COST OF RAISING CONTAINERIZED TREES IN THE UNITED STATES
PART A -- A COMPUTER PROGRAM [1/]

Richard G. Hallman [2/]

Abstract.--To help forest tree nurserymen determine if a greenhouse operation for growing seedlings is practical for them, a computer program has been developed. By using the program a potential greenhouse operator can quickly get an estimate of investment and operational costs.

INTRODUCTION

Ever since nurserymen began to grow forest tree seedlings, they have tried to improve growing conditions for their crops. They have made significant progress in practices such as watering, fumigation, fertilization and insect and disease control, to name a few.

However, because of their outdoor situation, nurserymen have not been able to control the environmental conditions that promote optimum growth. They looked with envy at horticultural growers who could afford glass greenhouses.

Today the picture has changed. New products and new construction methods now make greenhouse growing of a wide variety of crops economically feasible. This change, together with the development of seedling containerization, is causing a revolution in the forest tree nursery industry. Many nurserymen have already begun to produce greenhouse grown seedlings.

Many others are interested in the concept but are not sure if it is feasible for them, especially those located in the colder climates of the United States. To help forest tree nurserymen decide if a greenhouse operation is practical for them, the Missoula Equipment Development Center was assigned the task of making an economical and technical feasibility study of growing seedlings in a controlled environment. Working in cooperation with the Agricultural Engineering Department, Montana State University, Bozeman, Montana, a package consisting of three reports and a computer program was developed. The package includes the following reports:

Greenhouses: A Survey of Design and Equipment. The report is intended to serve as a primer for understanding the basics of how greenhouses operate.

A Tree Seedling Greenhouse: Design and Costs. The report takes the reader through the process of designing a greenhouse, selecting components and determining initial and operating costs.

Comparing Costs: A Computer Program. The computer program was developed to assist tree seedling producers to evaluate the costs of producing tree seedlings in greenhouses under controlled environmental conditions. By using the program, a producer can compare many different production methods and greenhouse design alternatives in a short time. The effect of these alternatives on total seedling production and costs can be determined with a minimum of effort before detailed designs are developed.

1/Paper presented at North American Containerized Forest Tree Seedling Symposium, Denver, Colorado, August 26-29, 1974.
2/Forester, Missoula Equipment Development Center, USDA Forest Service, Missoula, Montana.

DESCRIPTION OF THE COMPUTER PROGRAM

The computer program was written for Xerox Sigma 7 computer. The programming language is Xerox Basic. The program has been tested on a Sigma 7 computer at Montana State University. It can be used on other computers with a minimum of modification. The person using this program does not have to be skilled in computer use. He does, however, have to know something about greenhouses and their operation.

The program will run on a sample design if not altered, which means that greenhouse components and an operating schedule have been programmed. The sample design serves as a standard around which variations can be made. Figure 1, Computer Run on Sample Design, illustrates how the printout will appear if no new variables are added. To depart from the sample design program, the operator can introduce new and different variables over and over while the program is running until he finds the particular combination he feels is best for his operation.

The computer program was divided into two parts to solve two types of problems. In Part I, the program helps determine the space needed to produce the desired number of seedlings. In Part II the program considers the design and operating conditions for the greenhouse and calculates the investment and operating costs.

Part I - Space Requirements

In this portion of the program the computer determines the space required to grow the desired number of seedlings. The operator controlled inputs and the computer outputs are as follows:

Inputs

1. Number of seedlings to be grown per year.
2. Percentage of seedling survival.
3. Number of crops to be grown per year.
4. Number of months of operation per year.
5. Level of mechanization, high or low.
6. Type of container used, dimensions, number of cavities and size of cavities.

Outputs

1. Possible number of seedlings per house.
2. Number of seedlings per house with a given percentage survival.
3. Number of greenhouses needed.
4. Number of seedlings produced per crop with all houses filled.
5. Number of seedlings that can be produced annually.
6. Amount of land area required.

All values are calculated using a 30 x 108 foot greenhouse module. With high mechanization the containers are on pallets that can be rolled on a track into the greenhouse. The watering is semiautomatic and no space is left for a worker to move between the pallets. With low mechanization the containers are placed on tables or frames and the watering is by hand. Space is left for the worker to move around the containers. With high mechanization there will be 2,400 square feet of containers in each 30 x 108 house. With low mechanization the container space is reduced to 1,620 square feet per house. The land area calculation assumes that each house will need approximately 0.3 acre and that an additional 1.3 acres will be needed for other support facilities.

Part II - Design Conditions and Costs

Investment Calculations (A-I)

A. Site Preparation

Blacktop is used for driveways and walks at the rate of 1,260 square feet + 1,000 square feet per house. Gravel is used at the rate of 5,200 square feet per house.

B. Water Supply

A well and pump with adequate capacity for greenhouse use will cost $200 + $53 per foot. The hookup fee for city water is $425.

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GROWING TREE SEEDLINGS IN A GREENHOUSE
AGRICULTURAL ENGINEERING DEPARTMENT
MONTANA STATE UNIVERSITY; BOZEMAN, MONTANA;
USDA FOREST SERVICE; MISSOULA, MONTANA


THIS PROGRAM CONSIDERS ALTERNATIVES IN SELECTING MATERIALS
AND OPERATING METHODS TO BE USED IN A GREENHOUSE OPERATION


PROGRAM WILL RUN ON A SAMPLE DESIGN IF NOT ALTERED

 1640000  SEEDLINGS PER YEAR AT 90  % SURVIVAL
 2  CROPS PER YEAR
 12  MONTHS OF OPERATION
 HIGH LEVEL OF MECHANIZATIoN
 CONTAINER DIMENSIONS ARE 20.25  X  14  INCHES
 192  SEEDLINGS PER CONTAINER
 2.4  CUBIC INCH SEEDLING CAVITY VOLUME

DO YOU WANT TO CHOOSE GREENHOUSE SYSTEM SIZE AND CROP
PRODUCTION OBJECTIVES ?  1-YES  0-NO
?0

NUMBER OF SEEDLINGS DESIRED PER YEAR IS 1640000

NUMBER OF CROPS PER YEAR IS 2

POSSIBLE NUMBER OF SEEDLINGS PER HOUSE IS 234057.

