FIELD MACHINERY SELECTION USING STORED PROGRAMS

By

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PREFACE

The work reported in this thesis resulted from the development of two stored programs to be used with a digital computer for solving problems of field machinery cost analysis and field machinery selection. The purpose of these stored programs is to provide a simpler and more accurate approach to problems of this type.

The author is grateful to Professor Jay G. Porterfield, the thesis adviser, for his encouragement and counsel during the study. His appropriate comments and suggestions in the writing of this thesis are acknowledged.

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INTRODUCTION

An organized approach to the problems of farm machinery selection and cost accounting becomes more important as the size of farms continues to increase and the total capital investment in farm machinery continues to rise. Farmers realize they must manage their financial affairs and investments in much the same manner as that of any other large business.

In earlier times the need for efficient machinery selection was not so apparent. The major problem was more likely that of obtaining sufficient labor to meet the requirements of a particular farm. Power and machines continue to be substituted for labor in order to increase productivity. This addition of power and machines now represents such a large portion of the capital expense of farming that skilled planning in their selection and application may often mean the difference in profit or loss. Personal judgement has always played a major role in the selection of farm machinery but may be expected to become less important in the future. Future decisions on farm machinery selection will be based more upon economic considerations than personal preference.

The number of operations and variety of equipment used on most farms presents machinery selection problems unlike those faced by other businesses of comparable size. In addition farm machinery use is seasonal. Total annual use may be only a few days each year. This presents a different type of selection problem as contrasted to the problem of selection of industrial machinery. Because of these and other factors, the efficient selection of farm machinery is a long tedious operation. In fact, simplifying assumptions to reduce the tedium of the calculations has often been a more important factor in the choice of a method for the systematic selection of farm machinery than has the accuracy of the results. Simplifying assumptions are usually made to reduce the amount of effort required to perform the necessary calculations for selecting farm machinery on an economic basis. Even with such assumptions the required computational procedure is often quite lengthy and complex when analyzing machinery selection or cost problems.

The digital computer is admirably suited to solve many problems which are characterized by the tedious manual calculations required to arrive at the desired solutions. Computer programs may be developed to receive the data for complex problems and then perform the desired calculations. These programs, when entered on punched cards, are of a permanent nature and may be stored for future use when similar problems arise. Increased usage of these stored computer programs is made possible by making them as general as practical in order to fit a wider range of problem types and data to a single program. It was the purpose of this study to develop such stored computer programs which could be used to solve a wide range of problems dealing with farm machinery cost calculations and efficient farm machinery selection based on system economics.

The programs that have been developed were written for use with an IBM 650 magnetic drum data-processing machine and appropriate peripheral equipment. A minimum of computer operating knowledge is required for anyone desiring to use these programs. Familiarization with the required forms for input data and with the computer output data in order that the results may be analyzed is required. In the event that an operator for the computer is not available, the procedures for preparing and processing the data cards are easily mastered.

CHAPTER II

OBJECTIVES AND LIMITATIONS

The objectives of this study were to:

A. Develop a stored program which could be used to solve problems dealing with the calculation of annual costs for field machinery.

B. Develop a stored program which could be used to solve problems dealing with efficient field machinery selection for a given farm based on system economics.

These stored computer programs are valid only for those machinery cost and selection problems which deal with field machinery and field operations. The annual amount of use for any machine must be determined from the annual acreage covered by the machine. No provision was made within the programs for machines that are used for stationary or non-field operations or for machines that are used for hauling or transport purposes where the amount of use is determined from the distance traveled rather than the acreage covered.

Limitations concerning the choices of computational procedure which may be used are discussed in the following chapters. Limitations concerning the nature and amount of data which may be handled for any single problem are explained in Appendixes A and B.

CHAPTER III

REVIEW OF LITERATURE

Much has been written about farm machinery costs and methods of farm machinery selection. Most of these articles discuss the significance of the various factors affecting farm machinery costs. A recommended method of calculation along with suggested values for the pertinent factors affecting farm machinery costs is included in most of these discussions. This chapter briefly reviews some of the previous approaches which have been made to problems of farm machinery costs and selection.

A. Factors Affecting Farm Machinery Selection and Cost Analysis

A discussion of the various factors which affect farm machinery costs and some recommended procedure for calculating the various items of fixed and variable costs was presented in nearly all of the literature reviewed. Most of these discussions also presented values for the items affecting costs. These could be used in the event that more exact information was not available. For many of the factors, only one method of approach is presented herein for each factor.

1. Depreciation. Depreciation is defined as the loss in value and/or service capacity of a machine which results from natural wear, obsolescence, accidental damage, abuse, rust, corrosion, and weathering. (1) Numerous methods have been purposed for calculating depreciation

costs for farm machinery. Some of the more common methods are:

a. Straight-line

b. Constant percentage

c. Declining balance

d. Sum-of-the-digits

e. Compound interest, or sinking fund

Of the methods listed above, the straight-line method enjoys the widest use largely because of its simplicity. The straight-line method is found to be undesirable for the reason that it depreciates a machine less during the first years of a machine's life than the resale value would indicate. This error is usually not considered to be significant if the assumption is made that a machine will be kept for its entire useful life, thus spreading the total loss in value over the years of use. In fact a charge for depreciation which is the same each year is desirable for estimating the average annual machinery cost over a period of years.

Constant percentage, declining balance, and sum-of-the-digits methods of calculating depreciation tend to give realistic values of the resale value of a machine. The major disadvantage of these methods is that during the period of ownership of a machine the depreciation cost varies from year to year depending upon the age of the machine. While this is the pattern followed by the actual depreciation of the machine, indicated by the resale value, it may be more desirable to have an equal charge for each year to estimate the average annual costs which will be incurred.

The compound interest or sinking fund method of calculating depreciation charges provides for the payment of an equal amount each year into a sinking fund, which if invested at compound interest together with the trade-in value would be equivalent to the first cost of the machine at the end of the period of the machine's useful life. (2) This method depreciates a machine less during the earlier years of its life and more toward the end. While the depreciation by this method does not represent that which the resale value would indicate, it does more nearly represent the present worth of the machine to perform the services for which it was purchased. The principal objection to the sinking fund method of depreciation is the difficult nature of the required calculations for determining the annual depreciation costs.

2. Interest on investment. Money invested in farm machinery cannot be used for other enterprises such as livestock, bonds, or other investments returning dividends or interest. For this reason interest on investment should be considered a cost of machine ownership whether the owner has actually borrowed the money to buy the machine or not.

Due to depreciation, the amount invested in a machine during earlier years is actually greater than the amount invested as the machine grows older. Since the investment becomes smaller, the actual charge for interest will also decrease as the machine ages. Most of the literature suggests the desirability of average annual machinery costs which are the same for each year of machine ownership. To accomplish this, most references recommended calculating an annual interest charge on the average investment in a machine over its full life.

3. Taxes. Considerable variation exists among states as to the valuation of farm machinery for tax purposes. Additional variation in tax rates for different townships and school districts within a state is also common. For these reasons the setting of an exact figure for taxes

on farm machinery is dependent upon the particular locale where the machinery is to be used. In general, property tax can be expected to average from 0.4 to 1.0 percent of the original cost of the machine over the machine's expected life.

Depending upon the percent sales tax charged within a state and the expected life of the purchased machine, sales tax will amount to from 0.1 to 0.3 percent of the original cost annually when averaged over the life of the machine.

Total charges for all taxes will vary from 0.5 to 1.3 percent of original cost per year in most localities with the figure of about <u>1.0 percent of first cost annually</u>, the preferred assumption if exact information is not available.

4. <u>Insurance</u>. A charge for insurance should be included when figuring machinery costs whether the owner carries insurance or elects to carry the risk of loss or damage himself. Insurance rates vary among locations and companies and the type coverage desired. Rates will also vary depending upon whether the coverage for machinery is separate or part of a larger "blanket" policy covering several types of risks. The rates vary also depending upon the method of premium payment and the amount of coverage.

Insurance charges for farm machinery will usually range from 0.25 to 1.0 percent of the original cost per year. If more exact information is unavailable a figure of <u>0.25 percent of the original cost</u> annually is commonly used.

5. <u>Shelter</u>. Charges for shelter vary from 0.5 to 2.0 percent of original cost per year for farm machinery. The higher rate is appropriate

where special buildings are erected and maintained expressly for the shelter of farm machinery. Lower rates are often possible if machinery is sheltered in unused animal shelters or driveways. A charge of 1.0 percent of original cost per year is regarded as a good estimate for most cases.

6. Machine life. Since depreciation is dependent upon both time and the amount of use, the expected life of a given machine may be estimated in years or in hours of use. The useful life of a machine is usually measured in years. The expected years of life being the time when the machine will have to be replaced because of obsolescence if not replaced earlier due to wear or other reasons. The useful life of a machine may be determined by use measured in hours. This method is generally preferred for machines where a high annual use rate is anticipated causing the machine to wear out before becoming obsolete.

The most common method of expressing machine life found in the literature reviewed was to simply use an average expected life in years for all machines of a given type. This average expected life was assumed to represent the life of the machine regardless of the type of use. These figures were usually obtained as the result of surveys of farmers who owned the different pieces of machinery.

The expected machine life in both hours and years for some of the more common farm machines is listed in Table I.

7. Repairs. Considerable difference of opinion exists over whether repairs should be treated as a fixed or variable cost when solving farm machinery cost problems. Some investigators have chosen to express annual repair costs as a fixed percentage of the initial cost of the

TABLE I

ESTIMATED IMPLEMENT LIFE AND COSTS IN PERCENT OF IMPLEMENT PURCHASE PRICE

Implement	Life in years	Life in hours	Total repair costs	Annual repair costs	Annual lubrication costs	Total annual fixed costs
Baler	12	2500	40	3.0	0.8	14.6
Binder, Grain	12	1000	40	2.5	1.0	10.5
Binder, Row crop	12	1000	40	2.5	1.0	10.3
Blower, Forage	12	2500	25	2.5	0.5	13.5
Combine	10	2000	40	3.0	0.5	17.0
Cultivator	12	2500	40	3.5	0.3	13.0
Drill, Grain	20	1200	25	1.5	0.7	11.0
Endgate Seeder	20	800	30	1.0	0.3	10.5
Ensilage Cutter	10	1200	30	3.0	0.5	10.8
Forage Harvester	12	2000	60	5.0	0.5	14.5
Grinder, Feed	15	2000	25	2.0	0.5	12.0
Harrow, Disk	15	2000	30	3.0	0.5	12.0
Harrow, Spike-tooth	20	2500	30	1.0	0.1	10.0
Harrow, Spring-tooth	20	2000	40	2.0	0.1	10.0
Lister	15	2000	60	5.0	0.5	12.0
Loader, Hay	12	1200	25	1.5	0.5	10.5
Manure Loader	10	2000	25	2.5	0.5	13.5
Manure Spreader	15	2500	25	1.5	0.5	10.5
Mower, Sickle	12	2000	70	3.5	0.7	12.0
Mower, Rotary	12	2000	35	3.0	0.6	11.0
Picker, Cotton	10	2000	55	5.5	0.5	17.0
Picker, Corn	10	1500	30	3.0	1.0	15.0
Planter, Row crop	20	1200	30	2.0	0.5	10.5
Plow, Moldboard	15	2000	80	7.0	0.5	17.0
Plow, One-way	15	2000	50	5.0	0.5	15.0
Rake, Side Delivery	15	1500	50	2.0	0.5	12.5
Rod Weeder	15	2000	30	2.0	0.4	12.0
Roller	25	1500	10	0.5	0.2	7.0
Rotary Hoe	15	1500	20	1.5	0.4	12.9
Sprayer, Field	10	1500	30	5.0	0.4	15.0
Stripper, Cotton	10	2000	30	3.0	0.7	16.5
Swather	12	1200	35	4.0	0.7	16.0
Tractor - Gasoline	15	12000	50	3.5	0.7	15.5
- Diesel	15	12000	60	4.0	0.7	16.0
- LPG	15	12000	45	3.0	0.7	15.0

References (1, 3, 4, 5, 6)

particular machine. (1, 3,) Others have preferred to express total repair costs for the entire life of the machine as a percentage of the initial cost. (6) When the figure for total repair costs for the machine's life is divided by the expected machine life in hours, an hourly repair cost expressed as a percentage of the initial cost may be found. When treated in this manner annual repair costs become a variable depending upon the hours of use.

Since repair costs may increase with use, the first method mentioned, that of a fixed yearly repair cost, is suitable only when the machine is kept for its entire useful life and above normal yearly use doesn't occur. This is true because the figure is an average over the life of the machine with the actual repair costs being lower during the first years and higher in the later years of the machine's life. The method of assuming fixed annual repair costs as a percentage of initial cost is probably best suited to cases where the useful life of a machine is determined by time rather than the amount of use. Some flexibility may be given this method if the figure from Table I is adjusted upward in cases of higher than average yearly machine use and is decreased for machines that are not to be kept for their entire useful life.

Repair costs figured on the basis of hours of use are usually more accurate for machinery with high annual usage or for machines whose expected life is determined by wear instead of time. Again the actual repair costs would be expected to become higher as the machine ages and hourly repair costs should be reduced for machines that will not be retained for their entire useful life. This method is probably less suitable for machines with low annual usage and where repairs tend to be seasonal in nature regardless of use.

Mention should be made of the fact that both the methods presented for calculating repair costs are intended to give figures representative of average conditions. Repair costs vary depending upon the nature of use, care, and maintenance given each machine. For some cases it may be desirable to alter the listed figures to allow for special conditions.

Repair costs for various farm implements are listed in Table I both in the form of a fixed percentage of new cost yearly and as total repair costs over the life of the machine in percent of new cost. The repair charges include both the materials and labor required to make the repairs.

8. Lubrication. Lubrication costs for farm machinery are considered to include the cost of the lubricants, the labor required for lubricating the machines, and lubrication equipment. Since this cost is small when compared with other items of machinery cost, little error is incurred by calculating lubrication costs on the basis of a fixed percentage of the machine's initial cost yearly. Suggested values for estimating annual lubrication costs for farm machinery by this method are listed in Table I.

9. Fuel and oil. The cost of fuel and oil is a major operating expense for any machine that has a power unit. All engine powered machine operations will have fuel and oil costs either for the tractor pulling the equipment or for the machine itself in the case of self-propelled equipment. Some machines which are equipped with auxiliary engines must be charged with fuel and oil expenses both for the tractor and the machine's engine. Fuel and oil costs for the machines are dependent upon two functions, the rate of machine consumption of fuel

and oil, and the local price for these items. Since local prices may be easily found for most situations, the problem when determining machine fuel costs is that of determining fuel and oil consumption. Two principle methods are commonly used to arrive at estimates of fuel and oil consumption. Consumption may be computed by using hourly figures for fuel and oil consumption or by figures relating fuel and oil consumption to the amount of work that the machine does.

Hourly estimates of fuel and oil consumption may be known from experience or by observation on similar machines. Hunt (7) estimates that for full load conditions the following amounts of fuel will be consumed for each 10 horsepower exerted by a tractor:

Gasoline - 1.0 gal./hr.

Diesel - 0.8 gal./hr.

LPG - 1.2 gal./hr.

1 gal. oil per 100 hours for all 3 types

Fuel and oil consumption on an hourly basis may be found from Table II which represents average values for tractors in different power ranges.

TABLE II

AVERAGE TRACTOR FUEL AND OIL CONSUMPTIONS IN GALLONS PER HOUR

Max. Belt HP	Gasoline		L. P. Gas		Diesel	
Classification	Fuel	Oil	Fuel	Oil	Fuel	Oil
10-20	.99	.008	....	....	....	....
20-30	1.53	.009	2.72	.010	....	....
30-40	2.02	.010	2.88	.010	1.59	.014
40-50	2.47	.012	3.14	.011	1.98	.016
50-60	2.96	.017	3.75	.012	2.16	.025
60-70	3.66	.016	4.84	.011	2.81	.022

Hunt (4)

When the horsepower requirement is known for a machine operation, fuel consumption may be estimated by using the average fuel consumption for the power unit in pounds per horsepower-hour or by using horsepower-hours obtained per gallon of fuel for the engine. Estimates of fuel consumption using this method may be made by using the following figures:

Gasoline - 8.25 hp.-hr./gal.

Diesel -11.75 hp.-hr./gal.

LPG - 6.75 hp.-hr./gal.

More exact information may be obtained from tractor tests. Test figures may be used for a particular tractor or an average value found from several tractors that have been tested.

Fuel and oil consumption for self-propelled machines and machines with auxiliary engines may be estimated on the basis of 8.5 hp.-hr./gal. for gasoline engines. Oil consumption may be figured as approximately 3% of the fuel consumption. (2, 8,) Hourly fuel and oil consumption rates for machines with individual power units may also be used.

10. Labor. Whether the farm operator actually hires extra labor or operates his machinery himself, he should charge each operation for the amount of labor required. Prevailing local rates are regarded as acceptable when calculating labor costs for machinery operation. Charges for labor are usually expressed as cost per hour.

11. Consumable items. Consumable items are considered to be those items exclusive of fuel and oil which are used up during the operation of a machine. These items may or may not be included when figuring machinery costs since it is often questionable as to whether these items represent machinery costs or other costs of production. The preferred practice would be to include necessary items such as baler wire, twine, etc. that may be included in custom charges in order that accurate comparisons

with custom rates may be made. Production costs such as seed, fertilizer, etc. should not be included when figuring machinery costs. Charges for consumable items are generally operating costs dependent upon the quantity of crop materials handled or acreage covered.

12. Power requirements. The problem of machine selection involves the use of power requirements for the various machines to be selected. Machine power requirements, particularly those of tillage implements, vary considerably from one location to another. Estimates of the speed and draft of an implement may be used to calculate an estimated power requirement when more exact information is unavailable. Draft is usually estimated on a unit width basis in pounds per foot. When the implement width is known, the total draft may be calculated. Hunt (7, 9,) includes the rolling resistance of the implement and tractor with the draft to obtain the total force requirement. This force when expressed on a unit width basis is called a force factor. Effective force factors may be estimated for pto-operated and harvesting implements to facilitate calculations. Table III gives the usual ranges of force factors for some of the more common farm implements.

13. Field efficiency. Knowledge of the field efficiency of machinery is necessary in order to evaluate the expected effective field capacity. Machine field efficiency is dependent upon the percent of machine width utilized and the percent time loss encountered in the field. Exact values for field efficiency vary among the different field operations. Field efficiency for a given operation is in turn dependent upon actual field conditions and the skill of the machine operator. Field efficiencies for some of the more common farm operations will usually fall within

TABLE III

FORCE FACTORS AND FIELD EFFICIENCIES

Machine	Normal range of force factors (pounds per foot of width)	Normal range of field efficiency (%)
Tillage:		
Plow	600-1200	75-85
Lister	200-320	75-85
One-way disk	175-375	75-85
Single disk harrow	75-150	75-90
Tandem disk harrow	100-180	75-90
Heavy duty tandem disk harrow	190-240	75-90
Spike-tooth harrow	50-90	75-90
Spring-tooth harrow	120-200	75-90
Roller	40-80	75-90
Field cultivator (spikes)	120-180	75-90
Field cultivator (sweeps)	70-260	75-90
Noble blade	160-330	75-90
Planting:		
Grain drill	50-130	65-85
Row crop planter	80-120	55-75
Cultivating:		
Rotary hoe	40-100	80-90
Row crop cultivator	80-190	70-85
Rod weeder	90-120	75-85
Harvesting:		
Mower	80-140	75-90
Grain binder	75-150	65-80
Combine	300-450	60-75
Corn picker	690-720	50-75
Baler	310-500	75-90
Forage harvester	400-1000	55-75
Cotton picker	1100-1400	55-70
Rake	80-100	60-90
Sprayer		55-70

References (6, 7, 8, 10)

the ranges given in Table III. Values from this table may be used to estimate field efficiency if more exact information is not available.

14. Custom Rates. Custom rates for machinery operations vary among different locations and sometimes from season to season. Custom rates are usually known or can be easily found for a given location. Some information may be available as a result of surveys of custom rates over a statewide or local area.

Custom rates are of interest in problems of machinery selection because a comparison may be made between machinery costs when owned and operated by the farmer and the unit cost for custom work. Ownership of some machinery may be undesirable if custom rates are lower. Such comparisons are possible only in cases where custom machine work is available.

B. Methods of Calculating Annual Farm Machinery Costs

The usual procedure for calculating annual machinery costs consists of determining the amount of each of the items of fixed costs and variable costs for a year then adding all of the items up to arrive at the total cost. The difficulty of this procedure is dependent upon the methods used to calculate the various items of cost. If no simplifying assumptions are made the procedure may be long and tedious. In most instances, the persons performing the calculations are willing to sacrifice some degree of accuracy by making simplifying assumptions to reduce the computational requirements.

The most common approach found in the literature reviewed consisted of calculating depreciation charges and interest on the basis of straight-line depreciation and estimating other items of fixed costs as constant annual percentages of the machine's purchase price. Operating costs were calculated on an hourly basis for fuel, oil, and labor. The total annual hours of use was found by dividing the total acres covered annually by the effective field capacity of the machine in acres per hour.

Several sources advocated the calculating of total annual fixed costs as a fixed annual percentage of the initial machine cost with operating costs calculated on an hourly basis. This approach was the simplest and shortest procedure suggested for estimating annual machinery costs. Suggested values for calculating the annual fixed costs of a machine in this manner are listed in Table I.

To reduce the computational requirements for estimating annual machinery costs, several of the sources reviewed had included helpful aids. Nearly all references provided tables to assist individuals in estimating the various items of cost. Hunt (7) presented a simple "cost per acre" equation for calculating the costs of machinery operation. Larson, Fairbanks, and Fenton (1) provided alignment charts for calculating machinery costs.

Bookkeeping and accounting are the major difficulties encountered with most approaches to finding machinery costs. The required calculations, while not complex, may be quite numerous and lengthy for large operations with many machines. The more complex approaches to machinery cost calculation involving sinking fund depreciation and compound interest are almost completely rejected in favor of simpler methods which do not involve such laborious computations.

C. Methods of Farm Machinery Selection

The problem of efficiently selecting field machinery is one of adjusting the factors of implement performance, power availability, labor, timeliness, and costs until an optimum return results. (9). The efficient selection of field machinery is a complex problem at best, since many different types of machinery may be required for a single farm. Most field machinery receives power from a tractor which also supplies power to a number of other implements. Such an arrangement means that the entire group of implements must be considered during the selection process since a change in one tractor-implement operation may affect other implement sizes within the system.

Few of the sources of literature reviewed presented any organized procedure for methodically selecting an efficient array of implements for a given farming operation. Some sources suggested that a tentative selection of machinery be made, the total annual costs calculated, and then the costs minimized as much as possible by adjusting the sizes of the selected machines. This approach usually amounted to calculating total annual costs for several alternate setups and choosing the least cost arrangement.

One method of approach was to list the various operations to be performed along with the total annual acreage that each operation would cover and the allotted time that was permitted to complete these operations. Implement sizes were selected which would complete the required operations within the allotted time periods. The required power was found by examining the different implements to find the one requiring the greatest amount of power.

Hunt (7, 9,) and Link (11) developed systematic approaches to the problem of selecting field implements and power sizes. Equations were developed to provide a method of determining the most efficient width for each machine in an operation as well as the most efficient power size. Using these equations an efficient system of machinery can be selected for any given situation. Since the annual hours of use for the power must be estimated at the beginning of the problem, several sequences of calculations may be necessary before a satisfactory trial and error solution is found. The required calculations may be somewhat tedious for systems containing many different implements but the procedure does have an orderly systematic approach which gives it an advantage over most other methods. Another desirable feature of this method is the inclusion within the developed equations of a provision for considering the value of timely operations because of the seasonal requirements of crops.

Pfundstein (5) developed equations for the calculation of farm tractor costs using different type fuels. The equations were programed for solution with a computer. The principal use of this computer program was to provide data for tables indicating the annual hours of operation required to amortize the higher initial costs of LPG and diesel tractors as compared with gasoline models.

This review of literature indicates that limited information on systematic machinery selection was available. The methods which have been developed are often tedious and long if exact solutions are desired. There is definite need for a simpler approach which would either eliminate some of the required manual calculations or allow them to be performed by some computational aid such as a computer.

CHAPTER IV

CALCULATION OF ANNUAL FIELD MACHINERY COSTS

One of the objectives of this study was to develop a stored program which could be used with a digital computer to solve problems dealing with the calculation of annual costs for field machinery. This program was not intended to solve problems of field machinery selection but is to be used to calculate the annual field machinery costs for operations where the number and types of machines that are either being used or that will be required is known.

The stored program that has been developed was intended to be of a general nature in order that several different approaches to the problem of calculating field machinery costs could be handled within the same program. Such flexibility was considered desirable in order that the program would have a wide range of possible uses rather than be limited to problems of any one particular type. The possible choices for handling machinery cost data are determined entirely by the form of the input data so that the person using the program is able to change the method of calculation from problem to problem without disturbing the internal order of the stored program.

In Chapter III, it was noted that often the approach which is used to calculate annual machinery costs is determined by the extent of the required calculations. Methods which require tedious manual calculations are usually rejected in favor of simpler ones. The use of digital computers for solving machinery cost problems renders such considerations unimportant and the method used should be the one which will give the most accurate solutions regardless of the complex nature of the required calculations. For this reason the various factors affecting farm machinery costs have been re-examined and an attempt has been made to provide for some of the more complex approaches as well as the simple in the stored program. In some areas new approaches are suggested. The reasons for these are presented in the discussion of the appropriate items.

Flow diagrams have been included to illustrate the procedure followed by the computer in arriving at the desired solutions. Equations which were used are included and explained. It should be realized that although some methods would be extremely long and difficult, no calculations were included which would be impossible to perform manually. Essentially the same procedure as outlined on the flow diagrams and in the discussion could be followed for manual calculations. The great advantage of computer usage lies in the ease, speed, and accuracy with which solutions to all types of field machinery cost problems may be obtained.

A. General Procedure for Calculating Annual Field Machinery Costs

The flow diagram for the general procedure followed by this stored program is illustrated in Figure 1.

The input data for all machines included in the problem is entered on a basic three card form. These cards are read into the computer in groups of three in order to provide data for the machines one at a time. These three cards may be in any order, but if all three cards are not for the same machine, the computational procedure is halted. This step prevents possible errors due to mixed data cards from different machines.

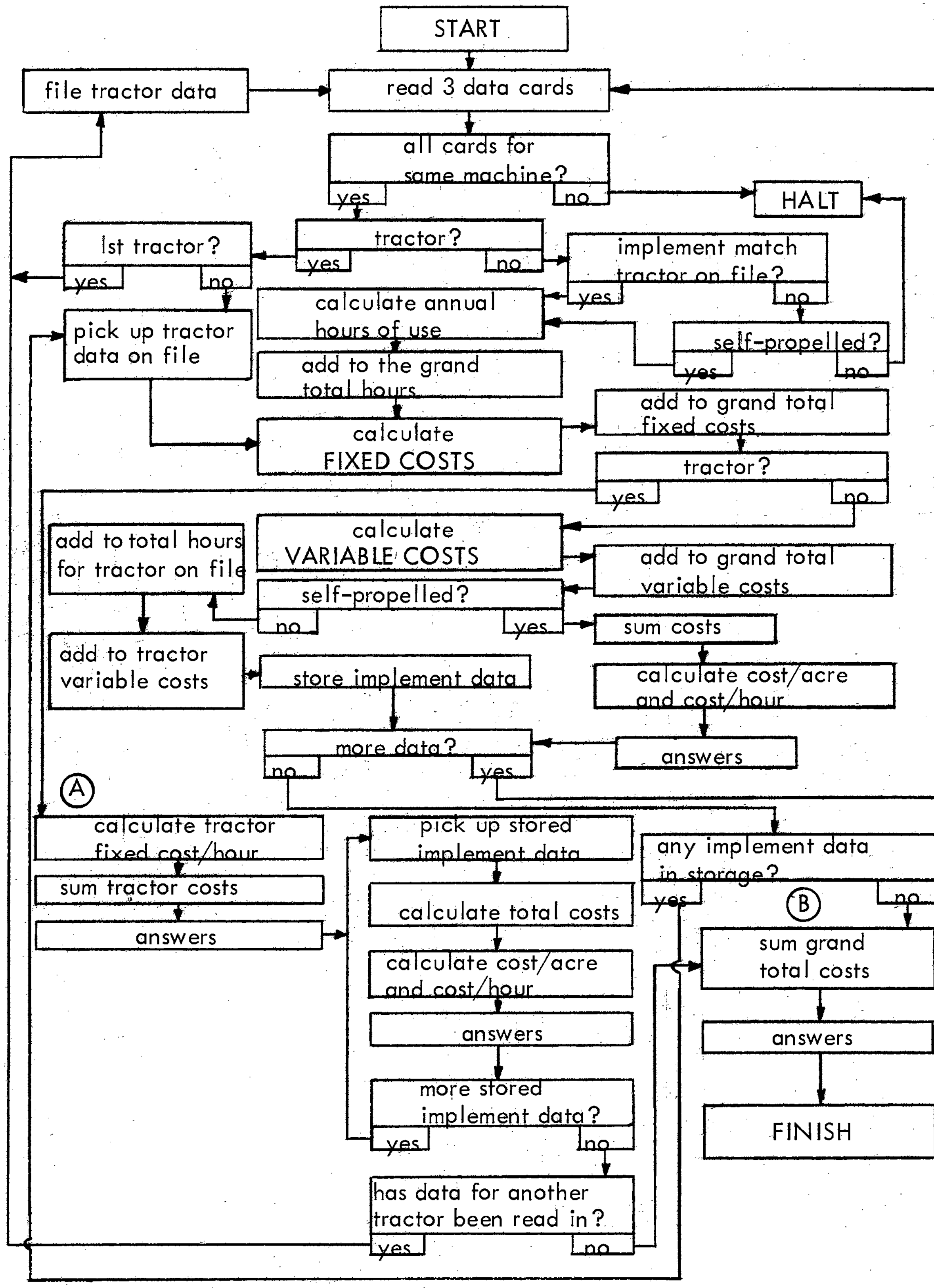

Figure 1. Flow Diagram of General Procedure for Calculating Annual Field Machinery Costs.

