a 26-foot by 84-foot greenhouse with every eighth row of blue-colored glass. His results were rather astonishing (as reported in his book, *THE INFLUENCE OF THE BLUE RAY OF THE SUNLIGHT AND THE BLUE COLOUR OF THE SKY, In Developing Animal and Vegetable Life, In Arresting Disease, and In Restoring Health in Acute and Chronic Disorders to Human and Domestic Animals;* Philadelphia, 1876).

At the end of five months the grapevines in his greenhouse produced 1,200 pounds of fruit; growth reached 45-foot lengths, with stems 1 inch in diameter. Consider his explanation for this fabulous yield:

> That blue light of the firmament, if not itself electro-magnetism, evolves those forces which compose it in our atmosphere, and applying them at the season, viz, the early spring, when the sky is bluest, stimulates, after the torpor of winter, the active energies of the vegetable kingdom, by the decomposition of its carbonic acid gas—supplying carbon for the plants and oxygen to mature it, and to complete its mission.

In a second experiment, General Pleasonton introduced diseased livestock in a greenhouse which had equal proportions of white and blue glass. After a short while the animals regained their health and increased remarkably in weight. After much experimentation he found that an 8-to-1 proportion of white to blue glass would be used in vegetable production, and a 1-to-1 proportion for animals.

Interested readers might refer to the patent that General Pleasonton filed, IMPROVEMENT IN ACCELERATING THE GROWTH OF PLANTS AND ANIMALS, September 26, 1871, No. 119,242. The following is taken from the original patent:

> . . . combining the natural light of the sun transmitted through transparent glass with the natural light of the sun transmitted through blue glass or any of the varieties of blue, such as indigo, or violet . . .
>
> I do not pretend to be the first discoverer of the vitalizing and life-growing qualities of the transmitted blue light of the solar rays, and its effect in quickening life and intensifying vitality.

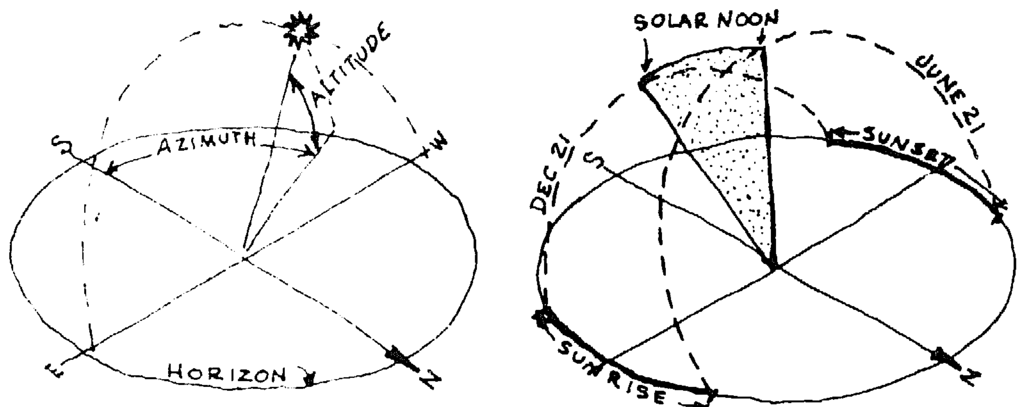
I have found, upon patient and long experiments, running through many years, that plants, fruits of plants, vines and fruits of vines and vegetables so housed and enclosed as to emit the natural light of the sun through ordinary glass, and the transmitted light of the solar rays through the glasses of blue, violet or purple colours in the proportion of eight of natural light to one of the blue or electric light, grow much more rapidly, ripen much quicker, and produce much larger crops of fruit than the same plants housed and treated with the natural light of day, the soils and fertilizers and treatment and culture being identical in both cases and the exposure the same.

I have also discovered, by experiment and practice, special and specific efficacy in the use of this combination of the caloric rays of the sun and the electric blue light in stimulating the glands of the body, the nervous system generally, and the secretive organs of man and animal. It therefore becomes an important element in the treatment of diseases, especially such as have become chronic or result from derangement of the secretive, perspiratory or glandular functions, as it vitalizes and gives renewed activity and force to the vital currents that keep the health unimpaired, or restores them when disordered or deranged.

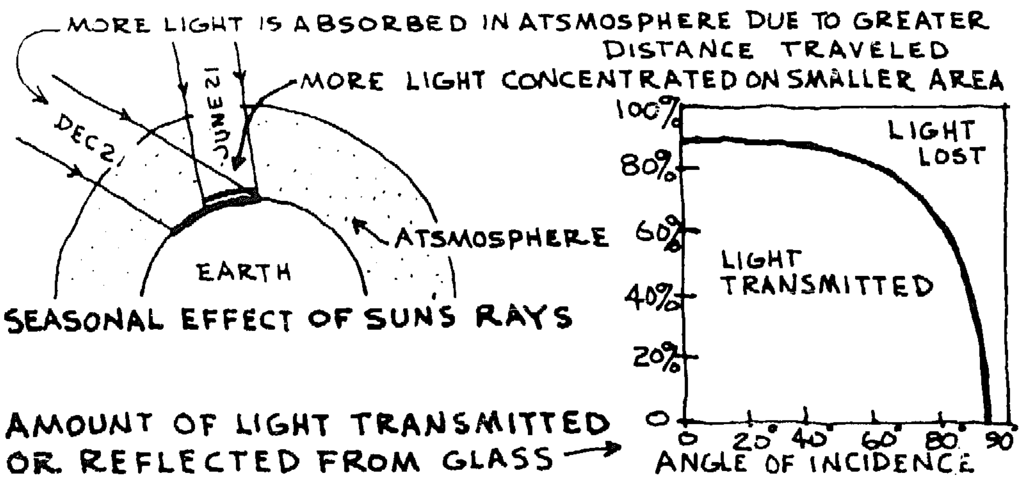
Greenhouse experts, like gardening experts, are never in agreement as to proper direction to orient the structure or to plant the crops. A southwest exposure may provide more light, but in the afternoon the energy of the plant has started to wane. So actually a southeast exposure is best, as the morning hours for a plant are most productive. Of greater importance than orientation is the slope of greenhouse walls; the amount of light transmitted or reflected depends upon the angle that the light beam makes with the greenhouse wall. The angle of incidence should not be less than 70 degrees. Some solar heating engineers use the formula "Latitude + 13 degrees = angle of glass to horizon" to get maximum winter penetration and maximum summer reflection.

About 50% of the total sunlight striking a greenhouse is dissipated. This loss can be reduced considerably by reflecting the light from the southern half of the sky against a north-facing wall. This north wall should have a smooth white surface for maximum reflection. And of course this north wall should be properly insulated. From my accompanying drawings it becomes clear that the ideal greenhouse should have a *dome shape*, cut vertically along an east-west line.

My half-dome sun pit greenhouse was designed to meet theoretical solar conditions—both from the standpoint of maximum mid-winter absorption and mid-summer reflection of the sun's rays. The accompanying drawing illustrates some of these solar considerations, and how they might influence greenhouse design. As shown, the noontime altitude of the sun gives only a minor part of necessary design criteria; among other things one needs to know the azimuth angles. And of course these sun angles vary according to latitude, north or south of the equator.



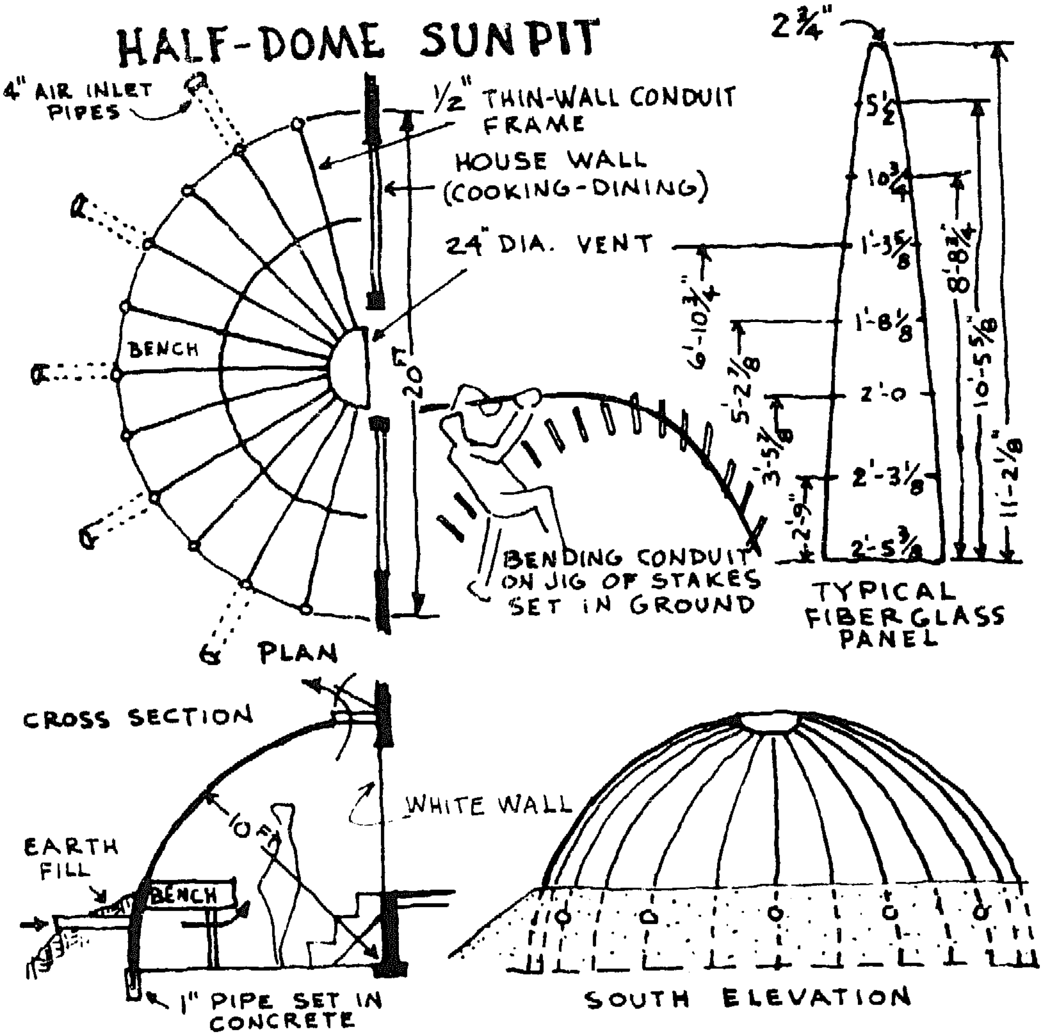
SUN PATH AT SEASONS FOR SPECIFIC LATITUDE

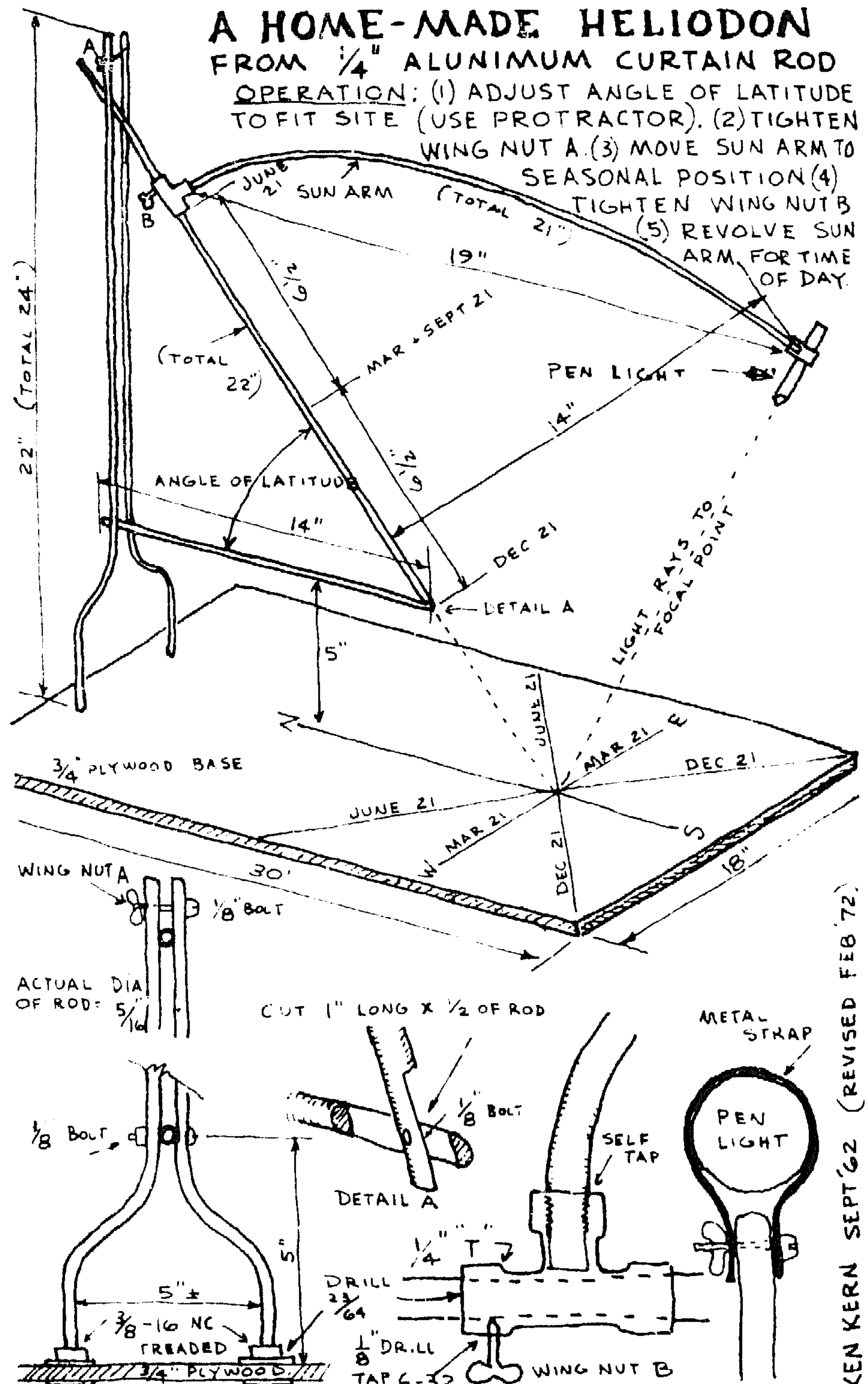


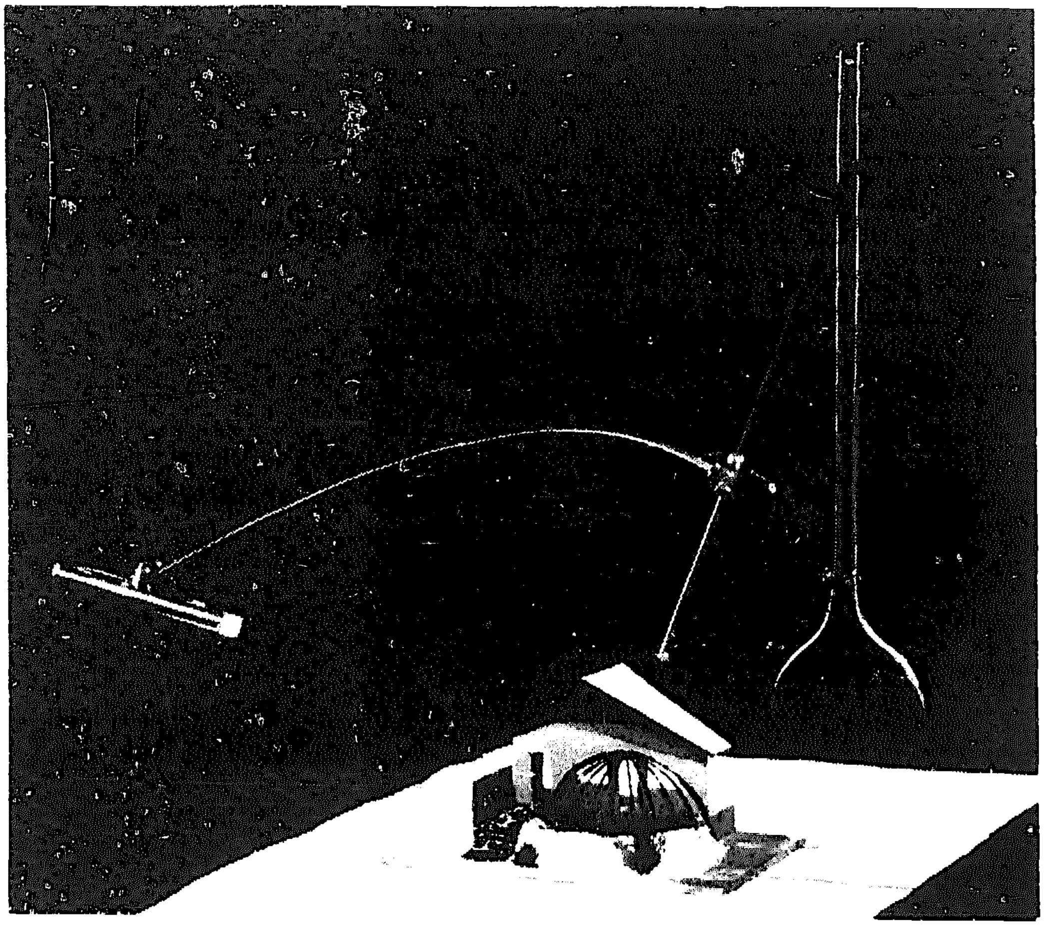
So following theoretical considerations, the *practical* approach to homestead greenhouse design is to build a scale model and investigate the yearly sun path with a *heliodon.* A heliodon is simply a simulated sun machine. It gives an accurate solar account for any time of the day, at any season of the year, for any specific latitude.

The heliodon that I have used in the past (mostly in conjunction with architectural models) was recently revised so large-size three-dimensional homestead layouts could be designed and analyzed. I also simplified the fabrication, to make it feasible for any homesteader-builder to have his very own. With this machine, one can determine optimum building location and orientation, roof overhang and window placement. It is especially valuable for locating new trees—shade tree size and positioning, in particular. The solar effect on every homestead building can be immediately perceived, as with garden, fields, wood lot, and general land topography. All of this contributes to that all-important, number-one factor of homestead planning: *make your mistakes on paper.*

HALF-DOME SUNPIT




A HOME-MADE HELIODON
FROM 1/4" ALUNIMUM CURTAIN ROD
OPERATION: (1) ADJUST ANGLE OF LATITUDE TO FIT SITE (USE PROTRACTOR). (2) TIGHTEN WING NUT A. (3) MOVE SUN ARM TO SEASONAL POSITION (4) TIGHTEN WING NUT B (5) REVOLVE SUN ARM FOR TIME OF DAY.
SUN ARM
(TOTAL 21")
19"
PEN LIGHT
14"
MAR & SEPT 21
JUNE 21
DEC 21
(TOTAL 22")
22" (TOTAL 24")
ANGLE OF LATITUDE
DETAIL A
LIGHT RAYS TO FOCAL POINT
5"
3/4" PLYWOOD BASE
30"
18"
N E S W
WING NUT A
1/8" BOLT
ACTUAL DIA OF ROD: 5/16
CUT 1" LONG X 1/2 OF ROD
1/8" BOLT
DETAIL A
SELF TAP
METAL STRAP
PEN LIGHT
1/4" "T"
DRILL 23/64
1/8" DRILL TAP 6-32
WING NUT B
5"±
3/8-16 NC TREADED
3/4" PLYWOOD
KEN KERN SEPT '62 (REVISED FEB '72)



Woodland

A people conscious of its hills has demonstrated the strongest impulse toward independence in history. Woe to this people, however, if it no longer lifted its head above the valley floor to the peaks, sought only its own advantage in the working day and forgot to survey the problems of life from a high point of vantage. Then it would bubble and stew over its own little problems and give itself over to a preoccupation with its own image.

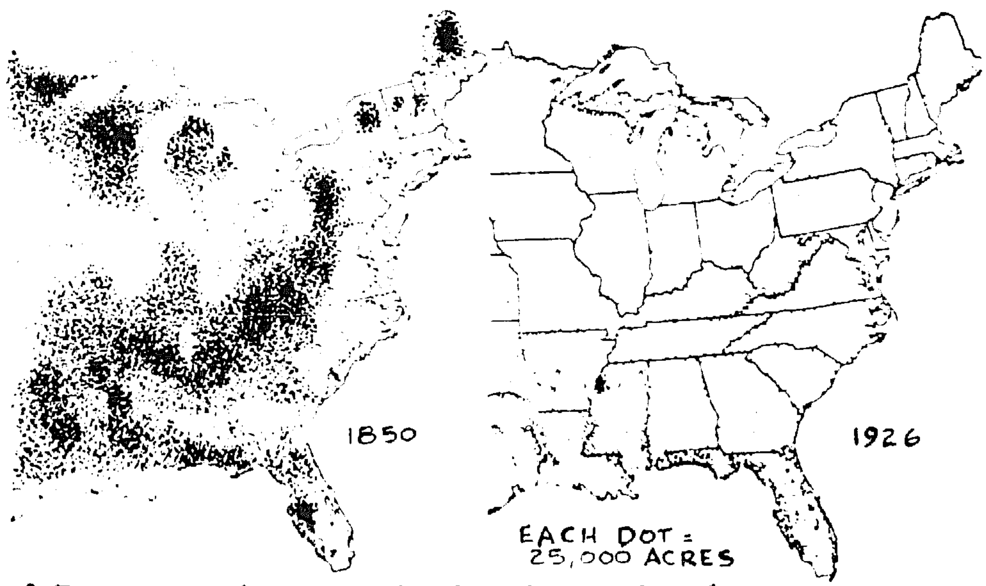
Ehrenfried Pfeiffer

Woodland management practices in this country are not unlike agricultural practices: both are currently based on a *ground-line* philosophy. That is, the harvest, the cutting, the profit are secured at ground-line. Monoculture is the accepted ground-line agricultural practice, and the same mentality results in clear-cutting and even-growth production in woodland management. A top-of-the-ground harvest orientation even twists the minds of trained foresters who advocate such abhorrent practices as control-burning and crop-dusting.

Bad forestry is in some respects more serious to a nation's welfare than bad farming. For one thing, there is more to lose: the world contains twice as much forest area as it contains land under cultivation . . . a third of the earth's surface is classified as forest soil. Originally in the U.S., before the white man came, over one-half of our two billion acres was in forest. Forests have been decimated in places like England for so many centuries that even the forest terminology has atrophied . . . forests become known as "woods".

Every seriously operated homestead should contain within its bounds some percentage of woodland acres. Besides the obvious "ground-line" value of timber, firewood, fenceposts and pulpwood, a woodland helps to control wind and water erosion. Experiments in Wisconsin showed that soil losses were one hundred times as great from pastured land as from unpastured woodland, and water losses were sixty times as great. Protection and shelter from the wind can be an essential attribute of proper woodland planning. And the food and shelter offered to wildlife from a woodland can help to maintain one's homestead as a balanced, complex association of plants and animals—which includes in its natural harmony birds, bacteria, insects and fungi—rather than *attempting* to eliminate them, something which never succeeds and only results in their lopsided development.

Woodlands can also influence the microclimate. Winds carry moisture that is lifted by the sun from large bodies of water. This moisture-laden air will move indefinitely or until it reaches a woodland. Trees transpire . . . cooling the air, spraying the sky and multiplying the cloud cover. This *upward* rainfall rises until it meets the moisture-laden air and then drops down as precipitation. Trees located on hills and mountains offer the best obstruction to clouds and thereby increase the rainfall.



AREA OF VIRGIN FOREST

Traditionally, woodlands are located on land classed as non-agricultural because of inaccessibility, steepness or poor soil. The ground-line "growth factory" concept keeps most farmers from planting trees and shrubs in rich, deep soils. No matter. Conifers are best planted on eroded, compacted, humus-lacking soils that perhaps once supported hardwood trees. In time the conifers will build up the soil to the point where hardwoods can become re-established. Trees differ widely in their soil and moisture requirements: where yellow poplar requires a deep and moist soil, black locust will thrive on a soil deep or shallow, moist or dry. Alders survive in wet, undrained soil while willows require wet, drained soil. Eucalyptus will dry up a swamp, but will also drain ground water on a water-needy land.

The inherent capacity of a tree species to withstand shade becomes a second factor that determines a woodland type. Again, the range of tolerance is very wide as accompanying charts indicate. Sugar maple seedlings require only two-percent full sunshine, and loblolly pine seedlings require nearly full sunlight to grow satisfactorily. Seedlings are generally more tolerant of shade than mature trees, especially if they are grown in a good exposure and on good soil. Shade givers grown near seedlings also provide valuable physical protection.

Someone once discovered that trees have one or another of three different-shaped root systems: a *spear* shape, as found in the oak which taps minerals from great depths; a *heart* shape, as found in the birch tree which lifts huge quantities of water; and a *flat* shape, which is designed for the support required by such trees as the Sitka spruce. Now it becomes obvious that a plantation of a single tree species would offer fierce competition at the same root level for food, moisture or support. For this reason a homesteader should make certain that his woodland contains a mixed variety of trees—different evergreens and different deciduous trees—with a wide variance in age and growth. A mixed woodland is far less subject to insect damage mainly because mixed woods supply a mixed humus. A loose, crumbly layering of mixed leaves is certainly a better stimulus to germination and to growth than a dense, impermeable layer of a single variety of needles or leaves. Witness the fatal Dutch elm disease which totally wiped out mono-planted roadside elm tree plantings all over the East. A mixed woodland also provides a varied supply of materials for use and for sale. One naturally aims at producing the highest grade woodland products . . . such as black walnut furniture wood, hardwood veneer, or saw logs, poles and pilings. Low-grade products such as fuelwood, pulpwood or railroad ties can be mostly a by-product or culls from high-grade products. Each of these main woodland products will be discussed in detail below.

RELATIVE TOLERANCE OF COMMON WOODLAND TREES

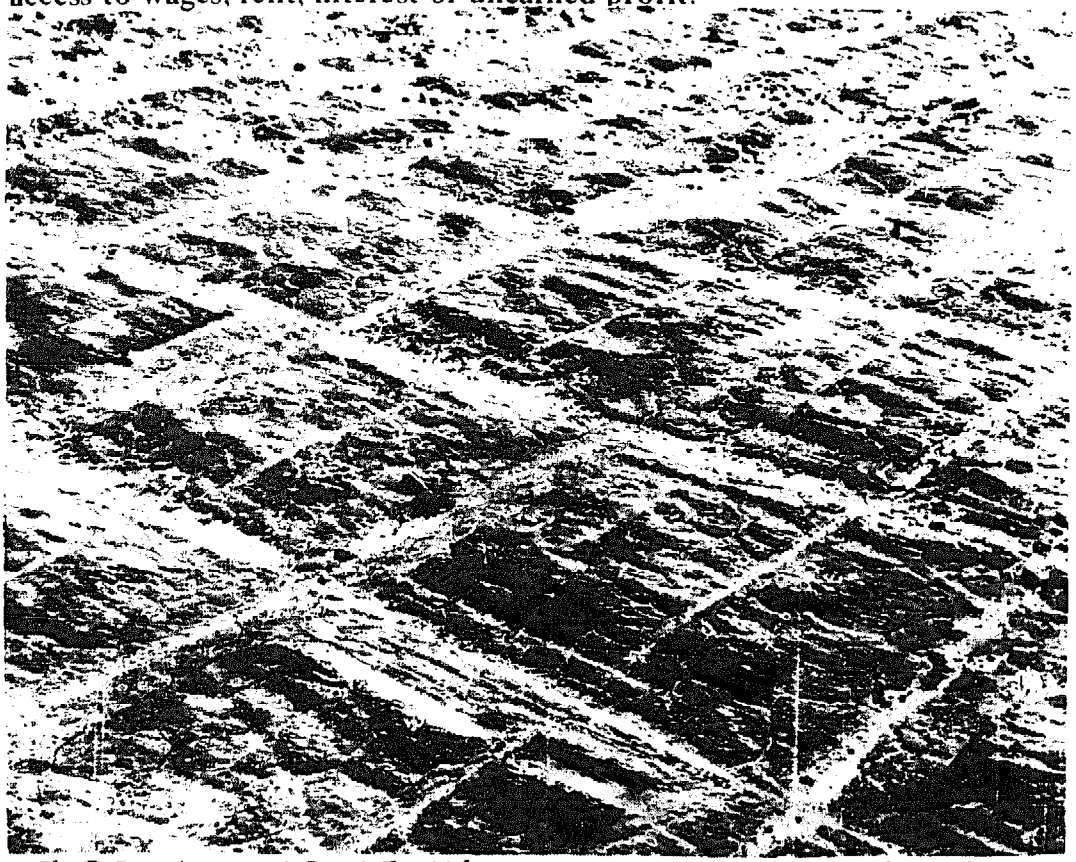
TOLERANT	INTERMEDIATE	INTOLERANT
CEDAR	DOUGLAS FIR	PINE
HEMLOCK	ASH	LARCH
REDWOOD	BIRCH	ASPEN
SPRUCE	CHESTNUT	BLACK WALNUT
BEECH	ELM	HICKORIES
MAPLE	OAK	WILLOW

RELATIVE DIAMETER GROWTH

RAPID	MODERATE	SLOW
EUROPEAN LARCH	DOUGLAS FIR	CEDAR
LOBLOLLY PINE	PONDEROSA PINE	HEMLOCK
ASPEN	REDWOOD	LONGLEAF PINE
BLACK LOCUST	SPRUCE	BEECH
COTTONWOOD	BLACK WALNUT	OAK - BLACK & WHITE
WILLOW	ELM	SUGAR MAPLE

High-grading wood products from one's own woodland is only possible where the homesteader does his own harvesting, as contrasted to selling "stumpage" (standing timber) to a contractor. Homestead-sized woodlands only attract the small "gyppo" contractor, who is notoriously destructive in his timber removal operations . . . destructive, that is, to the remaining woodlands that aren't stolen by him. The sale of stumpage brings only about 15% of the timber market value. About 30% of the operation is allocated to felling and to bucking the trees. Another 40% is taken up in yarding and in hauling, with the balance in profit. There is no part of this timber harvest operation that cannot be handled—even single-handed—by the homesteader. In due course one learns that a tall, straight, well-tapered southern yellow pine or Douglas fir will bring more money sold as a pole than sold as a saw log; large, high-grade logs are best sold as veneer timber.

Lower-grade timber can be high-graded, too, and sold as saw logs or finally as pulpwood, fenceposts or cordwood. While contemplating this whole woodland operation, keep in mind two important factors: First, the work is performed during "slack time", in the winter months when homestead chores are minimal. Second, the homesteader can supplement his income by utilizing to the best advantage the resources that he has at hand. They are, in order of availability, *land, labor, management* and *tools*. Unlike other members of our society, the homesteader generally does not have access to wages, rent, interest or unearned profit.



TOPSOIL COMPLETELY LOST DUE TO LACK OF WIND-BREAK PROTECTION AND MULCH-PLANTING. NOTE INTERSECTING PATTERNS OF PLOW MARKS. U.S.S.C.S. PHOTO

Before delving further into the economics of woodland management, something should be said of woodlands as *sheltering* devices. My interest in windbreaks was first aroused years ago when I read about the Lake States Forest experiments at Holdrege, Nebraska. In these experiments exact fuel requirements were recorded in two identical test houses . . . one exposed to the winds and one protected by a nominal windbreak. With both houses maintained at a constant 70-degree inside temperature, *the one having windbreak protection required 30% less fuel*. It was also found that animals in a tree-protected yard gained 35% more pounds during a mild winter!

There is a distinct but thorough science to shelterbelt planting involving tree varieties, planting layout and tree spacing. For example, poplars are often used as windbreaks because they are able to withstand high wind pressure, but poplars are great soil robbers. So it becomes prudent to alternate poplars with a complementary variety such as an alder tree. The alder brings nitrogen into the soil . . . being one of the few non-legumes which have this property. And for reasons mentioned earlier, it is important to combine coniferous and deciduous trees. A dense monoculture of conifers may successfully break the force of prevailing winter winds, but at the same time they may obstruct the flow of cold air, thus impeding natural air drainage. The winter-bared branches of deciduous trees will not obstruct this important air movement.

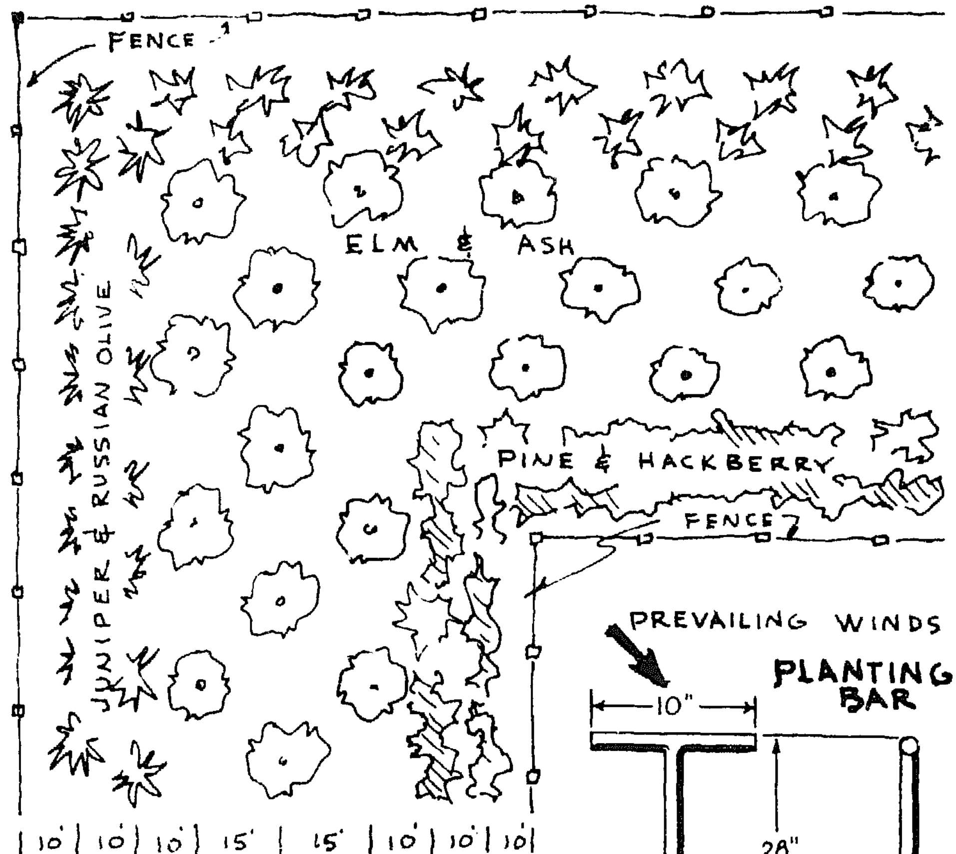
The most effective windbreak is in the form of an "L", with the point to the prevailing winter winds. This layout is best both for preventing evaporation of soil moisture (thus raising soil temperature) and for catching and preventing drifting snow around walks and buildings. Snow in the shade of shelter trees melts slowly in the spring, conserving moisture for row and sod crops.

Row and sod crops benefit in other indirect ways by planting windbreak-woodlands in close proximity. The traditional treeless, field-crop pest is, of course, the sparrow. Its birds of prey are the buzzard, the owl and the sparrow hawk, which cannot function without the protection and the vantage point offered by woodlands. Birds are attracted to woodlands, and this is important to the *control* (not ground-line *eradication*) of insects. The tomtit is known to consume 80 pounds of agriculturally injurious caterpillars in a summer; the starling destroys harmful larvae. The thrushes, jays and starlings are all valuable tree-seed planters. Wherever possible plant shrub fencing–such as multiflora roses–where fencing is required, to encourage bird habitations.

Some form of fencing–shrub, wood or wire–should definitely be installed around the homestead woodlands. Grazing a woods may help reduce fire hazard, but animals (especially sheep and goats) destroy young shoots and seedlings, compact the soil and, in general, disturb the physical structure of a woods.

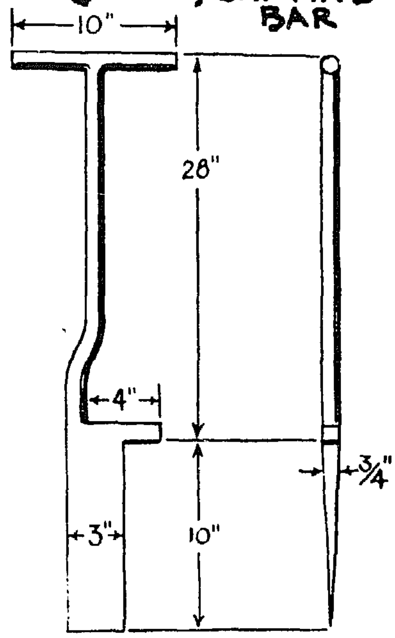
Fenceposts, incidentally, are an important homestead resource, entirely available from a well-managed woodland. The involved process of growing, treating and installing fenceposts and fencing will be discussed in the following chapter.

The demand for saw logs is greater than for any other timber product, and a well-managed homestead woodland produces a minimum of 500 board feet of lumber for each acre each year. The key word here is "well-managed". According to the Department of Agriculture, an optimum-managed woodland with a good growing stock produces three times as much wood as the average untended woodland.

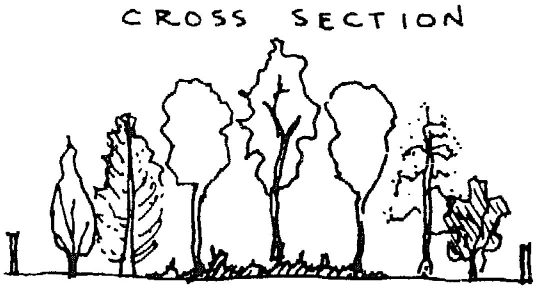


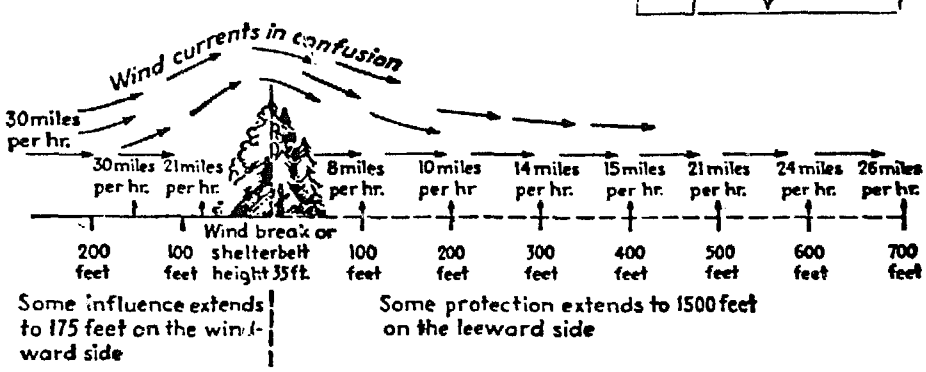
GROUND PLAN - WINDBREAK DESIGNED FOR PLAINS STATES

PLANTING BAR



CROSS SECTION





I can list three rules essential to the maintenance of optimal woodland conditions: [1] choose the best species, [2] keep the stand at optimum density and [3] correctly cut and prune. These factors will now be discussed in detail.

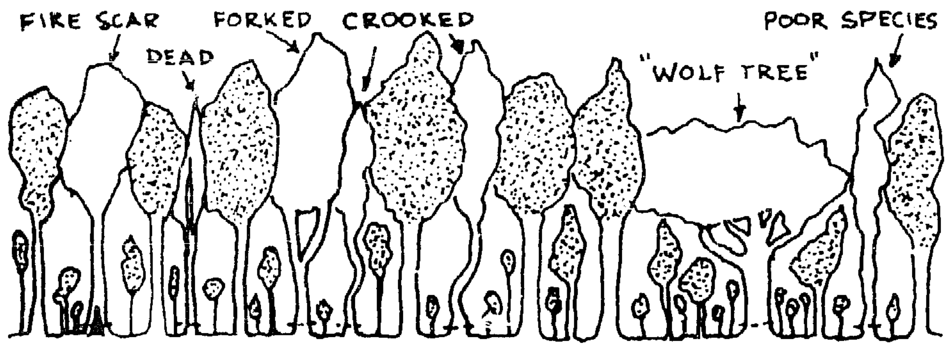
A conifer is preferred for construction because it is a softer wood and easier to work. Especially valuable, building-wise, are the pines, spruce, hemlock and Douglas fir. In checking over current nationwide lumber prices one notes that hemlock and beech have a very low stumpage value, whereas birch and maple have a very high value. There is an even greater price range in lumber *grade*: select white pine sells for $300 a thousand board feet, while number 4 common grade sells for $100.

A high lumber grade is best obtained by maintaining the woods at proper density. The younger the trees the greater the density. When forests are planted from scratch about 1,000 trees per acre are usually set out . . . the mature crop should contain about 200 trees. One should maintain a uniform rate of growth in a correctly managed woodland. If the trees are sparsely planted they will grow too fast. The faster a tree grows the more taper it will have. And, of course, the greater the taper the larger the knots. Lumber without knots brings three or four times more money. When a timber stand is crowded while the trees are young the lower branches naturally die and break off, thereby reducing knots. Conversely, a timber stand should not be allowed to grow too slowly . . . that is, in too crowded conditions. When a conifer or hardwood grows slowly the wood is light and weak and is, thus, a poor building material where structural strength is required.

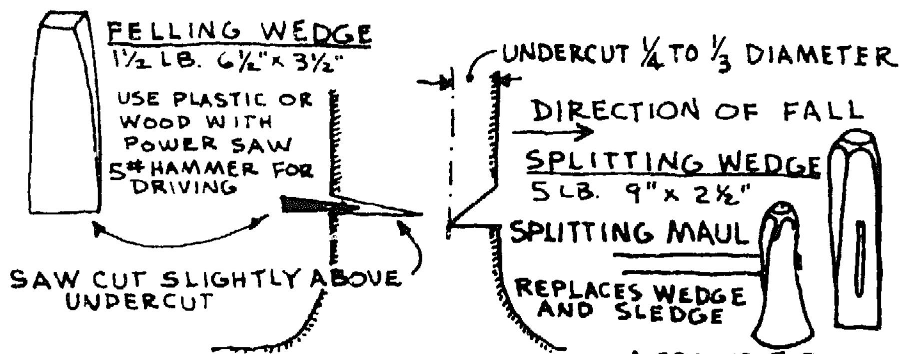
Correct pruning, thinning and cutting practices constitute the final factor for maintaining optimum woodland conditions. Woodland thinning is done to reduce the density . . . maintaining a fast-growing diameter and slow-growing height. It is better to make moderate thinnings at frequent intervals than heavy thinnings infrequently. And pruning and thinning should be done in early spring, just before the growing season begins.

Some thought needs to be given to the question of when to harvest a saw log. A four-foot-diameter log contains more board feet of lumber, but it is not economical to grow a tree to such a large size. Small trees increase in board-foot volume much more rapidly than large trees: as a tree grows from 10 to 11 inches in diameter the board-foot volume increases 33%; from 20 to 21 inches the volume increases only 10%.

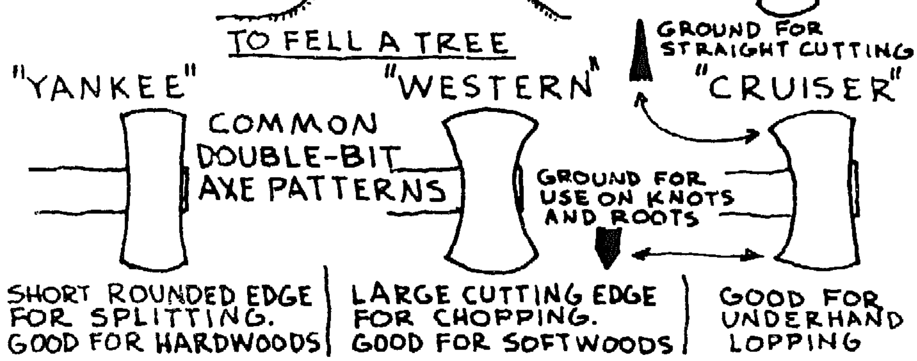
Before attempting to fell a mature tree, first consider the damage that may occur to surrounding trees on its way down. Keep in mind the slope of the ground, the lean of the tree, wind movement and final positioning for removal from the woods. An undercut is first made to guide the direction of fall. On a conifer the undercut chunk should be about one-fourth the diameter of the stump; a hardwood tree should be cut one-third the diameter. The main cut is made on the opposite side of the undercut, slightly above its base.

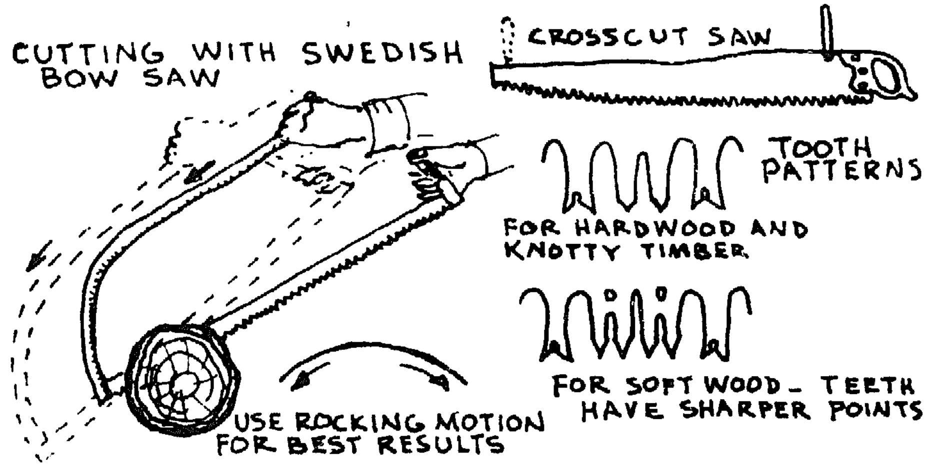


IMPROVEMENT CUTTING



TO FELL A TREE





On the assumption that a picture is worth a thousand words, the accompanying drawings should present the final statement necessary to acquaint one with all the important facets of woodland harvesting.

Fuelwood is one of the neat cottage industry by-products of a well-managed woodland. From thinnings and prunings alone, about one cord of new wood is realized per acre per year. A cord of hardwood weighs two tons (twice the weight of soft wood) and, if dry, will give as much heat as 200 gallons of fuel oil or one ton of the very best anthracite coal.

Maple sugar production is practical in many homestead woodlands throughout the eastern U.S. I urge anyone interested in maple sugar to read Scott and Helen Nearing's *Maple Sugar Book*. It contains everything one needs to know on the subject, as well as some beautiful and well-documented historical commentary. One of their references is quoted here . . . one which sums up the subject succinctly:

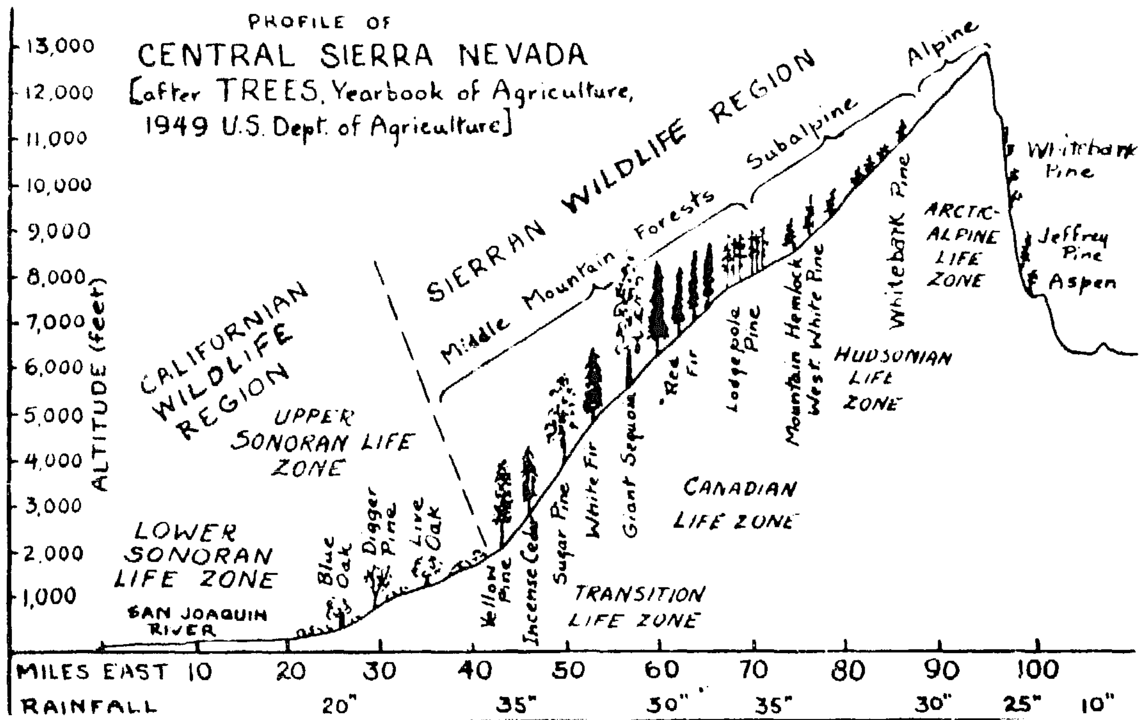
The maple grove that is planted by a young man may be enjoyed by him through more than half of an ordinary lifetime. With proper care it will perpetuate itself through a long course of years, and for aught we know (if the young growth is protected) forever. It will occupy broken grounds that could not otherwise be cultivated, and the timber, when taken out at greatest maturity, has a value which is gaining every year, aside from the annual revenue to be derived from the sap. The maple adorns and beautifies perhaps more than any other of our native forest trees . . . The sugar season comes at a time when farm labor is least employed, and the occupation presents amenities beyond those which any other form of farm labor can afford.

Franklin Hough, Report on Forestry, 1884

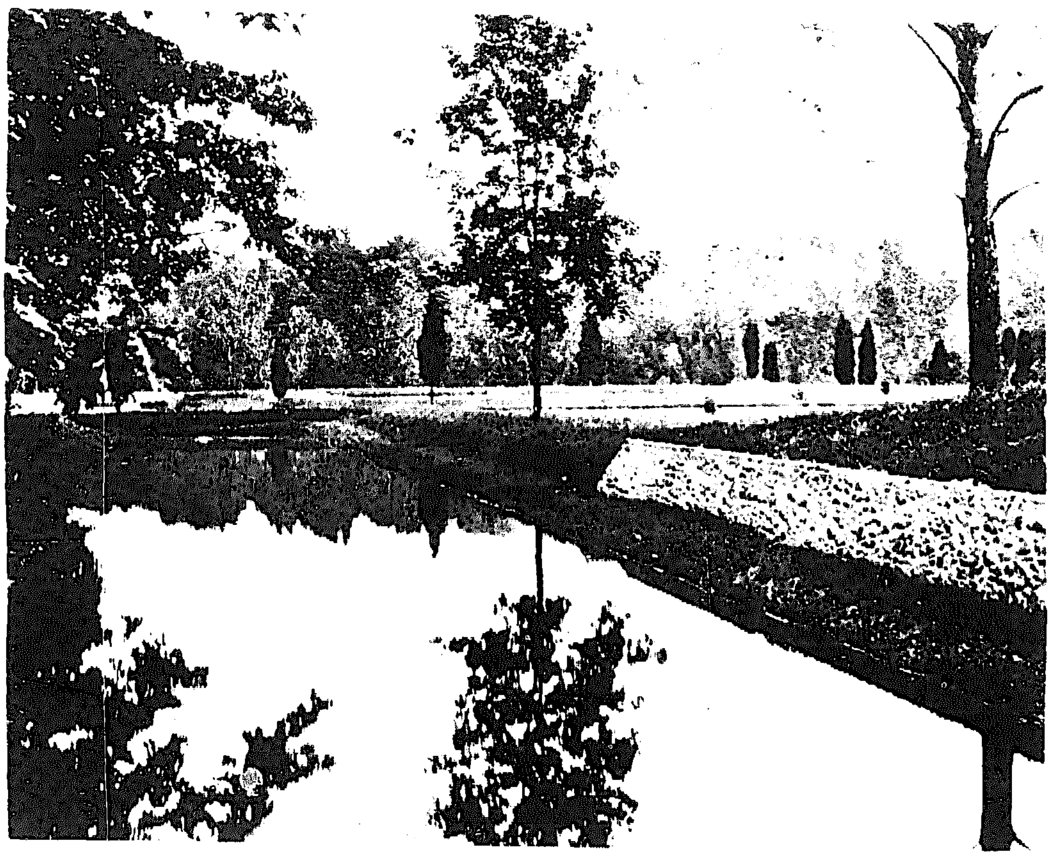
A final word should be reserved for the most current get-rich-quick woodland production schemes . . . Christmas trees. The 1970's Christmas tree craze reminds one of the chicken-ranch mushroom-growing enterprises of the 40's; the fishing-worm rabbit-farm production of the 50's; and the chinchilla-raising herb farms of the 60's. To this day I still build fireplaces from used concrete block salvaged from nutria-raising pens constructed in 1948. Many entrepreneur homesteaders have lost life savings in these earlier schemes, but the homesteader who is "into" Christmas trees can stand to lose more than money. From my point of view he degenerates a possibly beautiful tree-growing experience for profit from a pagan ritual.

It has been calculated that 100 Christmas trees can be raised on one acre of land per year. On this basis, 600,000 acres will supply all the Christmas trees needed for the entire nation. But today, there are over *50 million* acres of submarginal farmland ideally suited to Christmas tree production. A Christmas tree homesteader who invests in, sets out and attends the seedlings (which includes annually shearing the trees to develop a thick and symmetrical foliage) can expect a $1.00 profit from each balsam fir at the end of a ten-year growing season. A loblolly pine, cut for piling, at the end of sixty years will net $50.00.

Economic advantage may hold the greatest appeal for many, but remember: windbreak, soil and moisture-conserving objectives can only be attained with a proper form of woodland management which, incidentally, brings the greatest woodland income. Good harvesting . . . and look to your hills.



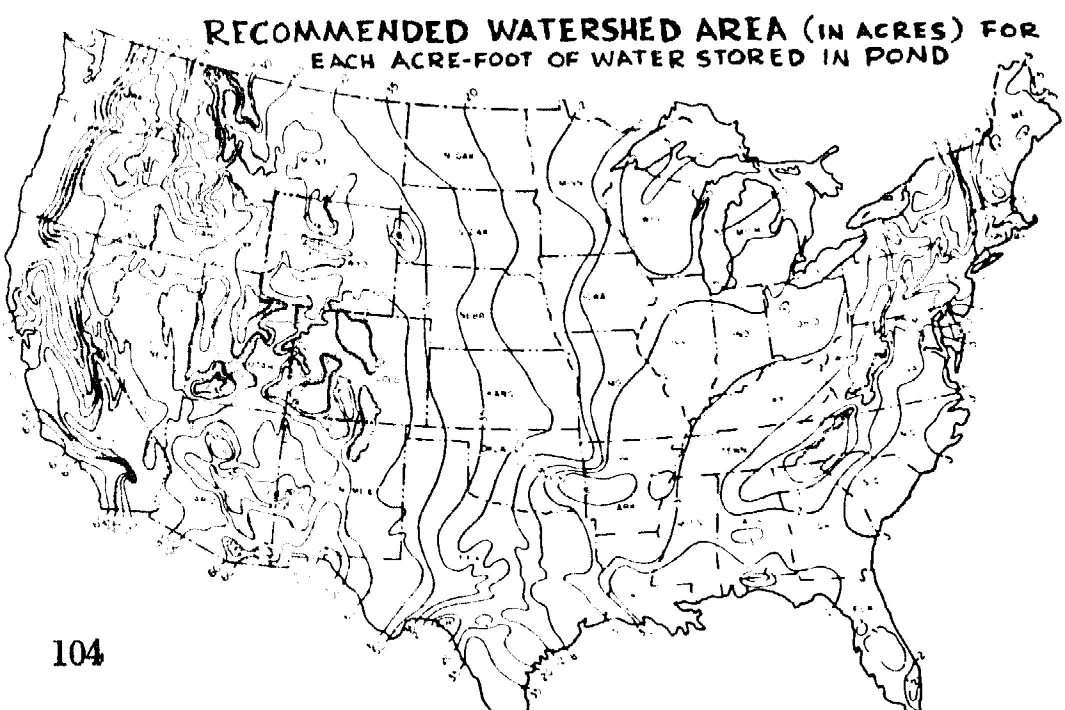
Fish Culture



The old saw that goes, "There are more fish in the sea than ever came out of it," is rapidly becoming questionable: witness the endangered survival of some fish species, like the salmon. For at least one good reason, therefore, a thoughtful fish management program is one of the really exciting prospects for homestead food production. Yet, it never ceases to amaze me how few North American homesteaders get into a fish management program. Practically all the ancient civilizations — Mesopotamia, Egypt, China, Peru — maintained fish farms in their gardens. Fish farms in Europe date back to the stone-lined Roman-style ponds. During the Dark Ages monks perpetuated farming practices to supply fish for Lenten and Friday sacramental observances.

Fish culture continues to interest European farmers, and in Asia practically every small homestead includes a series of ponds where intensive fish production is maintained. With the North American farmer's regard for livestock as having prestige value the unseen fish offers no commensurate status symbol. What the land-animal farmer doesn't appreciate is that fish cultivation can produce twenty-times as much protein as can animal production. On good permanent pasture young cattle may gain 300-pounds per acre per year; on poor land the gain is about one-tenth this amount. But average fish production under intensive management is in excess of 6,000-pounds per acre per year. To be exact, fish increase in weight two-times more than cattle do in terms of increase per unit weight of animal per unit weight of food consumed. And fish protein is superior to meat in quality: it contains no carbohydrates and only one-tenth of one percent fat. Being lower on the food chain, much less energy is consumed by a fish in its life activity. An important part of the energy that a land animal obtains from food is required just to maintain its body temperature and to support its weight. Being cold-blooded and being supported by water, fish become a far more economical (efficient) meat producer.

A farmer's need for tangible (grazing) status symbols may, thus, partially account for his reluctance to get next to fish production. There are other reasons, too, besides his obvious ignorance of what fish production is all about. Here one notices the dominant influence government agencies can have on a farm program. Franklin Roosevelt started the farm pond program in the early 1930's with the enactment of federally subsidized CONSERVATION PONDS. Even today, as much as one-half the construction cost of a homesteader's pond will be paid for by the Conservation Service. When the pond is completed it can be stocked with free fish from State Fish and Game hatcheries. The hand-out obscures the fact that the pond is not built to maximize fish production — and the free fish are the wrong varieties.



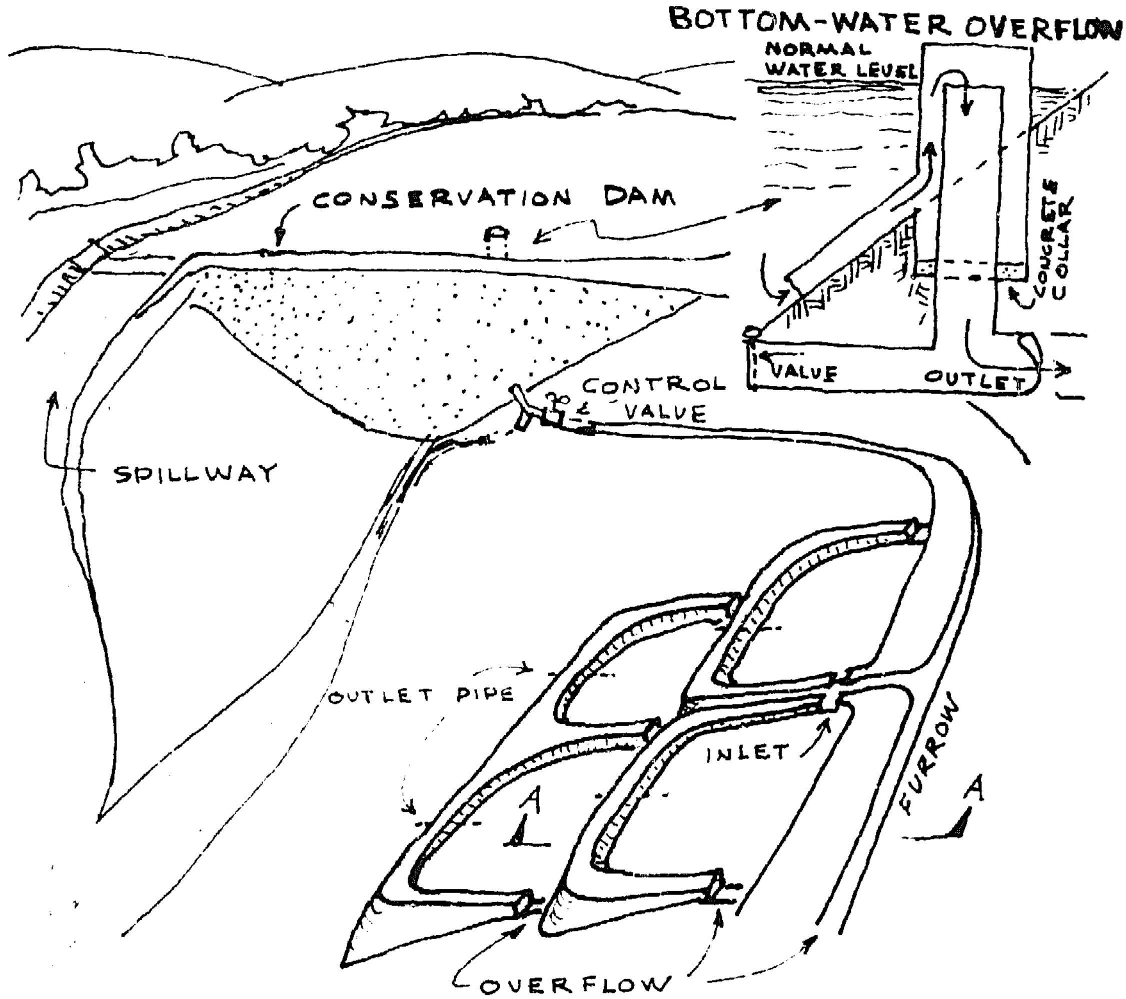
The American-style conservation pond will, therefore, be differentiated from Asiatic-European pond management practices which will be discussed later in this chapter. Fish in a conservation pond perpetuate by annual reproduction and are harvested by hook-and-line, a method invented in late Paleolithic times. A well-managed conservation pond will yield to a patient hook and line as much as 500-pounds of fish per acre per year. From an uncared-for pond one would be lucky to land 100-pounds of fish per year.

Proper pond management starts with a properly engineered pond. Consider, first, the water shed area. In the eastern U.S., where well-distributed rainfall averages 40-inches a year, the water shed should not be more than 20-times the surface acreage of the pond. Here in the West a considerably larger water shed area is required due to dry summers and high evaporative rates. Excessive water flow and flooding should be avoided by building diversion terraces. There is really no good method of screening fish from an overflow. A wide spillway, however, saves more fish than a deep one. Pond depth is related to climate: a 3-to-12 foot depth is ideal except in northern states where WINTER-KILL is avoided by deepening the pond to 16-feet. Winter ice creates a seal over a pond, preventing an adequate exchange of gases between air and water.

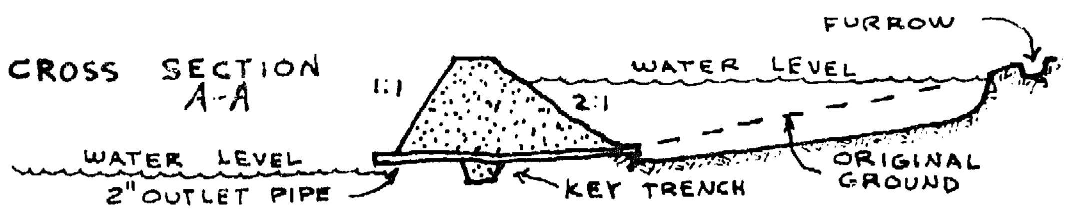
Sufficient oxygen content of pond water is insured when the depth is kept shallow. Fish culturists have found that oxygen content and fish stress are related, leading to disease when undue stress activates a latent virus in the fish. Disease outbreaks occur following low-oxygen periods. When the water temperature is the same from surface to bottom, as in early spring, the evenly distributed weight or density of the water makes for an equal circulation and an evenly distributed oxygen content. But in the summer there is a danger of oxygen deficiency in a pond, called SUMMER-KILL. The combination of cloudy skies, calm winds and high temperatures in a shallow, weed-laden pond can wipe out a fish population overnight. In the summer shallow water often becomes choked with aquatic vegetation, such as cattail and bulrush. Under such conditions the organic decay and respiration demands are high on the available oxygen supply of the water. Basic forms of plankton and algae die off, and in the process of dying they, too, use up valuable oxygen.

Even a small-but-constant flow of water into a pond will raise the oxygen level. Water from the bottom of the pond should be replaced with fresh water, especially in deeper ponds where temperature differences cause a stratification or layering of water levels. To insure adequate circulation of lower and upper water levels some sort of releasing device must be installed on the bottom of the pond. Details of one such conservation pond bottom-water overflow is illustrated below.