SEEDLINGS PER HOUSE WITH 90  % SURVIVAL IS 210651.

NUMBER OF GREENHOUSES NEEDED IS 4

SEEDLINGS PER CROP WITH FULL HOUSE PRODUCTION IS 842606.

ANNUAL PRODUCTION IS 1.68520E+6  SEEDLINGS

LAND AREA REQUIRED IS 2.5 ACRES


DO YOU WANT TO CHANGE OPERATION SIZE OR CROP PRODUCTION
OBJECTIVES ? 1-YES  0-NO
?0


DOUBLE LAYER POLYETHYLENE FILM ON GALVANIZED PIPE
QUONSET STRUCTURE
GREENHOUSE ROOF -   ONE LAYER UV INHIBITED, THE OTHER
                    LAYER GREENHOUSE GRADE
GREENHOUSE CORRIDOR COVERED WITH 15% MODIFIED ACRYLIC
FIBERGLASS


INITIAL INVESTMENT = $ 124382.

ANNUAL OPERATING COST = $ 28848.7

ANNUAL FIXED COST = $ 23564.1

TOTAL ANNUAL COST = $ 52412.8

COST PER SEEDLING = 3.11016  CENTS

DO YOU WANT TO MAKE CHANGES?
?0
```

Figure 1.--Computer run on sample design.

C. Structure Selection

The costs for the greenhouse structure are as follows:

Galvanized steel bow quonset - $995 per house
Corridor to connect houses - $295 per house
Extruded aluminum quonset - $2,920 per house
Aluminum truss frame - $5,000 per house
Construction cost - $500 per house (except the aluminum truss frame which is $1,000 per house)
Wood truss house with double layer plastic cover - $0.75 per square foot (can be changed)

D. Cooling and Heating Requirements

A pad and fan cooling system is used with an air flow of 8 ft^3/min per square foot of floor space plus corrections for elevation, solar radiation and temperature rise in the greenhouse. Air flow through the pad is designed at 150 feet per minute. The heating system uses one or more 192,000 BTU heaters per house.

Cooling pads ($956 + $0.70 per square foot) per house
Fans ($505 + $0.01 (fan ft^3/min)) per house
Heaters ($1,470 x # of heaters) per house
Control equipment $127 per house

E. Optional Equipment

Automatic watering system - $2,010 per house
Cyclic lighting - $540 per house
CO2 generator - $100 per house
Telephone alarm system - $850 per house
Standby generator - $2,550 + $652.50 per house

F. Support Structures

Headhouse - $6,870 + $1,350 per house
Lathhouse - $1,733 per house
Lathhouse sprinkler - $100 + $162 per house

G. Materials Handling Equipment Including Pallets, Tracks and Seeding Equipment

Low mechanization, 1-4 houses - $825 + $2,670 per house
Low mechanization, 5 or more houses - $1,650 + $2,670 per house
High mechanization, no lathhouse, 1-4 houses - $4,420 + $2,400 per house