The data is then examined to determine if it represents a tractor or an implement. If the data is for a tractor, a check is made to see if this is the first tractor data that has been read in. If it is, the tractor data is placed on file for future reference. If data for a previous tractor has been read in, the appearance of a second tractor indicates that all implements drawn by the tractor on file have been read in. In this event the tractor data which has just been read in is placed in storage and the tractor data on file is picked up for the calculation of tractor fixed costs.

If the examined data is found to be an implement, a check is made to see if the implement is pulled by the tractor on file. If it is, the annual hours of use may be calculated. If the implement is not drawn by the tractor on file, a check is made to determine whether or not the implement is self-propelled. If it is, the annual hours of use may be calculated. If not, the procedure will halt since the implement data has not been placed behind the proper tractor. One of the requirements for reading in the data is that the data for all implements pulled by a particular tractor must be read in after the tractor data and before a different tractor's data is read in.

The annual hours of use for an implement is determined from the following equation:

$$h = \frac{825A}{SWE} \qquad (4.1)$$

Where, h = annual hours of use

A = annual acres covered

S = implement speed (mph)

W = implement width (ft.)

E = implement field efficiency (%)

The annual hours of use is added to a grand total which at the end of the problem will indicate the total annual machine hours required for the entire operation.

The fixed costs for the machine are calculated and added to a grand total for all machines. A check is then made to determine if the machine is a tractor. If it is, the remaining calculations for the tractor and all implements drawn by it may be completed. Discussion on this procedure starting at point A in Figure 1 will follow.

If the machine is not a tractor the variable costs are calculated. Variable costs for tractors are calculated with the implements pulled by the tractors then totaled to find the annual variable costs incurred by each tractor. It is at this point that reference is made to the tractor data on file for such information as fuel consumption rates, fuel prices, etc. Labor is considered a variable cost incurred by the operation performed by an implement and is not included as a tractor variable cost but is placed with the implement drawn by the tractor.

After the calculation of the variable costs a check is made to see if the implement is self-propelled. If self-propelled, the various costs are totaled, the cost per hour and cost per acre are found, and the answers obtained. A check is then made to see if any more data remains to be read in. If the implement is not self-propelled, the annual hours used and the tractor variable costs incurred while pulling the implement are added to totals for the tractor on file. The partially completed calculations for the implement are then stored to await the calculation of tractor fixed costs. The check for additional data is then made.

If more machine data is waiting to be read in, three more cards are brought in and the procedure starts over again. If no more data remains to be read in, a check is made to see if any implement data is waiting in storage for the calculation of tractor fixed costs. If no implement data is in storage, the next step is at point B of Figure 1.

If implement data is still in storage, the tractor data on file is picked up for the calculation of tractor fixed costs.

At point A of Figure 1 after the calculation of tractor fixed costs, the tractor fixed cost per hour is found. The various tractor costs are then totaled and the answers obtained. The partially completed calculations for an implement drawn by the tractor are removed from storage and the tractor fixed cost per hour is multiplied by the annual hours of use for the implement. This gives the share of tractor fixed costs which should be charged to the operation performed by the implement. The various costs for the implement are then totaled, the cost per hour and cost per acre are calculated, and the answers made available. A check is then made to see if more implement data is still in storage, if so data for another implement is picked up and the procedure repeated until all the implement data is removed from storage.

When no more implement data is in storage, a check is made to determine whether or not data for another tractor has been read in and is in storage waiting to be placed on file. If it is, the tractor data is placed on file and three more data cards are read in. If no tractor data is waiting in storage, the only other condition which could have caused the calculations for the tractor data on file and the data for implements drawn by it to be completed would be the end of data for the entire problem. The next step would be at point B of Figure 1.

At point B of Figure 1 the overall costs for the entire problem are totaled and the grand totals are available. This marks the end of the computational procedure for the problem of calculating the annual field machinery costs.

B. Calculation of Fixed Costs

1. Depreciation. In Chapter III some of the more common methods of calculating depreciation costs were discussed. Some of the advantages and disadvantages of each of the methods were discussed. Two desirable features for any method of depreciation to be used were considered to be the assessment of an equal charge for depreciation each year and that the undepreciated value of a machine at any time should represent the actual resale value of the machine. No single method combined both of these desirable features. The usual procedure was to assume that a machine would be kept for its entire useful life. With this assumption a method which would provide equal yearly charges was more desirable than a method which could be used to estimate the approximate resale value at any time during the life of the machine.

From a practical viewpoint it should be realized that many machines are not kept for their useful life and for economic or other reasons are disposed of before the end of their useful service life. For problems where this earlier trade-in time can be anticipated, a method of estimating the approximate value of the machine at the time of trade-in is desirable. With this figure the basis for calculating the annual machine depreciation charge would be machine's loss in value from the purchase price to the estimated trade-in value for the years of machine ownership. This approach would yield a much more accurate estimate of actual depreciation charges for the years of ownership than would be found if the annual depreciation cost was considered to be the same as for a machine which is kept for its entire useful life and depreciated to salvage value.

Since the constant percentage method of calculating depreciation costs is considered to give a good indication of the actual resale value of a machine, a combination of the constant percentage method and the straight line method for calculating depreciation costs would appear desirable. The annual depreciation charges could be calculated on a straight-line basis for the loss in value between the purchase price and the trade-in value. The trade-in value at any time within the machine's expected life could be estimated by use of the constant percentage method. The fallacy of this approach lies in the assumption that charges for depreciation are either paid each year and forgotten or deposited in a replacement fund which draws no interest.

In an actual situation it is much more realistic to assume that the charges for depreciation which are subtracted from gross income each year are put to use where they will produce a return. An efficient operator would certainly not let this money lie idle but would probably invest it in some type of enterprise to allow it to draw interest, or he might invest it in some other portion of his overall operation where again it should bring some type of return. In either event the interest or income from the depreciation charges should be compounded periodically. In this manner it may be seen that early depreciation charges will actually earn money which may be used to offset later depreciation charges resulting in an actual <u>lower</u> average depreciation cost to the owner because the depreciation fund is actually helping to pay part of the machine's loss in value.

The compound interest or sinking fund method of calculating depreciation charges provides for the payment of an equal amount each year into a sinking fund, which if invested at compound interest together with the trade-in value would equal the purchase price at the end of a machine's service life. (2). Equation 4.2 may be used for calculating the actual depreciation cost per year by the compound interest method.

$$D = (C - V)\left[\frac{i}{(1 + i)^n - 1}\right] \qquad (4.2)$$

Where, D = annual depreciation charge

C = purchase price

V = trade-in value

i = interest rate

n = total years of expected ownership

The constant percentage method may be used in combination with the sinking fund method to find the trade-in value (V) of a machine that is not kept for its entire useful life. Equation 4.3 is used to determine the rate or percentage necessary to reduce the original value to the salvage value at the end of the machine's useful life.

$$r = 1 - \sqrt[L]{\frac{S}{C}} \qquad (4.3)$$

Where, C = purchase price

S = salvage value

L = years useful life

r = percentage of annual rate of depreciation

The value (V) at any age (n) during the useful service life of the machine may be found from Equation 4.4.

$$V = C(1 - r)^n \tag{4.4}$$

In the event that a machine is kept until the end of its useful life, the constant percentage method is not needed since the trade-in value (V) would be equal to the salvage value (S) and (n) would be equal to (L). It should also be noted that the lower the interest rate (i) used in the sinking fund method, the more nearly the values calculated approach those that would be found by using the straight-line method of depreciation. If zero interest is charged for the sinking fund the equation is invalid in the form that has been presented. The actual depreciation charge, however, would be equal to that found by the straight-line method.

The following example will illustrate the use of the proposed combination method of compound interest and constant percentage:

C = \$10,000

S = \$ 1,000

L = 10 years

i = 5%

n = 5 years (machine is traded in before end of useful life)

First the trade-in value of the machine at the end of 5 years must be found.

$$r = 1 - \sqrt[L]{\frac{S}{C}} = 1 - \sqrt[10]{\frac{1000}{10000}} = 1 - (0.1)^{0.1} =$$

$$1 - 0.794 = 0.206$$

$$V = C(1 - r)^n = 10000(1 - 0.206)^5 = 10000(0.794)^5 =$$

$$10000(0.316) = \$3160.$$

Now the annual sinking fund payment over the first five years may be found.

$$D = (C - V) \left[\frac{i}{(1 + i)^n - 1}\right]$$

$$= (10000 - 3160) \left[\frac{0.05}{(1.05)^5 - 1}\right]$$

$$= 6840 \left[\frac{0.05}{.276}\right] = 6840\ (0.181) = \underline{\underline{\$1240.}}$$

The total loss in value for the machine over the five year period is \$6840.00. The five equal annual payments of \$1240 were charged as the cost of depreciation to the owner each year for a total cost of \$6200 over the five year period. The remaining \$640 loss in value was derived from the interest on the sinking fund.

Equation 4.5 could have been used to calculate the annual depreciation charges for the five year period using the straight-line method:

$$D = \frac{C - V}{n} \tag{4.5}$$

Where, D = annual depreciation charge

C = purchase price

V = trade-in value

n = years of expected machine ownership

For the example:

$$D = \frac{(10,000. - 3160)}{5} = \frac{6840}{5} = \$1368.$$

It is of importance to note that if the trade-in value at the end of five years had <u>not</u> been found and straight-line depreciation had been assumed for the entire useful life of the machine, the annual yearly charge for depreciation would be $900.

The compound interest and straight-line methods of calculating depreciation charges along with the constant percentage method for estimating trade-in values are included in the stored program which has been developed.

2. Interest on investment. In order to arrive at average machinery costs which are the same for each year of machine ownership, interest charges for the total life of a machine must be found. This figure is then divided by the years of machine life to arrive at an average figure for interest on investment. When using the compound interest or sinking fund method of depreciation, the remaining value must be found at the end of each year and the interest rate applied to this value. This procedure is then repeated for each year of machine ownership and all the yearly interest charges are then summed and divided by the years of ownership to arrive at an average annual charge for interest. If it is desirable to compound the interest, as may be the case when comparing the income that the money would provide if invested in bonds, livestock, etc., the interest found for each year's machine investment would be added to the previous interest that has been paid. This total is then added to the machine value for the next year for the purpose of calculating the interest on that year's investment.

The value of a machine at any year (x) when using the sinking fund depreciation method may be found from Equation 4.6.

$$Y = (C - V) \left[\frac{(1 + i)^n - (1 + i)^x}{(1 + i)^n - 1} \right] + V \qquad (4.6)$$

Where, Y = undepreciated value of machine at year (x)

C = purchase price

V = trade-in value

i = interest rate (sinking fund)

n = total years of machine ownership

x = year for which the undepreciated value of the machine is sought

For problems using straight-line depreciation and simple interest, an equal yearly charge for interest on investment may be found from Equation 4.7.

$$I = \frac{(C + V)}{2} r \tag{4.7}$$

Where, I = annual charge for interest on investment

C = purchase price

V = trade-in value

r = rate of interest on investment

3. Taxes, insurance, and shelter. These costs are grouped together and calculated as an annual fixed percentage of the initial machine purchase price.

4. Repairs. To insure the greatest accuracy, some method which will combine the advantages of the fixed annual cost and hourly cost methods of calculating machinery repair costs is desirable.

The approach used in the stored program is to compute annual repair charges as a fixed percentage of the initial machine cost. The percentage is adjusted upward whenever the life of a machine allowed by wear or use is shorter than the life allowed by time or obsolescence. Equation 4.8 is used to achieve this result.

$$M = N \frac{T_t}{T_w} \tag{4.8}$$

Where, M = annual repair charge in percent of initial machine cost

N = average repair charge in percent of initial cost

T_t = years of expected life due to time

T_w = years of expected life due to wear

5. Lubrication. Annual charges for lubrication are calculated on the basis of a fixed percentage of the initial machine purchase price. For machines with high annual use rates this percentage is adjusted upward by using figures for lubrication instead of repairs in Equation 4.8.

A flow diagram indicating the procedure followed for calculating fixed costs within the stored program is shown in Figure 2. All formulas which are used as part of the computational procedure have been presented in the previous discussion.

The first step in the calculation of fixed costs is to determine the years of machine life which would be allowed by wear. This figure is found by dividing the total hours of machine life allowed by wear by the annual hours of use for the machine. This machine life allowed by wear is now compared with the average expected machine life or the machine life allowed by obsolescence. The smaller of these two values is retained as the expected useful life for the machine.

If the machine is to be traded in before the end of its useful life, a trade-in value is found using the constant percentage method for depreciation. This trade-in value is used to replace the salvage value for use in further calculations.

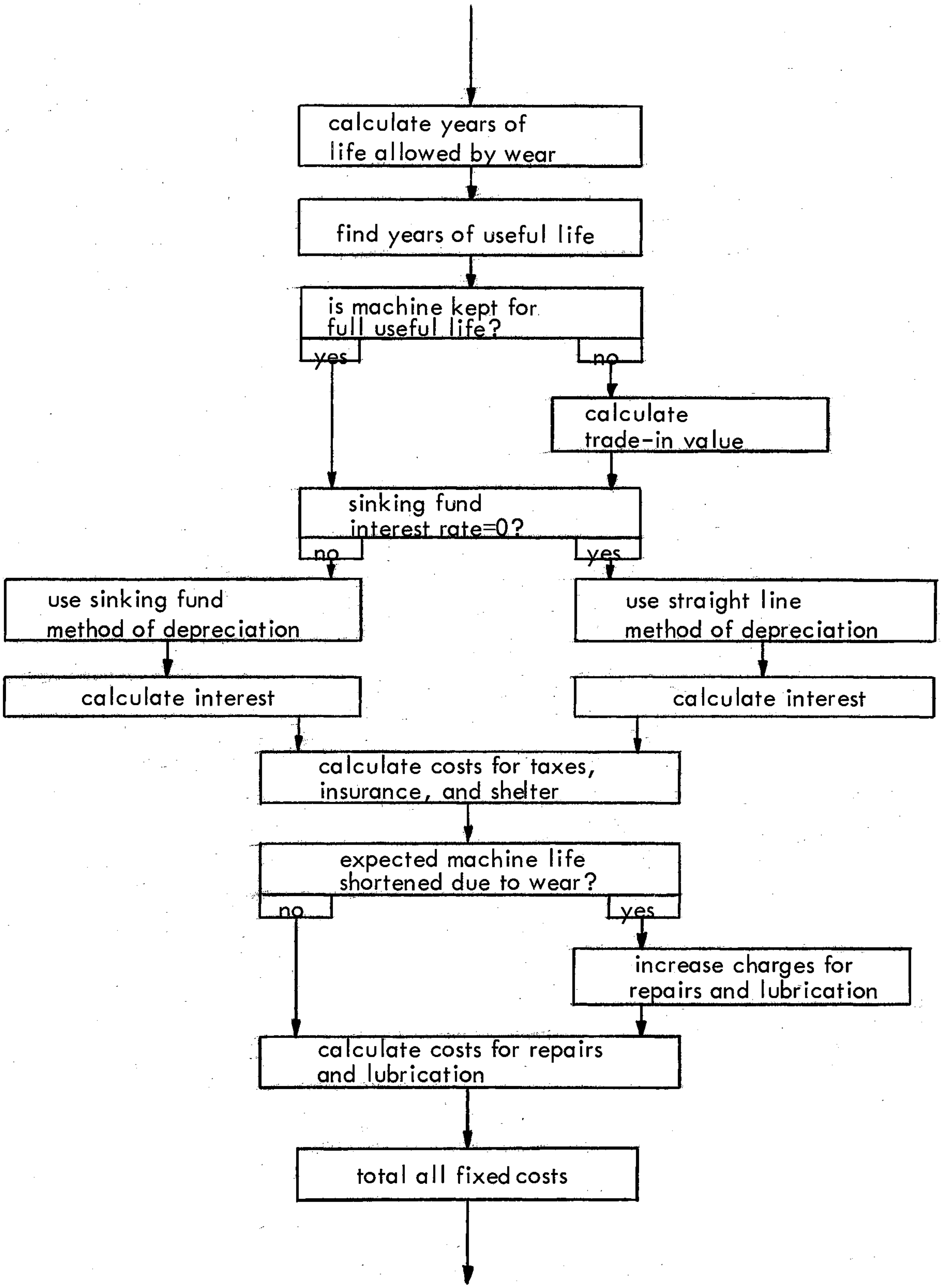

Figure 2. Flow Diagram of Procedure for Calculation of Fixed Costs.

A check is made to determine if the interest rate on the sinking fund is zero. If zero, depreciation is calculated using the straight-line method. If the sinking fund interest rate is not zero, the compound interest or sinking fund method of depreciation is used.

Charges for interest on investment are calculated after depreciation costs have been determined for both the straight-line and sinking fund methods of depreciation. Since the undepreciated value must be found at the end of each year for the purposes of calculating interest charges, the approach used for calculating interest charges depends upon the type of depreciation method used. Either simple or compound interest may be calculated for either case.

Following the calculation of charges for interest on investment, the costs for taxes, insurance, and shelter are calculated. A check is then made to see if the expected useful machine life was shortened due to wear or high annual usage. If so, the annual charges for repairs and lubrication are increased accordingly. The annual costs for repairs and lubrication are then calculated.

The various items of fixed costs are now totaled and the calculation of annual fixed costs for a machine is complete.

C. Calculation of Variable Costs

1. Fuel. Fuel costs for both tractors and implements are calculated on the basis of fuel consumption rate as measured in gallons per hour or by the amount of work obtained per gallon of fuel. The hourly rate is used unless the force factor and the ground speed of an implement are known. If these items are known, the total horsepower-hours of work accomplished by a machine during a year may be calculated. This

figure divided by horsepower-hours obtained per gallon of fuel consumed gives the annual gallons of fuel used for an operation. Hourly fuel consumption rates are always used for tractors pulling implements equipped with auxiliary engines.

2. Oil. Oil costs for both tractors and implements are calculated on the basis of consumption in gallons per hour.

3. Labor. Labor costs are calculated for implements only on the basis of cost per hour.

4. Consumable items. In the event that any consumable items are to be included as machinery costs they are calculated on the basis of cost per acre covered.

The flow diagram indicating the procedure followed for calculating variable costs is shown in Figure 3.

At the beginning of the calculation of variable costs a check is made to determine whether or not the implement is self-propelled. If so, the next step is at point A of Figure 3. If the implement is not self-propelled, a check is made to determine whether or not the implement has an auxiliary engine. This fact is indicated by the absence or presence of fuel and oil data for the implement. If the implement has an auxiliary engine the fuel costs incurred by the tractor pulling the implement are calculated on an hourly basis.

If the implement has no auxiliary engine, a check is made to see if a force factor for the operation to be performed by the implement is given. If no force factor is given, the annual fuel costs incurred by the tractor while pulling the implement are calculated on an hourly basis. The hourly fuel consumption rate for the tractor is multiplied

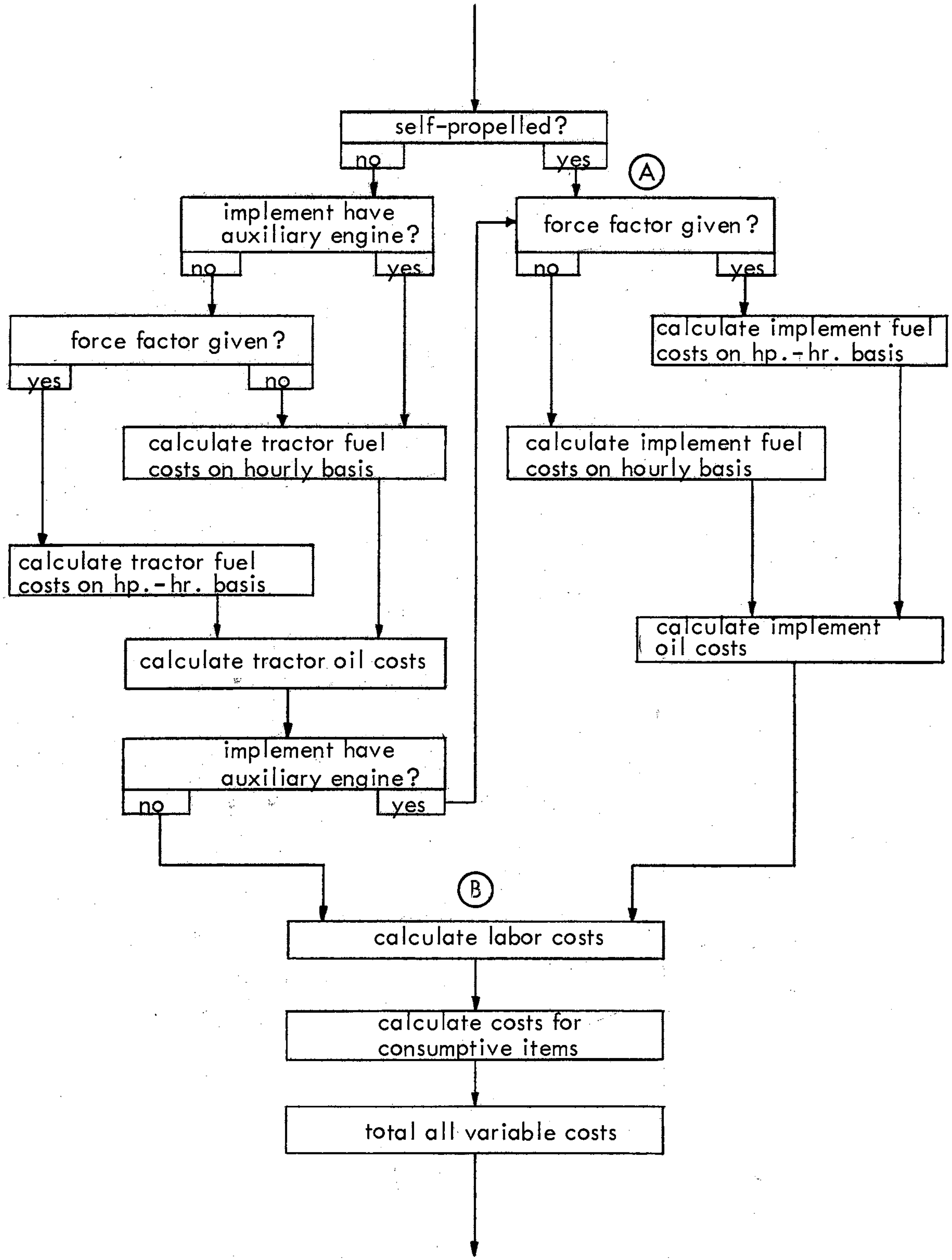

Figure 3. Flow Diagram of Procedure for Calculation of Variable Costs.

by the annual hours of use for the implement. This figure is then multiplied by the fuel price to obtain the annual tractor fuel costs incurred while pulling the implement.

When a force factor is given, the annual fuel charges for the tractor for the operation performed are found from Equation 4.9.

$$Q = \frac{S\ W\ h\ ff\ F}{375R} \tag{4.9}$$

Where, Q = annual fuel cost in dollars

S = implement speed (mph)

W = implement width (ft.)

h = annual hours of implement use

ff= force factor (lb/ft)

F = fuel price ($/gal.)

R = horsepower-hours per gallon of fuel

Following the calculation of tractor fuel costs the tractor oil costs are calculated and another check is made to see if the implement has an auxiliary engine. If so, the next step is at point A of Figure 3. If the implement has no engine the next step is at point B of Figure 3.

At point A of Figure 3 the procedure for calculating the annual fuel and oil costs for an implement begins. This procedure is used for self-propelled implements and tractor-drawn implements with auxiliary engines. A check is made to determine if a force factor is given. If so, fuel costs are calculated using Equation 4.9. If not, implement fuel costs are calculated on an hourly basis. Implement oil costs are then calculated on an hourly basis. The next step is at point B of Figure 3.

At point B of Figure 3 the annual labor costs for the implement are calculated. Costs are calculated for any consumptive items that are used. The various items of variable costs for the operation performed by the implement are then totaled and the calculation of annual variable costs is complete.

The rules and procedures for using this stored program for the calculation of annual field machinery costs are explained in Appendix A. An analysis of the answers which the stored program provides to field machinery cost problems is presented in Chapter VI.

CHAPTER V

FIELD MACHINERY SELECTION

The principal objective of this study was to develop a stored program which could be used with a digital computer to solve problems dealing with field machinery selection. This program does not calculate the annual costs for the machinery selected but supplies adequate information concerning the optimum machinery sizes for a given operation so that an efficient selection of machinery may be made in sizes that are commercially available. Once the final selection is made, the calculation of annual costs for the selected machines may be performed through use of the stored program discussed in Chapter IV.

This stored program is intended to solve machinery selection problems in which the types of implements and the acreage to be covered by each type is known. Equipped with this information the stored program is able to solve the problem for the optimum sizes of both implements and power for the overall farming operation. To provide flexibility within the stored program, two general approaches are included. Provision for a selection based on a combination of the two methods is also included. The method of solution chosen is dependent upon the nature of the input data. No changes within the stored program are necessary to accommodate the various methods of solution.

The principal reason for developing a stored program of this type was to relieve the tedious and involved procedure required to make efficient machinery selections using manual calculations. The methods of approach included within the stored program have been chosen because they are considered to give the most accurate solutions. The procedures and equations outlined in the following discussion could be followed using manual calculations to obtain the same solutions that would be provided by using the stored program with a digital computer. The difference lies in the speed, ease, and accuracy of obtaining solutions.

A. Selection of Implement Widths

The size or capacity of all implements selected is represented by the effective width of the implement. An effective width of action is assumed for such implements as balers. The same basic equation is used to determine the least-cost widths of implements for all problems solved using the stored program. Different approaches are used for determining the additional width of implement justified because of the need for timely field operations.

Hunt (7, 9) developed an equation which may be solved for the least-cost width of implement in a given system. The derivation of this equation is based on the following formula for determining the total annual costs for an implement:

$$AC = FC\%\ p\,W + \frac{825A}{SWE}(L + O + F + T)$$

Where, AC = annual cost for the implement's use, \$/year

FC%= annual fixed costs for implement in % of purchase price, (decimal form)

p = purchase price of implement, \$/foot

W = effective implement width, feet

A = total acres covered annually

S = forward speed, miles per hour

E = implement field efficiency, percent

L = cost of labor, \$/hour

O = cost of engine oil, \$/hour

F = cost of fuel, \$/hour

T = power fixed cost charge, \$/hour

This formula was differentiated with respect to W and set equal to zero. When solved for W, Equation 5.1 was developed.

$$W^2 = \frac{825A\ (L+T)}{FC\%\ p\ S\ E} \qquad (5.1)$$

The following assumptions are made with respect to Equation 5.1:

a. That oil and fuel usage are linearly related to W and therefore not significant in the selection process

b. That E and FC% are constants independent of W

c. That power fixed cost charges may be proportioned on the basis of the time the power source is used

d. That the unit width purchase price, p, is constant over a range of W values

e. That the forward speed, S, is the maximum value that does not reduce the effectiveness of the operation

f. That S and E are the same for all operations performed by the implement

Equation 5.1 is used to calculate the least-cost width for all implements selected by the stored program. Since the timely performance of field operations has an economic value in most instances, a method for selecting an implement size which will take into account the value of timely operations is desirable. By using such a method an implement width may be selected which will yield maximum profit rather than least-cost.

Hunt (7, 9) expanded Equation 5.1 to include a procedure for considering the value of timely operations when selecting field machinery. This was done by developing a series of timeliness factors which are considered to be the reduction in value of a crop for each hour required by the operation. These timeliness factors when multiplied by the total value of a crop are considered an hourly cost along with the labor and power costs indicated in Equation 5.1. Equation 5.2 includes this cost for timeliness.

$$W^2 = \frac{825\left[A\ (L + T) + \sum (A_i\ K_i\ Y_i\ V_i)\right]}{FC\%\ p\ S\ E} \tag{5.2}$$

Where the added symbols are:

A_i = acres for each crop ($\sum A_i$ must equal A, total acres)

K_i = timeliness factor, 1/hours

Y_i = potential <u>total</u> crop yield, bushels, tons, etc.

V_i = crop values, $/bushel, $/ton, etc.

Suggested values for K are listed in Table IV. Equation 5.2 is used to select optimum implement sizes whenever the timeliness factors for the various operations performed by the implement are known. Unfortunately however, such information for evaluating timeliness is unavailable for many crops and farming areas. Quite often implements must be selected for operations where no timeliness data is available. Because of this fact, provision has been made within the stored program for selecting implements of optimum size by an alternate method.

TABLE IV

TIMELINESS FACTORS

Operation	"K" Value
<u>Seeding</u>:	
Barley	.0004
Corn	.0010
Cotton	.0010
Oats	.0005
Soybeans	.0003
Wheat	.0005
<u>Tillage</u>:	
Plowing	.00005
Disking	.00005
Harrowing	.00001
<u>Cultivation</u>:	
Rotary hoeing	.0005
Row crop cultivation	.0005
<u>Harvesting</u>:	
Barley	.0010
Corn	.0005
Cotton	.0005
All hay harvesting operations	.0010
Oats	.0007
Soybeans	.0006
Wheat	.0005

Hunt (7)

A more common approach to the problem of field machinery selection has been to select implement sizes which will furnish adequate capacity to complete field operations within an allotted time period. Nearly all farm operators have some estimate of the time which they consider allowable for the completion of various operations in their farming area. These estimates are usually based on past observations of crop yield as related to planting dates, harvest dates, etc. While such information may be inaccurate, the use of such a method is considered to be better than ignoring the value of timeliness altogether.