Asiatic-European pond management practices are far more sensible about the maintenance of fish oxygen and food requirements. In these



CONTOUR PONDS BELOW CONSERVATION DAM



countries it is a common practice to stock ponds with a wide variety of fish species and sizes to best utilize the available food supply. Too little available food in a pond may cause predacity among its population. On the other hand, too much food causes oxygen deficiencies along with the formation of toxic gases. Some fish, like grass carp, are stocked for the primary purpose of devouring grass and underwater weeds. Furthermore, it has been found that faeces from the grass carp contain massive amounts of half-digested vegetable matter which is fed upon by other fish. And, of course, the manural value of fish wastes stimulate plankton growth. Grass carp do well in colder climates, and their vegetive-eating nature permits a more extensive shoreline area. Shoreline creatures (such as water insects, tadpoles and crawfish) should be encouraged. Some forward-thinking pond builders even suggest the use of interior tree-planted islands to further increase the shoreline perimeter.

In China fish ponds are drained every few years. Aquatic vegetation and surplus muck are removed to fertilize gardens and orchards, and the pond bottoms are exposed for a period to the sun and the air. The pond bottoms are then planted to soybeans, rice or alfalfa — with far less fish disease and parasitic incidence when the pond bottoms are harvested and later re-stocked with fish.

Correct STOCKING practices constitute another important feature of pond management. It is the water temperature that influences fish spawning, and so, obviously, the species chosen should be attuned to its water-environment. Large mouth bass, bluegill and catfish thrive in warm water ponds; trout, in cold water. Small mouth bass, pike, and yellow perch do well in water of intermediate temperature. In general, trout are a poor choice. They live high on the food chain, requiring generous quantities of protein food themselves.

Bass live relatively high on the food chain, too, but stocking practices have been formulated to make bass one of the best choices for conservation ponds. That is, bass are stocked with bluegill at the ratio of 1-to-10. Bass feed on the bluegill during the summer and fall months, thereby controlling the bluegill population whose prodigious reproduction constantly threatens their own survival. This mutual association works in other ways, too. Bass, like all fish, are caught when they are hungry — in the spring — when their food supply is scarce. In the winter, the cold water temperature de-activates their digestive process, and the fish feel no hunger. So, at the time of the year when bass are least available (summer), the bluegill are most prevalent. A well-managed pond will yield 5-pounds of bluegill for each pound of bass.

Fish yield can be tripled by fertilizing the pond, clear water denoting poor production. If one can see a white object a foot beneath the surface of the water it is not adequately fertilized. Organic fertilizer provides food for a heavy growth of microscopic algae. Worms and larva live on this algae, and, of course, fish live on the worms and larva. Fertilization also indirectly reduces weed growth since the microscopic plants (which it supports) supply shade, thereby reducing weeds. Water weeds and shallow-water plants should be discouraged, for, as I already pointed out, they cause excessive stagnation and oxygen depletion.

Conservation pond management can prove to be an enjoyable pastime for the time-affluent sports-minded homesteader. But the best use for the conservation pond of the serious-minded fish producer is as a water supply for real, honest-to-goodness fish CULTURE PONDS. Culture ponds are different from conservation ponds in four important respects: they are shallow; they can be drained, they can be kept dry or under water alternately; and they are managed in conjunction with two-or-more, adjacent, gravity-fed ponds. Also, there should be no through flow of water in a culture pond. Seepage from one pond may be used to keep the next in the series full.

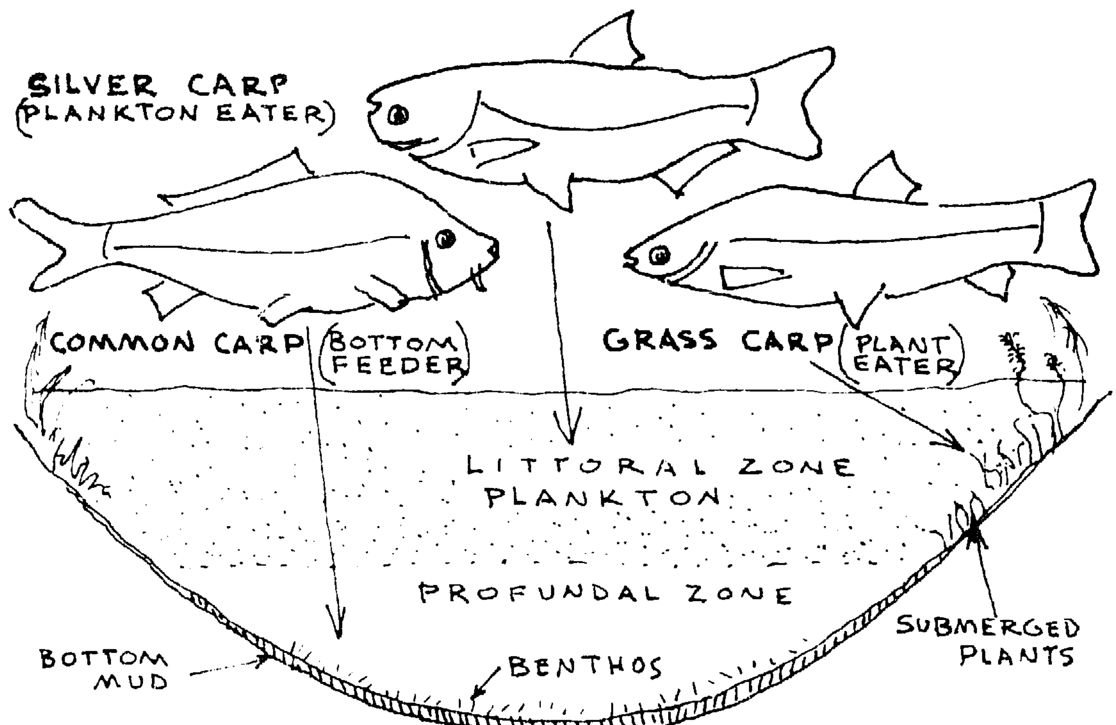
An ideal culture pond arrangement consists of three, ⅛th-acre ponds, adjacent to each other but terraced to allow for gravity drainage. The 3-foot depth may be increased to 5-feet at the deep end in less water reliable areas or where winter frosts occur.

Three-hundred-and-fifty million years of life on this planet have enabled fish to develop a high reproductive potential that enables them to outlive their predators. Even so, fish mortality in a natural environment is considered to be 80 per cent. Under artificial (culture pond) conditions the mortality is reduced to 10 per cent. As background for the understanding of a dynamic fish culture program, consider for a moment the most basic mutual exchange relationship; a fish, a snail, and a water plant are placed outside in a bowl of water. The plant uses fish and snail waste, prepared and made available to the plant by the snail. And, with a little help from the sun, the plant releases the necessary oxygen to purify the water and keep the snail and the fish from suffocating. The fish, in turn, lives off the plant. This ecology may be over-simplified, but it does demonstrate the basic relationship that takes place. In a real life situation one finds bacteria and algae at the base of this food chain. Bacteria utilize complex waste materials in the water, and algae utilize inorganic salts, carbon dioxide and water in the presence of sunlight to produce protein and carbohydrate. One form of plankton (phytoplankton) feed from these basic food forms; another plankton (zooplankton) eat the phytoplankton; minnows eat the zooplankton; and larger fish eat the minnows.

A balanced environment of this sort can be reproduced on an economic scale by any homesteader. Farmers in the Rhine Valley have been doing it for a hundred years. After a few years of grain crops these farmers flood their fields and stock them with carp. The carp thrive on vegetive residue, mature rapidly, and are then harvested by draining the field. The fish-manured fields once more are sown to grain and the cycle is repeated.

Of course, the Chinese perfected pond culture two thousand years ago. They developed complex water-control and dam-construction techniques, and they knew almost everything we know today about fish stocking and reproduction, pond fertilization and weed control. One of the greatest contributions that the Chinese made was the breeding of fish varieties to live on the wide variety of food found in a balanced pond situation. Their multi-species stocking includes an herbivorous-eating, a plankton-eating, and a bottom-feeding fish. Even single species of fish, like carp, were bred to a specific regimen. Mainland China today produces more fish than any other nation in the world — over a million-and-a-half tons in 1965!

Modern homesteaders could do no better than to pattern their pond culture program after that of the Chinese. We know it works! First

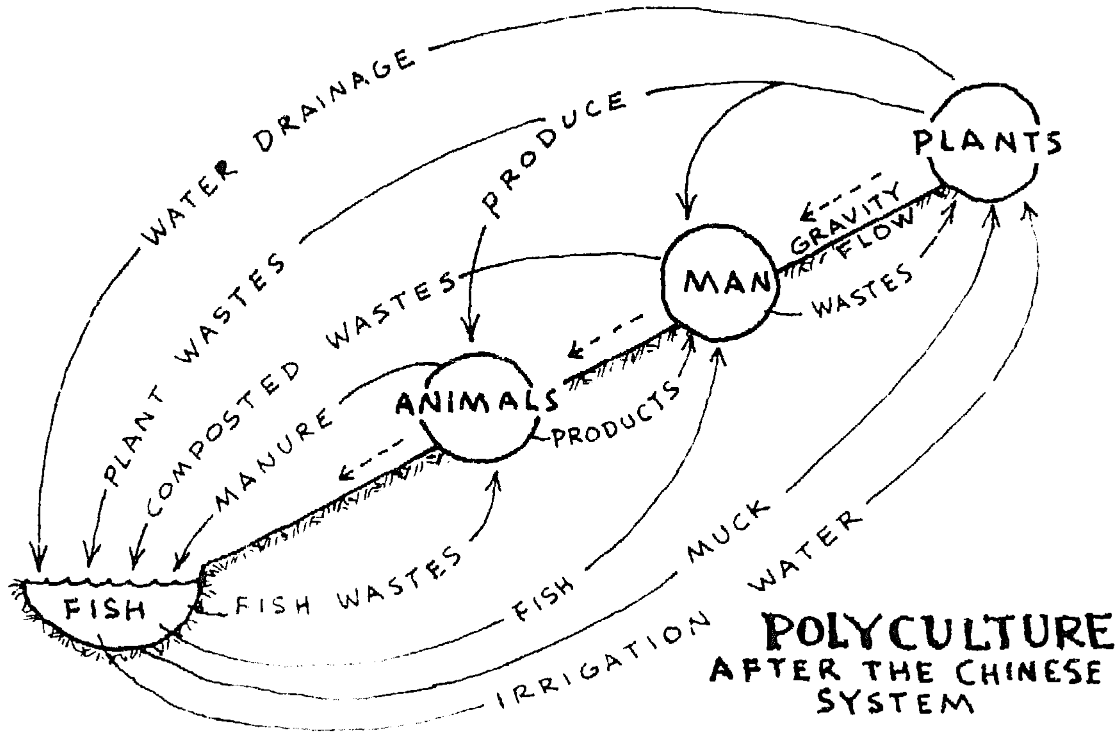


FEEDING ZONES AFTER THE CHINESE SYSTEM

of all, the multi-pond arrangement is employed, especially to separate the breeding and growing stages. Under Chinese management, fish culture is a small scale activity that includes the orchard, garden, pig, duck and chicken in its cycle of production. Wherever possible this polyculture program is set up on a slope to take advantage of gravity flow. Here's how it works: nutrients leached from garden and orchard drain into the fish pond.. Fertilizer from pig and poultry is also washed into the pond, pig dung containing 70 per cent digestible food for fish. When the fish are harvested their offal and the undersized are fed to pig and poultry. Muck from the pond is then scraped out and placed on garden and orchard terraces. Or a field crop, such as rice, is planted in the harvested pond. Nutrient-rich water from the fish-manured pond is also used to irrigate orchard and garden crops. In China, it is the plant that is manured, not the field.

Centuries ago the Chinese discovered the importance which ducks have in this mutual exchange. Ducks are allowed on the pond to help control weeds and snails. The Muscovy breed seem to be hardiest and easiest to raise. It has been found that carp, grown in ponds to which ducks have access, grow from 2-to-5 times as fast as those grown without duck populations.

Ducks, in China, also function — along with frogs, chickens and pigs — as natural pesticides. The Asian principal of pest control creates good food for farmyard inhabitants through thoughtful husbandry of insects and weeds. The old adage, "If you can't beat 'em,

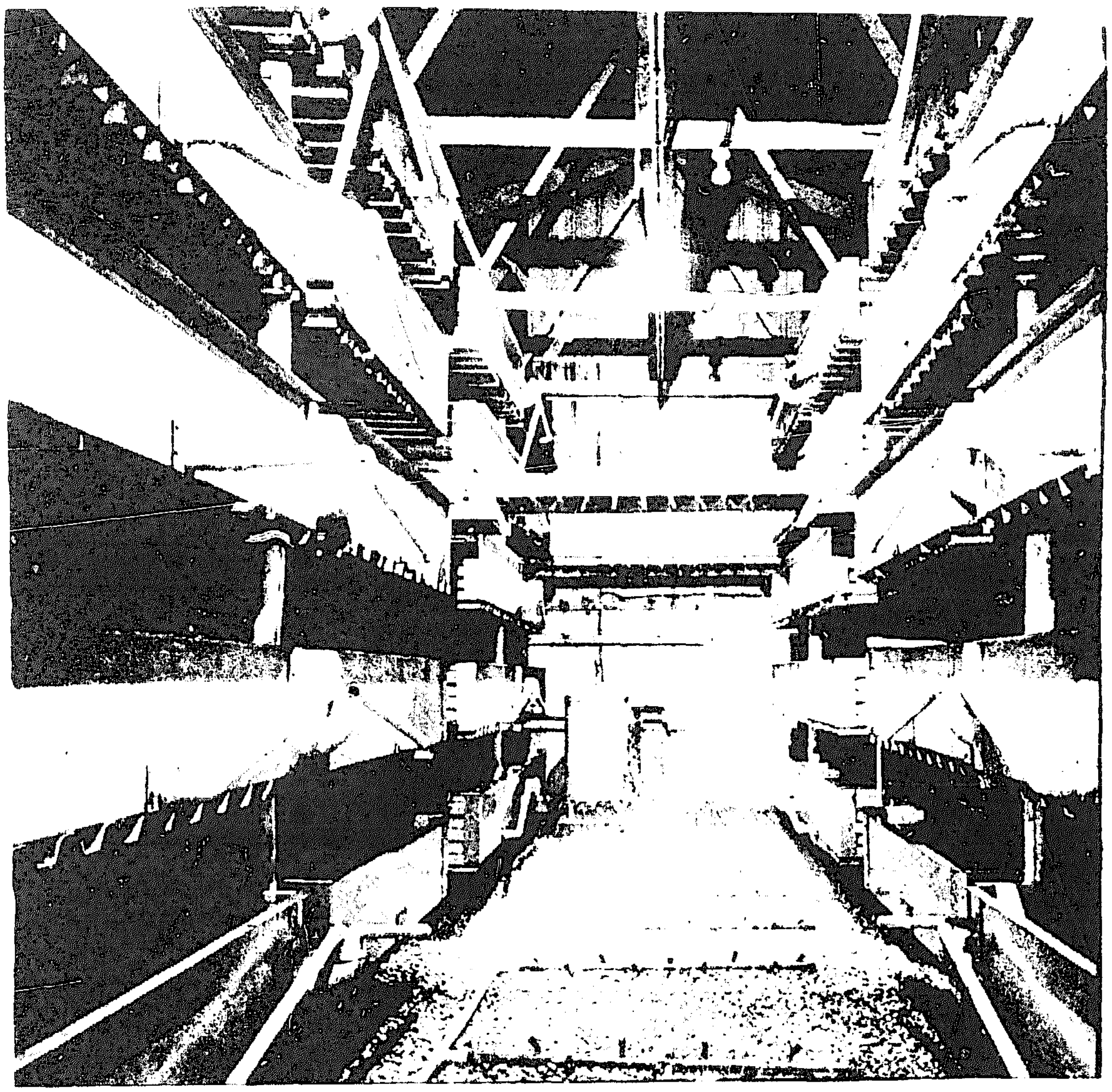


join 'em," may be rewritten in Chinese usage, "If one cannot eradicate them, use them." One other thing: it is a custom in China for the fish farmer to establish field privies over his ponds to encourage the passer-by to stop to rest.

In recent years the Food and Agricultural Organization of the United Nations has done extensive research in fish culture. This organization has, in fact, made a science of intensive fish production, called aquaculture (the growing of aquatic food organisms). Polyculture, the management of a variety of crops in a single production area, is now being promoted and recommended by an impressively qualified scientific community. Much work has been accomplished in developing improved fish strains. One of the most promising of these is a species originally raised in Africa — the Tilapia. Tilapia are easy to breed. A pair raised under favorable conditions will reproduce their numbers to 1½-million in one year! Besides being generally free from parasites under crowded conditions, Tilapia are herbiverous and convert waste foodstuffs efficiently. They live low on the food chain, but do require warm water growing conditions.

Along with other phases of aquaculture, original research work raising Tilipia in North America is being done by a privately-funded group who call themselves the New Alchemists (Woods Hole, MA 02543). Currently, "backyard fish farms" are being managed experimentally as the aquaculture aspect of homesteading gains popularity. New Alchemists can provide an essential coordination service to these novitiate aquaculturists. As more and more people become turned on to fish culture and their own experiences become coordinated and related to others', a re-birth of this valuable homestead activity will, hopefully, occur.

One member of the New Alchemists recently collaborated on the issuance of a massive book, AQUACULTURE — THE FARMING AND HUSBANDRY OF FRESHWATER AND MARINE ORGANISMS, (John Wiley, N. Y., 1972). I would urge that seriously interested homesteaders read this book — if it can be borrowed from some university or research library. The printing price ($37.50) in no way warrants the small amount of USABLE information for homesteaders contained therein. Far too many of its 868 pages are devoted to such scary, but commercially viable topics as induced breeding, artificial propagation, or hormonally-induced spawning through intra-muscular injection of



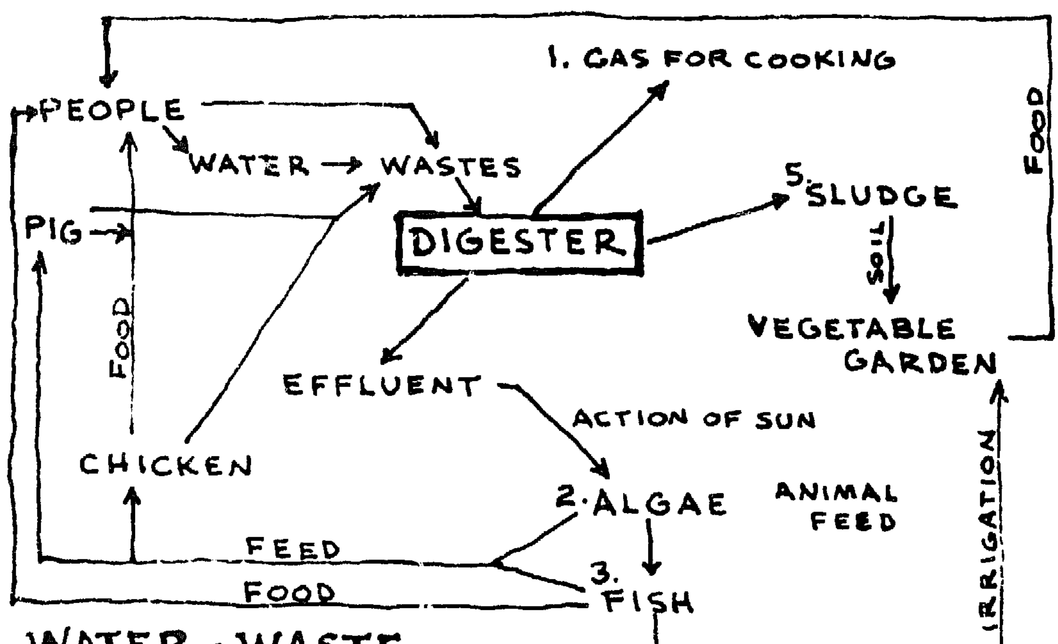
FEATURES OF CONTROLLED ENVIRONMENT AQUATIC PRODUCTION:
1) WATER TEMPERATURE MAINTAINED AT CONSTANT 78° WITH THERMOSTATICALLY CONTROLLED HEATERS.
2) AERATOR IN EACH TANK ALLOWS HEAVY STOCKING, PRODUCTION CAPACITY 10 LB. CU. FT. FEED CONVERSION 2.5 : 1 HIGH PROTEIN FEED
3) 40 UNIT TRAY (PICTURED) EQUIVALENT TO 30 ACRES SURFACE WATER
4) 40,000 LBS CATFISH PER YEAR AT 35¢ LB LIVE WEIGHT

pituitary extract. The current state and future direction of commercial fish production in this country is not unlike any other of our ridiculous, monoculture farming practices — like chicken and rabbit production, for instance. Similar closed-system, indoor-cage, food-rationed, controlled-environment practices prevail. One company even offers "controlled marketing" features: "There is no need to market immediately when fish reach 1¼-pounds. If prices are unfavorable, it is possible to reduce the water temperature and withhold feed. Fish will hold their weight until market conditions are more favorable."

In contrast to the American-style agribusiness approach to fish production, some agencies like the United Nations Food and Agricultural Organization offer valuable research and development for third world countries. In 1966, the U. N. held a world symposium on warm water pond fish culture and subsequently published a 5-volume proceedings.

Since 1934, extensive fish pond research has been carried on by H. S. Swingle at Auburn University in Alabama. At one time over one hundred ponds were drained and refilled in order to develop simple pond management techniques which could be used by farmers to increase their fish yields.

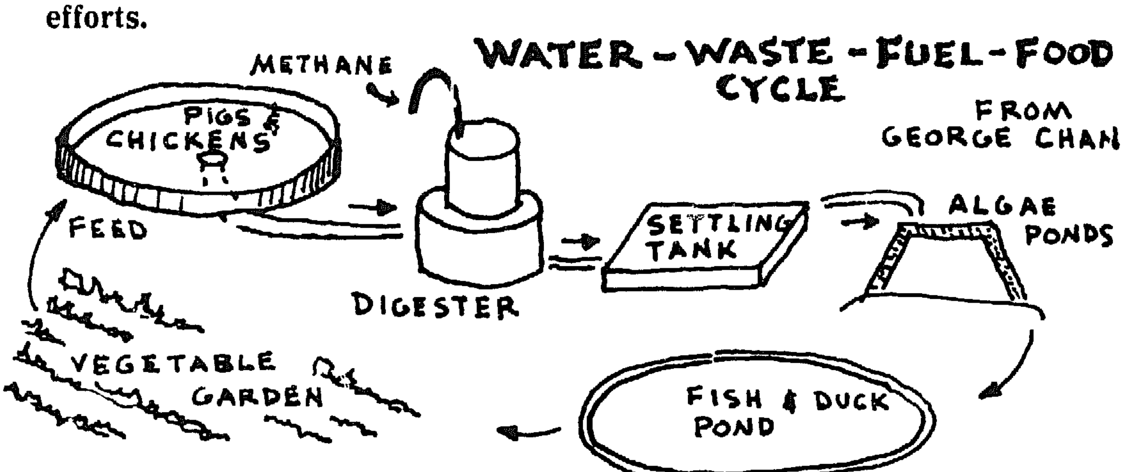
I have reserved a description of today's most significant fish production research for last. It summarizes the very best thinking in polyculture subsistence where fish are but a small, integral part of a homestead ecosystem. Mr. George Chan, currently teaching at the University of Papau, New Guinea, has built a working demonstration of a full-cyctle waste digester. Here's how it works: homestead wastes — excrement from humans, pigs and poultry — are washed into a simply-constructed, 300-gallon, concrete digestor tank. Anaerobic decomposi-



WATER-WASTE FOOD CYCLE

tion takes place, producing methane gas which is piped into the homestead for cooking and refrigeration. Effluent wastes from the digestor are then discharged into a small pond where sunlight and warmth cause a high-protein algae to grow. The algae is harvested, fed back to the pigs and poultry, and the algae-purified effluent is then channeled into a small fish pond. Tilapia, carp and other varieties of fresh water fish readily fatten on the algae. The fish are harvested for human consumption and are also cooked and mixed with dried algae for a highly nutritious animal feed. The final stabilized sludge from the digestor waste is drained into a garden plot where mineral-rich vegetables are grown for human and animal consumption. Pond water is also used for irrigation.

The Taiwan government has sponsored these digestor units in an effort to advance rural development and to prevent the drift of young people to already over-crowded cities. George Chan points out that there are now over 5,000 such digestor units in operation in Taiwan alone. This is quite amazing in view of the fact that American methane-freaks have for years been playing around the periphery of the idea with hardly a single WORKING digestor to show for their efforts.



Animal Waste

Pig and Chicken manure is ideal. Circular barn has concrete floor sloping into central digester.

Digester

Capacity 300 gallons for 30 pigs and 24-hours of effluent flow. Fresh waste should be discharged into the digester each day.

Settling Tank

Capacity 24-hours of effluent flow. Bacteria complete digestion of organic matter and destruction of harmful organisms.

Algae Basin

Concrete floor and walls one-foot high. Surface area about 600 square feet with two longitudinal baffles to prevent short circuiting. Shallow depth insures maximum sunlight penetration.

Algae Ponds

Pond size about 60x15x3 feet deep. Several ponds may be installed for larger operations. Pond is formed in the earth into a truncated "V" shape, lined with puddled clay and covered with 3-4 inches of sand to prevent colloidal suspension of clay. Algae is removed daily and mixed with animal feeds or is sun-dried for future use.

Fish Ponds

Pond size about 100x15x5 feet deep, built like an algae pond, but without the sand cover. Growth rate is about one-pound each month. Fish may be processed into meals for animals or eaten by humans. They feed on algae and water microbes and not on excreta. Several ponds may be installed.

Ducks

Ducks do not compete with fish for food. Together they keep the pond clean, controlling mosquito larvae and weeds.

Vegetable Garden

Watered and fertilized with rich effluent and humus (sun-dried sludge). Vegetables provide the bulk of animal feed.

(Adapted from George L. Chan, senior lecturer in environmental Health, University of Papua, Port Moresby, New Guinea--as reported in EARTH GARDEN No. 8)

Fences

Fence building is the kind of development expenditure for which homesteaders seldom allocate sufficient time or funds. Consequently, a temporary, slip-shod installation is a familiar sight among modern-day landowners. The construction of an adequate fence is not unlike the construction of any other adequate homestead structure for it necessitates the proper choice of tools, correct construction methods and procedures and one's use of the right kind of materials. And, of course, prior to the actual implementation of the fence-building project one needs a good layout plan.

Due to high labor and to material costs (which alone average forty cents per lineal foot), proper fence building requires the homesteader's establishment of a program of priorities before commencement on any part of the fencing plan. A homestead developed from unimproved land may have as many as seven priority fencing stages:

1) BOUNDARY. A permanent fence around the homestead perimeter is necessary to contain one's own — or to exclude others' — livestock.

2) ROW AND TREE CROPS. No successful crop management can take place without adequate protection against encroachment by domestic or wild animals.

3) HOLDING YARD. Some form of enclosure is necessary for the close confinement of farm animals.

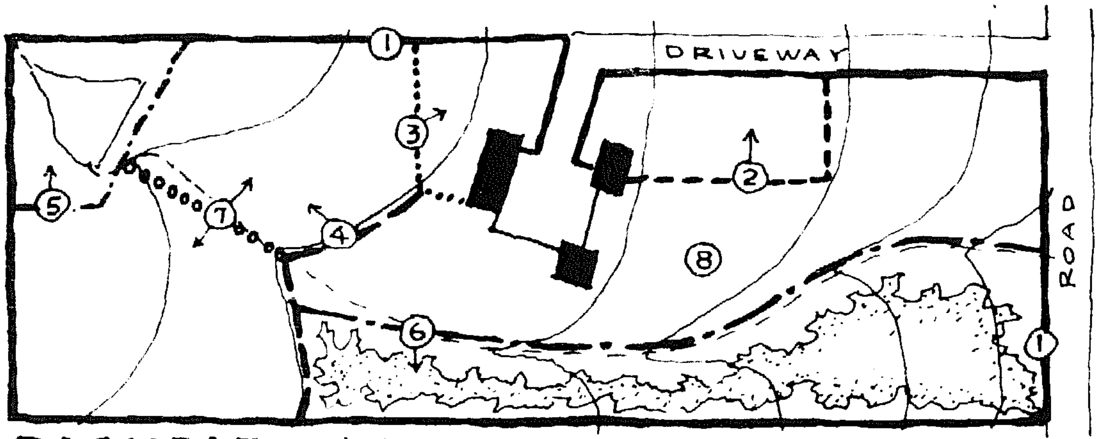
4) PERMANENT PASTURE. To prevent over-grazing and for purposes of crop rotation controlled access to a number of pasture areas should be provided.

5) POND. Proper maintenance of a pond requires its fencing from livestock.

6) WOODLAND. A fence around the woods delineates the serious purpose of this enclosure to fire-making picnickers and keeps livestock from damaging small trees.

7) FIELD DIVISION. Grazing areas having similar soil type, moisture or steepness, should be fenced separately. Early spring grazing may occur on higher land while summer and fall grazing can be reserved for lower, bottom land.

A number of things may occur in the process of building a boundary fence. True property corners and lines are established when the lines are surveyed. Then as a further bonus from the fencing operation, land becomes cleared for a firebreak and for boundary road access. It is generally advisable to remove trees adjacent to boundary lines where falling branches and windblown limbs can cause havoc to an otherwise well-built fence line.

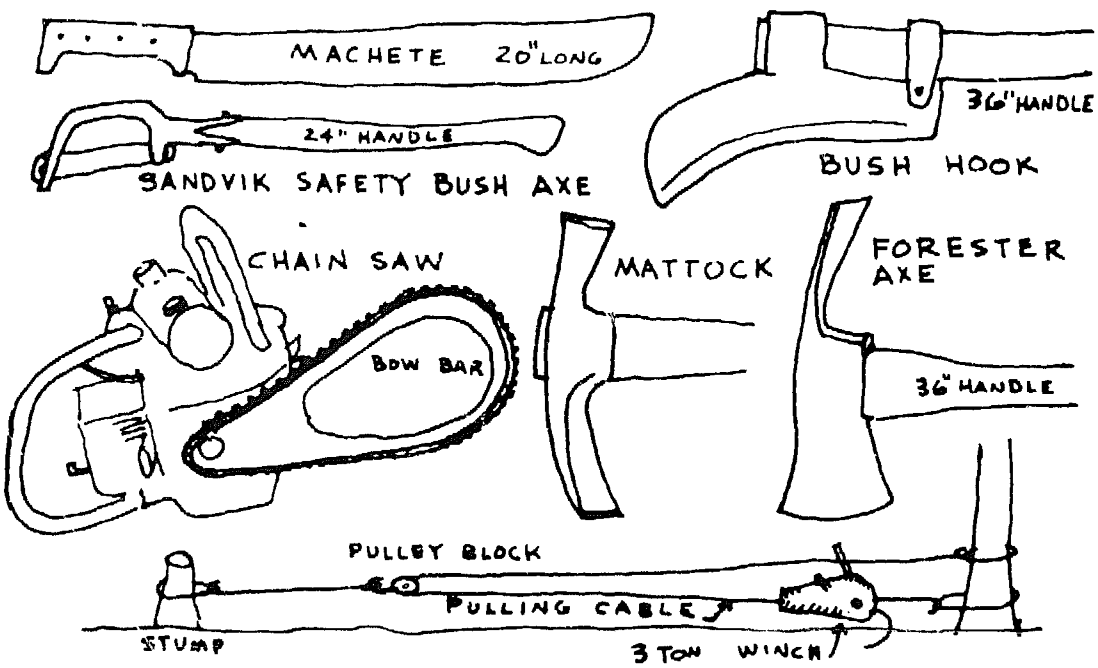


POSSIBLE FENCE-BUILDING SEQUENCE
(1) BOUNDARY
(2) ROW & TREE CROPS
(3) HOLDING YARD
(4) PERMANENT PASTURE
(5) POND
(6) WOODLAND
(7) FIELD DIVISION
(8) SOD CROPS

Before posts can be set and wire strung, some consideration needs to be given to the process of land clearing. An investment in a small, blade-equipped crawler-tractor would solve this problem with dispatch, but there are often inaccessible places on the homestead where even tractors cannot be used to advantage. And — many homesteaders prefer, through choice or by necessity, to grub their boundary lines by hand methods.

A wide variety of hand and power tools are available for use in land clearing. Each tool realizes its most efficient use, depending upon the job to be done. Most basic of all clearing tools is the machete, an excellent choice for cutting vines and small brush. Larger vines and

LAND CLEARING TOOLS



saplings can be efficiently removed by using a bush hook. Although handled like an axe, the bush hook is preferable to the axe in that it has a wider blade which, when clearing land, has a tendency to wear out at the two extreme edges and yet show little wear in the center. The Swedish (Sandvik) safety bush axe has proven to be faster, safer and easier to use than is a common axe. Thin, flat (replaceable) blades cut quickly through young, springy stems. Few tools can outperform the mattock for general grubbing work. A Pulaski or Forester axe, patterned after the mattock, is a practical choice for general clearing work where maneuverability and tool-weight become a factor. Finally, when removing larger brush and trees, a homesteader would do well to invest in a gas-powered chain saw equipped with a bow bar. The bow bar is specially desgined to cut and to trim smaller-sized trees. The narrow rail, which follows the saw teeth closely, is unlikely to bind.

The mowing machine is an indispensable tool, especially on a mulch-planted homestead. A good mower will cut young brush if it has not gone through a winter's hardening. The late summer months of August and September are, therefore, the best time to clear brush in order to retard sprouting the following year.

Browsing stock, like goats and sheep, will do a thorough job of eliminating brush and tree shoots for the few years that reviving growth persists since hoof-packing of the soil by these animals, as well as their nibbling, favors the decay of these roots. If the tree is girdled or treated with ammate crystals (ammonium sulfate) and left standing a year before being cut down sprouting will not later occur. If land is not kept free of brush after its first clearance, in a period of three years there will be more brush than previously encountered.

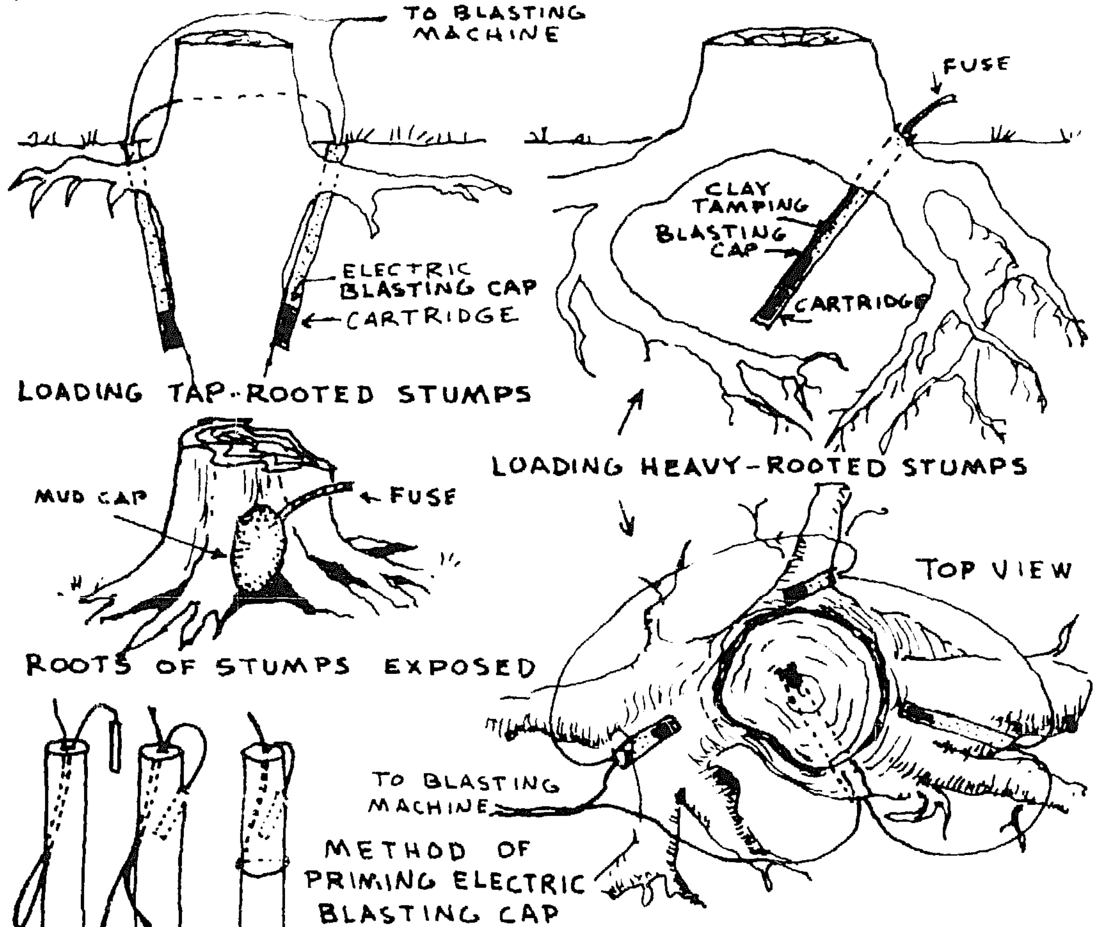
Some success has been achieved by sowing newly cleared land with a ryegrass-crimson clover mix. No special tillage-type soil preparation is necessary. Kudzu grass is another good sod crop used for clearing land. Its luxuriant growth will rot stumps and actually choke out trees and brush.

It may become necessary to remove stumps entirely. This can be accomplished by a number of methods short of pushing them out with a tractor. Perhaps the simplest way to remove a stump is by using a combination of pulley blocks, powered by a hand-operated winch. A sturdy, 2-ton winch is the sort of tool that is put to constant good use on a developing homestead, and it is one of those essential, "first investment" tool acquisitions, like a chain saw or a mowing machine.

Wherever possible, tree stumps are best terminated at ground line and left to decompose back into the soil. With some durable species, like oak, cedar and locust, the decomposition process takes a long time, and, if the stump sprouts new growth, it becomes harder with age and is increasingly difficult to remove.

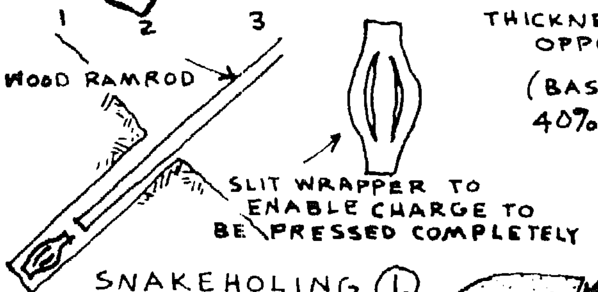
Stumps can also be (slowly) burned out. Two 1-inch holes are drilled diagonally into the stump, and hot coals are placed at the intersection.

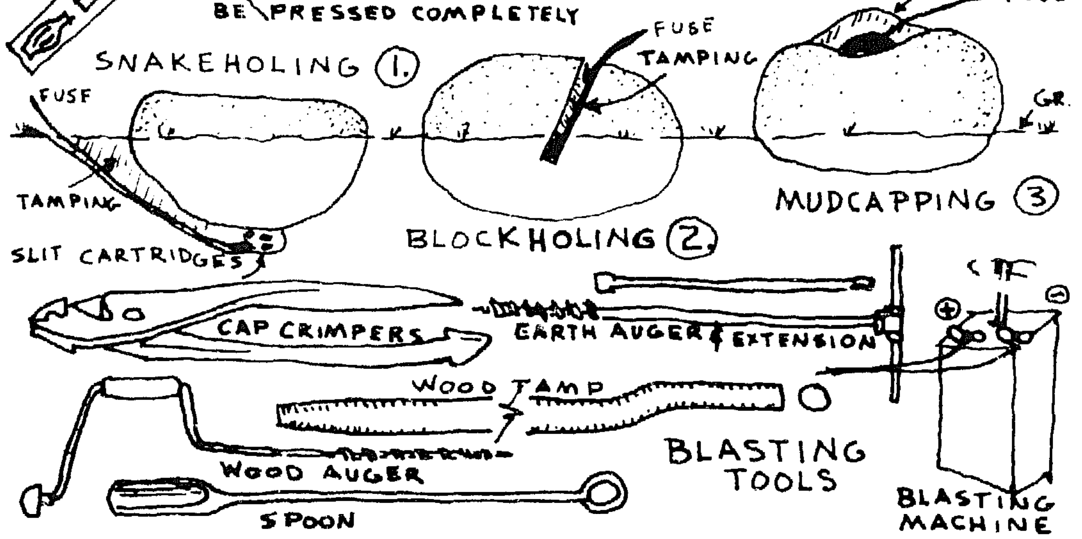
STUMPING AND BOULDER BLASTING



CHARGES FOR BOULDER BLASTING

THICKNESS OF BOULDER OPPOSITE CHARGE		①	②	③
(BASED ON 40% DYNAMITE)	1½ FT	1	¼	1-2
	2 FT.	2	¼	2-3
	3 FT.	3-4	½	4-5
	4 FT.	5-7	1	6-8





In a short time, the section between the intersecting holes will burn out entirely. An oil drum can be easily fashioned into a down-draft, stump burner. Bark from the stump should first be removed to encourage incineration.

Blasting can be, at the same time, the most expedient and the most economical method of stump removal. Using dynamite is like one's approaching the butchering of a hog; first contemplation of the act is that it is a formidable one, and one's tendency is to let the "experts" perform the task. But, once one's first hog is butchered or once one has set off his first dynamite charge, it is readily recognizable that the amount of essential expertise involved in these tasks does not warrant professional, outside assistance.

Dynamite used to be a standard homestead item, as common as a salt lick or a smokehouse. Every pioneer homesteader handled dynamite for well digging, road building, tree planting, ditching — and for stump removal. Powder monkeys, men who use dynamite for hire, can still be found in many rural areas. A greenhorn homesteader would do well to enlist such experienced aid for at least the first blasting project. In an effort to revive interest in the use of this important tool, I will take the time here to acquaint the reader with some of its significant properties and functions.

Dynamite is sold on the basis of the percentage of its nitroglycerine content. Twenty-percent strength is the lowest available charge, and a charge of this amount results in a slow, propelling force. Where a rapid, shattering effect is desired, sixty-percent strength will be required. A slow charge will raise a boulder or a stump, while a fast charge will shatter rock. A slow charge is set in clay soil, but a fast charge should be used in light, sandy soil. Stump blasting in sandy soil is not as effective for the force of the explosion will dissipate around the roots. Generally speaking, a pound of dynamite will move a yard of earth. Best results are realized when the ground is wet. The secret of using dynamite is the thorough confinement of the explosive gasses for, the more resistance that the soil offers to the force of the explosion, the greater will be the force exerted against the stump. For this reason a thorough tamping of the explosive in the drill hole is essential for good results. Tamping is done with a wooden rod.

A device called a blasting cap is used to explode the charge. When a single charge is desired, a fire-ignited fuse is used to combust the charge in the cap which explodes the dynamite. When a multiple charge is necessary, an electric-detonated cap is preferrable — though not mandatory inasmuch as a series of fire-ignited fuses, cut to different lengths, may be used to simultaneously detonate the explosion. A blasting machine is used to detonate an electric cap. This cap, as well as the fuse-ignited cap, must be primed; that is, either kind of cap is set into a stick of dynamite. A diagonal hole is made in the dynamite cartridge so that the cap will lie lengthwise to it. The following drawing depicts some of the features of using explosives in stump and boulder removal.

The best possible use of the commercial fertilizer, Ammonium Nitrate, is as a blasting agent. Since 1955, when it was discovered that No. 2 fuel oil could be mixed with Ammonium Nitrate to make a safe, inexpensive and readily available explosive, a definite revival has been observed in the use of explosives by homesteaders. About 1-gallon of oil added to a 100-pound bag of fertilizer is thoroughly mixed in a cement mixer. The fuel oil absorbs oxygen when the charge is detonated, confining the charge and thereby affecting the blasting action. Sawdust, added to nitroglycerine, serves the same purpose as fuel oil in the recipe described above. For removing huge stumps and boulders, fertilizer explosives are best used on large-scale projects and best placed in large-sized boreholes. Regular sixty-percent dynamite is used as a primer to detonate the fertilizer. A primer cartridge is usually placed at both the top and at the bottom of the borehole.

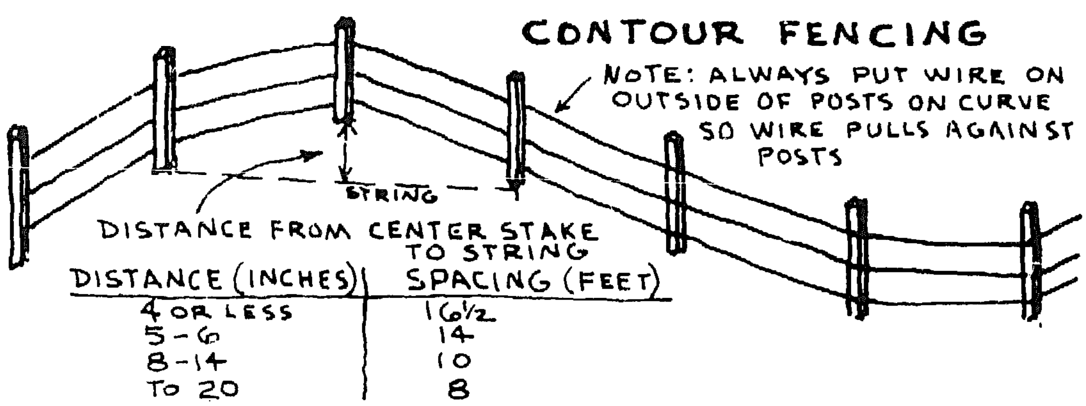
Following the completion of a line-clearing operation, one must decide where to subdivide the homestead acreage with fence lines and what type of fence materials to use in each separate area. Hard and fast rules are impossible to give here, but it should be of some help to list the many alternatives. In general, permanent fences — other than boundary lines — should be located along equal contours, at ridge lines or through draws. A familiar sight in rural America is the badly eroded tence line built from the top to the bottom of a hillside. Erosion is caused by livestock which customarily choose to walk along fence lines.

FENCE SELECTION FOR LIVESTOCK

TYPE	COST INDEX (RELATIVE)	LIFE (YEARS)	UPKEEP	CATTLE	HOGS	SHEEP GOATS	HORSE
BARBED WIRE							
2 pt. 3 ROW 12 GA.	12	40	HIGH	FAIR	POOR	POOR	POOR
2 pt. 4 ROW 12 GA.	13	40	HIGH	GOOD	POOR	FAIR	FAIR
2 pt. 5 ROW 12 GA	14	40	HIGH	GOOD	POOR	GOOD	GOOD
2 pt. 3 ROW 14 GA	11	25	HIGH	FAIR	POOR	POOR	POOR
4 pt. 3 ROW 12 GA	12	40	HIGH	FAIR	POOR	POOR	POOR
4 pt. 4 ROW 12 GA	13	40	HIGH	GOOD	POOR	FAIR	FAIR
4 pt. 5 ROW 12 GA	14	40	HIGH	GOOD	POOR	GOOD	GOOD
WOVEN WIRE (10 GA. TOP & BOT., 12 GA. FILLER) — HT. / SPACE		(B = ROWS OF BARBED WIRE NEEDED) (▭ = RECOMMENDED BY AUTHOR)					
26 / 12	15	40	MED	FAIR 4B	GOOD 2B	GOOD 1B	POOR
26 / 6	16	40	MED	FAIR 4B	GOOD 2B	GOOD 1B	POOR
32 / 12	16	40	MED	FAIR 3B	GOOD 1B	GOOD 1B	POOR
32 / 6	17	40	MED	FAIR 3B	**EXC 1B**	GOOD 1B	POOR
39 / 12	16	40	MED	**GOOD 2B**	GOOD	**EXC 1B**	GOOD 2B
39 / 6	18	40	MED	GOOD 2B	GOOD	EXC	**GOOD 1B**
47 / 12	17	40	MED	GOOD 1B	GOOD	GOOD	GOOD 1B
BOARDS							
1 × 6	25	50	LOW	EXCL	EXCL	EXCL	EXCL
2 × 6	35	50	LOW	EXCL	EXCL	EXCL	EXCL
ELECTRIC							
BARBED WIRE							
1 ROW 12 GA	4	40	HIGH	FAIR	POOR	POOR	GOOD
2 ROW 12 GA	5	40	HIGH	GOOD	GOOD	POOR	GOOD
STEEL WIRE							
1 ROW 12 GA	3	40	MED	FAIR	POOR	POOR	GOOD
2 ROW 12 GA	4	40	MED	GOOD	GOOD	POOR	GOOD

One important fence-building factor pertains to building costs which are relative to the size and the shape of the field. The larger the field, the less fencing cost there is per acre. It requires 825-feet of fencing material to enclose a square acre, but only 33-feet of material for an acre when a square section is fenced. A 40-acre field twice as long as it is wide requires 25% more fencing material than a square 40-acre parcel.

Contour fencing, curved lines on curved land, is a relatively new method of defining land-use areas. It is especially useful along terraces, diversion ditches or where plantings are to be maintained along the land contour. Always remember to put the fence on the outside of the posts so that, when the wire is stretched, it will pull against the posts and not against the staples. Posts for a contour fence should be set with the tops leaning out a few inches. When wire is stretched the posts will tend to straighten to a plumb position. Wire need only be stretched to a moderate tension on a curved fence, which is much less than the tension-stretch required on a straight-line fence. The sharper the curve, the less tension is required.



DISTANCE (INCHES)	SPACING (FEET)
4 OR LESS	16½
5 - 6	14
8 - 14	10
TO 20	8

After the general homestead plan is established, one must make the often difficult decision to choose correct fencing materials. And, of the various materials that go into building a fence, the proper choice of line posts represents the greatest cost differential. Posts can be made from wood or of cement, or steel and pipe units can be purchased. Choice of post material will be influenced by:

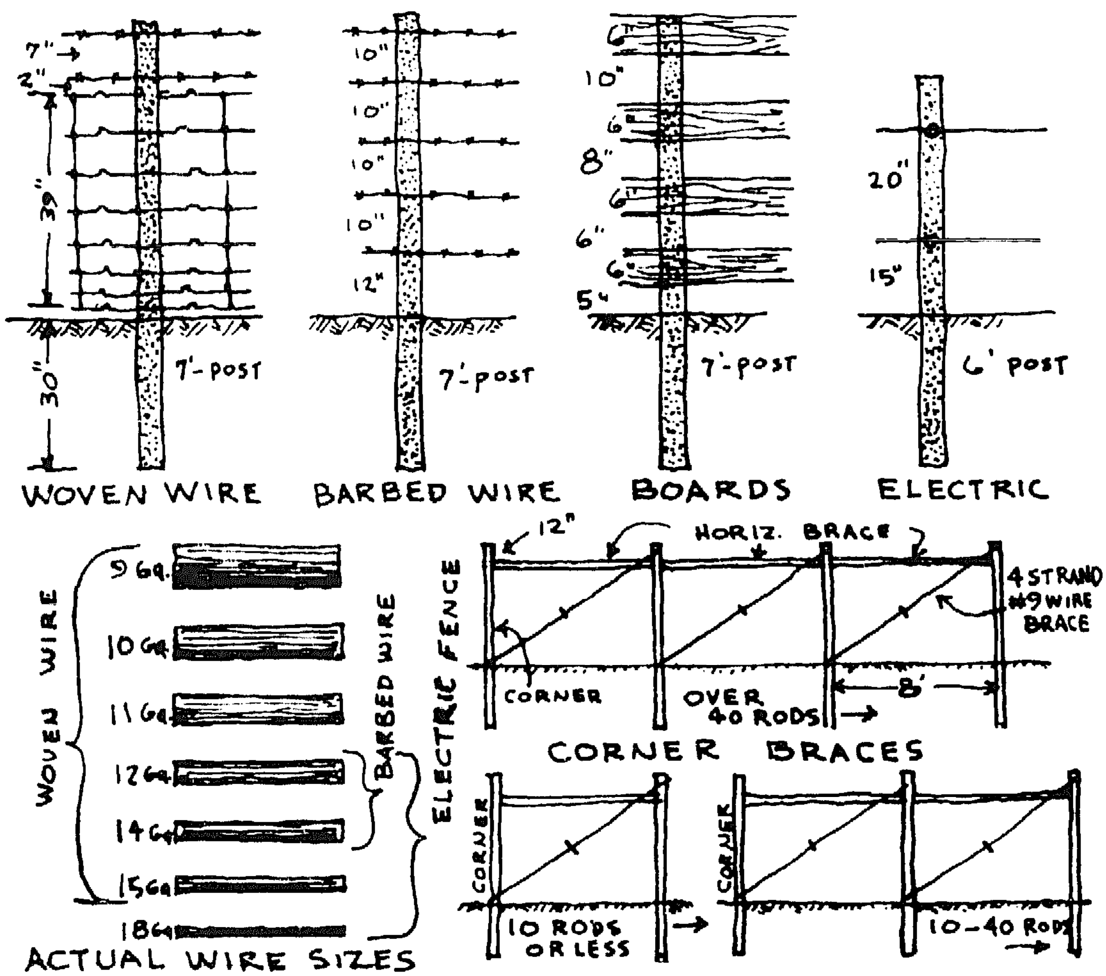
1) Availability of raw materials. A well-maintained woodland or a sand and gravel source would influence the choice between wood or concrete posts.

2) Strength of fence required. A thousand-pound force will break a 4-inch round wood post; a three-hundred-pound force will break a 3-inch square concrete post; a one-hundred-pound force will permanently bend a steel fencepost.

3) Soil conditions. Heavier posts are required in sandy or wet soils. Steel posts can be hand-driven into average soil conditions in seven minutes, whereas a wood or a concrete post requires a setting time of 22 minutes.

4) Accessibility. At places where a pickup or a tractor cannot be used to distribute fence materials, it is easier to haul a bundle of steel posts weighing 10-pounds apiece than it is to haul a single concrete post weighing 120-pounds. A 20-pound wood post might prove to be a satisfactory alternative for hauling, in this instance.

There are other considerations, too, which influence fencepost choice. A concrete post is inexpensive to build, it is fire and rot proof, and it looks substantial and impressive in the ground. A steel post is expensive to buy, but it is also fire and rot proof as well as being easier than the concrete post to set. Many alternative lifestyle homesteaders, however, would object to the "commercial", totally unaesthetic appearance of steel-posted fence lines. For areas of very close confinement, such as corrals, loading chutes or sorting pens, steel fenceposts prove totally inadequate in strength. But for a temporary, movable fence, or for electric fencing needs, steel posts are the obvious best choice. They can be easily driven into the ground and later removed with minimum effort.

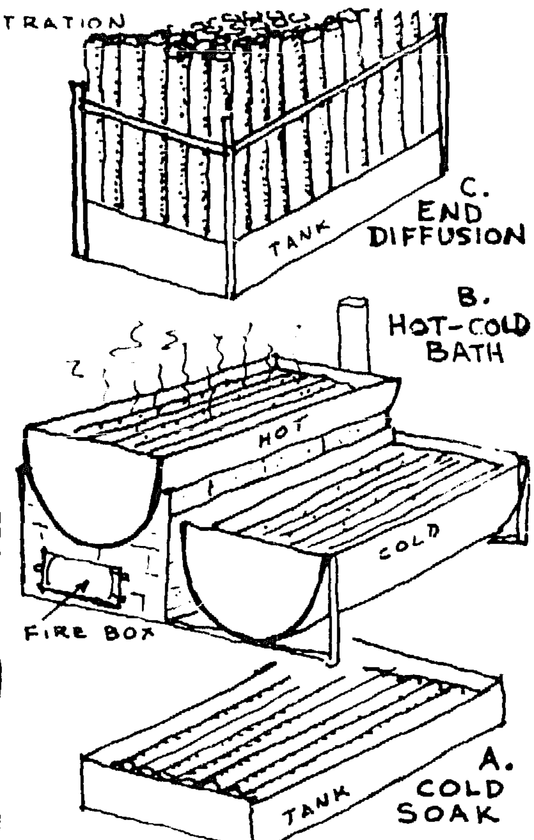


Another fencing alternative, which has conservation value, is the utilization of the "living fence" which is established by planting a living barrier of plants, like multiflora rose or Osage orange. In another approach, many homesteaders prefer to grow wood for posts in conjunction with the proper management of their woodland acres. If durable woods, such as Osage orange, black locust, redwood or red cedar are not available, it becomes necessary to devise some method of treating the posts against wood-rotting organisms. A treated pine post will last up to 30 years but, untreated, it will decay in 3 years. There are more than a dozen effective methods for the preservation treatment of wood fenceposts, and, again, the choice of the proper post-preserving method can be difficult to make. This choice depends upon a wide variety of factors, beginning with the species of wood selected, the size of post and the degree of age (greeness), the number of posts to be treated and the labor and equipment available. Some preservatives, it should be noted, will be more effective than others, providing better penetration.

Those wishing to investigate more fully the various wood preservation processes are urged to review the excellent literature on the subject distributed by the Forest Products Laboratory, Madison, Wisconsin. Discussion here must necessarily be limited to those few methods applicable to small-scale, low-cost post-preservation production: namely, the cold-soak method and the hot-and-cold bath method.

The hot-and-cold bath process is nearly as an effective preservation treatment as is treatment under pressure. It consists of heating the wood in the preservative in an open tank for several hours and of,

SPECIES	POST LIFE	TREATMENT A	B	C	PENETRATION
ASPEN	2		20	10	POOR
BASSWOOD	2		20		POOR
BEECH	4		20		FAIR
BIRCH	3		20		POOR
BL. CHERRY	8		20		FAIR
BL. WALNUT	15		20		GOOD
BUTTERNUT	8		20		FAIR
CEDAR	18		25		GOOD
CHESTNUT	18		20		GOOD
COTTONWOOD	4		20	5	POOR
CYPRESS	22	NOT NECESSARY			
DOUGLAS FIR	15		20		FAIR
ELM	4	15			FAIR
FIR	4		20		FAIR
HICKORY	5	15			FAIR
HONEY LOCUST	15		20		FAIR
LOCUST, BL.	22	NOT NECESSARY			
MAPLE	3		20	..	POOR
MULBERRY	22	NOT NECESSARY			
OAK	6	20		10	GOOD
OSAGE OR.	22	NOT NECESSARY			
PINE, LONGL.	15	20			GOOD
REDWOOD	22	NOT NECESSARY			
SPRUCE	4		20		FAIR
SYCAMORE	4	10	20	10	POOR
TAMARACK	8		20		FAIR
WHITE ASH	4		20		FAIR
WILLOW	3		20	5	POOR
PINE, WHITE	3	20		10	GOOD



FENCE POST TREATMENT

then, quickly submerging it in a cold preservative for an equal length of time. Heating causes the air in the wood to expand. When cooled, air in the wood contracts, creating a partial vacuum and forcing preservative into the wood by atmospheric pressure. A coal tar creosote solution, mixed half-and-half with used crankcase oil or diesel fuel, is kept at about 200° F. in the hot-bath tank. The temperature of the cold-bath tank should be maintained at 100° F., warm enough to liquify and to thin the oil thoroughly.

A less elaborate solution, requiring less work but producing less satisfactory results, can be achieved by using the cold-bath preservation process. This method consists of submerging posts for several days in a coal tar-creosote-crankcase oil solution. About a half-gallon of preservative, at a cost of 40 cents, is absorbed into each post. This cost can be substantially reduced by treating only the butt end of each post, called "end diffusion", to a point six inches above ground line. The freshly cut, unpeeled posts are set vertically into a metal trough containing preservative and are allowed to stand from one to ten days.

Trees for post use should ordinarily be cut in the late fall or winter, except where end-diffusion preservation methods are used. Bark peels best in the spring and early summer, but rapid summer seasoning results in severe checking of the wood, especially for hardwoods, like oak. So, for this reason, checking can best be controlled by peelng the post as soon as it is cut in fall or in winter. Posts should be allowed to season a few months before treatment. Water is, thereby, removed to make room for the penetration of the preservative. Open-pile the posts so that air will circulate freely around each one.

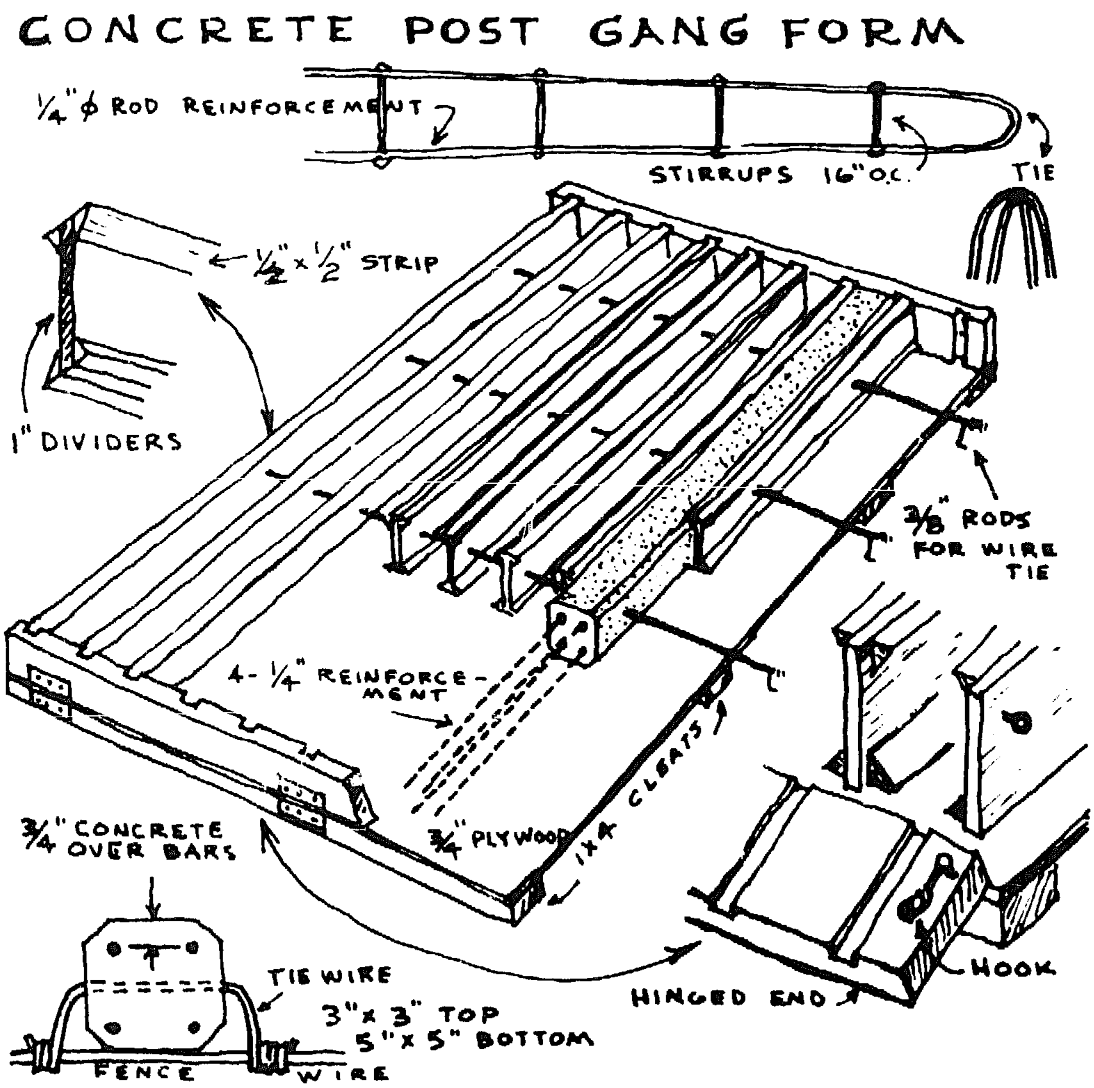
In 1917, K. J. T. Ekhlaw published a book, FARM CONCRETE, which had this to say about the use of concrete in building fenceposts:

> "Ignorance of construction methods and carelessness in handling have been responsible for a great deal of the blame which has been unjustly laid upon the concrete post."