High mechanization, no lathhouse, 5 or more houses - $5,170 + $2,400 per house
High mechanization + lathhouse, 1-4 houses - $4,420 + $2,800 per house
High mechanization + lathhouse, 5 or more houses - $5,170 + $2,800 per house

H. Containers

Program determines the number of containers and cost.

I. Calculate Total Cost and Add a Contingency Fund of 5 Percent

Operating Cost Calculations (J-P)

J. Fuel Costs

Costs for natural gas or propane for heaters.
Cost for CO2 generator fuel.
Total fuel cost.

K. Electricity Cost

L. Fertilizer Cost

M. Greenhouse Cover Maintenance Cost

Single or double layer plastic - 1-1/2 percent of $950 per house
15 percent acrylic modified fiberglass - 1-1/2 percent of $5,450 per house
Tedlar clad fiberglass - 1/2 percent of $5,450 per house
Glass - 1-1/2 percent of $950 + 1-1/4 of $4,500 per house

N. Structure Maintenance Other Than Cover

Assumed as a percent of investment.
Percentage can be varied.

O. Labor

High mechanization - $14,000 + 51,750 per house
Low mechanization - $14,000 + $3,500 per house

P. Water

City water charge.
Well pumping cost.

Fixed Cost Calculations (Q-V)

Q. Insurance

Average investment x insurance rate

R. Taxes

Percent of investment x mill levy

S. Interest

Average investment x interest rate

T. Land Cost

Number of acres x $ per acre

U. Depreciation

Site preparation	30 years
Well	20 years
Plastic cover	1 year
15 percent acrylic modified fiberglass	12 years
Tedlar clad fiberglass	20 years
Glass	20 years
Galvanized steel bows	12 years
Aluminum frames	20 years
Wood truss	6 years
Environmental control equipment	7 years
Telephone alarm system	7 years
Standby generator	20 years
Pallet tracks and seeding equipment	10 years
Containers (can be varied)	5 years (in example)
Headhouse	25 years
Lathhouse structure	20 years
Lathhouse cover	7 years
Investment in contingency items	10 years
Total depreciation	

V. Total Fixed Costs

W. Output

Initial investment
Annual operating cost
Annual fixed cost
Total annual cost
Cost per seedling

Limitation of the Program

This computer program can be used over a wide range of variables. However, only those items that appear on the program worksheet can be changed. Those items that do not appear, i.e., depreciation costs, heating and cooling equipment, greenhouse structural members, etc., cannot be changed without modifying the program. The program can be updated when needed but it will require a computer programmer to make these changes. These changes may be needed frequently to correct for major price changes, etc.