Allotted time for field operations is usually given in days. Difference in the length of working days among different operators tends to make this method difficult to use in machinery selection problems. A better method is to state the allotted time for a given field operation in hours. This approach more accurately indicates the available field time for each operator. By this method, the operator who is willing to work longer hours or work at night when possible, will have more time available to him than will the operator who prefers to work only during the daylight hours. Total hours of allotted time available are dependent upon the same factors as working days available times the daily hours kept by the individual operator. Operators who prefer not to work during all possible hours must pay for the privilege by owning larger machinery in order to have the larger field capacity needed to complete the job in less hours over the same period of days.

When an allotted time is given for an implement, Equation 5.3 is used within the stored program for determining the implement size required to complete an operation with the allotted time.

$$W = \frac{825A}{S\ h\ E} \tag{5.3}$$

Where, W = effective implement width, feet

A = total acres covered annually

S = ground speed, miles per hour

h = allotted time for completing all operations, hours

E = field efficiency, percent

In order to determine the total allotted time, h, for all operations performed by the implement, the allotted time for the individual operations must be totaled. Since the required capacity for some operations may be larger than for others, use of this method may select an implement which does not have the required capacity to complete some of the operations within their allotted time period. For example, it may be desired to harvest 500 acres of wheat during the summer within a period of 100 hours and 100 acres of grain sorghum in the fall over the same length of time. When totaled this would give a total allotted time of 200 hours to harvest 600 acres. The required field capacity would be 3 acres per hour, too low for the wheat harvesting operation. The usual procedure for such problems is to select an implement with adequate field capacity to complete all operations <u>within</u> their allotted time periods. For the example used, the required capacity for wheat harvesting is 5 acres per hour. This capacity when divided into the total annual acres covered gives a total allotted time of 120 hours for use in Equation 5.3. Another approach would be to determine a weighted average field capacity required for all operations performed by the implement. For the example used this would be:

$$\frac{(500 \text{ acres} \times 5 \text{ acres/hour}) + (100 \text{ acres} \times 1 \text{ acre/hour})}{600 \text{ acres}} = 4.33 \frac{\text{acres}}{\text{hour}}$$

This weighted average field capacity divided into 600 acres gives a total allotted time of 138 hours for all operations.

These methods of determining the total allowable time, h, are not included within the stored program since the determination of the allotted time is largely a matter of individual choice and the calculations, if necessary, are quite simple. The purpose of this discussion is to indicate the possible errors which could result in selected implement sizes if proper attention is not given to the total allotted time as an item of input data for the implement being selected.

When an allotted time is given for the operations performed by an implement, the least-cost width is first calculated using Equation 5.1. The width required by the allotted time is then calculated using Equation 5.3. If the least-cost width is larger than the width found using Equation 5.3, it is selected as the desired width of implement. If the least-cost width from Equation 5.1 is smaller than the width found from Equation 5.3 the width given by Equation 5.3 is selected as the desired width. By this approach the values found using the least-cost method may be adjusted for timeliness as measured by allotted time.

A combination of methods may be used within the program if desired. If timeliness factors and allotted time are both given in the input data for an implement, this combined approach is used. The implement width found from Equation 5.2 is compared with the implement width found from Equation 5.3. The larger of the two widths is accepted as being the desired implement width for the operations to be performed.

B. Selection of Power Sizes

Two methods for selecting the total amount of power required are included within the stored program. Which method used is determined by the type of timeliness data provided for the implements for which power is to be furnished. Consideration of the value for timely operations is equally important for the selection of power sizes as for the selection of implement widths. Power sizes are represented by horsepower in much the same manner as implement sizes were represented by width. The horsepower selected by the methods contained within the stored program is considered to be the usable horsepower of a tractor or group of tractors. This usable horsepower is defined as 75 percent of a tractor's maximum drawbar horsepower as determined by the Nebraska Tractor Tests.

1. Method A. This method is used to select the total amount of power required for a system of implements when the timeliness requirement for the implements is measured by allotted time. The amount of power selected is equal to the maximum power required by any one implement to complete its operations within the allotted time given. Equation 5.4 is used to determine the amount of power required by each implement.

$$HP = \frac{.022\ ff\ A}{h\ E} \tag{5.4}$$

Where, HP = required horsepower

ff = force factor for implement, pounds/foot

A = total annual acres covered by the implement

h = total allotted time in hours

E = implement field efficiency, (decimal form)

This procedure consists of examining all implements within the system and determining the required horsepower for each using Equation 5.4. The maximum horsepower required by any one implement is considered to be the amount of power required for the overall operation.

2. Method B. This method is used to select the total amount of power required for a system of implements when the timeliness data for the implements is given in the form of timeliness factors of the type listed in Table IV. The equation used for selecting power sizes by this method was developed by Hunt (7, 9) in the same manner that Equation 5.2 was developed for selecting implements of optimum widths. Where acreage expressed the amount of implement use, total energy requirement is adopted for expressing tractor use. An equation for calculating annual power costs was minimized and solved to obtain a relationship for selecting an optimum amount of power for a given system. Equation 5.5 which was derived is used within the stored program to select power size using Method B.

$$HP^2 = \sum \frac{.022\ ff}{FC\%\ t\ E} \left[A\ (L) + \sum (A_i\ K_i\ Y_i\ V_i) \right] \tag{5.5}$$

Where, t = purchase price per usable horsepower, \$/HP

(Other terms are previously defined)

The following assumptions are made with respect to Equation 5.5.

a. That fuel and oil consumption are directly related to HP

b. That t is constant over a wide range of purchase values

c. That FC% is a constant independent of HP

d. That all non-field operations performed by the tractor or tractors are of a type that any tractor could do regardless of size

The procedure for using Method B within the stored program consists of performing the calculations indicated within Equation 5.5 for all operations within the system which will require tractor power and then summing these figures and solving for the optimum amount of power required.

C. General Procedure for Field Machinery Selection

A flow diagram indicating the general procedure followed within the stored program is illustrated in Figure 4. Additional flow diagrams and discussion are included later to explain in greater detail some of the steps shown in Figure 4.

At the start of the procedure followed within the stored program, the data for one machine is read. The data is examined to determine whether or not a total fixed cost percentage of initial cost is given. If not, a fixed cost percentage is calculated using the same procedure illustrated in Figure 2 of Chapter IV. The only changes are that an average life in years for the machine is used and no consideration is given the expected machine life allowed by wear. Since the machine sizes are not known, the annual hours of use cannot yet be calculated. Repair and lubrication costs are included with taxes, insurance, and shelter as fixed annual percentages of initial cost. The total fixed costs are calculated using the unit purchase price of the machine as the initial cost and 10 percent of the unit purchase price as the salvage value. The total fixed cost is then divided by the unit purchase price to obtain the fixed cost percentage.

After the determination of a fixed cost percentage a check is made to determine whether or not the data is for tractors. If so, the

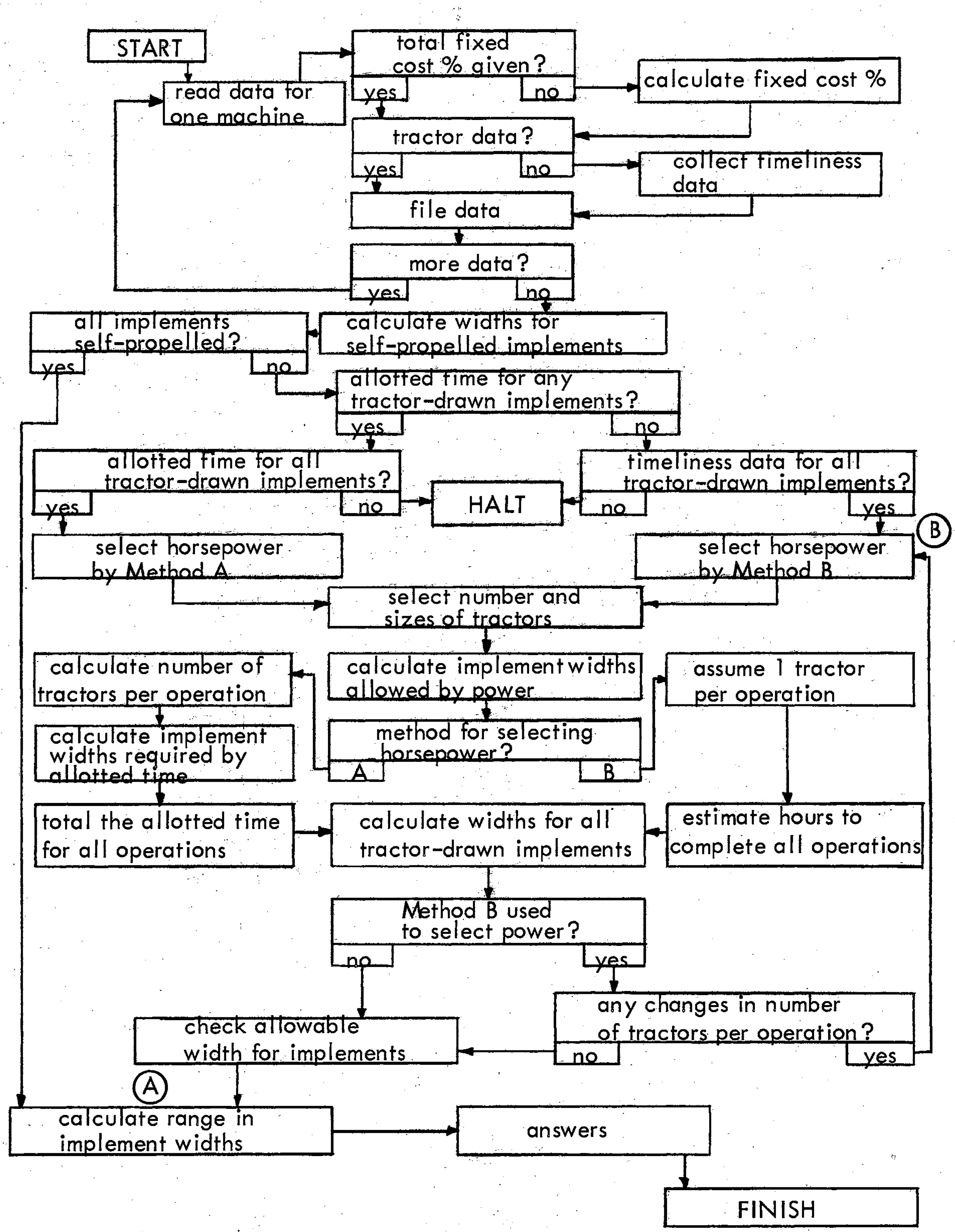

Figure 4. Flow Diagram of General Procedure for Field Machinery Selection.

tractor data is placed on file for future reference. If not, any timeliness data for the implement is processed and totaled. The value for $\sum(A_i\ K_i\ Y_i\ V_i)$ to be used in Equation 5.2 is determined at this point. If no timeliness data of this nature is present, a zero is recorded as the value of $\sum(A_i\ K_i\ Y_i\ V_i)$ for the implement. The implement data is then placed on file for future reference.

A check is now made to see if any more data remains to be read. If so, data for another machine is read. If not, the data is checked for self-propelled implements. The optimum widths for all self-propelled implements are calculated at this point. Following the calculation of widths for self-propelled machines, a check is made to see if all implements in the system are self-propelled. If all implements are self-propelled, the next step is at point A of Figure 4. If all implements are not self-propelled, the tractor-drawn implements are examined to determine whether or not an allotted time is given for any of the tractor-drawn implements. If an allotted time is given, a check is made to determine whether or not an allotted time is given for <u>all</u> tractor-drawn implements. If so, the amount of power required for the system is determined by Method A. If not, the procedure halts. One of the requirements for the input data of all tractor-drawn implements is that if an allotted time is given for one tractor-drawn implement, an allotted time must be given for all tractor-drawn implements. Such data is essential for the calculation of required power by Method A.

If no allotted time is given for any of the tractor-drawn implements, a check is made to determine if timeliness data is given for all tractor-drawn units. If so, the amount of power required for the system is determined by Method B. If not, the procedure is halted since adequate data for calculating required power size by either Method A or Method B is not available.

After the total amount of power required has been determined, the number and sizes of tractors are determined. The maximum width of each type of implement within the system which may be pulled by the total amount of power available is calculated along with the width that can be pulled by each size of tractor selected. The implement width that can be pulled by a given amount of power is calculated from Equation 5.6.

$$W = \frac{375\ HP}{ff\ S} \tag{5.6}$$

Where, W = implement width permitted by available power, feet

HP = amount of power available, horsepower

ff = force factor for the implement, pounds/foot

S = ground speed, miles per hour

These widths of implements allowed by the available power are filed for future reference.

If Method B was used to select the total amount of power required, the number of tractors that will be required for each type of implement to be selected is assumed along with the total annual hours of use for the power sources. The procedure of the stored program is to assume that one tractor will be used for each operation and that the total annual hours of use for the power sources will be 500 hours. An assumption of the number of tractors used per operation is necessary in order to calculate the total labor costs, L, in Equations 5.1 and 5.2 for tractor-drawn implements.

If Method A was used to select the total amount of power required, the number of tractors required for each operation is estimated by dividing the power required to complete each operation within the allotted time period by the maximum size of tractor used. The power required to complete each operation within the allotted time has been previously calculated as part of the procedure of Method A for calculating total required power. The implement widths required by allotted time are then calculated using Equation 5.3. These calculated widths are filed for future reference. The total allotted hours for all operations to be conducted by tractor-drawn implements are then totaled to be used as an estimate of the annual hours of power use.

After the number of tractors required for each operation and the total annual hours of use for the power are estimated, the optimum widths for all tractor-drawn implements are calculated. Following the calculation of optimum widths, a check is made to determine whether or not Method B was used to calculate the total required power for the system. If so, an additional check is made to determine if more tractors are needed for any operations than was last assumed when solving Equation 5.5. The number of tractors used per operation must be known when using Equation 5.5 in order to determine the correct value for labor, L, to be used. If more tractors are needed for any operations, the procedure reverts back to point B of Figure 4 where the total required power is recalculated using Method B. The steps following the calculation of required power by Method B are then repeated using the new figure for total power.

If no changes are made in the number of tractors assumed for each operation, or if Method A was used to determine total required power, a check on the maximum allowable widths for all tractor-drawn implements is conducted. When the allowable widths have been determined the selection of a system of tractors and implements is complete and the next step is at point A of Figure 4.

The calculation of implement width, W, by the procedures followed within the stored program produces a very precise solution. Since the calculated width selected is seldom available in a commercial implement size, a commercial size must be chosen which will match the calculated optimum width, W, as closely as possible. Since implements that are slightly over-sized are usually considered preferable to under-sized implements, the first commercial implement size available which is larger than the calculated width, W, is usually acceptable.

To facilitate the selection of implements in commercially available sizes, Hunt (9) developed Equation 5.7 to calculate a range in the selected implement width, W, which is allowable for a preselected difference in annual cost.

$$W_{1,2} = W + \frac{d}{2FC\%\ p} \pm \sqrt{\frac{d}{FC\%\ p} \left(W + \frac{d}{4\ FC\%\ p} \right)} \qquad (5.7)$$

Where previously undefined terms are:

d = the selected number of dollars which is judged insignificant when compared with the minimum annual cost for the operation

$W_{1,2}$ = the double answer obtained which defines a range in implement widths wherein the annual costs of operation are approximately the same

If the annual cost for an operation is allowed to vary 5 to 10 dollars above the minimum (d = 5-10), a range in W may be calculated which will nearly always allow the selection of a commercially available implement size of a width which will fall between the two acceptable limits. For a given value of d, the range in W will be much larger for lower cost implements than for high cost implements.

Following the calculation of an acceptable range in implement widths all data which will be of importance for the selection of commercial implement sizes is gathered and the answers are written. This finishes the procedure followed by the stored program for selecting optimum sizes of field machinery.

The procedure for analyzing the output data and selecting commercially available machine sizes is presented in Chapter VI.

Further discussion and expanded flow diagrams of some of the more detailed steps of the machinery selection procedure outlined by Figure 4 are now presented.

D. Calculation of Widths for Self-propelled Implements

The procedure followed by the stored program for calculating the optimum widths of self-propelled implements is illustrated by the flow diagram in Figure 5.

Since self-propelled implements do not share a common power source with other implements, the selection of an optimum width may be accomplished independently without consideration of any of the other machines within a system. The calculation of optimum widths for self-propelled implements takes place within the program as soon as all data has been read. Once the optimum widths for all self-propelled implements have been determined, no further consideration is given the self-propelled machines until the computational procedure reaches point A of Figure 4.

One of the requirements of the input data is that operations for which self-propelled implements are desired must be so designated before

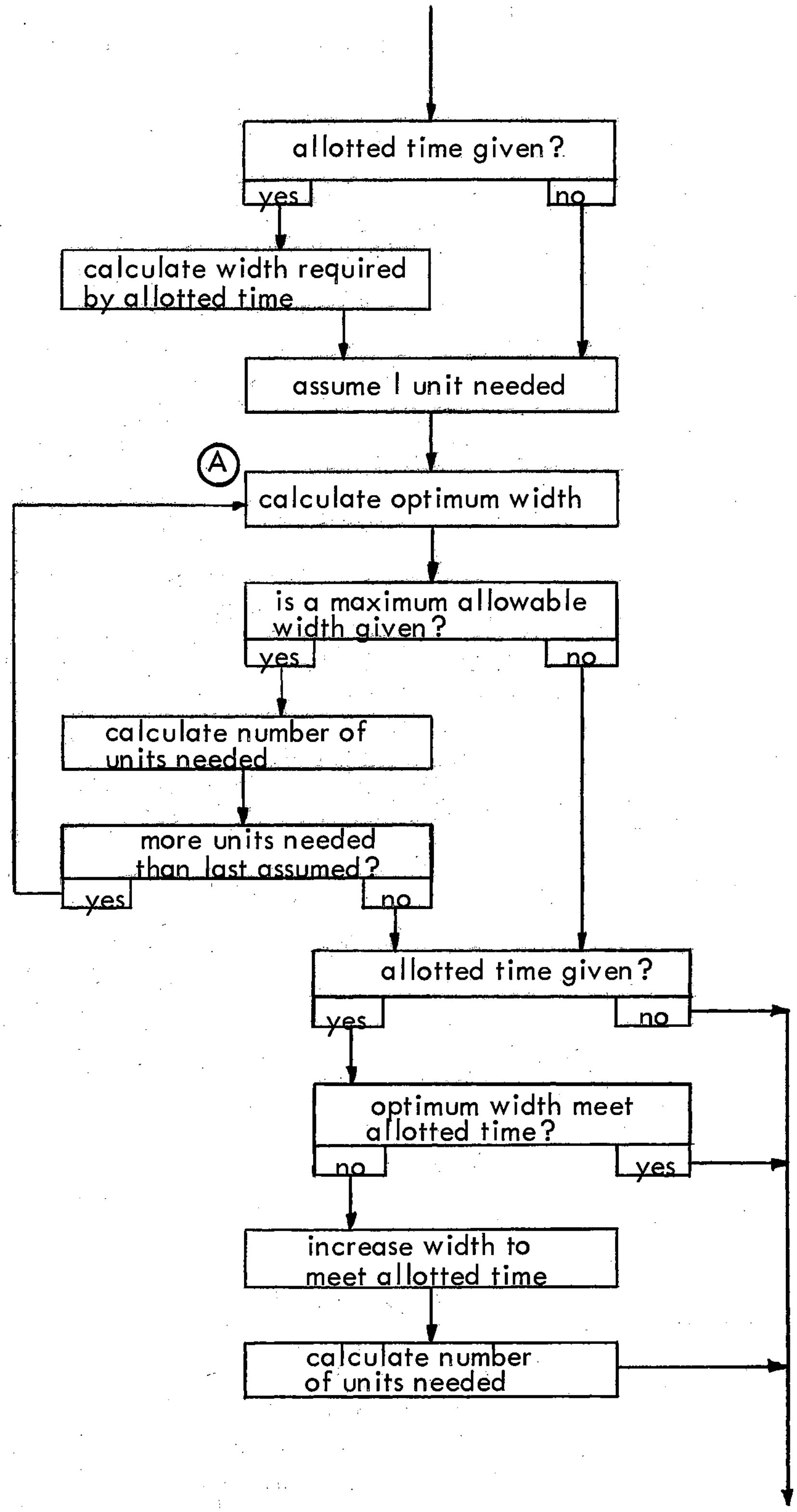

Figure 5. Flow Diagram of Procedure for Calculation of Widths of Self-propelled Implements.

the start of the selection procedure. No provision is made within the stored program for arbitrarily selecting either a self-propelled or tractor-drawn implement to perform a given operation. The selection equations used would tend to discriminate against self-propelled machines if such a procedure was followed since no economic value for the convenience and possible increased efficiency of self-propelled implements is given.

The first step for calculating the optimum widths of self-propelled implements consists of checking the implement data to determine if an allotted time for completing the operations to be performed by the implement is given. If an allotted time is given, the required implement width for completing the operations within the allotted time period is calculated using Equation 5.3. After the calculation of the implement width required by the allotted time is finished or after the allotted time check, if no allotted time is given, the number of implements needed to supply the total required implement width is estimated. In the procedure followed by the stored program, one unit is assumed at this point.

The optimum width for the implement is now calculated using Equation 5.1 or if timeliness data is available, Equation 5.2. Following the calculation of the optimum width a check is made to determine if a maximum allowable width is given for the implement. If a maximum allowable width is not given, it is assumed that the required width for the implement may be included in one unit. If a maximum allowable width is given, the calculated width is divided by the allowable width per unit to determine the number of units required. If more units are required than last assumed, the procedure reverts back to point A of Figure 5 where the optimum implement width is recalculated using a different value for labor, L, since labor for more units is needed.

When the optimum size and number of units required to make up the optimum size is finally determined, another check is made to see if an allotted time is given. If so, the width required to meet the allotted time period, which has been previously calculated, is compared with the width calculated using Equation 5.1 or 5.2. If the optimum width calculated is larger than the width required to meet the allotted time, or if no allotted time was given, the calculations for determining the total width and number of units for the self-propelled implement are completed.

If the width required by allotted time is larger than the previously calculated optimum width, the desired width for the implement is assumed to be equal to the width required by the allotted time. The number of units required for the width required by allotted time is calculated and the selection of implement width and number of units is complete.

E. Selection of Number and Sizes of Tractors

The procedure followed by the stored program for calculating the number and sizes of tractors to be used in a system is illustrated by the flow diagram in Figure 6.

Once the amount of total power required for the system has been calculated using either Method A or Method B, the number and sizes of tractors must be found. The first step in this procedure is to compare the total required horsepower with the horsepower of the minimum allowable tractor size. If the total required horsepower is less than that of the minimum allowable tractor size, one tractor of minimum allowable

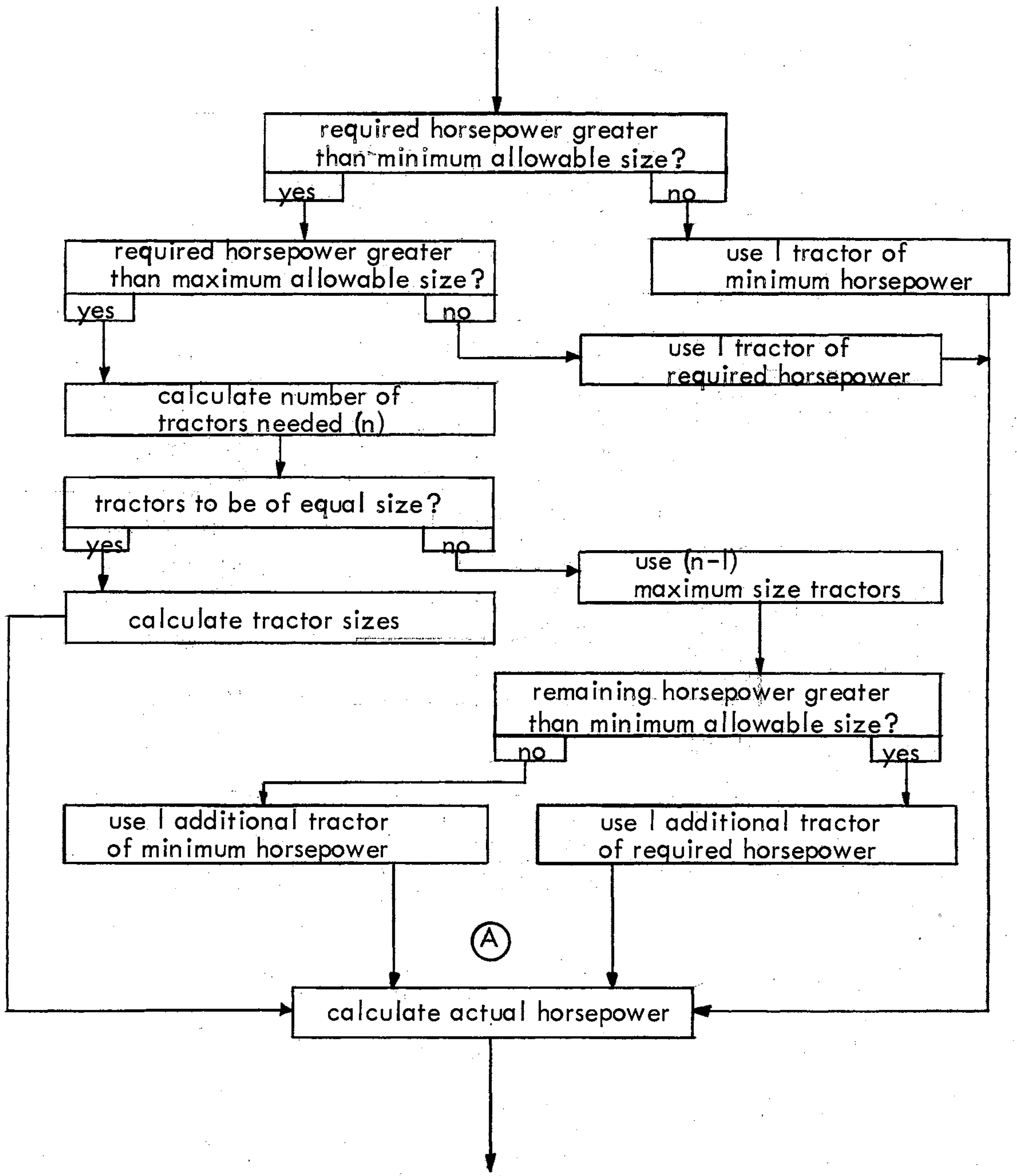

Figure 6. Flow Diagram of Procedure for Selecting Number and Sizes of Tractors.

size is selected to fulfill the power requirements for the system. The next step is at point A of Figure 6.

If the minimum size tractor will not meet the total power requirement, a check is made to see if the total power requirement may be met by a tractor of the maximum allowable power size, if so, one tractor with a power size equal to the total power required for the system is selected. The next step is then at point A of Figure 6.

If the total power requirement exceeds the power available with the maximum allowable tractor size, more than one tractor must be selected. The total number of tractors required, n, is found by dividing the total power requirement for the system by the horsepower of the maximum allowable tractor size. This figure is then increased to the next whole number to represent the number of tractors required in the event that the number does not come out even after division.

Once the number of tractors to be used within the system is known, two procedures are available within the stored program for dividing the total required power into the proper number of tractors. The choice of the two methods must be indicated in the input data before the start of the selection procedure for the system.

One method is to select all tractors for the system in equal sizes. These sizes are determined by dividing the total required power by the number of tractors to be used. This procedure produces (n) tractors, all of which are equal in size. The principal advantage of this approach is the flexibility of the final selection since any of the tractors could be used with any implements selected. After completion of this step the next step is at point A of Figure 6.

If the tractors are not selected in equal sizes, the alternate method consists of selecting (n-1) tractors of the maximum allowable size and satisfying the remainder of the total power requirement with a tractor of smaller size. This method has the advantage of possibly providing a smaller tractor for some of the operations requiring less power. Selection by this method should generally be the cheapest from a cost viewpoint since the maximum tractor sizes will permit the performance of more operations with a minimum labor cost. A disadvantage of this approach is that the flexibility provided by equal power sizes may not be present if only 2 or 3 tractors are selected. This factor may not be important if numerous conflicting operations are not encountered. Following the calculation of numbers and sizes of tractors the final step in the procedure occurs at point A of Figure 6.

The horsepower of all tractors which have been selected has been defined as the usable horsepower of the individual tractors. To facilitate the selection of tractors which are commercially available, the usable horsepower of the tractors is converted to the maximum drawbar horsepower for each of the selected tractors. This is accomplished by dividing the usable horsepower for each tractor by 0.75.

F. Calculation of Widths for Tractor-drawn Implements

The calculation of optimum widths for tractor-drawn implements is the most involved process in the entire procedure of machinery selection followed by the stored program. This section also requires the major portion of all calculations necessary to efficiently select field machinery for a given system. The selection of tractor-drawn implements is difficult because all of the implements require power from another source. For this reason the entire system of implements must be selected as a group. Any change in the size of one implement results in a change of the total annual hours of use for the power. Since this change in turn affects the tractor fixed cost per hour, T, which is used in Equation 5.1 and 5.2 for selecting implement widths, a change in the size of one implement will bring about a change in the size of all other implements in the system.

The procedure followed within the stored program for calculating the widths of tractor-drawn implements is illustrated in Figure 7.

After the total annual hours of use for the power required by the system has been estimated, an initial estimate of the power fixed cost per hour, T, is made.