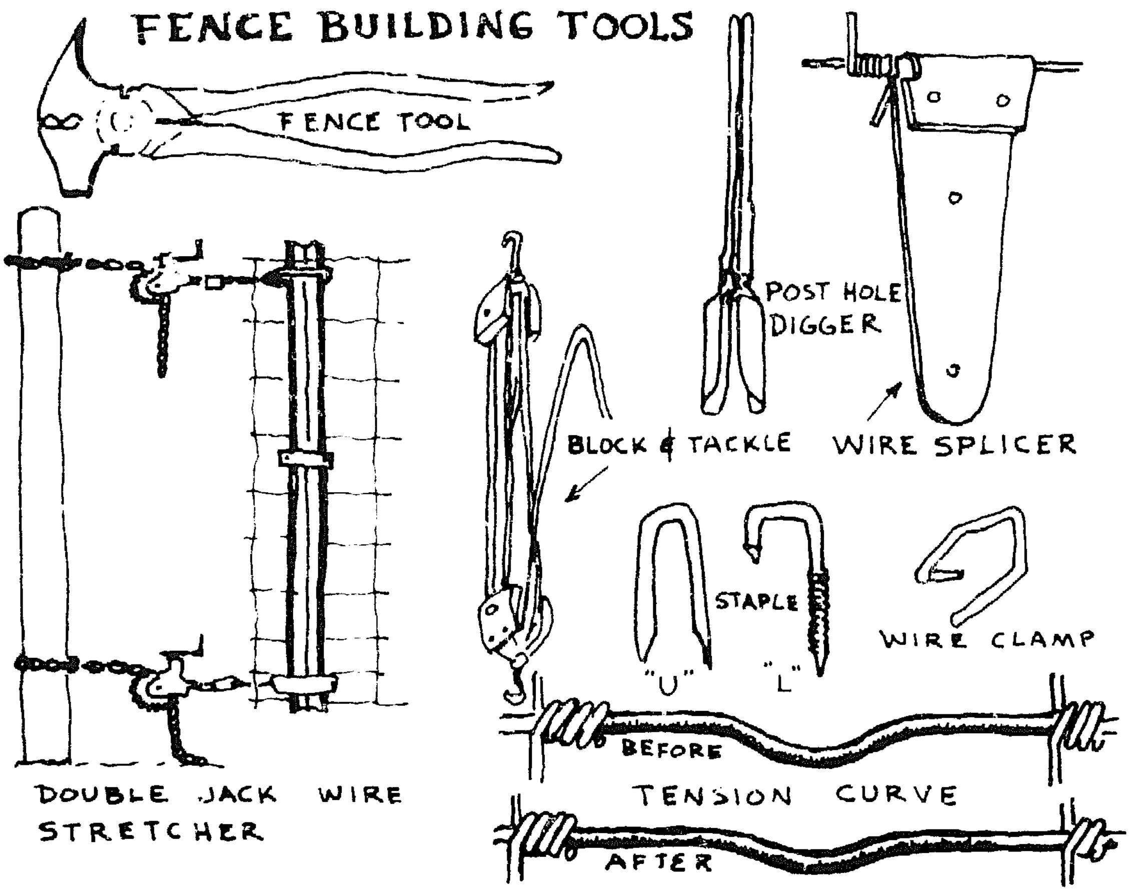
This situation persists today. Failure is almost certain if basic essentials of cement construction are not observed. Requirements are not complex. They are, in fact, simple, but they must be met. Much of the concrete fencepost information presented below has been taken from my own personal, practical experience with the resulting satisfaction experimentally verified.

About eight, 7-foot posts can be made from a two-dollar sack of cement. If a free source of sand and gravel is available on or near the homestead, total material costs can be little, including the necessary steel reinforcing rods. As well as being low in material cost, concrete posts are strong, durable, fireproof and rotproof.

Judicial placement of reinforcing rods can be the determining factor for a poor or a well-built concrete post. Rods must have adequate tensile strength to equalize the compressive strength of the concrete. Also, rod placement must be as far as possible from the plane of neutral strain, and must yet possess enough concrete covering to prevent destruction by rust. It is advisable to bend two lengths of 1/4-inch rods at their centers and to tie them together at the top, thus increasing the bond. Before casting the cement, stirrup tie wires are used to maintain a rigid rod framework. A dense, smooth surface is assured by investment in the purchase or the rental of a mechanical vibrator, or, otherwise, adequate hand tamping can be sufficient. Aggregate size should not exceed 1/2-inch, and a mix of one-part cement to five-parts aggregate has proven sufficiently strong. The consistency should be soft enough to permit concrete to settle rapidly in the form when tamped. Excessive water weakens the concrete. Seven-feet is a standard post length. The top section should be three-inches square, and the bottom section should be five-inches square.



A simple wooden mold, illustrated above, can be fabricated to accommodate any number of posts in a single pour. Concrete post strength is determined, to a large extent, by the curing it receives. One should leave the freshly poured post in its form for several days, or at least until it is thoroughly hardened. Form sides and ends may then be removed for use on another platform where more posts are to be moulded. Keep the formed posts damp-curing for a week after removing them from the form; then store the posts in a shady place for several months before using them. Adequate curing before use insures uniform hardening of the posts, preventing shrinkage cracks. Concrete gains considerable strength for the first year after it is mixed and poured.

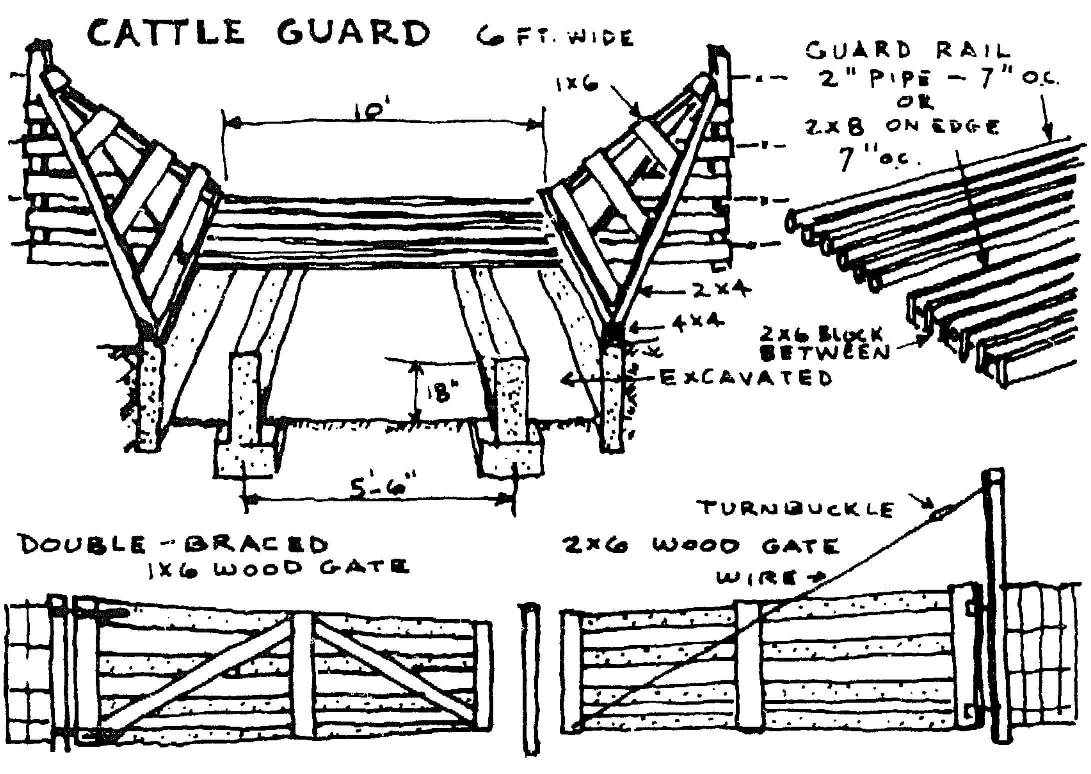


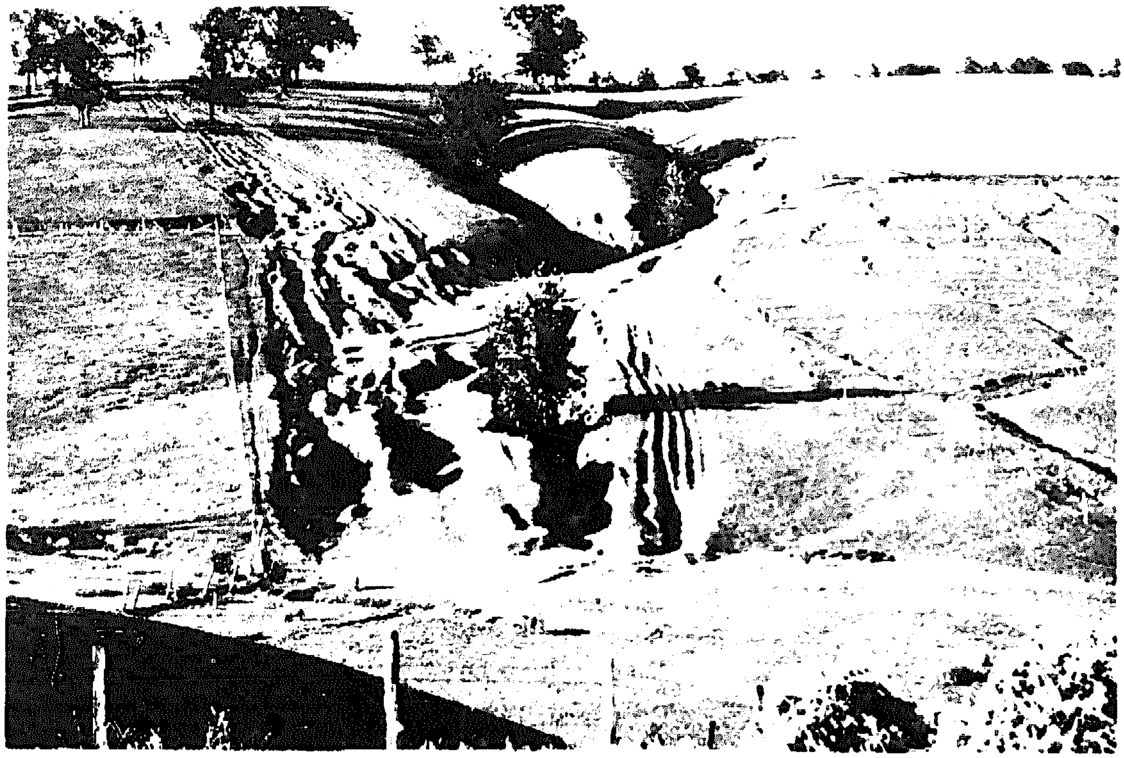
For a standard, straight-line, woven-wire fence on level land, posts can be spaced 16-feet apart. A barbed-wire fence requires a closer, 12- to 14-foot post spacing. Posts for a board fence in an open field are usually spaced 8-feet apart. All posts should be set 30-inches into the ground.

The first step for one building any type of fence is his erection of the corner posts. Proper corner construction is very important. About 3,000-pounds pull is exerted against the posts when a fence is first stretched. A pull of as much as 4,500-pounds can result as the wire contracts in cold weather. Many corner assemblies fail to meet these basic structural requirements. The method shown in the accompanying drawing has been proven best since it adequately offsets the usual tendency of the taut wire to lift the anchor post out of the ground. With this method, pulling pressure is evenly distributed among the posts and requires less labor to construct. Corner posts should be set 3-feet into the ground.

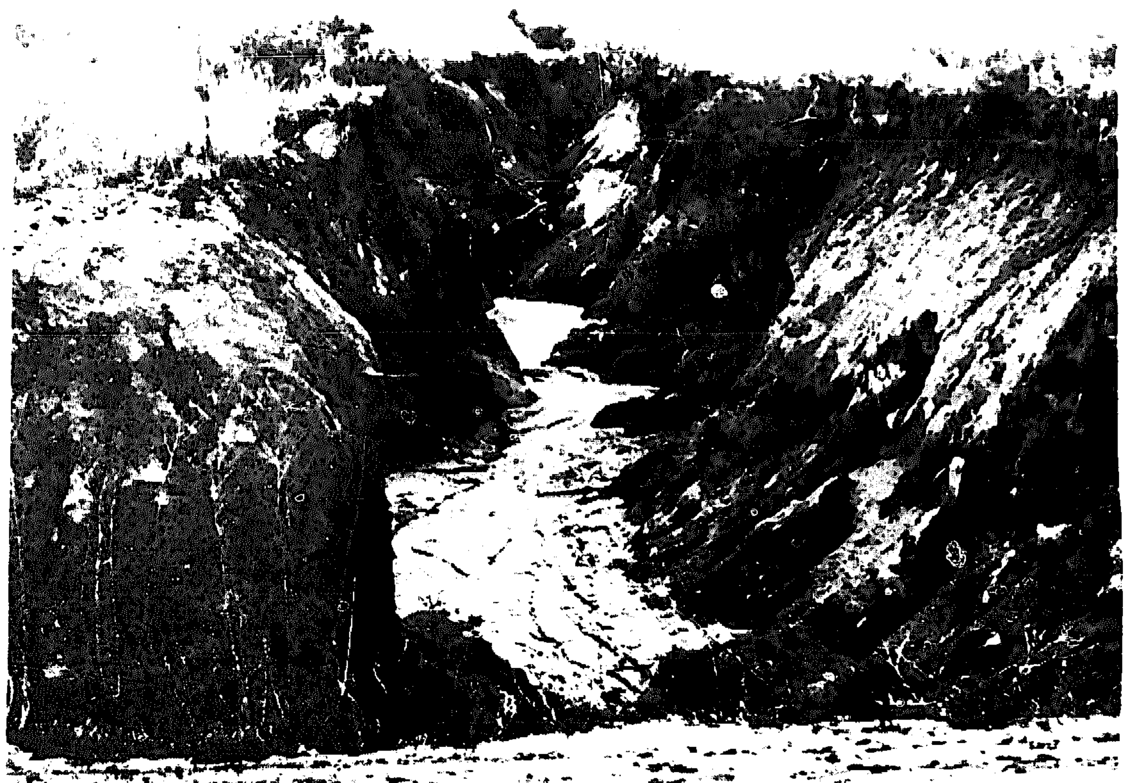
After line posts are set, wire is stretched from each corner. Stretching should be done with double-jack or block-and-tackle fence stretchers. Woven wire should be stretched only until the tension curves in the wire are approximately one-half eliminated. Staples should not be driven into the post to force the wire into the wood, for the wire must be free to expand and to contract along its length. "L"-shaped, threaded staples have a holding power advantage over the usual wood-splitting variety, especially when used in preservative-treated soft-woods.

At various places along fenced areas, provision must be made for the flow of machinery, livestock or people. Farm gates should be at least 12-feet wide. Good gate design should include the necessary bracing to make a gate self-supporting. Cattle guards are practical installations where equipment must pass through a fence opening numerous times a day. They consist of a two-foot-deep pit, six-feet wide and ten-feet long. Railings can be built of wood planking set on edge, of steel pipe or of cast concrete. Where sheep and goats are to be turned, smooth strips on the top of the guard which are wider than 2-inches must be avoided. Location of the guard should be where animals have ample opportunity to study it and to evaluate the danger to themselves before attempting to pass through. In a farmyard where livestock are held in heavy concentration a cattle guard is inappropriate since animals may inadvertently be crowded onto the device. A wide gate adjacent to the cattle guard for the passage of livestock and extra-wide equipment is advisable. Drawings of practical gate and guard designs are included below.





SHEEP TRAVELING UP AND DOWN THE SLOPE MADE THE PATHS THAT GRADUALLY DEVELOPED INTO THESE GULLIES. REARRANGING PASTURE LANES WOULD HAVE PREVENTED IT.



ONCE A PROPERTY-LINE FENCE! WATER FROM TWO ADJACENT FARMS EMPTIED INO THIS GULLY

Roads and Transport

Horse power was safer when only the horse had it.
—Will Rogers

The geodesic dome and the Volkswagen have now become standard home and transportation choices for would-be establishment drop outs. Both are reactions against conventional solutions; the dome replacing the four-square box-house and the VW replacing Detroit's over-powered, over-weighted, chrome-finished vehicles. But, for the productive homesteader, at least, both choices are poorly made. There is a third, more viable alternative — a site-and-climate attuned home and a vehicle with the versatility for both work and transport.

The vehicle which I, personally, feel meets all homestead requirements most satisfactorily happens to be the one which we are now driving. I should not say "happens" as the choice was made and the vehicle built-up after 30 years' trial-and-error experience with a wide variety of makes and models. This is not to say that my preference is exclusive of other makes. For many years my personal choice of an ideal vehicle was the 1931 Model A Ford. Today, if money were no object, my choice would be the Mercedes-Benz Unimog. Meanwhile, our 1954 GMC 6-cylinder ¾ ton flat-bed truck does the job nicely. The 1950's were vintage years for trucks. These were the years before Detroit bastardized the pickup, giving it passenger-car roadability by replacing heavy-duty leaf springs with light coil springs, for example.

International and GMC are the only two companies which manufacture trucks exclusively. Chevrolet and Ford, for instance, use the same frame, suspension, and engine in their pickups as they do in their passenger cars. Consequently, even though Chevrolet and GMC are both divisions of General Motors with many engine parts interchangeable, the older model GMC proves to have twice the engine performance of the Chevrolet.

The GMC engine has a full internal force-fed oil system (not the usual by-pass, for instance), along with heavier radiator, piston rods, crankshaft bearings and cylinder head. For over 20 years the standard "6" overhead valve, low compression GMC engine remained virtually unchanged. It is an amateur mechanic's dream engine — easy to work on with readily available, inexpensive replacement parts. The GMC pickup is also a homesteader's dream vehicle — extremely rugged and dependable with tremendous lugging power and operational efficiency.

Of equal importance, older GMC pickups are readily available and inexpensive to buy. Mine cost $100. I have made it my primary rule to PAY A VERY SMALL FIRST COST FOR A TRUCK. The comparative cost between a NEW ½-ton or ¾-ton pickup, or between a Chevrolet and a GMC, is considerable. But after 20 years the costs stabilize so one is better off with the heavier-duty model and make. If you establish your homestead need as requiring a ¾-ton Chevrolet 235 cu. in. engine with 3 forward speeds and 14-inch, 6-ply tires consider, instead, a 1-ton GMC 270 cu. in. engine with 4 forward speeds and 16-inch, 8-ply tires. The resulting cost for either 20-year-old truck will be about the same.

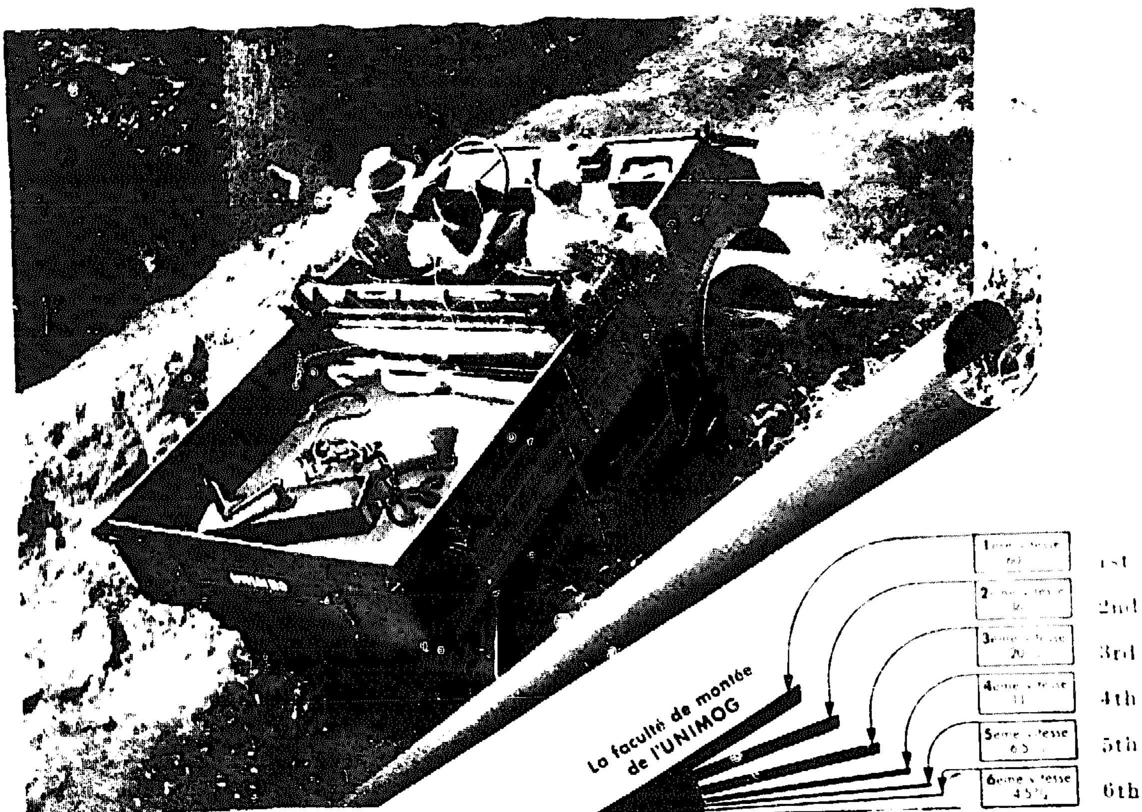
This same rule applies when buying a passenger car. After 10 years a Cadillac and Ford have about the same resale value. But new, someone paid several thousand dollars for the better-designed and better-equipped, more powerful and more dependable Caillac. Old Fords, from the 40's to the 60's, are mostly junk, but old Cadillacs can be rebuilt to give many thousands of satisfactory miles.

Once we find the truck we want we totally recondition and modify it to fit our particular homestead needs. First to be removed is the pickup style bed. A "flat bed" stake body is more practical for most homestead hauling needs, especially for light, bulky loads like manure and mulch. Heavier, 1-ton rear ends can be found at most junk yards and easily installed on the ¾-ton pickup chassis. Dual rear wheels and over-load springs make it possible to triple the load-carrying capacity (without having to pay additional license fees to the state). With such heavy hauling prospects an investment in a 2-or-3 speed auxiliary transmission (called a "Brownie") becomes mandatory. So equipped, my GMC has 14 forward gear ratios, and, when leaving the flatlands with a 5-ton load destined for our mountain homestead, each gear position is used at least once. Thus the engine performs at its most efficient RPM, neither over-lugging nor over-racing.

There is a second rule that I follow in buying and equipping an older truck or other homestead machinery: OVERDESIGN THE COMPONENT PARTS. This partly makes up for the age and subsequent wear and tear on the vehicle. Most older trucks had a 6-volt electrical system. This should be replaced with a 12-volt system, requiring new generator, battery, and light bulbs. Oil cleaners were not standard equipment in older trucks. I, personally, believe in the toilet paper oil filter (Frantz, for example). The GMC power train (heavy-duty clutch plate, 4-speed transmission, 3-speed Brownie, twin universal joints connecting open line drive shaft to differential) is extremely rugged and well-engineered. Expect only long and satisfying service. Add large (18-inch) dual wheels on the rear and a power winch on the front, and one nearly has a match for the expensive four-wheel drive vehicle.

My third transport rule is to STANDARDIZE ON ALL VEHICLE MAKES AND MODELS. A Chevrolet is therefore our best choice for a passenger car since many component parts are interchangeable with our GMC truck. Thus, too, it becomes possible to stock spare parts in the shop and to invest in necessary specialized engine-rebuilding tools. Often we purchase similar model vehicles for $50 merely to have important spare parts on hand.

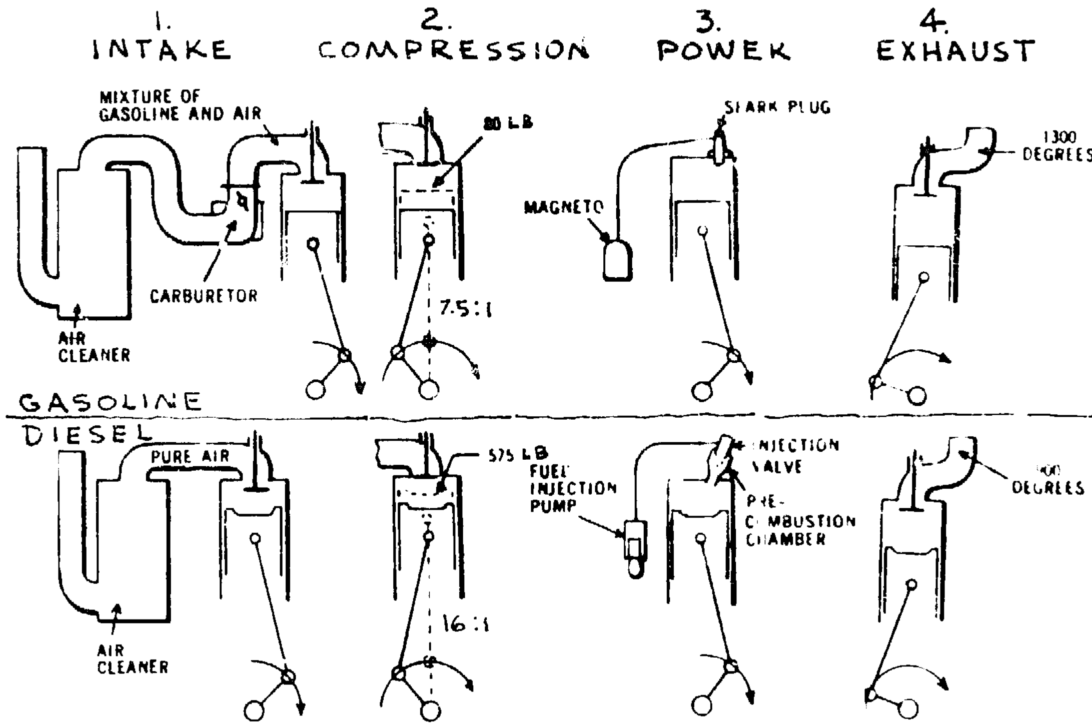
Any required equipment need for a small homestead can be met by one, diesel-powered source — the Unimog, which has to be the most versatile, diesel-powered, four-wheel drive truck in existence today. Manufactured in Germany by Mercedes-Benz, it has 20 forward speeds, ranging from 50 to 1 mile per hour. The latter gear is used in conjunction with a front-end bulldozer blade. For traction the Unimog has differential locks on both axles. Other detachable equipment includes a front-end loader, grader, excavator, compressor, earth drill, loading crane, concrete pump, rotary hoe, snow plow, gravel spreader, and many more features.



CLIMBING ABILITY OF THE UNIMOG — GEAR

Due to their remarkable "lugging" ability, diesel engines are the world-wide choice for stationary or mobile work in agriculture. Essentially, the diesel engine differs from the gasoline (spark-ignited) engine in that the diesel fuel is metered out in definite quantity for each cylinder for each power stroke according to load. Engine speed is controlled by built-in governor, integral with the injector pump. During heavy loading, the diesel engine resists stalling because each cylinder receives an increased volume of fuel by way of the injector system. Under such conditions a spark-ignition engine slows down under its weight, thereby reducing the fuel mixture drawn in. A weakened power source results, slowing down and eventually stalling the engine.

As the accompanying diagram illustrates, combustion of a diesel engine occurs with the injection of fuel into compressed air in a compression ratio of 16:1 as against a compression ratio of 7:1 which is



GASOLINE AND DIESEL CYCLES COMPARED

used in most gasoline engines. This feature gives diesel engines a far-lower fuel consumption-per-hour per-horse-power. Combined with the lower cost of diesel fuel one wonders why these engines are not more commonly used in this country. Notice, too, the indication in the diagram of the lower exhaust temperatures of diesel fuel. A diesel engine operates at lower temperatures and pressures, and, therefore, repairs are less frequently required. Its relatively clean exhaust helps keep the injectors, pistons, and valves free from carbon sticking.

As air pollution becomes an important consideration one might rather choose conversion of a gasoline ignition system to liquid petroleum. (LP). LP is a dry gas which readily mixes with air and burns cleanly and completely so that it can be used in any high-compression engine. And, best of all, LP burns cleanly, thereby reducing engine wear and up-keep expenses. There is less carbon build-up, less piston ring and cylinder wear, and no crankcase dilution.

In many ways a tractor is the heart of a homesteader's power-program. The tractor can become an essential tool for land-clearing, road-building, site-leveling, terracing, pond-building, and general land maintenance. When choosing a tractor for use on a homestead the type will doubtless be harder to determine than the method of fuel-powering. A number of factors enter into this decision: topography, homestead size, soil characteristics, and the kind of homesteading in which one is interested. With few exceptions homesteaders purchase a wheel tractor, without even considering a crawler track-layer. Before purchase, however, one should acquaint oneself with the salient features of crawler tractors which are versatile enough to tackle these jobs. The discussion here is limited to track-type tractors because of their pertinence to homestead activities.

CRAWLER TRACTORS
FOR HOMESTEAD USE

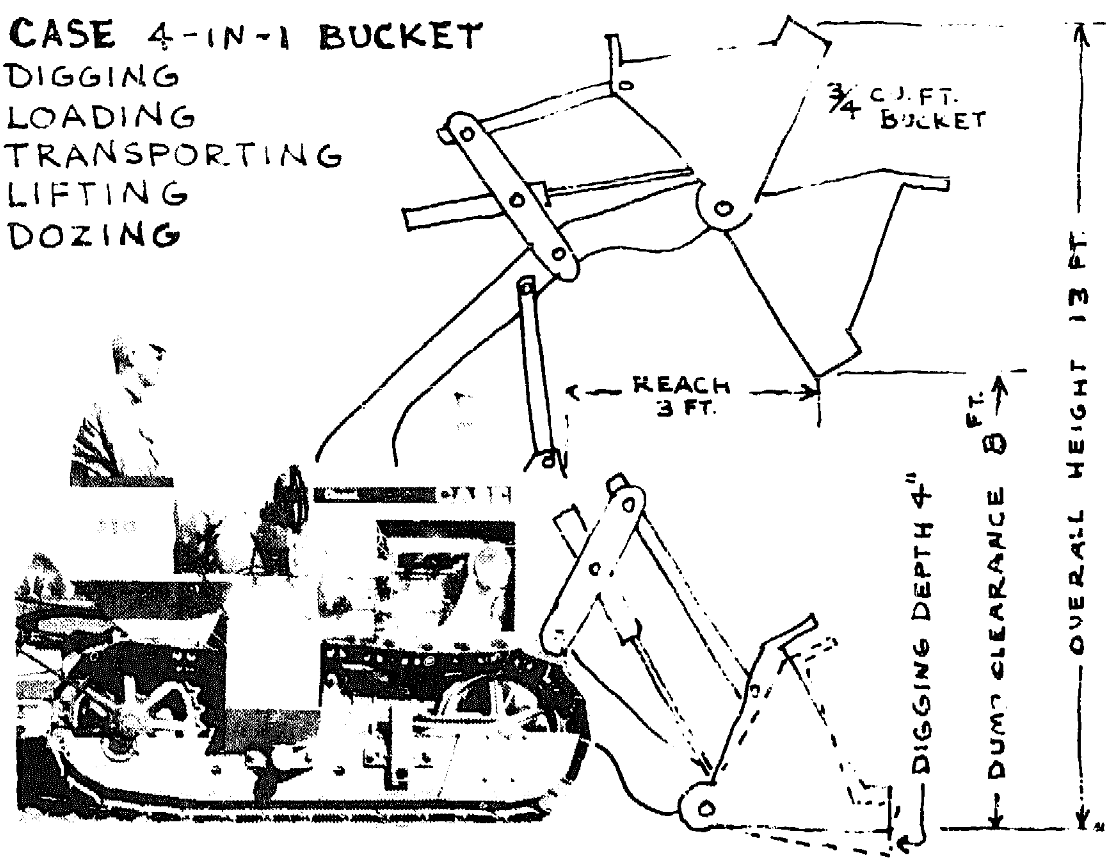
YEAR	MAKE	WEIGHT	FUEL	CYLINDERS	BORE & STROKE	HORSE-POWER	DRAW-BAR PULL LBS.	D.B. HP. H.R. PER. GAL.
54	OLIVER OC-6	7500	D OR G	6	3.4 X 3.7	26	4000	12.14
55	OLIVER OC12	11700	D OR G	6	3.7 X 4.5	40-50	6500	10.65
55	CAT D2	8500	D	4	4 x 5	29-39	4100	10.68
56	INTER. TD6	9400	D OR G	4	4 X 5.2	32-44	5300	11.13
56	J. DEERE 420C	5000	G	2	4.2 X 4.0	18-25	2400	8.97
58	OLIVER OC-4	5300	D OR G	3	3.5 x 4.5	18-23	2800	10.61
59	CASE 310-C	6000	G	4	3.4 X 4.2	26-33	5800	11.30
59	J. DEERE 440IC	7200	D OR G	2	4 x 4.5	18-32	7000	14.50
59	INTER. T340	6700	G	4	3.2 x 4.1	25-36	6500	11.60
60	INTER. T-5	7000	G	4	3.2 x 4.1	27-36	7400	12.28
60	INTER. T-4	6900	G	4	3.1 x 4.0	19-32	7400	12.30
60	INTER. TD5	7100	D	4	3.4 x 4.0	27-35	7600	14.00
60	INTER. TD340	7100	D	4	3.7 X 3.8	26-40	6800	13.10
61	A-C HD3	7600	D OR G	4	3.5 x 4.3	25-32	8200	12.68
61	J. DEERE 1010C	7600	D OR G	4	3.6 x 3.5	27-36	7500	13.80
61	CASE 310E	7500	D	4	3.8 x 4.1	31-37	7000	15.00
62	J. DEERE 2010C	9600	D OR G	4	3.8 x 3.5	39-47	10200	14.11
66	INTER. 500	7900	D OR G	4	3.5 x 4.0	31-36	7900	13.90

Crawler tractors are ruggedly built. Two structural steel frames connect engine and power train. The power train consists of clutch, transmission, differential, final drive, axle shafts, and brakes. The track frame consists of front idler to maintain upper and lower tracks parallel, yet free to oscillate and conform to the ground. Power is transmitted through steering clutches to spur-type final drive gears, and thence to driving sprockets on each axle shaft which drive the tracks. Tractor steering is accomplished by dry-disk hand lever steering clutches. When the clutch is disengaged, power to that particular track is cut off and the tractor turns. A foot-operated brake can also be engaged when quick, short turns are desired.

Tractor functions described above apply to models built for 40 years, until the 1960's. Nowadays, the tractor industry provides new and sophisticated engine and power train features. These innovations are attractive in spite of their far-greater cost, but they are impossible for the homesteader to repair or to rebuild. Manual gear shifting is eliminated by using such hydraulic transmission devices as torque converter and fluid drive. This utilizes the energy of a fluid in motion (or under pressure) for the purpose of transmitting power. Thus, varying load demands are met with the engine running at its most efficient speed.

A 2-speed planetary transmission power shift is used on some tractors, replacing steering clutches. This makes it possible to shift into lower gear ratios without engaging the clutch. Tracks can be driven at various speeds so that a turn can be made under full power.

A dozer blade is an essential attachment to any homestead crawler tractor. Blade size should match tractor size, of course, and tractor size should be related to homestead need and soil type. For safety, where land slopes exceed 20-degrees, one should use a WIDE TRACK crawler. An ANGLE DOZER is desirable for pioneering roads across rough country, and a TILTING DOZER is handy for sidehill work involving road-building or terracing. Blade pitch can be made to fit ground conditions, the harder the ground, the steeper the pitch. Drott Manufacturing Company makes a front-end tractor shovel which can be used for digging, loading, or for transporting material.



A ruggedly-built utility trailer is another important piece of homesteading equipment. It can be towed by the crawler tractor over otherwise inacessible terrain, or by the pickup truck for use on roads. A trailer can virtually double the loading capacity of a sturdy truck — another good reason for beefing-up the power train. Four wheel (tandem) trailer frames are readily available due to the current influx of mobile homes throughout the country.

Finally, a homestead transport rig would not be complete without a front-end-mounted power winch. Uses for a winch around a homestead are too numerous to mention — from loading a hay loft to freeing a stuck vehicle. Electric winches are the most common as they are easiest to install, their motors often being made from aircraft surplus. If a choice is offered, however, obtain the far more powerful hydraulic winch, instead. This type of winch uses a small hydraulic pump, driven by the truck fan belt and connected by hoses to the hydraulic motor in the winch. According to the manual . . . a hydraulic winch will pull a wheels-locked, fully-loaded Land Rover across a dry surface!

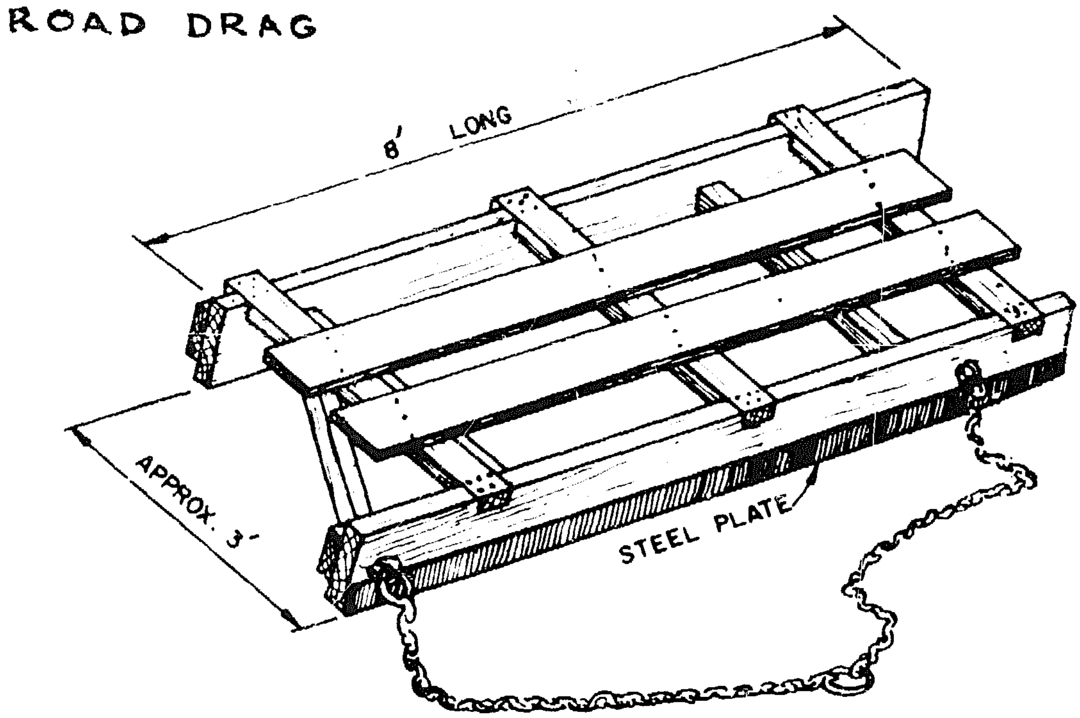
Invariably, the principle development project on any unimproved homestead is the provision for adequate access. Access from public thoroughfare to the homestead building site should first be developed. One's truck, trailer, winch, and blade-equipped crawler tractor will all be put to good use developing roadways. Late Spring is the best time to do the work — after the last frost but before the ground loses much of its winter moisture content. Where possible, locate the roadway on south and east slopes to minimize difficulty with snow and ice.

Good engineering practices used in highway construction should also be employed by the homesteader. A specific road alignment should first be staked out, keeping in mind the amount of earth to be filled and the amount to be cut so that a general balance can be established between high and low spots. Make certain that earth deposited in low places becomes thoroughly compacted. This is another good reason for doing the work while the soil is moist. Humus, silt and clay all lack bearing strength and should be avoided as subgrade fill material. Clay, for instance, may have a very high supporting power when dry, but after a rain it becomes soft and slippery. Subgrade fill material should have good permeability so that water drains through it readily. Sand and gravel have this quality, but they are hard to compact. The best subgrade material has a proportion of clay, silt, sand, and gravel. Here in the West, we have a native material, called DG (decomposed granite). It is rough, coarse sand with just enough clay binder to give it excellent compaction and drainage characteristics. Subdrainage is especially important in areas where severe frost damage occurs. Frost-susceptible soils, such as fine sands and silts, should not be used. The proportion of fine material used with gravel can be most critical: over 10% fines is not suitable, but with less than 5% fines the subgrade may loosen in hot, dry weather.

The importance of adequate surface drainage for the maintenance of year-round earth roads cannot be over-emphasized. A properly built and maintained aggregate-surfaced road can be as serviceable and as long-lasting as the most expensive asphalt-surfaced road. In the presence of water, however, an aggregate-surfaced road will soften and will rut under normal loading; therefore, water should be removed from the road as quickly as possible. One accomplishes this by crowning the road and by keeping the surface smooth, firm, and free of loose material. A proper crown may vary from ¼-inch to ½-inch per foot.

Culverts must be provided to carry the water from a drainage area to below road level. The size of culvert pipe is determined by the amount of rain that is likely to fall during a certain period in the watershed area. Speed of water flow, slope of the ground, and absorption characteristics of the soil all contribute to the determination of culvert size.

Homestead roads require periodic maintenance which is usually accomplished by dragging the loosened material back again, depositing it in depressed areas. Road dragging should be done as soon as practicable after a rain to obtain best compaction.



For general road maintenance purposes a simple drag is all that is needed. A wood unit (illustrated above) can be easily constructed in the homestead workshop. The homestead workshop is also the place where the crawler tractor is maintained, and where the pickup truck is modified and serviced. As I intend to illustrate in the following chapter, the homestead workshop should be considered the heart and the nerve center of any truly productive homestead.

Shop and Tools

There's an ancient Near-East saying advising that, "Every man should have a son and plant a tree . . ."; to which I would add, ". . . and build a work shop." Homestead shop work, whether it be for creating new objects or for maintaining and repairing old ones, can be a most gratifying activity. Gratifying, that is, if substantial thought and effort have gone into creating an environment conductive to shop work, and gratifying if care and concern are given to the choice of tools and equipment which go inside the shop. The hypothetical shop structure presented below is a guide to this proper choice. I designed the layout to meet AVERAGE homestead requirements which include the production of certain needed items along with storage, maintenance, and repair of all equipment found on the homestead.

First, consider the shop structure and its placement on the homestead. This facility is very much the nucleus, the nerve center, of the homestead. It is the place where all the food-and-shelter operational systems are maintained, and where essential tools and implements are located to keep the homestead functioning properly. Having a central placement, the shop can be easily reached from any place on the homestead — and is, thus, more apt to be used. There must be an unobstructed path for materials to flow into and for finished articles to flow out of the shop.

The building is built of fireproof (masonry) materials: concrete slab floor, stone walls, sod roof. This is a prudent decision considering the hazardous nature of shop work which involves welding, grinding, paint and solvent storage, and wood stove heating. Similar thought suggests the need for adequate ventilation and indirect, natural lighting. Direct glare from windows is eliminated by providing clearstory and skylight illumination, which, at the same time, reserves valuable wall space for tool storage. This shop building is divided into four work centers, each of which will be discussed separately and in detail below.

A. GENERAL WORK SPACE.

This area should be a size spacious enough in which to conveniently work around the largest homestead equipment: the pickup truck, tractor, or passenger car. A 10-foot wide, 8-foot high overhead door is provided for access. When open, the overhead door gives maximum internal space, and, when closed, a 3-foot wide swinging door is framed into this overhead unit to provide people-access without having to open the larger ovehead unit. Door steps should be avoided to facilitate cart and hand-truck traffic. This double-acting door is specified so that loads can be carried into and out of the shop without obstruction and without the delay of having to shift the load while passing through. Swinging doors at the south end of the work space are used primarily to close off the area for winter heating.

B. GREASE PIT.

A good example of multi-use space can be demonstrated with a pit for vehicle maintenance, general parts storage, a loading platform, overhead rail chain-hoist for removing engines and for moving heavy objects, and for equipment storage when the pit is not in use. A grease pit is a prime necessity on any homestead. For adequate preventive maintenance the undercarriage of a vehicle must be fully exposed and all parts accessible to the homestead mechanic. A pit is especially handy for greasing vehicle parts and changing oil, for engine and transmission removal and repair, and for brake and front-end adjustment and replacement.

While the east track of the grease pit is adjustable to fit the differing wheel bases of truck, auto, and tractor the west track incorporates into a permanently-located loading platform. With this provision of a loading platform one man, with a small hand truck, can move the same material that five men can move. Gravity force is used wherever possible in the shop: one never lifting or carrying objects which can be slid on rollers. An overhead 1-ton rail chain-hoist is a handy tool for moving heavy loads from loading platform into shop, and it is an ESSENTIAL tool for removing and for installing engines. The 50-gallon metal trash barrel (1) can be moved onto the loading platform using a small hand truck.

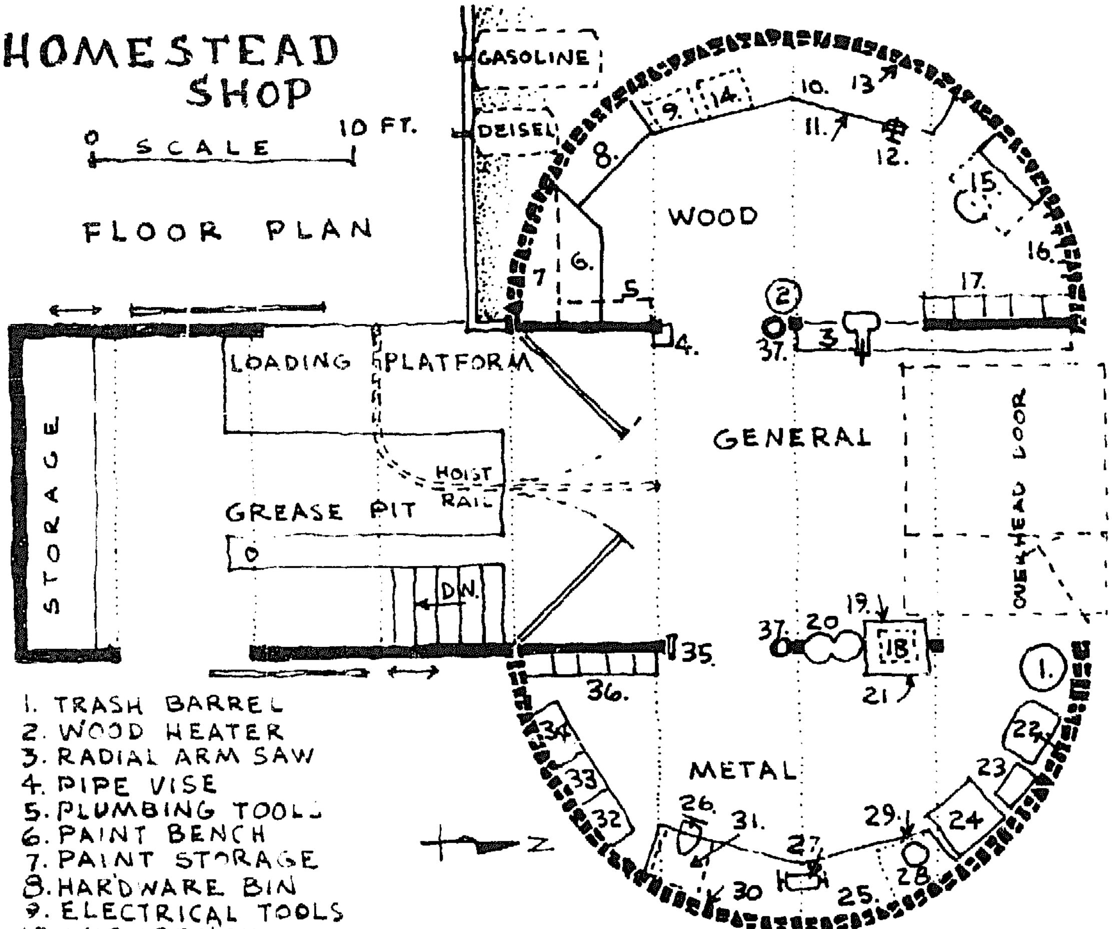
A cabinet for general storage is provided at the south end of the grease pit. Heavier automotive and machinery parts are stored at the most accessible level, while little-used items are stored at lower and upper-reach positions in the cabinet. Sliding doors on the east and west sides of the grease pit make it possible to secure the area, protecting any equipment stored there during dormant-activity months.

C. WOOD WORK.

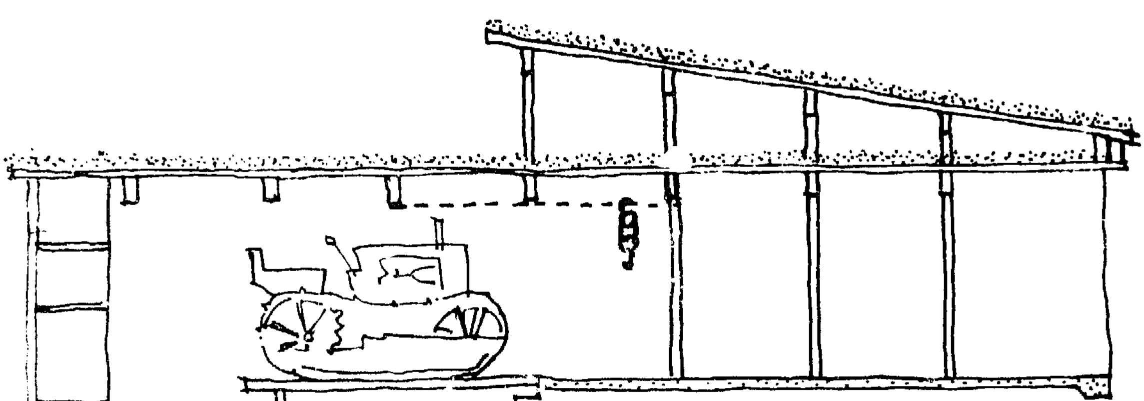
One factor in good shop arrangement is locating equipment, tools, and materials around and in front of the worker, as close to him as possible. Another good arrangement is the provision for short-distance circular travel so that, as in production work, one step is started as another finishes. Idle movements such as back-tracing should be eliminated; thus, one reason for the half-circle shape of the work area. The semi-circular aspect of the building also provides with its shape structural advantage and esthetic quality.

An obvious location for the wood heater (2) is for its central placement in the work area, near the radial arm saw where wood scraps are produced and conveniently stored. The radial arm saw (3) operates from the central work side so that long wood members can be ripped by opening both overhead and swinging doors. These doors remain open, too, when full lengths of pipe are cut and threaded. A pipe vise (I prefer the chain-type) is located at (4). The vise is mounted directly onto a roof-supporting post so that threading or tightening, requiring strong downward movement, are provided greater stability.

HOMESTEAD SHOP



1. TRASH BARREL
2. WOOD HEATER
3. RADIAL ARM SAW
4. PIPE VISE
5. PLUMBING TOOLS
6. PAINT BENCH
7. PAINT STORAGE
8. HARDWARE BIN
9. ELECTRICAL TOOLS
10. WORKBENCH
11. ELECT. POWER TOOLS
12. WOOD VISE
13. HAND TOOL RACK
14. MASONRY TOOLS
15. DESK-STOOL
16. IMPLEMENTS
17. BINS
18. ARC WELDER
19. WELDING TABLE
20. OXY-ACETYLENE
21. WELDER TOOLS
22. SINK
23. BATTERY EQUIP.
24. PORTABLE BENCH
25. WORKBENCH
26. VISE
27. GRINDER
28. DRILL PRESS
29. TOOL DRAWER
30. TOOL RACK
31. AUTO REPAIR TOOLS
32. LUBE CENTER
33. AIR COMPRESSOR
34. TIRE REPAIR TOOLS
35. TUBE REPAIR
36. STORAGE BIN
37. FIRE EXTINGUISHERS



CROSS SECTION

Another consideration when laying out a work shop is providing for storage of tools and materials near the place where they are to be used. There should be a definite, fixed position for all equipment, tools, and materials. For instance, on a wall panel (5) near the pipe vise the following tools might be hung and silhouetted (silhouetting being the painting of the tool outline on the wall so that a quick in-place check-up of tools is possible): 3-wheel pipe cutter, ratchet-type threader with dies from ½-inch to 2-inch, ratchet reamer, two 24-inch pipe wrenches, an 8-inch and a 10-inch pipe wrench. On a shelf at eye-level height are stored cans of pipe joint compound and pipe-cutting oil, measuring tape, crayon, wire brush, and rags. Below the shelf a series of bins are provided for assorted fittings, faucets, and odd lengths of pipe. At (6) a bench is placed for mixing paints and other preservative compounds. On the wall above this bench brushes are hung on nails, along with putty knives, mixing sticks, caulking gun, paint rollers, and paint scrapers. On open shelves above these tools the usual homestead assortment of paints and solvents are kept (7). Putty and glass cutters also are located among painting paraphernalia.

A floor-to-ceiling bin is provided at (8) for often-used hardware and electrical items, like hinges, plugs, and switches. Next to the electrical bin, in the first drawer below the work bench (9), are located the electrical-working tools: solder gun, acid, solder, plastic tape, wire cutters, screwdrivers, and testers. The work bench itself (10) should be sturdily built and well-braced to receive major impact. Laminated 2 x 4's on edge make an especially strong bench construction. On a shelf below the work bench are stored various power tools (11); ⅜-inch portable electric drill, 6-inch and 8-inch portable circular saw, portable belt sander, saber saw, and chain saw. A wood vise is mounted at the right hand edge of the work bench (12), and above the bench are silhouette-painted racks for wood-working hand tools (13). The following items are considered by me to be a minimal collection of tools for homestead wood-building projects and general maintenance: 2 straight-claw hammers (13 and 20 oz.), 8-pt. crosscut saw, 5-pt. rip saw, 24-inch level, 16-foot box tape, combination square, T-bevel, 30-inch wrecking bar, power bit set, chisel set, slip-joint pliers, screwdriver set, spiral ratchet screwdriver, rafter square, keyhole saw, nail set, gun tacker, 50-foot steel tape, 8-inch block plane, 14-inch jack plane, plumb bob, push-type hand drill, offset ripping chisel, nail puller, nail claw, miter box and back saw, oil stone, and leather work apron.

Another tool drawer is provided at (14) for masonry tools: brick trowel, pointing trowel, two plastering trowels, two finishing trowels, wood float, brick hammer, rubber mallet, hawk, nylon line, line level, 4-pound stone hammer. Also included in the masonry drawer are tile-working tools, cutter, nippers, and sawtooth trowel. To minimize weight the drawers are kept narrow and shallow. Guides should be installed inside the drawer so that a sliding tray, one-half the length of the drawer, can be incorporated for the storage of smaller items. Drawers are designed to be removed and transported directly to projects elsewhere on the homestead.

At (15) I have allocated sufficient space for a two-foot square wall-mounted folding-top desk and stool. Closed, the desk top protects from dust a 12-inch deep series of shelves designed to hold books, repair manuals, simple drafting tools, paper and various parts manuals. The desk center is also a good location for an intercom phone connection to the homestead.

The wall panel at (16) is reserved for general land-working implements — all silhouetted and hung on nails: square nose and pointed shovels, rake, hoe, mattock, post hole digger, hay fork, manure fork, splitting maul, double-bitted axe, pry bar, and pick.

Before implements are returned to their respective locations on the wall panel they should first be cleaned, repaired and sharpened. Sharp tools reduce fatigue. Major repairs, like replacing broken handles or welding broken parts, should be made during off-season periods so that delay is avoided at times when the implement is most needed.

Real care should be given to proper implement selection. Shovels, for instance, vary in container size, length of handle, and blade-to-handle angle. Square nose shovels are best used on even ground, while pointed ones serve best on uneven ground. The blade size should be relative to the weight of material handled. Shovel studies have been made showing that the use of the right shovel may increase work output by 20% without causing higher stress and fatigue to the worker.

Work output is also increased by stocking only the very finest quality tools. Quality cannot be determined by brand "name". Stanley, for instance, makes fine tools, but they also make a "Handyman" line which is pure junk. Avoid "combination" tools, like the Shopsmith, which compromise the function of one operation to make another possible. Too often the multi-purpose implement is too light for heavy work and too heavy for light work. Thousands of gadgets are offered each year to shop-workers, who, like the proverbial fishermen desirous of catching more fish, are prone to spend money and time on worthless items which only purport to save money and time.

At (17) I have located compartmentalized floor-to-ceiling bins for the storage of nails, bolts, nuts, screws, washers, and miscellaneous small items.

D. METAL WORK

Central to all metal-working shop needs and central in location within the shop is the indispensable arc welder. (18). This one machine, which tucks away neatly under an all-steel welding table (19), replaces a complete blacksmith: forge, bellows, anvil, and countless hand tools. Traditionally, to fuse metals together, blacksmiths had to heat metal in forges and then hammer the two pieces together to make a union. This was done with much patience and skill as the two pieces of metal had to reach the anvil at the same temperature for a perfect surface union. For repair and maintenance and for constructing new homestead equipment the arc welder has opened up a vast potential for the unskilled metals worker. With about $50. one can purchase a used 100 amp. 220 v. AC transformer-type welder, a size entirely suitable for homestead shop needs.

Investment in an oxy-acetylene outfit (20) is not mandatory but is certainly handy for cutting and heating metal and for thin-metal welding. If used gas tanks with regulators cannot be acquired (tank rental is high), it would be more economical to rely on the arc welder for heating and cutting metal. The old workhorse of welders, "Lincwelder AC-180", manufactured by Lincoln Electric Company of Cleveland and found in practically every other farm shop in this country, is equipped with an arc torch for heating metal. Carbon rods are also used for brazing, soldering, or for applying hard-surface powder. Certain carbon rods are used for cutting metals. Other welders besides Lincoln doubtless offer the same design features, but I wager there is no other company in the U. S. which has given so much practical assistance to the American farmer at the same time that it has given socio-economic advantage to its own production workers.

A single metal drawer (21), mounted on the welding table, is provided for welding paraphernalia: welding electrode, gloves, head shield, goggles, chipping hammer, wire brush, and soapstone pencils.

At (22) a galvanized metal, cold water sink is provided. Its location should be convenient to the welding center for metal cooling and tool tempering. Other uses for a sink include wash-up, tire tube testing and battery filling. A small stand (23), adjacent to the sink, holds a few reserve batteries and a battery charger. A 30-ampere-hour battery charging attachment can be plugged into the Lincwelder AC 180, incidentally. On a rack above the charger are hung the few tools associated with battery installation and maintenance: hydrometer, carrying strap, terminal cleaner, battery pliers, terminal remover, booster cables, electrical tester, and spare cables and terminals.

A portable workbench cart is stored at (24) when not in use. Since the bench will most often be in use for projects at other places around the shop and homestead, two front wheels make it possible to move the bench (along with handy, lower tool tray) anywhere on the homestead.

The permanently-mounted metal-working bench (25) is a facsimile of the wood-working bench, also sturdily built from laminated 2 x 4's. Three essential power tools are secured to this bench: 5-inch machinist vise (26), ½ h.p. bench grinder (27), ½-inch drill press (28). A narrow drawer below the drill press holds the usual assortment of drill bits, files, punches, and chisels (29).

The metal-working hand tool rack above the work bench (30) is also a facsimile of the wood-working hand tool rack since tools are located at a point on the rack where they are most often used on the bench. The most frequently used tools — like screwdrivers and pliers — are placed in a central location, within easy reach. I consider the following tools essential to any metal-working homestead project: 7- and 10-inch locking plier-wrenches (vise grips), arc-joint pliers, screwdriver set, 12-foot box tape, adjustable wrenches (4-, 8- and 12-inch), wire cutters, ball-peen hammers (8-, 16- and 24-ounce), 5-lb. sledge, hack saw, tin snips, 10-inch duck-bill, tap and die set (¼-½ x sixteenths, both USS and SAE threads), 24-inch bolt cutters, and "easy out" removers.

In a drawer below the vise are located automotive repair tools (31). The upper sliding tray contains a set of combination box-open-end wrenches, $\frac{3}{8}$ to 1-inch and $\frac{1}{2}$-inch drive socket set, same size range and with ratchet, drive, and assorted extensions. Below the sliding tray are stored the seldom-used engine tune-up and overhaul tools, comprising feeler gauge, gear puller set, compression gauge, timing light, vacuum gauge, valve-seating tool, cylinder-honing tool, valve lifter, piston ring expander, piston groove cutter, piston ring compressor, brake cylinder surfacing hone, valve grinder, hand impact tool, torque wrench, cylinder ridge reamer, ignition wrench set, and inside and outside micrometer.

Lubricant and lubricating tools are stored at (32). Varieties of grease may include that specifically formulated for wheel bearings, water pumps, and general bearings. Gear oil and bulk engine oil are stored directly on the floor in 5-gallon containers. Other lubricant equipment includes: portable grease gun, gear-oil hand pump lubricator, spare toilet paper rolls for automotive oil filters, various oil cans, and compressed-air grease gun.

The last named item is a convenience when the homesteader does preventive maintenance for a truck and tractor as well as fore one or more passenger vehicles. Grease is dispensed under pressure created by a 20-gal., 1 h.p. portable air compressor (33). This size compressor is designed to emit 5 cu. ft. of air at 100 pounds-per-minute, sufficient to operate grease gun, spark-plug cleaner, blow gun, paint spray gun, engine cleaner, and, of course, tire pump.

Tire repair tools are conveniently located on shelves above the air compressor (34). These includes the usual assortment of tire irons, mallet, lug wrenches, bumper and hydraulic jacks, portable lever-action bead breaker, hot and cold patches, air pressure gauge, spare valve cores and tools. Hot patch tube repair is done on a wall-mounted clamp located at (35).

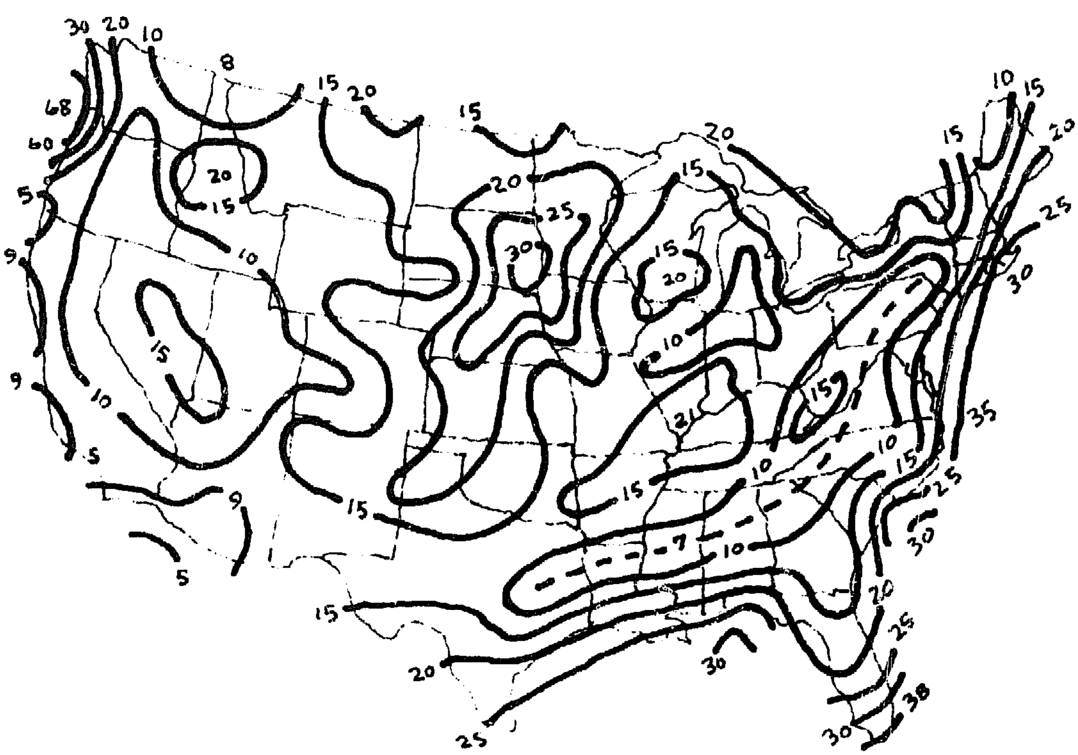
Numerous small parts for machine items are required on a homestead. Things like pulleys and belts, gears and bearings, spare electric motors and bushings all require some sort of ORGANIZED storage. Too often a trip to town could be averted if only it were possible to locate a necessary part when needed. An elaborate bin-type, floor-to-ceiling cabinet is therefore provided at (36).

Finally, at least two fire extinguishers should be visibly situated and centrally located at (37). Be sure these are annually serviced as per instructions on this equipment.

The layout of the tools and equipment specified here for this hypothetical shop actually DOES exist in my own homestead shop — but not with quite the same organization. The overhead door opening into my shop is too narrow and too low. Natural lighting is poor. The grease pit is too deep, and the shop is difficult to heat in winter. Tool accumulation has extended over a 20-year period with too many tools borrowed, broken, lost, or misplaced. Sets are incomplete, and many are obsolete. For instance, who needs a plumber's lead-melting pot in this era of plastic plumbing?

So, at least in one respect, I am envious of the young homesteader just starting to plan to equip his workshop. He should know that this project will be the first one to be started, and the last one to be completed. My advice, of course, is to follow the plan outlined above. Other good advice has come from an accomplished shopman of many years, Milton Wend, who says in his book, HOW TO LIVE IN THE COUNTRY WITHOUT FARMING:

> Every activity touched upon requires information, analysis, planning, capital investment, a lot of time and physical effort, and the attainment of that knowledge that comes only with actual experience. It is very easy to undertake too many ventures in any one year. It is much sounder practice to draw up a program of proposed undertakings spread out over many years to come. At least there will be no danger of future boredom. Start a few new ones each year if you want to, and prepare for next year's well in advance. The satisfaction due to sound achievement and new skills mastered is more important than the number of activities under way.