Many factors other than those included in this analysis might also affect the cost and operation of a greenhouse. These factors might include unusual site problems, alternate water sources, excess water disposal problems and many more. These additional problems are beyond the scope of the computer program, but should be considered prior to construction.

Many simplifying assumptions have been made in the analysis that might not be practical for some users. Some examples are as follows:

All depreciation has been calculated on a straight line depreciation schedule with zero salvage value.

Land values are calculated on an equivalent dollar per year lease basis.

Heaters have been selected on the basis of one or more 192,000 BTU units per house. Other combinations may be more appropriate under the same conditions.

COMPUTER VARIABLES DESIGN VALUES AND WORKSHEETS

To help the prospective greenhouse operator systematically consider all the necessary variables, a worksheet was designed for the program. The worksheet is included in the computer report and is divided into eight categories.

1. Greenhouse Size and Crop Production Objectives

Computer variable	Description	Example value	Desired value
A(1,1)	Seedlings per year	1,640,000	______
A(1,2)	Percentage seedling survival	90	______
A(1,3)	Number of crops per year	2	______
A(1,4)	Months of operation per year	12	______
A(1,5)	Level of mechanization (high or low)	High	______
A(1,6)	Container length - inches	20.25	______
A(1,7)	Container width - inches	14	______
A(1,8)	Number of seedling cavities per container	192	______
A(1,9)	Size of each container cavity - cubic inches	2.4	______

2. Structure Specifications

Computer variable	Description	Example value	Desired value
A(2,1)	Cost for U.V. plastic film, ¢/ft^2	2.1	______
A(2,2)	Cost for 15% acrylic fiberglass, ¢/ft^2	30	______
A(2,3)	Cost for greenhouse grade plastic film, ¢/ft^2	1.25	______
A(2,4)	Cost for Tedlar coated fiberglass, ¢/ft^2	43	______
A(2,5)	Cost for glass, ¢/ft^2	50	______
A(2,6)	Cost for wood truss structure with double layer plastic cover, $/$ft^2$	.75	______
A(2,7)	Annual maintenance cost for plastic film, ¢/ft^2	0	______
A(2,8)	Annual maintenance cost for 15% acrylic fiberglass, ¢/ft^2	1.5	______