At point A of Figure 7, the widths for all tractor-drawn implements are calculated using Equation 5.1 or Equation 5.2 if timeliness data is given. The hours required for the operations performed by each implement to be completed using the implement width calculated are found from Equation 5.8.

$$h = \frac{825A}{S\ W\ E} \tag{5.8}$$

Where, h = annual hours required to complete operations using calculated implement width

A = annual acres covered by the implement

S = ground speed, miles per hour

W = calculated implement width

E = field efficiency, percent

The annual hours found for all tractor-drawn implements in the system are then totaled and the hourly fixed cost charge for power, T, is recalculated. This value for T is compared with the last estimate used

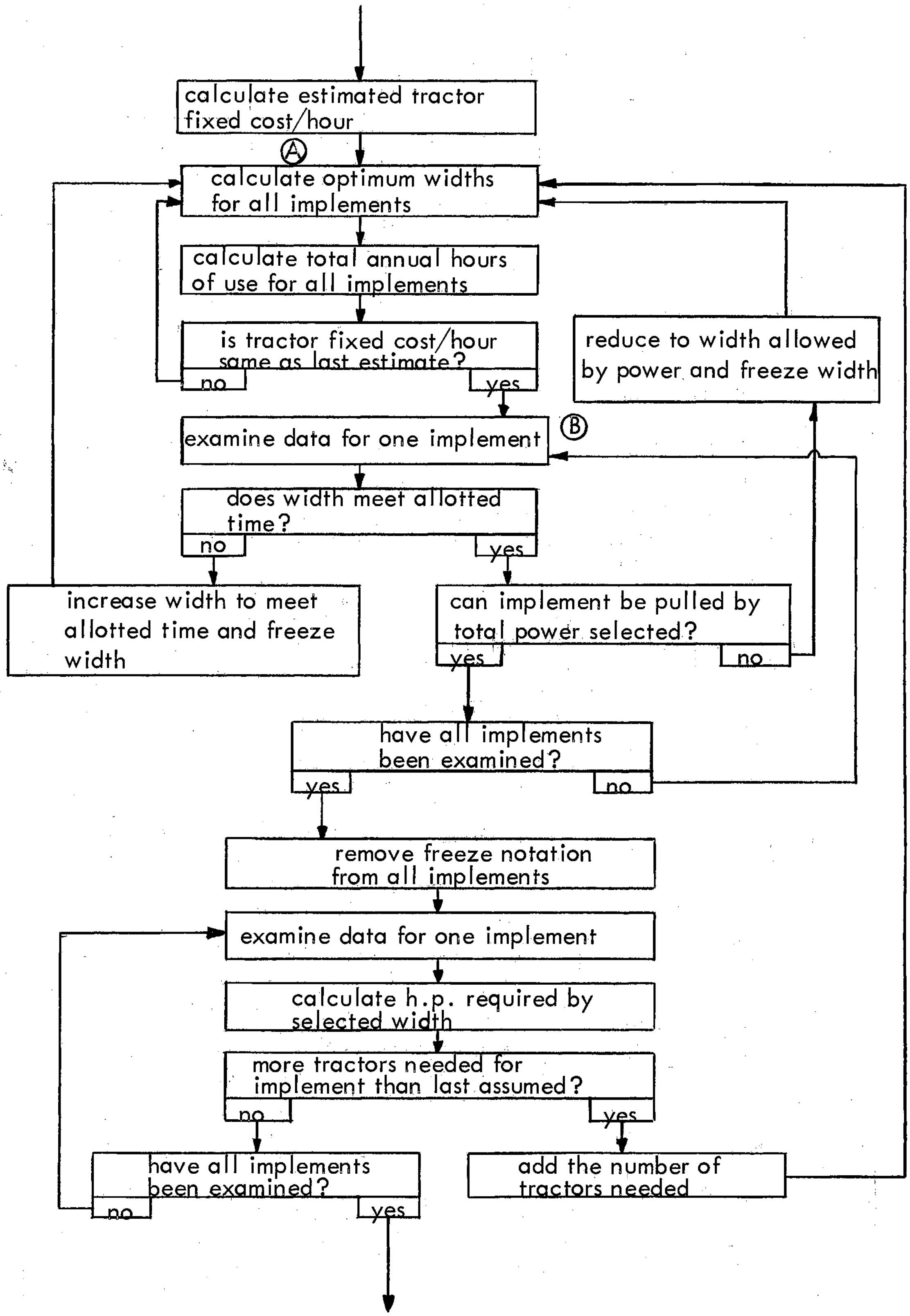

Figure 7. Flow Diagram of Procedure for Calculation of Widths of Tractor-drawn Implements.

for T, if a difference exists between the two values, the procedure reverts back to point A of Figure 7 where the widths for all tractor-drawn implements are recalculated using the new value for T. This cycle is continued until the two estimates for T are equal. To prevent needless cycling at this point the two values for T are considered equal when the first four significant figures at the left are the same.

After the values for T are found to be equal the implements are examined one at a time at point B of Figure 7 to determine whether or not the calculated widths are adequate for meeting an allotted time period if given. The implement width required by allotted time has been previously calculated and may be compared with the calculated implement width found using Equation 5.1 or Equation 5.2. If the implement width required by allotted time is larger, this width is assumed to be the desired width of implement. The procedure then reverts back to point A of Figure 7 where the widths of all other implements are recalculated since a new T value will result after the change in size of one implement. A "freeze" notation is attached to the implement for which the size was increased to meet allotted time requirements. This notation signifies that the width for that particular implement is to be considered constant for the time being and that the width for the implement is not to be recalculated at point A of Figure 7.

If no allotted time is given or if the calculated implement width will meet the allotted time requirement, a check is made to determine if the implement width which has been calculated can be pulled by the total amount of power available. The implement widths allowed by total power have been previously calculated and may be compared with the implement width found using Equation 5.1 or Equation 5.2. If the width allowed by power is smaller than the calculated width, the width of the implement is reduced to a size which may be pulled by the total power available. A "freeze" notation is attached to the implement for which the size was reduced because of power limitations and the procedure reverts back to point A of Figure 7 for the recalculation of the widths of other implements.

If the calculated width for an implement should meet both the allotted time requirement and the power limitations a check is made to see if the data for all implements has been examined for conformance to these conditions. If all implements have not been examined, the data for another implement is examined. If all implements have been examined and meet the restrictions, the implement widths are temporarily settled.

The "freeze" notation is now removed from any implements for which it has been imposed. The data for the implements is again checked one at a time and the horsepower required to pull the implement width which has been selected is calculated using Equation 5.9.

$$H\,P = \frac{S\ W\ ff}{375} \qquad (5.9)$$

(All symbols are previously defined)

The number of tractors required to pull the total implement width selected is determined by dividing the horsepower required to pull the selected implement width by the horsepower of the largest tractor available. A check is made to determine if the number of tractors required for the implement is greater than was last assumed. If so, the procedure reverts back to point A of Figure 7 since the change in number of tractors will change the value of L in Equations 5.1 and 5.2 resulting in the calculation of a different implement size for the other implements.

If no change in the number of tractors used with one implement has occurred, the data for another implement is checked. When the data for all implements has been checked and no additional tractors are added for any of the implements, the procedure for calculating the widths of all tractor-drawn implements within the system is completed.

G. Checking Allowable Widths of Tractor-drawn Implements

A flow diagram indicating the procedure followed by the stored program for checking the allowable widths of tractor drawn implements is illustrated in Figure 8.

Although many tractor-drawn implements may be connected in series so that there is actually no limit to the size that may be pulled by a tractor with adequate power, it is often desirable to limit the size of implement to be pulled by any one tractor. For some implements which cannot be connected in series, there is a maximum commercial size available which may be pulled by one tractor.

The first step indicated in Figure 8 is a check to determine if a maximum allowable width for an implement is given. If not, the procedure is completed. If a maximum allowable width is given, a check is made to see if this width is larger than the width of implement that the largest tractor in the system will pull. If so, the allowable width has no bearing on the problem and the procedure is complete. If the allowable width is smaller than the width which may be pulled by the largest tractor, the total allowable width which may be pulled by the tractors available is calculated.

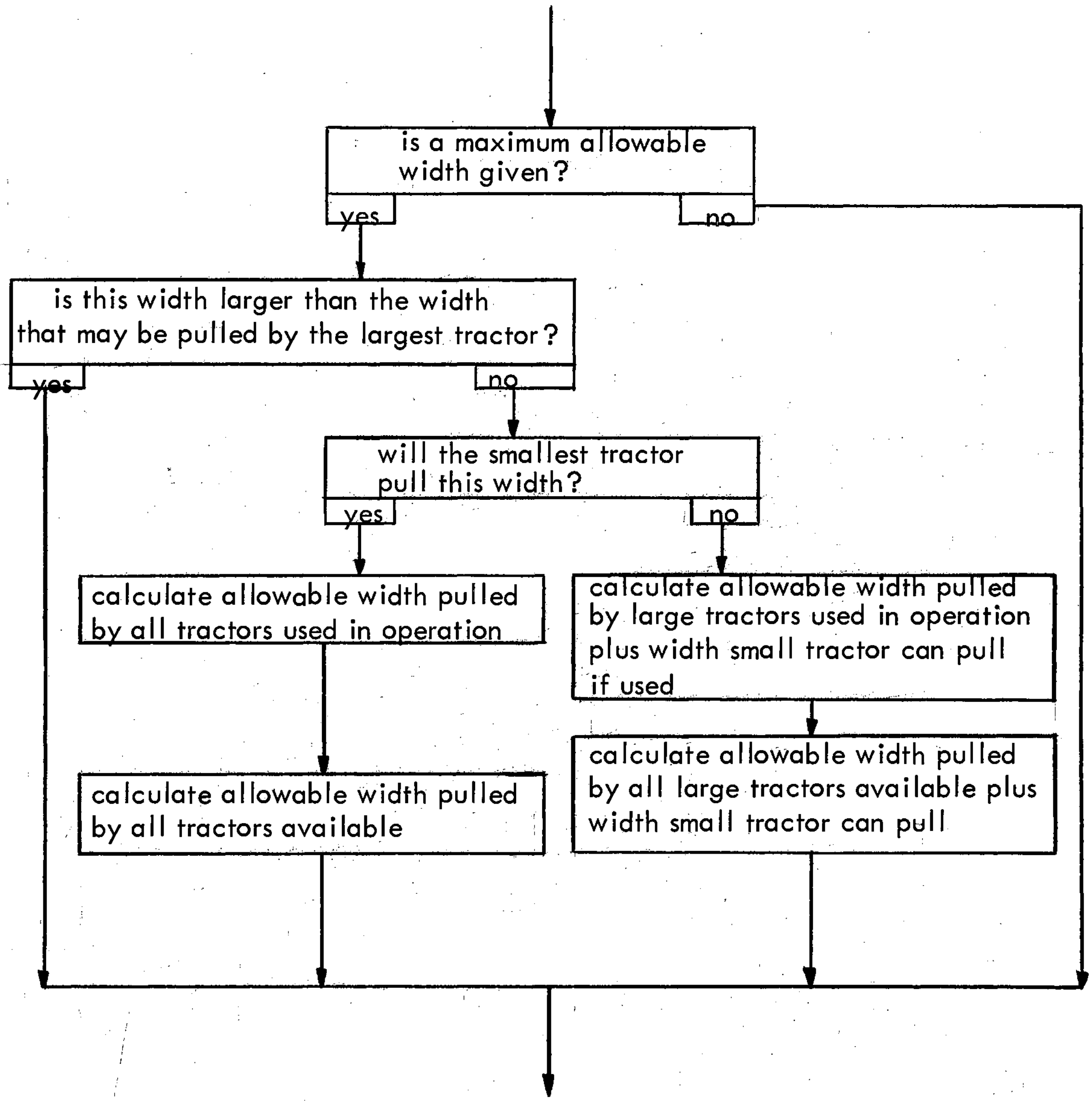

Figure 8. Flow Diagram of Procedure for Checking Allowable Widths of Tractor-drawn Implements.

The total allowable width which may be pulled by the number of tractors which are to be used with the implement is calculated following the procedure shown in Figure 8. The total allowable width which may be pulled by using all tractors which have been selected for the system is then calculated. These calculations complete the procedure.

The data calculated at this point is used to aid in the selection of commercially available implement widths later. The range of permitted implement widths calculated from Equation 5.7 will usually permit the selection of an allowable total width which may be pulled by the available number of tractors.

Large differences in calculated widths and maximum allowable widths should never occur. The selection of maximum allowable horsepower per tractor as an item of input data should be based on the consideration of the maximum size of implements that will be available or that will be desired for the operations to be performed.

The rules and procedures for using this stored program for the selection of field machinery are explained in Appendix B.

CHAPTER VI

ANALYSIS AND DISCUSSION

The stored program which has been developed for solving problems of field machinery selection does not select implement widths which are available in commercial sizes. The purpose of the stored program is to provide sufficient information so that an efficient selection of implements in sizes which are commercially available may be made. Since the sizes which will actually be used for a given system are not yet known at the completion of the selection procedure followed by the stored program, the calculation of the annual costs for the selected system cannot be achieved within the same program.

When the data provided by the machinery selection program has been analyzed and implement sizes which are available have been selected, the calculation of annual machinery costs may be performed by the stored program discussed in Chapter IV. In this manner complete information concerning the expected annual costs for a selected system of implements may be found.

The following items of information are provided by the stored program for selecting field machinery:

1. The optimum width of the implement in feet which has been calculated by the procedure followed within the stored program.

2. An allowable range in implement width which extends on either side of the optimum implement width. This range is to

allow the selection of a commercial size of implement which will result in approximately the same annual costs that would be incurred if the optimum width of implement were used.

3. The implement width which can be pulled by the maximum amount of power which is available within the system. This item is intended as a check to prevent the selection of an implement width within the allowable range which cannot be pulled by the available power. If this width is equal to the optimum width, the optimum width selected was probably restricted by the total amount of power available.

4. The number of tractors used to pull the total selected implement width. The number of tractors denotes the number of individual implements which will be selected to make up the total required implement width.

5. The horsepower required by the optimum implement width. This item is included largely as a matter of interest to determine which implements require the most horsepower. It may also help to determine the tractor size needed to pull the implement.

6. The implement width required by an allotted time period if given. This item may be compared with the optimum width to determine which implement sizes were determined by the allotted time requirement.

7. The maximum width of implement which can be pulled by the largest tractor selected.

8. The maximum width of implement which can be pulled by the smallest tractor selected. Items 7 and 8 are important for determining the widths of the individual implements which may be chosen to

make up the total required implement width. It should be remembered in the selection process that if (n) tractors have been selected by the unequal size method, that there will be (n-1) large tractors and only one small tractor. There is no smaller tractor to consider if the tractors were all selected in equal sizes.

9. The maximum width of implement which is available as a single commercial unit. This item was also an item of input data but is included here to guard against the selection of implement units which are not available.

10. The maximum width which may be pulled by the number of tractors selected for use with the implement being considered. If the width per unit is limited, this item indicates the total width which can be pulled by the assumed number of tractors. This is a limitation due to available size of individual units not the available power. Generally this total available width will fall within allowable range of widths given by item 2.

11. The maximum width which may be pulled by all tractors selected for the entire system for situations where the available implement width per unit is limited. This item may be referred to if the width indicated by item 10 does not fall within the allowable range. If the total number of tractors in the system are already being used with this type of implement, the maximum widths given by item 10 and item 11 will be the same. Items 9-11 are usually zero since in most instances consideration of a maximum available width which is smaller than the width permitted by power is not necessary.

For self-propelled implements, only items 1,2,4, and 6 are given.

Item 4 lists the number of units which are to make up the total required width for self-propelled implements.

The information provided for tractor selection is:

1. The total number of tractors selected for the system.

2. The total usable horsepower selected for the system.

3. The usable horsepower of the largest tractor selected.

4. The actual horsepower of the largest tractor. This item indicates the maximum drawbar horsepower of the tractor and is included to aid selection of a commercial size.

5. The usable horsepower of the smallest tractor selected.

6. The actual horsepower of the smallest tractor selected.

Items 5 and 6 for tractors are zero if equal sized tractors are selected.

To illustrate the type of selection which may be made from the data furnished by the stored program, two examples are presented. The basic data for the two examples is the same and is listed in Table V. For Example 1 the implements and power were selected using timeliness data. The tractors were chosen in equal sizes. For Example 2 the implements and power were selected using an allotted time period for the operations performed by each implement. The tractors were chosen in unequal sizes.

Timeliness data for Example 1 is listed in Table VI. The solutions for Example 1 which were provided by the stored program are listed in Table VII. The following selection of implement widths in commercially available sizes was made for Example 1 using the data provided in Table VII:

TABLE V

DATA FOR EXAMPLES 1 AND 2

Machine	Speed (mph)	Force factor (lb/ft)	Field efficiency (%)	Purchase price ($/ft)	Years life	Rep., lub., taxes, ins., shelter (%)	Labor ($/hr)	Sinking fund interest (%)	Interest on investment (%)	Max. avail. width (ft)
Plow	4.5	900	80	120	15	8.5	1.25	4	3	---
Harrow	6.0	170	90	15	15	3.5	1.25	4	3	---
Grain drill	5.0	115	70	75	15	4.0	1.25	4	3	26.67 (8 row)
Cultivator	5.0	135	75	40	12	5.0	1.25	4	3	26.67
Planter	5.0	110	65	55	15	4.0	1.25	4	3	16.00
*Combine	4.0	375	75	400	10	6.0	1.50	4	3	---
Mower	5.0	130	85	50	12	6.0	1.25	4	3	---
Rake	5.0	80	90	60	15	4.0	1.25	4	3	---
Baler	3.0	405	80	350	12	6.0	1.25	4	3	---
Tractor	---	---	---	$100/hp	12	7.0	---	4	3	---

*Self-propelled

Allowable cost range for implements (d) - $10.

Maximum allowable tractor size - 52.5 h.p. (usable) - 70 h.p. (actual)
Minimum allowable tractor size - 15.0 h.p. (usable) - 20 h.p. (actual)

TABLE VI

TIMELINESS DATA FOR OPERATIONS IN EXAMPLE 1

Implement	Wheat		Oats		Grain Sorghum		Hay		Total Annual Acres Covered
	Acres	Timeliness Factor	Acres	Timeliness Factor	Acres	Timeliness Factor	Acres	Timeliness Factor	
Plow	500	.00005	100	.00005	300	.00005	---	---	900
*Harrow	1500	.00001	200	.00001	600	.00001	---	---	2300
Grain drill	500	.0005	100	.0005	---	---	---	---	600
*Cultivator	---	---	---	---	900	.0005	---	---	900
Planter	---	---	---	---	300	.0005	---	---	300
Combine	500	.0005	100	.0007	300	.0005	---	---	900
Mower	---	---	---	---	---	---	150	.001	150
Rake	---	---	---	---	---	---	150	.001	150
Baler	---	---	---	---	---	---	150	.001	150

*Acres covered more than 1 time.

Total Crop Values (Y_i V_i)

Wheat = 500 acres x 25 bu./ac. x $2.00/bu. = $25,000

Oats = 100 acres x 30 bu./ac. x $ .75/bu. = $ 2,250

Grain Sorghum = 300 acres x 35 bu./ac. x $1.00/bu. = $10,500

Hay = 150 acres x 0.75 ton/ac. x 20.00/ton.= $ 2,250

TABLE VII

SOLUTIONS FOR EXAMPLE 1

Implement	Optimum width	Allowable range in width	No. of tractors used	Width allowed by total H. P.	H. P. required by optimum size
Plow	9.60	7.54-12.23	2	9.60	103.70
Harrow	38.12	25.05-58.01	2	38.12	103.70
Drill	55.23	47.38-64.36	2	67.63	84.68
Cultivator	57.61	47.91-69.26	2	57.61	103.70
Planter	38.96	31.50-48.19	2	70.70	57.14
Combine	21.95	20.14-23.94	2 (units)	---	---
Mower	17.24	12.91-23.02	1	59.82	29.88
Rake	17.69	13.08-23.92	1	97.21	18.87
Baler	8.67	7.43-10.12	1	32.01	28.09

Implement	Max. width pulled by largest tractor	Max. width pulled by smallest tractor	Available width per tractor	Available width for tractors used	Available width for total tractors selected
Plow	4.80	---	---	---	---
Harrow	19.06	---	---	---	---
Drill	33.81	---	---	---	---
Cultivator	28.80	---	26.67	53.33	53.33
Planter	35.35	---	26.67 per	53.33	53.33
Combine	---	---	16.0 (unit)	---	---
Mower	29.91	---	---	---	---
Rake	48.61	---	---	---	---
Baler	16.00	---	---	---	---

Total power required - 103.70. Total no. tractors selected - 2. Usable h.p. per tractor selected - 51.85. Actual h.p. per tractor - 69.13.

Implement	Number	Size	Tractors Used
Plow	2	4-14	2
Harrow	2	18 ft.	2
Drill	4	20 x 8	2
Cultivator	2	8 row	2
Planter	2	6 row	2
Combine	2	12 ft.	-
Mower	2	9 ft.	1
Rake	2	8½ ft.	1
Baler	1	-	1

Two tractors were also selected with a maximum drawbar horsepower of 69 each.

Several interesting observations may be made for the data produced by the stored program. The widths of three of the implements which were selected, plow, harrow, and cultivator, were restricted by the total power available. This is indicated by the fact that the selected optimum widths for these implements are equal to the widths permitted by the total available power. Also the power required to pull these widths is equal to the total available power, 103.70 horsepower. Two units are coupled together to meet the required width for mower and rake. These double units are both pulled by one tractor. Since eight-row equipment is the largest available size for row crop work the optimum width of 57.6 feet for the cultivator cannot be met using only two tractors. The allowable width of 53.3 feet obtained by using two eight-row cultivators with the tractors selected is easily within the allowable range in width however. The required width for the baler is 8.67 feet. Since this is usually within the width covered by a single swath picked up by a baler, one baler is chosen to meet the requirement.

On the basis of a \$10 variation in annual cost a much larger range in allowable width is permitted for implements such as the harrow and cultivator which have a low unit cost, p, than is permitted for higher cost implements like the combine and baler.

The data for Example 2 is identical to the data used for Example 1 with the exception that an allotted time period for the completion of all operations performed by each implement is given instead of the timeliness data. Tractors are selected in unequal sizes. The allotted times permitted for the implements to be selected in Example 2 are listed in Table VIII.

The solutions for Example 2 which were provided by the stored program are listed in Table IX. The following selection of implement widths in commercial sizes was made for Example 2 using the data provided in Table IX:

<u>For the large tractor</u>:

1 - 4-14 plow

1 - 18 ft. harrow

2 - 16 x 8 drills

1 - 8 row cultivator

1 - 6 row planter

1 - baler (large capacity)

<u>For the small tractor</u>:

1 - 1-14 plow

1 - 5 ft. harrow

1 - 2 row cultivator

1 - 9 ft. mower

1 - 8½ ft. rake

2 - 14 ft. combines

After checking the solutions for Example 2 in Table IX, several factors may be noted. While an allotted time was given for all implements, the width required for meeting the allotted time requirement was

TABLE VIII

ALLOTTED TIME FOR OPERATIONS IN EXAMPLE 2

Implement	Total annual acres covered	Total allotted days	hrs./day	Total allotted hours
Plow	900	18	*20	360
Harrow	2300	23	10	230
Drill	600	12	10	120
Cultivator	900	15	10	150
Planter	300	6	10	60
Combine	900	9	10	90
Mower	150	4	10	40
Rake	150	4	10	40
Baler	150	4	10	40

*Plowing is conducted day and night to reduce required capacity

TABLE IX

SOLUTIONS FOR EXAMPLE 2

Implement	Optimum width	Allowable range	No. of tractors	Width allowed by total h.p.	H.P. required by opt. width	Width req. by allotted time
Plow	6.25	4.63-8.43	2	6.25	67.5	5.73
Harrow	24.82	14.77-41.67	2	24.82	67.5	15.28
Drill	22.56	17.76-28.66	1	44.02	34.60	11.78
Cultivator	37.50	29.85-47.11	2	37.50	67.5	13.20
Planter	19.33	14.30-26.13	1	46.02	28.36	12.69
Combine	27.5	25.46-29.70	2 (units)	---	---	27.50
Mower	10.84	7.53-15.61	1	38.94	18.79	7.28
Rake	11.12	7.61-16.26	1	63.28	11.86	6.88
Baler	12.89	11.35-14.63	1	20.83	41.77	12.89

Implement	Allow. width for large tractor	Allow. width for small tractor	Available width per tractor	Available width for tractors used	Available width for total tractors selected
Plow	4.86	1.39	---	---	---
Harrow	19.30	5.51	---	---	---
Drill	34.24	9.78	---	---	---
Cultivator	29.16	8.33	26.66	35.00	35.00
Planter	35.80	10.23	26.66 per	26.66	36.89
Combine	---	---	16.00 (unit)	---	---
Mower	30.29	8.65	---	---	---
Rake	49.21	14.06	---	---	---
Baler	16.20	4.63	---	---	---

Total power required - 67.5. Total no. tractors selected - 2. Usable h.p. of large tractor - 52.5. Usable h.p. of small tractor - 15. Actual h.p. of large tractor - 70.0. Actual h.p. of small tractor - 20.

the determining factor for only two implements, the combine and the baler. For all other implements the calculated width which would produce minimum costs was larger than the width required by allotted time. The widths for the plow, harrow, and cultivator were restricted by the power available.

The selection of commercial sizes using the data provided by Table IX provides about the same number of implements for each of the two tractors. The baler is assigned to the large tractor since a pto baler receiving power from the tractor was assumed during the calculations. The small tractor is unable to furnish adequate power for the baler. If a baler with an auxiliary engine were selected, it could be pulled by the small tractor. A 9 foot mower was selected for the small tractor although the calculated width which is allowed for the small tractor due to available power is slightly smaller, 8.65 feet. It was felt that the sizes were close enough that a serious power shortage would not result. Matching the mower with the small tractor was considered a better choice than placing the mower with the large tractor. A 7 foot mower could be used with the small tractor although 7 foot is slightly outside the allowable range in widths.

Some striking differences are noted when the solutions for Example 1 are compared with the solutions for Example 2. Both selections were made for the same crops and acreages. All of the basic data is the same with the exception of the timeliness data for Example 1 and the allotted time data for Example 2. The calculated optimum widths and selected power for Example 1 are much larger than for Example 2. For some implements the optimum width found in Example 1 is more than double the width found in Example 2. The only implements which are larger in

Example 2 are the combine and baler.

Since the allotted times used in Example 2 are approximately equal to those generally assumed in actual practice, it would appear that the value for timely operations is much greater than is generally recognized. In fact when the reduction of crop value is considered an hourly charge, this cost is often considerably greater than the total hourly costs for both labor and power when the optimum implement width is calculated.

The advantages of each of the methods for selecting tractor sizes is indicated by the two examples. In Example 1, maximum flexibility is possible since either of the equal size tractors may be used to pull any of the selected implements. In Example 2, a small tractor is selected for use with some of the implements requiring less power. When the maximum size tractor is used, some operations may be performed with one tractor where two tractors would be required if equal sized tractors had been selected for Example 2.

The annual costs for the system of implements selected in Example 2 were calculated using the stored program discussed in Chapter IV. The data used for calculating these annual costs is listed in Table X. For the purposes of calculating annual costs gasoline tractors are used since this was the type tractor considered when, t, the tractor cost per usable horsepower was estimated for the purposes of power selection. Since the costs for the implements pulled by each tractor are calculated separately, the total acreage covered for each operation is divided up and the acreage covered by each implement is assumed proportional to the implement width. This is done for the plowing, harrowing, and cultivating operations where two tractors are used.

TABLE [illegible]

DATA FOR CALCULATING ANNUAL COSTS FOR IMPLEMENTS SELECTED IN EXAMPLE 2

Machine	Purchase price*	Salvage value	Repairs	Lubrication	Taxes, ins., and shelter	Life in hours
70 h.p. tractor	$ 5500	$500	3.5%	0.7%	2.5%	12000
4-14 plow	600	60	7.0	0.5	1.5	2000
18 ft. harrow	350	40	2.0	0.1	1.0	2000
2-16x8 drills	1800	150	1.5	0.7	2.0	1200
8 row cultivator	1150	100	3.5	0.3	1.5	2500
6 row planter	1400	140	2.0	0.5	2.0	1200
Baler	2200	250	3.0	0.8	2.5	2500
20 h.p. tractor	2100	300	3.5	0.7	2.5	12000
1-14 plow	180	30	7.0	0.5	1.5	2000
5 ft. harrow	100	15	2.0	0.1	1.0	2000
2 row cultivator	300	50	3.5	0.3	1.5	2500
9 ft. mower	450	45	3.5	0.7	2.0	2000
8½ ft. rake	700	100	2.0	0.5	2.0	1500
2-14 ft. combines	12000	1000	3.0	0.5	2.5	2500

* Estimated

Implement speed, field efficiency, years life, sinking fund interest, interest on investment, and labor charges which were indicated in Table V are used again for the calculation of annual costs.

Hourly fuel and oil consumptions for the tractors are taken from Table II.

Fuel consumption per combine - 2.5 gal/hr. Oil consumption per combine - 0.01 gal/hr. Fuel price - $.20/gal. (gasoline). Oil price - $1.25/gal.

The annual costs calculated by the stored program are listed in Table XI. At this point accurate comparisons of the costs of using the different implements selected may be made with charges for custom work. If the decision is made that custom hiring would be preferable to machine ownership, the implement performing that particular operation may be eliminated.

If the most efficient selection of a system of implements is desired, the machinery selection procedure should be repeated if any implements are removed because custom hiring is chosen. This is relatively simple using the stored program for machinery selection since the data cards for the implements which have been eliminated are removed from the input data and the remaining cards fed into the computer once more.

Since assumptions are made that field efficiencies and unit costs are the same over all ranges of sizes, when in fact they are not, it may be desirable in some cases to run the selection procedure over again using more accurate values for these items once the approximate sizes of implements that will be selected are known.

The form of the output data which has been discussed in this chapter and the order in which it is listed on the punched cards removed from the computer after the calculations have been performed is explained in Appendix A and Appendix B.