WIND PRESSURE AGAINST EXPOSED WALLS (LB./SQ. FT.)
PREDICTED 25-YEAR FREQUENCY

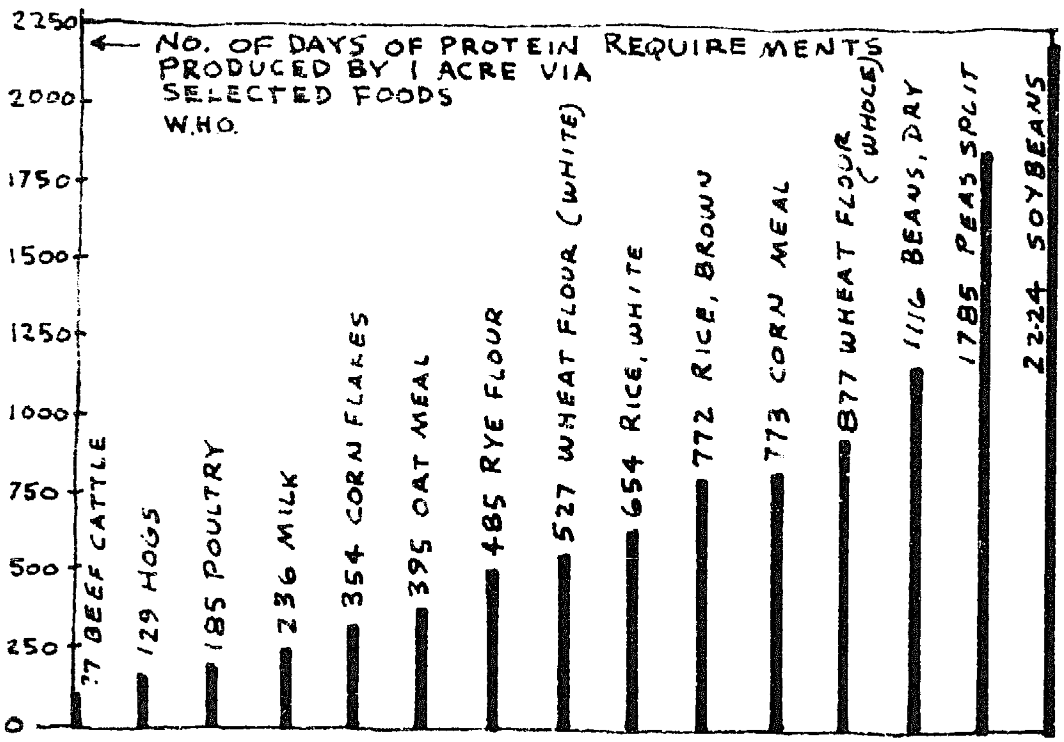
Animal Products

Maintaining animals on a homestead is both a LUXURY and a NECESSITY. This maintenance is a necessity if animal products are to be consumed, since purchasing commercially-raised animal products at the market place is out of the question for the serious homesteader. Much can be said about the abhorrent conditions under which commercial livestock is raised and from which livestock products are extracted. For the marketer's economic advantage animals are force-fed in controlled environments. They are raised in building cages on concrete or wire mesh floors. They are removed from the soil — and from fresh air, sunshine and rain — and have little chance for natural exercise lest precious fat or space be lost. Hormones (artificial estrogens) are administered to animal feed to increase rate of growth and body weight. Dangerous antibiotic food additives are administered to stimulate growth and to "combat disease". Antibiotics and pharmaceuticals are administered so that many of the sickliest will not die.

Under such living conditions disease is inevitable. Hepatitis in man has been correlated with the increased use of insecticides. In animals, diseases such as Newcastle's Disease affecting chickens, hyperkaroloris affecting cattle, and blue tongue affecting sheep were unknown in 1942 when the U.S.D.A. compiled its extensive KEEPING LIVESTOCK HEALTHY handbook. In 1959, an English scientist made a year-long survey of food value of eggs and found that eggs from chickens raised on free range had 8800 units of Vitamin A and Beta Carotene, while eggs from battery-caged chickens had only 4500 units of these necessary elements. Not long ago farmers supplied four pounds of feed for each pound of gain in chickens' weight. Today this amount of feed has been cut in half by replacement with antibiotics, arsenic and pharmaceuticals which spur an even greater rate of growth.

Maintaining animals is also a LUXURY. Grain-feeding animals for the purpose of producing meat, milk or eggs is far less efficient than providing grains directly for man's consumption. A hundred-pound sack of corn has enough energy and protein to keep a man alive for about 60 days. But when that same sack of corn is fed to livestock only enough protein and energy will be produced by the animal to sustain a human from 5-10 days. The World Health Organization published a graphic illustration of just where animals rate in terms of protein requirement as against protein produced per acre of land.

Contrasting this position the argument is often heard that ruminant animals (cattle, sheep, goats) really do not compete with man for food



RELATIVE NUTRITIVE VALUE OF DIFFERENT FOOD SOURCES PER LAND UNIT (BASED ON 100% PRODUCED BY SOYBEANS)

FOOD	ENERGY	PROTEIN	MINERALS	VITAMINS
SOYBEANS	100	100	100	100
WHEAT	73	26	38	47
MILK	23	11	6	19
EGGS	9	8	2	11
HOGS	32	5	1	21
BEEF	3	2	3	3

because their more complex stomach structure digests fibrous foodstuffs which cannot be digested by man. The fact is, however, that animal pasture and feed are grown on land that COULD be utilized directly by man. The number of domestic animals in the world today roughly equals the human population.

Accepting the fact that maintaining animals on the homestead is a luxury — since there is about a 15% efficiency for animals to convert plant materials to animal products — it then behooves us to evaluate the range and variety of animal products we require to determine which animal population best suits our specific homestead production. Again, reference should be made to "efficiency" charts.

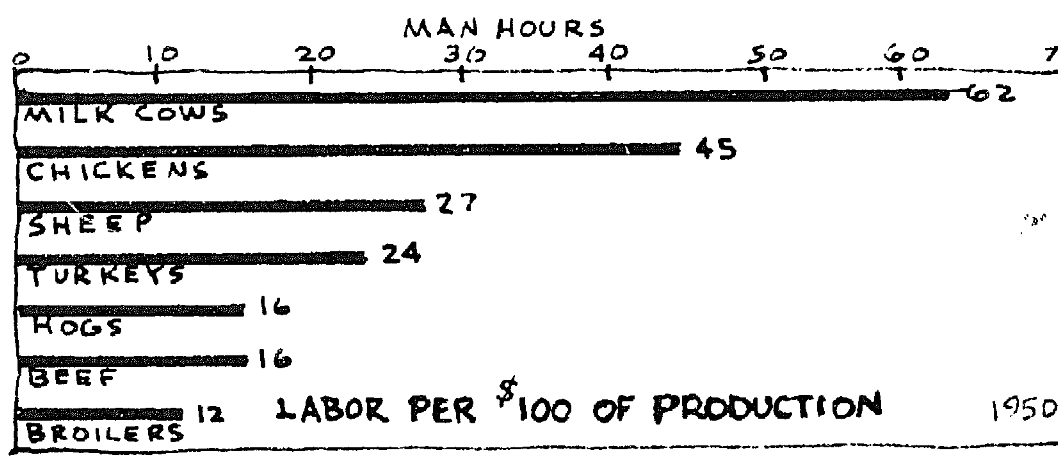
Beef cattle and sheep are at the bottom of the food-conversion efficiency list. Cattle, at one time, revolutionized agriculture when the males were used for draft purposes. Breeding cattle for meat came much later. If a homesteader has an abundance of low-cost, low tax-rate land, climatically conducive to adequate year-round pasture and sufficient water supply, he might be tempted to raise a few beef. Less care is required raising cattle than any other type of livestock. Fence maintenance is about the only chore involved.

Sheep were first domesticated to supply meat. Later they became milk producers, and much later they were bred for wool. Primitive farmers had a choice between sheep, cattle and goats. Goats were the primary choice for their effectiveness in clearing brush from virgin, forested land. Goats are leaf-eaters while sheep are grass-eaters. Consequently, more effort was taken to breed goats for milk production. But when the land was cleared of brush and trees sheep and cattle became the best choices for a grassland agriculture. And, of course, when it was discovered that cattle could be employed to till the soil and could be bred to give milk goats and sheep became less desirable.

The dairy cow evolved out of all this concerned breeding. Due to her phenomenal milk production, the dairy cow is rated on a par with poultry for being more than twice as efficient as are cattle and sheep when converting vegetable protein to animal protein. Pigs fall somewhere in a middle category.

Milton Wend is one of the most knowledgable authors to write on the subject of animals for the productive homestead. He ventures an "order" of animals by preference as follows: ". . . chickens, a cow or several goats, bees, swine (if one has a cow), a dog, a cat, possibly a horse, rabbits or sheep if they appeal."

I have no quarrel with Milton about the low status he ascribes to dog and cat as their function on the homestead has definitely been



MILK COW — 47%
HEN EGGS — 36%
CHICKEN — 23%
HOG — 17%
BEEF — 7%

CONVERSION EFFICIENCY OF PLANT TO FOOD PROTEIN over-rated. Cats may rid the garden of gophers but at the same time they kill valuable insect-eating birds. Sheep (and I would add beef cattle) are well-placed at the end of the sequence. I do take issue with the high placement of bees on the list. About the only value bees offer is pollenization of certain fruit varieties. As a food, honey has negligible value since it contains over 80% sugar and only minute traces of calcium and iron. Milton's list was published in 1944 at a time when the horse was still considered a viable draft and transport prospect. And 30 years ago (even 5 years ago!) who would have thought that homesteaders would be raising fish as a main source of human protein and animal feed? So my own updated sequence is tempered by some major advances in animal husbandry, by new knowledge of diet and nutrition, by an inflated valuation of land and land tax, and by revolutionary progress in plant management. In order of importance I suggest goats, fish, ducks, pigs, rabbits.

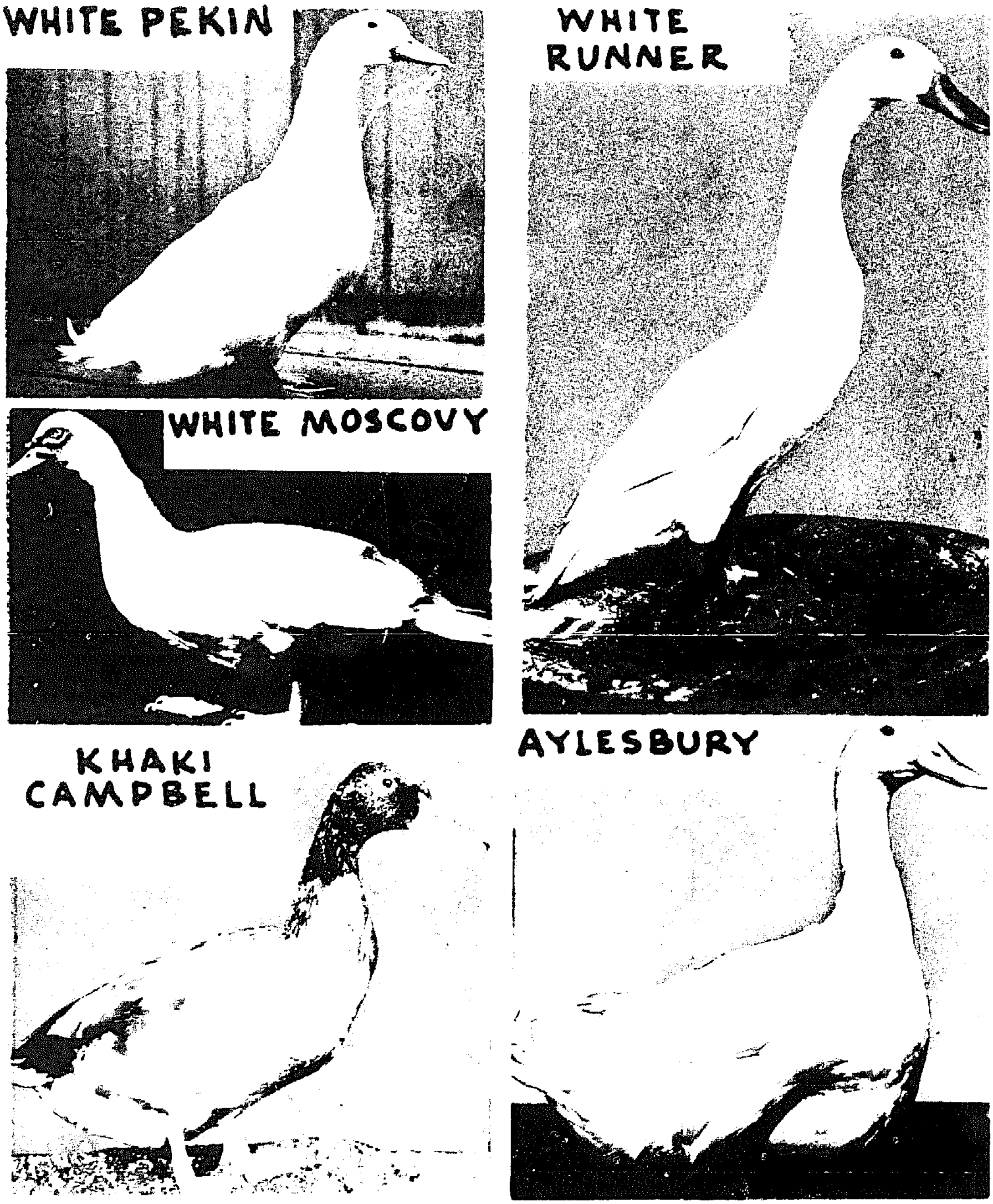
The goat always has been, and probably will continue to be, the symbol of subsistence homesteading. It is a maverick, an independent animal, and people who raise goats seem to be of the same ilk. When managing our goats I like to think of the world fraternity of marginal farmers doing similarly with these animals and, hopefully, holding the same nice thoughts. Goats are well-suited to the marginal-land farmer. They thrive on poor brush-pasture, on steep land, and in hot climates. They require a certain amount of human attention which can result in a gratifying man/animal relationship for the homesteader, but one which the agribusiness dairy farmer cannot afford since it nets no cash return.

In proportion to body weight a goat produces more milk than a cow. Goats milk is also more quickly and more easily digested than cows milk. Although chemically and nutritionally similar to cows milk, the fat globules in goats milk are small and tend to be naturally homogenized making the milk more desirable for infants, the elderly, and for those growing numbers who are becoming allergic to cows milk. Cows milk may be suitable for the FAST-GROWING calf, but, as I will point out in the following chapter, there is good reason to maintain the human infant's normally SLOW rate of growth.

Fish culture is such an important new development for the productive homestead that I have reserved a separate chapter for it in this book. On homesteads where a serious fish culture program is initiated one would do well to include a duck and pig population for balanced fertilization.

By living on the water much of the time, ducks naturally balance a fish production program better than chickens. Even the constant action of wings and feet is known to seal a leaky fish pond. Few people are aware of the fact that some duck varieties lay more eggs than chickens (as many as 50 per year). Also, duck eggs are larger; it takes 4 hen eggs to equal the size of 3 duck eggs. A duck's profitable laying life is two-to-three times greater than a chicken's.

Unlike chickens, ducks do all their egg laying at night. Thus, free-ranging is possible during the day without concern for secreted eggs. Ducks are like goats in their resistance to disease — in the same way that chickens and cows are alike in their susceptibility. The death rate among growing ducklings is very low. Like goats, ducks thrive on marginal land.



PEKIN- GOOD TABLE 8# 120 EGGS/YR. NERVOUS. POOR SETTERS
MOSCOVY - GOOD GRAZING 7# GOOD SETTERS POOR LAYERS (45)
KHAKI CAMPBELL - BEST LAYERS (300) POOR TABLE 5#
RUNNER - GOOD LAYERS (150) POOR TABLE 5#
AYLESBURY - GOOD TABLE 9# POOR LAYERS (100) POOR SETTERS

George Orwell was observant when he picked the pig to be the leader of his farmyard revolution against man. Pigs are second only to man in brain power. They are even capable of more original thought than the dog. Pigs are naturally clean, being the only domestic animal which will not soil its litter if allowed outside access. They are lively, intelligent and extremely adaptable to changes in environment. Like the duck, the pig is an important adjunct to a fish culture program. As mentioned in a previous chapter, 70% of pig dung contains digestible food for fish. The labor involved in raising pigs is on a par with beef cattle and only slightly higher than raising broilers.

Interestingly, the words "meat" and "pork" are synonymous in China. As well as being a high protein food, pork also contains the essential amino-acids that people's tissues require for cell-building. Someone once suggested that the reason pork is such a complete, easily assimilated food for man is that the pig is, of all domestic animals, most like the human in physical and chemical composition. A pig's internal system is a near-replica of man's. Similar tooth structure can be observed: low-crowned, grinding teeth with rounded cusps suitable for chewing both plant and animal foods. It was also suggested that the ideal food for any organism is that which is the most similar in constitution. Nutritionally, for us, human flesh cannot be equaled.

Domestic rabbits have always been a good meat source for the small homesteader. About 80% of this animal is edible, and its fine-grained, highly nutritious meat figures at about 20% protein and about only 10% fat. A doe produces 4 litters, averaging 8 to a litter, each year. Fryers dress out to 2 pounds in 2 months. The reader may wonder why I place such an efficient meat-machine last on my selected list of homestead animals. Frankly, no one has yet devised a satisfactory method of producing rabbits in colonies on free range. The usual intensive wire-cage production methods are intolerable. In the following two chapters I will discuss ways in which animals may live and feed together for mutual benefit. Rabbits, however, can have no relationship to animal society with their requirement for wire-cage confinement.

Animal Feed

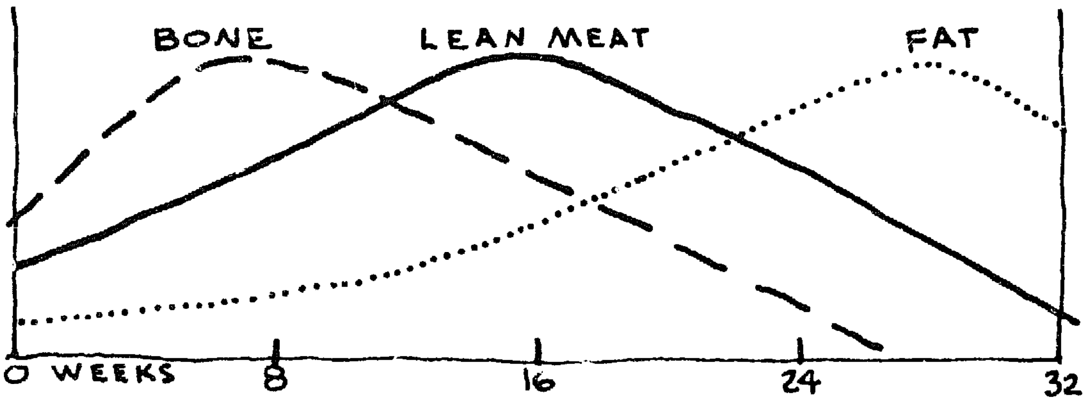
Trends in animal management during the past half-century have gone from FREE-RANGE pasturage to intensive FEED-LOTTING to FACTORY agribusiness. And, concurrent with these latter developments, the commercial feed industry has advanced to ninth-place rank among expanding manufacturing industries in the United States. The growth of the feed industry is akin to the enormous growth of farm product distribution; one-sixth of the 6,000 feed manufacturers account for 80% of feed industry production. Louis Bromfield, therefore, sums up the small farmer's dilemma with the statement that:

> You can breed the pigs and buy the corn and get on; you can raise the corn and buy the pigs and get on;
> If you buy the corn and buy the pigs to feed, you haven't a chance;
> But if you breed the pigs and raise the corn, you'll make money.

The homesteader has even less reason for buying animal feed than the small farmer. I would venture the opinion that if a homesteader cannot supply feed from his own place he has no business keeping animals. Economic considerations only partly support this viewpoint. Primarily, commercial feeds are just not suitable for producing healthy animals and nutritious animal products.

Modern feeding concepts (for both human and animal nutrition) are, for the most part, based on the calorie and on protein requirement. Fast growth of our livestock — and of our children — is deemed highly desirable. Yet, we now know that in the bones of children whose growth has been stimulated the physiological age of these bones is prematurely OLDER than those of children who have grown more slowly. Our "high-energy", concentrated-foods approach to food requirements (as opposed to a "nutrient" approach to these requirements) has created a barnfull — and a schoolyardfull — of obese individuals. We have lost sight of the properties of natural growth, and one-out-of-every-five Americans has become over-weight.

The ratio of non-essential to essential fats in domestic animals is 50 to 1. It is 2 to 1 in wild animals. Essential fats, called lipids, are also called STRUCTURAL FATS as they are important to forming new cell structures. Earliest growth development takes place in the embryo stage with the nervous system developing faster than the remainder of the body. After birth, bone structure should assume the more rapid growth. And, before fat accumulates, the young animal should develop



CHANGES IN THE TYPE OF LIVEWEIGHT GAIN MADE BY A NORMALLY GROWING PIG

a lean-flesh, muscular structure. Fat deposition should properly occur only after an animal reaches maturity.

A diet of commercial feed, however, is far too rich in digestible protein. Mineral deficiency diseases are apt to occur where saturated high-energy rations are fed — especially to young livestock. The normal changes that occur in the liveweight gain of a growing pig are illustrated below. Unlike ruminants, pigs are equipped with only a small number of cellulose-splitting bacteria so that their diet should be limited to 5% fiber content as opposed to 50% content for cattle. Commercial pig feed is high in carbohydrates and is designed to "harden" the natural, polyunsaturated soft fat of the animal. In storage soft fat eventually becomes rancid — that is, it becomes "oxygenated" and, therefore, "stabilized" as well as becoming less assimilable and less palatable. This rancidity interferes with curing so that meat processors demand "finishing" of barley-fed rations to produce hard fat. In contrast to the free-range porker, commercially-produced pigs barely live a full lifetime. For the most part they are sick animals, victims of obesity and must be marketed before death overtakes them!

Some animal feed nutritionists claim that from 50% to 90% of a pig's food requirements can be met through proper pasture management. A succulent, fast-growing annual (like rape or perennial comfrey) makes an excellent pasture for pigs. High water-content succulents are an important addition to the diet of all animals, water being an essential vehicle for transfering nutrients within the body. Water plays an important part in body metabolism and should be made constantly available to all animals. Additionally, nitrogen-bearing legumes (alfalfa, ladino clover, field peas, coybeans, vetch) are excellent pasturage choices.

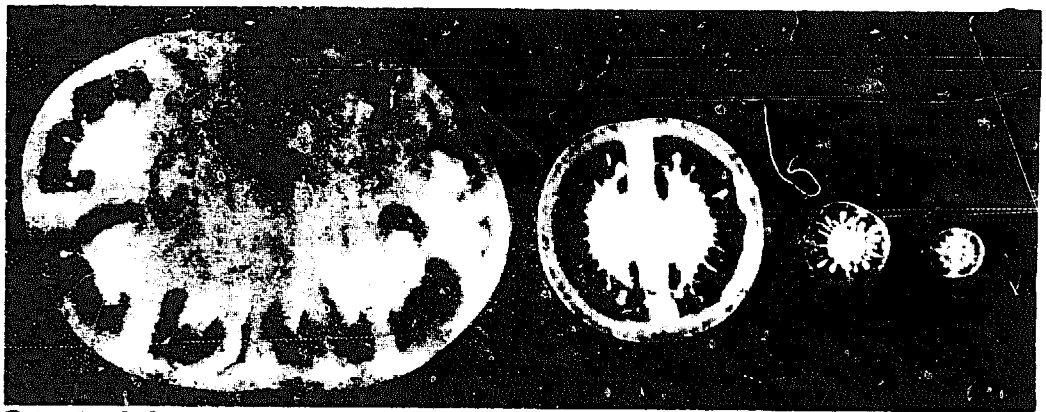
In a previous chapter on sod crops mention was made of the Swiss dairymen who doubled protein values in forage by harvesting grass in an immature stage. An even higher percentage of nutrient increase can be achieved when the grass is harvested, or grazed at a period of growth called the JOINTING stage. Dr. C. F. Schnable, a biochemist from Kansas City, found that one pound of "jointing grass" contains more vitamins than a ton of the same grass when matured. Full-growth oats, having a 5% protein content, progress through a jointing stage where the protein content runs as high as 45%. It was Schnable who, in 1930, found that stored-up nutrient in grass reaches a peak just prior to the reproductive stage — on the day the first joint starts to form.

There is more to this matter of joints and grass than the average teenager might suspect. . . . Plants create the original, amino-acid building blocks used by all living animals and arrange them into useable protein structures. When consuming vegetable protein animals re-align this structure into simple units and, thus, form a more complete ANIMAL protein. It is the amino-acids that animals reconstitute in their systems. A protein food may be deficient in one or another of these amino-acids, but if two protein foods with different amino-acid content are eaten together, these differently constituted protein foods may compliment one another forming a more useable, "whole" protein. More discussion on food combination will appear in a later chapter on nutrition.

A pea-bean meal can be a main source of home-grown protein for livestock. Plants should be cut when stems and leaves are green and tender — in a stage, as noted above, when they have their highest protein content. The well-cured (dried) plants are ground in a hammer mill which is an essential tool for homestead-produced foodstuffs. Cob meal (corn kernels and cob) can be ground for chickens. This is only 65% as nutritious as pure corn meal, but it offers essential roughage.

Cob meal can also be prepared for rabbits. Pure grain-feeding of rabbits is a questionable practice. Root crops from the garden and alfalfa or clover hay from the pasture are a preferred supplement to cob or soybean meal for these animals. Large amounts of green feeds should be made available to animals so as to make full digestive use of ground meals or grains.

Diversity and regularity in diet are important. We now know that certain foods release in other foods nutrients which would otherwise be lost. High-energy, carbohydrate, mono-diet foodstuffs are fed to animals at the expense of their need for minerals and oil-soluble components. The WHOLE plant should be fed to animals since seeds, leaves, and stems (even roots) have a profound supplementary action in their diet. Minerals in leaves supplement those in seeds while oil-rich seeds render liquid-soluble vitamins readily absorbable. On the one hand, plant propagationists scurry to develop new strains of high-producing, seedless (hybrid) plants while nutritionists must, additionally, formulate supplemental diet additives to replace the seed-rich nutrients along with their vitamin components that are now bred out of plants. 'Ever hear of the seedless tomato? To get full nutritional value from eating one, these fruit should be taken with supplemental Vitamin C to replace the oil-rich seed, which formerly released the benefit of its Vitamin C content. In another related, "improvement" tragedy, the blight that destroyed 700-million bushels of Midwest corn



PROPORTIONAL SIZE OF TOMATO AND AMOUNT OF SEED:
BEEFSTEAK — USUAL GARDEN VARIETY — CHERRY — WILD

in 1970 was caused by a virus which happens to prefer the leaves and tissues of male sterile corn; that is which prefers this HYBRID variety of corn. Open pollinated varieties were not touched by the blight.

Concerning the regularity of feeding, a goat requires twice as much food per gallon of milk produced if that food is supplied at a single time than if it is fed at five separate intervals. Nutrients are just not sufficiently digested when they are packed in the stomach for long periods. It is a better rule to feed little but often. Better yet, let the animal graze and choose his own diet. As illustrated in the valuable manual, OBSERVATIONS ON THE GOAT (Food and Agriculture Organization of the United Nations), an equation for animal nutrition requirements reads:

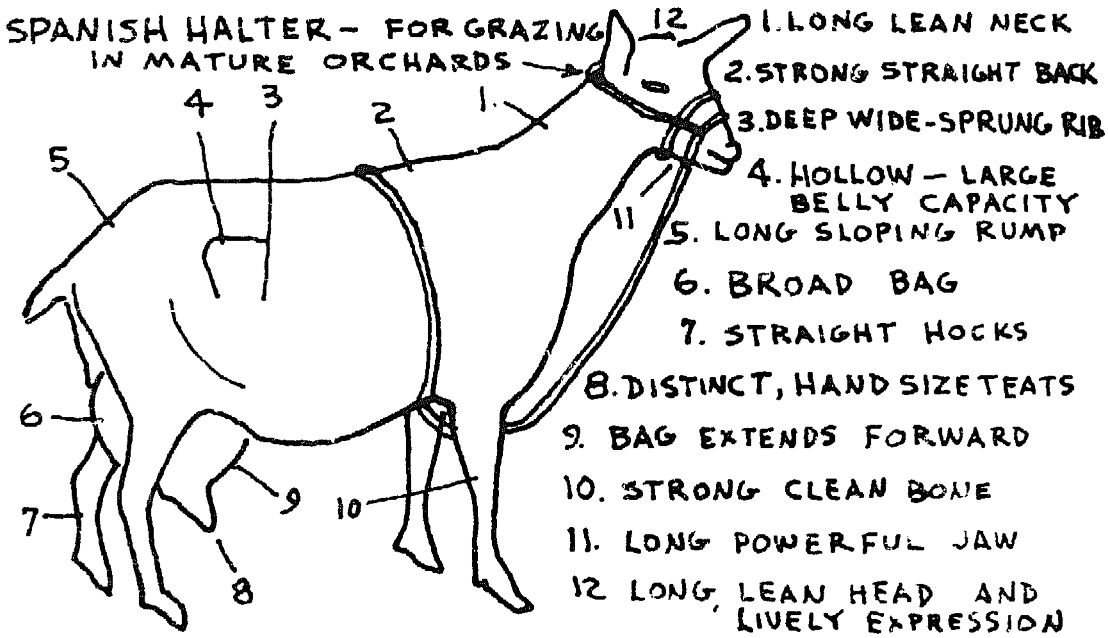
. . . . $R = aM + bG + cL + dF + eW$,

and may be translated to read:

Requirement = Maintenance + Growth + Lactation need + Foetal development + Energy of movement.

The feedlot understanding of "Requirement" can differ widely from a homesteader's regard for and his understanding of proper animal nutrition. Consider, for instance, the thesis that it is biologically advantageous to strive for food and, thus, to be hungry part of the time. Some nutritionists, experimenting with rats, found that when less food than normally eaten was offered the critter its life span was increased 30% over the feedlot style of feeding others. Underfed goats produce milk that is richer in butterfat while overfed goats produce milk in greater quantity but poor in butterfat.

A properly organized homestead layout provides animals with a controlled access to garden and orchard. Pigs and sheep do well in a harvested potato field, or any crop-harvested field, for that matter. Chickens and ducks pasture well in orchard and berry patches, destroying insects in the process. Ducks are scavengers. They thrive on parasites that ordinarily kill sheep and cattle and even chickens, such as husk or liver fluke. It is a good practice to have goats graze in mature orchard, provided that some sort of halter is used to prevent them from reaching into the branches.



THE PRODUCTIVE GOAT (FROM MACKENZIE)

BREEDING HABITS OF MAMMALIAN LIVESTOCK

SPECIES	AGE AT PUBERTY MONTHS	BREEDING SEASON	ESTRUS CYCLE DAYS	GESTATION PERIOD DAYS	LITTER	NURSING PERIOD DAYS
CATTLE	4-14	ALL YEAR	14-23	281	1	120-365
GOAT	5-8	FALL-WIN	18-24	148	1-5	120-180
SWINE	3-8	ALL YEAR	18-24	114	1-20	40-70
SHEEP	5-8	FALL	16-21	148	1-4	100-180
RABBIT	5-8	ALL YEAR	INDUCED OVULATION	31	1-13	28-56

Wherever possible let farmstead animals graze together or "follow" one another. Ducks will follow pigs, and pigs will follow cattle. Cattle, sheep and goats graze together companionably because each animal prefers a different proportion of leaves, stems and fruit in their diet; cows preferring tall grass, sheep relishing short grass and goats thriving contentedly on woody brush. Having a split lip, sheep are able to bite closer to the ground than do cattle. They graze less uniformly than cattle do, however.

Contrary to popular opinion about grazing, a pasture in good condition need not be fallowed, plowed or re-seeded. The mere presence of weed plants in a pasture is indicative of good productivity in so-called "poor" soil. Weedy hay from "poor" pasture has a better balance of minerals than seed hay from "fertile" soil. This practice of also forcing pasture YIELD with additives of high nitrogen content is likely to result in the nitrogen (protein) content of the crop being low, especially in a mature stage.

It is possible for young pasture grass to be too rich in nutrients yet too poor in minerals to be satisfactory for grazing animals, especially young animals. It has been found that pasture plants grown in dry regions have higher nutritive value than the same plant grown in above-average rainfall conditions. Pasture growth is stimulated — increased — BY MAINTAINING A RAPID CYCLING OF NUTRIENTS. Grazing animals can do this better than any type of tillage equipment. They do so in their digestive tracts through plant material decomposition which releases minerals to the environment (in the form of animal manure) even faster than is done by the process of organic decomposition.

Even seeding can be done by the animals. Hard-seeded legumes fed to animals will be spread throughout the pasture area in their droppings — provided, of course, that the soil has a high humus (mulch) content. Harold Heady, professor of Forestry at the University of California, conducted a mulch study on some annual grassland in California. Removal of mulch material immediately before the new growing season resulted in a reduction of new growth the following year. An average of 1000 pounds per acre were realized when all mulch was removed as compared with the 2300 pounds per acre which were realized when mulch was allowed to remain on the land.

It would be a mistake — and a real disservice to the serious reader — to leave the impression that just about any soil-depleted, drought-ridden pasture acreage would prove feed-worthy for any number of animals. Grazing management requires close control and constant attention. Cross fencing must be planned so that field size and shape is designed relative to the realities of existent vegetation and to soil type, wind and topography. Fencing also facilitates a planned field rotation program designed to keep ALL herbage evenly grazed. Livestock tend to congregate near water and salt lick, so these amenities should be provided at outlying areas of the pasture to insure even grazing. Trails and roads may have to be built to less accessible areas. Cattle prefer level land and will avoid grazing on steep slopes. Sheep normally face into the wind while grazing and ten to over-graze the windward side of a field. Knowing the direction of prevailing winds is, therefore, necessary for the proper installation of cross fencing.

Given the necessary planning, even the most-consuming animal, the milk cow (on the shortest growing-season homestead) can be maintained entirely from homestead-produced foodstuffs. One acre will produce a sufficient quantity (3 tons) of alfalfa or clover hay to feed a cow from October to May, and one acre of good pasture will feed the cow from May to October. One acre of pea-bean meal or cob meal supplemented with carefully-administered amounts of turnips or other root crops from the garden will keep a cow in good milk production throughout the year.

Pigs might fare even better than the cow. There's an old farm joke about the city man who criticized the farmer for allowing his pigs free range around the farmstead. "If you feed those pigs in a pen you can get them to market in half the time," his critic said. The farmer's astute reply was, "What's time to a pig?"

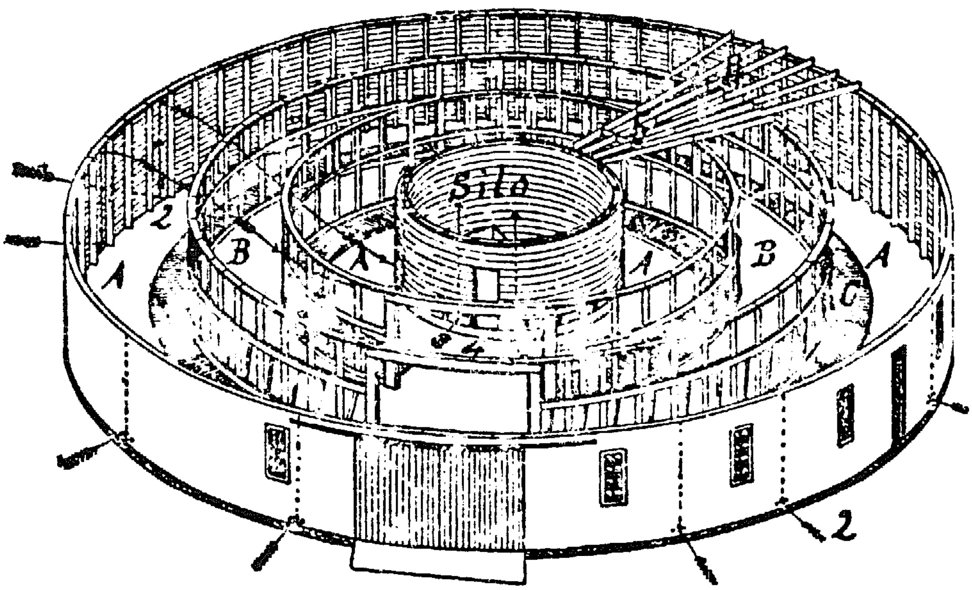
Animal Housing

In an earlier chapter the soil work and the Asian travels of F. H. King were mentioned. Recognized as the foremost soil scientist of his day, Professor King also did much original thinking on the environmental needs of livestock. In the 1907 edition of his TEXTBOOK OF THE PHYSICS OF AGRICULTURE he proposed some totally unorthodox concepts for animal housing. Barns, he maintained, should be consolidated by bringing all animals together under one roof. One of his barn designs was cylindrical and had a central, cylindrical silo. King claimed that the cylindrical barn was the most labor-efficient, least costly, and structurally strong barn a farmer could build.

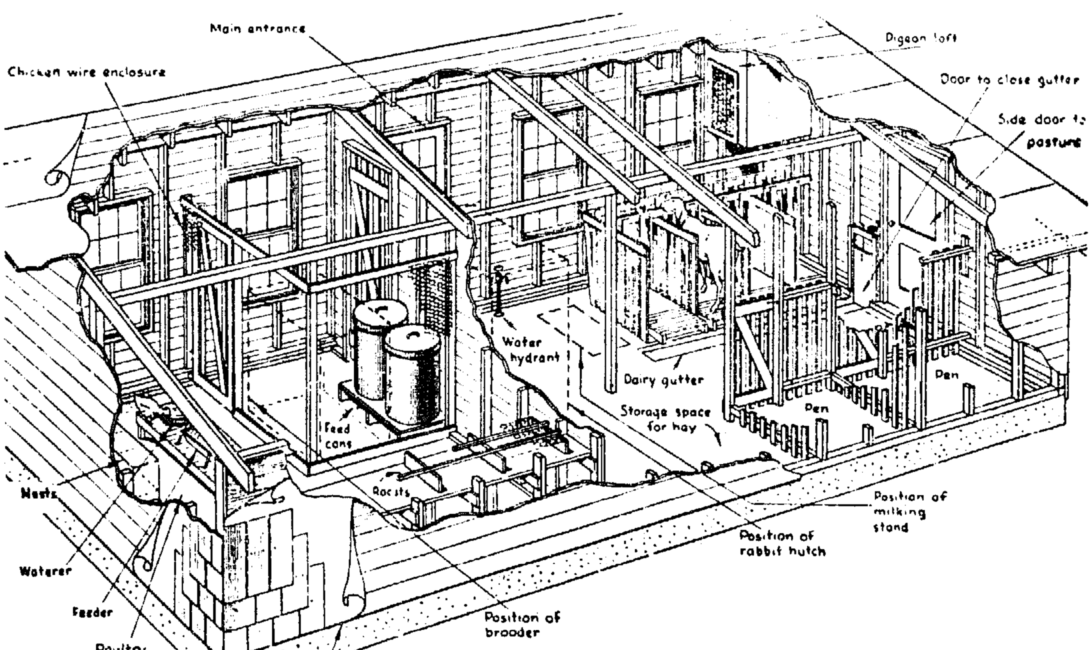
Countless barns have been erected in the intervening 60 years since Professor King's book appeared, but few have risen incorporating the good-sense ideas proposed by him. To this day, barns represent the personal pride of their farmer-builder, and yet they exhibit too little functional value for the task of their erection. A recent study indicates that dairy buildings costing $200 per cow to construct may be used to produce milk of quality equal to milk produced in buildings costing $500 per cow.

Even barns designed expressly for homesteaders, by people who purport to know what animal housing-needs are all about, are notable only for their badly planned features. Take, for example, Ed Robinson's Have More Plan concept of a small barn. His 16-feet by 30-feet structure is planned to house 30 hens, varying numbers of broilers, fryers and pullets, 6 pens of rabbits (which never see sunlight), 4 goats and 3 pairs of breeding pigeons. In plan, the barn looks like a disaster area with every square foot of floor area subdivided and allocated to serve a specific function: pens and stalls and roosts and nests and places for feed cans, milk cans, water cans, etc. Some may call the generous use of partitions and doors "organization", while an animal living inside the complex might more aptly consider itself frustratingly "boxed-in" — an experience irritatingly similar to the five-room box-residence of man.

The first criteria of good barn design is the maintenance of flexibility of space. As soon as a pen, roost or rest is nailed down that space becomes dead to a future, expanding function. Special facilities have to be provided, but they should be adjustable and movable. Partitions may be necessary at times, too, but when not in use they should slide or fold up out of the way. Homestead animal populations are in constant flux. At times, extra space may be needed for the newly-born, whereas a barn area may, overnight, be doubled following a day's butchering activity.



CYLINDRICAL BARN F.H.KING 1907



HAVE-MORE-PLAN BARN

I am certainly partial to Professor King's suggestions for a centrally-located silo. For one thing, it puts the feed source at equal proximity to all parts of the barn. This, of course, necessitates storing a variety of silage satisfactory to all animals. Any of the grains, even sunflower seeds, can be successfully made into silage. Cob meal may be stored — or a pea-bean mixture or alfalfa, soybeans, or comfrey, etc. Vigorous, late varieties of soybeans make excellent silage. Due to their high nitrogen content, soybeans are best mixed with corn. Such a mixture improves silage by counteracting the acid reaction of corn. Molasses is often added for palatability when legumes of low-sugar content are stored. Ordinarily, just enough moisture is contained in the silage to allow for partial fermentation, keeping it in a slightly sour condition. The main concern at this critical point should be for nutritional loss due to the weighting of moisture-laden material, resulting in the exclusion of air content and causing a sugar-to-acid conversion of the mass. In a cylindrical silo the amount of spoilage that takes place (15%) is less than one-half the spoilage (32%) in stacked ensilage.

The process of making silage on the homestead need not be complicated or unnecessarily time-consuming. Material is, first, cut into ½-inch lengths using a flail chopper mounted behind a tractor power take-off. A blower is required to deposit the silage into the top of the silo. There, it must be spread and compacted evenly. Silo walls should be smooth and perpendicular to allow the mass to settle without forming cavities along the wall. Silage should, also, completely fill the silo to maintain the fodder under considerable pressure, eliminating air pockets.

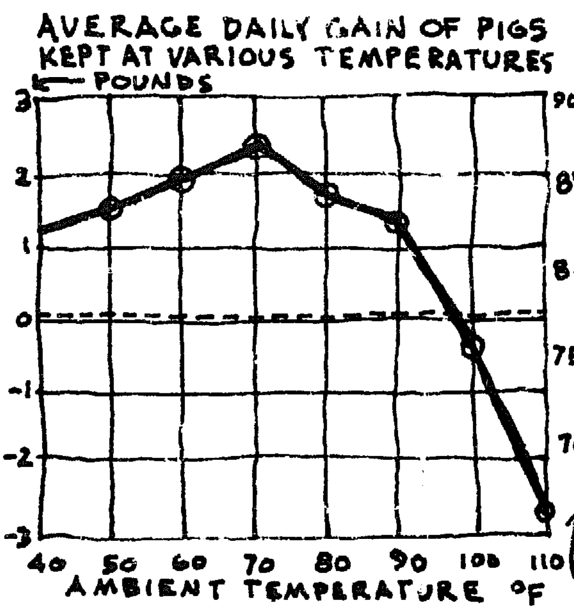
As soon as the silage is "uncapped" it begins to spoil. At least 2-inches of silo-depth, removed from the top, must be fed out daily to be ahead of the spoilage.

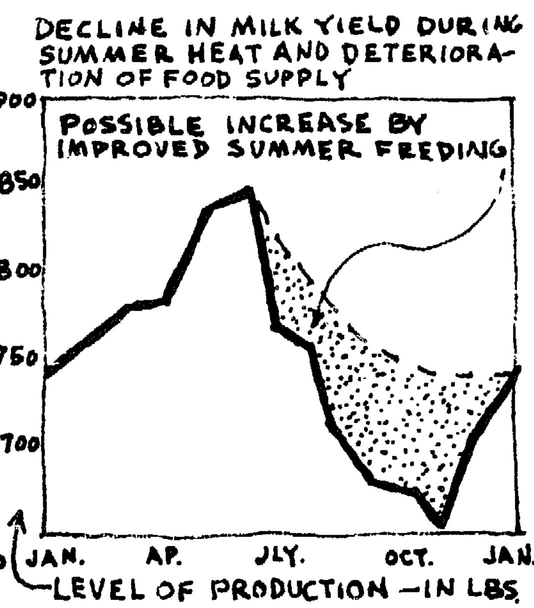
Centrally located, the cast concrete silo becomes an important structural support and bracing for the barn proper. King makes a point of mentioning how the shape of his cylindrical barn resists excessive wind pressure. Openings in the barn walls should be of sufficient size to allow machinery to enter. Several double-faced, fiber-glass doors should be provided to supply summer cross-ventilation and light, as well as allowing human, animal and equipment access. This three-in-one door function obviates the need for separate window installations. Knowledgable people have suggested that window glass obstructs beneficial ultraviolet emission, allowing only the less healthy infra rays to enter. In place of south-facing solar fenestration, I would suggest installation of a heat-absorbing masonry wall panel, to be heated by air that circulates between the storage wall and an exterior fiberglass collector panel. A sensor-controlled fan can distribute heated air throughout the barn during cold but sunny winter days. At night, heat re-radiates from the masonry storage wall.

Hay and bedding material storage in the barn loft constitute a major amount of ceiling insulation. Floor insulation is provided by starting a bacterial litter colony on an air-space insulated, concrete slab. Deep litter is usually started in the early Fall when there is still enough warmth to insure bacterial growth. A six-inch layer of porous material, like shavings or chopped straw, is placed on the floor, innoculated with a thin layer of old manure and moistened. As bacteria multiply and form a surface crust, another six-inches of dry bedding material, like straw or leaves, is added. It is this bacterial action and not litter absorption that effectively keeps the moisture content of the barn atmosphere low. Poultry droppings, to the contrary, contribute large, unwanted amounts of moisture to that atmosphere. In the process of night-time bedding and day-time living, animals naturally compact the litter, helping to exclude the air content. This results in the slowing down of the bacterial action, preventing over-heating, leaching, or drying with the attendant nutrient losses. Both slightly acid condition and slow fermentation should be maintained.

It might understandably be expected that an earthen floor would be not only satisfactory but desirable for a litter underlayment. However, experiments at Ohio Agricultural Experiment Station have disclosed a 25% liquid excrement loss to earth floors. Some type of moisture barrier is necessary. A ground cardboard- (or sawdust) clay-bitumul-asphalt mixture troweled directly onto the earth makes an excellent flooring material when dried. If concrete is used, an air-space insulation layer between the native ground and the slab is desirable. A simple method of creating this air space is achieved by first roto-tilling the floor area to a depth of 8-inches. Then, using a crowbar, one makes a series of holes for concrete-poured pillars on a 3-foot grid. A thin (2-inch) layer of concrete is next poured over the loose earth. After a few weeks the loose earth will subside, and the floor will remain suspended on the concrete pillars, leaving a continuous air space of insulation between floor and earth.

A year-round draft-free ventilation system should be provided in the barn. Louver-controlled air inlets function best in winter, whereas summer cooling can best be achieved by creating cross-ventilation through large doorway openings. A revolving hood, central exhaust ventilator is an essential device for removing foul air. The suction power of wind exerts a pull on the outlet flue (on the order of the Venturi principle), emptying the used air from the enclosure.



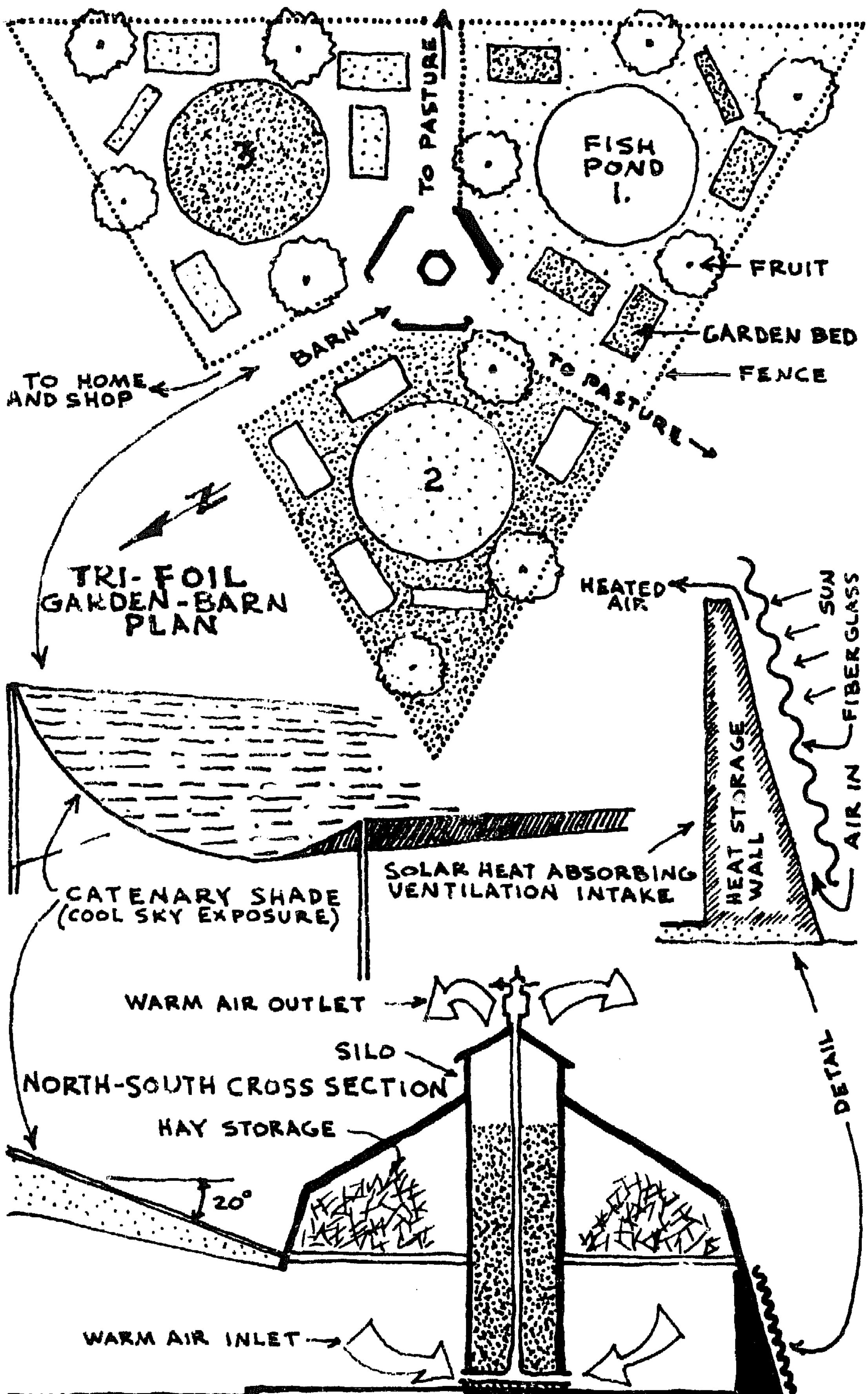


Pure air is as essential to livestock health in winter as it is to the proper combustion of a fireplace in the same season, similar principles applying. When exposed to cold and drafty conditions, animals tend to compensate their heat losses by increasing the amount of food consumed. In the summer months milk, meat, and egg production can be substantially reduced by high temperature. Pigs, for example, need to wallow in mud to keep cool. Thick layers of fat act as insulation, obstructing the transmission of temperature change between the interior of the pig's body and the surrounding atmosphere. In addition, fat limits the effectiveness of a pig's sweat glands.

In his book, BIOENERGETICS & GROWTH, Samuel Brody claims that, with cattle, at least, one-third of the grass energy of feed is dissipated as heat. With the increase in atmospheric temperature there is a corresponding increase of animals' body temperature, resulting in less efficiency of feed-utilization and less efficient breeding control. Animal comfort in hot weather can be said to be a problem of heat transfer. Four methods of heat transfer available to an animal for cooling purposes are conduction, convection, radiation and evaporation. Incoming solar radiation can be diverted most readily by artificial means, as with the use of sun shades.

Twenty years ago, at the Swedish Institute of Technology, Gunnar Pleijel found that, ". . . a clear sky results in a minimum (of temperature) at a compass point opposite to that of the sun and approximately at right angles to the direction of the sun." The mirror-like reflection of the cooler north sky explains why animals stand in the north-side shade of high-walled buildings in preference to even trees. They are, in effect, exposing their bodies to the radiant cooling effect of the "cold spot" in the northern sky. This cooler area is known as a "spot", or "sink" as Pleijel called it, because of its reverse image to the sun: mornings, the cold spot is in the west, moving in reverse of the sun's path; evenings, it lies to the east. Sun shades can, therefore, be constructed to take advantage of this "cold spot". A properly-designed sun shade will provide eastern and western sky shade, along with noontime, northern sky shade.

Much research has been done on "cold-spot" cooling, culminating in some extremely interesting design concepts by Dr. Neubauer of the University of California. At noon in California's Imperial Valley, the "spot" registered temperatures 28-degrees F. cooler than the surrounding air. The cool, north sky was determined to be 25-degrees above the horizon, while the average vertical angle of the cool east or west sky was about 40-degrees above this point. Neubauer found that a catenary-type shade structure provided the most effective heat relief for animals. The roof was sloped up 25-degrees to the north, and, sagging between east-west supports, it formed a slope of about 40-degrees. As much as 20 F. animal comfort was achieved with this sloping, catenary shade construction. Neubauer also found that the structure should be about 12-feet high in the dry, western states as contrasted with a height of


TO PASTURE
FISH POND 1.
3
FRUIT
GARDEN BED
BARN
TO HOME AND SHOP
TO PASTURE
FENCE
2
TRI-FOIL GARDEN-BARN PLAN
HEATED AIR
SUN
FIBERGLASS
AIR IN
HEAT STORAGE WALL
SOLAR HEAT ABSORBING VENTILATION INTAKE
CATENARY SHADE (COOL SKY EXPOSURE)
WARM AIR OUTLET
SILO
NORTH-SOUTH CROSS SECTION
HAY STORAGE
20°
DETAIL
WARM AIR INLET

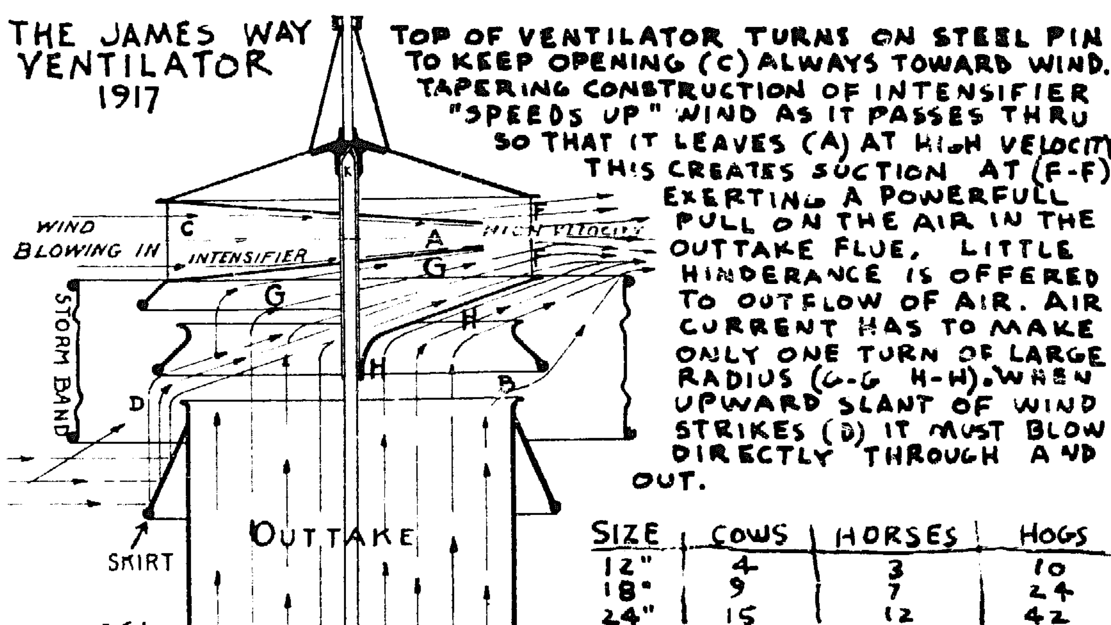
F. H. KING

about 8-feet for the high-humidity, high cloud-cover conditions found in the southeastern United States. Painting the top white and the undersides of the shade black increased cooling efficiency notably.

The barn plan proposed in this book operates in conjunction with three separate and alternately-used animal yards. Each independently fenced yard contains a pond construction, garden beds, and tree and vine crops. In alternate periods the fish pond in any one yard is drained and planted to sod crops or left fallow for animal use as an inner holding yard. Animal access from barn to appropriate yard is controlled by opening or closing respective doorways. As each fish pond is yearly-harvested, the breeding stock and fingerlings are transferred to the adjacent, gravity-fed pond. The vacated pond is then planted to a silage-producing sod crop for winter feed storage. Duck flocks rotate with the fish crop and, at times, may be released into outlying pastures. Goats and pigs are, also, allowed controlled access to pasture grazing areas. Vegetable crops are produced in raised beds in alternate yards vacated by the animals.

The hypothetical barn and yard layout suggested here would take different forms in different regional areas. The topography and exposure of a specific site would greatly influence the design layout. Specific climatic conditions would also affect the insulation and ventilation requirements of each individual barn — as would the availability of local materials and labor resources. And, finally, an individual homesteader's choice of optimum-desired livestock numbers and varieties certainly influences the barn size and layout. My intent, here, is merely to suggest the most basic concept of animal shelter and to suggest the implementation of the basic animal-to-animal-to-plant relationship.

This proposed ecosystem has one missing factor which is posed here as a question: How is the bacteria-laden, manure-saturated litter recycled into the system? An appropriate answer requires the following chapter-treatment.



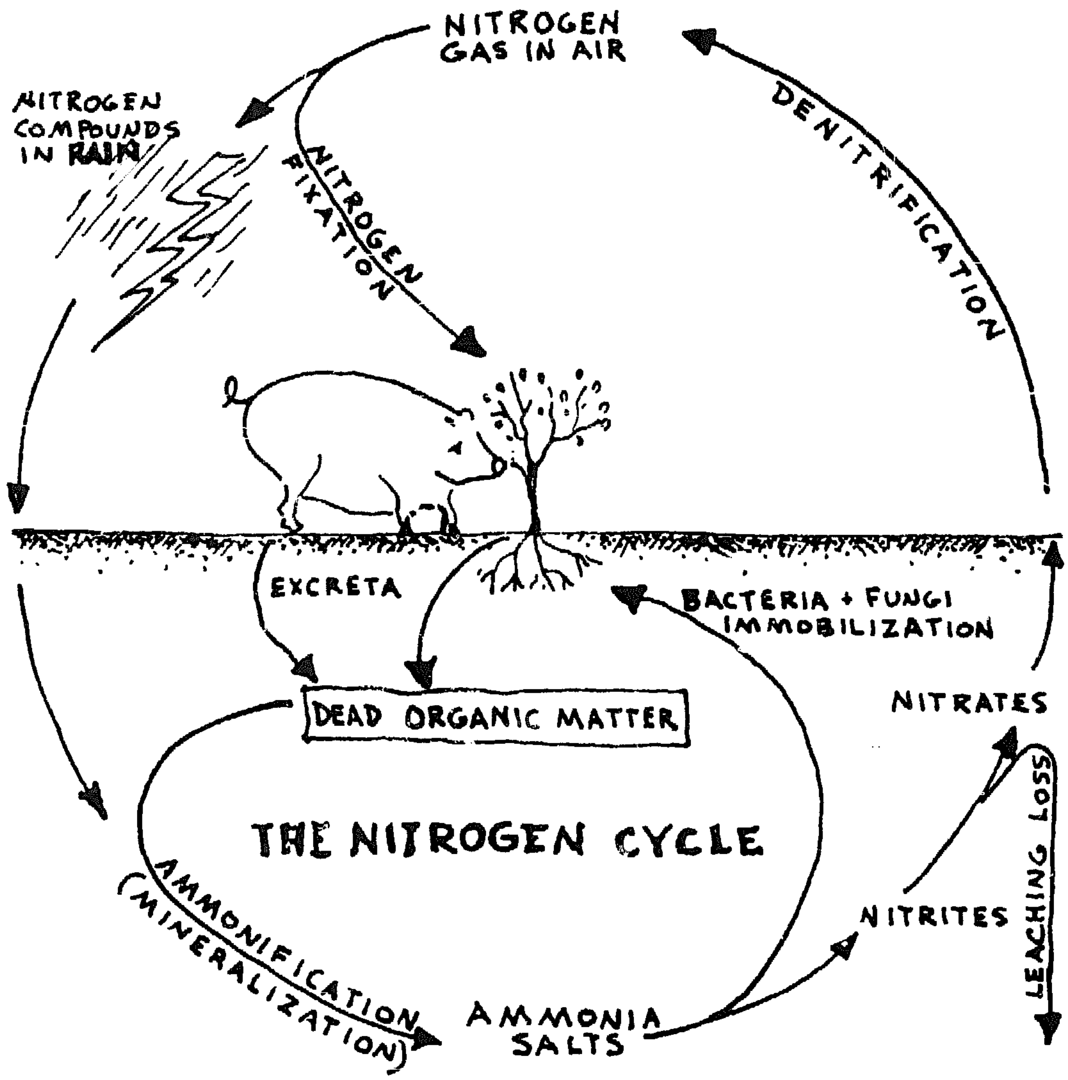
SIZE	COWS	HORSES	HOGS
12"	4	3	10
18"	9	7	24
24"	15	12	42

Sanitation

As a final chapter to most books on country living contemporary authors invariably, although inappropriately, begin the discussion of sewage disposal. The standard, two-chamber septic tank and tile leach line have been illustrated in so many books that I imagine there are few homesteaders-to-be, and certainly few county building officials, who suspect that an alternative method exists. Yet, sewage "treatment" should not be a final chapter-flush. The BIOLOGY OF DIGESTION is A BEGINNING, a first stage, in an extremely vital and significant process that can contribute to an alternative source of power, to food production and to soil enrichment. In other words, all homestead wastes can be treated to produce, first, a methane fuel supply, then a high-protein single-cell animal food, and, finally, a stabilized sludge for soil enrichment. In this process of decomposition any pathogenic organisms in the sewage are rendered harmless or are destroyed.

A first discipline in the biology of digestion involves the cycle of nitrogen, whereby nitrogen compounds are altered by a progressively different group of microbes. One set of microbes exists to DENUTRIFY; that is, to change fixed nitrogen back into free nitrogen which is released to the atmosphere. Another set of microbes exist to FIX nitrogen into the mass, making it available to plants through protein manufacture. Nitrogen in protein is essentially immobilized and will not progress through the cycle until these microbes decompose the protein.

There are two methods of microbial decomposition: anaerobic, or putrefactive breakdown, whereby oxygen does not gain access within the process, and aerobic, requiring oxygen in its fermentation process. The first stage of protein decomposition (putrefaction) releases ammonia. If the carbon-to-nitrogen ratio in this first stage is greater than 30-to-1 the dry ammonia which is produced will be reassimilated as rapidly as it is formed. It is converted into microbial protein through a process called immobilization. This process uses the nitrogen of protein and of ammonia for cell building and releases carbon in the form of carbohydrates for energy requirements. This carbon-nitrogen balance is upset when there is an even greater excess of carbon, say 60-to-1. This situation is not unlike a high carbohydrate food diet: the microorganism population is stimulated and increased and rapidly consumes the carbon for its energy needs but lacks nitrogen to take care of cell-growing demands. When the C-N ratio contains excessive nitrogen, say more than 15-to-1, the ammonia resulting from protein breakdown enters another phase, called NITRIFICATION. That is, carbon soon becomes exhausted, fermentation stops, and the remaining nitro-



gen is lost to the atmosphere as ammonia. In effect, that is what happens when raw, uncomposted sewage is spread on the land, as is commonly done in the Orient.

Therefore, the first component of a homestead fuel-food-fertilizer waste system is an ANAEROBIC DIGESTER. A digester is an air-tight, insulated container built of metal or of concrete, above or below ground level and supplied with a watered-down "slurry" at either regular, daily intervals or with one, single loading. Fifty cubic-feet is about the minimum digester volume required for a small homestead. A population of thirty ducks, three goats, three pigs and five people supply about 25-cubic-feet of waste material daily, which is a minimal amount for efficient operation. However, this amount is sufficient to produce enough methane to operate homestead lights and refrigeration and to meet cooking-fuel needs. It must be remembered that during most of the year when animals are allowed free-range only one-half the animal manure supply can be recovered.

The digester is equipped with a charging chute for loading, a dome cover for gas pressurization and an outflow for removing the effluent.