A(2,9)	Annual maintenance cost for Tedlar coated fiberglass, ¢/ft^2	.5	______
A(2,10)	Annual maintenance cost for glass, ¢/ft^2	1.25	______
A(2,11)	Percentage of initial investment used to estimate general maintenance cost	.5	______

3. Environmental Condition

Computer variable	Description	Example value	Desired value
A(3,1)	Barometric pressure, inches of Hg	24.5	_______
A(3,2)	Design solar energy, fc	7,160	_______
A(3,3)	Design summer outside dry bulb temperature, °F	90	_______
A(3,4)	Design summer outside wet bulb temperature, °F	65	_______
A(3,5)	Design maximum greenhouse temperature, °F	80	_______
A(3,6)	Design minimum greenhouse temperature, °F	60	_______
A(3,7)	Design winter outside dry bulb temperature, °F	-20	_______
A(3,8)	Design wind velocity, mph	10	_______
A(3,9)	Temperature of water supply, °F	45	_______
A(3,10)	Heating degree days	8,129	_______
A(3,11)	Light transmitted by a single layer of polyethylene, %	73	_______
A(3,12)	Light transmitted by a double layer of polyethylene, %	70	_______
A(3,13)	Light transmitted by fiberglass, %	90	_______
A(3,14)	Light transmitted by glass, %	89	_______

4. Optional Equipment

Computer variable	Description	Example value	Desired value
A(4,1)	Cyclic lighting (Y or N)	Y	_______
A(4,2)	Lathhouse (Y or N)	Y	_______
A(4,3)	Telephone alarm (Y or N)	Y	_______
A(4,4)	Standby generator (Y or N)	Y	_______
A(4,5)	Container cost, $/container	2.40	_______
A(4,6)	CO_2 generator (Y or N)	Y	_______

5. Operating Cost Rates

Computer variable	Description	Example value	Desired value
A(5,1)	Natural gas rate, \$/1,000 ft^3	.88	______
A(5,2)	LP gas rate, ¢/gal	24	______
A(5,3)	Electric power rate, ¢/kWh	3	______
A(5,4)	Jiffy Mix, \$/ft^3	1.25	______
A(5,5)	Vermiculite, \$/ft^3	.583	______
A(5,6)	Peat, \$/ft^3	1.00	______
A(5,7)	Perlite, \$/ft^3	.321	______
A(5,8)	City water rate, ¢/100 ft^3	30	______
A(5,9)	Source of water, (Well 1) (City 0)	1	______
A(5,10)	Water heating option (Y or N)	N	______
A(5,11)	Fuel type, (Natural gas 1) (LP gas 2)	1	______
A(5,12)	Growing media, (Cornwell Mix 1) (Jiffy Mix 2)	1	______
A(5,13)	Fertilizer cost, ¢/seedling	.148	______

6. Fixed Cost Rates

Computer variable	Description	Example value	Desired value
A(6,1)	Portion of average investment used to estimate annual insurance cost, percentage	2	______
A(6,2)	Tax levy, mills	193.37	______
A(6,3)	Interest rate, percent	9.25	______
A(6,4)	Land rental rate, \$/acre	100	______