TABLE XI

ANNUAL COSTS FOR IMPLEMENTS SELECTED IN EXAMPLE 2

Implement	Annual hrs. of use	Tractor operating costs	Implement fixed cost	Implement operating (1) cost	Total annual (2) cost	Cost per acre	Cost per hour
4-14 plow	353.5	$266.30	$ 219.94	$441.93	$1315.60	$1.83	$3.72
18 ft. harrow	152.8	115.08	36.81	190.97	510.27	0.28	3.34
2 16x8 drills	66.30	49.94	189.65	82.87	395.11	0.66	5.96
8 row cultivator	59.40	44.74	150.80	74.25	334.88	0.47	5.64
6 row planter	38.08	28.68	150.86	47.60	268.86	0.90	7.06
Baler	57.29	43.15	307.40	71.61	484.95	3.23	8.46
1-14 plow	353.5	112.14	64.34	441.84	785.75	4.36	2.22
5 ft. harrow	152.8	48.47	10.81	190.97	322.62	0.65	2.11
2 row cultivator	59.40	18.84	12.78	74.25	134.01	0.74	2.26
9 ft. mower	32.35	10.26	62.75	40.44	128.78	0.86	3.98
8½ ft. rake	32.35	10.26	74.34	40.44	140.37	0.94	4.34
2-14 ft. combines	88.4	---	1841.85	355.78	2197.63	2.44	24.86

Tractor	Annual hours of use	Total operating cost	Total fixed cost	Fixed cost per hour	Total annual cost
70 h.p. tractor	727.4	$547.90	$797.08	$1.10	$1344.99
20 h.p. tractor	630.35	199.98	298.59	0.47	498.56

Grand total operating costs = $2843.99
Grand total fixed costs = $4218.00
Total annual machinery cost = $7061.99

(1) Represents charge for labor only unless implement has auxiliary engine
(2) Includes that portion of tractor fixed costs charged to the operation

CHAPTER VII

SUMMARY AND CONCLUSIONS

Two stored programs have been developed to solve problems of field machinery selection and cost analysis. One of these stored programs may be used to calculate the annual field machinery costs for operations where the number and types of machines are known. The other stored program may be used to make efficient selections of field machinery for operations where the types of implements desired and acreage to be covered are known.

The stored program for the calculation of annual field machinery costs was discussed in Chapter IV. Provision was made for calculating annual depreciation charges by either the sinking fund or straight-line methods. A trade-in value may be calculated for use in fixed cost calculations for a machine that is to be disposed of before the end of its useful life. Interest on investment may be calculated as either simple or compound interest for either method of depreciation used. Fixed annual rates are used for calculating repair and lubrication charges. These rates may be increased proportionately for cases of high annual use. Fuel consumption rates may be measured on an hourly basis or by the amount of work obtained per gallon of fuel. This stored program provides answers giving the annual hours of use, total variable costs, total fixed costs, cost per acre, and cost per hour for all implements included in the problem. The total annual machinery costs for the entire operation are provided.

The stored program for field machinery selection was discussed in Chapter V. This stored program does not select machinery sizes which are available commercially. Sufficient information concerning the desired optimum machinery sizes is provided in order that an efficient selection of machines in commercially available sizes may be made. The size or capacity of all implements is determined by the effective width. Implement sizes are determined on a least-cost basis and then adjusted to meet timeliness requirements in order that the maximum profit implement size may be found. Increased implement size to meet timeliness requirements may be determined by using timeliness data which may be used to assess an hourly charge for operations performed. An alternate method may be used whereby an implement size is selected which will complete the operations within an allotted time period.

The amount of power required is determined by one of two methods. Total power may be equal to the maximum amount of power required by any single implement in order to complete its operations within an allotted time. For problems where timeliness data is available, a total amount of power may be selected which, along with the implements selected, will produce maximum profit. A choice of two methods for selecting the number and sizes of tractors is provided. All tractors may be selected in equal sizes or for a system requiring (n) tractors, (n-1) tractors of the maximum allowable size may be selected along with one tractor of smaller size.

The stored program for field machinery selection provides answers giving the optimum sizes of implements for all operations, the number and sizes of tractors selected, plus additional information to facilitate the final selection of a complete line of machinery in commercial sizes.

The stored program for calculating annual machinery costs may be used to follow up the stored program for field machinery selection. In this manner, accurate comparisons may be made between expected costs for the selected implements and the rates for custom work.

The two stored programs, developed as the result of this study, should be useful to persons who work problems in the areas of machinery cost calculation and machinery selection. The solutions obtained are simple and easily interpreted. Enough flexibility has been included within the procedure followed by the stored programs that several different approaches to an individual problem are possible.

As has been mentioned previously, none of the procedures which have been outlined in the discussion are impossible to conduct with manual calculations. The use of stored programs with a digital computer merely eliminates all of the tedious and involved computations which must be performed manually. To use stored programs it is necessary to list the desired items of input data on punched cards so that the information may be read into the computer.

Stored programs which have been developed will be useful to people who have access to a digital computer. In the future it may be expected that more people will have access to digital computers as the demand continues to increase and as smaller, cheaper sizes of computers are made available.

While these stored programs were developed for use with one particular type and make of digital computer, similar type programs could be developed to be used with other computer models. Some work may be required for the original development of a stored program, but once assembled it may be kept and used to solve all future problems of the type for which it was designed.

Further study in the areas of machinery cost analysis and machinery selection would be well justified. More efficient and accurate procedures may be found for solving problems of these types. The real need for the present, however, lies in obtaining more accurate information concerning some of the factors affecting machinery cost calculation and selection. Most of the assumptions made for energy requirements and timeliness data are rather arbitrary in nature. Information on these items is non-existent for many farming areas. The need for accurate methods of assessing the value of timely operations was pointed out by the examples presented in Chapter VI. Accurate evaluation of timeliness is essential for selecting a system of machinery which will maximize farm profits. Until better information concerning some of the factors affecting machinery selection is available, the accuracy of the solutions to problems of field machinery selection will be limited.

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APPENDIX A

Rules and Procedure for Using the Stored Program for Calculation of Annual Field Machinery Costs

I N P U T   D A T A   R U L E S

All input data is entered on the same basic three card form. The three cards contain all the information needed to calculate the annual machine cost along with an identification code number for each implement and card. The card form used is identical for all implements and is modified only slightly for tractors. A location is reserved on the input cards for all factors which <u>may</u> be pertinent to a problem of machine cost calculation. For cases where some items are not considered pertinent, the locations for these items may be represented by entering zeros on the input cards.

A numbering system or code is used to identify the type of machine, the tractor used with the machine, and the number of the input card for the machine. The general form for the code is uniform for all machines and is illustrated below with the four digit identification system explained.

CODE IDENTIFICATION NUMBER: General Form - XXXX000000

X|XX|X

- X — Tractor or power unit number, all machines receiving power from this source will have this number. NOTE: This number is 0 for self-propelled implements.
- X (last) — Machine card number (must be 1,2, or 3). All three are required for each machine.
- XX — Implement number for a given tractor, implements drawn by one tractor are identified by this number. Self-propelled machines will all have different numbers in this location also. NOTE: This number will be 00 for a tractor.

Examples: (Card #1 used for each case)

1. Tractor #1 - 1001000000
2. Implement #1 drawn by the above tractor - - - - - -1011000000
3. Implement #2 drawn by the above tractor - - - - - -1021000000
4. Self-propelled implement #1 - - - - - - - - - - - -0011000000
5. Self-propelled implement #2 - - - - - - - - - - - -0021000000

The above identification system enables the computer to identify the different types of machines and to store each of the three input data cards for any given machine in their proper locations.

All other locations on the three input data cards that are not occupied by the code identification number are reserved for input data. To facilitate the entering of the data on the input cards all data is entered in fixed decimal point form. To avoid confusion, the same decimal point location is used for all input data. The standard form is indicated below:

0 0 X X X X X . X X X

The two digits at the extreme left are always zero since any digits placed in those locations are lost in a shifting operation when the computer converts the data to a floating decimal point system. All input data must lie within a range of values of from 00000.001 to 99999.999. <u>Care must be exercised when entering data onto the cards to always place the decimal in the same location regardless of whether any significant figures exist to the right of the decimal or not</u>.

Examples:

1. Initial machine cost of $4500 - - - - - - - - - - - -0004500000

2. Oil consumption of 0.05 gal/hr - - - - - - - - - - 0000000050

3. Fuel consumption of 1.645 gal./hr- - - - - - - - - 0000001645

4. Quantity not pertinent to problem - - - - - - - - - 0000000000

The form for entering data on the input cards is shown on the next page. Each location on the input cards for both implements and tractors is labeled. The storage location within the computer for each item of data is also given. The card number for each implement or tractor is indicated in the location for the identification code to illustrate the data that is to be placed on the card bearing that particular number. Care must be taken when making up data cards to insure that the machine data corresponds to the proper machine card identification number, otherwise the data will not be stored in the proper locations. Each of the items of data for both implements and tractors will be discussed separately. Rules and methods for indicating different desired computational procedures will be pointed out with the discussion of the appropriate item of input data. The computer storage location for each item of input data will be followed by the discussion for that item of data. NOTE: It is important that no items on the input data card be left blank, non-pertinent items should have zeros entered in their location.

IMPLEMENT INPUT CARDS

0010 - Identification code number for card #1.

0011 - Annual once-over acres covered by the implement. If an implement should cover 100 acres a total of 3 times, the once-over acreage is 300 acres. This item must never be 0.

0012 - Implement width measured in feet. This item must never be 0.

0013 - Implement speed in miles per hour. This item must never be 0.

IMPLEMENT INPUT DATA CARDS:

Code XXX10 0	Acres covered	Imple- ment width (ft.)	Imple- ment speed (mph)	Imple. field effi- ciency (%)	Hours of expected life	Years of expected life	Years of owner- ship
0010	0011	0012	0013	0014	0015	0016	0017

Code XXX20 0	Purchase price ($)	Salvage value ($)	Force factor (lb/ft)	Fuel cons. (gal/hr) or (hp-hr/gal)	Oil cons. (gal/hr)	Fuel cost ($/gal)	Oil cost ($/gal)
0020	0021	0022	0023	0024	0025	0026	0027

Code XXX30 0	Repairs (%)	Lubri- cation (%)	Labor ($/hr)	Consum- able items ($/ac)	Taxes, insur- ance, shelter (%)	Interest (%)	Sinking fund interest (%)
0030	0031	0032	0033	0034	0035	0036	0037

TRACTOR INPUT DATA CARDS:

Code X0010 0	Hours used for other operat- ions	Tractor hp	ZERO	ZERO	Hours of expected life	Years of expected life	Years of owner- ship
9032	9033	9034	9035	9036	9037	9038	9039

Code X0020 0	Purchase price ($)	Salvage value ($)	Fuel cons. (hp-hr/gal)	Fuel cons. (gal/hr)	Oil cons. (gal/hr)	Fuel cost ($/gal)	Oil cost ($/gal)
9042	9043	9044	9045	9046	9047	9048	9049

Code X0030 0	Repairs (%)	Lubri- cation (%)	ZERO	ZERO	Taxes, insur- ance, shelter (%)	Interest (%)	Sinking fund interest (%)
9052	9053	9054	9055	9056	9057	9058	9059

The listed locations for tractor information are referred to only when the implement operating costs are calculated. When tractor fixed costs are calculated, the tractor data will occupy the same locations as the implement data above.

0014 - Implement field efficiency measured in percent not decimal. This item must never be 0.

0015 - Total machine service life measured in hours of expected life. This figure divided by the annual hours of use gives the years of expected machine life allowed by wear. The years of machine life allowed by wear is compared with the years of machine life allowed by obsolescence (0016). The smaller of these two figures is then considered to be the expected useful life for the given machine. This item may be zero if it is not desired to consider the service life of the machine allowed by wear and obsolescence is intended to determine machine life.

0016 - Machine expected life in years allowed by obsolescence. This item may not be zero. If wear life is not considered, this item may be the average expected life of the machine in years.

0017 - Total years the machine ownership is to be retained. If this figure is shorter than expected machine life, the computer will calculate a trade-in value for the machine at the end of the period of ownership. This trade-in value will be used to calculate depreciation and interest costs during the period of machine ownership. This item may be zero if the machine is to be kept for the extent of its expected useful life.

0020 - Identification code number for card #2.

0021 - Implement purchase price in dollars. This item may not be zero.

0022 - Implement salvage value at the end of the machine's expected useful life. This item may be zero if the machine is considered to have no value at the end of its expected useful life.

0023 - Implement force factor in pounds per foot of width. This item is used if it is desired to calculate fuel consumption on the basis of horsepower-hours obtained per gallon of fuel. If the implement has an engine this information will be used to calculate implement fuel consumption. If not, then it will be used to calculate tractor fuel consumption. This item may be zero if it is desired to calculate fuel consumption on an hourly basis for either tractor or implement.

0024 - Implement engine fuel consumption rate in either gallons per hour or horsepower-hours per gallon. For this item the following rules must be followed closely:

1. This item must list fuel consumption in horsepower-hours per gallon if a force factor (0023) is given and implement has an engine.
2. This item must list fuel consumption in gallons per hour if force factor (0023) is zero and implement has an engine.
3. This item must be zero if the implement is tractor drawn and has no engine.

NOTE: If a tractor drawn implement has an engine, tractor fuel consumption will always be calculated on an hourly basis.

0025 - Implement engine oil consumption rate in gallons per hour. This item is zero if implement has no engine.

0026 - Implement engine fuel price in dollars per gallon. This item is zero if implement has no engine.

0027 - Implement engine oil price in dollars per gallon. This item is zero if implement has no engine.

0030 - Identification code number for card #3.

0031 - Average annual implement repair cost expressed as a percent of implement purchase price. This item may be zero if there are no implement repair expenses.

0032 - Average annual implement lubrication cost expressed as a percent of implement purchase price. This item may be zero if there are no implement lubrication expenses.

0033 - Total labor cost in dollars per hour. For tractor drawn implements the labor cost for implement and/or tractor is entered here. The unit rate must be multiplied by the number of laborers before entering, if more than one laborer is required for the operation. This item may be zero if no labor is required for the operation.

0034 - Total cost for consumable items in dollars per acre. This location provides an entry for all items such as wire, twine, etc. if it is desired to include these items as machinery costs. This location may be zero if there are no consumable items to be included.

0035 - Average annual charge for taxes, shelter, and insurance for implement. This charge is expressed as a percent of implement purchase price. This item may be zero if there are no costs in any of these areas.

0036 - Interest on investment for implement entered as percent. Interest may be calculated as either simple or compound. The method of entering the data in this location determines which of the two methods will be followed for any given implement. For simple interest no special identification is needed and the figures are entered just as for any other data. Compound interest is indicated by entering a 1 three places from the left end of the data or 5 places to the left of the decimal.

Examples of entry form:

1. Simple interest - 0000005000

2. Compound interest - - - - - - - - - - - - - - - - - - - 0010005000

This item may be zero if no charges for interest are to be made.

0037 - Sinking fund interest rate entered as percent. This item determines the type of depreciation that will be used for the implement. If a rate of interest is given, sinking fund depreciation will be used. If this item is zero, straight-line depreciation will be used.

TRACTOR INPUT CARDS

Tractor input data is stored in different locations than implement data and is left in these locations for reference until all implements drawn by the tractor have passed through. At this time the tractor data is placed in the same locations as the implement's data and tractor fixed costs are calculated. For this reason items which are pertinent to fixed cost calculations occupy the same position on the tractor cards as on the implement data cards. Items on the tractor input data cards for which the same rules as implements apply will not be discussed since reference to the corresponding item on the implement data discussion may be made.

9032 - Identification code number for card #1.

9033 - Hours of tractor use for other operations not included with the implements that are included as part of the overall problem. This item may be zero if the tractor is not used for any operations not included in the problem. The hours that a tractor is used for non-field operations may be entered in this location.

9034 - Tractor drawbar horsepower. This item should never be zero.

9035-9036 - Always zero.

9037-9039 - Same as for implements (0015-0017).

9042 - Identification code number for card #2.

9043-9044 - Same as for implements (0021-0022).

9045 - Tractor fuel consumption rate in horsepower-hours per gallon. May be zero if tractor fuel consumption is always calculated on an hourly basis.

9046 - Tractor fuel consumption in gallons per hour. May be zero if tractor fuel consumption is always calculated on basis of horsepower-hours per gallon. NOTE: This would not permit any tractor drawn implements with auxiliary engines if this item is zero.

9047 - Tractor oil consumption rate in gallons per hour. This item should never be zero.

9048 - Tractor fuel price in dollars per gallon. This item should never be zero.

9049 - Tractor oil price in dollars per gallon. This item should never be zero.

9052 - Identification code number for card #3.

9053-9054 - Same as for implements (0031-0032).

9055-9056 - Always zero.

9057-9059 - Same as for implements (0035-0037).

For any particular problem the methods for calculating depreciation, interest, and other fixed costs would probably be the same for all machines included within the problem. This is not a necessary requirement, however, and different methods may be used within a given problem if desired since the calculation of fixed costs for any machine is independent of data pertaining to other machines in the problem.

Cost information for tractor-drawn implements is stored within the computer and held until all implements drawn by a particular tractor have been read in. The end of the implements for a tractor is indicated by either the reading in of another tractor or a trailer card indicating the end of data for the problem. After all the implements have been read in, tractor fixed costs are calculated and the cost information for both tractor and implements is read out by the computer. Index Register "C" of the computer is used to store the implements in order until the calculation of tractor fixed costs. Self-propelled implement costs are not stored but are read out by the computer after being calculated. Ample storage is available within the computer to store a maximum of 96 implements drawn by any one tractor. Due to the calculation procedure followed by the program <u>all implements must be used with one tractor only for the purposes of cost calculation</u>. Assumptions must be made for the amount of use an implement would incur if used for only one tractor in cases where an implement is used for more than one tractor in actual practice.

INPUT DATA READ IN RULES

The following order must be followed when reading input data cards into the computer:

1. Machine Program Deck
2. Transfer Card
3. Data Cards
4. Trailer Card (indicates end of data for problem)

Once the machine program has been entered additional problems may be solved by using only the transfer card followed by the data cards and trailer card. More than one problem may be solved without stopping since input data for another problem may follow the trailer card for the first. A trailer card must follow the input data for each individual problem when this procedure is used.

The following rules must be followed for the input data cards of each individual problem:

1. The 3 input data cards for each machine may be read in in any order, but must be together. <u>The input data cards for any given machine must not be intermingled with those of other machines</u>.
2. Input data for a tractor <u>must precede</u> the data for any implements used with the tractor. <u>All data for implements used with a given tractor must be read in before data for another tractor is read in</u>. Implements for a given tractor may be read in in any order.

NOTE: If either of the above two rules is not observed the computer will halt.

3. Data for self-propelled machines may read in at any time since these machines have no connection with the tractors.

D A T A   O U T P U T   F O R M

Output data cards may be identified with the proper machines by use of the code number. The first three digits at the left of the output card for a given machine are identical to the first three digits at the left of the three input data cards for the machine. The only difference between input and output code numbers is that the output data card is numbered as card number 4 while the input cards are numbered 1,2, or 3. All output data is in floating decimal point form. Persons not familiar with this form can easily learn to interpret it.

The storage locations for the various items of output data are indicated on the following page. Each type of output data card will be discussed.

IMPLEMENT DATA CARDS - This type of data card is used for the output data of all implements both tractor-drawn and self-propelled.

0040C - Implement identification code number.

0041C - Annual hours of use for implement.

0042C - Tractor operating costs incurred for the hours the tractor is used with implement. This item includes tractor fuel and oil costs. This location will be zero for self-propelled implements.

0043C - Total annual fixed costs for the implement alone.

0044C - Total annual implement operating costs. This item includes fuel and oil costs for implements with engines along with costs for labor and consumable items. Labor for tractor driver is considered an implement operating cost.

0045C - Total annual costs for the operation performed by an implement. This item is the total of tractor operating costs (0042C), implement fixed costs (0043C), implement operating costs (0044C), and the portion

IMPLEMENT OUTPUT DATA CARD:

Code XXX4	Annual hours of use	Tractor operating costs ($)	Implement fixed cost ($)	Implement operating cost ($)	Total annual cost ($)	Cost per acre ($/ac)	Cost per hour ($/hr)
0040C	0041C	0042C	0043C	0044C	0045C	0046C	0047C

TRACTOR OUTPUT DATA CARD:

Code X004	Annual hours of use	Total operating cost ($)	Total fixed cost ($)	Fixed cost per hour ($/hr)	Total annual cost	BLANK	BLANK
0040C	0041C	0042C	0043C	0044C	0045C		

PROBLEM SUMMARY DATA CARD:

Total annual machine hours	Total annual operating costs ($)	Total annual fixed costs ($)	Total annual cost ($)	BLANK	BLANK	BLANK	BLANK
9006	9007	9008	9009				

of tractor fixed costs charged to the operation.

0046C - Cost per acre for the operation performed by the implement. This includes all items and could be used for comparison with custom machine rates. This item is total cost (0045C) divided by acres covered.

0047C - Cost per hour for the operation performed by the implement. This is total cost (0045C) divided by the hours of annual use (0041C).

TRACTOR DATA CARDS - This type of data card is used exclusively for tractors.

0040C - Tractor identification code number.

0041C - Total annual hours of tractor use. This item is the sum of the hours of use for all implements drawn by the tractor plus tractor hours spent on other operations not included in the problem.

0042C - Total annual tractor operating costs. This item is the sum of the tractor operating costs incurred for all implements drawn by the tractor.

0043C - Total annual tractor fixed costs.

0044C - Tractor fixed costs per hour. This item is total fixed costs (0043C) divided by hours of use (0041C). This figure multiplied by the annual hours of use for any implement gives the share of tractor fixed costs to be charged to the operation performed by that implement.

0045C - Total annual tractor costs. This is the sum of tractor operating costs (0042C) and tractor fixed costs (0043C).

PROBLEM SUMMARY DATA CARD - This card gives the cost totals for a given problem and marks the end of the output data for a problem. These cards may be used to separate the output data if more than one problem is run at once. NOTE: This card is the only output data card with no code identification number.

9006 - Total annual machine hours. This is the sum of the annual hours of use for all implements both self-propelled and tractor drawn for field operation.

9007 - Total annual operating costs. Sum of all operating costs for implements and tractors.

9008 - Total annual fixed costs. Sum of all fixed costs for implements and tractors. This includes that portion of tractor fixed costs that is assessed to non-field operations if any exist.

9009 - Total annual machinery cost. This is sum of total operating costs (9007) and total fixed costs (9008).

SPECIAL OUTPUT DATA CARDS:

XXX4000000	4444444444	BLANK ——→

Input data cards for the machine indicated were not grouped together. (Rule #1, page 103)

XXX4000000	5555555555	BLANK ——→

An input data card for an implement has been read in before the input data card for the corresponding tractor. (Rule #2, page 103)

XXX4000000	9999999999	BLANK ——→

The combination of implement size, speed, and force factor stated in the input data requires more horsepower than is available with the tractor being used This safeguard will be applied only for tractor drawn implements with no auxiliary engine for which a force factor is given. It is included primarily to guard against errors in judging implement power requirements and speed.

SPECIAL PROGRAM USES

Some machinery cost problems are solved by making several simplifying assumptions. One of the more common of these assumptions is to calculate machine fixed costs as a fixed annual percentage of the purchase price. This type of approach may be taken by this program by using the following form for the input data cards. Location numbers refer to those given in the input data discussion. All rules except those governing the following data locations are unchanged from those explained in the original discussion (pages 95-100).

0015 - Zero

0016 - Enter 10 if fixed cost percentage is greater than 10%, enter 20 if less than 10%.

0017 - Zero

0022 - Zero

0031 - This item will be annual fixed cost percent minus 10 if 10 appears in 0016, fixed cost percent minus 5 if 20 appears in 0016.

0032 - Zero

0035 - Zero

0036 - Zero

0037 - Zero

Fuel costs are usually calculated on an hourly basis for these problems and this is compatible with the original data input rules so no changes are necessary for items affecting operating costs. Output data form for this type of approach is the same as that explained for the other more complex methods.

A complete listing of the steps used in the stored program for the calculation of annual field machinery costs is included on the following pages. The stored program was written for assembly with a Symbolic Optimal Assembly Program (SOAP). The original "SOAP" program which was written and the machine language program which was assembled are both listed. The "SOAP" program is listed at the right of each page. The machine language program is listed at the left. The number of each step is indicated at the left of the machine language program.

The parts of the machine language program are indicated in the example below:

```
┌─ Location of instruction
│        ┌─ Operation code
↓        ↓
1050     69  1003  1006
              ↑     ↑
              │     └─ Location of next instruction
              └─ Location of data
```

The storage locations from 1961 - 1985 are available for additions or alterations of the steps in the present stored program.

In order to use the machine language program for processing data, a transfer card and a trailer card are needed. The forms for these cards are indicated below:

TRANSFER CARD:

+0000001050+	BLANK ⟶

TRAILER CARD:

+0000001300+	ZEROS ⟶

(+ signs must be punched in columns 20,30,40,50,60,70, & 80, also.)

```
                                        BLR  1950      1999
                                        BLR  0000      1000
1050   69 1003 1006      BEGIN   LDD  ZERO
1006   24 9032 1013              STD  9032
1013   24 9000 1020              STD  9000
1020   24 9001 1027              STD  9001
1027   24 9010 1034              STD  9010
1034   69 1037 1040              LDD  FLONE
1040   24 0038 1041              STD  0038
1041   88 0000 1047              RAC  0000      START
1047   70 9002 1048      START   RD1  9002
1048   70 9012 1049              RD1  9012
1049   70 9022 1100              RD1  9022
1100   80 0000 1056              RAA  0000      CHECK
1056   60 9202 1015      CHECK   RAU  9002 A
1015   35 0003 1023              SLT  0003
1023   30 0008 1091              SRT  0008
1091   82 8003 1150              RAB  8003
1150   27 9202 1005              SET  9002 A
1005   28 4000 1012              SIB  0000 B
1012   51 0020 1018              SXA  0020
1018   40 1021 1022              NZA            ORDER
1021   50 0030 1056              AXA  0030      CHECK
1022   60 0010 1065      ORDER   RAU  0010
1065   10 1115 1019              AUP  DIGIT
1019   11 0020 1025              SUP  0020
1025   44 1029 1030              NZU  NORDR     NEXT
1029   60 0030 1035      NORDR   RAU  0030
1035   10 1115 1069              AUP  DIGIT
1069   21 9008 1028              STU  9008
1028   69 1031 1084              LDD  FOUR
1084   24 9009 1141              STD  9009
1141   71 9008 1042              WR1  9008      HALT
1042   01 0001 1047      HALT    HLT  0001      START
1030   60 0020 1075      NEXT    RAU  0020
1075   10 1115 1119              AUP  DIGIT
1119   11 0030 1085              SUP  0030
1085   44 1029 1090              NZU  NORDR
1090   82 0000 1046              RAB  0000      FLOAT
1046   80 4011 1053      FLOAT   RAA  0011 B    CONTU
1053   60 2000 1055      CONTU   RAU  0000 A
1055   35 0002 1011              SLT  0002
1011   10 1061 1165              AUP  FIFIV
1165   32 1003 1079              FAD  ZERO
1079   21 2000 1103              STU  0000 A
1103   51 4017 1010              SXA  0017 B
1010   40 1063 1014              NZA            ADDB
1063   50 4018 1053              AXA  0018 B    CONTU
1014   53 0020 1070      ADDB    SXB  0020
1070   42 1073 1024              NZB            FLTED
1073   52 0030 1046              AXB  0030      FLOAT
1024   60 0010 1215      FLTED   RAU  0010
1215   35 0001 1071              SLT  0001
```

```
1071   30 0008 1039            SRT   0008
1039   44 1043 1044            NZU   IMPLE     TRCTR
1044   60 9032 1153    TRCTR   RAU   9032
1153   44 1007 1008            NZU   NTFST     FIRST
1008   69 1003 1106    FIRST   LDD   ZERO
1106   24 9030 1113            STD   9030
1113   24 9031 1120            STD   9031
1120   27 9032 1125            SET   9032
1125   08 0010 1072            LIB   0010
1072   27 9042 1077            SET   9042
1077   08 0020 1032            LIB   0020
1032   27 9052 1087            SET   9052
1087   08 0030 1047            LIB   0030      START
1043   60 9032 1001    IMPLE   RAU   9032
1001   30 0009 1121            SRT   0009
1121   80 8003 1080            RAA   8003
1080   60 0010 1265            RAU   0010
1265   30 0009 1135            SRT   0009
1135   11 8005 1093            SUP   8005
1093   44 1097 1098            NZU             HOURS
1097   60 0010 1315            RAU   0010
1315   30 0009 1185            SRT   0009
1185   44 1089 1098            NZU   WRONG     HOURS
1089   60 0030 1235    WRONG   RAU   0030
1235   10 1115 1169            AUP   DIGIT
1169   21 9008 1078            STU   9008
1078   69 1081 1134            LDD   FIVE
1134   24 9009 1191            STD   9009
1191   71 9008 1042            WR1   9008      HALT
1098   60 0011 1365    HOURS   RAU   0011
1365   39 1068 1118            FMP   CONST
1118   34 0012 1062            FDV   0012
1062   34 0013 1163            FDV   0013
1163   34 0014 1064            FDV   0014
1064   21 6041 1094            STU   0041 C
1094   32 9000 1175            FAD   9000
1175   21 9000 1184            STU   9000      FXCST
1184   60 0015 1219    FXCST   RAU   0015
1219   44 1123 1074            NZU             OBSOL
1123   34 6041 1241            FDV   0041 C
1241   21 0002 1105            STU   0002
1105   21 0028 1131            STU   0028
1131   33 0016 1143            FSB   0016
1143   46 1096 1074            BMI   WEAR      OBSOL
1074   69 0016 1269    OBSOL   LDD   0016
1269   24 0002 1155            STD   0002      TIME
1096   60 0002 1057    WEAR    RAU   0002
1057   35 0008 1225            SLT   0008
1225   30 0008 1193            SRT   0008
1193   80 8003 1002            RAA   8003
1002   51 0050 1058            SXA   0050
1058   82 0008 1114            RAB   0008
1114   53 2000 1171            SXB   0000 A
1171   65 0002 1107            RAL   0002
```

```
108 1107  30 0002 1213              SRT   0002
109 1213  31 4000 1137              SRD   0000 B
110 1137  60 8002 1045              RAU   8002
111 1045  35 0002 1051              SLT   0002
112 1051  80 0058 1157              RAA   0058
113 1157  10 8005 1263              AUP   8005
114 1263  32 1003 1129              FAD  ZERO
115 1129  21 0002 1155              STU   0002       TIME
116 1155  60 0002 1207      TIME    RAU   0002
117 1207  35 0008 1275              SLT   0008
118 1275  30 0008 1243              SRT   0008
119 1243  80 8003 1052              RAA   8003
120 1052  51 0050 1108              SXA   0050
121 1108  82 0010 1164              RAB   0010
122 1164  53 2000 1221              SXB   0000 A
123 1221  60 0002 1257              RAU   0002
124 1257  30 4000 1179              SRT   0000 B
125 1179  21 0007 1060              STU   0007
126 1060  60 0017 1271              RAU   0017
127 1271  44 1325 1026              NZU              DEPRC
128 1325  33 0002 1229              FSB   0002
129 1229  46 1082 1026              BMI  TRDIN       DEPRC
130 1082  60 0022 1127      TRDIN   RAU   0022
131 1127  44 1181 1132              NZU  NOWGO       FILLN
132 1132  60 1037 1181      FILLN   RAU  FLONE       NOWGO
133 1181  34 0021 1321      NOWGO   FDV   0021
134 1321  21 0003 1156              STU   0003
135 1156  60 0007 1111              RAU   0007
136 1111  80 8003 1170              RAA   8003
137 1170  51 0001 1076              SXA   0001
138 1076  65 8005 1285              RAL   8005
139 1285  20 0006 1009              STL   0006
140 1009  60 1037 1291              RAU  FLONE
141 1291  21 0004 1307              STU   0004
142 1307  82 0015 1313              RAB   0015       ROOT
143 1313  60 0002 1357      ROOT    RAU   0002
144 1357  33 1037 1363              FSB  FLONE
145 1363  39 0004 1004              FMP   0004
146 1004  21 0005 1158              STU   0005
147 1158  60 0003 1407              RAU   0003       DIV
148 1407  34 0004 1054      DIV     FDV   0004
149 1054  51 0001 1110              SXA   0001
150 1110  40 1407 1214              NZA  DIV         ON
151 1214  32 0005 1231      ON      FAD   0005
152 1231  34 0002 1102              FDV   0002
153 1102  21 0004 1457              STU   0004
154 1457  53 0001 1413              SXB   0001
155 1413  42 1016 1017              NZB              FINSH
156 1016  65 0006 1161              RAL   0006
157 1161  80 8002 1313              RAA   8002       ROOT
158 1017  60 0017 1371      FINSH   RAU   0017
159 1371  35 0008 1139              SLT   0008
160 1139  30 0008 1507              SRT   0008
161 1507  80 8003 1066              RAA   8003
```

```
1066   51 0050 1122                 SXA   0050
1122   82 0010 1128                 RAB   0010
1128   53 2000 1335                 SXB   0000 A
1335   60 0017 1421                 RAU   0017
1421   30 4000 1293                 SRT   0000 B
1293   21 0007 1160                 STU   0007
1160   80 8003 1168                 RAA   8003
1168   60 0004 1059                 RAU   0004
1059   51 0001 1415                 SXA   0001
1415   40 1218 1319                 NZA   MULT         VALUE
1218   39 0004 1104         MULT    FMP   0004
1104   51 0001 1210                 SXA   0001
1210   40 1218 1319                 NZA   MULT         VALUE
1319   39 0021 1471         VALUE   FMP   0021
1471   21 0022 1026                 STU   0022         DEPRC
1026   60 0037 1341         DEPRC   RAU   0037
1341   44 1095 1146                 NZU   SINKF        STLIN
1095   60 0021 1375         SINKF   RAU   0021
1375   33 0022 1099                 FSB   0022
1099   21 0002 1205                 STU   0002
1205   60 0007 1211                 RAU   0007
1211   80 8003 1220                 RAA   8003
1220   51 0001 1126                 SXA   0001
1126   60 0037 1391                 RAU   0037
1391   34 1144 1194                 FDV   ONEHD
1194   32 1037 1463                 FAD   FLONE
1463   21 0004 1557                 STU   0004         INCR
1557   39 0004 1154         INCR    FMP   0004
1154   51 0001 1260                 SXA   0001
1260   40 1557 1264                 NZA   INCR
1264   21 0001 1204                 STU   0001
1204   33 1037 1513                 FSB   FLONE
1513   21 0003 1206                 STU   0003
1206   60 0037 1441                 RAU   0037
1441   34 1144 1244                 FDV   ONEHD
1244   34 0003 1203                 FDV   0003
1203   39 0002 1152                 FMP   0002
1152   21 6043 1196                 STU   0043 C
1196   65 8007 1255                 RAL   8007
1255   20 0008 1261                 STL   0008
1261   60 0036 1491                 RAU   0036
1491   35 0008 1109                 SLT   0008
1109   30 0008 1177                 SRT   0008
1177   11 1061 1465                 SUP   FIFIV
1465   44 1369 1270                 NZU   SIMPL        COMP
1369   82 0000 1425         SIMPL   RAB   0000         CLEAR
1270   60 0036 1541         COMP    RAU   0036
1541   35 0001 1147                 SLT   0001
1147   30 0001 1253                 SRT   0001
1253   32 1003 1279                 FAD   ZERO
1279   21 0036 1189                 STU   0036
1189   82 0001 1425                 RAB   0001         CLEAR
1425   69 0021 1124         CLEAR   LDD   0021
1124   24 0005 1208                 STD   0005
```

```
1208   60 0007 1311          RAU   0007
1311   80 8003 1320          RAA   8003
1320   88 0001 1176          RAC   0001
1176   60 0002 1607          RAU   0002
1607   34 0003 1303          FDV   0003
1303   21 0002 1305          STU   0002
1305   60 0001 1355          RAU   0001
1355   33 0004 1281          FSB   0004
1281   39 0002 1202          FMP   0002
1202   32 0022 1149          FAD   0022
1149   21 0003 1256          STU   0003
1256   32 0005 1331          FAD   0005
1331   34 1234 1284          FDV   TWO
1284   39 0036 1036          FMP   0036
1036   34 1144 1294          FDV   ONEHD
1294   21 0009 1112          STU   0009
1112   59 2000 1419          SXC   2000
1419   48 1172 1173          NZC               STOW
1172   88 0001 1329          RAC   0001        INTER
1329   60 0003 1657   INTER  RAU   0003
1657   21 0005 1258          STU   0005
1258   65 8007 1067          RAL   8007
1067   20 0006 1159          STL   0006
1159   60 0004 1209          RAU   0004        BACK
1209   39 0004 1254   BACK   FMP   0004
1254   59 0001 1310          SXC   0001
1310   48 1209 1314          NZC   BACK
1314   21 0003 1306          STU   0003
1306   60 0001 1405          RAU   0001
1405   33 0003 1379          FSB   0003
1379   39 0002 1252          FMP   0002
1252   32 0022 1199          FAD   0022
1199   21 0003 1356          STU   0003
1356   32 0005 1381          FAD   0005
1381   34 1234 4018          FDV   TWO          0018 B
0019   32 0009 0018      19  FAD   0009         0018
0018   39 0036 1086      18  FMP   0036
1086   34 1144 1344          FDV   ONEHD
1344   32 0009 1385          FAD   0009
1385   21 0009 1162          STU   0009
1162   65 0006 1361          RAL   0006
1361   88 8002 1469          RAC   8002
1469   58 0002 1475          AXC   0002
1475   51 6000 1182          SXA   6000
1182   40 1435 1136          NZA               LAST
1435   59 0001 1092          SXC   0001
1092   60 0007 1411          RAU   0007
1411   80 8003 1329          RAA   8003        INTER
1136   60 0003 1707   LAST   RAU   0003
1707   32 0022 1249          FAD   0022
1249   34 1234 1334          FDV   TWO
1334   42 1187 1038          NZB   ADDI        DONTA
1187   32 0009 1038   ADDI   FAD   0009        DONTA
1038   39 0036 1186   DONTA  FMP   0036
```

```
1186   34 1144 1394          FDV   ONEHD
1394   32 0009 1485          FAD    0009
1485   21 0009 1212          STU    0009
1212   60 0007 1461          RAU    0007
1461   35 0002 1117          SLT    0002
1117   10 1167 1521          AUP   FIVET
1521   32 1003 1429          FAD   ZERO
1429   21 0007 1360          STU    0007
1360   60 0009 1563          RAU    0009
1563   34 0007 1757          FDV    0007
1757   21 0009 1173          STU    0009       STOW
1173   65 0008 1613   STOW   RAL    0008
1613   88 8002 1571          RAC    8002
1571   60 0009 1663          RAU    0009
1663   32 6043 1519          FAD    0043 C
1519   21 6043 1246          STU    0043 C     TAXES
1146   60 0007 1511   STLIN  RAU    0007
1511   35 0002 1217          SLT    0002
1217   10 1167 1621          AUP   FIVET
1621   32 1003 1479          FAD   ZERO
1479   21 0001 1304          STU    0001
1304   60 0021 1525          RAU    0021
1525   33 0022 1299          FSB    0022
1299   34 0001 1101          FDV    0001
1101   21 0002 1455          STU    0002
1455   21 6043 1296          STU    0043 C
1296   60 0036 1591          RAU    0036
1591   35 0008 1259          SLT    0008
1259   30 0008 1227          SRT    0008
1227   11 1061 1515          SUP   FIFIV
1515   44 1569 1370          NZU   ZIMPL      POUND
1569   60 0021 1575   ZIMPL  RAU    0021
1575   32 0022 1349          FAD    0022
1349   34 1234 1384          FDV   TWO
1384   39 0036 1236          FMP    0036
1236   34 1144 1444          FDV   ONEHD
1444   32 6043 1619          FAD    0043 C
1619   21 6043 1246          STU    0043 C     TAXES
1370   60 0036 1641   POUND  RAU    0036
1641   35 0001 1197          SLT    0001
1197   30 0001 1353          SRT    0001
1353   32 1003 1529          FAD   ZERO
1529   21 0036 1239          STU    0036
1239   60 0021 1625          RAU    0021
1625   33 0002 1579          FSB    0002
1579   32 0021 1247          FAD    0021
1247   34 1234 1434          FDV   TWO
1434   21 0003 1406          STU    0003
1406   39 0036 1286          FMP    0036
1286   34 1144 1494          FDV   ONEHD
1494   21 0009 1262          STU    0009
1262   60 0007 1561          RAU    0007
1561   80 8003 1420          RAA    8003
1420   51 0001 1226          SXA    0001
```

```
1226   40 1629 1130            NZA   CYCLE       STASH
1629   60 0003 1807    CYCLE   RAU    0003
1807   33 0002 1679            FSB    0002
1679   21 0003 1456            STU    0003
1456   32 0009 1535            FAD    0009
1535   39 0036 1336            FMP    0036
1336   34 1144 1544            FDV   ONEHD
1544   32 0009 1585            FAD    0009
1585   21 0009 1312            STU    0009
1312   51 0001 1268            SXA    0001
1268   40 1629 1222            NZA   CYCLE
1222   34 0001 1130            FDV    0001       STASH
1130   32 6043 1669    STASH   FAD    0043  C
1669   21 6043 1246            STU    0043  C    TAXES
1246   60 0021 1675    TAXES   RAU    0021
1675   39 0035 1635            FMP    0035
1635   34 1144 1594            FDV   ONEHD
1594   32 6043 1719            FAD    0043  C
1719   21 6043 1346            STU    0043  C
1346   60 0015 1769            RAU    0015
1769   44 1223 1174            NZU               DONT
1223   60 0028 1033            RAU    0028
1033   33 0016 1343            FSB    0016
1343   46 1396 1174            BMI   STEP        DONT
1174   69 1037 1140    DONT    LDD   FLONE
1140   24 0001 1354            STD    0001       REPAR
1396   60 0016 1671    STEP    RAU    0016
1671   34 0028 1178            FDV    0028
1178   21 0001 1354            STU    0001       REPAR
1354   60 0031 1685    REPAR   RAU    0031
1685   32 0032 1309            FAD    0032
1309   39 0001 1151            FMP    0001
1151   34 1144 1644            FDV   ONEHD
1644   39 0021 1721            FMP    0021
1721   32 6043 1819            FAD    0043  C
1819   21 6043 1446            STU    0043  C
1446   60 0010 1565            RAU    0010
1565   35 0001 1771            SLT    0001
1771   30 0008 1289            SRT    0008
1289   44 1393 1694            NZU   NO          YES
1393   60 0010 1615    NO      RAU    0010
1615   30 0009 1735            SRT    0009
1735   44 1339 1190            NZU   TRAIL       SELFP
1339   60 0024 1729    TRAIL   RAU    0024
1729   44 1083 1484            NZU   ENGIN       NOENG
1484   60 0023 1277    NOENG   RAU    0023
1277   44 1431 1083            NZU   POWRQ       ENGIN
1431   39 0012 1362    POWRQ   FMP    0012
1362   39 0013 1713            FMP    0013
1713   39 1116 1166            FMP   EIGHT
1166   34 1869 1919            FDV   THIRT
1919   21 0002 1505            STU    0002
1505   60 9034 1763            RAU    9034
1763   33 0002 1779            FSB    0002
```

```
378 1779  46 1232 1133          BMI  STOP
379 1133  60 0002 1857          RAU   0002      OK
380 1232  60 0030 1785   STOP   RAU   0030
381 1785  10 1115 1470          AUP  DIGIT
382 1470  21 9008 1228          STU   9008
383 1228  69 1481 1534          LDD  NINE
384 1534  24 9009 1691          STD   9009
385 1691  71 9008 1042          WR1   9008      HALT
386 1857  39 6041 1741   OK     FMP   0041 C
387 1741  34 9045 1145          FDV   9045
388 1145  39 9048 1399          FMP   9048
389 1399  21 6042 1195          STU   0042 C    OIL
390 1083  60 9046 1791   ENGIN  RAU   9046
391 1791  39 6041 1841          FMP   0041 C
392 1841  39 9048 1245          FMP   9048
393 1245  21 6042 1195          STU   0042 C    OIL
394 1195  60 9047 1403   OIL    RAU   9047
395 1403  39 6041 1891          FMP   0041 C
396 1891  39 9049 1295          FMP   9049
397 1295  32 6042 1520          FAD   0042 C
398 1520  21 6042 1345          STU   0042 C
399 1345  60 0024 1829          RAU   0024
400 1829  44 1190 1584          NZU  SELFP
401 1584  69 1003 1506          LDD  ZERO
402 1506  24 6044 1297          STD   0044 C    LABOR
403 1190  60 0023 1327   SELFP  RAU   0023
404 1327  44 1531 1282          NZU  GIVEN      NOT
405 1531  39 0012 1412   GIVEN  FMP   0012
406 1412  39 0013 1813          FMP   0013
407 1813  39 1116 1216          FMP  EIGHT
408 1216  34 1869 1570          FDV  THIRT
409 1570  39 6041 1941          FMP   0041 C
410 1941  34 0024 1224          FDV   0024
411 1224  39 0026 1276          FMP   0026
412 1276  21 6044 1347          STU   0044 C    MAOIL
413 1282  60 0024 1879   NOT    RAU   0024
414 1879  39 6041 1142          FMP   0041 C
415 1142  39 0026 1326          FMP   0026
416 1326  21 6044 1347          STU   0044 C    MAOIL
417 1347  60 0025 1929   MAOIL  RAU   0025
418 1929  39 6041 1192          FMP   0041 C
419 1192  39 0027 1377          FMP   0027
420 1377  32 6044 1821          FAD   0044 C
421 1821  21 6044 1297          STU   0044 C    LABOR
422 1297  60 0033 1237   LABOR  RAU   0033
423 1237  39 6041 1242          FMP   0041 C
424 1242  32 6044 1871          FAD   0044 C
425 1871  21 6044 1397          STU   0044 C
426 1397  60 0034 1389          RAU   0034
427 1389  39 0011 1611          FMP   0011
428 1611  32 6044 1921          FAD   0044 C
429 1921  21 6044 1447          STU   0044 C
430 1447  60 6042 1497          RAU   0042 C
431 1497  32 6044 1272          FAD   0044 C
```

```
1272   32 9001 1453              FAD   9001
1453   21 9001 1462              STU   9001
1462   60 6043 1547              RAU   0043 C
1547   32 9010 1427              FAD   9010
1427   21 9010 1386              STU   9010
1386   60 0030 1835              RAU   0030
1835   10 1115 1620              AUP   DIGIT
1620   21 6040 1443              STU   0040 C
1443   60 0010 1665              RAU   0010
1665   30 0009 1885              SRT   0009
1885   44 1439 1240              NZU   ADDTR       OUT
1439   60 9030 1597      ADDTR   RAU   9030
1597   32 6041 1267              FAD   0041 C
1267   21 9030 1376              STU   9030
1376   60 9031 1935              RAU   9031
1935   32 6042 1670              FAD   0042 C
1670   21 9031 1278              STU   9031
1278   69 0011 1364              LDD   0011
1364   24 6046 1449              STD   0046 C
1449   58 0010 1047              AXC   0010        START
1240   69 1003 1556      OUT     LDD   ZERO
1556   24 6042 1395              STD   0042 C
1395   60 6043 1647              RAU   0043 C
1647   32 6044 1322              FAD   0044 C
1322   21 6045 1148              STU   0045 C
1148   34 0011 1661              FDV   0011
1661   21 6046 1499              STU   0046 C
1499   60 6045 1549              RAU   0045 C
1549   34 6041 1292              FDV   0041 C
1292   21 6047 1200              STU   0047 C
1200   27 9002 1555              SET   9002
1555   08 6040 1302              LIB   0040 C
1302   71 9002 1047              WR1   9002        START
1694   60 6043 1697      YES     RAU   0043 C
1697   34 6041 1342              FDV   0041 C
1342   21 6044 1747              STU   0044 C
1747   60 6043 1797              RAU   0043 C
1797   32 9010 1477              FAD   9010
1477   21 9010 1436              STU   9010
1436   69 9031 1493              LDD   9031
1493   24 6042 1445              STD   0042 C
1445   60 0030 1486              RAU   0030
1486   10 1115 1720              AUP   DIGIT
1720   21 6040 1543              STU   0040 C
1543   60 6042 1847              RAU   0042 C
1847   32 6043 1770              FAD   0043 C
1770   21 6045 1198              STU   0045 C
1198   27 9004 1503              SET   9004
1503   08 6040 1352              LIB   0040 C
1352   71 9004 1553              WR1   9004
1553   69 6044 1897              LDD   0044 C
1897   24 0001 1404              STD   0001        REMOV
1404   59 0010 1410      REMOV   SXC   0010
1410   60 0001 1605              RAU   0001
```

```
1605   39 6041 1392            FMP   0041 C
1392   32 6042 1820            FAD   0042 C
1820   32 6043 1870            FAD   0043 C
1870   32 6044 1372            FAD   0044 C
1372   21 6045 1248            STU   0045 C
1248   34 6046 1496            FDV   0046 C
1496   21 6046 1599            STU   0046 C
1599   60 6045 1649            RAU   0045 C
1649   34 6041 1442            FDV   0041 C
1442   21 6047 1250            STU   0047 C
1250   27 9002 1655            SET   9002
1655   08 6040 1402            LIB   0040 C
1402   71 9002 1603            WR1   9002
1603   48 1404 1907            NZC   REMOV
1907   60 0038 1593            RAU   0038
1593   44 1947 1298            NZU   ANOTH      END
1947   69 1003 1606     ANOTH  LDD   ZERO
1606   24 9030 1863            STD   9030
1863   24 9031 1047            STD   9031       START
1298   69 9000 1705     END    LDD   9000
1705   24 9006 1512            STD   9006
1512   69 9001 1920            LDD   9001
1920   24 9007 1527            STD   9007
1527   60 9010 1536            RAU   9010
1536   21 9008 1744            STU   9008
1744   32 9007 1725            FAD   9007
1725   21 9009 1634            STU   9009
1634   71 9006 1050            WR1   9006       BEGIN
1300   69 1003 1656     FINI   LDD   ZERO
1656   24 0038 1492            STD   0038
1492   48 1007 1298            NZC   NTFST      END
1007   27 9002 1562     NTFST  SET   9002
1562   08 0010 1422            LIB   0010
1422   27 9012 1577            SET   9012
1577   08 0020 1332            LIB   0020
1332   27 9022 1287            SET   9022
1287   08 0030 1542            LIB   0030
1542   27 9032 1348            SET   9032
1348   28 0010 1472            SIB   0010
1472   27 9042 1627            SET   9042
1627   28 0020 1382            SIB   0020
1382   27 9052 1337            SET   9052
1337   28 0030 1592            SIB   0030
1592   27 9002 1398            SET   9002
1398   28 0001 1913            SIB   0001
1913   27 9032 1318            SET   9032
1318   08 0001 1414            LIB   0001
1414   27 9012 1522            SET   9012
1522   28 0001 1464            SIB   0001
1464   27 9042 1572            SET   9042
1572   08 0001 1514            LIB   0001
1514   27 9022 1622            SET   9022
1622   28 0001 1564            SIB   0001
1564   27 9052 1672            SET   9052
```

```
540 1672   08 0001 1614              LIB    0001
541 1614   60 9030 1273              RAU    9030
542 1273   32 0011 1387              FAD    0011
543 1387   24 6041 1184              STD    0041  C   FXCST
544 1003   00 0000 0000        ZERO   00    0000        0000
545 1037   10 0000 0051        FLONE  10    0000        0051
546 1115   00 0100 0000        DIGIT  00    0100        0000
547 1061   00 0000 0055        FIFIV  00    0000        0055
548 1068   82 5000 0053        CONST  82    5000        0053
549 1144   10 0000 0053        ONEHD  10    0000        0053
550 1234   20 0000 0051        TWO    20    0000        0051
551 1167   00 0000 0058        FIVET  00    0000        0058
552 1116   88 0000 0052        EIGHT  88    0000        0052
553 1869   33 0000 0055        THIRT  33    0000        0055
554 1031   44 4444 4444        FOUR   44    4444        4444
555 1081   55 5555 5555        FIVE   55    5555        5555
556 1481   99 9999 9999        NINE   99    9999        9999
```

APPENDIX B

Rules and Procedure for Using the Stored Program for Field Machinery Selection

INPUT DATA RULES

The input data for a problem consists of data for the power to be selected and data for each operation for which an implement is to be selected. Two different card formats are used in order to read both types of data into the computer. A location is reserved on the input cards for all factors which may be pertinent to a problem of machinery selection. For cases where some items are not considered pertinent the locations for these items must be represented by entering zeros on the input cards. The number of input cards used for each implement to be selected may vary from 3 to 5 depending upon the amount of timeliness data included. Two input cards are always used for power.

A numbering system or code is used to identify the various types of machine data which are read into the computer. This code is used to identify power data cards and implement data cards, identify self-propelled implements, indicate the number of data cards for an implement, and determine whether or not tractors are to be selected in equal sizes. The code also numbers the cards for a given machine and numbers each implement selected in the problem. No two machines will ever have the same code number. This is necessary in order that the output data for each machine may be identified. The code identification system also enables the computer to identify the different types of machines and to store the data for each machine in the proper location. The general forms for the identification code numbers for both implements and power are illustrated.

POWER CODE IDENTIFICATION NUMBER: General Form - 100X000X00

```
┌──────────────Card number (must be 1 or 2).
↓
100X000X00
       ↑
       └──────────Tractor selection indicator (must be 0 or 1).
                  0 - all tractors selected in equal sizes.
                  1 - (n-1) tractors of maximum size selected
                      along with one smaller tractor.
```

The second and third digits from the left identify the data as being power data by being zero, Only one set of power data is needed for any machinery selection problem. For this reason the first digit on the left is always 1.

Examples:

1. Power card #1 (select equal tractor sizes)- - - - 1001000000
2. Power card #2 (select unequal tractor sizes)- - - 1002000100

IMPLEMENT CODE IDENTIFICATION NUMBER: General Form - XXXX0000XX

```
┌─Self-propelled indicator (must be 0 or 1)
│ 0 - self-propelled
│ 1 - tractor-drawn
│   ┌──────────────Card number (must be 1,2,3 4, or 5)
↓   ↓
X|XX|X0000X|X
   ↑       ↑ ↑
   │       │ └──────────5 if 5 cards are needed, 0 otherwise
   │       └──────── 4 if 4 or more cards are needed, 0 otherwise
   │
   Implement number in the system. All implements to be selec-
   ted will be assigned different numbers in this location.
   Identification numbers used may range from 01 to 99.
```

The code identification numbers for any one implement must all be the same with the exception of the card number which is used to identify the different cards for one implement.

Examples: (Card #1 used for each case)

1. Tractor-drawn implement, 3 cards needed - - - - - 1081000000

2. Self-propelled implement, 4 cards needed - - - - 0091000040

3. Tractor-drawn implement, 5 cards needed - - - - 1101000045

All locations on the data cards that are not occupied by the code identification number are reserved for input data. To facilitate the entering of data on the input cards all data is entered in fixed decimal point form. To avoid confusion, the same decimal point location is used for all input data except two items of timeliness data for implements. Form for these two items will be pointed out later in the discussion for implement input cards. The standard form for all other data is shown below:

0 0 X X X X X . X X X

The two digits at the extreme left are always zero since any digits placed in those locations are lost in a shifting operation when the computer converts the data to a floating decimal point system. All input data for which this form applies must lie within a range of values from 00000.001 to 99999.999. <u>Care must be exercised when entering data onto the cards to always place the decimal in the same location regardless of whether any significant figures exist to the right of the decimal or not</u>.

Examples:

1. Implement speed of 4 mph - - - - - - - - - - - - - 0000004000

2. Labor cost of $1.25 per hour - - - - - - - - - - - 0000001250

The form for entering data on the implement input cards is shown on the next page. Each location on the input cards is labeled. The storage location within the computer where each item of data is temporarily

IMPLEMENT INPUT DATA CARDS:

Code XXX1---	Years of expected life	Years of expected owner-ship	Cost per ft. of width	Rep., Lub., T, I, S (%)	Interest (%)	S.F. interest (%)	Time utilizat-ion (%)
0010	0011	0012	0013	0014	0015	0016	0017

Code XXX2---	Width utilizat-ion (%)	Fixed cost (%)	Total acres covered	Average speed (mph)	Allotted hours	Allowable size (ft)	Labor ($/hr)
0020	0021	0022	0023	0024	0025	0026	0027

Code XXX3---	Force factor (lb/ft)	(d) Allow. cost variat-ion	A_i (Acres)	K_i (Timeli-ness factor)	Y_iV_i (Total crop value)	A_2	K_2
0030	0031	0032	0033	0034	0035	0036	0037

Code XXX4---	Y_2V_2	A_3	K_3	Y_3V_3	A_4	K_4	Y_4V_4
0040	0041	0042	0043	0044	0045	0046	0047

Code XXX5---	A_5	K_5	Y_5V_5	A_6	K_6	Y_6V_6	ZERO
0050	0051	0052	0053	0054	0055	0056	0057

stored after being read into the computer is also given. The card number for each implement is indicated in the location for the identification code to illustrate the data that is to be placed on the card bearing that particular number. Care must be taken when making up data cards to insure that the implement data corresponds to the proper implement card identification number, otherwise the data will not be stored in the proper locations. Each of the items of data for implements will be discussed separately. Rules and methods for indicating different desired computational procedures will be pointed out with the discussion of the appropriate item of input data. The computer storage location for each item of input data will be followed by the discussion for that item of data. NOTE: It is important that no items on the input data card be left blank, non-pertinent items should have zeros entered in their location.

IMPLEMENT INPUT CARDS

0010 - Identification code number for card #1.

0011 - Years of expected implement life. This item is zero only when a fixed cost percentage (0022) is given.

0012 - Total years that machine ownership is to be retained. If this figure is shorter than expected implement life (0011), the computer will calculate a trade-in value for the implement at the end of the period of ownership. This trade-in value will be used to calculate depreciation and interest costs during the period of machine ownership. This item may be zero if the implement is to be kept for the extent of its expected service life or if a fixed cost percentage (0022) is given.

0013 - Implement purchase price in dollars per foot. This item may not be zero.

0014 - Annual charges for repairs, lubrication, taxes, insurance, and shelter in percent of the purchase price. This item may be zero only if a fixed cost percentage (0022) is given or if no charges are to be made for these items.

0015 - Interest on investment for implement entered as percent. Interest may be calculated as either simple or compound. The method of entering the data in this location determines which of the two methods will be followed for any given implement. For simple interest no special identification is needed and the figures are entered just as for any other data. Compound interest is indicated by entering a 1 three places from the left end of the data or 5 places to the left of the decimal.

Examples of entry form:

1. Simple interest - - - - - - - - - - - - - - - - - - 0000005000
2. Compound interest - - - - - - - - - - - - - - - - - 0010005000

This item may be zero if fixed cost percentage (0022) is given or no charges for interest are to be made.

0016 - Sinking fund interest rate entered as percent. This item determines the type of depreciation that will be used for the implement. If a rate of interest is given, sinking fund depreciation will be used. If this item is zero, straight-line depreciation will be used. This item may also be zero if fixed cost percentage (0022) is given.