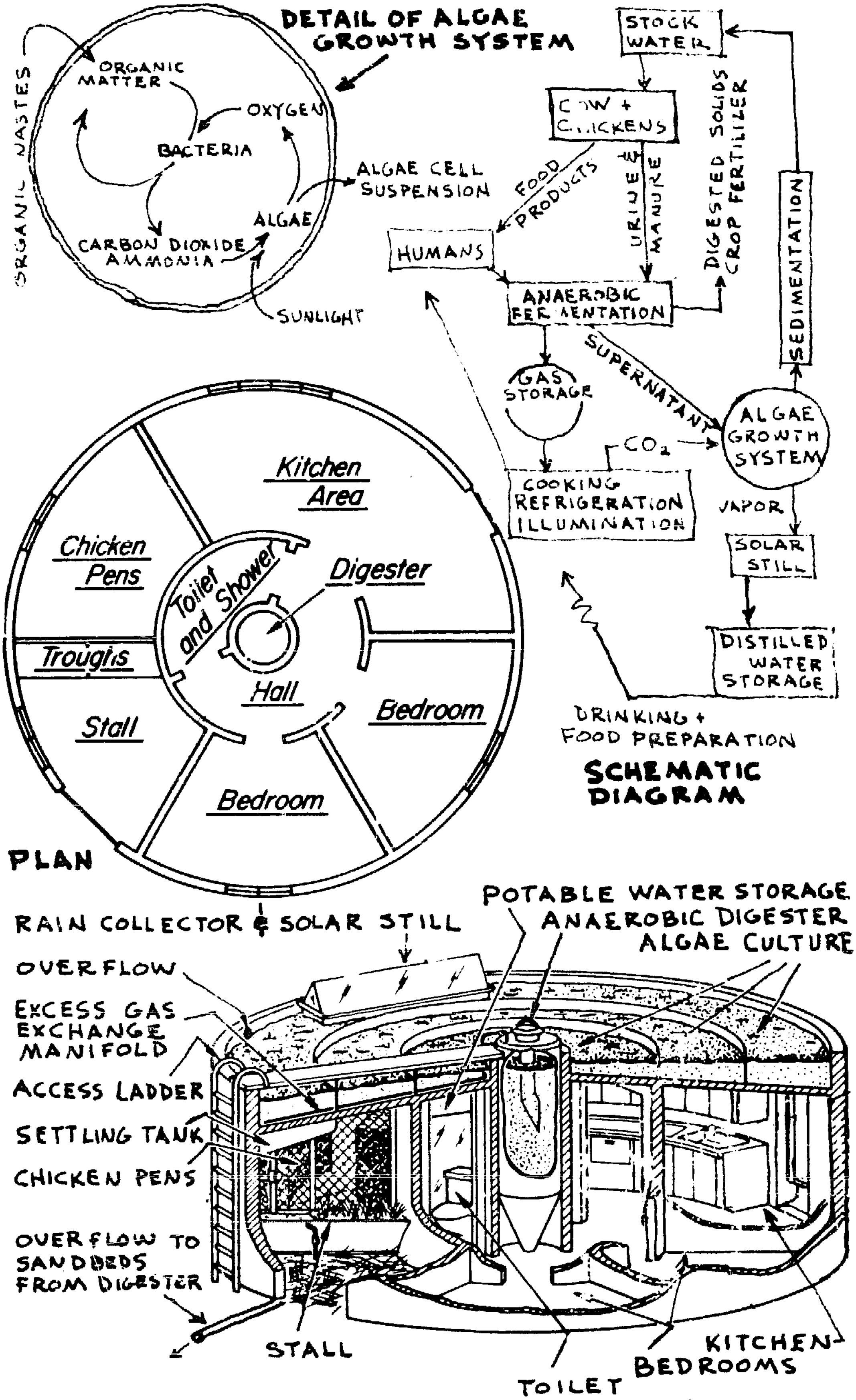
A digester design proposed by University of California professors, Golueke and Oswald, is especially applicable to low-cost homestead requirements as the digester is located in the center of a circular structure that houses both animals and man. In their system, effluent overflow dumps directly into a pond system located on the roof.

Effluent from the digester should be ponded in shallow layers to an optimum depth of 10-inches for the best accumulation of sunlight and warmth, which encourages algeal growth. Putrifaction of the organic matter in the effluent is achieved indirectly by algeal action which purifies the pond culture by producing the oxygen needed by bacteria to oxidize the organic matter in the effluent. Carbon dioxide is given off and, along with simple nitrogen compounds, is utilized by the algae for their growth. Algae, known as one type of single-cell protein, are collected, dried and mixed with feed for animal consumption.

The amount of nutrient oxidation that takes place is, of course, proportionately less than the amount of nutrient supply on which the algae live. The remaining excess of single-cell protein results in an extremely efficient method of food production. It takes a plant one week and an animal one month to reach food-useful size; whereas a single-celled, photosynthetic algae doubles its weight in half-a-day. Yeast is even more efficient than algae taking a mere two-hours to double its weight. A thousand-pound bull can synthesize less than one pound of protein a day whereas a thousand pounds of yeast will produce FIFTY TONS in the same time. This makes the production of yeast more than one-hundred-thousand times as efficient as the raising of a bull.

The outdoor, roof-top production of algae, as in the case of the experimental Golueke-Oswald house, is no more complex than the production of any other vegetable crop. Sunlight and water and supernatent are all that are required for the process. The annual water consumption for algae production may be twice that of other crops, but the protein-yield of algae is considerably higher, as the accompanying chart depicts.

SOURCE OF PROTEIN	COMPOSITION			COMPARISON OF WATER USE		
	% PROTEIN	FAT	CHO	ANNUAL PROTEIN YIELD LB/ACRE	ANNUAL WATER CONSUMPTION ACRE FT./ACRE	POUNDS PROTEIN PER ACRE FT.
SOYBEAN	46.7	7.1	40.9	576	2.0	288
CORN	10.2	3.9	85.2	240	2.0	120
WHEAT	13.6	1.5	84.1	135	1.5	90
ALGAE	63.1	4.4	2.1	20,000	4	5,000
EGG	48.8	44.5	2.8			
MILK	26.9	30.0	37.7			
FISH	55.4	37.9	—			
MEAT MUSCLE	57.1	37.1	2.0			



SINGLE-FAMILY MICROBIOLOGICAL ORGANIC WASTE RECYCLE SYSTEM - FROM GOLUECK & OSWALD

Algae harvest involves algae collection, sun-drying and admixture into animal (or human) food. Its use for human consumption is a consideration when one remembers that natives of the Republic of Chad have used algae as a staple food since prehistoric times. Likewise, Cortez observed in 1521 that, near what is presently Mexico City, natives ". . . sell some small cakes made from a sort of ooze which they get out of the great lake, which curdles, and from this they make a bread having a flavor something like cheese." The blue-green algae that Cortez referred to has been identified as SPIRULINA — the very same variety of algae that Chad natives to this day collect from oases and form into cakes.

Bacteria and yeasts, discussed above, form the major source of single-cell protein. Fungi are included in the general single-cell food grouping, but they will not be covered in this book. Fungi have no significant food value. At best, mushrooms are a pleasantly-flavored addition to the diet.

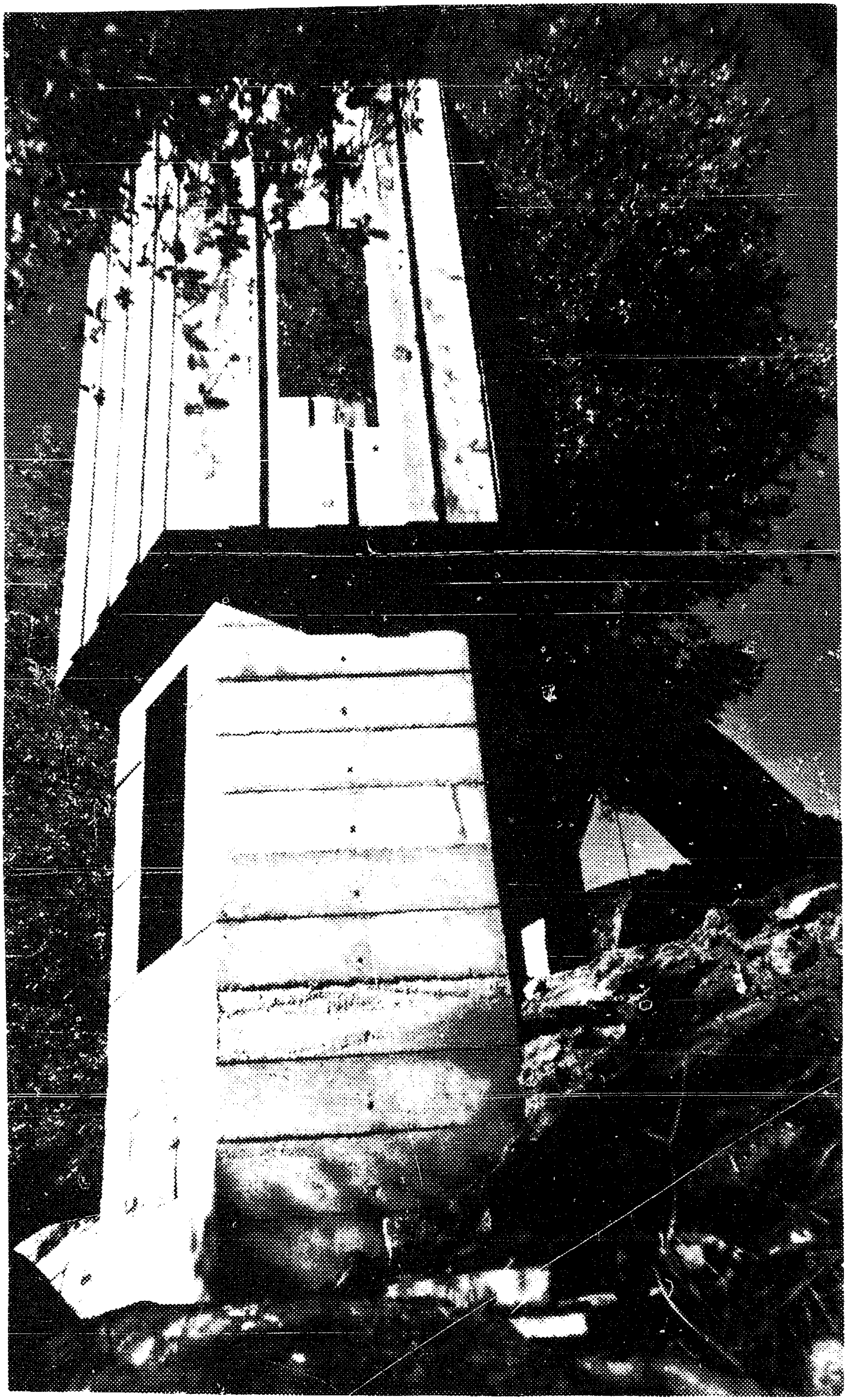
Following the algae harvest, purified effluent can then be drained into a fish pond. Scum from the digester should also be drained into the pond. Fish thrive on the nutrient-rich effluent which finally ends up at the bottom of the pond in the form of stabilized sludge. Pond areas during alternate years are planted to a silage crop, as discussed in a previous chapter.

Human excreta — I almost said human "wastes", but we need to get away from the concept of excreta as waste now that we have techniques for processing excreta in a sanitary and scientific manner — most definitely, human EXCRETA should be included in a homestead program of fuel-food-and-fertilizer production.

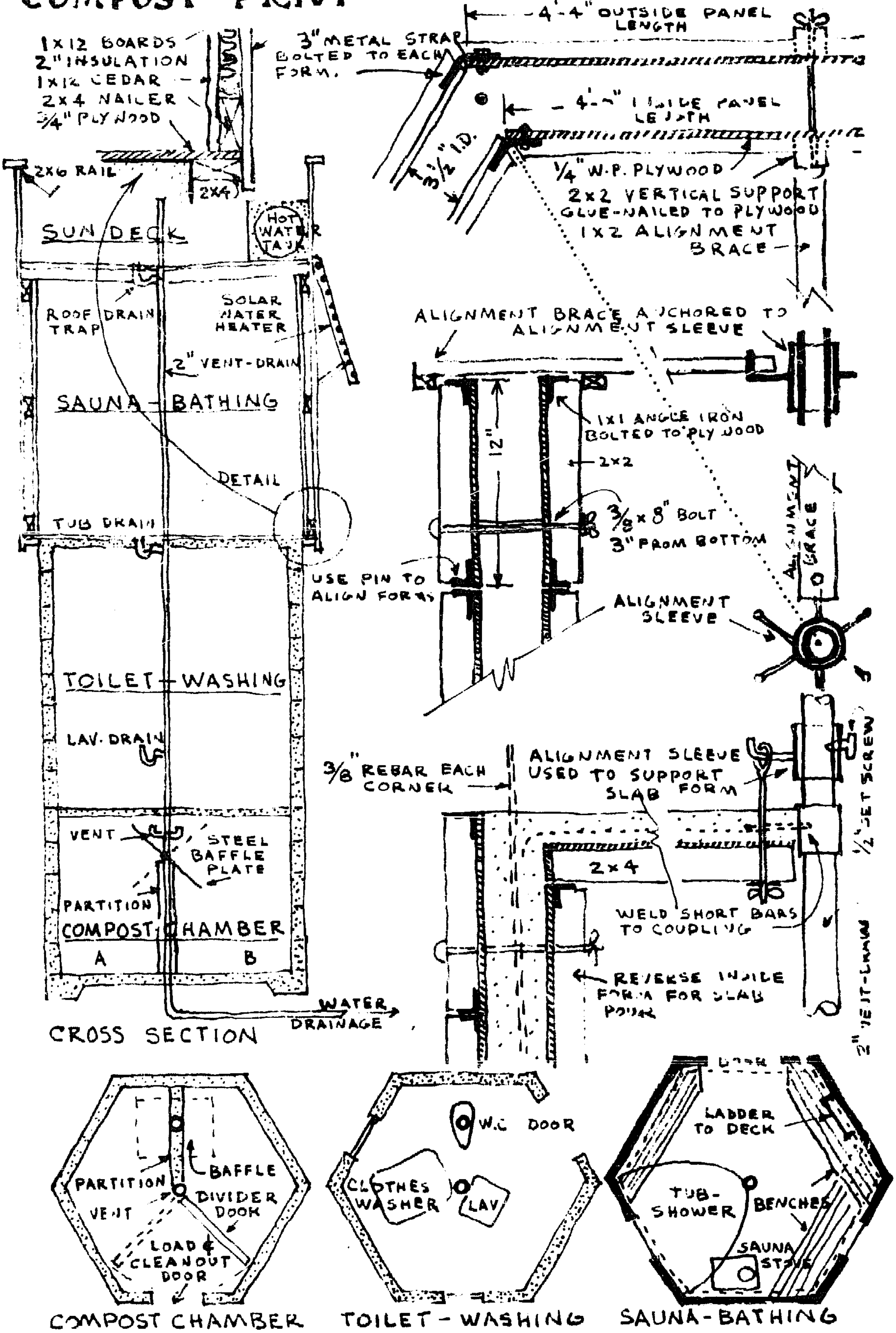
The first major obstacle to the utilization of human excreta is the receptacle — the common, stool-variety water closet. If an author is permitted just one chronic complaint or one indulgence-per-book mine will be registered against the flush toilet. A five-gallon wash-down of each evacuation nullifies subsequent utilization of the excreta material since water-born sewage is destined, irretrievably, for the septic tank. Furthermore, the seat-height evacuation posture is one of the worst of our unhuman, "civilized" habits.

My personal peeve against faulty bathroom design-use goes back a dozen years when I first started developing an improved compost-privy design. A number of schemes were tried but abandoned for one or another reason. The most recently developed facility has worked exceedingly well. Its salient features are enumerated below under the headings of DESIGN — MATERIALS — STRUCTURE — FUNCTION.

DESIGN: The fundamental design feature of my compost-privy is its adaptibility into the larger homestead complex. It is designed to nestle between the greenhouse and the cooking-utility and sleeping areas, yet, at the same time, it retains an outside, lower-level access for loading and emptying the compost chamber. Ideally, organic-matter ingress and finished-compost egress should be directly accessible to the anaerobic digester or to the garden or greenhouse in the case where finished



COMPOST PRIVY CONSTRUCTION DETAILS



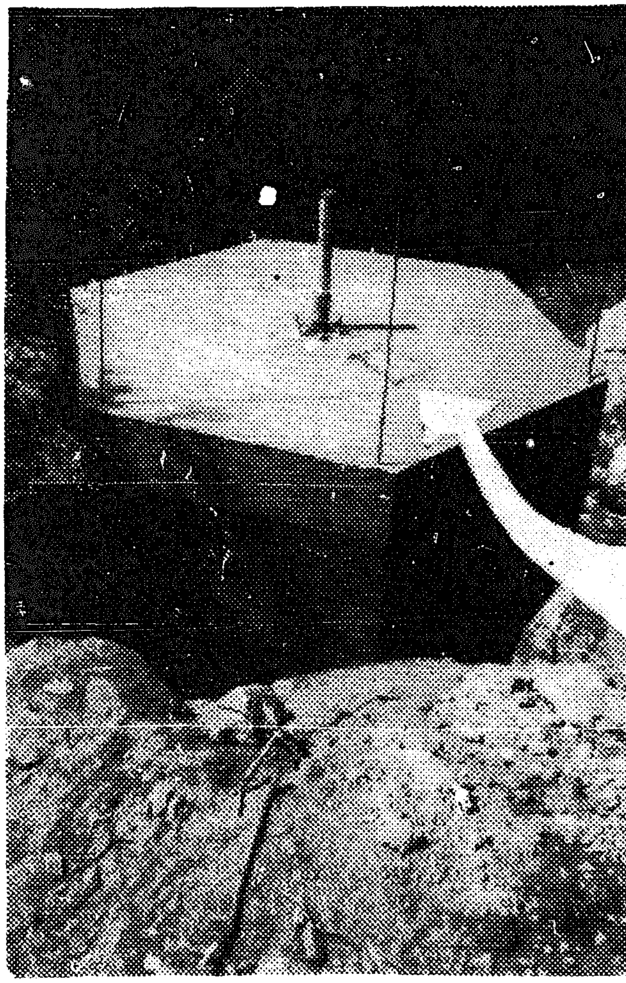
compost is to be directly used on crops. The drawing below illustrates the latter arrangement and includes an upper-level sauna and a roof-level sun deck. Where another arrangement is preferred, a single-level privy can include the functions of washing, bathing and excavation.

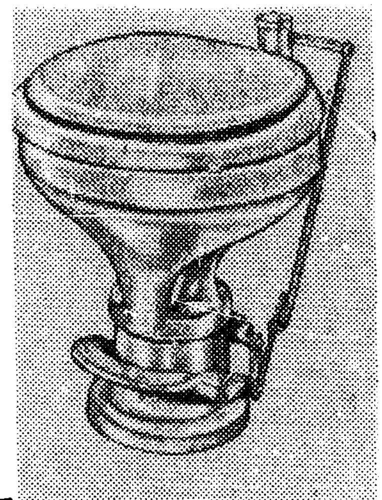
FUNCTION: Aerobic decomposition takes place in a divided, cast concrete chamber. Twice a year a simple, metal baffle plate is turned to divert material from one chamber to another, and twice a year alternate chambers are cleaned out in preparation for a new batch of compost. Of primary importance to the proper function of the privy is the moisture content of the compost. Where there is too little moisture, aerobic organisms have difficulty securing a soluble food supply, moisture being their main, food-transport medium. Where there is too much moisture air spaces are reduced, preventing oxygen circulation through the mass. As a general rule privy moisture-content should be maintained at 50%. This 50% privy moisture content will include faeces, which is 70% moisture, urine, which is 90% moisture, garbage and vegetable trimmings, which are 20% moisture, and an expectable (but, nevertheless, greatly reduced) water-flush on the order of from one-to-several quarts.

The compost-privy becomes a practical consideration when compared with the standard, five-gallon-flush water closet which uses about four-and-one-half gallons of water too much. A recent booklet, STOP THE FIVE-GALLON FLUSH!, $1.75, just released by McGill University's School of Architecture, Montreal, Canada, lists a number of toilet manufacturers throughout the world who make throne and squat toilets requiring a mere one-quart flush. Since the publication of McGill's booklet, a California plastics engineer has begun producing gel-finished fiberglass squat plates, illustrated below.

All privy washing and bathing water should be diverted from the composting chamber and drained into a separate leach field. The privy's central, two-inch, galvanized pipe handles the drain water adequately, and, at the same time, doubles as a fixture and a chamber vent.

STRUCTURE: The central pipe that provides water drainage and fixture and compost chamber ventilation to the outside also provides alignment during the structure's erection and, when finished, it provides structural support and bracing for walls, floor and roof. Concrete is poured by casting alternate, one-foot high layers in "climbing" plywood forms. As many as four, one-foot castings can be made in one day. Walls are cast vertically in the manner of children s' hand-over-hand game. Light-weight plywood forms make it possible for one person to form the walls while working inside the structure without the need for external scaffolding. This is an especially important feature where a two- or three-story structure is involved, as in the case of the silo construction mentioned in the previous chapter. The same form and the same building system is used for both structures.





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MATERIALS: Concrete was chosen as the basic wall material. Permanence makes it an essential choice for any underground (earth-covered) sections, for the compost chamber section and, certainly, for the feed-silo walls. When a gravity-fed water supply is desirable, concrete walls can be extended above the cast concrete privy roof to form a second-story, with another cast concrete roof over that to provide a place for a water storage. Inside, sauna-bathing facilities are properly faced with a moisture-absorbing material, such as redwood or cedar.

One finds, currently, very few Sanitation Department codes approving of the compost-privy concept. Fortunately, the majority of homesteaders locate outside building code jurisdiction where approval is not mandatory. Some people inside code-enforced districts have fought septic-tank-oriented City Hall — and won. They have done legal battle with the bureaucracies, armed with authoritative literature from The World Health Organization which, quite frankly, states that pathogenic bacteria and other parasites thrive in the anaerobic putrefaction of the septic tank environment for at least six months! In aerobic privy decomposition high temperatures destroy pathogens in a few hours!

Over the decades a number of people in the fields of medicine and agriculture have devoted their lives to establishing more rational sanitation. F. H. King followed the writings of Dr. Poore whose book, ESSAYS ON RURAL HYGIENE, was published in London in 1894. Poore raised vegetables on one-and-one-half acres of land kept fertile by the use of directly-applied but buried excrement from one hundred persons for a period of twenty-two years. It took four years to completely cover the garden, Dr. Poore writes, after which time, ". . . fertility and beauty of the garden have been increased enormously . . . No other crops, except cabbage, seem to flourish in the fresh material, but cabbage may be followed by potatoes, these by celery (planted between the rows), these by peas or beans and, after this, by parsnips or carrots without any fresh manuring and with a most abundant yield."

Another Poore quote makes a fitting close to this chapter:

> "That in a country or semirural district, where it is possible to give a house a decent curtilage or small garden, it is easy for a householder to make the sanitation of his dwelling quite independent of the local authority. In fact, the householder is able, if he be so minded, to make his sanitation complete and to finish, on his own premises and to his own profit that 'circulation of organic matter' which is the law of nature and the only true basis upon which the science of sanitation can possibly stand firm. The householder can do piecemeal what no public authority has ever succeeded in doing wholesale, albeit that millions of £'s have been wasted in silly attempts."

Food Preservation

For a very long time farmers have been concerned with methods for preserving foodstuffs throughout dormant crop seasons or during rigorous weather periods. Perhaps the initial discovery that sun-dried cereal grains could be kept through the winter months encouraged an even wider experimentation and application of preservation techniques. At one time it was found that the "shelf life" of heavy-textured flat breads could be extended by the addition of yeast, and grain-pastes soon became leavened bread. It was probably by accident that cheese became the preserved form for milk. Stored in leather-like containers made from calves' stomachs, milk reached a semi-stability when it curdled in the presence of the enzyme, rennin, which remained in the stomach-lined pouch. Some anthropologists have correlated an advanced food preservation technology with an advanced social structure. Certainly, man could not get on with the business of developing a culture as long as extensive periods of time every day required him to locate food sources or to chew tough meat for his sustenance.

Cooking, an early development along with the sun-drying of seeds, soon became an important means of preserving foods. Food can be kept for a number of weeks merely by cooking and re-cooking it regularly. The Chinese use a cooking vessel, called the Wok, that has a primitive origin and a functional design yet to be improved upon. Having a small, flat base (and tapered sides which concentrate reflected heat to the center of the pan where the cooking is done) the Wok, thus, requires only a small amount of water to cover the bottom. Chinese use the Wok for a kind of intense sautéing, called stir-frying. Vegetables, especially, are suited to Wok cookery since they normally contain a high percentage (up to 95%) of water. In the presence of little added water, along with rapid cooking under relatively high heat, there is little escape of nutrients or of flavor and texture.

Protein is best cooked with low heat since its amino acids (and especially B vitamins) are subject to deterioration when subjected to punishing heat. Broiling (quick external searing) or roasting are better methods for cooking meat than either boiling or frying. The muscle fiber of meat is held together by connective tissue. When properly cooked with moderate temperature, muscle protein gradually becomes firm while the connective tissue softens. But, when cooked with extreme temperature, muscle protein rapidly shrinks and compresses while connective tissue breaks down, softens and dissolves, forming, as result of enzyme action, a mass of gelatinous consistency. It must have been known for a long time that hanging any one of the over two dozen varieties of meat tenderizes it. Enzymes have a fermenting action on protein, softening the tissue. Pork, veal and lamb, however, should be processed as soon as they are butchered.

Primitive herdsmen were confronted with one major problem involving their traveling meat source. Their herd had to be kept to a number which could be fed between one harvest and the next. Otherwise, excessive numbers had to be slaughtered and the meat somehow preserved. Salting and smoking were, therefore, the primary methods used to this end. The preservative action of smoking meat comes partly from the dehydrating effect of the heated air of the process. Smoked meat and fish, like kipper, resist spoilage because surface tissues are smoke-dried and, at the same time, they are impregnated with preservative chemicals (distillation products) from the wood.

Three thousand years ago, meat was preserved by the Egyptians' rubbing it with salt or with sugar. The result is that tissues will with concentrated solutions of one of these agents and become unassailable to bacteria or non-reducible by enzymes. Salt also dehydrates muscle cells as it enters them by osmosis. Boiling salted meats can only remove part of the preservative. I remember reading about one laboratory research project which found that injection of an ounce of salt a day (not an uncommon dosage) can shorten a person's life by as much as thirty years! Smoking and salting may have been essential preservation techniques years ago when animals had to be slaughtered for lack of winter feed, but one wonders how justifiable these methods are today when slaughter can be regulated to need. Currently, we have far more efficient methods of preserving meat; methods which do not so heavily extract valuable nutriment.

When speaking of the subject of nutrient losses the reader should be reminded that, however desirable it may be to subject a food to prolonged cooking, such concentrated processing stops enzyme activity — enzymes in themselves having nutritional value. Eskimoes bury fish to produce an enzyme-activated semi-liquid "tilnuck", a maloderous product probably delectable to these northerners but entirely unsuitable to Anglo taste. In the presence of heat the taste and the texture of foods may be enhanced by chemically altering them for more immediate assimilation, but heat also destroys certain essential vitamins and minerals. Vitamin C losses can be as high as 75% during cooking. Rapid processing of vegetables promotes oxidation which destroys Vitamin C. Water-soluble vitamins, such as C, P and B-complex, are largely destroyed in hot-pot preparation. Again, as noted in a previous chapter, Vitamin A deficiency is the result of not so much its destruction through rigorous cooking practices as by the shortage of fat in the diet. Vitamin A and carotene for adequate eye chemistry are absorbed only in the presence of fat — which also appears to be true for the daily-required Vitamin C.

Preservation practices take their toll of nutrients, too. After three months of cool storage potatoes lose one-half of their ascorbic acid content, and nine-tenths of the remaining ascorbic acid is lost as a result of cooking and re-heating. Not much food value greets the consumer in the good, old American restaurant "hash browns" breakfast special! Fresh blueberries have 280 I. U. of Vitamin A, but, when canned in heavy syrup, they are reduced to 40 units of this necessary vitamin. A ripe apple has 90 units of Vitamin A, but, as apple sauce, this food item has been reduced to 20 units of the vitamin. These same "sour" fruits sustain little Vitamin C loss, however, because their acid content inhibits enzyme action which would eventually result in vitamin loss.

So-called sour fruits can be made into jams, jellies and preserves only by the addition of huge (70%) quantities of sugar. The moisture content of these fruits is high (above 15%), and they are, therefore, suitable as an environment for spoilage microorganisms. Their added sugar content acts as a preservative, opposing the break-down action of these organisms by creating a climate (exerted by high osmotic pressure) in which necessary moisture is rendered unavailable. On THE NUTRITION SCOREBOARD, which is the title, incidentally, of a valuable booklet by Dr. Michael Jacobson, published by the Center for Science in the Public Interest, all sugar products have a minus rating.

My personal recommendation for reducing the unhealthfully high sugar content of preserved foods is to reduce the amount of sugar used and to add some yeast. Yeast enzymes will convert the sugar therein to alcohol for, wherever a stable culture has been formed, there, too, one finds evidence of fermented beverages and foods. Fermentation is a natural means of preserving sweet foods and it becomes a viable technique worthy of our discussion here. Either sugar or starch foods can be fermented. Sugar-laden fruit juices can, thus, be converted directly into wine. To ferment starch, however, it is necessary, first, to convert the starch to sugar, either by diastatic enzyme action or by hydrolysis, as in the production of beer. Grain is allowed to steep and to germinate, and it is then dried and ground into "malt". The very same process that, in one case, renders a food spoiled can be deliberately employed to produce another, stabilized food (beverage).

Dairy products "spoil" as a result of microbial action, yet cheese is produced by the action on milk of these very same microbes. Bacteria ferment the lactose in milk to make lactic acid which results in the separation of the milk into "whey", a watery, mineral-laden liquid, and a proteinous "curd". Microbes are unable to grow in the presence of acid with the result that this liquid food is "stabilized" in this residual form which we call cheese. Sauerkraut and cucumber pickles are other examples of fermented preservation.

The Chinese found many centuries ago that sprouting also changes a seed's chemistry. Sprouting changes starch into easily digestible malt sugar with about ten-times the nutrient value of the plain, ungerminated seed. Sprouts contain the hormone, Auxin, which increases the size and the number of plant cells, multiplying vitamin content and making them one of the best sources for vitamins A, B, C, D and E. It has been reported that the seven-member Wheelwright Family in Logan, Utah, lived for six months on a sprouted-seed diet. Total food cost for the period was $52.50 and none of the family became ill or malnourished.

Any whole, dried bean, pea or grain seed can be sprouted in three-to-five days, and virtualy every healthfood store in the country sells its own favorite seed sprouter — supplies and varieties being numerous and prices being widely varied. Yet our own family has found that the common, wide-mouthed, quart canning jar works with simple, satisfying results. Several tablespoons of almost any preferred seed are bathed (soaked) in mildly warm water for a few hours. A jar lid, punched as full of holes as possible (from the inside out) or a piece of cheesecloth screwed in place by the jar lid ring, serves both to drain the tepid water from the inverted jar and to contain the germinating seeds, allowing air flow and evaporation of excessive moisture. As sprouts grow large, filling the jar, it is sometimes well to turn the jar on its side to make more room for sprout growth and for necessary air movement. Placed in a sunny window or a warm room, the seed-sprouts, thoroughly shaken in warm water and drained morning and night, exhibit accelerated growth in this "ideal" environment.

RECOMMENDED SPROUT LENGTHS

ALFALFA	3/4 - 1"	LENTILS, GR.	SEED LENGTH	SESAME (UNHULL)	1/4"
BUCKWHEAT	1"-1 1/2"	MUNG BEANS	1/4 - 1/2"	SOYBEANS	1/4 - 1/2"
CLOVER, RED	3/4 - 1"	OATS (UNHULL)	SEED LENGTH	SUNFLOWER (HULLED)	1/4"
CORN, YELLOW	1/4 - 1/2"	PEAS (GARDEN)	1/4 - 1/2"	TURNIP	1/4 - 3/4"
FLAX	3/4 - 1"	RADISH (BL.)	1/2 - 1"	WHEAT	SEED LENGTH
GARBANZOS	1/2 - 3/4"	RYE	SEED LENGTH	MUSTARD (BL.)	1/2 - 1"

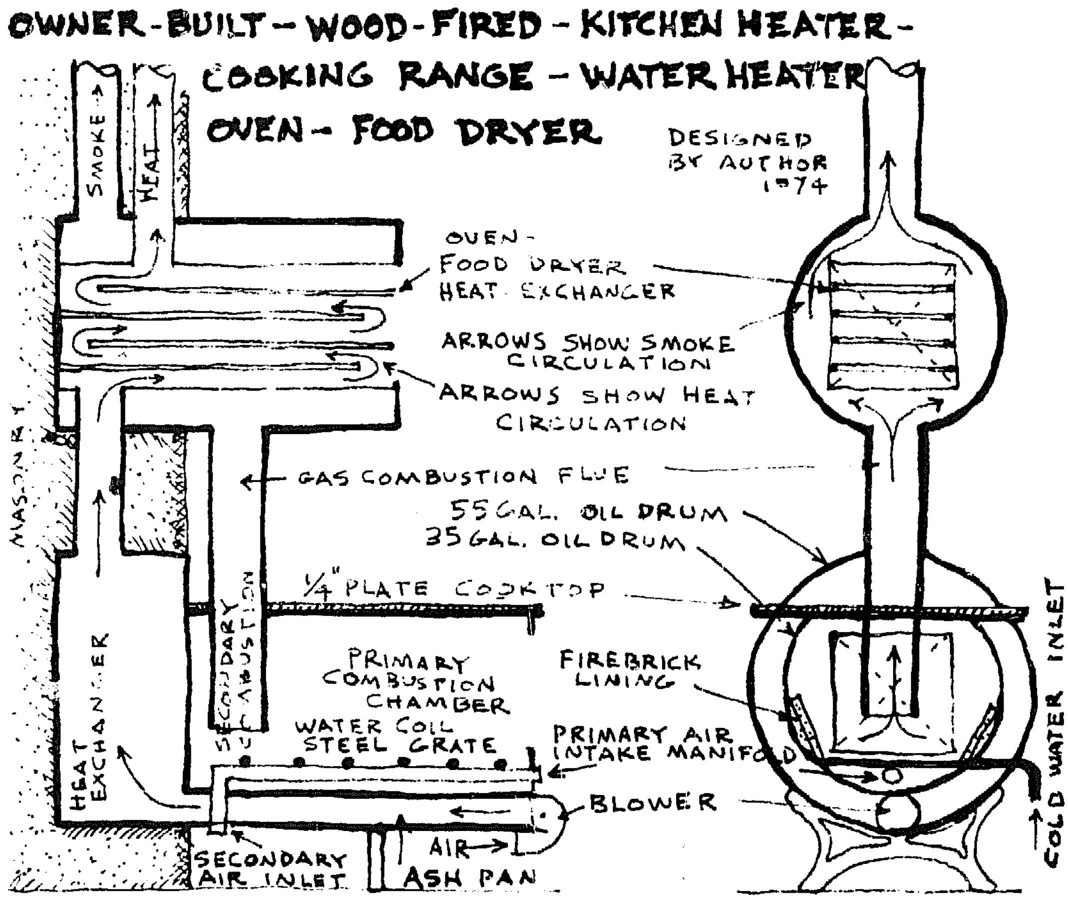
Sprouting is a process of re-hydrating; i.e., of adding moisture to dehydrated seeds. Grains and seeds cannot, of course, be preserved unless they are, first, thoroughly dried after harvesting. Spoilage organisms will not thrive in the absence of moisture. Open-air sun-drying methods of preserving foods has the advantage of free solar heat as its energy source, but it also has the disadvantage of considerable nutrient loss in its on-again, off-again system. Complete destruction of Vitamin C takes place when sun-drying fruits and vegetables. A goodly portion of Vitamin B-1 and carotene is also lost to solar rays.

Nutrient loss can be minimized by the installaton of a CONTROLLED HEAT dehydrator. This heat source reduces drying time with its continuous action after sundown, through cloudy weather, or "beyond season" when late varieties of certain foods mature and are available. The key to successful dehydration lies in temperature control and in the speed of air movement through the drying food. It is important that the food be stabilized quickly. When air circulation is not adequate, moisture will evaporate more rapidly on the surface of the drying substance. This is especially true of fruit which is high in sugar content. The result is a glazed surface texture, a kind of "case hardening" in which the food becomes brittle rather than rubbery. The humidity of the air passing over the food can be kept relatively high by controlling the amount of air exhausted from the dehydrator. Food should be kept in this moist atmosphere for about five hours, after which time circulation can be increased to the outside. The effect of air velocity on the drying rate of vegetables gradually decreases as the moisture content subsides, but, in general, a dehydrator offering a high total volume of air flow is most desirable. About one-half the hot air in a dehydrator may be re-circulated. Also, of design importance is the fact that a dehydrator which permits air circulation THROUGH the material is much more effective than one which circulates air OVER it. The average temperature range for dehydration of vegetables is from 120° to 150° F. for a period of 1 to 8 hours. During the first few hours the maximum amount of heat should be maintained until most of the moisture is evaporated. After this initial period of rapid evaporation, the temperature can be reduced and air circulation can be increased. At the end of 6 hours the water content of most vegetables will be reduced from 8-10%. A 5-hours "curing" period should then follow. During this time the moisture content is reduced to 5% or less. Curing prevents vitamin, flavor and texture losses during storage. One study conducted on the sun-drying of Thompson seedless grapes discovered the near-total destruction of Vitamin A as contrasted to cabinet dehydration which caused no appreciable loss.

Being a great believer in wood-fueled stove heating and cooking, I developed a combination cook stove-heater-waterheater-oven-dehydrator, designed specifically for homestead use. The complete unit can be fabricated in the homestead workshop, using readily-available components. Drawings below show the salient features of the stove's construction and its function.

The most successful homestead food program is one requiring the LEAST amount of preservation technology. Ideally, a continual, year-round vegetable supply is maintained in greenhouse and in garden. In many regions crops such as beets, cabbage, carrots, kale and parsnips, can be wintered, unharvested, outside in the garden, covered with mulch and snow to protect the dormant crops against injury by freezing. Diet can be adjusted to correspond with foods that are in season. More animal products may be consumed in winter months when fresh vegetabde protein is less available. Seeds and grains, peas and beans (and certainly sprouts) provides abundant winter-time diet choices.

Proper preservation of an 800-pound steer requires an investment in an expensive freezer and/or in numerous items of processing equipment. On the other hand, if smaller-sized goats, sheep, pigs, ducks or fish are chosen as the primary meat source the preservation chore is reduced to simple cooler or refrigeration space. Canned, sterilized foods exact a similarly high investment, especially in terms of one's time and labor, and it is certainly not worth the expenditure of energy merely to indulge the appetite with out-of-season foods. In areas with few reliable winter food sources months of shelf-life may be added to perishable foods by COOLING. The growth of microbes (bacteria, yeasts and molds) are considerably slowed down by cooling and are stopped entirely by deep freezing. Limiting the butchering of livestock to the winter months allows whole carcasses to be air-cooled at night, aloft, and to then be lower into insulated, underground pits during the daytime.



Insulated root cellars are traditional and worthwhile adjuncts to any serious food-processing program. The two key factors for controlling temperature and humidity in root cellars are insulation and ventilation. For this reason most cellars are located underground where temperature has little variation and where provisions can be made for air movement by gravity-effect and by stack-effect. In reality, it is the food's rate of RESPIRATION that must be controlled, and, to further complicate the process, all foods have differing respiration rates. An attempt to explain this reads thus: even though a food after harvest is separated from its sources of sustenance and water the food continues

RELATIVE RESPIRATORY ACTIVITY OF FRESH FOODS

1M - 4M BTU	4M - 7M BTU	7M - 10M BTU	10M - 30M BTU	ABOVE 30M
APPLES - FALL	BANANAS	APPLES - SUM	BEANS - LIMA	BEANS, SNAP
CRANBERRIES	CABBAGE	BEETS - TOP	CHERRIES - SO	BROCCOLI
GRAPFRUIT	ORANGES	CANTALOUPES	CUCUMBERS	CORN, SW.
GRAPES	SW. POTATOES	CARROTS - TOP	PEARS, BART.	LETTUCE
LEMONS	TOMATOES	CELERY	RASPBERRIES	MUSHROOMS
ONIONS	TURNIPS	PEACHES	STRAWBERRIES	PEAS
POTATOES		PEPPERS		SPINACH

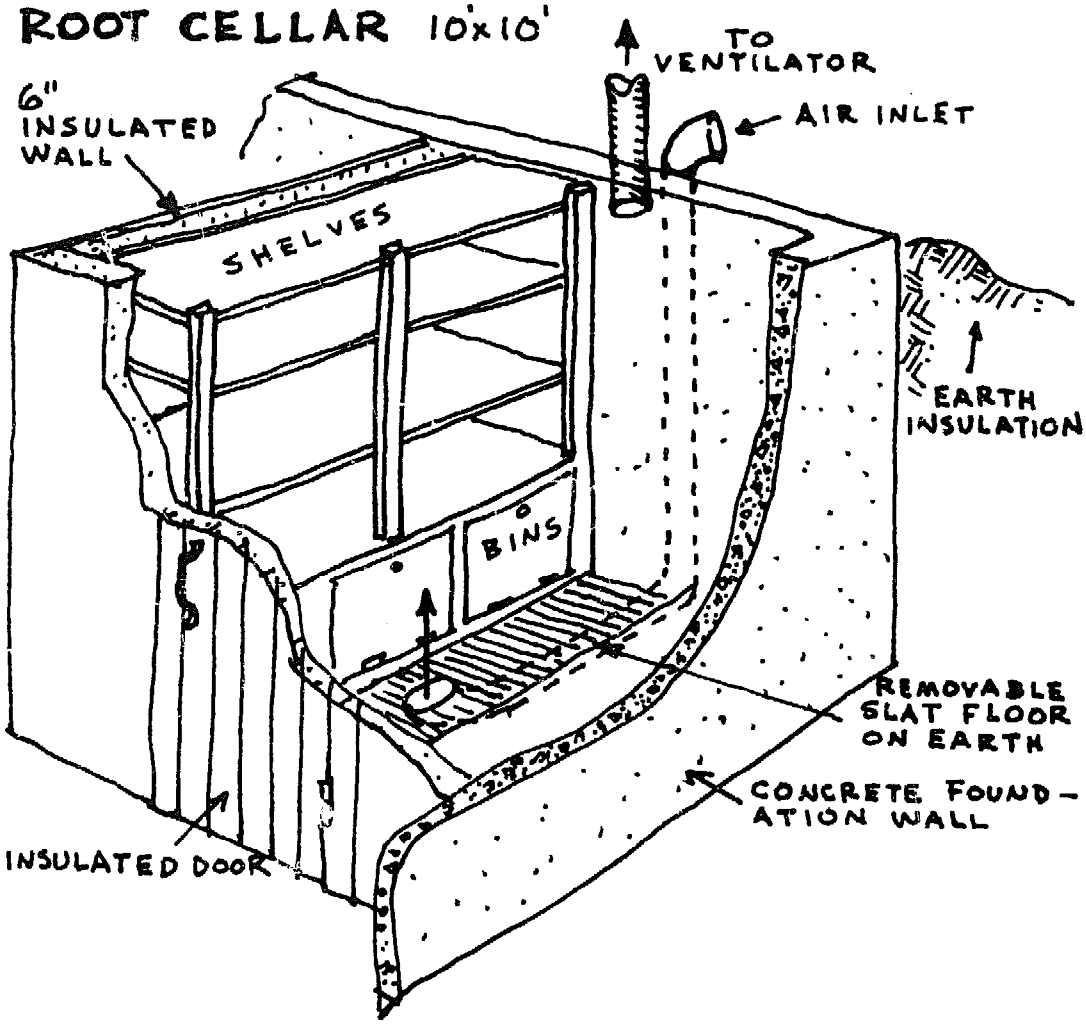
to combine the carbohydrates in its plant cells with oxygen from the air, forming carbon dioxide and water and reelasing heat energy. When the temperature is reduced the respiration rate is correspondingly reduced by way of slowing down the conversion of sugars and other carbohydrates stored in the cells. Crops having a high respiration activity (and, consequently, a high heat production in terms of BTU's) are more perishable due to the immaturity of their tissue structure or their leaf structure or their high sugar content. Respiration ratings have been established for many foodstuffs, and the graph above shows some

FOOD STORAGE REQUIREMENTS

KIND AND VARIETY OF FOOD	STORAGE CONDITION		APROX. STORAGE LIFE	VENTILATION AMOUNT
	TEMP. °F	REL. HUM. %		
APPLES	30-32	85-90	2-5 MO	HIGH
APRICOTS	31-32	85-90	1-2 WK	
ASPARAGUS - GREEN	32-35	90+	3-4 WK	
BEANS GREEN	45-50	85-90	8-10 DA	HIGH
LIMA	32-40	85-90	10-20 DA	
BEETS TOPPED	32	90-95	1-3 MO	LOW
BUNCHED	32	90-95	10-14 DA	
BROCCOLI	32	90-95	7-10 DA	
BRUSSEL SPROUTS	32	90-95	3-4 WK	
CABBAGE - LATE	32	90-95	3-4 MO	LOW
CARROTS - TOPPED	32	90-95	4-5 MO	LOW
CAULIFLOWER	32	85-90	2-3 WK	
CELERY	31-32	90-95	2-4 MO	
CHERRIES	32	85-90	10-14 DA	LOW
CORN - SWEET	31-32	85-90	4-8 DA	
CUCUMBERS	45-50	85-90	2-3 WK	
CRANBERRIES	36-40	85-90	1-3 MO	LOW
ENDIVE	32	90-95	2-3 WK	
GARLIC, DRY	32	70-75	6-8 MO	HIGH
GRAPES - VINIFERA	30-31	85-90	3-6 MO	LOW
LETTUCE	32	90-95	2-3 WK	LOW
MELONS	40-50	85-90	2-3 WK	
ONIONS - DRY	32	70-75	6-8 MO	HIGH
PARSNIPS	32	90-95	2-4 MO	LOW
PEACHES	31-32	85-90	2-4 WK	LOW
PEARS - FALL + WINTER	30-31	90-95	2-7 MO	LOW
PEAS - GREEN	32	85-90	1-2 WK	HIGH
PEPPERS - SWEET	45-50	85-90	8-10 DA	
PLUMS + PRUNES	31-32	85-90	3-4 WK	LOW
POTATOES - LATE CROP	38-50	85-90	5-8 MO	MODERATE
PUMPKINS	50-55	70-75	2-6 MO	HIGH
SPINACH	32	90-95	10-14 DA	
SQUASHES - WINTER	50-55	70-75	4-6 MO	HIGH
STRAWBERRIES	31-32	85-90	7-10 DA	LOW
SWEET POTATOES	55-60	85-90	4-6 MO	MODERATE
TOMATOES RIPE	50	85-90	8-12 DA	HIGH
GREEN	55-70	85-90	2-6 WK	HIGH
TURNIPS	32	90-95	4-5 MO	

of these findings. Another chart showing the storage requirements and characteristics of more important fresh fruits and vegetables is also reproduced below.

Notice that vegetables generally requiring a warmer temperature also require drier air. Cool-temperature vegetables by contrast require moist air conditions. Therefore, ventilation is especially important for warm temperature crops stored in the root cellar. One other matter of relevance to this consideration; the storage of food is not unlike the raising of those crops. Crowding in processing or in storing invites disease — in the very same way that disease abounds in monocultured crops — or for any of us living things.



Nutrition

As an art eating is ancient, but as a science it is very young. With the possible exception of work routine, discussed in the next chapter, no other homestead discipline can have a more profound influence on the success-failure result of that undertaking than the choice of family diet. Being a relatively new science, nutrition is chuckful of faddism, half-truths and downright ignorance. Society on this planet has yet to establish, through scientific analysis, all the nutritive elements considered best for man. Instead, food preferences continue to be based on man-made values or on symbolic or religious tradition. As modern life becomes more complex, the number of different edible foods dwindles. An example of this is the virtual extinction of man's past acceptance of insects as food — still a favorite staple of "uncivilized" tribes of people living in more remote areas of the globe. Dried locust cannot be matched for its 75% protein content. Termites are far-superior to animal foods, containing 36% protein, 44% fat and offering 561 calories per 100 grams. There's an old Chinese saying conceding that, "Anything that lives is edible — provided you know how to cook it."

Eating habits, as well as the food eaten, are also subject to custom and to mis-education. At least one anthropologist feels that a single, regular eating period was early MAN'S invention. By this regulation, food preparation became the specific, delegated chore for women. When the meal was completed, the women returned to work in the fields beside the men whose work had remained uninterrupted except for eating the food prepared by the women. The system worked so well that it continued in practice throughout the world. Recent industrial society, through the "invention" (adoption) of a three-meals-a-day pattern, found that less time was taken by workers away from work, more conveniently fitting man-the-worker to the factory machine. Eating had to be coordinated so that work could be coordinated.

Feeding practices for animals, discussed in Chapter 16, apply in large measure to humans. That is, the structure of the human intestinal tract, not unlike that of animals (and especially of pigs), is designed to handle most efficiently frequent ingestion of food. A sudden influx of food floods the system with more nutrient than it can use. Surpluses form unavoidable and abnormal fat deposits. As huge amounts of food are being digested, the gastro-intestinal tract draws blood from other parts of the body for abnormally long periods. Heart attacks may more likely occur, especially if arteries are fat-clogged, since blood requirements of the heart-muscle are short-changed and shunted from the main arterial system to the digestive system. Less quantity and frequent nibbling are preferred since we insist on cooking most foodstuffs. Our digestive system is able to assimilate cooked and, especially, boiled foods much more readily and more rapidly than it does raw foods. Therefore, less should be consumed at one time to avoid the hazard of over-assimilation.

The food-diet-nutrition dilemma faced by the conscientious homesteader can be resolved by examining the many diverse views on the subject offered from the one extreme of the "organic food" cultists to the other extreme of the establishment medics. And, herein, the homesteader can examine some of the alternative proposals at which I've arrived and which I, hopefully, present as a call for a more moderate, common-sense approach to human nutrition.

Food-cultists are correct in their first premise that chronic, degenerative diseases are increasing rapidly in privileged countries, although less commonly and less frequently in third world countries. For us, obesity is commonplace; dental caries, cancer and atherosclerosis are ever increasing; one-fourth of all adults have diverticulitis of the colon. The American dental surgeon, Dr. Weston Price, was one of the first to evaluate the changes wrought in primitive peoples by civilized diets. He studied fifty different tribal communities throughout the world where health and physique were outstanding alongside that degenerative element of the community more influenced and corrupted by the introduction of civilized diet. Price's book, NUTRITION AND PHYSICAL DEGENERATION, is now a classic. For those unable to peruse it, I quote here a pertinent section:

> "After spending several years approaching this problem by both clinical and laboratory research methods, I interpreted the accumulating evidence as strongly indicating the absence of some essential factors from our modern program, rather than the presence of injurious factors. This immediately indicated the need for obtaining controls. To accomplish this it became necessary to locate immune groups which were found readily as isolated remnants of primitive racial stocks in different parts of the world. A critical examination of these groups revealed a high immunity to many of our serious affections so long as they were sufficiently isolated from our modern civilization and living in accordance with the nutritional programs which were directed by the accumulated wisdom of the group. In every instance where individuals of the same racial stocks who had lost this isolation and who had adopted the foods and food habits of our modern civilization were examined, there was an early loss of the high immunity characteristics of the isolated group and also from the displaced foods of our modern civilization."

In all fifty communities studied Price found that, whereas climate, diet, religion and environment might be different, food, in the case of each group, was grown on fertile soil and eaten whole, directly from the source. Where the diet was influenced by civilization changes were marked: dental deformaties and tooth decay were common. Bacteria, which produce tooth-decaying acids, live on starch and sugar — the mainstays of civilized diet.

The various interpretations that cultists have pertaining to modern-day physical degeneration is often extreme and not well-founded. What is there about novel and unorthodox foods and eating habits that makes them so popular, for the most part, to liberal-minded people? Among those who have proclaimed extreme views about food and nutrition are Eugene Debs, Upton Sinclair, and Bernard Shaw among contemporaries, with Confucious, Lao-Tze, Zoraster and Moses among the ancient proponents of "the way". Perhaps radicalism is associated to a degree with digestive discomfort and undernourishment. Any form of faddism may, actually, keep a neurotic happy. When the allegations were made that such "health foods" as blackstrap molasses, wheat germ or brewer's yeast in themselves contributed to longer life, Jimmy Durante responded, "Not so. They just made it SEEM longer!"

In terms of numbers vegetarians head the food-extremist list. They condemn as PUTREFACTIVE and stultifying a diet that includes meat and animal products. Some amino-acids and Vitamin B-12 are, however, very difficult to obtain without animal sources — so why restrict them? Macrobiotic diets, created to support the in-activity of the contemplative, meditative posture, are dangerously low in protein content. Such regimen of largely grain products has killed more than one devotee.

Quite a large percentage of the American population is hooked on the diet addition of vitamin and mineral tablets and food supplements. At one time there were 15,000 salesmen peddling a food supplement, called Nutrilite. This supplement, which simply consisted of a tablet of processed alfalfa, parsley and watercress, was heralded as healing 57 different diseases. The number '57' recalls the success of H. J. Heinz with his 57 varieties of canned foods! Vitamin freaks attribute all health value to vitamin concentration in a package of pills, but as a result, over-dosing of Vitamins A and D has become common — and harmful. Increasingly, it is becoming apparent to nutritionists that the careless intake of unprescribed amounts of one vitamin may very likely cause an unrealized increased need for another vitamin, resulting in a deficiency where none before existed.

A new, "miracle" food seems to be always before us, proffered by the hawkers. All of the "name author" nutritionalists, including Carlton Fredericks, Gayelord Hauser, Lelord Kordel, and Bob Cummings, were at one time or another financially involved with a company that sold their favorite supplement. The "miracle" of Yogurt has been highly overrated, having about the same nutritional value of plain milk. The minerals in blackstrap molasses, trumpeted by numerous name-brand food companies in support of fad-nutritionists, is merely the end-product of the sugar-refining process. Someone calculated that, to get the necessary iron requirement from blackstrap molasses, one must consume a full gallon daily. Remember the royal bee jelly fad? Ingestion of this very selected substance was purported to stimulate sexual appetite. (Don't believe it!) Then there was the honey-vinegar cure for just about every ailment and the cod liver oil-orange juice cure for arthritis . . . One may justifiably, cynically snort, "What next?"

An organization calling itself The National Health Federation has become spokesman and political protector for most of the border-line health-food-supplement peddlers, including health food stores, electronic-device users and non-surgical-cures-for-cancer believers. Natural Hygenists, who help to support this organization, are a particular breed of vegetarians believing in such far-out therapy as exclusive use of only raw foods and use of extensive fasting for bodily rehabilitation. (Upton Sinclair popularized the therapeutic fast in a book he wrote in 1911, claiming that fasting is an efefctive cure for TB, syphilis, asthma, cancer and the cold.) Hygenists believe that almost all bodily ills come from toxins created within the body system, requiring this fasting technique for their elimination. The cause attributed to toxin-concentration ("acidosis") is the digestive union of protein and carbohydrate. Protein, Hygenists say, requires acid for digestion while carbohydrates require an alkaline medium, and they, therefore, conclude that starches and protein should be eaten only at different meals. Yet, this does not account for the fact that some foods, such as peas and beans, for instance, naturally contain BOTH starch and protein. The whole acid-alkaline, ying-yang, sanpaku myth-like attempts put nutritional thinking on an unjustified esoteric level — above reality — and beyond the judgement of this writer.

It isn't my purpose, here, to unnecessarily put-down food-cultists. After all, I do admit to their basic premise that something is terribly wrong with civilized man's health. And I do whole-heartedly subscribe to their contention that we should eschew all commercially manufactured, refined, artificially-ripened, processed and otherwise-treated foods. No preservative, artificial coloring, flavoring, modifier, bleach, emulsifier or antioxidant should be added to our foods. Neither should the foods we consume be robbed of essential nutrients in the ways they are grown or the way they are processed. By no means should the life-giving food we ingest be treated with any residue of pesticide, herbicide, antibiotic or hormone.

Establishment medical-nutritionists see "no problem at all" with the above-mentioned growing and processing of our sustenance. Their focus is, rather, on often admittedly obscure "minimum daily requirements", calories and uncertain, ill-defined "needs". True, three major foodstuffs can be identified; protein, fat and carbohydrate, all of which must be consumed to supply energy to the animal organism, with protein supplying indispensible amino acids for the absolutely imperative and vital function of body cell construction. It is also just as true that health and well-being and bodily regeneration are dependent upon a critical BALANCE of adequate protein (containing, furthermore, an all-important "correct" composition of amino-acids), sufficient calories, and essential vitamins and minerals well-established to be *requisite to* human metabolic processes. But, at this juncture, I part company with the average, status quo nutritionist. His "minimum daily requirement" is far too high to satisfy the individual differences discussed below. Secondly, variations in food value, itself, are too fluctuating to be prescribed by the International Unit, the calorie, or by any other arbitrary measure. In a sample examination of a thousand patients one doctor found that the Vitamin B-6, Pyridoxine, requirement VARIED from 5 to 400 miligrams daily. The calcium requirement of a representative sample of young men varied five-fold. Sometimes people are only able to absorb one-fifth of the calcium they receive. Vitamin D which has a beneficial effect on calcium absorption can easily, to the contrary, become toxic to human variance.

Variations in food composition are even greater. The Vitamin C content of tomatoes depends mostly upon how much sunlight strikes the fruit just prior to harvest. A fertile soil may produce large leaves which shade the fruit, lowering the amount of Vitamin C contained therein. Dr. Firnan Bear reported to the Soil Science Society of America in 1948 that the iron content of tomatoes varied from 1-part per million to 2,000-parts per million. He found that calcium in lettuce can vary 400%, and that copper in spinach can vary from 12-parts to 88-parts per million.

In the conclusion of this aspect of the discussion, it should be stated that the prescription of a universally balanced diet for all of mankind is an absurdity. People of differing physiques contrast vastly in their nutritional requirements. (See William Sheldon's VARIETIES OF HUMAN PHYSIQUE in which the ectomorphic, the endomorphic and the mesomorphic physical types are compared.) We may conclude: it is true, we are constituted of the food we eat! Coincidentally, the expression, "Tell me what you eat, and I will tell you who you are," offers great insight. The thirty-odd tons of food consumed by an individual in his lifetime certainly has a most decisive influence on his behavior in that lifetime.

The question, finally, becomes one of, "On what basis is this dietary choice made?" Actually, the body, for all of its regenerative abilities, dies a little every day. No regimen can stop that process. The best we can do is to follow our instincts, listen to our body's language and try to choose our own balance. I, personally, believe in a return to a simple, traditional diet of consuming as many possibly different foods that are least removed in time and proximity from their original, growing environment. It is now reasonably well known that our bodies have built-in control mechanisms — which means, simply, that we must learn to "listen" to our bodies' language and not to rely upon the clock or other arbitrarily set patterns for our food needs. A great part of the evil in a civilized diet lies in the unbalancing of the control centers of the brain which guide our food choices. When foods are whole and natural one's body is able to inform its consciousness of its needs. Very old experiments with infants and young children have shown that they AUTOMATICALLY SELECTED a balanced diet when there was a choice from whole, natural foods. They did not consciously choose a balanced diet on any given day. A child would concentrate on one food for awhile, unconsciously supplying a specific need. The child would then, later, after that food jag, change to eat perhaps a variety of foods or a different specific one. But, in time, the intake balanced! It would seem that when a food is balanced the body, itself, "learns" the value of that food and learns to desire it when the need arises.

It is as unrealistic to seek total "peace of mind" as it is to try to find complete "physical well-being". As with any organism, man is constantly evolving and, thereby, establishing and re-establishing dynamic equilibrium with his environment. It is simply not practical to attempt to concern ourselves with every possible nutritional deficiency. We are confronted with too many variables. Imagine attempting a balance of 16 different mineral elements, 17 essential vitamins, and 10 indispensible amino acids! Actually, it may be that the body thrives on dis-equilibrium. We would therefore, do well, I reckon, to vary our diets as much as possible. By contrast, try eating a meal of pure starch as an example of the effect of a monodiet. Notice the early hunger experienced soon after the meal due to the rapid digestion of the starchy food, resulting in the indiscriminant flushing of the monotonous mass through the system. If fat, however, is eaten with the starch, as with buttered bread, the fat helps to delay passage of the food from the stomach by restricting the flow of gastric juice, slowing down the starch progression.

There are only two, relatively complete foods, milk and eggs. Although a homesteader's raw milk supply may lack iron to be a complete food, milk from commercial dairies is short of several vitamins lost through the Pasteurization process. People in China and Japan, however, remain healthy with little milk, eggs or meat consumed. Their diet does contain large quantities of vegetable protein, like the very valuable soybean. Peanut flour, nutritionally superior to all other flours, contains four-times the protein, 8-times the fat and 9-times the mineral content of whole wheat flour — and a peanut crop is much simpler for a homesteader to grow and to process.

The long-established practice of combining foods is nowadays receiving scientific recognition. A complete, high-quality protein results from the admixture of foods containing vegetable protein, normally limited by the absence of the amino acid, lysine, and containing animal protein, normally limited by the absence of methionire. This complimentary combination of otherwise incomplete proteins provides a complete, balanced food. The reader is urged to read Francis Lappe's, DIET FOR A SMALL PLANET, in this regard.

Given that homesteading is a way of life, in the final analysis food production is what it's all about, and successful homesteaders are often tempted to expand their operation to market their wholesome food products. I have known of half-a-dozen such projects which all ended with disastrous results for the homesteader involved. At the risk of over-burdening this subject of nutrition, something needs to be said here about the economics (and related politics) of food production and distribution in this country — if for no other reason than to discourage homesteader participation in attempted commercial enterprise.

A Phillipino farmer once told me that AGRICULTURE, ". . . is what the government does; a farmer farms." I was in his country during the formative years of the International Rice Research Institute. Government "agriculture" (financed by the Rockefeller and Ford Foundations) was intent on turning farmers' heads around to the use of "high-yield" variety seeds. At that time, we all felt that such new developments were of world-shaking value. One agriculturalist was, eventually, awarded a Nobel prize for his research-development of such seed at the Mexican International Maze and Wheat Improvement Center.

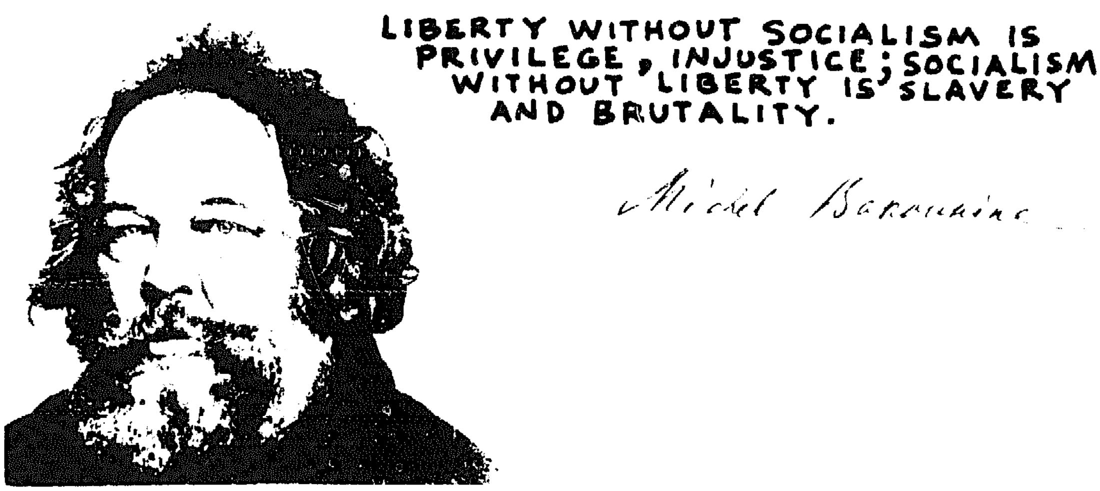
The small-scale Phillipino rice grower was then, twenty years ago, of the same marginal financial status that the American homesteader is right now. The difference between these two land-workers is that the Phillipino farmer accepted government agricultural assistance and, thereby, hoped to expand his farm production. Technilogical improvement "solved" all of the agricultural problems at the time — except for those connected with much-needed social and economic change. Naturally, such an incomplete program failed, and now a thorough-going revolution in the Phillipines seeks those changes then over-looked (ignored) by government bureaucrats and Messers Ford and Rockefeller, alike.

Traditionally, the small scale American homesteader earned his "tax money" by selling surplus cream to the local dairy. Even farther back in our history, farmers sold unpasteurized milk directly to the consumer. Pasteurization of milk was, originally, introduced to guarantee "safer" milk for the consumer, but, ultimately, this guarantee became perverted to an assurance of monopoly profits to large distributors. Outlawing unpasteurized milk has changed the small farmer from direct distributor to a seller of the raw product to a huge processing manufacturer. Health laws and government-enforced dairy-building ordinances have harried the small scale distributor while the huge, politically-active milk producers' monopoly-associations (the National Dairy Products and the Dairymen's League) have gained control of this national resource.