A(6,5)	Container depreciation, years	5	______

7. Fixed Costs, Site Preparation

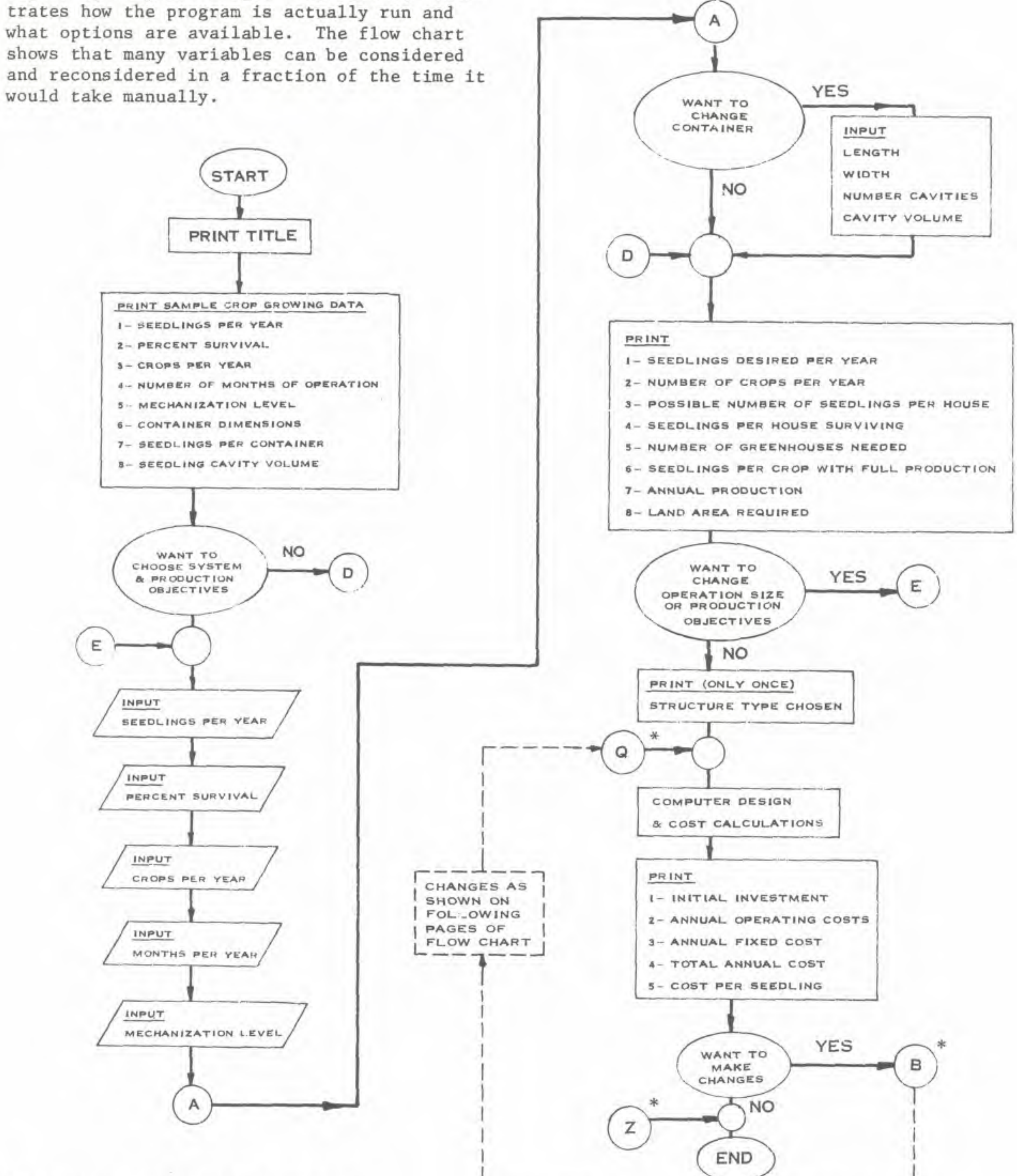
Computer variable	Description	Example value	Desired value
A(7,1)	Blacktop application, $\$/ft^2$	.475	_______
A(7,2)	Graveling, $\$/ft^2$	.111	_______
A(7,3)	Well depth, feet	100	_______

8. Greenhouse Cover Construction Factor (Heat loss relative to glass)

Computer variable	Description	Example value	Desired value
A(8,1)	Single layer polyethylene film, C.F.	1.2	_______
A(8,2)	Double layer polyethylene film, C.F.	.7	_______
A(8,3)	Fiberglass or glass, C.F.	1.0	_______

COMPUTER PROGRAM FLOW CHART

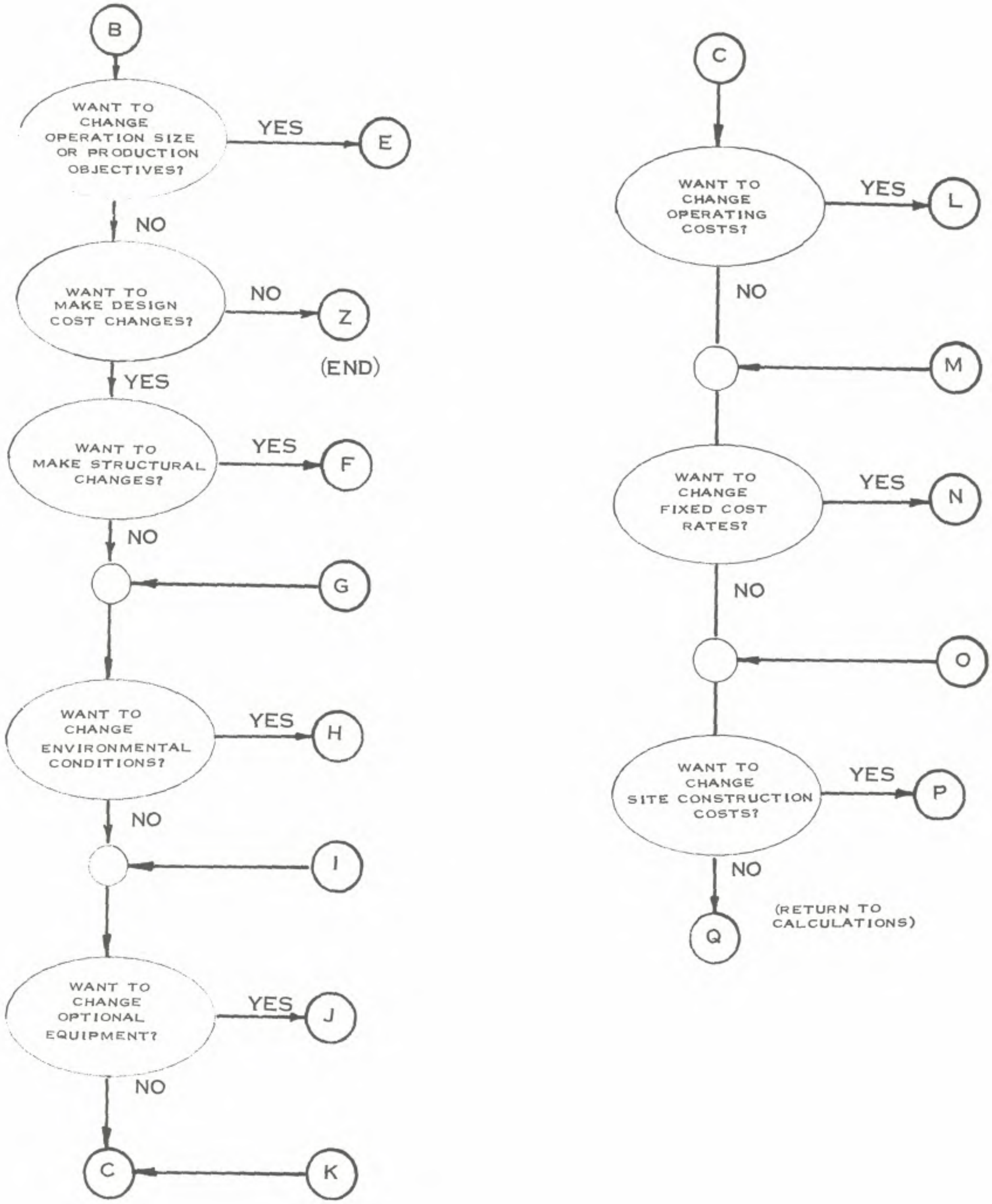
Figure 2, Computer Program Flow Chart, illustrates how the program is actually run and what options are available. The flow chart shows that many variables can be considered and reconsidered in a fraction of the time it would take manually.

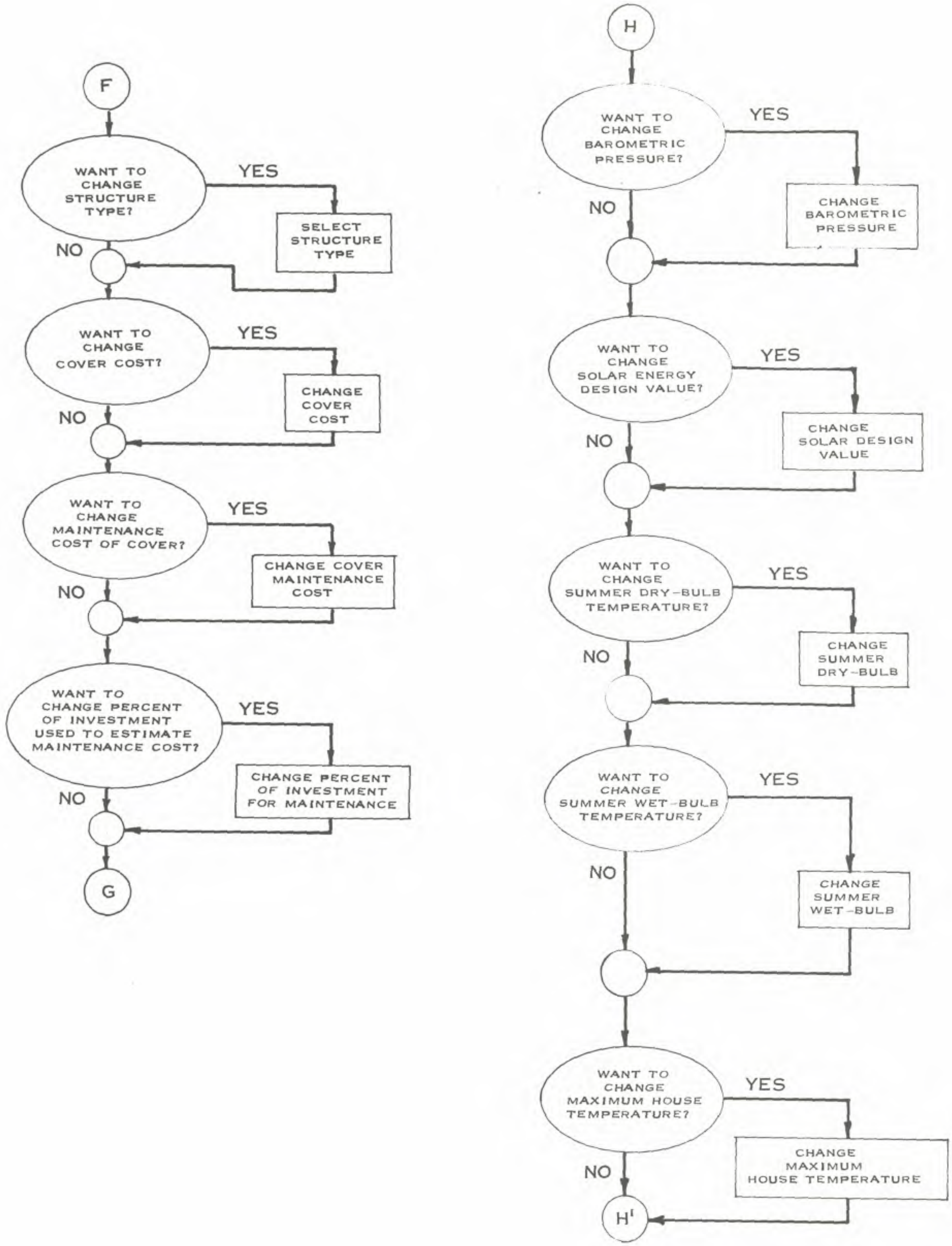


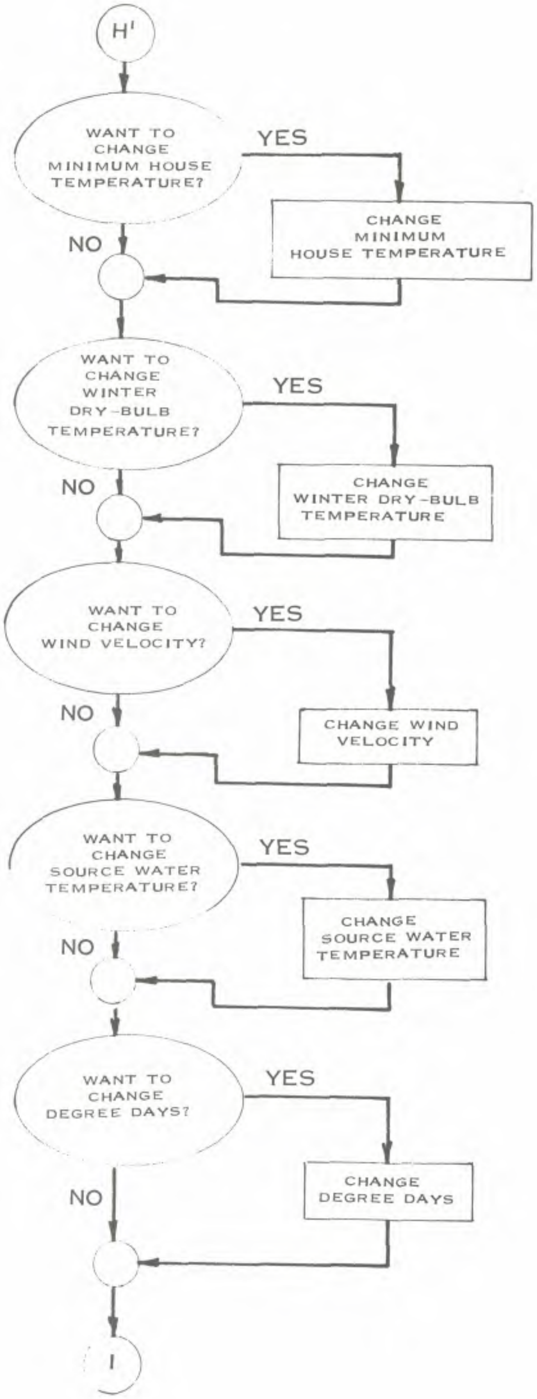
* SEE FOLLOWING PAGES FOR DETAILS

Figure 2.--Computer program flow chart.

NOTE: Figure 2 runs for 6 consecutive pages.


B
WANT TO CHANGE OPERATION SIZE OR PRODUCTION OBJECTIVES?
YES
E
NO
WANT TO MAKE DESIGN COST CHANGES?
NO
Z
(END)
YES
WANT TO MAKE STRUCTURAL CHANGES?
YES
F
NO
G
WANT TO CHANGE ENVIRONMENTAL CONDITIONS?
YES
H
NO
I
WANT TO CHANGE OPTIONAL EQUIPMENT?
YES
J
NO
C
K
C
WANT TO CHANGE OPERATING COSTS?
YES
L
NO
M
WANT TO CHANGE FIXED COST RATES?
YES
N
NO
O
WANT TO CHANGE SITE CONSTRUCTION COSTS?
YES
P
NO
Q
(RETURN TO CALCULATIONS)


F
WANT TO CHANGE STRUCTURE TYPE?
YES
SELECT STRUCTURE TYPE
NO
WANT TO CHANGE COVER COST?
YES
CHANGE COVER COST
NO
WANT TO CHANGE MAINTENANCE COST OF COVER?
YES
CHANGE COVER MAINTENANCE COST
NO
WANT TO CHANGE PERCENT OF INVESTMENT USED TO ESTIMATE MAINTENANCE COST?
YES
CHANGE PERCENT OF INVESTMENT FOR MAINTENANCE
NO
G
H
WANT TO CHANGE BAROMETRIC PRESSURE?
YES
CHANGE BAROMETRIC PRESSURE
NO
WANT TO CHANGE SOLAR ENERGY DESIGN VALUE?
YES
CHANGE SOLAR DESIGN VALUE
NO
WANT TO CHANGE SUMMER DRY-BULB TEMPERATURE?
YES
CHANGE SUMMER DRY-BULB
NO
WANT TO CHANGE SUMMER WET-BULB TEMPERATURE?
YES
CHANGE SUMMER WET-BULB
NO
WANT TO CHANGE MAXIMUM HOUSE TEMPERATURE?
YES
CHANGE MAXIMUM HOUSE TEMPERATURE
NO
H'


H'
WANT TO CHANGE MINIMUM HOUSE TEMPERATURE?
YES
CHANGE MINIMUM HOUSE TEMPERATURE
NO
WANT TO CHANGE WINTER DRY-BULB TEMPERATURE?
YES