0017 - Implement time utilization. The percent of time spent actually performing an operation while in the field. This item may not be zero. This item is combined with width utilization (0021) to produce implement field efficiency. A value of 100 may be placed in this location if it is desired to use a single figure for field efficiency.

0020 - Identification code number for card #2.

0021 - Implement width utilization. The percent of implement width used effectively when performing an operation. This item may not be zero. A single value for field efficiency may be entered in this location if a value of 100 is entered for time utilization (0017).

0022 - Total annual fixed cost in percent of implement purchase price. This item may be zero only if items 0011, 0014, 0015, and 0016 are given.

0023 - Total annual once-over acres covered by the implement. If an implement should cover 100 acres a total of 3 times, the once-over acreage is 300 acres. This item must never be 0.

0024 - Average implement ground speed in miles per hour for all operations performed. This item may not be 0.

0025 - The total allotted hours in which an implement must complete all of its operations on the acreage it covers. This item determines the method which will be used to calculate the total amount of power needed for an operation. If an allotted time is given for one implement, it must be given for all implements that are to be selected. This item may be zero only if it is zero for all implements and all implements have timeliness data. A single implement may have both allotted time data and timeliness data provided that all implements have allotted time data. In this case other implements may or may not have timeliness data.

0026 - Maximum implement width which can be pulled by one tractor. This item is used when the size of implement that can be pulled by one tractor is limited due to the available commercial size. A limit may also be placed here to prevent the selection of an implement width which is larger than desired. For self-propelled implements this item indicates the maximum size of individual unit that is available or that is desired.

This item may be zero if there is no limit on the available size of the individual implement that may be included within one unit.

0027 - Labor cost in dollars per hour for each implement unit selected. For tractor-drawn implements this includes the charge for the tractor driver. This should not be an estimate of the total labor charge that will be made for all units that will be selected of a particular implement type. This is a charge for each tractor and the implement it pulls or for each unit of a self-propelled implement that is selected.

Example:

If a charge of $1.25 per hour is made for labor for a tractor and plow, $1.25 would be entered here as the charge for labor for the selection of the total width of plow required. This item may be zero if no labor is required for an operation.

0030 - Identification code number for card #3.

0031 - Force factor for the implement in pounds per foot of width. This item may not be zero.

0032 - The allowable variation in dollars of annual cost that will be considered insignificant or permissible. This item is used to determine the allowable range of implement width which will extend on either side of the optimum width to permit the selection of an implement in a commercial size. Values of 5-10 dollars for this item are usually sufficient. This item may be zero if no range in implement widths is desired.

Items 0033-0037, 0041-0047, and 0051-0056 are used to include timeliness data for the operations performed by an implement. A maximum of six different crops may be included for each implement. The amount of timeliness data used determines the number of input data cards required.

If timeliness data is used, it should be included for all crops covered by an implement. The total number of data cards required is:

For 1 crop - 3 cards

For 2-4 crops - 4 cards

For 5-6 crops - 5 cards

Care should be taken to insure that any unused locations on each card are filled with zeros. If timeliness data for only 3 crops is needed, 4 cards would be needed and zeros entered in locations 0045, 0046, and 0047 of the forth card. When more than three cards are used the code identification numbers of the first three cards must also indicate the use of a fourth or fifth card. Data for all these locations may be zero if an allotted time (0025) is given and only 3 cards would be needed.

0033 - Total once-over acreage for the crop covered by an implement. If 40 acres of corn is cultivated 3 times, 120 acres would be entered here.

0034 - Timeliness factor for the operation and crop covered. NOTE: This is one of the items of input data that can not use the standard decimal point location. Since timeliness factors may extend more than 3 places to the right of the decimal, they are multiplied by 1000 before entering on the data cards. This is compensated for by shifting the crop value (0035) three places to the right since the computer will treat all items of input data as if the standard decimal point location were used.

Examples:

1. Timeliness factor of .00005 - - - - - - - - - - - - -0000000050

2. Timeliness factor of .00040 - - - - - - - - - - - - -0000000400

3. Timeliness factor of .0010- - - - - - - - - - - - - -0000001000

The minimum value of timeliness factor that can be used is .000001.

0035 - Total crop value in dollars, This item is found by multiplying the <u>total</u> crop yield by the unit price.

Example:

500 acres x 20 bu./ac. x $2.00/bu. = <u>$20,000</u>

This is one of the items of input data that does not use the standard decimal point location. Since total crop value could possibly exceed $99,999 in some instances, provision is made to include larger figures. <u>This item is divided by 1000 before being placed on the input data card</u>. This value must always be given in whole dollar amounts.

Examples:

1. Total crop value = $20,000 - - - - - - - - - - - - - 0000020000
2. Total crop value = $ 2,250 - - - - - - - - - - - - - 0000002250

0036, 0042, 0045, 0051, 0054 - Same as for item 0033 if needed.

0037, 0043, 0046, 0052, 0055 - Same as for item 0034 if needed.

0041, 0044, 0047, 0053, 0056 - Same as for item 0035 if needed.

0040 - Identification code number for card #4 (if needed).

0050 - Identification code number for card #5 (if needed).

0057 - Always zero if 5 cards are used.

POWER INPUT CARDS - The data cards for power are read into the same locations as the data cards for implements. The items which are essential for the calculation of fixed costs occupy the same positions on both power and implement data cards. Items on the power data cards which occupy the same locations as the corresponding items on the implement data cards will not be discussed since the same rules will apply. The form used for power data cards is shown on the next page.

0010 - Identification code number for card #1.

0011 - 0012 - Same as for implements.

0013 - Purchase price of power in dollars per usable horsepower. (Usable horsepower = 75% of maximum drawbar horsepower). <u>This item may not be 0</u>.

POWER INPUT DATA CARDS:

Code 1001---	Years of expected life	Years of expected owner-ship	Cost/HP	Rep., Lub., T,I,S (%)	Interest (%)	S. F. interest (%)	ZERO
0010	0011	0012	0013	0014	0015	0016	0017

Code 1002---	Hours used for non-field operations	Fixed cost (%)	Max. allow. size	Min. allow. size	ZERO	ZERO	ZERO
0020	0021	0022	0023	0024	0025	0026	0027

0014 - 0016 - Same as for implements.

0017 - Always zero

0020 - Identification code number for card #2.

0021 - Hours that power is used for non-field operations. The selection problem deals only with field machinery but tractors are often used for other miscellaneous jobs that any tractor could accomplish regardless of size. This item allows for the consideration of such tractor use if desired. Use of this item reduces the hourly cost for power charged to all the field implements selected. This item may be zero if the power is not used for non-field work or if this item is not to be considered.

0022 - Same as for implements.

0023 - The maximum usable horsepower that is to be obtained from any one tractor. This item represents the maximum size of tractor that is available or that is desired. This item determines the number of tractors that will be selected since the total required power is divided by this item to determine the number of tractors required for a system. <u>This item should never be zero</u>.

0024 - The minimum usable horsepower that is to be obtained from any one tractor. This item represents the minimum size of tractor that is available or that is desired. <u>This item should never be zero</u>.

0025 - 0027 - Always zero.

For any particular problem the methods for calculating depreciation, interest, and other fixed costs would probably be the same for all machines to be selected. This <u>is not</u> a necessary requirement, however, and different methods may be used within a given problem if desired since the calculation of fixed costs for any machine is independent of data pertaining to other machines in the problem.

The input data for all implements and power in a problem is read into the computer,one group of cards at a time. All cards with data for a single implement or for the power are read in together. Before another group of cards are read in, several computations are performed on the data in the locations which have been discussed.

If a total fixed cost percentage (0022) is not given, this item is calculated using the other fixed cost data provided. The fixed cost percentage is multiplied by the unit purchase price (0013) and this value is stored in 0022. Location 0022 now contains the annual fixed costs in dollars per foot of width or per horsepower.

The percent time utilization (0017) and the percent width utilization (0021) for implements are combined to form field efficiency which is stored in 0021.

The timeliness data for the operations performed by an implement is collected and a value for $\sum\left(A_i \; K_i \; Y_i \; V_i\right)$ for the implement to be selected is stored in location 0033.

When these calculations have been completed the data is moved to different locations to permit another group of data cards to be read in. Power data is stored in a special location for easy reference during later calculations. Implement data is stored in bands of 30 locations within the computer for later reference. Ample space is provided within the storage locations to permit storage of additional data that is developed later in the problem. Index Register "C" of the computer is used to store the implements for further calculations. <u>Storage is available for a maximum of 26 different implements that may be selected within any one problem.</u>

The locations occupied by the input data and calculated values during the selection procedure followed by the stored program are indicated below:

IMPLEMENT DATA STORAGE LOCATIONS:

Code XXX2---	Field efficiency (%)	Fixed cost ($/ft)	Total acres covered	Average speed (mph)	Allotted hours	Max. allow. size (ft)	Labor ($/hr)
0060C	0061C	0062C	0063C	0064C	0065C	0066C	0067C

Force factor (lb/ft)	(d) Allowable cost variation	ΣAKYV	HP req. to meet allotted time	(1)	(1)	BLANK	(1)
0068C	0069C	0070C	0071C	0072C	0073C	0074C	0075C

Min. size	Optimum size	Max. size	Size permitted by total hp	No. of tractors used	HP req. by optimum size	Size req. by allotted time	Allow. size pulled by large tractor
0076C	0077C	0078C	0079C	0080C	0081C	0082C	0083C

Allow. size pulled by smallest tractor	Allow. size per tractor	Allow. size for tractors used	Allow. size for all tractors	BLANK	BLANK
0084C	0085C	0086C	0087C	0088C	0089C

POWER DATA STORAGE LOCATIONS:

BLANK	Code 1002---	Hours used for non-field operations	Fixed cost ($/hp)	Max. allow. size	Min. allow size	(1)	(1)
9044	9045	9046	9047	9048	9049	9050	9051

BLANK	Total no of tractors used	Total usable hp req.	Total usable hp selected	Usable hp of largest tractor	Actual hp of largest tractor	Usable hp of smallest tractor	Actual hp of smallest tractor
9052	9053	9054	9055	9056	9057	9058	9059

(1) These locations are used for indicators and temporary storage during the selection procedure.

INPUT DATA READ IN RULES

The following order must be followed when reading input data cards into the computer:

1. Machine Program Deck
2. Transfer Card
3. Data Cards
4. Trailer Card (indicates end of data for problem)

Once the machine program has been entered additional problems may be solved by using only the transfer card followed by the data cards and trailer card. More than one problem may be solved without stopping since input data for another problem may follow the trailer card for the first. A trailer card must follow the input data for each individual problem when this procedure is used.

The following rule must be followed for the input data cards of each individual problem:

1. The input data cards for the power or for each implement to be selected may be read in in any order, but must be together. <u>The input data cards for any given machine must not be intermingled with those of other machines</u>. NOTE: If the above rule is not observed the computer will halt.

D A T A   O U T P U T   F O R M

Output data cards may be identified with the proper machines by use of the code number. The same identification code number is used for output cards that was used for input cards with the exception of the card number which has been changed to 6 and 7. One output card is provided for the power or tractors selected. Two output cards are provided for tractor-drawn implements selected. One output card is provided for self-propelled implements selected. All output data is in floating decimal point form. Persons not familiar with this form can easily learn to interpret it.

The temporary storage locations for the various items of output data are indicated on the following page. Each type of output data card will be discussed.

IMPLEMENT DATA CARDS - This type of data card is used for the output data of all implements both tractor-drawn and self-propelled. Only the first card is used for self-propelled implements selected while both cards are used for tractor-drawn implements.

9012 - Identification code number for card #6.

9013 - Lower limit of the allowable range in implement width permitted to facilitate the selection of an implement in a commercial size.

9014 - The optimum width of implement selected by the procedure followed within the stored program.

9015 - Upper limit of the allowable range in implement width permitted to facilitate the selection of an implement in a commercial size.

9016 - The maximum width of implement which can be pulled by the total amount of power selected for the system. This item is zero for self-propelled implements.

IMPLEMENT OUTPUT DATA CARDS:

Code XXX6---	Min. size	Optimum size	Max. size	Size permitt-ed by total hp	No. of tractors used	HP req. by optimum size	Size req. by allot-ted time
9012	9013	9014	9015	9016	9017	9018	9019

Code XXX7---	Allow. size pulled by large tractor	Allow. size pulled by small tractor	Allow. size per tractor	Allow. size for tractors used	Allow. size for all tractors	BLANK	BLANK
9024	9025	9026	9027	9028	9029		

POWER OUTPUT DATA CARD:

Code 1006---	Total no of tractors used	Total usable hp req.	Total usable hp sel-ected	Usable hp of largest tractor	Actual hp of largest tractor	Usable hp of smallest tractor	Actual hp of smallest tractor
9052	9053	9054	9055	9056	9057	9058	9059

9017 - The number of tractors used to pull the optimum width of implement selected (9014). The number of tractors denotes the number of individual implements which must be selected to make up the total required implement width. For self-propelled implements this item indicates the number of individual units to be selected.

9018 - The horsepower required to pull the optimum implement width (9014). This item is zero for self-propelled implements.

9019 - The width of implement required to complete its operations within an allotted time period. This item is zero if an allotted time period was not included as an item of input data.

9024 - Identification code number for card #7.

9025 - The maximum width of implement which can be pulled by the largest tractor selected.

9026 - The maximum width of implement which can be pulled by the smallest tractor selected. This item is zero if all tractors are selected in equal sizes.

9027 - The maximum width of implement which is available or is desired in a single unit. This item was also an item of input data. This item is zero if it was zero for the input data or if the maximum available width is larger than the width that the largest tractor can pull.

9028 - The maximum width of implement which may be pulled by the number of tractors (9017) selected for use with the implement. This is a limitation due to the size of available units, not available power. This item is zero if item 9027 is zero.

9029 - The maximum width of implement which may be pulled by all tractors selected for the entire system. This item is zero if 9027 is zero.

POWER DATA CARD

9052 - Identification code number for card #6.

9053 - Total number of tractors selected for the system.

9054 - Total usable horsepower required for the system.

9055 - Total usable horsepower selected for the system. (This item may differ from 9054 because of limitations on minimum tractor size).

9056 - Usable horsepower of largest tractor selected.

9057 - Actual or maximum drawbar horsepower of largest tractor selected.

9058 - Usable horsepower of smallest tractor selected. This item is zero if tractors are selected in equal sizes.

9059 - Actual or maximum drawbar horsepower of smallest tractor selected. This item is zero if tractors are selected in equal sizes.

SPECIAL OUTPUT DATA CARDS:

XXX60000XX	4444444444	BLANK →

Input data cards for the machine indicated were not grouped together or there is an error in code numbers for this group of cards. (Rule #1, page 136.)

XXX60000XX	6666666666	BLANK →

An allotted time has been given for some implements but not for all. (Input data rules, page 128)

XXX60000XX	5555555555	BLANK →

No allotted time is given for any implements and all implements do not have timeliness data. (Input data rules, page 128)

S P E C I A L   P R O G R A M   U S E S

In some instances it may be desired to select a single implement for a system where the other implements are already in use or have been selected. For a self-propelled implement this may be accomplished by following the same procedure outlined for the selection of all implements in the system. Such an approach is possible since self-propelled implements are not dependent upon a common power source. Selection of self-propelled implements proceeds independently of the selection of all other implements within the system.

To select a single tractor-drawn implement the input data must be adapted to follow the same procedure as self-propelled machines. The following steps can be used:

1. Calculate the annual hours that the power is used with other implements and add the estimated hours that power will be used with the implement to be selected.

2. Calculate the cost per hour for power.

3. Add the hourly power cost to the hourly labor cost and process the implement data as if it were self-propelled. Note: A self-propelled code identification must be used. No limit should be placed on the size of individual unit to be selected.

4. Examine the selected optimum width. If more than one unit is desired to make up this width, multiply hourly labor cost per unit by the number of desired units, add the power cost per hour and recalculate the optimum width. This procedure can be repeated until the selected width is made up of the number of units assumed before selection.

5. A check using manual calculations may be advisable to prevent selection of a width that cannot be pulled by the available power.

A complete listing of the steps used in the stored program for field machinery selection is included on the following pages. The stored program was written for assembly with a Symbolic Optimal Assembly Program (SOAP). The original "SOAP" program which was written and the machine language program which was assembled are both listed. The "SOAP" program is listed at the right of each page. The machine language program is listed at the left. The number of each step is indicated at the left of the machine language program.

The parts of the machine language program are indicated in the example below:

```
┌── Location of instruction
│         ┌── Operation code
↓         ↓
0850      69 0853 0856
              ↑    ↑
              │    └── Location of next instruction
              └── Location of data
```

The storage locations from 1965-1985 are available for additions or alterations of the steps in the present stored program.

In order to use the machine language program for processing data, a transfer card and a trailer card are needed. The forms for these cards are indicated below:

TRANSFER CARD:

+0000000850+	BLANK →

TRAILER CARD:

+0000001000+	ZEROS →

(+ signs must be punched in columns 20, 30, 40, 50, 60, 70, & 80, also.)

```
                                         BLR   1950      1999
                                         BLR   0000      0849
0850     69 0853 0856          BEGIN     LDD   DIGIT
0856     24 9000 0863                    STD   9000
0863     88 0000 0869                    RAC   0000      START
0869     70 9002 0870          START     RD1   9002
0870     70 9012 0871                    RD1   9012
0871     60 9012 0879                    RAU   9012
0879     35 0001 0885                    SLT   0001
0885     30 0008 0903                    SRT   0008
0903     44 0857 0858                    NZU   OPERA     POWER
0858     21 9000 0866          POWER     STU   9000      CHECK
0857     70 9022 0908          OPERA     RD1   9022
0908     60 9022 0867                    RAU   9022
0867     35 0008 0935                    SLT   0008
0935     30 0009 0855                    SRT   0009
0855     44 0859 0866                    NZU             CHECK
0859     70 9032 0917                    RD1   9032
0917     60 9032 0875                    RAU   9032
0875     35 0009 0895                    SLT   0009
0895     44 0899 0866                    NZU             CHECK
0899     70 9042 0866                    RD1   9042      CHECK
0866     80 0000 0872          CHECK     RAA   0000      MOOVE
0872     60 9202 0881          MOOVE     RAU   9002 A
0881     35 0003 0889                    SLT   0003
0889     30 0008 0907                    SRT   0008
0907     82 8003 0916                    RAB   8003
0916     27 9202 0921                    SET   9002 A
0921     28 4000 0862                    SIB   0000 B
0862     51 0010 0868                    SXA   0010
0868     40 0971 0922                    NZA             SEEAA
0971     50 0020 0872                    AXA   0020      MOOVE
0922     60 9000 0931          SEEAA     RAU   9000
0931     44 0985 0886                    NZU             ORDER
0985     80 0020 0892                    RAA   0020      LASTA
0892     60 9202 0851          LASTA     RAU   9002 A
0851     35 0003 0909                    SLT   0003
0909     30 0008 0877                    SRT   0008
0877     82 8003 0936                    RAB   8003
0936     27 9202 0891                    SET   9002 A
0891     28 4000 0912                    SIB   0000 B
0912     51 0040 0918                    SXA   0040
0918     40 1021 0886                    NZA             ORDER
1021     50 0010 0942                    AXA   0010
0942     40 0945 0896                    NZA             ALLAA
0945     60 9022 0905                    RAU   9022
0905     35 0008 0873                    SLT   0008
0873     30 0009 0893                    SRT   0009
0893     44 0897 0886                    NZU             ORDER
0897     50 0040 0892                    AXA   0040      LASTA
0896     60 9032 0955          ALLAA     RAU   9032
0955     35 0009 0925                    SLT   0009
0925     44 0929 0886                    NZU             ORDER
0929     50 0040 0892                    AXA   0040      LASTA
```

```
0886    60 0010 0865      ORDER   RAU    0010
0865    10 0853 0957              AUP   DIGIT
0957    11 0020 0975              SUP    0020
0975    44 0979 0880              NZU   NORDR      NEXTA
0979    60 0020 1025      NORDR   RAU    0020
1025    21 9008 0884              STU    9008
0884    69 0887 0890              LDD   FOURA
0890    24 9009 0947              STD    9009
0947    71 9008 0898              WR1    9008      HALTA
0898    01 0001 0850      HALTA   HLT    0001      BEGIN
0880    60 9000 0939      NEXTA   RAU    9000
0939    44 0943 0894              NZU              DONEA
0943    60 0020 1075              RAU    0020
1075    10 0853 1007              AUP   DIGIT
1007    11 0030 1035              SUP    0030
1035    44 0979 0940              NZU   NORDR
0940    60 0030 1085              RAU    0030
1085    35 0008 0953              SLT    0008
0953    30 0009 0923              SRT    0009
0923    44 0927 0894              NZU              DONEA
0927    60 0030 1135              RAU    0030
1135    10 0853 1057              AUP   DIGIT
1057    11 0040 0995              SUP    0040
0995    44 0979 0900              NZU   NORDR
0900    60 0040 1045              RAU    0040
1045    35 0009 0915              SLT    0009
0915    44 0919 0894              NZU              DONEA
0919    60 0040 1095              RAU    0040
1095    10 0853 1107              AUP   DIGIT
1107    11 0050 1005              SUP    0050
1005    44 0979 0894              NZU   NORDR      DONEA
0894    82 0000 0950      DONEA   RAB    0000      FLOAT
0950    80 4011 1157      FLOAT   RAA    0011 B    CONTU
1157    60 2000 1055      CONTU   RAU    0000 A
1055    35 0002 0861              SLT    0002
0861    10 0911 0965              AUP   FIFIV
0965    32 0968 1145              FAD   ZEROA
1145    21 2000 1003              STU    0000 A
1003    51 4017 0860              SXA    0017 B
0860    40 0913 0864              NZA              ADDBB
0913    50 4018 1157              AXA    0018 B    CONTU
0864    53 0040 0920      ADDBB   SXB    0040
0920    42 0973 0874              NZB              FLTED
0973    52 0050 0950              AXB    0050      FLOAT
0874    60 0022 0977      FLTED   RAU    0022
0977    44 0981 0882              NZU   GIVEN      FXCST
0981    60 0022 1027      GIVEN   RAU    0022
1027    39 0013 0963              FMP    0013
0963    34 0966 1016              FDV   ONEHD
1016    21 0022 1125              STU    0022
1125    60 9000 0883              RAU    9000
0883    44 0937 0888              NZU   IMPLE      TRCTR
0888    27 9045 0993      TRCTR   SET    9045
0993    08 0020 0932              LIB    0020
```

```
0932   69 0853 0906           LDD   DIGIT
0906   24 9000 0869           STD    9000       START
0937   60 0017 1071   IMPLE   RAU    0017
1071   34 0966 1066           FDV   ONEHD
1066   39 0021 1121           FMP    0021
1121   21 0021 0924           STU    0021
0924   27 9002 1029           SET    9002
1029   08 0020 0982           LIB    0020
0982   27 9002 0987           SET    9002
0987   28 6060 0972           SIB    0060 C
0972   60 0033 1037           RAU    0033
1037   44 0941 0992           NZU               COLCT
0941   39 0034 0934           FMP    0034
0934   39 0035 1185           FMP    0035
1185   21 0033 0986           STU    0033
0986   60 0036 0991           RAU    0036
0991   44 1195 0992           NZU               COLCT
1195   39 0037 1087           FMP    0037
1087   39 0041 1041           FMP    0041
1041   32 0033 0959           FAD    0033
0959   21 0033 1036           STU    0033
1036   60 0042 0997           RAU    0042
0997   44 0901 0992           NZU               COLCT
0901   39 0043 1043           FMP    0043
1043   39 0044 0944           FMP    0044
0944   32 0033 1009           FAD    0033
1009   21 0033 1086           STU    0033
1086   60 0045 0949           RAU    0045
0949   44 1053 0992           NZU               COLCT
1053   39 0046 0946           FMP    0046
0946   39 0047 1047           FMP    0047
1047   32 0033 1059           FAD    0033
1059   21 0033 1136           STU    0033
1136   60 0040 1245           RAU    0040
1245   35 0009 1015           SLT    0009
1015   44 0969 0992           NZU               COLCT
0969   60 0051 1105           RAU    0051
1105   39 0052 0852           FMP    0052
0852   39 0053 1103           FMP    0053
1103   32 0033 1109           FAD    0033
1109   21 0033 1186           STU    0033
1186   60 0054 1159           RAU    0054
1159   44 1013 0992           NZU               COLCT
1013   39 0055 1155           FMP    0055
1155   39 0056 0956           FMP    0056
0956   32 0033 1209           FAD    0033
1209   21 0033 0992           STU    0033      COLCT
0992   69 0031 0984   COLCT   LDD    0031
0984   24 6068 1171           STD    0068 C
1171   69 0032 1235           LDD    0032
1235   24 6069 1022           STD    0069 C
1022   69 0033 1236           LDD    0033
1236   24 6070 1023           STD    0070 C
1023   69 0968 1221           LDD   ZEROA
```

```
1221   24 6073 0876          STD   0073 C
0876   69 1079 1032          LDD   FLONE
1032   24 6080 0933          STD   0080 C
0933   24 6072 1175          STD   0072 C
1175   58 0030 0869          AXC   0030       START
1000   59 0030 1006   TRALR  SXC   0030
1006   60 8007 1065          RAU   8007
1065   21 9000 0974          STU   9000
0974   69 0968 1271          LDD   ZEROA
1271   24 9051 0878          STD   9051
0878   24 9008 1285          STD   9008
1285   24 9009 1042          STD   9009       LOOPA
1042   60 6060 1115   LOOPA  RAU   0060 C
1115   30 0009 1335          SRT   0009
1335   44 0989 0990          NZU   INSPT      SELFP
1050   48 1153 0854   ELIMN  NZC              WHICH
1153   59 0030 1042          SXC   0030       LOOPA
0854   60 9008 1063   WHICH  RAU   9008
1063   44 1031 1018          NZU   TYPEA
1018   60 9009 1077          RAU   9009
1077   44 0967 1082          NZU   TYPEB
1082   60 9000 1091          RAU   9000
1091   88 8003 1100          RAC   8003
1100   80 0000 1056          RAA   0000       RANGE
0989   60 6065 1019   INSPT  RAU   0065 C
1019   44 1073 1024          NZU   MARKA      MARKB
1073   69 1079 1132   MARKA  LDD   FLONE
1132   24 9008 1039          STD   9008       ZROCK
1024   69 1079 1182   MARKB  LDD   FLONE
1182   24 9009 1039          STD   9009       ZROCK
1039   48 1092 0854   ZROCK  NZC              WHICH
1092   59 0030 1042          SXC   0030       LOOPA
0967   60 9000 1225   TYPEB  RAU   9000
1225   88 8003 1034          RAC   8003
1034   69 1079 1232          LDD   FLONE
1232   24 9050 1089          STD   9050
1089   69 0968 1321          LDD   ZEROA
1321   24 9004 0928          STD   9004       CULLA
0928   60 6060 1165   CULLA  RAU   0060 C
1165   30 0009 1385          SRT   0009
1385   44 1139 1040          NZU   LOOPB
1040   48 1093 0994          NZC              TOTAL
1093   59 0030 0928          SXC   0030       CULLA
1139   60 6070 1275   LOOPB  RAU   0070 C
1275   44 1129 0930          NZU              ERROR
1129   60 0983 1137          RAU   TOTWO
1137   39 6068 1068          FMP   0068 C
1068   34 9047 1072          FDV   9047
1072   34 6061 0961          FDV   0061 C
0961   39 0966 1116          FMP   ONEHD
1116   21 9001 1074          STU   9001
1074   39 6070 0970          FMP   0070 C
0970   21 9002 0978          STU   9002
0978   60 9001 1187          RAU   9001
```

```
1187   39 6063 1113           FMP   0063 C
1113   39 6080 0980           FMP   0080 C
0980   39 6067 1017           FMP   0067 C
1017   32 9002 1097           FAD   9002
1097   32 9004 1127           FAD   9004
1127   21 9004 1286           STU   9004
1286   48 1189 0994           NZC              TOTAL
1189   59 0030 0928           SXC   0030       CULLA
0994   80 0000 1150   TOTAL   RAA   0000
1150   60 9004 1259           RAU   9004
1259   34 0962 1012           FDV   TWOAA
1012   21 9003 1020           STU   9003
1020   33 1079 1205           FSB   FLONE
1205   46 0958 1309           BMI              ROOTA
0958   69 1079 1282           LDD   FLONE
1282   24 9003 1309           STD   9003       ROOTA
1309   60 9004 1067   ROOTA   RAU   9004
1067   34 9003 1371           FDV   9003
1371   32 9003 0951           FAD   9003
0951   34 0962 1062           FDV   TWOAA
1062   21 9003 1070           STU   9003
1070   51 0012 0926           SXA   0012
0926   40 1179 1030           NZA              HPAAA
1179   50 0013 1309           AXA   0013       ROOTA
1031   60 9000 1239   TYPEA   RAU   9000
1239   88 8003 0948           RAC   8003
0948   69 0968 1421           LDD   ZEROA
1421   24 9050 1028           STD   9050
1028   24 9003 1435           STD   9003       SORTA
1435   60 6060 1215   SORTA   RAU   0060 C
1215   30 0009 1485           SRT   0009
1485   44 1289 1090           NZU   LOOPC
1090   48 1143 1030           NZC              HPAAA
1143   59 0030 1435           SXC   0030       SORTA
1289   60 6065 1069   LOOPC   RAU   0065 C
1069   44 1123 1124           NZU              WRONG
1123   60 0983 1237           RAU   TOTWO
1237   39 6068 1118           FMP   0068 C
1118   39 6063 1163           FMP   0063 C
1163   34 6061 1011           FDV   0061 C
1011   39 0966 1166           FMP   ONEHD
1166   34 6065 1265           FDV   0065 C
1265   21 6071 1174           STU   0071 C
1174   33 9003 1255           FSB   9003
1255   46 1008 1359           BMI   SMALL      LARGE
1359   60 6071 1325   LARGE   RAU   0071 C
1325   21 9003 1008           STU   9003       SMALL
1008   48 1061 1030   SMALL   NZC              HPAAA
1061   59 0030 1435           SXC   0030       SORTA
1030   60 9003 1339   HPAAA   RAU   9003
1339   21 9054 0998           STU   9054
0998   33 9049 1229           FSB   9049
1229   46 1332 1033           BMI   MINIM      MOREA
1332   69 9049 1389   MINIM   LDD   9049
```