Interestingly, corporate monopoly control and government sponsored foundation grant money from one huge, world-wide conglomerate, intent on controlling for profit any of the world's natural resources while trading on the public's health and freedom. If this observation seems far-removed from the discussion of our one-horsepower homestead interests in "nutrition" just try raising an extra half-acre of tomatoes for the local market. The attempt to do just this on the part of one local homesteader recently resulted in his having to confront Mafia-like broker-wholesalers who succeeded in forcing him to surreptitiously distribute his fine crop (at a loss to himself and his family) from the back of his pickup in the turnout on a California highway.

American agricultural foundation aid for the third world has been an economic tragedy for the rural poor in those countries, but this aid has proved a windfall for the already-wealthy, land-controlling monopolies of these regions. "Miracle rice" and "miracle wheat" has become a travesty for the people of these areas since the miracle can be afforded only by those wealthy enough to own large acreages of land, by those already wealthy enough to afford the advanced technological equipment required to farm such acreages and such specialized crops, by those wealthy enough to afford the necessary insecticide and herbicide programs and the required, vast irrigation systems heretofore unheard-of in their part of the world! By all means, the interested reader should consult THE DEATH OF THE GREEN REVOLUTION, published by Third World First, 4 Marston Ferry Rd., Oxford, England.

Zero population growth is, in reality, in the corporate interest. After all, more people on earth would mean a clamor for more living space, threatening the selfish interests of the multi-square-mile factory farms which are, insidiously, taking over vast agricultural lands in every country of the world today. Efforts by Rockefeller-hired Malthusian prophets of doom-by-starvation appear to be aimed at obscuring the fact that the Food and Agricultural Organizations of the United Nations emphatically states that, of the 3½-billion acres under cultivation in the world today, there could be an increase to as much as 15-billion acres under cultivation supporting an unimaginable (!) population of 500-billion people. IF this were necessary or desirable this would represent a resource potential for an increase of about 150-times the world's present population — if that potential could be, indeed, if it were ALLOWED to be developed.



Development Goals

Reduced to basic terms, a productive homesteader must exert some measure of *control* over his environment. Implementing control requires various forms of physical development, starting with *goals* and ending with the *means* for achieving these goals. We are constantly perceiving new needs and, to satisfy them, new patterns of activity are adopted: new forms are created and new means utilized. The developmental process is cyclic. We start with the elimination of old, unsatisfactory forms and patterns and—through the process of research, design and production—we create new, more satisfying forms and patterns. This process creates a rhythmic and balanced continuity in homestead development. It is truly a work of art.

Art is the making of things for the right reason. A homesteader is an artist therefore, to the extent that he makes things according to the purpose of right reason, and to the extent that he becomes fully involved in the making: He uses his *whole person* . . . his body, his mind, his choosing and his imagination. In other words, the artist-homesteader first determines the *purpose* of the thing made (the Moral Cause); second, he uses his imagination to *design* an image of that thing which is foreseen (the Formal Cause); third, he seeks an understanding of the *materials* selected and used to create the thing imagined (the Material Cause); and finally, he selects the right *tool* to shape the material into the form desired (the Efficient Cause). Look after the *causes* of things; the effects will take care of themselves.

No one expressed these sentiments better than did Eric Gill who, in a lecture on Work and Culture, had this to say about man's sublimation into a "condition of intellectual irresponsibility"

> *How can it be agreed that food, clothing and shelter shall be produced en masse, by machinery, and simply as objects of merchandise, things produced solely for the profit of investors of capital, and yet that, fed on machine-made food, dressed in machine-made clothes, housed in machine-made buildings, we shall be able in our leisure hours—the hours when we are not working in the factories—to produce and enjoy the products of human cultivation?*
>
> *What an environment!*
>
> *And environment is important, because it is as necessary as the thing environed.*

You cannot have responsible human beings in their leisure time, if they are not responsible in their working time.

For working is the means to living, and it is life for which we have responsibility.

You cannot have responsibility for your work unless you have control over it.

You cannot have control over it unless individually or collectively you own it.

We have destroyed the ownership and control, and therefore the responsibility of the workers, and placed these things in the hands of those who, by the nature of the case, neither have, nor can have, any interest in the matter other than a financial one.

And the evil recoils on them also.

For what can be bought with the precious dividends but the inhuman and degraded products of sub-human and degraded workers and of a sub-human and inhuman method of production.

The subject of this and the following chapter deals with setting up homestead development goals and implementing these goals through developmental means. This twin thought-and-work concern comprises the essential backbone of the homestead process. It surely has more to do with a homesteader's success or failure than any other single factor. And it answers the probing questions: What to do? And how to do it? That is, what type of homestead program—in terms of crops, livestock, foods, etc.—is to be set up; and what practices and operations—in terms of time, energy and labor—is to be adopted to achieve these goals. It is hoped that these final two chapters provide the degree of insight required for the culmination of a totally satisfying, successful homesteading experience.

Observation becomes the starting point for any systematic analysis of homestead goals: SURVEY BEFORE PLAN BEFORE CONSTRUCTION. A thorough site observation is needed before one can complete the form, "To Program Your Homestead Development", found at the end of this book. Before any amount of planning can take place one needs to know exactly with what he has to work. Existing climatic, soil, topography, and vegetation resources are as important bits of information to the homestead-designer as are the homesteader's personal needs, likes and dislikes.

M.G. Kains, author of many fine books on homesteading, has this to say about the translation of observation into terms of understanding, decision and action:

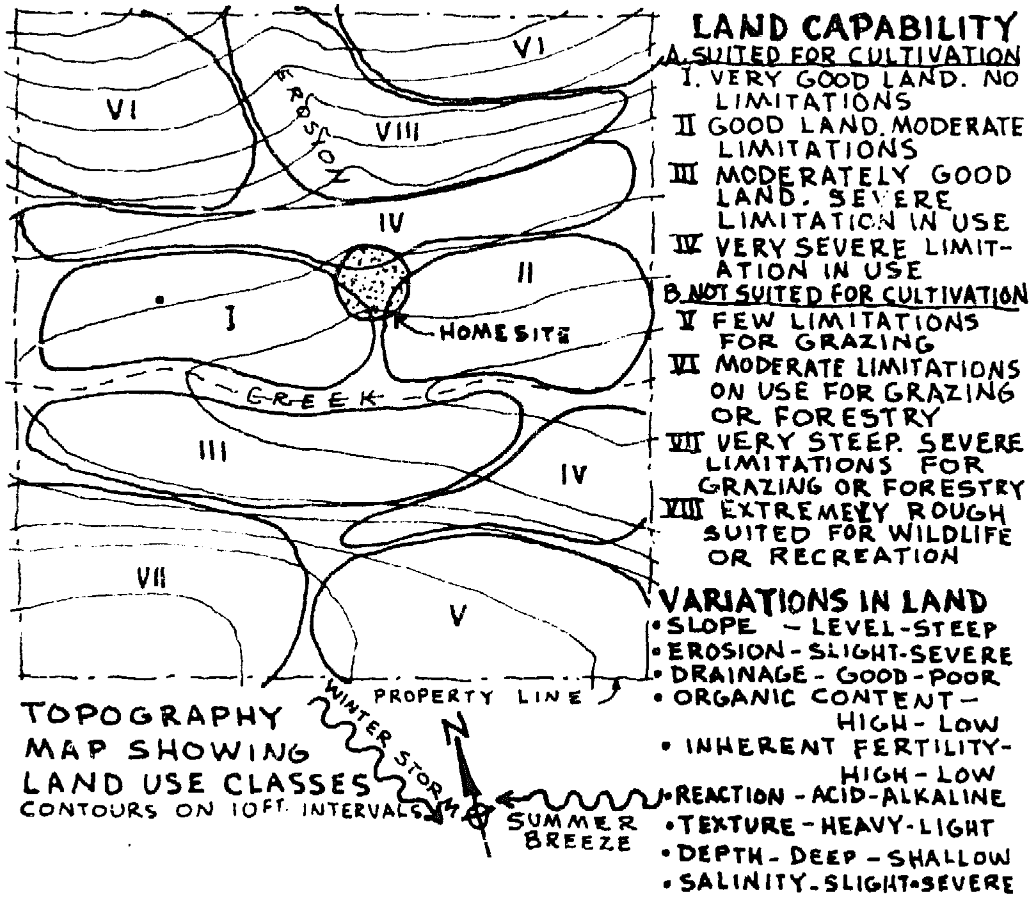
One of the most profitable habits you can form is systematically, every day, to go over at least part of your premises in a leisurely, scrutinizingly thoughtful way, and the whole of it at least once each *week throughout the year to reap the harvest of a quiet eye and fill the granary of your mind with knowledge of the habits of helpful and harmful animals, birds and insects; to observe and understand the characteristics of plant growth from the sprouting of the seed through all the stages of stem, leaf, flower, fruit and seed development; to note and interpret the behavior of plants, poultry and animals under varying conditions of heat and cold, sunshine and shade, drought and wetness, fair weather and foul, rich and poor feeding*

One most important part of the *survey* process is classification of homestead land capability. As used here "capability" relates to best usages and limitations in handling the land and not to mere productive capacity. In most regions of the U.S. the Soil Conservation Service will prepare anyone a land classification map, free of charge. But an essential part of discovering a proper solution for land use lies in the assemblage of facts for the preparation of the map itself . . . each homesteader should therefore be directly involved in preparing his own inventory map.

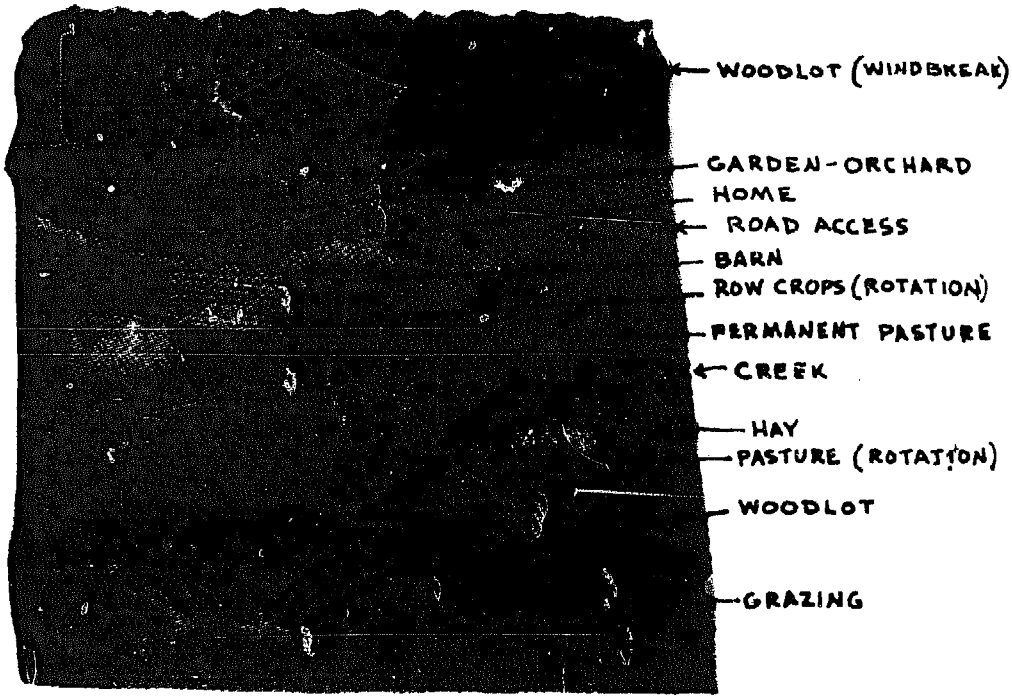
The map is prepared by first walking over the land and carefully examining all the significant variations in land features. The soil variations can be simply determined by using a soil auger. One brief sample of earth will indicate topsoil depth, texture, permeability, available moisture capacity, inherent fertility, organic matter content and other characteristics that affect the use, management and treatment of the land. Simple visual observation will indicate slope of land, degree of erosion, wetness and drainage. All of this information should be recorded on an aerial map (oftentimes available from the Soil Conservation Service) or on a U.S. Geological Survey map.

The Soil Conservation Service has categorized eight land-capability classes, according to those properties that determine the ability of the land to produce on a virtually permanent basis. Classes range from the best and most easily farmed land (Class I), to land which has no value for cultivation, grazing or forestry but which may be suitable for wildlife, recreation or watershed protection (Class VIII).

Following the survey, the planning process involves matching personal need to existing resources. It is here that first failures occur: Too often limited resources are utilized to satisfy unrealistic needs. Or the balance and rhythm of slow growth is superseded by a more impatient *tour de force*. Remember, it takes time to organize and operate a homestead. At any given moment a homesteader may still be far from an optimum level of management, or from the ultimate goals for which he is striving. Even goals themselves change over a homesteader's life cycle. A dynamic approach is therefore required.



"Survey before plan before construction"



SCALE MODEL OF 100ACRE HOMESTEAD PROPOSAL
(DEVELOPED FROM ABOVE TOPOGRAPHIC LAND USE MAP)

One of my favorite, long-term but still incompleted projects is the formulation of a self-test for potential homesteaders, to determine homestead abilities, probable success and failure. The test is self-scoring and should go far in at least determining probable dropouts before their own tragic discovery of ineptitude. This self-appraisal is divided into three categories: an evaluation of a homesteader's *character* . . . his interest and attachment and patience to deal with plants and animals; his *physique* . . . stamina to handle the extra work, and his *motivation* . . . willingness to give up time on a regular basis for chores and homestead maintenance.

The fact that homesteading is a family affair somewhat complicates the formation of a self-test of this nature . . . the lack or presence of some essential attribute in a homesteader's background may be compensated for by characteristics found in his wife (or husband), or in the children.

Homestead vocational guidance programs are more easily organized and deal primarily in three areas: tests for proficiency, evaluation of personal characteristics, and some indication of past experience and performance in homestead activities.

Agribusiness economists have been studying the attributes and characteristics of "good" and "poor" farmers since 1929 when the first questionnaire by the Bureau of Agricultural Economics was published. It is interesting to compare the 10 most significant factors in determining financial success, established by this early study, with those attributes found to be important in a study made 23 years later:

1929 Questionnaire	1952 Questionnaire
1. Farm experience	1. Takes pride in farm and work
2. Wife's cooperation	2. Ambitious
3. Ambition to succeed	3. A good manager
4. Liking for farm work	4. Plans his work
5. Getting work done on time	5. On time with his work
6. Hard work	6. Financially successful
7. County Agent help	7. Builds up soil
8. Production management	8. Progressive
9. Farm papers	9. Good business judgment
10. Father having been a good farmer	10. Enjoys working with livestock

The purpose of studying good and bad farmer attributes, by the various college departments of agricultural economics, was done primarily to benefit landlords and their farm managers . . . as an aid to seek the best farm tenants. Bankers and other creditors are also aided by these questionnaires in the help received for evaluating the personal characteristics of prospective borrowers. Subsistence-level landholders can effect little assistance from such "public" institutions. In only a small way do these studies relate to the self-actuating, owner-builder-homesteader. In one study (University of Illinois, 1949) 360 questionnaires were filled out by farmers describing the attributes they felt constituted a *poor* farmer. Some of the attributes associated with poor farming practices seem to qualify that farmer for homesteading, like the comment made by one farmer describing attributes of his poor farmer neighbor: "Neither whiskers, nor weeds, nor uncastrated pigs annoy him."

Actually, there has been only one period in American history when a public agency was established specifically to aid the poor farmer, subsistence-homesteader class. This was during the Great Depression when President Roosevelt started the Farm Security Administration. Quite early in its operation the FSA challenged the cheap labor "plantation" system in the South, and threatened established "farm" and landlord interests in its effort to deal comprehensively with rural poverty. Destitute farmers were taught cooperative marketing techniques and self-help farmstead enterprises. Even cooperative farmstead communities were established (a total of 13, throughout the U.S.) which further threatened our free-enterprise, private-land-ownership way of life.

The demise of the FSA was wrought by our conglomerate agricultural administration . . . from the Secretary of Agriculture to the County Agent. I say "conglomerate" because a little study of the U.S. farm structure will show its interrelatedness. The powerful American Farm Bureau Federation, for instance, is a direct outgrowth of the County Agent system. The Extension Service is but one segment of this public bureaucracy which actually serves as a bureaucracy of a private organization . . . the Farm Bureau. These forceful bureaucracies, along with their counterpart, the land-grant agricultural colleges, were all originally promoted by the omniscient U.S. Department of Agriculture . . . and the whole kit and caboodle is financed by the taxpayer and controlled by agribusiness.

Agribusiness, usually in the form of a corporate-conglomerate-absentee-landlord, uses the tax-funded agricultural research of Federal and State agencies and hides behind tax laws originally set up to benefit the poor farmer . . . only to further drive him out of business. In 1950 there were 5-1/2 million farms in the U.S., with an average size of 215 acres. In 1970 there were 3 million farms, with an average size of 380 acres. The farm situation here in California is probably the worst in the nation. A big company like Tenneco exacts a $1.5-million-a-year subsidy for not growing crops! Such multi-thousand-acre companies use federally subsidized irrigation water in direct violation of the 1902 Reclamation Act . . . which limits use of such water to farms no larger than 160 acres so as to prevent monopoly land ownership!

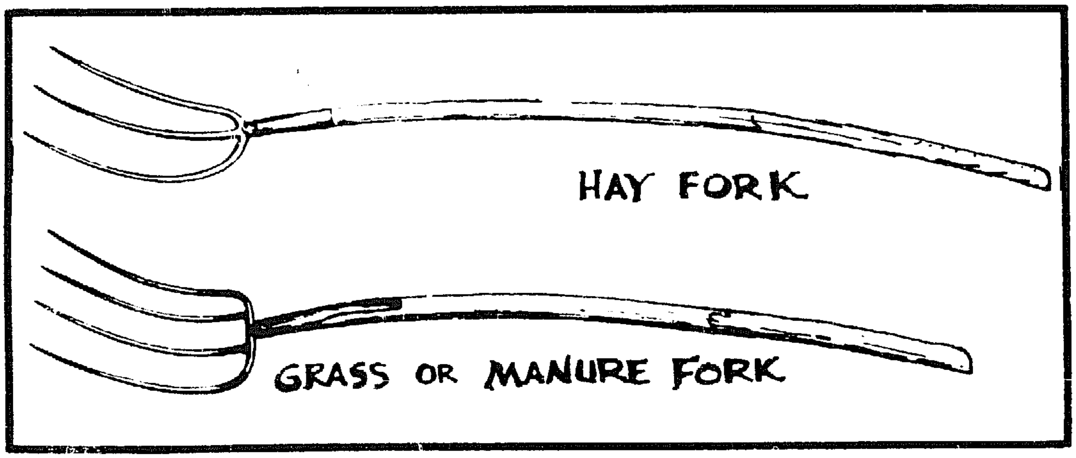
So the small landholder can expect little assistance from the County Agent or the land-grant college . . . they are fully immersed in plant-and-animal-disease-insecticide-fungicide-herbicide crop-picking machinery research for agribusiness. The American Farm Bureau Federation people are in state and federal capitols lobbying against some destitute-migrant-minimum-wage-right-to-strike Chicano for the benefit of some absentee fat cat. And bureaucratic Department of Agriculture administrators disperse monies and direct the policies for an ever more powerful agribusiness. Given a choice, the Department of Agriculture favors bigness: power reserves from the federally subsidized TVA, for example, can produce either nitrate or phosphate fertilizers. Nitrates are traditionally the poor farmers' fertilizers, but prosperous farmers benefit more from phosphates. You guessed it, phosphates are produced by the TVA.

As I perceive it, grass-roots leadership in the productive homestead movement can take direction from either or both of two possible routes . . . if, indeed, homesteading is ever to be thought of as a significant, viable, alternative lifestyle for more people than those of the counter-culture. First, the cooperative homestead concept fostered by the Farm Security Administration must be modernized, reevaluated and reconstituted. The physical, social and economic ramifications of the homestead community will be the subject of my following book, *THE OWNER-BUILT COMMUNITY*.

Secondly, regional learning centers—homestead schools, if you will—need to be established immediately. I envision five such centers throughout the U.S., and at this writing the first such center seems close to realization here in California. Recruiting the necessary expertise to operate such a plant has already begun here. Many things might happen at a homestead school besides the obvious learning of essential skills. The center can become a regional information clearinghouse; a land location service can be maintained for prospective homesteaders; certain experimental methods and processes associated with living on the land can be demonstrated or even initiated. Besides being an experimental learning center, an individualized consultation service could be made available from the center's team of experienced instructors . . . experts in everything from building, gardening, animal care and land development to home food processing and craft production.

My Homestead Planning Program offered at the end of this book is one other important adjunct to our proposed learning center. It is designed to operate as a mail-order service, "on location" at our future school or in direct relation with the homestead site.

One of my earliest homestead experiences clearly demonstrated the value and need of instruction in basic skills. In the 1950's I happened to be visiting the School of Living center in Ohio. John Loomis was putting up hay and I had occasion to assist him in this seemingly routine chore. John was one who felt that "one good head is better than a hundred strong hands", and he proceeded to instruct me in the fine art of loading the ubiquitous hayfork. Really now! A special technique for picking the hay up on the fork? John showed me how the prongs are first woven in and out of the first layer of hay so that a matted foundation is formed for the remainder of the hay to rest upon. And when hay is pitched onto the wagon, large "wads" must first be filled along both sides, to hold the central portion in place. At the end of that first day of haymaking I came away fully convinced that any prospective homesteader not instructed in the art of pitching, loading and unloading hay into the barn loft would be sure to fail in his attempt to live off the land . . . the sheer work would be sufficient to figuratively—if not literally—break his back!



A hayfork can well become the symbolic weapon of the green revolution. As such it must be used properly, as John Loomis instructed. And make certain that you do not mistakenly pitch hay with a grass or manure fork.

At this stage, however, even such common errors as improper use and choice of tools cannot substantially impede the green revolution. For actually, the revolution has come and gone, and as Ken Kesey puts it . . . "We Won!" An unknown poet says it this way:

Don't look for its soldiers in the city. Most of the real ones are long since gone to their domes and gardens, with goats and chickens the day was won. You now see only plastic imitations who will starve yelling "What's it all mean?" not knowing that the revolution has come and gone and was won in a patch of beans.

Development Means

Perusing the already written chapters of this book, I am aware of my oft-repeated statement to the effect that, "If such-and-such a consideration is not taken into proper account one's homestead venture is certain to fail." This is not a false or an over-worked caution. Certainly, regard for an optimum site location, water development, shop and tool arrangement, transport equipment procurement, soil management and nutritional observances all contribute to a successful — or a failing — homestead venture. If it were not for the fact that my acquaintance has been often with FAILING homesteads, not successful ones, this book would never have been written. It doesn't take much perception on my part to pin-point the reasons for the failures.

If a success-fail ratio were determined for all the homestead ventures known, I would say that a combination of the above-mentioned considerations would account for 40% of the failures, with fully 60% of the failure being exclusively attributable to one, two-fold aspect — to the disregard for one's manner of PHYSICAL investment in the homestead development — and to the unawareness of the part played in homestead living by one's own personal SELF-CONCEPT; that is to say, a disregard and an unawareness of the physical and the psychological MEANS OF DEVELOPMENT. Furthermore, shortcomings in this particular area result in a most complete as well as a most tragic dissolution of the homesteading effort. One can, somehow, often manage with a minimal water supply and some battered equipment, but when one's energy expenditure and one's self-image do not command a clear direction, a routine performance and a concerted effort within generally contented, secure and relaxed personal surroundings then one might just as well "throw in the towel" at the outset.

Pertinent to the homesteader's choice and use of his physical means of development is his expenditure of energy in the implementation of his homestead program (goals). This energy expenditure suggests a realistic allocation of TIME: it requires a comprehensive and resolute PLAN; it demands highly-motivated WORK activity.

A homesteader's work accomplishments can be substantially increased through systematic search for the simplest, most direct way of doing the work at hand. The simpler method, invariably, reduces the time required, and, as Plato reflected, "The most beautiful motion is that which accomplishes the greatest result with the least amount of effort." The adoption of the system of deep-littering the barn floor, for instance, eliminates the chore of having to frequently clean that area. Another clear example of good means involves proper timing:

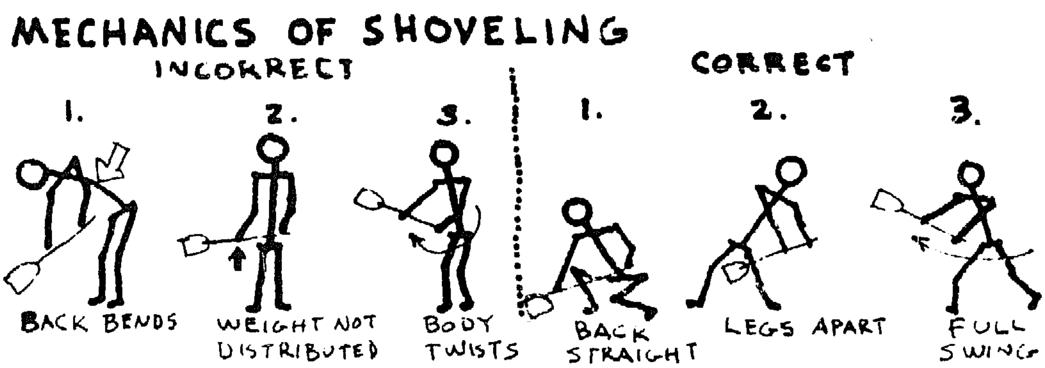
oil will drain more thoroughly and more quickly from the crankcase of a vehicle when it is hot, just after it has been driven.

Homestead tasks become simpler, easier, faster and more enjoyable when provision is made for 1) convenient physical layout of buildings and equipment, and for 2) simplifying one's work movements. These dual development means are discussed together below.

Possibly the first endeavor to study the effective use of labor was made by F. W. Taylor in 1898. Today we call such investigations "time-motion" studies. Taylor was hired by an eastern steel company to determine ways to increase pig-iron production. He, first, studied the process of hand shoveling the raw material. By simply reducing shovel size from a 30-pound load capacity to a 21-pound capacity production rose from 12- to 47-tons per day. Taylor's only other conclusion was to suggest proper use of workers' rest periods. He was one of the first investigators to understand man's natural, biological work rhythm, a rhythm that reaches a peak at 9 a.m. and a low at 3 a.m.

Upon reflection, it is staggering to realize how few people are aware of the simple mechanics incorporated in the act of shoveling. Habits for working are formed at an early age and become automatic (involuntary) and difficult-to-impossible to alter or to change. Energetic youth shovels its heart out, wasting energy expended, while learning improper working techniques. Later in life, when conservation of energy becomes more essential, improper working techniques learned in youth fatigue the body and may even be injurious to it.

There may be no better opportunity than now to interject some of my favorite shoveling concepts. A person's back should always be kept straight. Reaching down to load a shovel, one should bend the knees, the hips and the ankles. (The legs are spread apart, one in front of the other, to best balance the weight.) As one straightens, transfer of the weight should be made to the back leg. As the shovel load is thrust forward, weight from the back leg is transfered to the front leg. This provides for a full, even swing which does not involve the weighted momentum of the body for full execution.

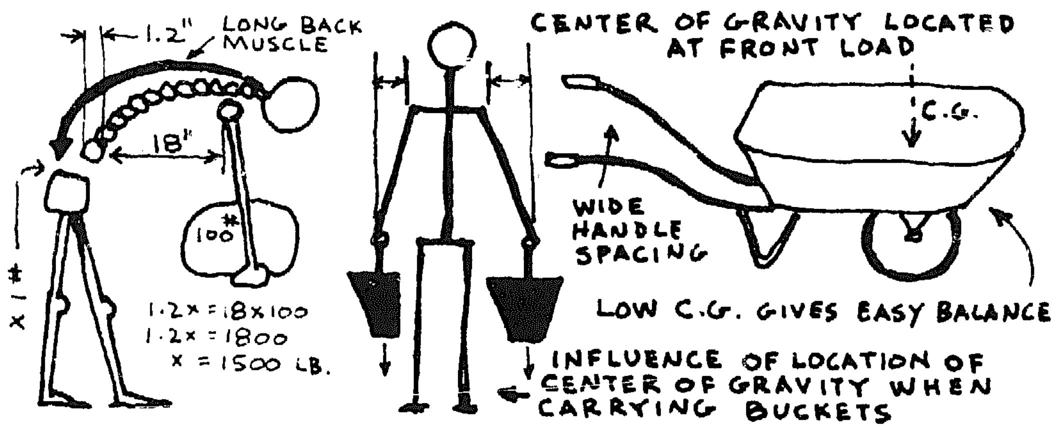


Once the mechanics of shoveling — or of any task, for that matter — are learned, a rhythm is developed so that the performance becomes smooth and automatic. Any type of forward-backward movement is desirable when working. In this manner, too, contrasting groups of muscles (flexors and extensors) work and rest alternately. It is well to learn to work with minimum movement, never using the whole body when a part of it can accomplish the same purpose. The energy expended using each part of the body is proportionate to its weight, so that one should always employ the lesser set of motions strong enough to do the task: in the order of finger, wrist, forearm, upper-arm, trunk. At the same time that one performs an "economy-of-means" in work practice, one must keep in mind the necessity of integrating the whole body in the performance of a particular function. More effort should not be put into the work than the task requires, but, at the same time, total body awareness is essential to the completion of any task.

Correct breathing, for example, must accompany every movement. A lazy, slumping posture is routinely accompanied by incorrect breathing. Poor posture, in turn, is influenced by one's "use of the self" — as well as by one's self-concepts, to be discussed further along in this chapter. This phrase, "use of the self", was originally authored by F. Matthias Alexander as a more comprehensive expression indicating how we stand, move and sit. In short, it is expressive of our general bearing. The term "posture" has a more specific and even static connotation. Alexander rejected the use of breathing "lessons" for an emphasis of the awareness of breathing as it supports movement — and of movement as it reinforces breathing.

A physiological explanation of the breathing-working posture is more than interesting since it focuses for us the problems which most of us must master before we can become effective workers. During childhood, we were beseeched, "Stand up straight!" with our chests out and our chins up. Proper chair-sitting was instituted in this time of our lives. Alexander, however, condemns chair-sitting as "the most atrocious institution, hygenically, of civilized life". Posture indoctrination, along with improper diet and faulty self-concepts, has undoubtedly been a prime cause of most rounded shoulders, of hollow or "sway" backs and of a forward-thrust neck structure. The resulting, accentuated, forward-curving of the base of the spine is the conclusion of this early training. The "small of the back", like the keystone of an arch, is the primary support for the muscular structure of our bodies. Muscles of the respiratory system are directly connected to the cervical and the lumbar vertebrae of the spine, which affect the quality and the rate of breathing. The spinal column at the small of the back is actually PULLED into an arch by the stronger back muscles. Usually, the abdominal muscles counter the force of these back muscles in work pattern. A pampered, "civilized", chair-sitting habit has, however, detrimentally relieved us of a well-developed abdominal structure. In its stead, we have inherited a sagging, fat-covered pot belly, and a contracted chest that has dropped to the abdomen, constricting lung capacity and subjecting our liver, stomach and other vital organs to unnatural compression. As the thoracic vertebrae are pulled back, the lumbar section is sucked in. The sacral region must then be required to transmit forces which are applied transversely. The result — in men, a predisposition for hernia which is, through weakened abdominal muscles, an extrusion of the abdominal viscera; and — in women, the susceptibility to a slumping uterus, making childbirth difficult.

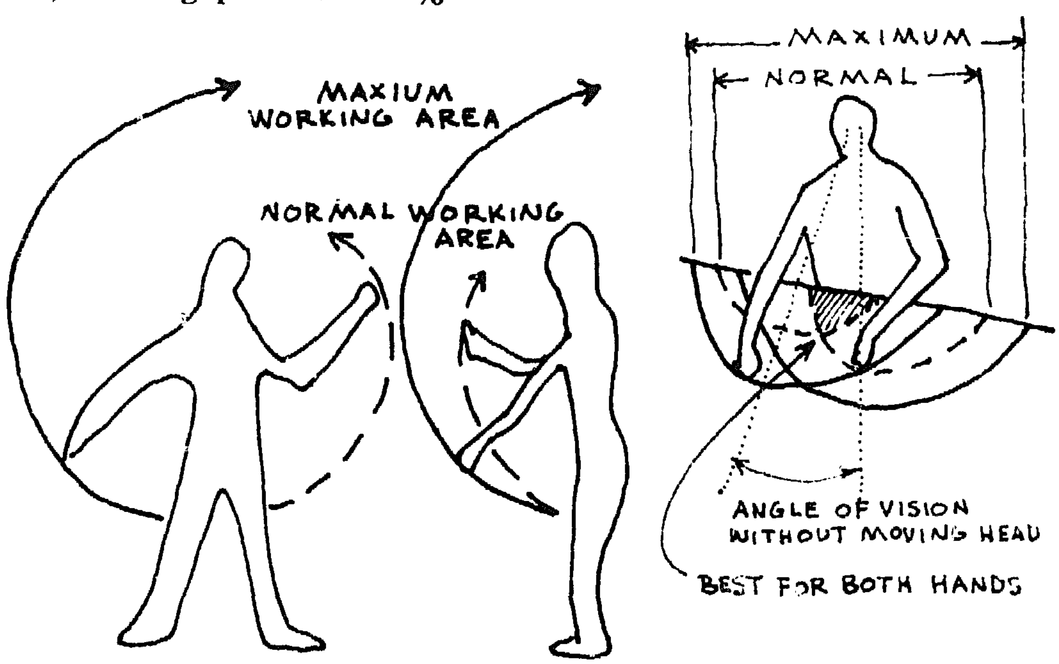
Behavior is primarily movement. Emotional disturbances can be thought of as restriction of movement. Emotion means "movement outward", and a disturbance of emotional behavior results in a blockage of the flow of energy, especially through the genitals. Movement in every act should involve the greatest lengthening of the spine, not its arching; therefore, the back should be kept flat. One instance of the tendency to arch the back involves the homesteader's performance of the often-repeated task of picking up heavy objects. If, while grasping the object, the neck is stretched and the chin is pulled in as one bends the knees, the back will remain straight. Then, while bending forward from the hip joints, the load can be lifted vertically by simultaneously straightening the knees, hips and back. Remember Alexander's technique: distribute the work load over as many joints and as many muscles as possible, but put no more effort into the work than the task requires. When picking up a 100-pound load, if one stoops down without bending the knees the weight exerted on the muscles and vertebrae of the lower back is on the order of 1,500 pounds!



Practically no effort to enhance the proper use of self has recently been expended in the re-designing of homestead implements and equipment. One exception, however, is the new bucket design developed in Britain. About one-third of the vertical capacity of this container was lopped-off and the resulting side flattened to be carried closer against the body. Thus, its center of gravity is altered, and fatigue is, correspondingly, reduced. I, personally, favor a wheelbarrow design which keeps the center of gravity well forward so that the load is not carried by the handles. A wider spacing of the handles, along with a lower center of gravity provides better balance as well. Commercially-made, back-buster wheelbarrows can be converted easily in the homestead work shop.

Well-designed equipment may not be available, but there is much that can be done to reduce fatigue on the homestead. Convenient building layouts help to reduce travel between chores which consumes excessive amounts of a homesteader's time. Planning work ahead of time will reduce most unnecessary trips, too. All buildings should be grouped in proximity to one another; e.g., feeds and supplies would be stored as near as possible to where they will be used, and they would be dispersed wherever possible by gravity dispensation, as in a well-planned loft-silo arrangement. All doors and gates and passageways should be wide, slopes gentle and travel surfaces smooth. Access to various facilities should be continuous, with a curved movement rather than as straight lines incorporating sharp changes of direction. Maximum loads should be moved when possible to reduce the number of trips, although it is wise to use push-carts or even power equipment for the heaviest loads.

One's body performance is enhanced by the conscious effort to reduce travel. An ear of corn for the pig may either be thrown with a full-arm movement, or, better yet, it can be thrown with a simpler, shorter wrist and forearm movement. Hands and eyes perform more usefully when their functions are kept in proximity to each other. For speed, accuracy and indefatigability short reaches should be arranged. Most frequently-used equipment should be near-at-hand. A study was once made of the efficiencies of hand-picking fruit. The contrivance of a simple, shoulder-supported device allowed both hands to be free to pick, boosting production 35%.



As a result of 1942 wartime labor shortages, Purdue University conducted a Farm Work Simplification Laboratory. Efficient production, it was found, required two types of decisions: 1) what to do, and 2) how to do it. An accurate observation will indicate to the homesteader whether or not a given operation should be maintained or should be relinquished. If the operation is, on the other hand, indispensible perhaps it can be combined with other operations. If not, perhaps the sequence of the operations can be improved upon or simplified.

Work centers for food preparation and processing and for general shop work require special planning consideration. Measurement must be made at each height-level of the amount of space which is to be required for equipment and supplies. (As drawn below, heights should be related to a specific human size and its ability to utilize those heights at each corresponding level.) Equipment and supplies are then arranged in the order of the sequence of their use for a specific, required task.

In summary of the physical means of development, it will be apparent that the starting point for the successful physical development of one's homestead is not the possession of a strong back but more a matter of the possession of a well-developed muscle girdle of the trunk. Firm development of the trunk's chest and abdominal muscles provides more support and relief for the spinal column, creating a stronger physique, better breathing, less fatigue, and more readily available and more efficient use of one's energy resources. This concept is well-substantiated if, unfortunately, over-simplified in such a limited presentation as this.

There is this to say about one's PSYCHOLOGICAL MEANS of development of a homestead life: people act in accordance with their own personal self-image. Wilhelm Reich called the physical structure of protection resulting from this self-perception "body armoring". None of the disciplines of athletics, calisthenics, deep breathing, yoga or what-have-you can significantly, in themselves, change our armored self-body image. Many physiological responses are elicited by our perceptions from birth, and we protectively carry the resulting guarded representation of ourselves with us — to our graves. This image extends far beyond our body confines. Self-image is involved in our EVERY action, in our feelings, thoughts, movements and sensations. Positive improvement of this inseparable duality in our personage can only be made through an awareness and consideration of our bodies and our feelings as an integral whole. We are, therefore, obliged to become familiar with our self-perceptions and with our body's "language". When performing a task, we must be aware of how we hold our body, stretching those parts that are tight, breathing into them and integrating the outer and inner awareness-experience. When coupled with a consciousness of the economy of movement in task performance, this awareness helps to free static posture. With improved posture will come an improvement in our breathing, bearing and vision. With improved awareness of our personal concept of ourselves, we can anticipate a personal renaissance of imagination and creativity. Work demands and tensions may then be effectively engaged when they occur, and individuals or family members, alike, may develop the capacity for achieving a more mutual harmony with all the elements of their living environment. Only then may the homestead flourish.

Therefore, a healthy self-image, comprised of one's attitudes and perceptions, must be simultaneously coordinated with the awareness of one's physical body-self and its movement. Then, as homestead development progresses, one can recognize the mastery of skills in the execution of the homestead work, and one can give oneself credit for its achievement. Thinking tall will help one to stand even taller. Actually, standing taller makes more room for the expansion for inner air and for the expansion of one's view and one's perceptions of the environs.

The models for Hagborg's painting, OCTOBER POTATOES, reproduced on the cover of this book, do not appear, upon thoughtful examination, to be thinking or standing tall. Whatever emotive value one might ascribe to the painting itself, the bioenergetics displayed by the working couple suggest elements of repression, rigidity, submission, fear and defiance. The painting was done on the eve of the Industrial Revolution and may well demonstrate why it was inevitable that agribusiness machine technology replaced subsistence farming hand efforts, as stereotyped in this painting.

Bioenergetics is an analysis of human form and movement. The analysis generally begins with an evaluation of a person's support system: namely, the legs and feet, which primarily function to support and to balance one's body. When the body weight is placed over the heels, as it is in the artist's female figure, her standing posture becomes easily upset by little backward thrust. She has, obviously, resigned herself to her role as a "pushover". Dynamic movement has to be executed through the front, not the rear, of the foot. Her essentially off-balance, weakened stance is partly a compensation for the forward-thrust of her pelvic area, which in turn, contracts the buttocks and causes undue tension in the abdominal muscles. Little wonder that bioenergetic therapists liken the immobilized pelvis to a decrease in sexual potency. The lady's sway back suggests little ego strength, part of the "pushover" syndrome. Weakness in the lower back would also seem to indicate serious psychological disturbance in her self-concept, possibly linked to sexual impotence. The forward thrust of her otherwise graceful head, while being a posture compensation, serves to illustrate the quality and the strength of this woman's ego. Her eagerness to please or her willingness to comply in the service of her man can be deduced from the bearing of her submissive head. Forward-curving shoulders force her chest downward and inward, restricting her free breathing and thinking.

The man in the picture surely has his own problems with himself. A wide stance, for the support of an insignificant weight such as that in his basket suggests a mulish, rigid backbone, inevitably resulting in pain of the lower back. From his jutting jaw and grim-set mouth one detects defiance of and resolute determination to try to control his surrounding environment. Yet fear, symbolized by his raised (hunched) and "squarely set" shoulders, stalks this attempt to manipulate his burdensome responsibilities. One can imagine the degree of his sensitivity and appreciation for his woman's person.

These were hard times in Western Europe. The painting illustrates none of the upper-body's out-reaching expansiveness essential to and exemplified by dynamic joy-in-living. Concern, rather, appears to be for a full potato sack — not for quality-in-life. Today we can have both.

The best fertilizer is the footsteps of the landowner.

Confucius

SILAGE, PASTURE & HAY MANAGEMENT

If the reader finishes this book with but a single appreciation for and, hopefully, with an undertaking of the concept of *diversified food production,* then he should consider his investment in the book justified. A mixed, multi-cultured, and balanced food production program is really what new-era homesteading is all about. I have attached a certain credibility to this polyculture concept of agriculture by introducing some important agriculturists who have advocated major departures from monoculture practices in this country. The earliest advocate for change--at a time in this century when husbandry was still considered a ground-based occupation--was, of course, F. C. King. As noted in an earlier chapter, Professor King stressed the importance of crop rotation, companion planting, minimum tillage, and intercropping.

Not long after Professor King made his contribution to an improved program of row cropping, Professor J. Russel Smith advanced similar concepts for tree crops. Smith proposed a regimen of multi-cultured, tree-based agriculture which would all but replace sod crop and row crop agronomy.

More recently, the case for sod crops has been stated by an eminently qualified agriculturist, A. T. Semple. Semple has been employed by the United Nations (O.A.S. and F.A.O.) to work on sod crop and livestock improvement in seventeen countries. He started his investigations into pasture improvement in 1916, working at first for the U. S. Department of Agriculture. A lifetime's work is summerized in his book, Grassland Improvement, published in 1970 by Leonard Hill Books, London.

Although King, Smith, and Semple maintain, respectively, their particular bias for either row crops, tree crops, or sod crops, they all advocate an *integration* of these various cropping methods into a balanced animal-crop management program. Together, these three men very early in the history of agriculture in this country spelled out the meaning and the method of animal-plant relationships and called for a system of food production especially applicable to a homestead-based food economy.

But today, A. D. 1975, even more is known about the effect that these plant relationships have on the food chain, on soil enrichment, on plant and animal health, and on the possibilities for super-abundant crop yield. It is known, for instance, from research conducted in Australia and New Zealand*, that the mere presence of animals in a pasture improves the quality of the nitrogen in the soil and the quality of the crops produced on that soil. The benefit derived is beyond that normally supplied by deposits in the form of animal manure and urine. No official explanation has been made by the agriculturists examining this curious result, but they can state that the crop and the grazing animal both have a complimentary role in the

*Forster, H. C. Soil Fertility and the Interaction of Soil with Plant and Animal, 1950, Journal of Australian Inst. Agricultural Science, Melbourne.

food cycle, and, in addition, that there is an important interaction when one stimulates the other. It was found, furthermore, where animals grazed continuously for eight to ten years before the land was intensively cropped that this *long term rotation* created an improved animal-plant relationship. The customary short term rotation of one or two years of pasture, followed by a wheat-fallow rotation, does not achieve the same good results. Twelfth century Scottish monks knew the difference between the use of short and long term crop rotation: a typical 8-year rotation plan, which includes planting legumes, has been used continuously on monastary land for six hundred years. The monks may have instinctively realized that, whereas the fine roots of the pasture grasses add organic matter to the soil, it is the accompanying legumes that stimulate growth by adding nitrogen to the soil.

Leguminous shrubs or trees planted among pasture grasses contribute to higher nutritive value in the grasses. Besides the nitrogen-rich and mineral-rich leaves that are deposited upon the soil, nitrogen and minerals are brought up from the subsoil by the deep roots of these plants. Deposited mulch and light shade from shrubs and trees keep the soil of the understory pasture cooler, thereby reducing the rate of oxidation in the humus of the soil.

J. Russel Smith proposed growing a wide variety of forage trees suitable to enriching a pasture area. Nut and fruit-bearing trees, such as the almond, olive, evergreen oak, honey locust, black walnut, persimmon, mulberry, plum, chinese chestnut, and the carob, are especially valuable forage-producing trees. Twelve carob trees grown on a half-acre will produce enough carbohydrate in one season to raise a pig from birth to two hundred pounds. Six mature acacia trees on an acre will produce as much as a ton of nutritious leguminous pods for livestock consumption, and will, at the same time, deposit leaves which increase the protein and mineral content of the surrounding soil.

Most of the trees and shrubs that Professor Smith lists as potential forage crops are exotic-sounding and often unknown. Yet, Professor Semple remarks that there are four hundred trees and shrubs listed as eaten by livestock in Latin America, alone. Some commonly known plant varieties are thought of only as ornamental or even as undesirable, comparable to the trash fish, carp. Few farmers, for instance, appreciate the value of spineless prickly pear cactus as a foodstuff for animal fodder. Yet, dairy cows have been known to produce high yield on rations comprised of over one-half spineless cactus. Planted in east-west rows, cactus plants also provide excellent wind protection for other forage plants.

We now come to the section of this supplement that concerns the actual implementation of integrated sod crop, tree crop, and row crop production. Semple uses the term "grassland agriculture" to define the production of grasses and legumes--a production including ample provision for rotation with row crops, fruit and nut-bearing trees, and even with woodlands.

On sloping land, rotation can yearly be advanced downslope. Strips of row and sod crops and of pasture can be planned to migrate downward on equal contour so that neither crop will occupy the same soil more than once every six years. For example, a twenty-foot strip of row crops may alternate with a parallel 40'-wide strip of sod crop. Above the row crop is a field of permanent pasture, and below it is an irrigated hay field. Each year, a four-foot-wide strip of the sod crop is seeded to the row crop.

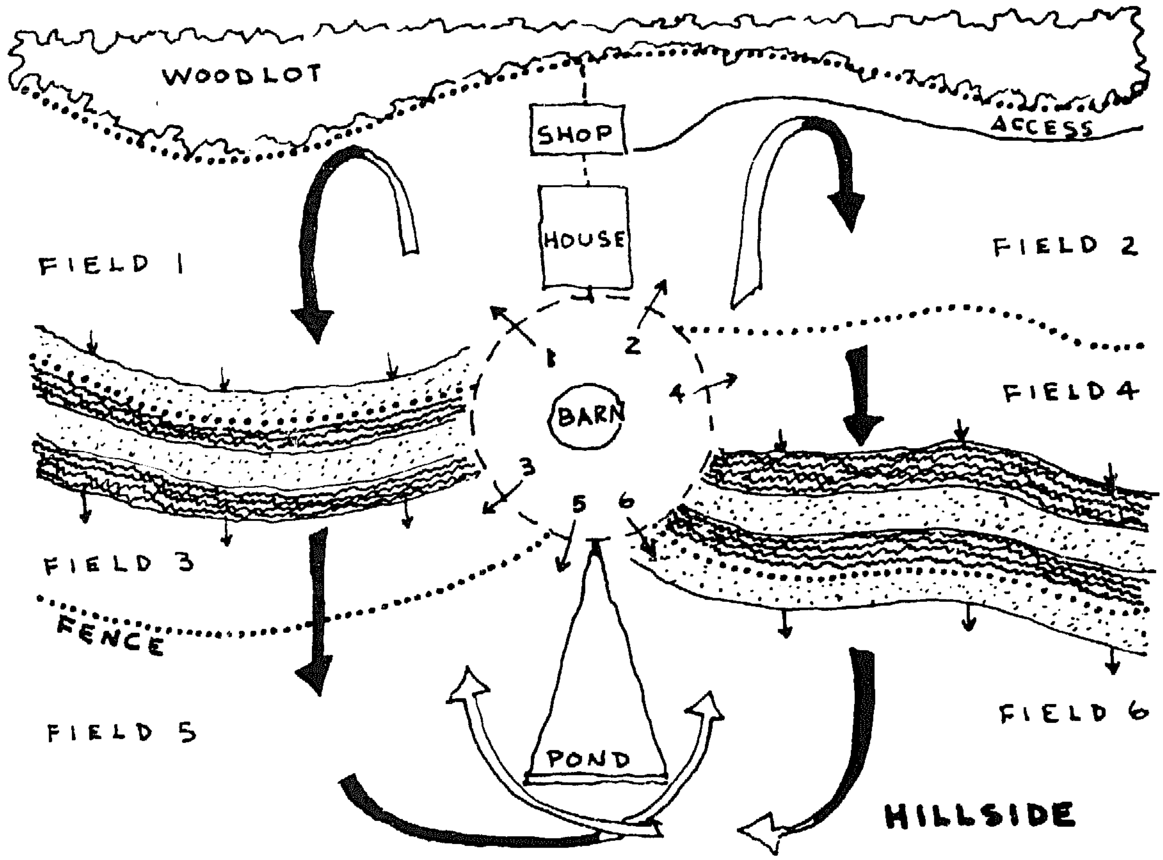
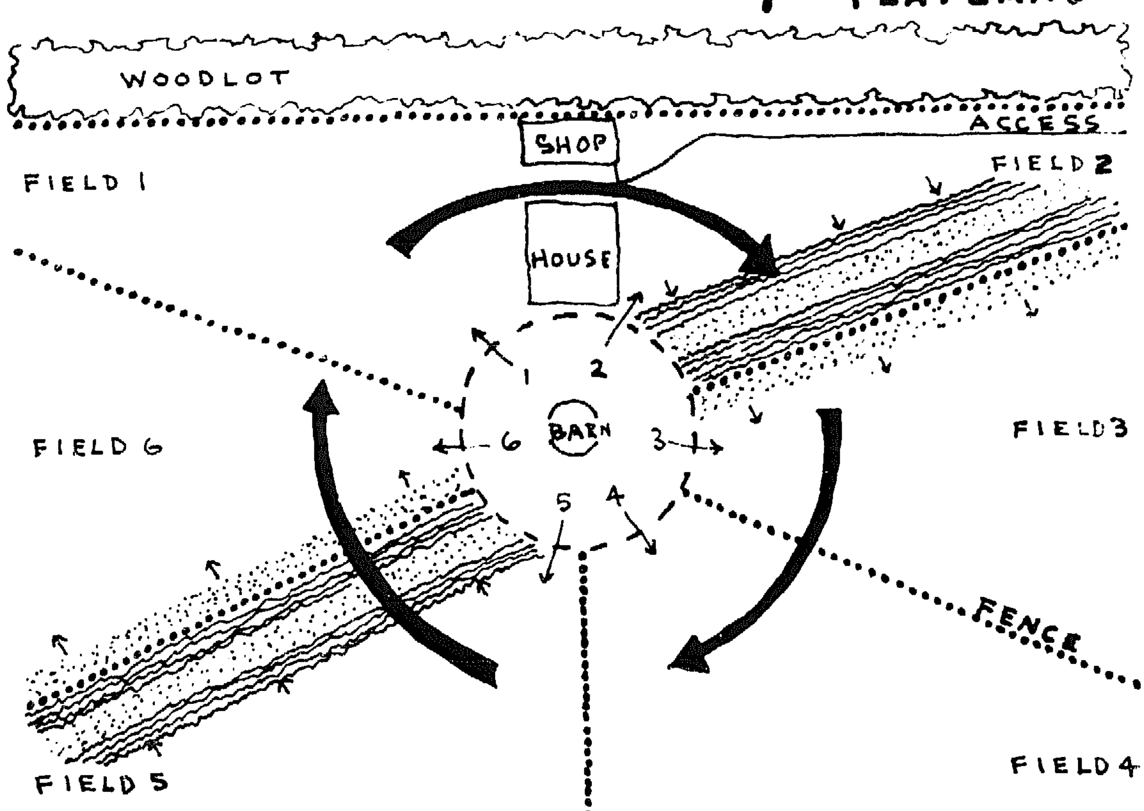


FIG. 1 HOMESTEAD LAYOUT



Likewise, the upper border of the row crop is seeded to grass and legume sod crops. Interspersed throughout the whole area are planted forage trees.

The model Hillside Homestead, illustrated above, is divided into six equal, fenced fields, each under an acre in size. At all times, the livestock have access to a single grazing field, and one parcel is allocated as an irrigated hay field. Silage crops are produced from one of the two combinations of row crop and sod crop fields. As crop areas advance downhill, part of the receding section is fallowed, or "hogged down", during the appropriate season. The fish pond location is patterned after the arrangement for Chinese polyculture--in which the pond, situated at the lowest point of the land, receives all used homestead irrigation water wastes by natural gravitation.

A model Flatland Homestead layout is also illustrated above. Here, the six fenced-in fields are concentric to the centrally located barn facility, and crop rotation progresses in a clockwise fashion.

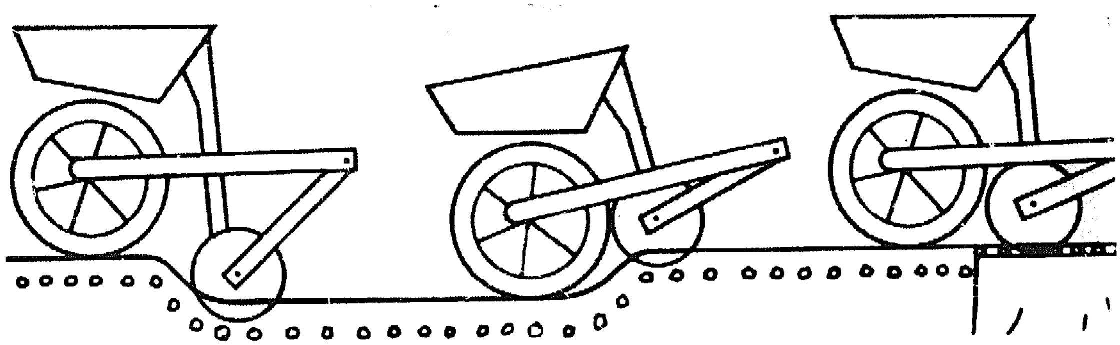
Commercial farmers who must rely on costly soil tillage would certainly ridicule our six-small-fields rotation plan. Obviously, extensive acreage is required for conventional soil manipulations, such as subsoil chiseling, moldboard plowing, disk plowing, rotary tilling, vibrating wheel track planting, and field cultivation, since all are applied *prior* to harvest. The energy requirements for this conventional, large-acreage tillage operation has been found to be 31 horse power per hour per acre farmed. However, farmers who use the *till-planting* method require an energy output of only 11 horse power per hour per acre farmed. Besides reducing the per acre equipment and labor needs, no-tillage crop management improves water and soil and provides greater flexibility in the choice of the cropping system. Thus, it is the practice of till-planting that makes our multi-field rotation program possible. The key to a successful till-planting program is the inclusion of either a permanent cover crop or mulch residue. The soil is, thus, protected from wind and water erosion, water infiltration of the soil is improved, and evaporation is minimized. Soil compaction is reduced by simply limiting the number of tractor trips over the field. The following table itemizes tillage costs.

FIG.2 TILLAGE COSTS *U of Neb.*

OPERATION	EQUIPMENT	LABOR	EQUIPMENT	LABOR
	CONVENTIONALLY PLANTED		TILL-PLANTED	
DISK	1.58	.14	—	—
PLOW	3.52	.39	—	—
HARROW	1.20	.14	—	—
PLANT	1.95	.21	2.64	.21
ROTARY HOE	.97	.10	—	—
CULTIVATE	1.64	.23	1.64	.14
CULTIVATE	1.64	.14	1.64	.14
HARVEST	—	.56	—	.56
COST/ACRE	$12.50	$1.91	$5.92	$1.05

Till-planting advocates claim that, when seed is packed in undisturbed soil and covered with mulch, an earlier and more positive germination results than is derived when seed is planted directly into dry, granular soil. Companies, like Cole Manufacturing which has been making planting units since 1900, now specialize in no-till planting machines. One exclusive Cole Multiflex feature permits the planter to hug the ground contour for uniform seed depth. Independent suspension of the press wheel assures constant drive to seed hoppers with a gentle firming of the soil over the seed. Spring-loaded covering devices place soil uniformly over the seed.

FIG. 3 COLE NO-TILL PLANTER ..... HUGS GROUND CONTOUR FOR UNIFORM SEED DEPTH



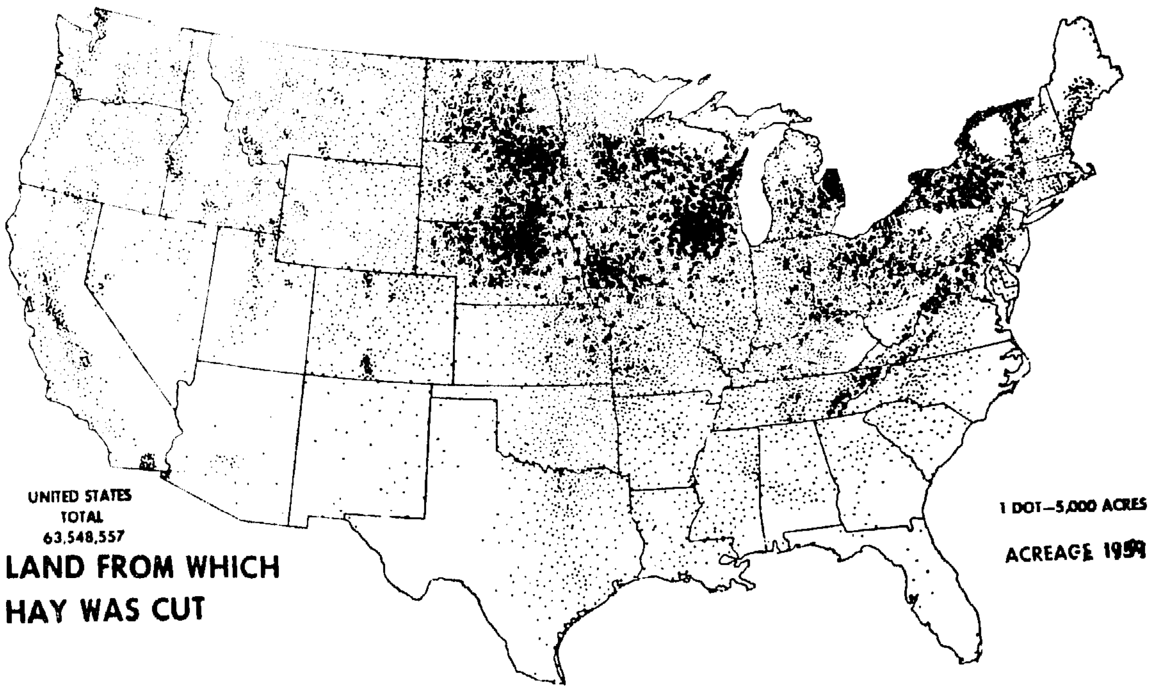
Farm equipment purchase is one area where the five-acre homesteader must be prudent and cautious. A $300 tractor-driven Cole planter may very well be the most efficient stubble planter available today, but a $12 hand-operated Cyclone broadcasting seed sower may, for small acreage planting, be an adequate substitute.

Comparative cost studies have been made in the Netherlands for starch equivalents of food value in grazing material and in various other forms of harvested forage products. Where the production cost of a unit of starch in grazing material is give as 100%, the cost of hay is 140%, silage is 187%, and concentrated feeds are 314%. In general, comparable figures are forthcoming from Cornell University Agricultural Extension Service which claims that the digestible nutrients in hay cost two-times as much as the digestible nutrients in pasture. In silage, these nutrients are reported to cost three-times more than those in pasturage and six-times more in grain than in pasturage.

It is primarily the use of *equipment* which raises the cost of farming. Measured in terms of calories consumed, equipment requires *energy* to operate and to produce. For each calorie of foodstuff harvested by today's agri-business technology, *20 calories* are consumed in production. Compare this cost to the expenditure of only *1 calorie* consumed in the harvest of an equivalent 50 calories of foodstuff--the notable achievement of modern, hand-based Chinese rice farming. Chinese agriculture is, by such comparison, 6,000-times more energy-efficient than our own!

To arrive at an understanding of what constitutes realistic need for homestead equipment, I will illustrate one farmstead activity--haymaking. I will describe, first, the traditional method of growing and storing hay, and then indicate in what areas it might prove advantageous to "modernize" these methods for the sake of greater efficiency or economy by the acquisition of certain specific equipment.

The U. S. Bureau of Census reports that, in 1959, about 74 million acres of hay were cut in the United States. All but 10 million acres of this enormous crop was cultivated. Of the *volunteer* hay that was cut, 90% of that crop grew in the state of Nebraska. Volunteer hay consists of any native growth of wild grain or grass. Of the cultivated varieties of grain perhaps the most widely grown are oats, barley, vetch, clover, alfalfa, and timothy.



LAND FROM WHICH HAY WAS CUT

It is true that all hay crops, even legume crops, are to some degree soil depleting. The Ohio Experiment Station once considered the collective influence of various crops on the organic matter, the tilth, and the nitrogen and mineral content of soil. They assigned a soil productivity index number to each crop. Soybeans ranked highest with a figure of -0.25, and corn ranked the lowest with a figure of -2.0. Wheat and oats each received an intermediate rating of -1.0. The graph below indicates the quantity of various minerals which individual crops remove from the soil.

Hay can be mulch-planted either in the fall or in the early spring. Generally, fall planting is preferred as a vigorous root system is established throughout rainy winter months, promoting rapid growth with the increased sunlight of early spring. Whether fall or spring planted, a hay crop is usually planted with a power-driven grain drill on land that has, first, been plowed, disked, and harrowed. A grain drill evenly distributes and automatically plants seed at the correct depth.

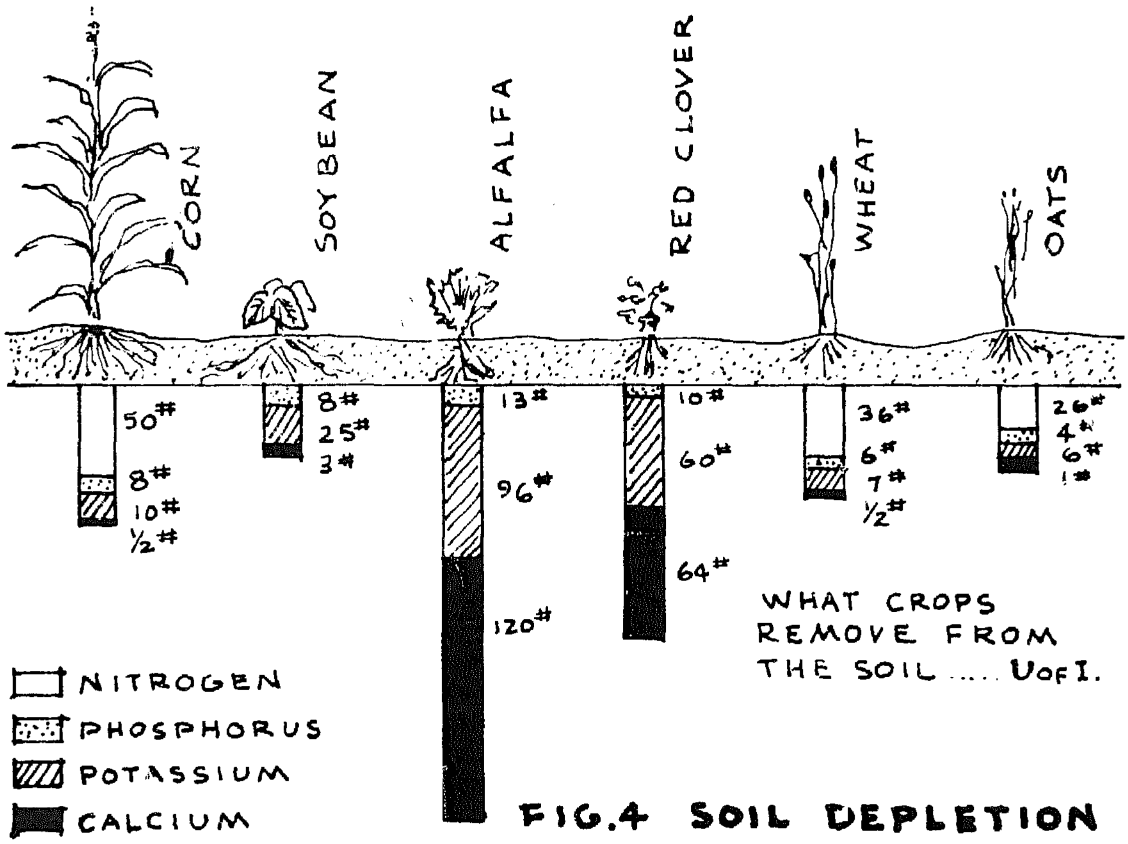


FIG.4 SOIL DEPLETION

First, sickles, then scythes, and finally horse-drawn cutter bars were traditionally used to cut (mow) hay. Following a short field-cure period of from one to three hours, the hay was raked into "windrows"--long, narrow rows of cut hay about twelve feet apart and extending the length of the field. Raking was once done by horse-drawn implements; today, farmers use a forage harvester that cuts and blows hay into a trailer or into a hay bailing machine. The windrow stage of hay-making protects the hay from rain and dew and from loss of carotene due to exposure to sunlight. The leaching action of just one rain may reduce the nutritive value of hay from 20-40%.