CHANGE WINTER DRY-BULB TEMPERATURE
NO
WANT TO CHANGE WIND VELOCITY?
YES
CHANGE WIND VELOCITY
NO
WANT TO CHANGE SOURCE WATER TEMPERATURE?
YES
CHANGE SOURCE WATER TEMPERATURE
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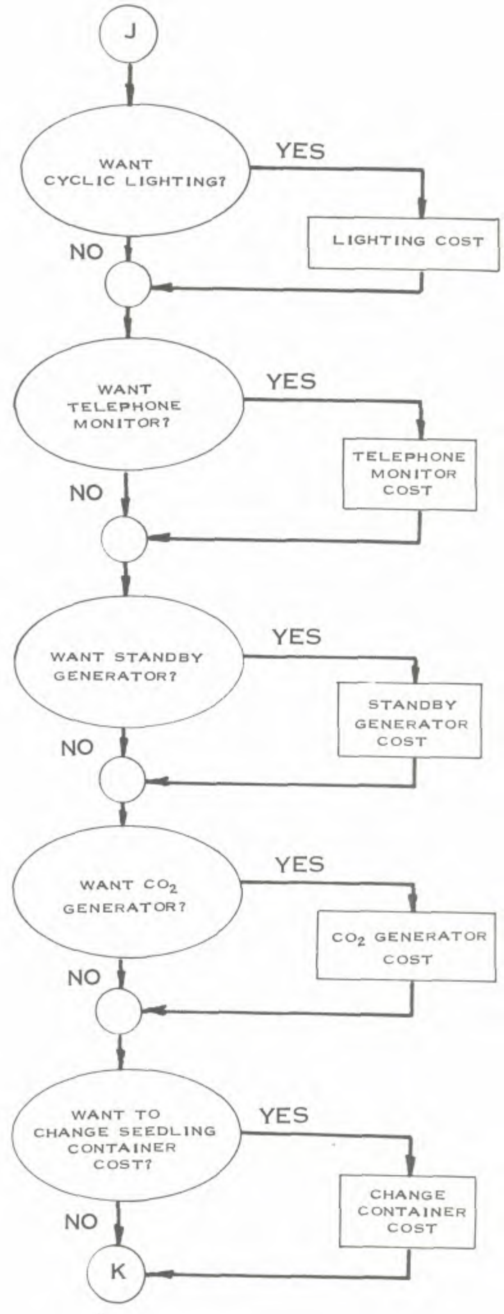
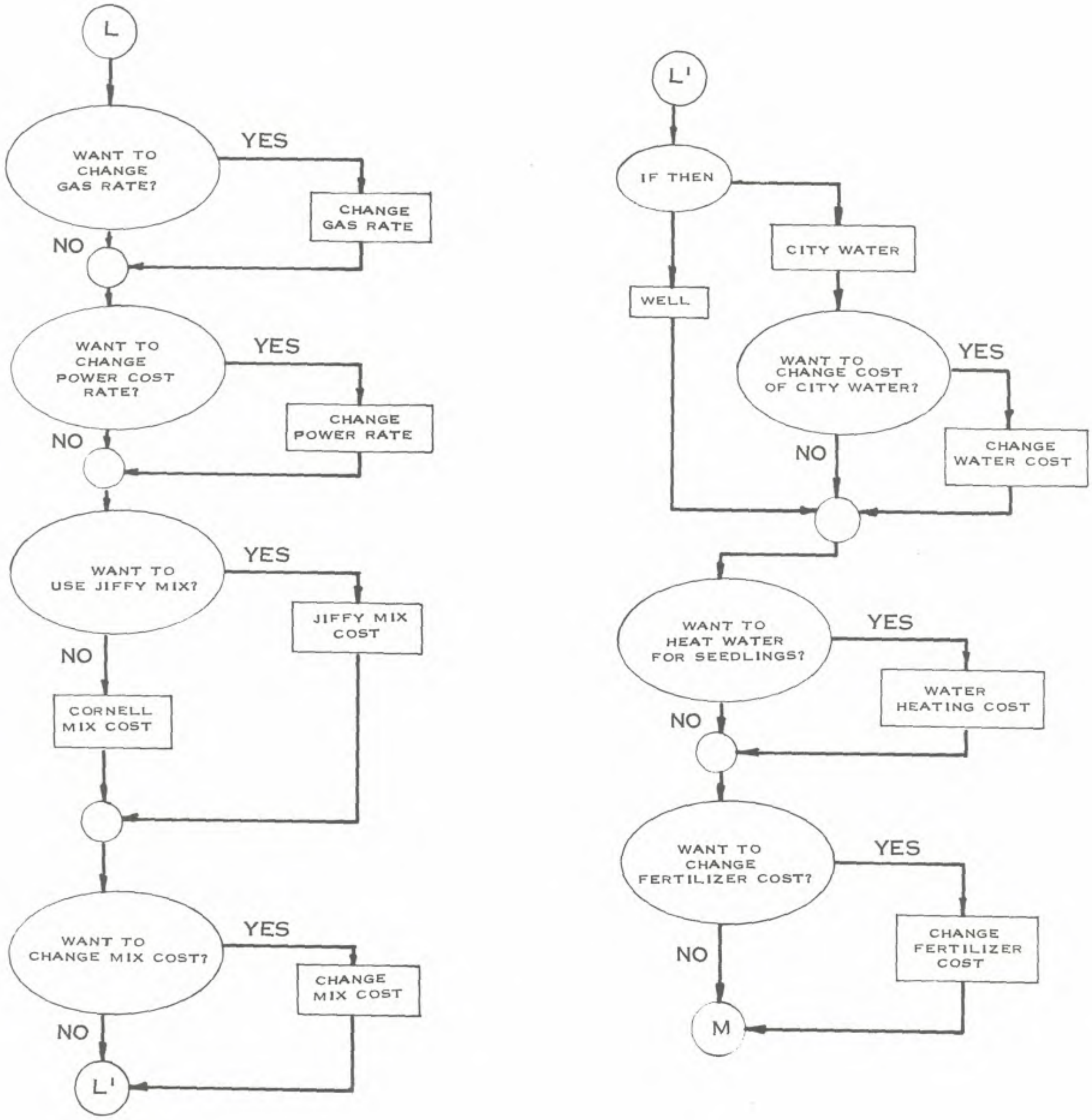
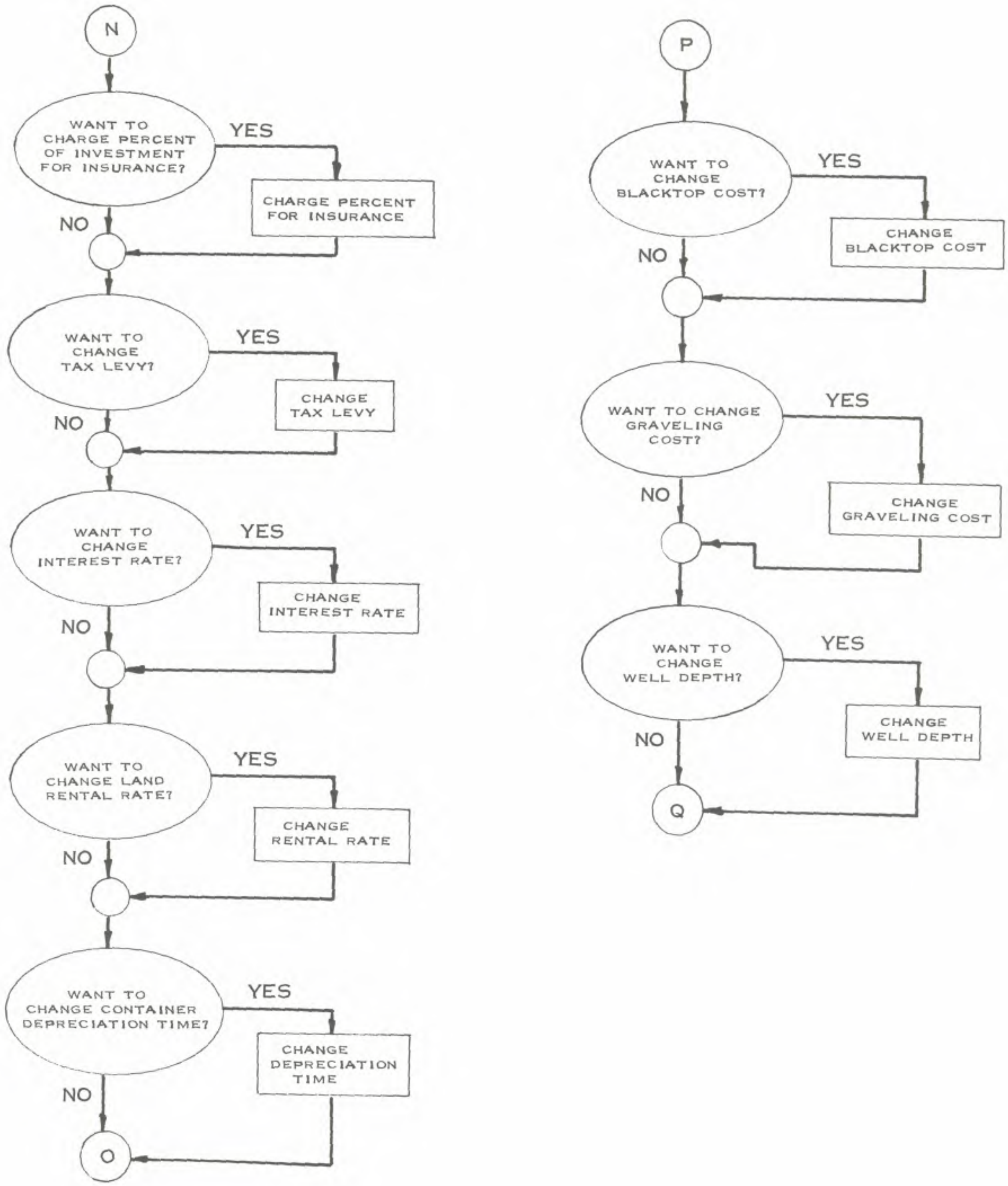
WANT TO CHANGE DEGREE DAYS?
YES
CHANGE DEGREE DAYS
NO
I


J
WANT CYCLIC LIGHTING?
YES
LIGHTING COST
NO
WANT TELEPHONE MONITOR?
YES
TELEPHONE MONITOR COST
NO
WANT STANDBY GENERATOR?
YES
STANDBY GENERATOR COST
NO
WANT CO_2 GENERATOR?
YES
CO_2 GENERATOR COST
NO
WANT TO CHANGE SEEDLING CONTAINER COST?
YES
CHANGE CONTAINER COST
NO
K


L
WANT TO CHANGE GAS RATE?
YES
CHANGE GAS RATE
NO
WANT TO CHANGE POWER COST RATE?
YES
CHANGE POWER RATE
NO
WANT TO USE JIFFY MIX?
YES
JIFFY MIX COST
NO
CORNELL MIX COST
WANT TO CHANGE MIX COST?
YES
CHANGE MIX COST
NO
L'
L'
IF THEN
CITY WATER
WELL
WANT TO CHANGE COST OF CITY WATER?
YES
CHANGE WATER COST
NO
WANT TO HEAT WATER FOR SEEDLINGS?
YES
WATER HEATING COST
NO
WANT TO CHANGE FERTILIZER COST?
YES
CHANGE FERTILIZER COST
NO
M


N
WANT TO CHARGE PERCENT OF INVESTMENT FOR INSURANCE?
YES
CHARGE PERCENT FOR INSURANCE
NO
WANT TO CHANGE TAX LEVY?
YES
CHANGE TAX LEVY
NO
WANT TO CHANGE INTEREST RATE?
YES
CHANGE INTEREST RATE
NO
WANT TO CHANGE LAND RENTAL RATE?
YES
CHANGE RENTAL RATE
NO
WANT TO CHANGE CONTAINER DEPRECIATION TIME?
YES
CHANGE DEPRECIATION TIME
NO
O
P
WANT TO CHANGE BLACKTOP COST?
YES
CHANGE BLACKTOP COST
NO
WANT TO CHANGE GRAVELING COST?
YES
CHANGE GRAVELING COST
NO
WANT TO CHANGE WELL DEPTH?
YES
CHANGE WELL DEPTH
NO
Q

SUMMARY

At the present time the greenhouse computer program is available through the terminal at the Missoula Equipment Development Center. Computer runs to date have been limited to hypothetical conditions. If the demand for this computer service is limited, the program will remain at the Missoula Center. Those requesting the use of the program from outside of the Forest Service, USDA, would be billed. It is estimated that the average computer run would cost from $25 to $35. The worksheet would have to be completed prior to activating the program.

If the demand for the program became larger, it could be stored at computer time share companies anywhere in the Country. In this case, arrangements could be made to allow interested persons to run the program themselves from their closest suitable terminal.