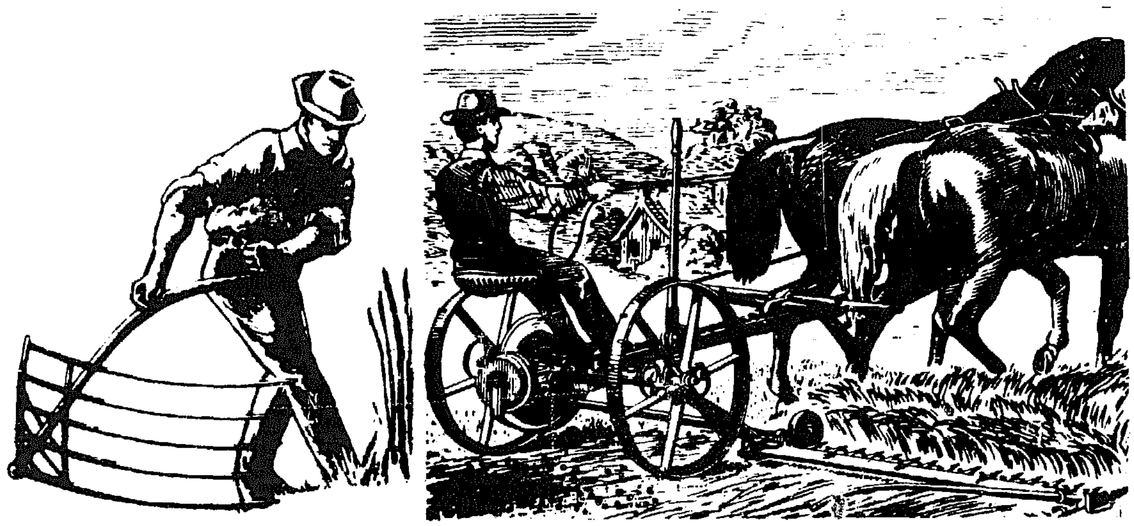
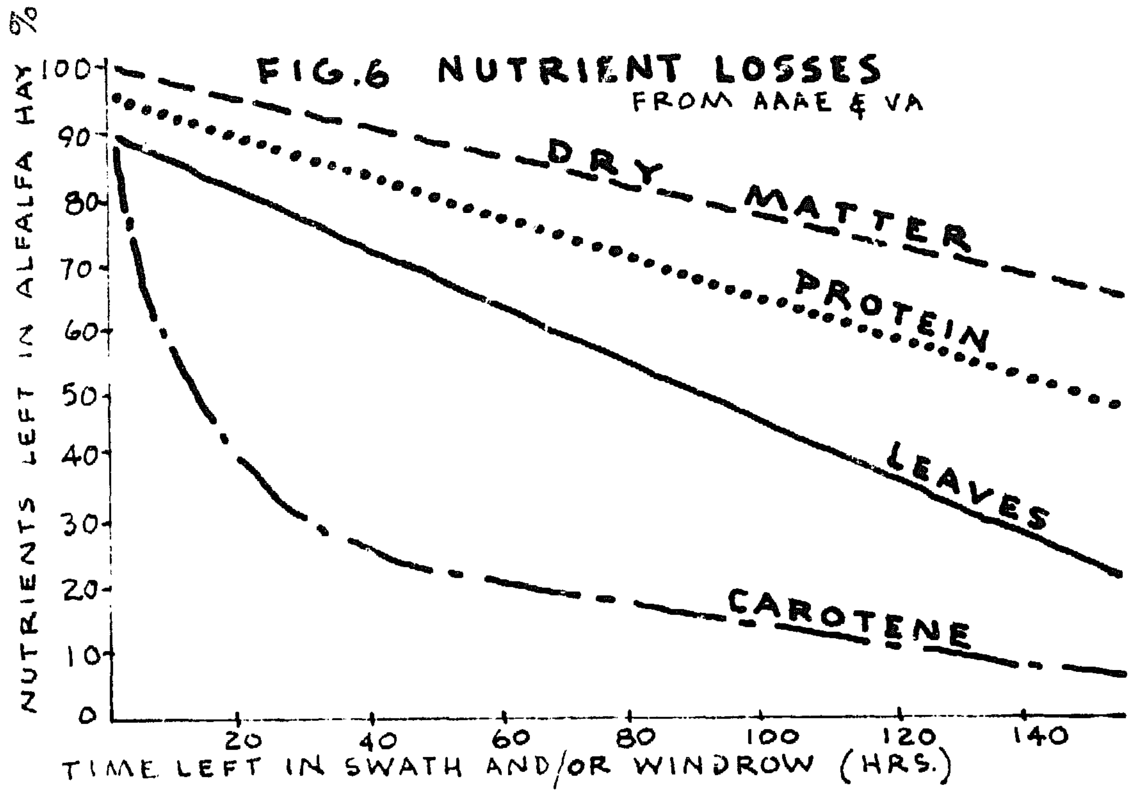


FIG.5 CRADLE SCYTHE — SICKLE BAR MOWER

Leaves tend to dry at a more even rate than that rate at which stems dry. However, even under the most ideal drying conditions, the leaves of the plant reach a safe-storage moisture content long before stems do so. When the stems finally do reach the safe-storage stage, the leaves are too dry, brittle, and easily shattered. Unavoidably, highly nutritious but shattered leaves remain in the field when the rest of the hay is removed to the loft.

Modern hay-making machinery is designed to "condition" the hay while mowing. That is, the stems are crushed and crimped so that they will dry out at the same rate as the leaves. As the chart below illustrates, the longer hay remains in the windrow (beyond a 20% moisture content) the greater will be its nutrient loss. Properly cured alfalfa hay will contain about 18% protein, but alfalfa hay improperly cured may contain as little as 9% protein. One may test hay for its moisture content by simply twisting a wisp of it in the hand. If the twisted hay is tough and if moisture is evident when the stems are broken, the hay is probably too sappy for safe storage and susceptible to spontaneous combustion when stored. For safe storage, the stems should be slightly brittle when broken, with no evidence of moisture.



Traditional hay-making practices required pitch-forking the windrows into large cylindrical bunches, called "shocks". In shocks, the hay continued to dry, but at a much slower rate. Finally, shocks were loaded onto wagons and transported to the hay loft for final storage. Finished hay has a pleasant aroma, the leaves are intact upon the stems, and the mass is green in color.

Sickle bar mowers are being replaced more and more by rotary mowers. Possibly one good reason for this change lies in the fact that sickle bar mowers cannot offer the necessary conditioning action for the preparation of hay for storage. To condition hay, a separate piece of equipment must be operated in conjunction with the sickle (cutter) bar. Nor can one windrow the hay using only a sickle bar. Again, a separate windrowing attachment must be acquired for this operation.

In dense, woody growth or when plants are fallen and matted due to storm damage, the sickle bar does not operate as a trouble-free tool.

The rotary mower, on the other hand, is a dependable, non-plugging, and highly versatile machine that will mow and swath, condition and windrow a hay crop. Furthermore, the same machine can be adjusted to chop hay or silage from a windrow. Some rotary mowers are even equipped with wagon hitches and blowers so that the chopped or shredded material can be loaded immediately.

Rotary mowers are of two types, classified according to the plane in which the cutting knife rotates: 1) a *rotary-cutter mower* has a single horizontal knife, 2) a *flail mower* has many knives (20 to 50 sets) which rotate in a vertical plane. In general, rotary cutters are designed for cutting and shredding stalks and underbrush, not hay. They tend to over-chop hay, making it difficult to pick up.

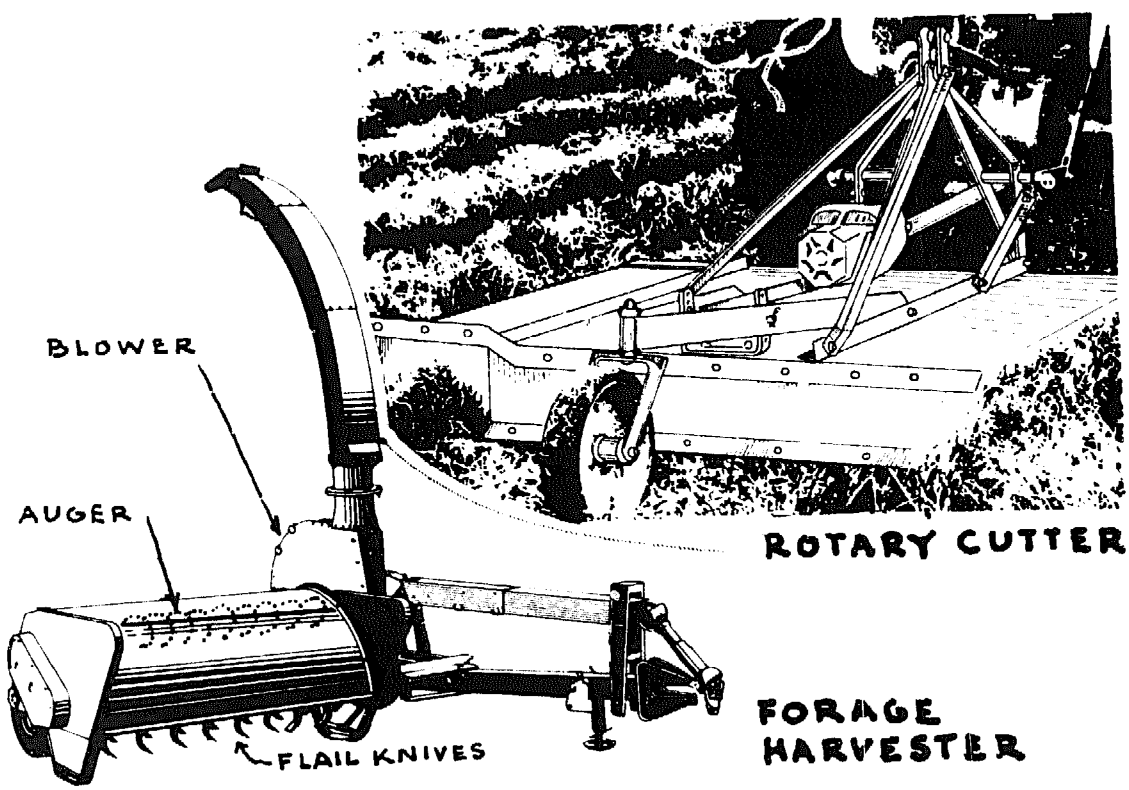
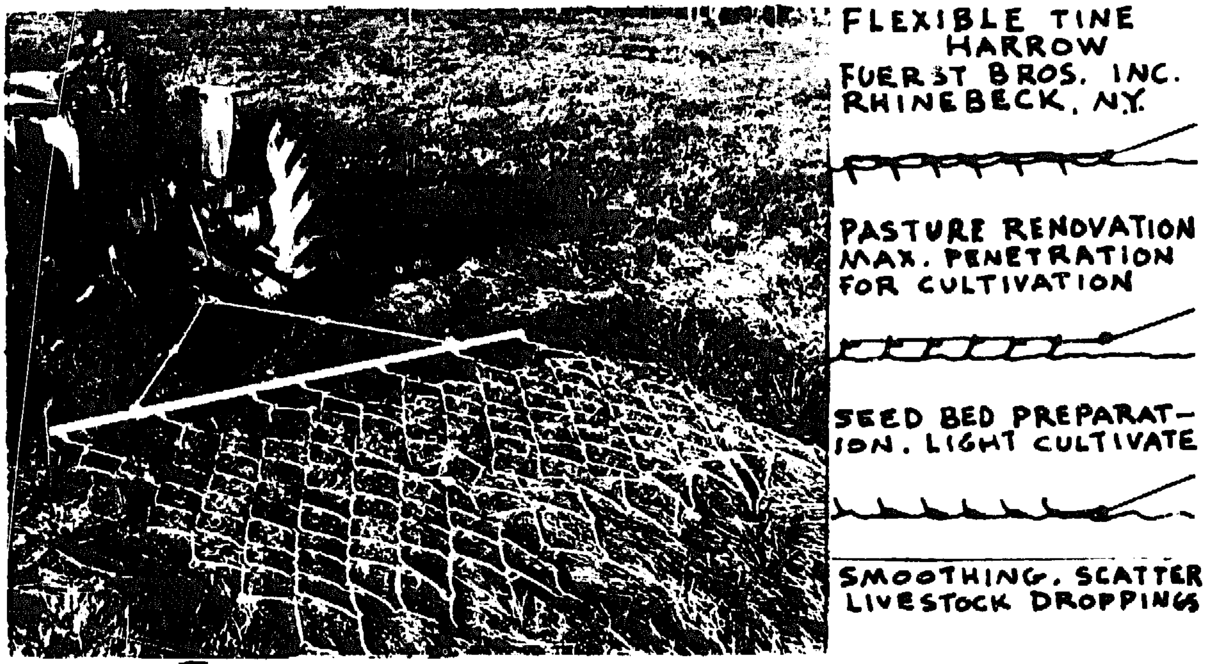
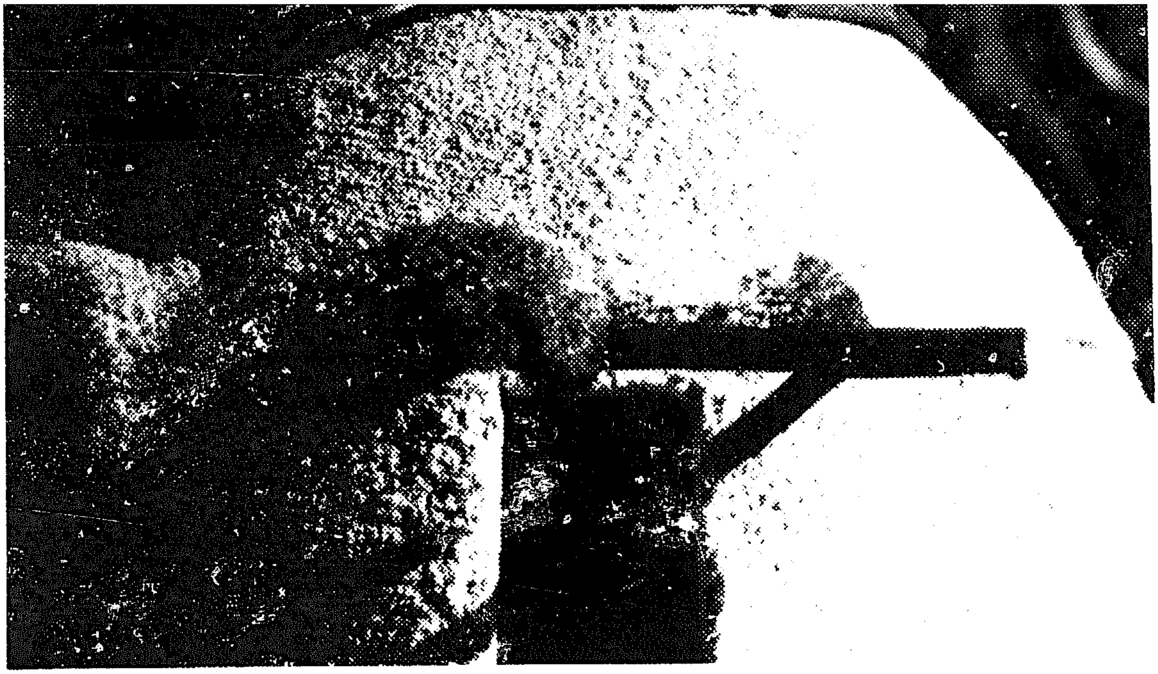


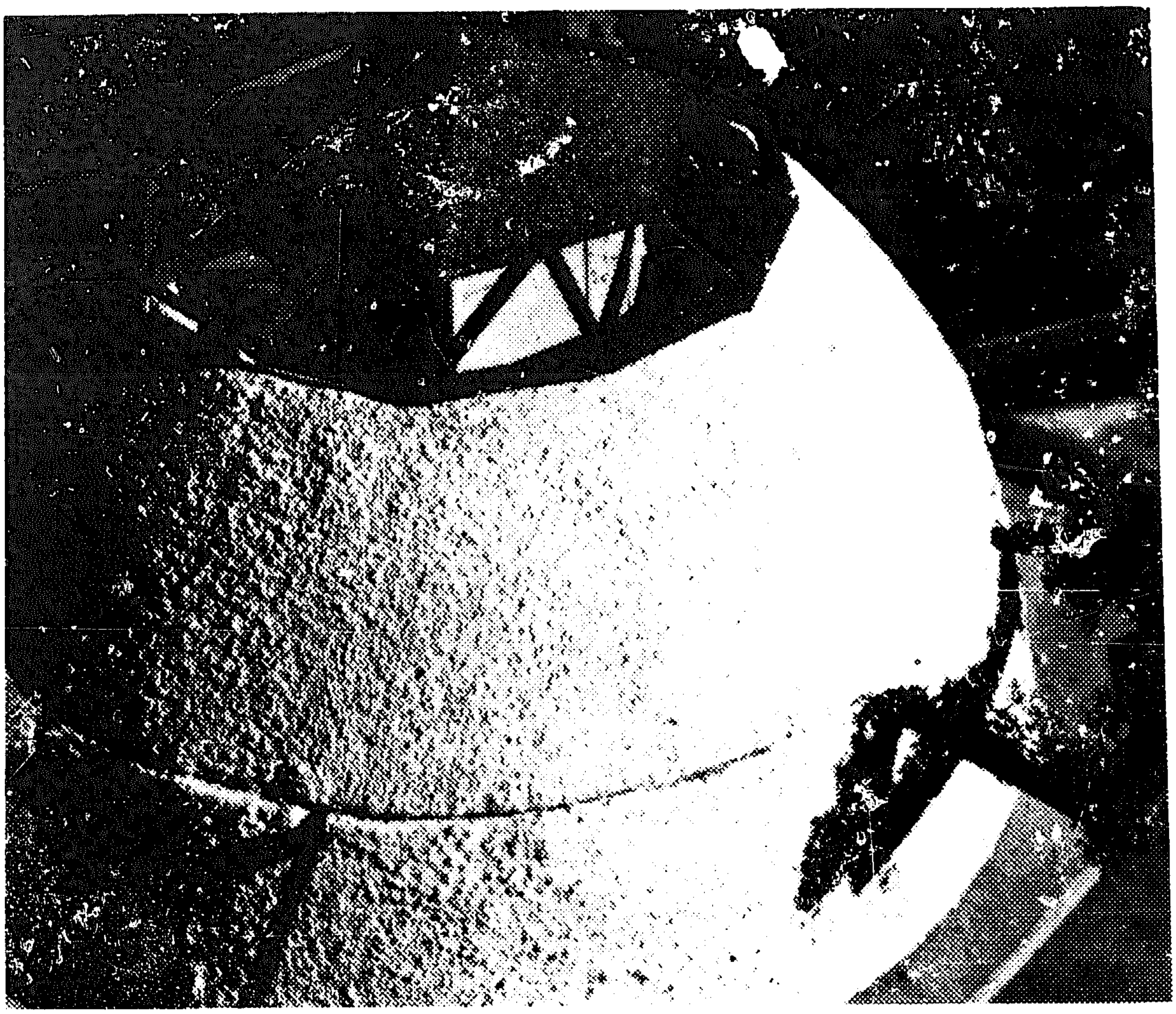
FIG.7 FIELD MOWERS

The ideal field mower for homestead use is one that can either mow, windrow, or condition hay (a flail mower) or, when desired, can cut grass silage (a flail forage harvester). One machine can be made to do both jobs merely by reducing or advancing the rotating speed of the knives. In addition, a flail forage harvester is equipped with a shear-bar chopper, an auger, and a blower, all of which can be removed when putting up hay.



SICKLE-BAR MOWER - LOADER   CHOPPER-WAGON   UNIMOG





DOME BARN & SILO

Proposed in this supplement is a concept for a primary homestead facility containing both animal shelter and animal feed management. This concept for this facility is best expressed by a statement from Stewart Udall: "If we are to master the sensitive arts of building a life-encouraging environment, we need to realize that bigger is not better, slower may be faster, less may well mean more." This comment contrasts sharply with present agri-business orientation since the economic purpose of modern animal husbandry is, first, to produce the highest yield of the most concentrated (however unnutritionally suited) foodstuffs, and, second, to feed this material at the fastest rate and in the largest quantity to achieve the greatest animal weight-gain in the shortest possible period of time.

With the emergence of this present kernel-fed animal production program, feed-grain has been considered the ideal, "miracle" weight builder for animal growth. At first, employing traditional farming techniques, it took 255 minutes to produce a bushel of this "ideal" grain food, but, with modern large-scale and heavily mechanized methods, a bushel of grain is now produced in 40 seconds. Yet, for some unfathomable reason, this fantastic increase in current grain production fails to economically benefit the individual livestock producer. On the contrary, feed costs rise as ever more phenomenal feed-grain production records are reached. The cost of a 100-pound sack of chicken feed has tripled in the last few years to its present $9 price, while it still takes about 4.5 pounds of feed to produce a dozen eggs. A hen will probably produce 20 dozen eggs over her 16 most productive months. The farmer, therefore, invests $9 to feed a $2 pullet for a return of $12 worth of eggs (figured at 60¢ a dozen). His $1 profit most likely will not pay for farm labor, capital investment, insurance and taxes.

Meat producers experience a production cost-crunch even greater than the egg raiser. At the ratio of 10 pounds of feed-grain fed to produce a pound of meat, there is no possible way for the usually debt-ridden rancher to survive the economic squeeze. Ralston Purina Company, largest feed producer in the U. S., will survive, however, as will Tenneco, the immense agri-business conglomerate.

There is only one, possible way for the small-acreage homesteader to rise above the high-cost-feed dilemma; he <u>must produce his own feed</u>. And, for starters, he must re-evaluate the whole animal feeding regimen. As Udall's comment suggests, high-yield may be of low value; fast growth may not be as desirable as slow growth; lean may be better than fat. Feed-grains, highly concentrated in protein content and energy value, are not now, in the opinion of knowledgeable experts on the subject, as valuable as a balanced mixture of mineral-rich forage crops. Furthermore, the production of feed-grain requires an extensive investment in land and in mechanization that is inappropriate to the average homesteader.

The healthiest food for farm animals--the most complete (natural) food and the most economical-to-produce--is <u>fresh young grass</u>. In most areas of the U. S., however, it is not possible to maintain a year-round, endless succession of high-grade productive

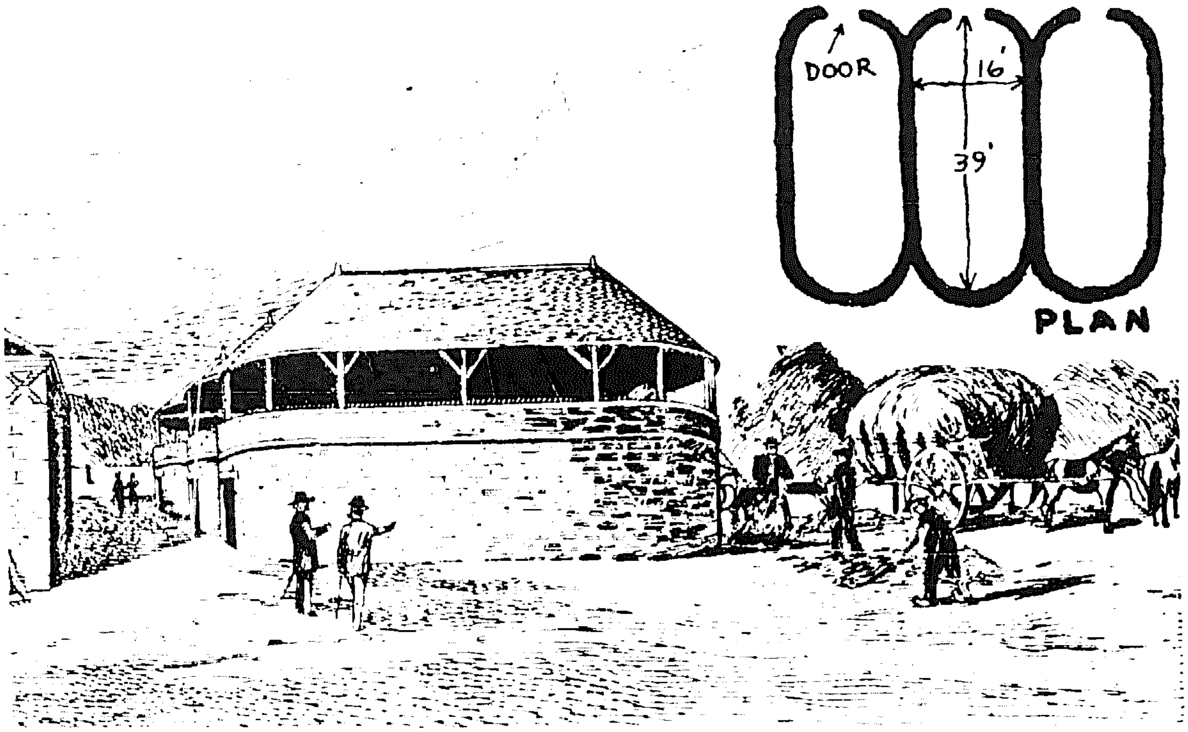


FIG. 1. GOFFART'S SILOS 1877

that the volume of air in the silage must be kept under control. This was accomplished by placing boards on top of the silage, after which the mass was weighted down with a foot-thick layer of earth. He knew, secondly, that it was essential for a certain degree of acidity to develop in the silage as quickly as possible. When the living crop is cut, changes can be brought about by continuing plant respiration and by the on-going action of plant enzymes. It is the condition of acidity in the silage that controls these changes which thereby occur. Later, Goffart found that the weighted boards and earth could be eliminated when replaced by the use of a structure that was deeper and of smaller diameter. In a tower-like container, less surface is exposed in proportion to the total silage contents than there is when silage is held in a shallow container. Silage in a deep container is also more thoroughly consolidated due to the shear weight of the material above.

Immediately after Goffart published his methods for ensiling fodder crops, farmers in Europe and America set to work building silos pasture. Seasonal fluctuations create an over-abundance of fodder in springtime, with contrasting shortages in the winter. It has, therefore, long been the practice with farmers to "put-up" hay, thereby bridging periods of under-abundant fodder growth.

Traditionally, haymaking has been recognized as the hardest chore of farming, with the concommitant detraction of possibly loosing one-third of its food value between the time of its summer mowing and its winter feeding. If hay is harvested at too late a stage of maturity, if it has been allowed to dry too long in the field (sunshine bleaches out nutrients), if the humidity was too high at the time of cutting or if the hay is handled too much and too carelessly both in and out of storage (resulting in leaf shattering and scattering) then the value of the stored feed will depreciate accordingly and often alarmingly.

A French farmer, Auguste Goffart, was the first agriculturist to reconcile the nutrient losses accompanying haymaking with a totally new and unorthodox method of forage crop harvest and storage. In 1877, Goffart built the first silo, writing about it in his book, <u>Manual of the Culture and Siloing of Maize and Other Green Crops</u>. Summarily, in Northern Europe, where the uncertainty of summer rainfall and low summer temperatures rendered difficult the proper curing of hay, the problem of haymaking was solved by Goffart's work. As the "father of modern silage", Goffart raised enough feed to keep 100 head of cattle year-round on his 86-acre farm in Burtin, France.

Goffart's silos are illustrated below. They were shallow, rectangular structures, each 16 feet by 39 feet and 16 feet high, with a door opening at one end. The principle of controlled fermentation was thoroughly understood by Goffart. He knew, first of all, of all shapes and description. The first ones were square towers built of wood. Adequate compaction of silage in corner spaces immediately became a problem of square silos due to the greater amount of friction at their corners, so octagonal and later circular designs were adopted. Then, frequent shrinkage and swelling of the structural material resulted in so destroying the wood's elasticity that the building would not return to its original form when the silo was refilled. Farmers eventually resorted to the use of masonry materials in their silo building, using brick, block, stone and poured concrete. Cast concrete proved to be the most ideal material for this construction because of its permanence, wind resistance, relative inexpensiveness and for being fireproof. In the early days of silo building, great care had to be taken when casting the concrete walls lest they not be waterproof. Silage juices, containing lactic acid, readily seep into silo walls, dissolving the cement binder. Today, of course, we have plastic materials available with which to coat concrete walls for their protection against this invasion.

Not many years after Goffart wrote his thesis, F. H. King, professor of agriculture in Wisconsin, formalized the process of silage making by investing it with scientific credance. Much of what we know about silage production has come from the disciplined research of Professor King. King also provided us with some highly imaginative silo designs, which will be described and illustrated later in this supplement.

In 1900, King mistakenly claimed that it required a minimum equivalent of 8 cows to support the use of a silo. He based his estimate on the fact that from 2 to 3 inches of silage must be removed each day from an 8-foot diameter silo to prevent the formation of mold.

The warmer the day, the more silage must be removed to avoid spoilage.

Since King's time, efficient slip-form building techniques for erecting smaller diameter, concrete silos have been perfected, making it now economically feasible to reduce the required capacity of the silo by one-half! A single cow (or two goats) can consume 40 pounds of silage each day. Over a 6 month, fall-winter feeding period, we are speaking of a requirement for 7,200 pounds of feed, utilizing 240 cubic feet of storage area. Add to this quantity the 10 pounds consumed each day by a single hog on the homestead and the variable amount eaten by chickens, ducks and perhaps a few beef calves. Even allowing for a percentage of waste, a silo with a minimum 15-ton capacity (which is the most efficient size to build, fill and maintain) is of sufficient size for the average, animal-based homestead. An equivalent 4-cow population can be supported from a silo of this capacity--a structure that is merely 20 feet high (described in detail later.)

A homesteader should allocate one acre of land to adequately stock the capacity of his 15-ton silo. Where he may expect a yield of 2 tons of hay per acre, a crop of fodder corn will yield from 40 to 75 tons per acre. Obviously, from the point of view of the amount of nutrient value received per acre of land farmed, a hay crop is the more expensive choice for animal feed. As noted before, unlike the considerable food value which is lost between the time of cutting and the actual feeding of a hay crop, well-made silage has the same food value as the original plant; that is, dairy farmers find it a suitable substitute for grain feeds.

The choice of a silage crop depends upon many factors, such as soil and climate, the variety of animals to be fed and the degree of mechanization at hand--for making silage utilizes far more equipment and less labor than does putting-up hay. But, in all instances, a silage crop must be a mixture of plants that are rich in fermentable sugar and high in protein content. One of the spectacular features of silage is that the proper mixture preserves the protein value of the silage at the same time that it creates a balanced ration to be fed to the animal. Alfalfa hay silage, for instance, has twice the protein composition of corn, but it is low in energy value. When alfalfa is supplemented with corn the mixture can be ideal. Grain-feeding farmers place far too much emphasis on protein content rather than on the total energy requirement of the animal. Soy beans are, by themselves, too high in protein. A mixture of 1-part soy beans to 4-parts corn should be used. Sorghum is a first-choice crop for silage in many parts of the U. S. for many farmers prefer its use over that of corn, but, like corn, it contains an excess of fermentable carbohydrates. A leguminous crop, like cow peas, will balance the mix. Cow peas, incidentally, grown in alternate rows with corn and harvested at the same time as the corn, make an excellent silage for hogs. Clover-corn silage makes an excellent winter feed for poultry.

About any imaginable variety and combination of plants can be successfully made in to silage. Farmers in Europe like to make silage from garden and root crops, such as beets, turnips, steamed potatoes, sunflower heads, beans, cabbage and windfall fruit. These succulent crops act as preservatives for the very young, chopped grass and leguminous plants that are added to the mix.

Some unusual combinations of plants have been made into silage. In Arizona, mineral-rich spineless cactus, run through a feed cutter, produced excellent silage feed for one farmer. Russian and Canadian thistles become soft, palatable and extremely nutritious after two weeks in a silo. Weeds, leaves, ferns and even twigs can be ensiled.

Producing good silage is not unlike making good wine. Many of the same principles are employed. First, the blend must be correct--as discussed above. Then, it is of the utmost importance to utilize the plant in the optimum stage of its growth. One can recognize three stages of growth in the grass plant: 1) the leaf, before the seed head forms, the carbohydrate content of the plant is low although it contains high protein, vitamin and energy values. The plant is also highly digestible at this age and ideal for silage. Then, there is the 2) bud stage, in which the vegetative matter of the fermentable carbohydrates are considerably increased while the protein, vitamin and mineral values are decreased. The 3) flower stage of the plant finds the plant with high carbohydrate and fiber content but with low protein and vitamin values. The plant is then beyond the stage at which is should be ensiled.

In general, grasses should be cut after the heads emerge but before they bloom. Exceptions to this requirement are alfalfa, which should be cut at a stage of early bloom, and red clover, which should be cut at the mid- to full-bloom stage. Soybeans and cow peas should be cut when the first seed pods are filled.

As a grass plant matures, the protein-vitamin-mineral content decreases, while crude fiber increases and digestibility is reduced. One valuable rule-of-thumb used by perceptive farmers in the Middle West declares that for every day's delay in harvesting a silage crop after June 1, the feeding value of that silage decreases 1 percent.

When making good wine or good silage fermentation must be controlled. This is accomplished in two ways: 1) by developing acidity in the mass as quickly as possible to deter any changes that are brought about in the newly harvested plant through its respiration and the action of plant enzymes; 2) by minimizing the volume of air in the mass since air and excessive moisture are the two, chief impediments to good silage-making.

The first factor of concern in silage production, then, is the creation of acidity in the mass. The difference between fresh fodder and silage is the difference in the content of lactic, acetic and butyric acid in each. These organic acids are produced by plant enzymes under normal conditions of anaerobic fermentation. Respiration is stopped as soon as the pH level reaches 4.0. Ideally, this pH level is reached soon after the silo is loaded, for the bacterial enzymes must first convert starches to sugar and then convert this sugar in the process which forms the more desirable, assimilable lactic acid and CO_2. At this stage, microorganisms are still alive, but they cannot grow at a low pH (high acidity), any more than they can grow without an oxygen supply.

This brings us to the second factor of controlled fermentation which is the volume of air in the mass. When air is allowed to enter the silage, fermentation continues by the action of bacteria, yeasts and molds which are undesirably present. If, on the other hand, air is excluded from entering the silage, the amount of oxygen within the material is, through respiration of the living plant cell, replaced by carbon dioxide. The best way to preserve any kind of crop is to replace the oxygen around it with carbon dioxide. Oxygen is essential for the respiration process, often referred to as a "ripening" process.

There are a few practical methods that can be used to control the air in a silo. One method thoroughly packs the silo, especially around the edges. Chopped fodder packs better as well as faster and aids the necessary fermentation of the starches since the plant sap thus released feeds lactic acid to the bacteria in the mass.

A "tower" silo provides the greatest amount of compaction for the exclusion of air from silage. Professor King found that silage weight creates a pressure on silo walls on the order of 11 pounds per square foot of wall area per foot of depth. For our proposed silo height of 20 feet, the lateral pressure is, for instance, 220 pounds per square foot. If the silage contains an extra quantity of water it will, of course, weigh even more, becoming more consolidated and self-sealing. The higher the moisture content, the easier it becomes to regulate oxygen by air displacement. But too high a moisture content creates a nutrient loss through seepage. Also, removal of silage from the top 2 to 3 inches will maintain a level surface and expose a minimum area of the top level of silage to the air.

Commercial farmers too often find controlled, scientific silage-making a burdensome, time-consuming process. The same attitude is prevalent among modern vintners. Consequently, "controlling" agents--chemical fortifiers--are introduced into both silo and vat. The Finnish scientist, A. I. Virtanen, was the first person to fully comprehend the value that acidity has in controlling the fermentation process in a silo. Monocultured farming practices could be promoted, Virtanen found, by simply introducing mineral acids into the silage as it was made. Thus, the "A. I. V. Process", as it has commonly become known, consists of the admixture of hydrochloric, sulphuric and phosphoric acids. It was found that formic acid fermentation could be stimulated by the introduction of some preserving agent, like molassas or ground cereals. Acid-forming materials establish an acid condition in the silage quickly, preventing the growth of anaerobic bacteria.

The most recent, post World War II development in silo design for monoculture agriculture is the fabrication of the completely air-tight container. These blue, glass-fused steel towers are seen everywhere these days. One unit, the Harvestore, has a unique bottom-unloading mechanism which allows the silo to be top-filled continuously. A pressure-equalizing breather system, consisting of huge plastic bags, are installed at the top of the silo to compensate for the fluctuation of the internal gas pressure. The company claims that the sealed storage feature preserves up to 98% of the total nutrients.

The $9,000 purchase price of a Harvestore can be saved by merely observing some basic commonsense rules when filling one's $300 homestead-built concrete silo. The A. I. V. Process is of no value to the homesteader who, himself, understands the fundamental process of aerobic fermentation. Long before Virtanen made his discovery of the value of acidity in the fermentation process, Professor King found that the best way to check undesirable fermentation in the silo is to wilt the crop after it is cut, while it is still in the field. There is no one single factor of greater importance for making quality silage than the factor of the percentage of dry matter present in the grass when it is ensiled. Cutting grass dispenses with the need for artificial preservatives. In slightly wilted fodder, which is about 24% dry matter, lactic enzyme fermentation occurs as soon as the silo is filled. As we have shown above, rapid fermentation is desirable. In wet fodder, the fermentation begins slowly and the action may last up to 6 weeks. If, on the other hand, the wilting exceeds 35% dry matter, spontaneous heating is inevitable. A rise in temperature in the cut fodder means that aerobic fermentation is taking place and that the protein content of the silage is being destroyed. The digestible, crude protein content of silage varies from 1/2% for wet grass silage to 6% for wilted grass silage. The variation of starch is from 6% for wet grass silage to 28% for wilted grass silage. These figures are from the European Productivity Agency of the Organization of European Economic Cooperation.

To determine the proper stage of wilt in a silage mass, one good gauge is to squeeze a handful of chopped fodder. When proper moisture content is present, the tightly squeezed fodder will recover its original volume when released. If it expands suddenly and then disintegrates, the crop is too dry. If it remains in a tight ball and exudes moisture, the fodder is too moist.

Level-of-moisture content within the barn can also be a critical factor for the health of livestock. Excess moisture is best removed by ventilation--by air flow. Air flow can be "natural", if some regard is given to the temperature and pressure differences which cause air movement. Professor King found that a temperature difference of 20°F is necessary to maintain a flow of air through ventilating ducts. Air expands 1/491 of its volume with each degree Farenheit rise in temperature, and, saturated, it decreases in weight slightly more than 1 grain/cu. ft. between 10°F and 70°F. The King Ventilating System, as it came to be known, consists of flues, one for the removal of impure air, the other for the admission of fresh air. Air that has been breathed contains a high percentage of carbon dioxide and is, consequently, heavier than pure air. Used-air outlet flues should, therefore, be placed near the floor where this accumulation of impure air collects. As impure air is forced out, fresh air is drawn in through inlet flues which open near the ceiling where it becomes pre-warmed before reaching the animal-breathing level. Cold drafts should be avoided for animal well-being. When functioning properly, King's system tends to establish a heat reservoir of warm air near the ceiling of the animal stalls.

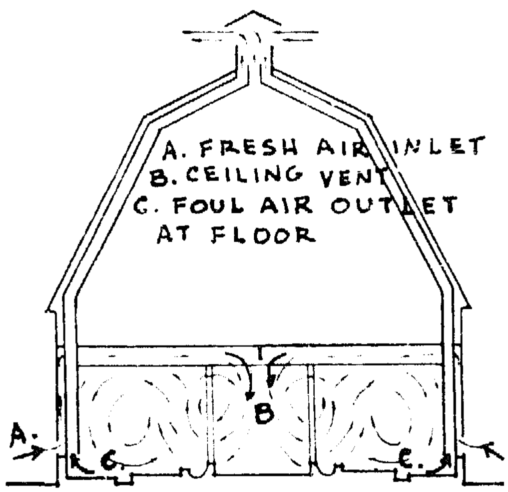
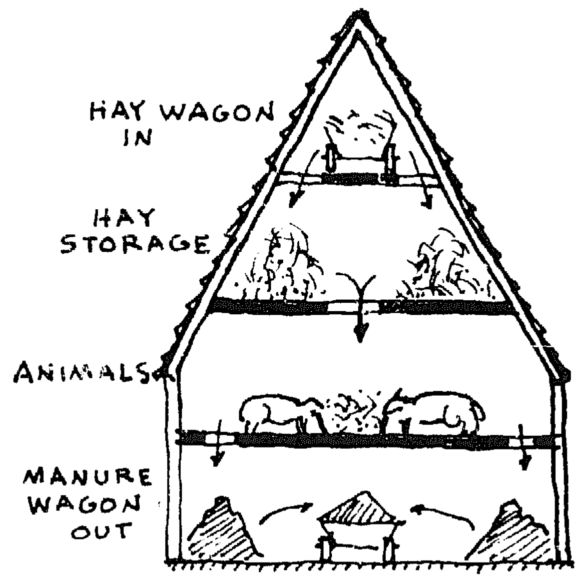


FIG 2. KING SYSTEM OF NATURAL DRAFT



TYPICAL BARN-NORWAY

Professor King was dismayed with the number of collapsed silos that dotted the early twentieth century American landscape. Few do-it-yourself farmers of that day realized what tremendous hydrostatic pressures could be exerted on the lower sections of 30-foot high silos. Nor did they realize how vulnerable an empty silo is to the force of intensive winds or to the action of ground-heaving frost or freezes. It was freezing temperatures, exceptional wind stresses, and unusual structural pressures--along with the need to adequately insulate silage against Wisconsin cold--that inspired King to enclose the silo, like a hub, within a circular barn.

It was a great idea. The silo was braced by the barn's structure and, in turn, the silo provided support for the barn. Some of King's barn designs may have been influenced by the traditional Norwegian arrangement in which feed delivery is brought in at the highest level, stored below that delivery level, and fed to animals at yet a third, lower level. Finally, gravity disposal of manure takes place at the basement level. The basement composting level produces heat through fermentation which rises in cold weather to benefit the animals housed above. Overhead, the thick compaction of hay in the loft also helps to insulate the animals against the rigors of Norwegian winters.

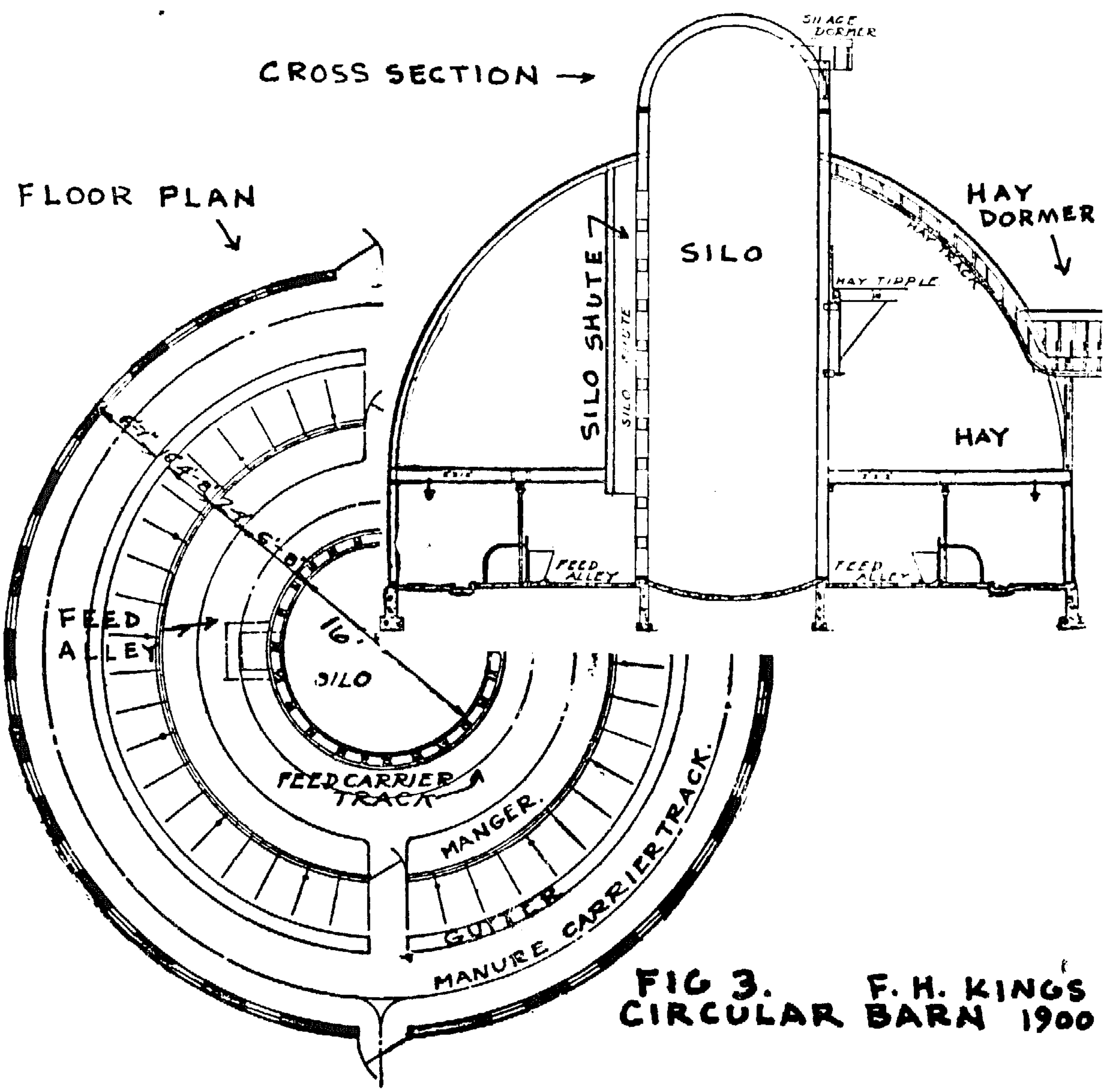


FIG 3. F.H. KING'S CIRCULAR BARN 1900

legume crop is grown for silage in alternating, one-acre parcels of one's homestead fields. The fodder from these field crops is mixed with surplus root crops, with greens and with windfall fruit from the inner garden area. Other one-acre fields, used in rotation for the fodder crop, are allocated as pasture or as hay field.

During the fall and winter when pastures are in minimal production hay is used as a supplement to pasture feeding. To preserve

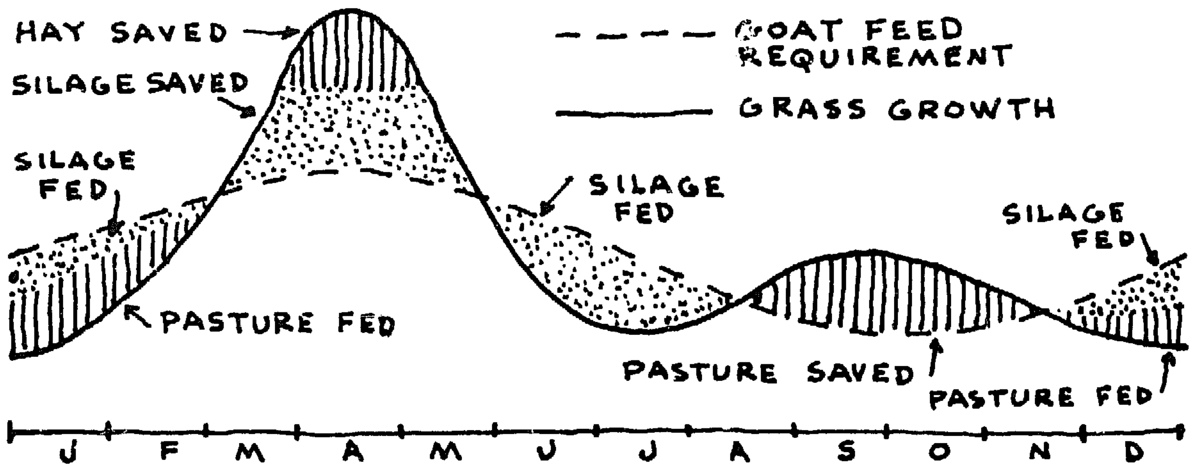


FIG 5. GOAT FEEDING PROGRAM

fall pastures from being over-grazed and unavailable as pasture for the animals during winter months, silage may be fed during summer months. Part of the silage is also fed throughout the winter months. Figure 5 illustrates the relationship between a goat's feed requirements and the growth of grass. Also illustrated in this figure is how one fills the gaps left by the periods of minimal feed growth with hay and silage production. The mechanics of preparing and managing the pasture, of growing and harvesting fodder and hay crops, and the filling of the silo and the hay loft will be covered in Supplement 6/1.

"Bigger is not better" inasmuch as the entire animal-plant production and feed storage enterprise which I propose can be organized on less than five acres of land. "Less may well mean more" for the first utilization

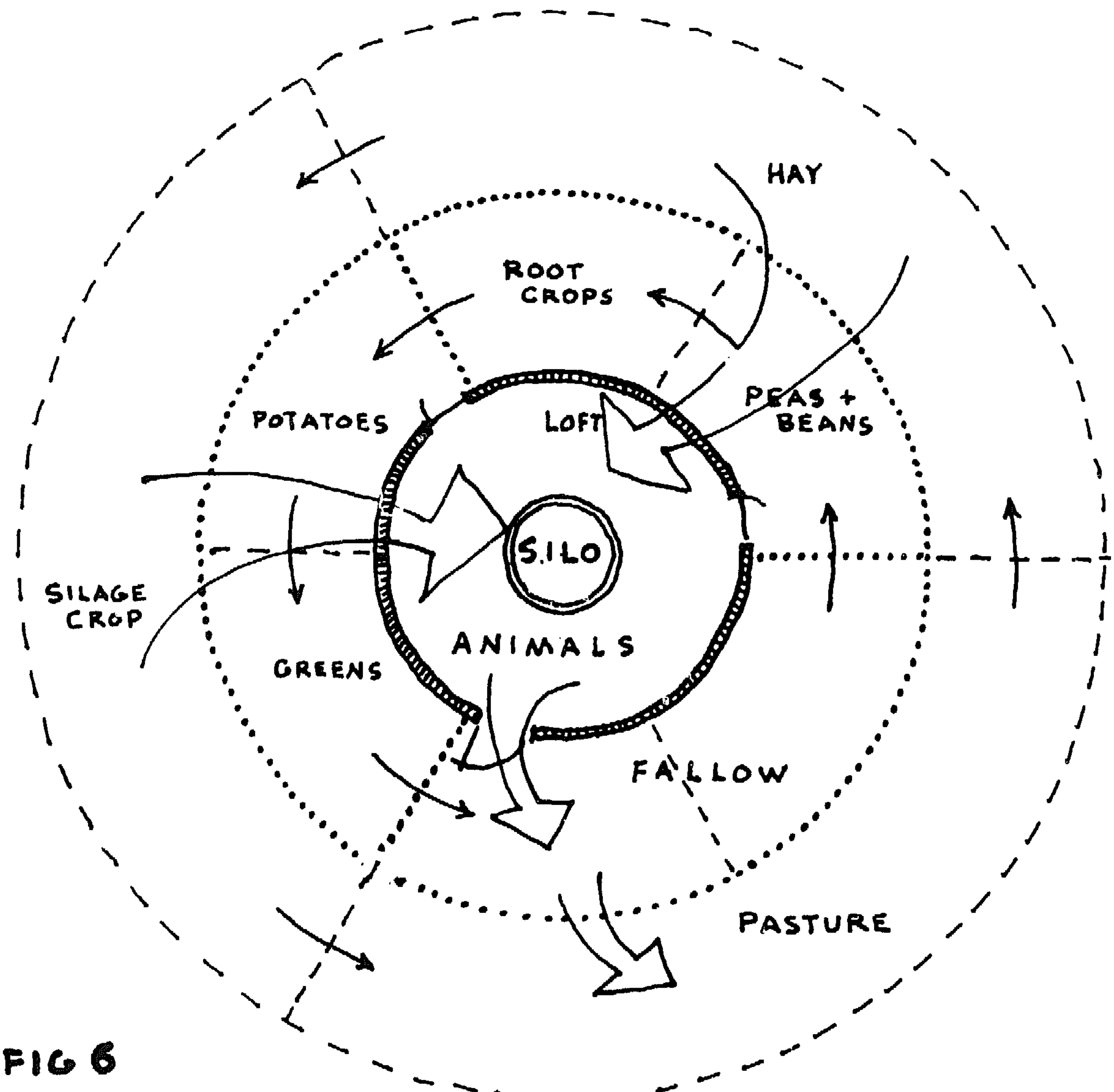
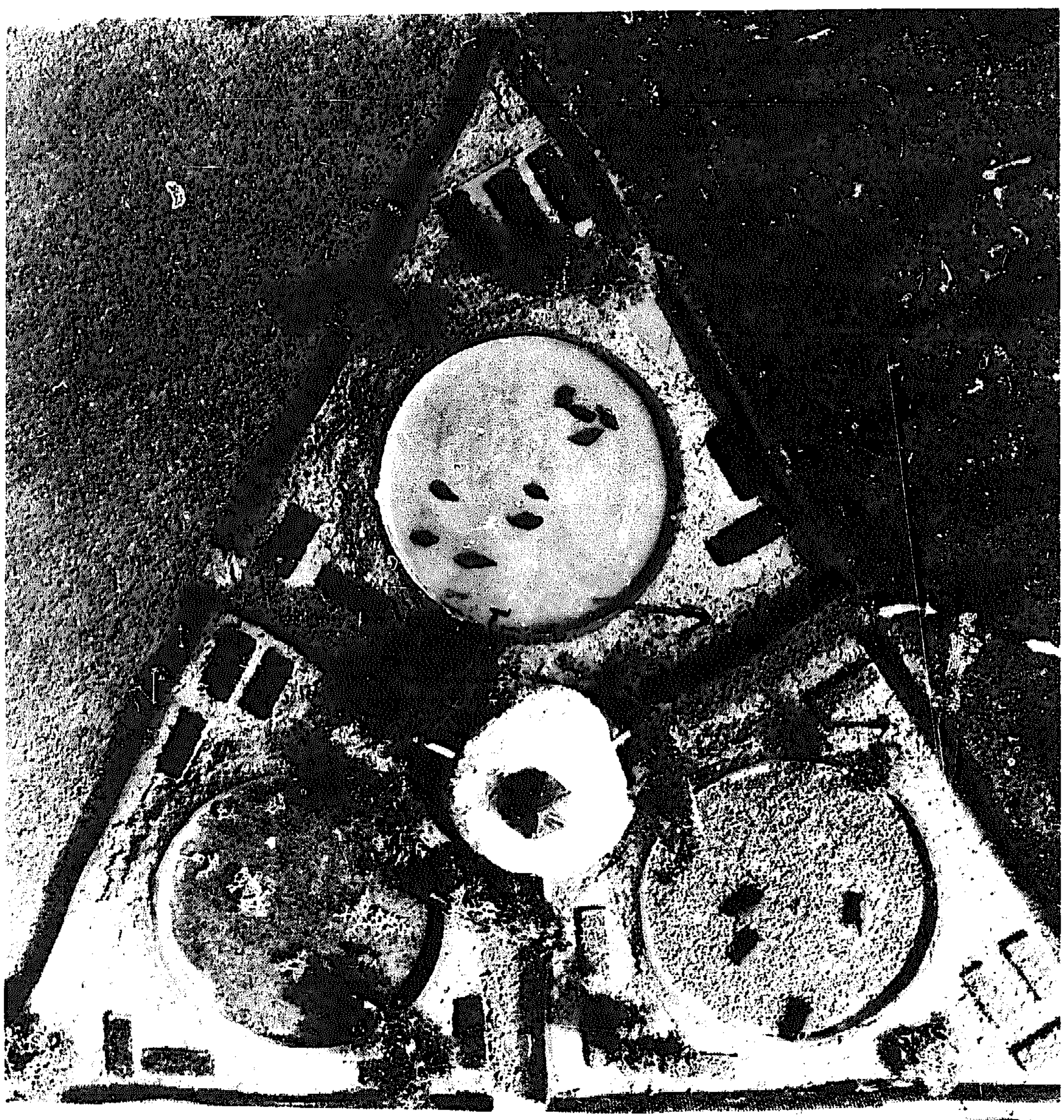


FIG 6
PLANTING SEQUENCE

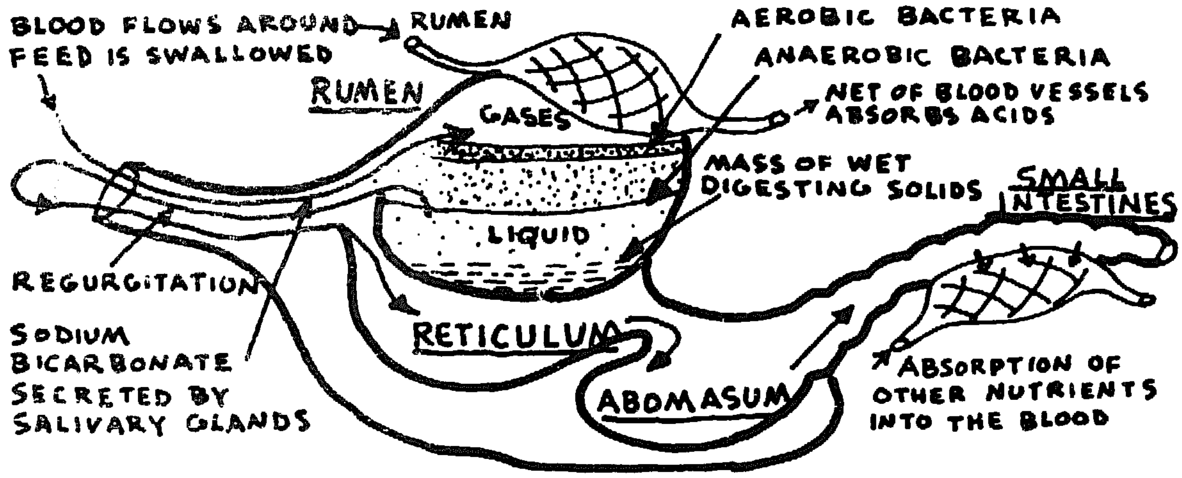
of the simple adobe dome barn design, proposed herein, can--first--be used as a honestead residence, with living, cooking and entry found below and with loft sleeping to be found above in the future hay loft. The silo is first used as a two-level composting toilet, with bathing and sauna located in the upper reaches of this structure. A family could be comfortably situated in this barn structure for as many years as it takes to develop the garden area, to build the shop and greenhouse and to construct the final homestead residence. The cast concrete silo is built with the same set of movable, plywood forms as are used to build the privy-sauna. The step-by-step construction process is illustrated in Supplement 18/1.



The model homestead farmyard, depicted above, requires five acres of land area. Total food requirements for an average family living in a temperate climate can be met with this amount of land for the support of goats, pigs, ducks, and fish. Furthermore, a family's total yearly requirement of fruit, vegetables, and grain can be met through intensive management of this plot.

Two, out-lying one-acre fields are allocated for alternate pasture, and for silage, mulch, grain, and hay production. The remaining area is divided into three equal one-acre yards, each containing garden beds, fruit trees, and a fish pond. In alternate years, one fish pond is planted to a fodder crop, and a second pond is left fallow for its use as an inner animal yard. The barn with its central silo functions as hub for the entire enterprise.

The microbial activity of external ensilage fermentation and internal rumen fermentation are similar:



Microbial phases of pre-fermenting animal food crops:

Phase 1) Respiration by plant cells with yeasts competing, utilizing simple carbohydrates, producing carbon dioxide. Water begins to flow from the plant material. Heat is produced.

Phase 2) Production of acetic acid from a small proportion of the bacterial population.

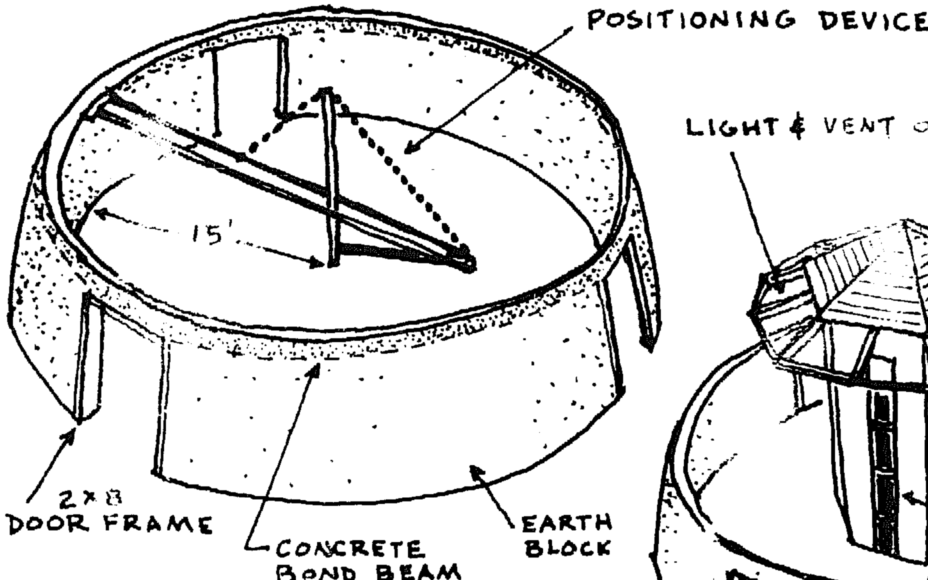
Phase 3) Initiation of the all-important lactic acid fermentation followed by massive production of this organic acid dependent upon whether or not the lactic acid microorganisms are supplied with enough carbohydrate. With sufficient carbohydrate available, the lactic acid concentration rises to approximately 1-2% and pH drops to just above 4.0.

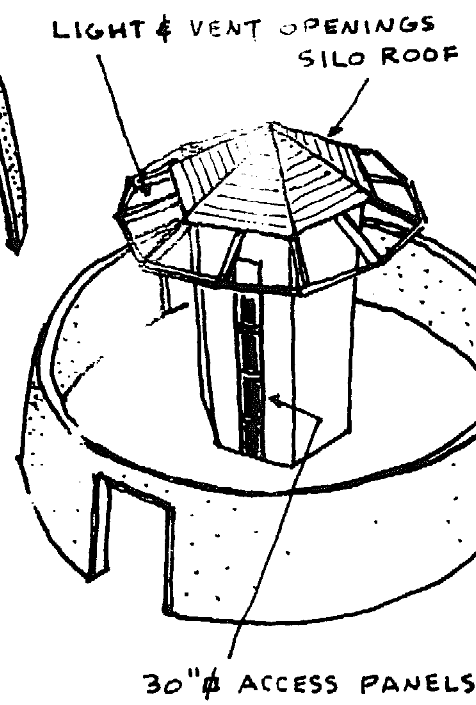
Phases 1 and 2 last about 3 days. Phase 3 continues for 17 to 21 days usually. If insufficient lactic acid is produced during Phase 3, to preserve the fermented mass, then another phase may set in.

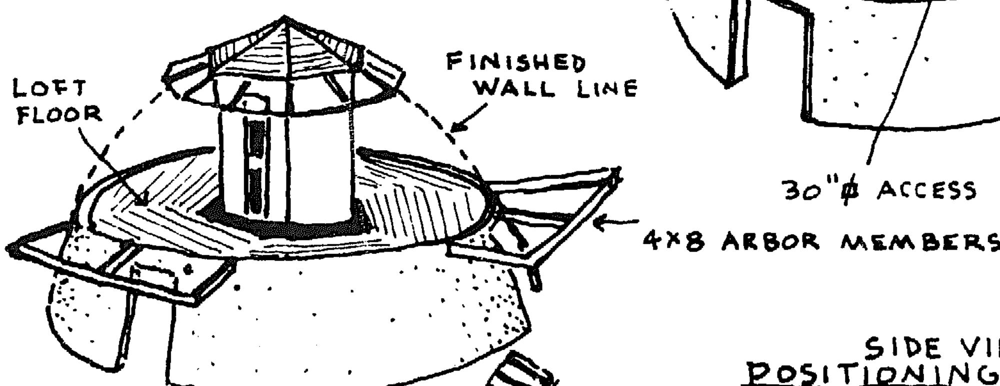
Phase 4) The attack by microbes on the material producing butyric acid, destroying lactic acid and protein. This attack yields ammonia which further neutralizes acids produced. The result is serious spoilage.