Question: Is there a summary report available showing the significance of various inputs, or a study of a few typical operations?

Hallman: No. We have only the reports I mentioned earlier by Ekblad (1973), Hallman (1973), and Huseby (1973)1/. We have not had enough experience with the program yet to identify its strong and weak points, and operational cost relationships.

1/ Ekblad, Robert B.
1973. Greenhouses: a survey of design and equipment. USDA Forest Service Equip. Develop. Center ED&T 2340 Project Record Part I, 70 p., illus. Missoula, Mont.

[Hallman, Richard G.]
1973. Comparing costs: a computer program. USDA Forest Service Equip. Develop. Center, Missoula, Mont. in cooperation with Agric. Eng. Dept. Mont. State Univ., Bozeman, Mont. 29 p.

Huseby, Kendell.
1973. A tree seedling greenhouse: design & costs. USDA Forest Service Equip. Develop. Center, Missoula, Mont., in cooperation with Agric. Eng. Dept. Mont. State Univ., Bozeman, Mont. 77 p., illus.

Question: Does the Forest Service have any plans to extend the computer analysis?

Hallman: Not at present, but I agree there is a real need for it.

Question: Do you consider the availability of labor in your computer program?

Hallman: Labor availability is reflected in the program by size of the labor cost input.

Question: Is the program available for translation into other, more common, program languages?

Hallman: Yes. The program is currently in the conversational language "Xerox Basic", which has worked well. We don't know what changes may be needed if we start using the USDA computer at Fort Collins.

Question: What does it cost to collect the necessary data and build such a program?

Hallman: A contract with Montana State University to assemble data and put it into a computer formula cost us about $7,000.

Question: In the horticultural field, air-supported greenhouse structures have worked well. Why do you say it is an unproved system?

Hallman: Yes, there are a number of very impressive sir-supported systems. he visited one near Cleveland, an acre or more in size. Although these structures have survived hurricanes, there have been failures and the whole top came down. Our computer program contains only what is in current use in forestry. Air-supported systems are promising and should be added to the program if and when they do come into use for trees.