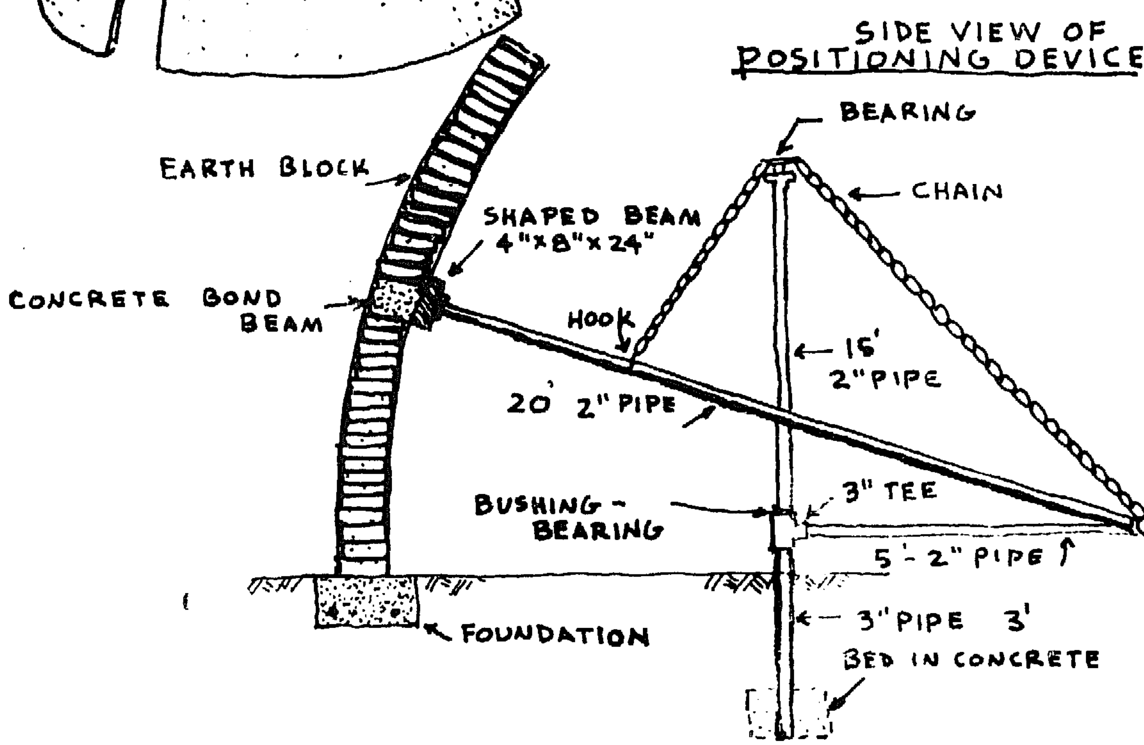
Sequence for building an adobe dome barn & silo:

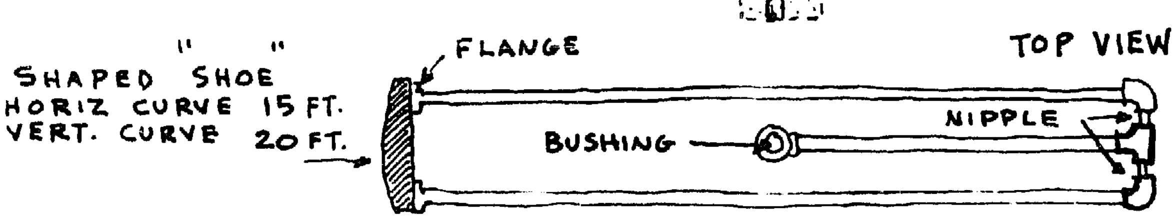
1) Set positioning device to establish 15-foot floor radius, I. D., (more or less footage as required) and 20-foot dome height.
2) Pour continuous, reinforced, concrete foundation grade beam.
3) Set and brace three, equidistant door frames Suggested opening = 4' wide by 7' high. Use treated 2 x 8 material.
4) Horizontal layers of 12" Cinva Ram block are laid against shaped shoe between door jams. As each layer is completed, support chain is adjusted, raising shaped shoe which guides following courses of brick.
5) At door lintel height (7 feet), attach external metal form to shaped shoe and cast 8"-thick reinforced concrete bond beam.
6) Block out between brick for 4" x 8" hay loft support beams and resume laying brick on bond beam until a 14-foot diameter opening at top of barn is realized.
7) Remove positioning device at 3" tee and erect silo (per design page 171). Provide four 30-inch square openings in one silo wall for silo access. At loft height, embed 1/2" bolts in concrete and continue silo wall to top. After silo concrete is firmly set, bolt on 2 x 6 wooden ribbon which supports loft members.
8) Frame 4" x 6" silo roof members to butt into edge of 14-foot diameter barn roof opening.
9) Fasten one end of 4" x 8" loft support member to ribbon on silo wall, bearing midpoint on concrete lintel. Other end cantilevers beyond doorway for arbor support.
10) Cover hay loft floor with 2 x 6 T & G decking. Retain 24-inch opening around silo for light and ventilation.
11) Plaster dome exterior with waterproof cement
12) Install fiberglass-covered panels in loft openings and in lower-level door openings.

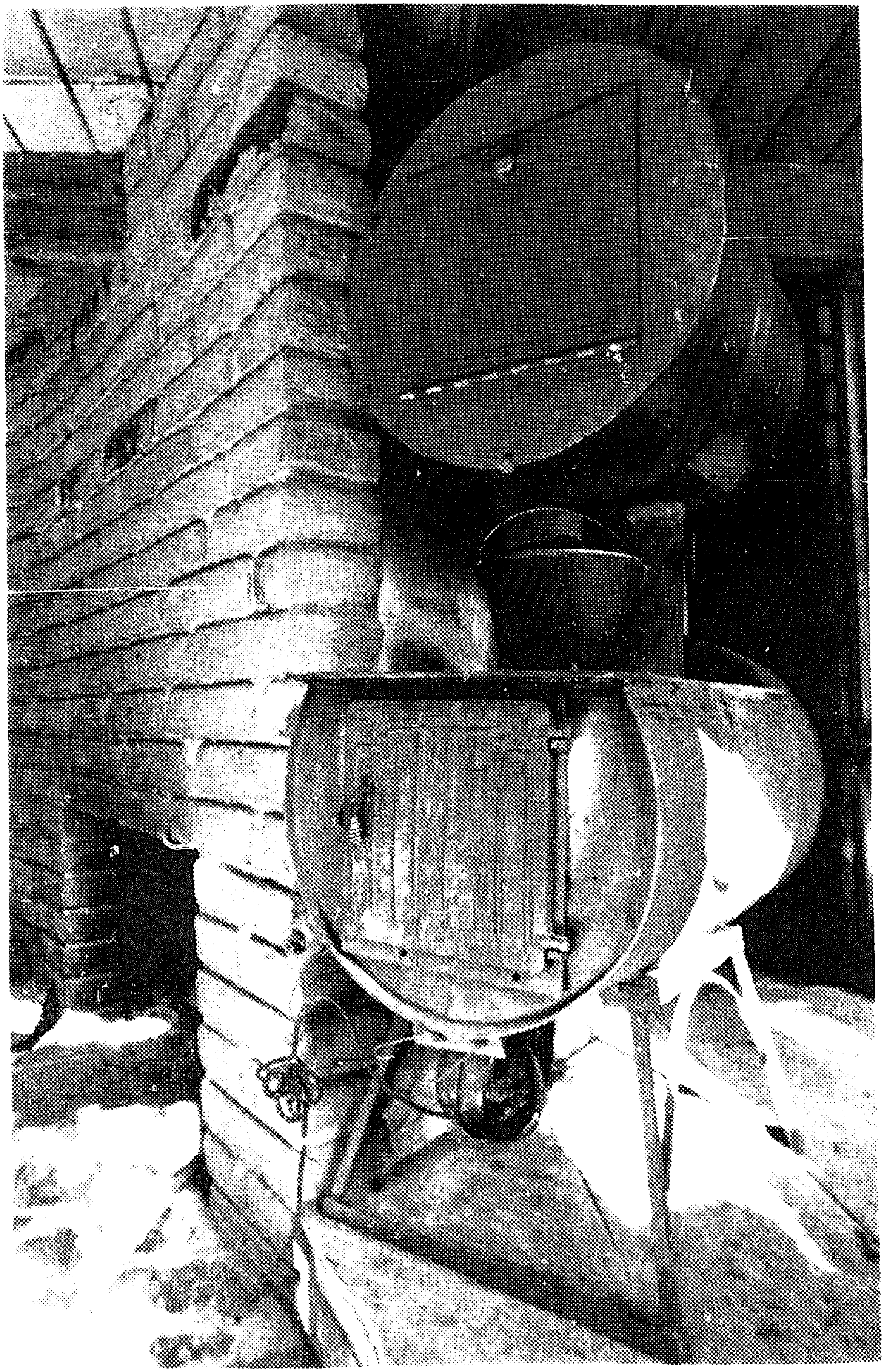

POSITIONING DEVICE
15'
2×8
DOOR FRAME
CONCRETE
BOND BEAM
EARTH
BLOCK


LIGHT & VENT OPENINGS
SILO ROOF
30"ϕ ACCESS PANELS


LOFT
FLOOR
FINISHED
WALL LINE
4×8 ARBOR MEMBERS


SIDE VIEW OF
POSITIONING DEVICE
BEARING
CHAIN
EARTH BLOCK
SHAPED BEAM
4"×8"×24"
CONCRETE BOND
BEAM
HOOK
15'
2" PIPE
20' 2" PIPE
BUSHING -
BEARING
3" TEE
5'- 2" PIPE
FOUNDATION
3" PIPE 3'
BED IN CONCRETE


SHAPED "SHOE"
HORIZ CURVE 15 FT.
VERT. CURVE 20 FT.
FLANGE
TOP VIEW
NIPPLE
BUSHING



Wood Heating & Cooking

Author's Note: Parts of this supplement appeared in Chapter 3, Wood Power, by Ken Kern from the book Producing Your Own Power, edited by Carol Stoner, published by Rodale Press, Inc., 1974.

The now-popular phrase *do your own thing*, coined more than a century ago by Ralph Waldo Emerson, aptly expressed traditional Yankee values. More and more people today, seeking an alternative to "contemporary living," have romantically turned their gaze back to those "fine times" of realism and self-reliance. But with all its earthy nostalgia, to do your own thing in 19th century Emersonian fashion would be extremely arduous and, assuming 20th century men and women could and did succeed in mastering such a lifestyle, it would still leave them esthetically, culturally and socially underfed. Consequently, at some point in our development during the last hundred years, Emerson's philosophy was scrapped in favor of a more comfortable and *technically* challenging existence: it was found that machines could do our thing for us.

In 19th century Massachusetts, Emerson did his own thing by chopping fireplace wood to keep his house warm. Fuel gathering was slow and difficult, fireplaces totally inefficient, houses inadequately insulated and improperly oriented. Little wonder his neighbors went forward to evolve new and improved methods of heating their homes. Typical of

20th century machine technology, heating methods were developed to give automatically controlled, equal, and evenly distributed heat flow by way of some umbilical fuel line. Dependence on the factory-produced furnace and radiator or duct-work and on the distant fuel supply would, of course, be abhorrent to Emerson: not only his self-reliance reduced to a thermostat setting, but one's very freedom and independence in the hands of centralized fuel monopoly and/or government control.

A modern technologist, eager to succeed, would find little reward in re-designing and properly engineering Emerson's wood-burning system to make it a viable house-heating solution. Rather, the modern challenge lies in thermocouples and microswitches, heat pumps and convector convertors. Even devising a sophisticated solar collector-storage system or a fancy generator to produce methane fuel can be more fun and present a greater challenge to an engineer's superior mentality.

Actually, there has been worldwide *behind-the-scenes* technological development to make wood-burning a viable method of house heating in colder climates. I stress behind-the-scenes because wood-burning technology in this country has been very much out of the heating and air-conditioning mainstream. Much of our knowledge on the subject has come out of or has been directed toward emerging third-world nations.

The knowledge that we have gained in the past few decades would warm Emerson heartily: he could have created a comfortable living environment, heated entirely by prunings and thinnings from his woodlot, by merely combining the skills and materials then at his disposal with our present technical knowledge.

Accordingly, I have re-designed Emerson's Concord house and heating system so that the entire unit can be fabricated by anyone well motivated toward mastering his existence.

The revised house design is mine, but I have borrowed ideas for the building and equipment design developed through the years by others: Frank Lloyd Wright offered ideas on earth-berming insulation (using packed earth as insulation against the cold north wall); Wendell Thomas contributed greatly with his "no-draft floor" inventions; from India, Dr. Billig assisted with his plunger pile floor ideas; Peter van Dresser recalled the need and value of suntempering; the English scientist, Dr. P. O. Rosin, contributed a wealth of information on the aerodynamics of open fires; Jack Bays showed how to make some truly low-cost, versatile building materials from waste materials; Scott Nearing demonstrated how anyone with minimal skill can build well insulated, native stone walls. These are only a few of the people concerned with new-era housing; their expertise is described in detail in my book, <u>The Owner-Built Home</u>.

At this point you may begin to realize that to efficiently heat Emerson's new Concord house with wood, much concern must be given to the wood-burning fixtures themselves. Glance for a moment at the plan: notice, first of all, the circular shape. The northern half is curved to better withstand hydrostatic wall pressure exerted as a result of earth-berm insulation; the southern half is curve-angled and sloped to achieve maximum solar-ray incidence--from southeast to southwest radiants. The circular form also insures optimum warm air circulation, emanating from the centrally located heat source. The circulation system itself employs registers along the perimeter of the floors where the floor joins the outside walls. Heated air, cooling as it rises to the higher levels, falls and flows downward along the outside walls, through the registers and thence <u>under</u> the floor and back to the heating unit for recycling (as indicated in the drawing by flow arrows).

Additionally, this system provides for the unheard of "no-draft floor." Sudden rushes of cold air from open doors fall into the ventilation inlets by virtue of their weight, instead of blowing across the lower area of a room as they do in houses of contemporary "design". Air space below the floor is achieved by casting the floor on loose, uncompacted earth fill between concrete plunger piles spaced every 3 feet each direction. The piles are made with a crowbar driven into the ground to a depth of 3 feet, then filled with concrete. After a few weeks the loose earth settles and an air space is formed under the slab which finally rests on the concrete piles. The heat circulating through the stove or the inner chamber of the fireplace, across the ceiling, down the walls, and thence under the floor and back to the heat source is *convected* heat.

An equally valuable heat source is obtained from direct *radiation* around the fireplace hearth or wood heater. A 12-inch sunken fireplace hearth puts the heat radiation at floor level where it is most needed. It also lessens the danger of flying sparks since the trajectory of a spark from a sunken hearth is considerably shorter than that from a raised one.

A smooth and optimum warm-air movement is possible in this house only if exterior drafts can be controlled and adequate insulation is provided. Windows accordingly are fixed; ventilation is provided by separate louvre openings. South-facing windows slope to an angle commensurate with the latitude of the Concord site. Thus, during the winter equinox, solar rays strike the glass at a near right-angle incidence, providing maximum penetration of the dark, slatecovered masonry floor. As the floor becomes heated by the sun, air below the floor expands and creates an air movement there. With all warm-air outlets located at the fireplace, a down-draft principle draws cool and moist air from the exterior window and wall area, then under the floor and up at the fireplace outlets.

After sunset, or during winter storms, insulated panels--old-fashioned "shutters", if you will--hinge over the glass windows. Insulation of the cold north wall is provided by earth-berming the masonry wall. Elsewhere--on walls, ceilings and roof--a heavy coating of asphalt-clay-fiber mixture is plastered onto wire mesh. (This mixture consists of equal parts of red clay and fiber--such as sawdust, straw, cardboard, corn cob, rice hull, etc.--which has been ground through a hammermill or shredder. To this is added enough bitumul--emulsified asphalt--and water to stabilize the compound.) The same ground fiber is packed as insulation between the wall and between the roof-framing members. An 8 inch layer of sod covers the exposed roof surface.

Note on the plan that the sleeping facilities are provided in the loft. This is a sensible arrangement, heatwise, especially in northeastern climate zones. A certain amount of heat naturally filters to the loft--with registers installed to control the amount. At bedtime the loft area is always comfortably warm.

Woodburning-firplace and heater-cooking stove development have a history not unlike that of many other of man's material acquisitions, such as his dwellings and his transport vechicles. Primitive (Paleolithic) solutions

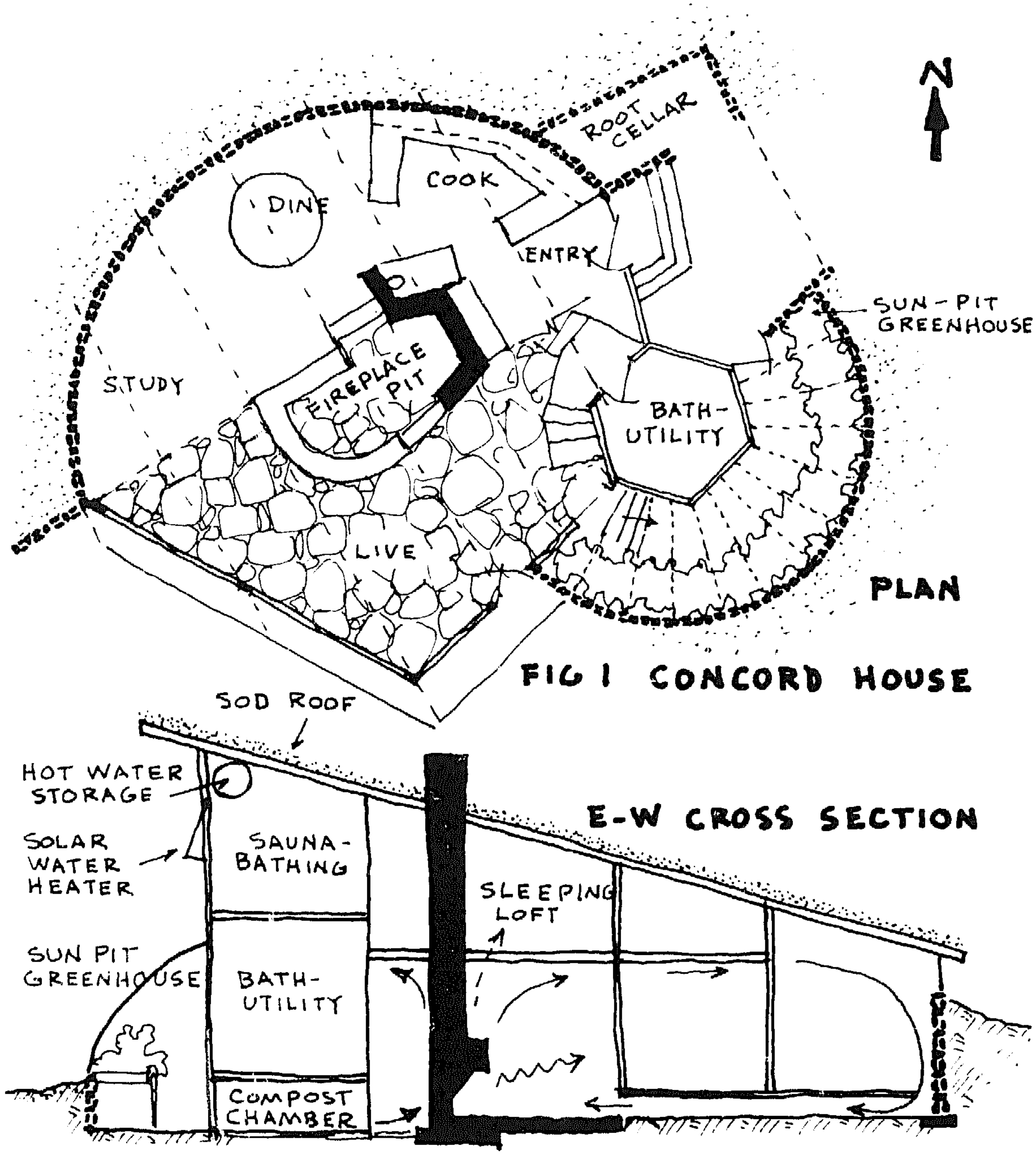


FIG I CONCORD HOUSE

for fireplace or stove were crude, but they worked. "Civilized" (Neolithic) models were gross, wasteful and worked poorly. Faint glimmerings of a new era (Biotechnic) life-style shine through our present-day morass. The light is carried by a few individuals who are able to see beyond the modern confines to a better future ahead.

Count Rumford was certainly one of these early, biotechnic torchbearers. In 1880, he published his comprehensive essay, "Chimney Fireplaces." His main contribution was in the alleviation of the smoking fireplace.

Rumford had an uncanny comprehension of fireplace aerodynamics, and, although he successfully cured the smoking fireplace, his prototype was far from being the heat efficient unit is could be. For this reason I am dismayed to see Rumford's ideas presented, as in *The Forgotten Art of Building a Good Fireplace* (by Vrest Orton, Yankee Inc., 1969), as the final authority on fireplace design. This book presents an excellent historical treatment, but modern fireplace builders, following the diagrams of this early proponent of fireplace design, realize only the disservice of half-truths for their labors. Much work preceded Rumford's revelations, and many advances have followed the Count's efforts.

For instance, Rumford apparently knew nothing about Louis Savat's circulating fireplace, installed in the Louvre 200 years before Rumford wrote his treatise. Savat's fireplace achieved an amazing 30 to 40 percent greater efficiency than present-day American tract-home fireplaces. He surrounded the grate with a metal air chamber which had warm air outlets above the fire opening. He also supplied the fire with air from under the floor, thereby subsequently reducing room drafts and further improving combustion efficiency.

Few people realize that practically all of the technical features of Ben Franklin's 1742 Pennsylvania Stove were copied from earlier inventors. Savat's concept of preheated draft was employed by Franklin with little change in design. The descending flue was also copied as follows: smoke rose in front of a hollow metal back, passed over the top and down the opposite side. Finally, at the same level as the hearth, the smoke ascended the flue.

The stove sold today as "The Franklin Stove" contains none of the ingenious heat-saving features that were incorporated in the original models. The only real saving grace of modern Franklin stoves is the closeable open-fire, which enables one to get a more efficient stove heat from a fireplace merely by closing a set of folding metal doors. According to The British Research Station, a closed fireplace unit is 50 percent more efficient than an open fire.

Count Rumford was horrified by the dirty, inefficient, labor-making, fuel-devouring cooking range that adorned the English kitchen. Cooks at work over them, he said, "...looked and felt like buttered mummies," so great was the heat loss from the average range. Rumford solved the problem in 1800, but the solution has yet to trickle down to 20th century biotechnic wood economy. The problem of heat emission was so well handled in Rumford's range that he later had to install a nearby fireplace to keep the cook warm! His principle was two-fold: produce heat only when needed, but not in excess; and, by insulating the range, use the heat before it is lost. His range was a massive brick affair. Cooking utensils were fitted into the masonry counter top and covered with insulating lids. Each utensil had its own separate fire source, grate, ash pit and air regulator. His large ranges were built on a U-shape which certainly made a convenient work space of the cook.

A hundred years elapsed between the time when Rumford made the first major breakthrough in range design and when a similarly efficient unit was produced in Sweden. During this interim millions of gross iron monsters were pawned off on an unsuspecting public. And worse, possession of the ornate, grandmotherly iron range has become the personal dream today of nearly all back-to-the-landers, people who should know better! Like Rumford a hundred years before him, Dr. Gustaf Dalem had a chance to observe all the unnecessary chores associated with cooking. This one-time Swedish physicist and Nobel Prize winner was kept at home by blindness, and, while there, he made himself useful by developing what is perhaps the most efficient range ever built, the AGA. Again, like Rumford, Dalem's creation was so efficient that later models were advertised to run on about $10 worth of fuel--the cooking cost for a whole year! Dr. Dalem employed the same goodsense principles that Rumford laid down: produce heat only when needed and use it before it is lost. The same deep-wells and insulated lids that Rumford proposed were incorporated in the AGA range.

Emerson's house in Concord, Old Manse, was originally built by his grandfather. Typical of houses of that era, it contained numerous wood-burning fireplaces, heater stoves, a cooking range, and even a laundry stove. Each of these heating units had to be kindled and stoked, and each contained an ash pan and a flue pipe requiring constant maintenance. Finally, every wood-burning unit in the house established an unique environment of convection currents. That is, throughout the house there resulted many separate currents of air circulation with an ensuing heat loss through the multitude of chimney flues. Little wonder that coal-burning, warm-air, gravity-fed furnaces became the rage soon after Emerson's time. Located in the basement, this single facility provided heat and hot water for all the upper-level living and sleeping areas.

For years, an extremely efficient wood-burning furnace, the Riteway, was manufactured in this country. Until recently, however, the model was unavailable, but now, because of our recent energy shortages, the

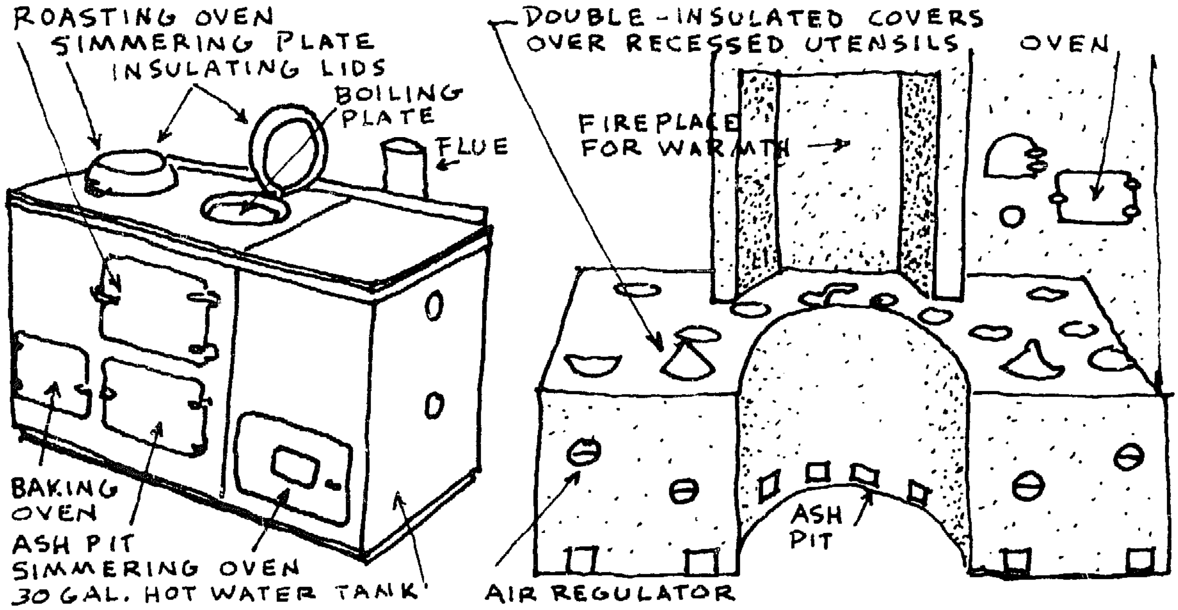


FIG 2 AGA COOKER (1929)—RUMFORD'S COOKER (1800)

stove is again being manufactured. Now called the Marco "Fuel-Master", this furnace uses either hot air or hot water as a heat medium. Fans or pumps distribute the heat so that lower-level basement installation is not required. The hot-air furnace requires room-perimeter registers connected to the furnace plenum by insulated metal ducts. Hot water installation could be either in radiant pipe coils in concrete floors or in room-perimeter baseboard radiation coils.

The basic design features of both hot air or hot water furnaces were similar. First, and most important, the furnaces provided for a *complete fuel combustion*. This principle, described below, contrasts with the usual downdraft stove, like the Ashley, in which fully 50 percent of the combustible gases leave the stove unburned, forming creosote and tars in the flue on the way out. Riteway and Fuel-Master furnaces and room heaters are equipped with a heavy cast-iron gas combustion flue located wholly inside the combustion chamber. This flue extends to the charcoal-burning level where wood gases accumulate. By providing several primary air jets over the charcoal bed, ignition of the wood gases is attained at the required 1200°F temperature. Preheated secondary air is then added to provide the necessary oxygen for complete combustion. Owners of Riteway and Fuel-Master stoves and furnaces report a fuel saving of up to 75 percent as a result of this complete combustion principle.

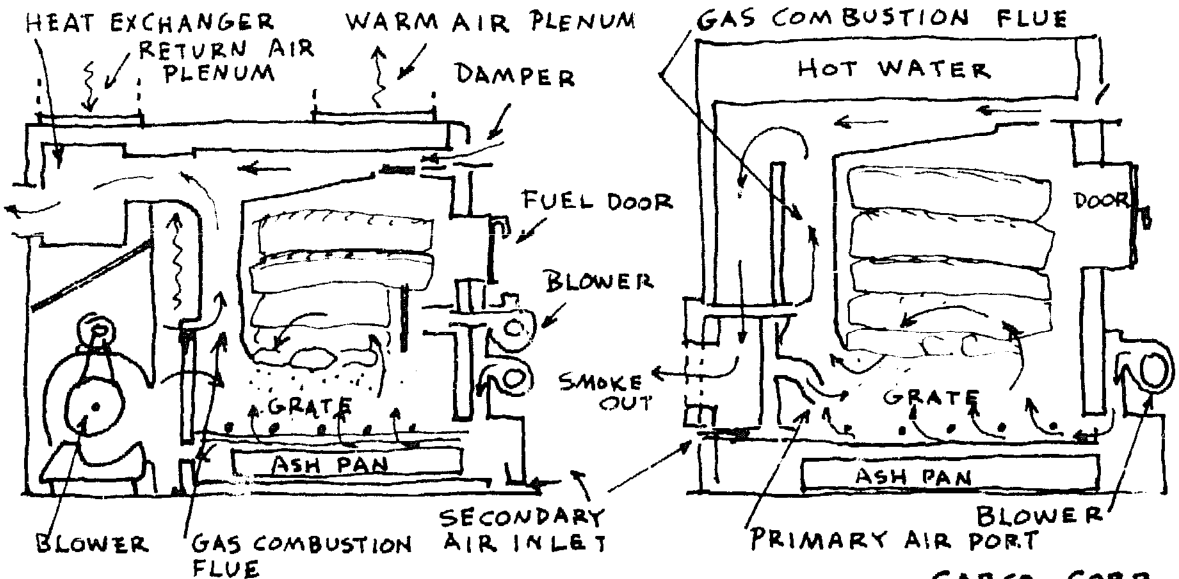


FIG 3 FUEL MASTER FURNACE & BOILER

SARCO CORP.
BOX 6
HARRISONBURG
VA. 22801

Both of these air-heating and water-heating furnaces have a wrap-around jacket containing air or water. In addition, a heat exchanger is provided on the hot-air furnace. This consists of a large chamber through which hot smoke passes before reaching the flue. The main blower forces air across and around this hot smoke chamber, deriving additional warm air for the household in the process.

Speaking now of space-heating furnaces, Emerson would have heartily praised the efficiency of performance and the prudent design of the Riteway. He would, undoubtedly, flash on such special features as fire-brick lining in the heat chamber which gives the furnace a near-indestructible quality. The Riteway heater in our homestead home has been burning continuously throughout each of 15 consecutive winters, and it is still as good as the day we bought it. The self-sustaining, continuously burning feature of this heater makes it possible that only one fire need be built in a season with only a few loadings every 24 hours to keep it going! An automatically maintained thermostat control, coupled with a heating unit that is completely airtight, makes fine control possible.

This general background introduction to efficient wood heater design demonstrates how utterly wasteful the usual installation is. But it says more: by understanding the basic fundamentals of complete combustion we can design and build our own superior unit. I would wager the opinion that, in recent years, more wood heaters have been put together in small blacksmith and backyard welding shops than in all stove foundries combined. Cast-iron stoves were popular in Emerson's time because people liked the evenly distributed heat which they radiated. But cast-iron stoves cannot be made airtight, and, of course, they require factory techniques for their mass production. Cutting and welding metal is no longer the specialized craft it once was in our grandfather's time; simple arc and oxy-acetelyene equipment have replaced blacksmithing skills.

The traditional home-fabricated stove is made from a 55-gallon oil drum, laid horizontally. A pair of cradle legs made from bent angle iron is welded to the bottom side, and a fuel access door is cut out of the front end. The outlet flue is customarily located at the rear top of this lower-level barrel and connects to a second, upper-level 55-gallon oil barrel which functions as both a heat chamber and an oven. The final flue outlet flows chimneyward at the upper back end of this heat chamber oven, although on more sophisticated barrel stoves the flue for this upper-level chamber is located above the front oven door and, thence, flows into the chimney.

These stoves were so common in the Northwest territories at one time that they were known as Yukon stoves. To meet the popular demand for the Yukon barrel stove (also called the "belly stove"), manufacturers can supply conversion kits consisting of a cast-iron fuel door, legs and a grate designed to fit the 55-gallon oil drum.

This kind of heater installation is, at best, crude and inefficient, fuel-wise. But it does speak to one of the major shortcomings of American stoves; that is, to the lack of fuel capacity. Quite a number of 3-foot-long logs can be packed into the Yukon stove. The old-fashioned school stoves had this faculty, too. They were made from half a ton of cast-iron and could burn 24 hours with one loading. Logs 2 feet in diameter and 3 feet long could be packed into these stoves, which are now collectors' items. The epitome of limited fuel capacity is the traditional cast-iron (and modern steel!) wood-burning stove.

There is good reason to combine cooking and heating functions in one unit, especially for a compact, open-planned house such as my proposed Concord design. We already imagined how Emerson (or more likely his wife) must have trotted to keep half a dozen separate fires stoked on chilly days. And, remember, each fire required a separate flue, each hot metal flue contacting potentially flammable roofing material in the attic, compounding the risk of destructive fire.

Wood-to-flue joining substantially decreases the risk of fire danger if done properly, but the build-up of creosote and tar in the flue as a result of using an inefficient stove (or green wood) is another matter. Wood is one of the hottest burning fuels. Unburned gases condense in an uninsulated metal flue, forming caked layers of combustible creosote and tar. A spark will ignite this shaft of concentrated fuel, blasting flames out of a cherry-red chimney. This is why houses burn down in the middle of a cold winter.

For fire safety, as well as for economy, I recommend combining the cooking and stove heating functions into one facility. The flue from this dual-purpose unit should be clay tile, wrapped with fiberglass insulation and encased in the centrally located fireplace masonry.

Some of the salient features of my proposed cooking-heating unit are illustrated below. The combustion chamber consists of a 35-gallon oil drum set inside and welded to an outer shell which is a 55-gallon oil drum. I chose oil drums because of their availability, their low cost, and their strong curvilinear construction. To provide a heat-absorbing cooking surface, a sheet of 1/4-inch steel plate is welded to the top of the intersecting drums. Spaced bars of 1-inch reinforceing steel form the grate. Below the grate is welded a continuous length of 2-inch diameter steel pipe, perforated *at the bottom* with drilled holes which, when open, emit a continuous draft of air the full length of the fuel bed. Draft inlets are provided at the front of the stove for quick starting and at the rear of the stove for the complete combustion of gases accumulating there. Both draft inlets are equipped with positive, fine-adjustment controls for opening and closing. The rear draft is supplied from under-the-floor air space , thereby creating a full-circle, no-draft convection current. During seasons of colder temperatures a front-mounted squirrel cage fan (virtually silent) is activated to help circu ate jacketed hot air into the room A second 55 gallon drum encases the oven at a convenient level above the cooking surface of the lower-level drum. Hot air flows from the central chamber of this upper-level drum, through a metal-boxed heat exchanger, and from there into the room.

One of the most unique--and valuable--features of the Riteway or Fuel-Master stove is its gas combustion flue. The use of such a flue should be included in our homemade version. Due to the high temperatures incurred at the point of gas combustion, a heat-resistant material, such as heavy steel pipe, should be used. It is connected directly to the heat exchanger.

Our total winter-time hot water needs are met because a thoughtful Riteway engineer provided space in the firebrick lining of the combustion chamber for a metal, water-heating collector. This one simple installation has, doubtless, saved enough electricity or gas to repay many times over the original cost of the heater itself through is uncomplicated, trouble-free, 15-year performance for our family. At one time Superior Fireplace Company, makers of the Heatform fireplace liner, offered a water-heating coil that fastened onto the metal fireback. Drawing hot water from heater <u>and</u> fireplace is an excellent idea and should certainly be included in the new Concord dwelling. Heated water naturally thermosiphons into an upper-level storage tank. In summer months a solar collector provides hot water. Solar, fireplace, and stove units are all tied into the same storage tank.

Heating water in a stove is best accomplished by circulating the water through a 1-inch iron pipe grate. One possible grate design is illustrated in Figure 6. Note that the iron pipe must be welded to 24-inch lengths of angle iron. The angle iron, in turn, rests on the inner drum combustion chamber.

With intensive use, ashes need to be removed from the stove periodically. To facilitate their removal, the grate can be swung upward against the bottom of the cook plate and secured with a wire hook. Iron pins are welded to the rear of the angle iron grate, providing this hinge action. When a water-circulating pipe grate is used, some form of swivel connection must be provided. A simple coupling should work, providing the connection is threaded an extra amount.

Water heating is only one of a half-dozen functions of this stove design. As illustrated in the drawing below, Figure 4, by simply

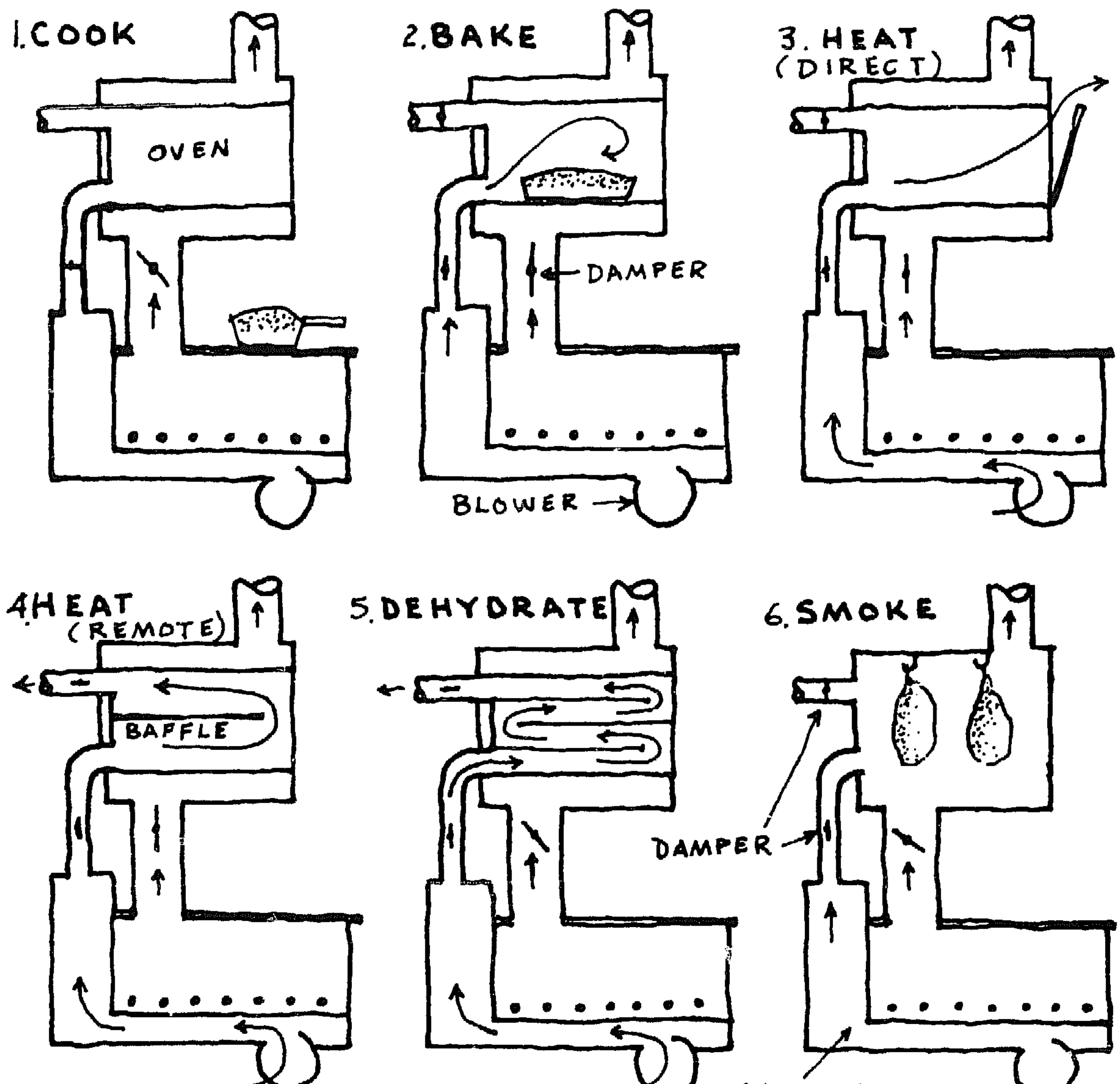


FIG 4 STOVE FUNCTIONS

adjusting a damper, a blower switch or a baffle plate one can use the stove for direct or remote room heating--or one can cook, bake, dehydrate or smoke food with it. The multi-functional aspects of this stove design make it especially well-suited for the average, wood-fueled productive homestead.

In the discussion that follows, I have disassembled each component of the stove and described its separate fabrication. Although I may specify a particular size or gauge of metal for various parts, the owner-builder should realize that his range of choice may vary widely. Many time my choice was influenced by the fact that a particular metal happened to be in stock on our homestead.

For instance, the gas combustion flue is specified to be 10-gauge, 7-inch round steel well casing. Theoretically, this flue should be heavier gauge, larger diameter cast iron and able to withstand the intense heat of combustion encountered in this section of the stove. But, while steel is easier to cut and to weld than is cast iron, well casing is cheaper and more readily available Furthermore, on my prototype stive, the well casing combustion flue proved to be entirely satisfactory.

I designed the stove unit so that any semi-skilled, metal-working homesteader could fabricate the entire unit in his home workshop. This happened only partly by choice for my own metal-working faculty is limited by inexperience and lack of sophisticated tooling. A basic understanding of arc and gas welding techniques is, of course, essential. But even here, an expertly applied bead of weld is not essential when liberal quantities of furnace cement are available. Furnace cement made the whole project possible! It took a $2 pint-size can of this amazing material to cover the multitude of welding sins on the prototype stove alone.

Stand

Construction of the metal base support is self-explanatory in Figure 5. The stand is anchored to the 55 gallon oil drum by 4-3/8" bolts which fasten the angle iron frame directly to the two ribs found on most oil drums. Note: oil drums, having these two mid-section ribs, are much preferred for their additional rigidity over plain metal drums. Drill and tap the ribs to receive the 3/8" bolts--two on each side.

Combustion Drum

A 4-inch segment is first cut longitudinally out of a 35 gallon oil drum. This cut

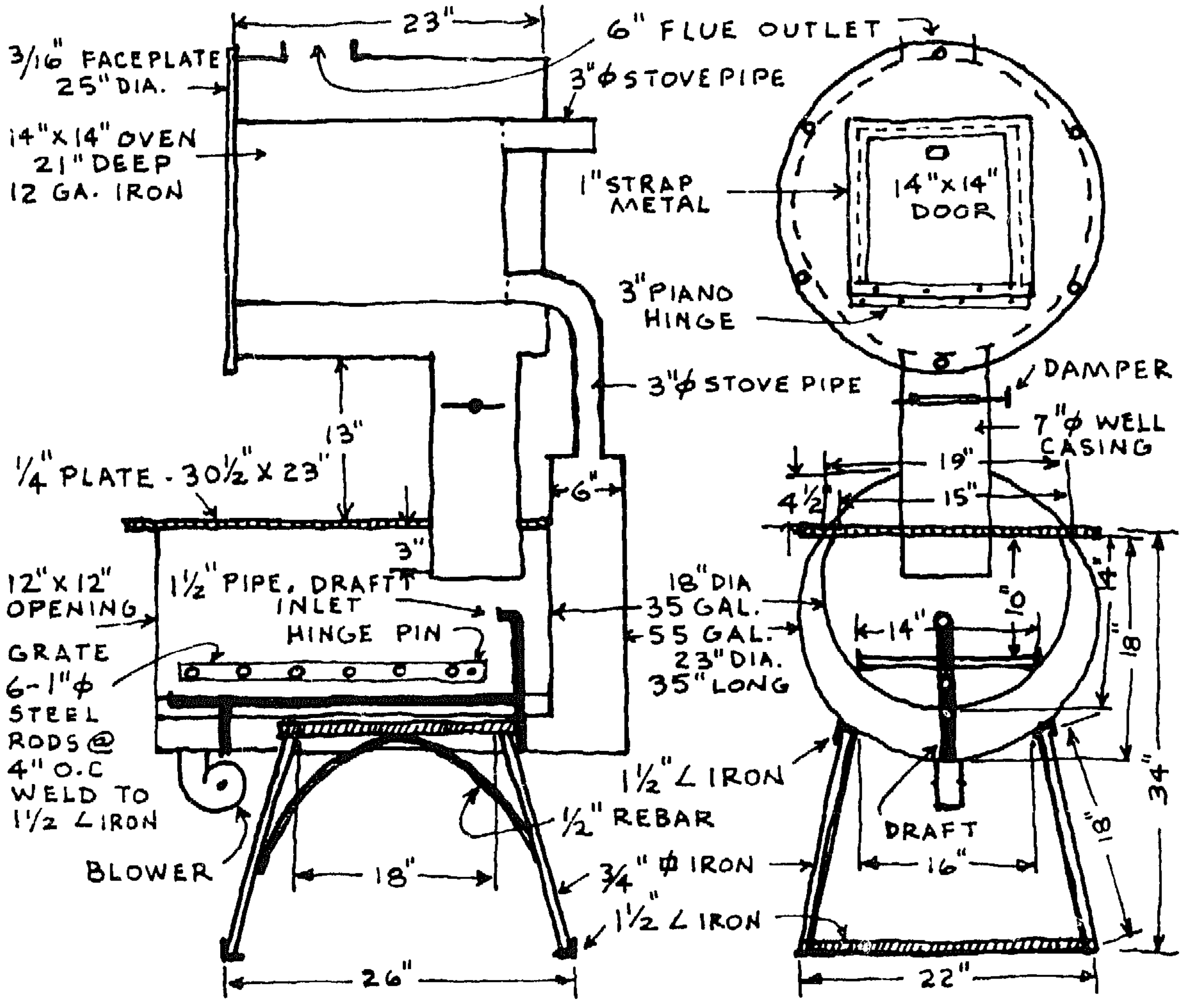


FIG 5 STOVE CONSTRUCTION

represents a chord length of 15 inches. When the plate steel cook top is welded to the cut surface there should be a net distance of 14 inches from the bottom of the barrel to the cooktop.

After the grate assembly is installed in the combustion drum and is anchored by a hinge pin on each end of the grate, the cooktop can then be welded to the combustion drum. Now cut out the front face of the combustion drum. With the grate swung up and anchored against the bottom of the cooktop, one can proceed to install the air-intake manifold. Details for assembling the manifold are illustrated in Figure 6. Now it becomes possible to weld the gas combustion flue into place. A connector flange is provided for attaching the oven assembly. Construction of this flange is also illustrated in Figure 6.

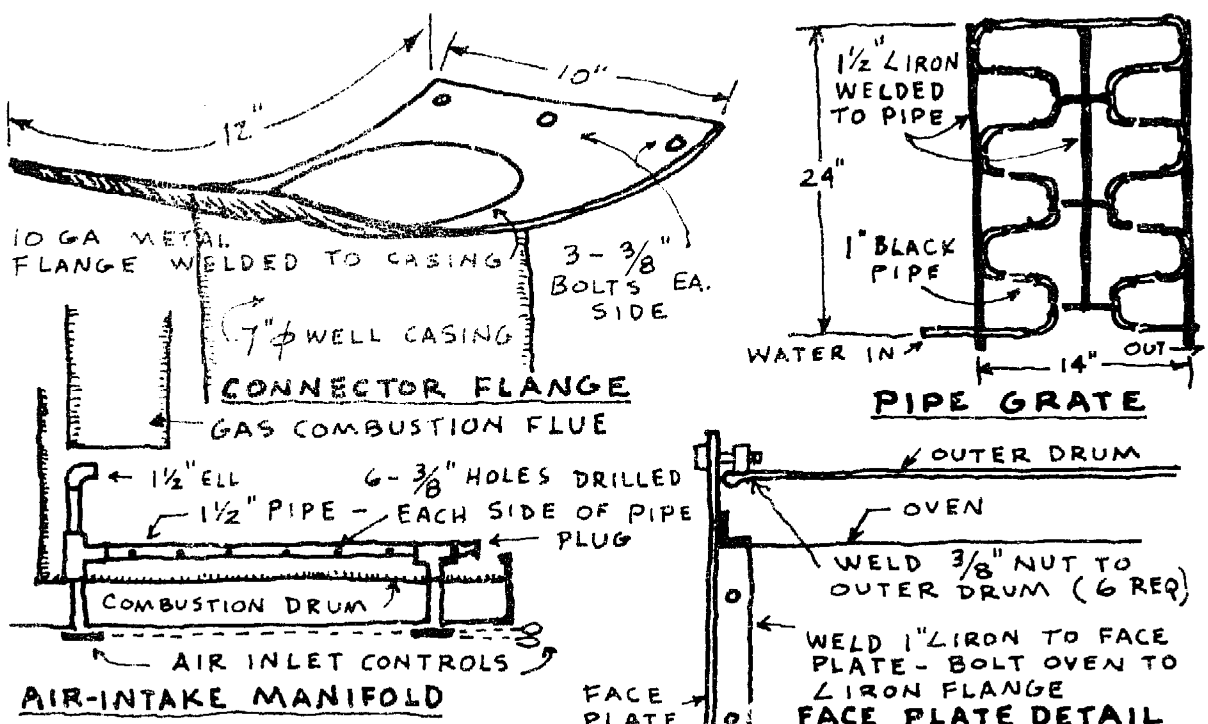


FIG. 6 DETAILS

Warm Air Chamber

The warm air chamber consists of a 55 gallon oil drum. A 5-inch segment is cut out of the drum, establishing a chord length of 19 inches and an 18-inch distance between the bottom of the drum and cooktop. Now weld the drum to the cooktop, install the fore and aft dampers and the blowers. The stand can now be bolted to the drums, and the fuel access door may be bolted in place. On the prototype model the fuel access door was salvaged from an old wood heater. One can also be made from 3/16" steel plate, using a 3-inch piano hinge.

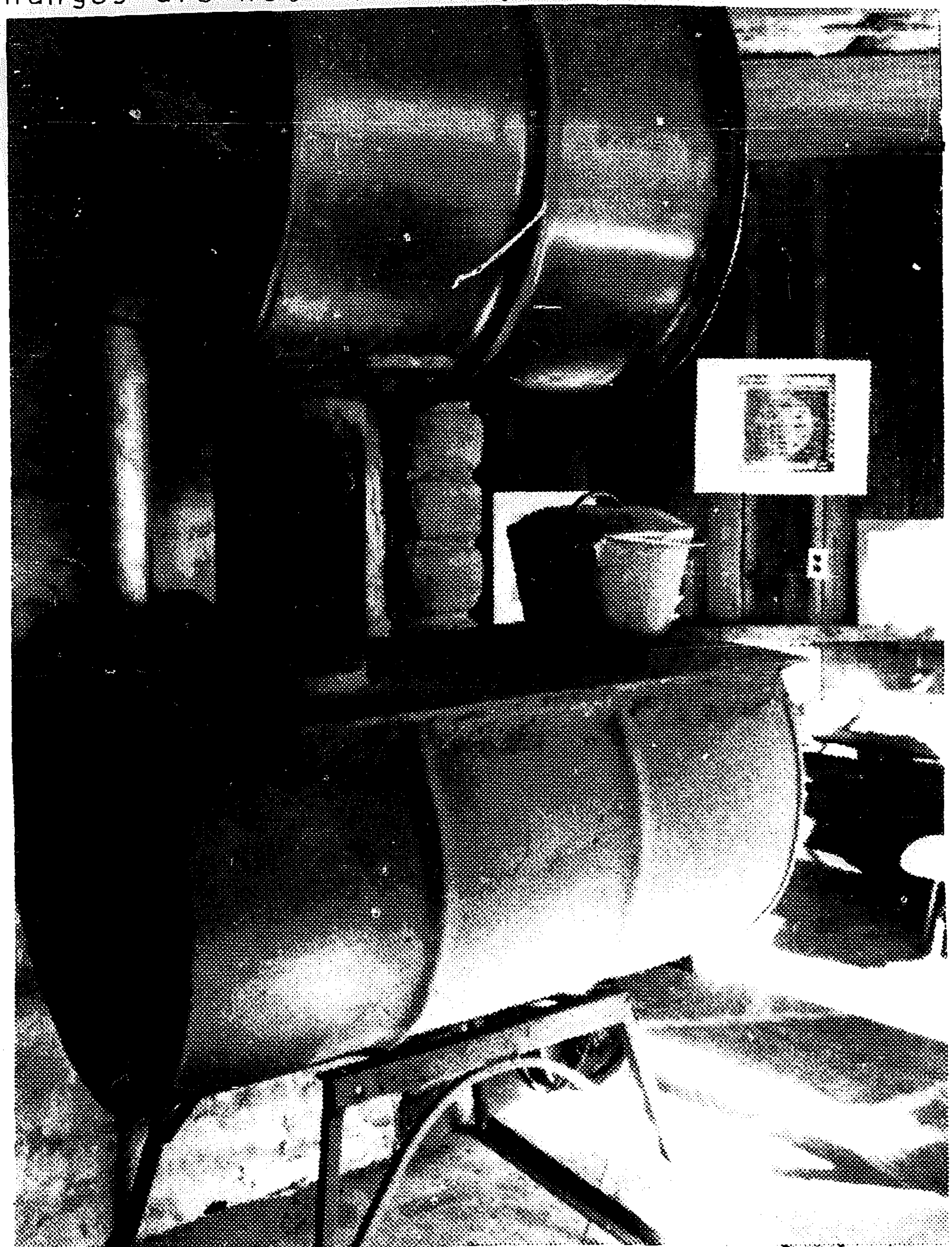
Oven

Smoke circulates between the outer shell and the actual oven chamber. To form the outer shell, cut a 1/3 section off of a 55 gallon drum. Remove the lip from the discarded section and weld it to the drum edge. This provides a finished edge onto which the oven face plate can be bolted. The 3/16" steel face plate is anchored to the outer oven shell with 6-3/8" bolts. An illustration, Figure 6, shows how this is done. The oven chamber is welded directly to the face plate. When the outer chamber is used for smoking meat, the inner chamber must be removed. One method for making this attachment is illustrated in Figure 6.

Outlets

All that remains to complete the stove is the provision for smoke flue, dampers and warm air outlets. A metal ring needs to be welded on the top of the outer oven shell to receive a 6-inch stove pipe. For this, I recurved a 2-inch section of well casing. All warm air outlet pipes were made from 3-inch galvanized iron flue pipe. A system of dampers is necessary if heat is to be supplied to other room areas.

Over a period of a winter season a number of adjustments and changes in the stove design were made, increasing its basic efficiency. This is not to say that further changes are not in order. As individual



owner-builders fabricate their own stoves I am certain that improvements will be forthcoming. Hopefully, feedback from the experience of others will enable us to update this material regularly.

To Program Your Homestead

My book suggests only general, sometimes briefly stated, homestead development concepts. Specific planning details can only develop from my personalized evaluation of your particular homestead site and your family homestead requirements. Consequently, a homestead planning service is initiated in conjunction with this book. The following questions relative to your site and your requirements should be answered and returned to me along with a $10 preliminary design fee. By return mail, I will submit to you a homestead layout plan for your approval. Following acceptance of this initial layout, detailed working drawings of any one or of all homestead structures, including the home itself, will be made at a drafting cost of 15c per square foot of building floor area. One-half of this cost is payable when plans are started; the balance is due when the plans are received and satisfactorily approved in all respects by you.

Complete blueprints include Floor Plan, Foundation and Roof Framing Plan, Elevations, Cross Sections and Typical Construction Details. All are sufficient for a building permit, sub-contract estimates, building loan and personal construction information.

1) HOMESTEAD SITE

A plot plan of your homestead property should be drawn to a scale of 1-inch equals 100-feet. Lightly color in the following areas: forest and woodland, dark green; meadowland and permanent grasses, light green; arable land, brown; rough hill pasture, yellow; garden and orchard, purple; agriculturally unproductive areas, red; ponds, ditches and streams, blue. Indicate North direction on this map. Draw contour lines of equal elevation at 10-foot intervals. Show existing and proposed road access, water and electrical power location and any existing buildings, fencing and other improvements. Draw arrows to specify winter wind direction, summer breeze direction and view direction from the preferred home location. Directional arrows can also be used to show water and drainage flow.

The following additional information should appear at some place on the plot plan: latitude and longitude, elevation above sea level, maximum summer temperature and minimum winter temperature, average number of growing days per year. A general description of soil conditions is useful classified as to the amount of clay, silt, fine sand, coarse gravel or stones and gravel it contains. Some indication of soil depth, drainage and amount of surface organic material should be suggested. Areas that have a tendency to erosion should be indicated. Also of use are photos of the homestead site taken from various directions, the location of which should be indicated on the plot map.

STANDARD AGRICULTURAL LABOR DEMANDS

MAN-DAYS PER ACRE		MAN-DAYS PER HEAD	
GRASS FOR GRAZING	.25	POULTRY TO 6 MO.	.1
GRASS FOR MOWING	2	POULTRY OVER 6 MO.	.3
WHEAT-BARLEY-RYE	3.5	SHEEP	1
TURNIPS	12	PIGS	1.2
POTATOES	20	CATTLE	3
VEGETABLES	20	SOWS + BOARS	4
SMALL FRUIT	45	DAIRY HEIFERS	4
ORCHARDS	55	BEEF COWS	4.5
HOPS	100	BULLS	7
GLASS	1320	DAIRY COWS	15

2) DEVELOPMENT GOALS AND MEANS

Two questions relative to the land potential of your chosen homestead site must be answered: For what use is this land most suitable? and What can I expect to receive back from my land, animal and plant husbandry efforts?

Homesteading can be classified in terms of the degree of subsistence living one desires: pure subsistence, where only property taxes and a few essentials are earned outside one's place; quasi-subsistence, where less than 25% of one's working time is devoted to outside money earning occupation; semi-subsistence, where 25-50% of one's earnings are derived from outside sources. Indicate to me which of these classifications best fits your expectations.

What one intends to receive back from the land has a lot to do with family needs and desires. The present (and anticipated future) family membership, along with ages and sex, should be listed. Describe special family interests and hobbies which might influence the homestead plan.

Food is the single largest, necessary homestead commodity. Its production is based on family need and is influenced by family taste. Some general indication of the extent to which animal and plant food sources will be sought should be made. For plants, this listing should include possibilities for their procurement from greenhouse, garden-orchard, field sod crops, pasture and woodland. If you expect to produce animal feed crops, provision must be made for processing and storage of those crops. Animal products, including meat, milk and eggs, may be desired so that some indication should be made of the extent to which you will be involved in this activity. Special production aspects, such as fish culture or products for outside sale, should be indicated. Requirements for food processing and for storage facilities should also be listed.

Finally, some thoughts need to be relayed to me regarding the degree of mechanization one anticipates. Numbers and varieties of equipment affect the shop layout and greatly influence the homestead development program.

And, last but certainly not least, this progressive consultation can be successful and satisfying to both of us, the homesteader and the consulting designer, if lines of communication are always open and freely used. Reader response is gratifying to the writer as well as to this designer-author. Successes and failures, alike, should be animatedly shared and discussed, so that failures may be explored, resolved and, hopefully, avoided by others in our human community, and so that your successes may help to establish viable alternatives for others desirous of living their lives close to the land.

The completion and final publication of The Owner-Built Homestead coincides with the formation of our new organization, Owner-Builder Publications. As a non-profit, charitable entity, chartered in California, we are primarily engaged in promoting self-help, owner-builder approaches for the satisfaction of human food and shelter needs. Specifically, we will research, develop and publish a series of bulletins on home building and homestead development topics. Many subjects briefly covered in this book will be expanded in detail. Working drawings for such items as the sun pit greenhouse, the homestead barn and silo combination, fish culture ponds, water storage tanks, the compost privy and the home-made cooking-heating stove are to be developments first on the agenda. A catalogue of available publications will be issued twice yearly. Those wishing to be placed on the free mailing list for this catalogue are urged to write:

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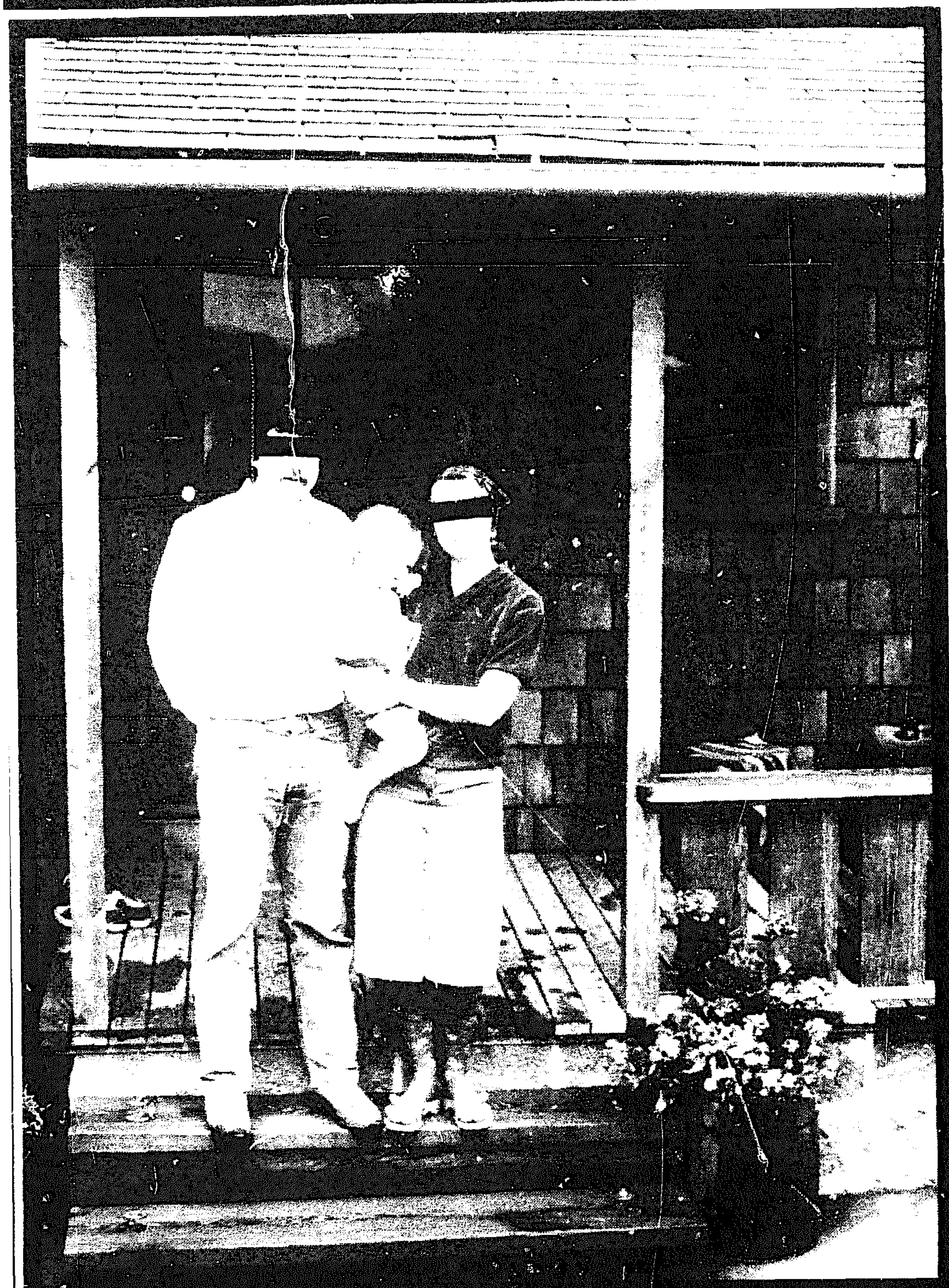
93644

THE OWNER-BUILDER AND THE CODE



POLITICS OF BUILDING YOUR HOME

Ken Kern Ted Kogon Rob Thallon

Further Reading

The Owner-Builder and The Code: Politics of Building Your Home The first indepth treatment of the building code, including reform measures, evasion techniques, individual case studies, along with a clear presentation of the owner-builder experience. Many photos. Paperback $5.00

Lewis and Sharon Watson (Stonehouse Publications, Sweet, ID 83670) operate Earth Books Lending Library. This is a valuable service for those wishing to read books on homesteading without having to purchase them. Send for their catalogue (25¢), Homesteading 1975!

The Alternative Sources of Energy group (Rt. 2, Box 90-Am Milaca, MN 56353) also offer an extensive lending library service. Send for their special "access, information and people" issue, No. 15. $1.00

Books recommended by the author can be purchased from Homestead Press (Star Route, Auberry CA 93602). Please prepay. Add 50¢ for postage and handling; California residents add 6% for tax.

Farmers of Forty Centuries	$7.95
Living the Good Life	2.25
Tree Crops	8.95
Flight from the City	1.95
Diet for a Small Planet	1.25
Go Ahead and Live	1.00
Five Acres and Independence	2.50
Farming for Self Sufficiency	7.50