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1389   24 9055 0996               STD   9055          SINGU
1033   60 9048 1141       MOREA   RAU   9048
1141   33 9054 1471               FSB   9054
1471   46 1224 1375               BMI   SPLIT
1375   69 9054 1382               LDD   9054
1382   24 9055 0996               STD   9055          SINGU
0996   60 9055 1305       SINGU   RAU   9055
1305   21 9056 0914               STU   9056
0914   34 1117 1167               FDV   SERFI
1167   21 9057 0976               STU   9057
0976   69 0968 1521               LDD   ZEROA
1521   24 9058 1078               STD   9058
1078   24 9059 1535               STD   9059
1535   69 1079 1432               LDD   FLONE
1432   24 9053 1439               STD   9053          ALLOW
1224   60 9054 1083       SPLIT   RAU   9054
1083   34 9048 1287               FDV   9048
1287   21 9001 1046               STU   9001
1046   35 0008 1315               SLT   0008
1315   30 0008 1133               SRT   0008
1133   80 8003 1142               RAA   8003
1142   51 0050 1048               SXA   0050
1048   82 0010 0904               RAB   0010
0904   53 2000 1111               SXB   2000
1111   50 0050 1217               AXA   0050
1217   60 9001 1425               RAU   9001
1425   30 4000 1147               SRT   0000 B
1147   60 8003 1355               RAU   8003
1355   35 4000 1177               SLT   0000 B
1177   10 8005 1183               AUP   8005
1183   21 9002 1192               STU   9002
1192   33 9001 1173               FSB   9001
1173   44 1227 1128               NZU                 NUMBR
1227   60 9002 1337               RAU   9002
1337   32 1079 1405               FAD   FLONE
1405   21 9002 1128               STU   9002          NUMBR
1128   60 9002 1387       NUMBR   RAU   9002
1387   21 9053 1096               STU   9053
1096   60 9045 1455               RAU   9045
1455   35 0007 1571               SLT   0007
1571   30 0009 1191               SRT   0009
1191   44 1295 1146               NZU   UNEQL         EQUAL
1146   60 9054 1505       EQUAL   RAU   9054
1505   21 9055 0964               STU   9055
0964   34 9053 1168               FDV   9053
1168   21 9056 1026               STU   9056
1026   34 1117 1267               FDV   SERFI
1267   21 9057 1076               STU   9057
1076   69 0968 1621               LDD   ZEROA
1621   24 9058 1178               STD   9058
1178   24 9059 1439               STD   9059          ALLOW
1295   60 9048 1203       UNEQL   RAU   9048
1203   21 9056 1112               STU   9056
1112   34 1117 1317               FDV   SERFI
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1317   21 9057 1126          STU   9057
1126   60 9053 1585          RAU   9053
1585   39 9048 1489          FMP   9048
1489   33 9054 1119          FSB   9054
1119   44 1223 1274          NZU   UNEVN      EVENA
1274   69 9054 1081   EVENA  LDD   9054
1081   24 9055 0938          STD   9055
0938   69 0968 1671          LDD   ZEROA
1671   24 9058 1228          STD   9058
1228   24 9059 1439          STD   9059       ALLOW
1223   60 9053 1131   UNEVN  RAU   9053
1131   33 1079 1555          FSB   FLONE
1555   39 9048 1409          FMP   9048
1409   21 9001 1218          STU   9001
1218   60 9054 1277          RAU   9054
1277   33 9001 1207          FSB   9001
1207   21 9002 1216          STU   9002
1216   33 9049 1197          FSB   9049
1197   46 1200 1001          BMI   SHORT      WITHN
1001   60 9002 1459   WITHN  RAU   9002
1459   21 9058 1268          STU   9058
1268   34 1117 1367          FDV   SERFI
1367   21 9059 1176          STU   9059
1176   69 9054 1233          LDD   9054
1233   24 9055 1439          STD   9055       ALLOW
1200   60 9049 1509   SHORT  RAU   9049
1509   21 9058 1318          STU   9058
1318   34 1117 1417          FDV   SERFI
1417   21 9059 1226          STU   9059
1226   60 9001 1635          RAU   9001
1635   32 9049 1365          FAD   9049
1365   21 9055 1439          STU   9055       ALLOW
1439   60 9000 1247   ALLOW  RAU   9000
1247   88 8003 1106          RAC   8003
1106   69 0968 1721          LDD   ZEROA
1721   24 9005 1278          STD   9005       LOOPD
1278   60 6060 1415   LOOPD  RAU   0060 C
1415   30 0009 1685          SRT   0009
1685   44 1539 1140          NZU   AOORB
1140   48 1193 1044          NZC              READY
1193   59 0030 1278          SXC   0030       LOOPD
1539   60 9050 1297   AOORB  RAU   9050
1297   44 1051 0902          NZU   BBBEE      AAAYE
0902   60 9056 1161   AAAYE  RAU   9056
1161   33 6071 1347          FSB   0071 C
1347   46 1250 1051          BMI              BBBEE
1250   60 6071 1475          RAU   0071 C
1475   34 9056 1279          FDV   9056
1279   21 9001 0988          STU   9001
0988   35 0008 1257          SLT   0008
1257   30 0008 1525          SRT   0008
1525   80 8003 1084          RAA   8003
1084   51 0050 1190          SXA   0050
1190   82 0010 1196          RAB   0010
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1196    53 2000 1253                   SXB    2000
1253    50 0050 1559                   AXA    0050
1559    60 9001 1467                   RAU    9001
1467    30 4000 1589                   SRT    0000 B
1589    60 8003 1397                   RAU    8003
1397    35 4000 1169                   SLT    0000 B
1169    10 8005 1575                   AUP    8005
1575    21 9002 1134                   STU    9002
1134    33 9001 1465                   FSB    9001
1465    44 1219 1120                   NZU             KEEEP
1219    60 9002 1329                   RAU    9002
1329    32 1079 1605                   FAD    FLONE
1605    21 6080 1051                   STU    0080 C   BBBEE
1120    60 9002 1379           KEEEP   RAU    9002
1379    21 6080 1051                   STU    0080 C   BBBEE
1051    60 9055 1609           BBBEE   RAU    9055
1609    39 1162 1212                   FMP    THSFI
1212    34 6068 1368                   FDV    0068 C
1368    34 6064 1014                   FDV    0064 C
1014    21 6079 1482                   STU    0079 C
1482    60 9056 1241                   RAU    9056
1241    39 1162 1262                   FMP    THSFI
1262    34 6068 1418                   FDV    0068 C
1418    34 6064 1064                   FDV    0064 C
1064    21 6083 1336                   STU    0083 C
1336    60 9058 1345                   RAU    9058
1345    39 1162 1312                   FMP    THSFI
1312    34 6068 1468                   FDV    0068 C
1468    34 6064 1114                   FDV    0064 C
1114    21 6084 1437                   STU    0084 C
1437    60 6065 1269                   RAU    0065 C
1269    44 1273 1324                   NZU    SOMEA    NONEA
1324    21 6082 1735           NONEA   STU    0082 C
1735    48 1038 1044                   NZC             READY
1038    59 0030 1278                   SXC    0030     LOOPD
1273    60 1276 1181           SOMEA   RAU    CONST
1181    39 6063 1213                   FMP    0063 C
1213    34 6065 1515                   FDV    0065 C
1515    34 6064 1164                   FDV    0064 C
1164    34 6061 1211                   FDV    0061 C
1211    21 6082 1785                   STU    0082 C
1785    60 6065 1319                   RAU    0065 C
1319    32 9005 0999                   FAD    9005
0999    21 9005 1058                   STU    9005
1058    48 1261 1044                   NZC             READY
1261    59 0030 1278                   SXC    0030     LOOPD
1044    60 9000 1303           READY   RAU    9000
1303    88 8003 1362                   RAC    8003
1362    60 9050 1771                   RAU    9050
1771    44 1625 1326                   NZU    ADDAA    HOURS
1625    60 1328 1283           ADDAA   RAU    FIVHD
1283    21 9005 1326                   STU    9005     HOURS
1326    60 9005 1835           HOURS   RAU    9005
1835    32 9046 1565                   FAD    9046
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1565   21 9005 1374               STU   9005
1374   69 0968 1821               LDD   ZEROA
1821   24 9004 1378               STD   9004
1378   60 9047 1487               RAU   9047
1487   39 9055 1291               FMP   9055
1291   21 9006 1300               STU   9006
1300   34 9005 0954               FDV   9005
0954   21 9007 1412               STU   9007
1412   35 0008 1231               SLT   0008
1231   30 0008 1049               SRT   0008
1049   80 8003 1108               RAA   8003
1108   60 9007 1517               RAU   9007
1517   30 0006 1281               SRT   0006
1281   60 8003 1639               RAU   8003
1639   35 0006 1353               SLT   0006
1353   10 8005 1659               AUP   8005
1659   21 9007 1518               STU   9007     MLOOP
1518   60 6060 1615       MLOOP   RAU   0060 C
1615   30 0009 1885               SRT   0009
1885   44 1689 1240               NZU   SOLVE
1240   48 1243 1094               NZC            TEEEE
1243   59 0030 1518               SXC   0030     MLOOP
1689   80 0000 1395       SOLVE   RAA   0000
1395   60 6073 1327               RAU   0073 C
1327   44 1331 1532               NZU   FROZE
1532   60 6074 1429               RAU   0074 C
1429   44 1331 1184               NZU   FROZE
1184   60 1276 1381               RAU   CONST
1381   34 6062 1462               FDV   0062 C
1462   34 6064 1214               FDV   0064 C
1214   34 6061 1311               FDV   0061 C
1311   21 9001 1170               STU   9001
1170   39 6070 1220               FMP   0070 C
1220   21 9002 1428               STU   9002
1428   60 6067 1871               RAU   0067 C
1871   39 6080 1080               FMP   0080 C
1080   32 9007 1361               FAD   9007
1361   39 9001 1665               FMP   9001
1665   39 6063 1263               FMP   0063 C
1263   32 9002 1293               FAD   9002
1293   21 9001 0952               STU   9001
0952   34 0962 1512               FDV   TWOAA
1512   21 9002 1270               STU   9002
1270   33 1079 1655               FSB   FLONE
1655   46 1158 1709               BMI            ROOTB
1158   69 1079 1582               LDD   FLONE
1582   24 9002 1709               STD   9002     ROOTB
1709   60 9001 1567       ROOTB   RAU   9001
1567   34 9002 1921               FDV   9002
1921   32 9002 1101               FAD   9002
1101   34 0962 1562               FDV   TWOAA
1562   21 9002 1320               STU   9002
1320   51 0012 1376               SXA   0012
1376   40 1479 1130               NZA            WIDTH
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487 1479   50 0013 1709          AXA    0013     ROOTB
488 1130   60 9002 1739   WIDTH  RAU    9002
489 1739   21 6077 1331          STU    0077 C   FROZE
490 1331   60 1276 1431   FROZE  RAU   CONST
491 1431   39 6063 1313          FMP    0063 C
492 1313   34 6077 1377          FDV    0077 C
493 1377   34 6064 1264          FDV    0064 C
494 1264   34 6061 1411          FDV    0061 C
495 1411   32 9004 1341          FAD    9004
496 1341   21 9004 1350          STU    9004
497 1350   48 1403 1094          NZC             TEEEE
498 1403   59 0030 1518          SXC    0030     MLOOP
499 1094   60 9004 1453   TEEEE  RAU    9004
500 1453   32 9046 1333          FAD    9046
501 1333   21 9004 1242          STU    9004
502 1242   60 9006 1151          RAU    9006
503 1151   34 9004 1705          FDV    9004
504 1705   21 9008 1314          STU    9008
505 1314   60 9008 1323          RAU    9008
506 1323   35 0008 1391          SLT    0008
507 1391   30 0008 1759          SRT    0008
508 1759   80 8003 1568          RAA    8003
509 1568   60 9008 1427          RAU    9008
510 1427   30 0006 1441          SRT    0006
511 1441   60 8003 1099          RAU    8003
512 1099   35 0006 1363          SLT    0006
513 1363   10 8005 1369          AUP    8005
514 1369   21 9008 1478          STU    9008
515 1478   33 9007 1809          FSB    9007
516 1809   44 1413 1364          NZU             OUTTT
517 1413   69 9008 1122          LDD    9008
518 1122   24 9007 1529          STD    9007
519 1529   60 9000 1537          RAU    9000
520 1537   88 8003 1246          RAC    8003
521 1246   69 9004 1503          LDD    9004
522 1503   24 9005 0910          STD    9005
523 0910   69 0968 1172          LDD   ZEROA
524 1172   24 9004 1518          STD    9004     MLOOP
525 1364   60 9000 1373   OUTTT  RAU    9000
526 1373   88 8003 1632          RAC    8003
527 1632   69 0968 1222          LDD   ZEROA
528 1222   24 9004 1579          STD    9004     INSPE
529 1579   60 6060 1715   INSPE  RAU    0060 C
530 1715   30 0009 1935          SRT    0009
531 1935   44 1789 1290          NZU   LOOKA
532 1290   48 1343 1144          NZC             SETLE
533 1343   59 0030 1579          SXC    0030     INSPE
534 1789   60 6077 1481   LOOKA  RAU    0077 C
535 1481   33 6082 1859          FSB    0082 C
536 1859   46 1612 1463          BMI   FREZA     POWRR
537 1612   69 6082 1386   FREZA  LDD    0082 C
538 1386   24 6077 1180          STD    0077 C
539 1180   69 1079 1682          LDD   FLONE
540 1682   24 6073 1426          STD    0073 C
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1426   60 9000 1436                RAU   9000
1436   88 8003 1518                RAC   8003     MLOOP
1463   60 6079 1383    POWRR       RAU   0079 C
1383   33 6077 1553                FSB   0077 C
1553   46 1156 1307                BMI   FREZB    CLEAR
1156   69 6079 1732    FREZB       LDD   0079 C
1732   24 6077 1230                STD   0077 C
1230   69 1079 1782                LDD   FLONE
1782   24 6073 1476                STD   0073 C
1476   60 9000 1486                RAU   9000
1486   88 8003 1518                RAC   8003     MLOOP
1307   48 0960 1144    CLEAR       NZC            SETLE
0960   59 0030 1579                SXC   0030     INSPE
1144   60 9000 1603    SETLE       RAU   9000
1603   88 8003 1662                RAC   8003     THAWW
1662   69 0968 1272    THAWW       LDD   ZEROA
1272   24 6073 1526                STD   0073 C
1526   48 1629 1280                NZC            THAWD
1629   59 0030 1662                SXC   0030     THAWW
1280   60 9000 1839    THAWD       RAU   9000
1839   88 8003 1098                RAC   8003     NUMER
1098   60 6060 1765    NUMER       RAU   0060 C
1765   30 0009 1536                SRT   0009
1536   44 1889 1340                NZU   VIEWA
1340   48 1393 1194                NZC            RIGHT
1393   59 0030 1098                SXC   0030     NUMER
1889   60 6068 1423    VIEWA       RAU   0068 C
1423   39 6064 1414                FMP   0064 C
1414   39 6077 1477                FMP   0077 C
1477   34 1162 1712                FDV   THSFI
1712   21 6081 1234                STU   0081 C
1234   60 6080 1586                RAU   0080 C
1586   33 9053 1617                FSB   9053
1617   44 1322 1372                NZU            WILDO
1322   60 6080 1636                RAU   0080 C
1636   39 9056 1390                FMP   9056
1390   33 6081 1357                FSB   0081 C
1357   46 1010 1372                BMI   ADDDD    WILDO
1010   60 6080 1686    ADDDD       RAU   0080 C
1686   32 1079 1755                FAD   FLONE
1755   21 6080 1433                STU   0080 C
1433   60 9000 1491                RAU   9000
1491   88 8003 1518                RAC   8003     MLOOP
1372   48 1675 1194    WILDO       NZC            RIGHT
1675   59 0030 1098                SXC   0030     NUMER
1194   60 9050 1653    RIGHT       RAU   9050
1653   44 1407 1208                NZU            ENUFF
1407   60 9051 1667                RAU   9051
1667   44 1208 1422                NZU   ENUFF
1422   60 9053 1531                RAU   9053
1531   33 1079 1805                FSB   FLONE
1805   44 1909 1208                NZU   CHNGB    ENUFF
1909   80 0000 1815    CHNGB       RAA   0000
1815   60 9000 1473                RAU   9000
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1473   88 8003 1832           RAC   8003      SIFTT
1832   60 6060 1865   SIFTT   RAU   0060 C
1865   30 0009 1736           SRT   0009
1736   44 1939 1440           NZU   UPDAT
1440   48 1443 1244           NZC             DIFFR
1443   59 0030 1832           SXC   0030      SIFTT
1939   60 6072 1527   UPDAT   RAU   0072 C
1527   33 6080 1457           FSB   0080 C
1457   46 1060 1461           BMI   ADDDA
1461   48 1464 1244           NZC             DIFFR
1464   59 0030 1832           SXC   0030      SIFTT
1060   50 0001 1266   ADDDA   AXA   0001
1266   60 6080 1786           RAU   0080 C
1786   21 6072 1725           STU   0072 C
1725   48 1528 1244           NZC             DIFFR
1528   59 0030 1832           SXC   0030      SIFTT
1244   40 0967 1208   DIFFR   NZA   TYPEB     ENUFF
1208   60 9000 1717   ENUFF   RAU   9000
1717   88 8003 1576           RAC   8003      APPLY
1576   60 6060 1915   APPLY   RAU   0060 C
1915   30 0009 1836           SRT   0009
1836   44 1490 1540           NZU   NEEED
1540   48 1493 1294           NZC             GOTIT
1493   59 0030 1576           SXC   0030      APPLY
1490   60 6066 1472   NEEED   RAU   0066 C
1472   44 1775 1626           NZU   BAADD     GOOOD
1775   60 6066 1522   BAADD   RAU   0066 C
1522   33 6083 1110           FSB   0083 C
1110   46 1513 1514           BMI   WORSE
1514   60 0968 1626           RAU   ZEROA     GOOOD
1626   21 6085 1088   GOOOD   STU   0085 C
1088   21 6086 1590           STU   0086 C
1590   21 6087 1640           STU   0087 C
1640   48 1543 1294           NZC             GOTIT
1543   59 0030 1576           SXC   0030      APPLY
1513   60 9058 1572   WORSE   RAU   9058
1572   44 1825 1676           NZU   WILLA     SAME
1825   60 6084 1690   WILLA   RAU   0084 C
1690   33 6066 1593           FSB   0066 C
1593   46 1296 1676           BMI   WONTT     SAME
1676   60 6066 1622   SAME    RAU   0066 C
1622   21 6085 1138           STU   0085 C
1138   39 6080 1330           FMP   0080 C
1330   21 6086 1740           STU   0086 C
1740   60 6066 1672           RAU   0066 C
1672   39 9053 1726           FMP   9053
1726   21 6087 1790           STU   0087 C
1790   48 1643 1294           NZC             GOTIT
1643   59 0030 1576           SXC   0030      APPLY
1296   60 9053 1855   WONTT   RAU   9053
1855   33 6080 1507           FSB   0080 C
1507   44 1511 1762           NZU   LESSS     USALL
1511   60 6066 1722   LESSS   RAU   0066 C
1722   21 6085 1188           STU   0085 C
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1188   39 6080 1380           FMP   0080  C
1380   21 6086 1840           STU   0086  C
1840   60 9053 1149           RAU   9053
1149   33 1079 1905           FSB   FLONE
1905   39 6066 1316           FMP   0066  C
1316   32 6084 1561           FAD   0084  C
1561   21 6087 1890           STU   0087  C
1890   48 1693 1294           NZC               GOTIT
1693   59 0030 1576           SXC   0030        APPLY
1762   60 6066 1772   USALL   RAU   0066  C
1772   21 6085 1238           STU   0085  C
1238   60 9053 1447           RAU   9053
1447   33 1079 1206           FSB   FLONE
1206   39 6066 1366           FMP   0066  C
1366   32 6084 1611           FAD   0084  C
1611   21 6086 1940           STU   0086  C
1940   21 6087 1541           STU   0087  C
1541   48 1344 1294           NZC               GOTIT
1344   59 0030 1576           SXC   0030        APPLY
1294   60 9045 1703   GOTIT   RAU   9045
1703   10 1753 1557           AUP   CONTR
1557   21 9052 1416           STU   9052
1416   71 9052 1767           WR1   9052
1767   60 9000 1875           RAU   9000
1875   88 8003 1056           RAC   8003        RANGE
1056   80 0000 1812   RANGE   RAA   0000
1812   60 6069 1523           RAU   0069  C
1523   44 1577 1578           NZU               NORGE
1577   34 6062 1862           FDV   0062  C
1862   21 9001 1370           STU   9001
1370   34 0962 1912           FDV   TWOAA
1912   21 9002 1420           STU   9002
1420   34 0962 1563           FDV   TWOAA
1563   32 6077 1803           FAD   0077  C
1803   39 9001 1607           FMP   9001
1607   21 9001 1466           STU   9001
1466   34 0962 1613           FDV   TWOAA
1613   21 9003 1822           STU   9003
1822   33 1079 1256           FSB   FLONE
1256   46 1160 1210           BMI               ROOTC
1160   69 1079 1882           LDD   FLONE
1882   24 9003 1210           STD   9003        ROOTC
1210   60 9001 1419   ROOTC   RAU   9001
1419   34 9003 1573           FDV   9003
1573   32 9003 1853           FAD   9003
1853   34 0962 1663           FDV   TWOAA
1663   21 9003 1872           STU   9003
1872   51 0012 1628           SXA   0012
1628   40 1581 1932           NZA               SUGRT
1581   50 0013 1210           AXA   0013        ROOTC
1932   60 9002 1591   SUGRT   RAU   9002
1591   32 6077 1903           FAD   0077  C
1903   21 9002 1713           STU   9002
1713   32 9003 1743           FAD   9003
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703 1743   21 6078 1631          STU   0078 C
704 1631   60 9002 1641          RAU   9002
705 1641   33 9003 1922          FSB   9003
706 1922   21 6076 1679          STU   0076 C  PUNCH
707 1578   69 0968 1623   NORGE  LDD   ZEROA
708 1623   24 6078 1681          STD   0078 C
709 1681   24 6076 1679          STD   0076 C  PUNCH
710 1679   27 9013 1284   PUNCH  SET   9013
711 1284   08 6076 1288          LIB   0076 C
712 1288   27 9017 1793          SET   9017
713 1793   08 6080 1292          LIB   0080 C
714 1292   60 6060 1516          RAU   0060 C
715 1516   10 1753 1657          AUP   CONTR
716 1657   21 9012 1566          STU   9012
717 1566   71 9012 1817          WR1   9012
718 1817   60 6060 1616          RAU   0060 C
719 1616   30 0009 1587          SRT   0009
720 1587   44 1691 1342          NZU   COUPL
721 1342   48 1445 1346          NZC           SETUP
722 1445   59 0030 1056          SXC   0030    RANGE
723 1691   27 9025 1396   COUPL  SET   9025
724 1396   08 6083 1495          LIB   0083 C
725 1495   60 9012 1004          RAU   9012
726 1004   10 0853 1707          AUP   DIGIT
727 1707   21 9024 1666          STU   9024
728 1666   71 9024 1867          WR1   9024
729 1867   48 1470 1346          NZC           SETUP
730 1470   59 0030 1056          SXC   0030    RANGE
731 0990   69 0968 1673   SELFP  LDD   ZEROA
732 1673   24 6075 1678          STD   0075 C
733 1678   60 6065 1469          RAU   0065 C
734 1469   44 1723 1424          NZU   THERE   EMPTY
735 1424   21 6082 1886   EMPTY  STU   0082 C  LOOPE
736 1723   60 1276 1731   THERE  RAU   CONST
737 1731   39 6063 1763          FMP   0063 C
738 1763   34 6065 1716          FDV   0065 C
739 1716   34 6064 1564          FDV   0064 C
740 1564   34 6061 1661          FDV   0061 C
741 1661   21 6082 1886          STU   0082 C  LOOPE
742 1886   80 0000 1392   LOOPE  RAA   0000
743 1392   60 1276 1781          RAU   CONST
744 1781   34 6062 1813          FDV   0062 C
745 1813   34 6064 1614          FDV   0064 C
746 1614   34 6061 1711          FDV   0061 C
747 1711   21 9001 1520          STU   9001
748 1520   39 6070 1570          FMP   0070 C
749 1570   21 9002 1728          STU   9002
750 1728   60 6067 1773          RAU   0067 C
751 1773   39 6080 1430          FMP   0080 C
752 1430   39 6063 1863          FMP   0063 C
753 1863   39 9001 1917          FMP   9001
754 1917   32 9002 1497          FAD   9002
755 1497   21 9001 1306          STU   9001
756 1306   34 0962 1913          FDV   TWOAA
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1913   21 9002 1823          STU   9002
1823   33 1079 1356          FSB   FLONE
1356   46 1260 1310          BMI               ROOTD
1260   69 1079 1483          LDD   FLONE
1483   24 9002 1310          STD   9002        ROOTD
1310   60 9001 1519   ROOTD  RAU   9001
1519   34 9002 1873          FDV   9002
1873   32 9002 1054          FAD   9002
1054   34 0962 1664          FDV   TWOAA
1664   21 9002 1923          STU   9002
1923   51 0012 1729          SXA   0012
1729   40 1533 1583          NZA               ANSWR
1533   50 0013 1310          AXA   0013        ROOTD
1583   60 9002 1741   ANSWR  RAU   9002
1741   21 6077 1480          STU   0077 C
1480   60 6066 1474          RAU   0066 C
1474   44 1627 1778          NZU   WHOLE       TIMLY
1627   60 6077 1831   WHOLE  RAU   0077 C
1831   34 6066 1766          FDV   0066 C
1766   21 9001 1524          STU   9001
1524   35 0008 1843          SLT   0008
1843   30 0008 1761          SRT   0008
1761   80 8003 1620          RAA   8003
1620   51 0050 1776          SXA   0050
1776   82 0010 1633          RAB   0010
1633   53 2000 1791          SXB   2000
1791   50 0050 1547          AXA   0050
1547   60 9001 1406          RAU   9001
1406   30 4000 1779          SRT   0000 B
1779   60 8003 1637          RAU   8003
1637   35 4000 1360          SLT   0000 B
1360   10 8005 1816          AUP   8005
1816   21 9002 1574          STU   9002
1574   33 9001 1456          FSB   9001
1456   44 1410 1460          NZU               EXACT
1410   60 9002 1569          RAU   9002
1569   32 1079 1506          FAD   FLONE
1506   21 9002 1460          STU   9002        EXACT
1460   60 9002 1619   EXACT  RAU   9002
1619   21 6080 1683          STU   0080 C
1683   60 6075 1829          RAU   0075 C
1829   44 1733 1334          NZU   FILUP
1334   60 6080 1936          RAU   0080 C
1936   33 6072 1199          FSB   0072 C
1199   44 1104 1778          NZU               TIMLY
1104   69 6080 1783          LDD   0080 C
1783   24 6072 1886          STD   0072 C      LOOPE
1778   60 6077 1881   TIMLY  RAU   0077 C
1881   33 6082 1510          FSB   0082 C
1510   46 1714 1733          BMI   MOVUP       FILUP
1714   69 6082 1687   MOVUP  LDD   0082 C
1687   24 6077 1530          STD   0077 C
1530   69 1079 1833          LDD   FLONE
1833   24 6075 1828          STD   0075 C
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1828   60 6066 1624          RAU   0066 C
1624   44 1627 1733          NZU   WHOLE      FILUP
1733   69 0968 1674   FILUP  LDD   ZEROA
1674   24 6079 1883          STD   0079 C
1883   24 6081 1050          STD   0081 C     ELIMN
0930   60 6060 1866   ERROR  RAU   0060 C
1866   10 1753 1757          AUP   CONTR
1757   21 9008 1916          STU   9008
1916   69 1669 1724          LDD   FIVEA
1724   24 9009 1931          STD   9009
1931   71 9008 0898          WR1   9008       HALTA
1124   60 6060 1618   WRONG  RAU   0060 C
1618   10 1753 1807          AUP   CONTR
1807   21 9008 1668          STU   9008
1668   69 1774 1677          LDD   SIXAA
1677   24 9009 1384          STD   9009
1384   71 9008 0898          WR1   9008       HALTA
1346   82 0800 1002   SETUP  RAB   0800
1002   80 0059 1258          RAA   0059       ZCORE
1258   69 0968 1824   ZCORE  LDD   ZEROA
1824   24 9200 1933          STD   9000 A
1933   40 1737 1787          NZA              ZDRUM
1737   51 0001 1258          SXA   0001       ZCORE
1787   27 9000 1442   ZDRUM  SET   9000
1442   29 4000 1052          STI   0000 B
1052   42 1556 0850          NZB              BEGIN
1556   53 0050 1787          SXB   0050       ZDRUM
0853   00 0100 0000   DIGIT  00    0100        0000
0887   44 4444 4444   FOURA  44    4444        4444
0911   00 0000 0055   FIFIV  00    0000        0055
0968   00 0000 0000   ZEROA  00    0000        0000
0966   10 0000 0053   ONEHD  10    0000        0053
0983   22 0000 0049   TOTWO  22    0000        0049
1079   10 0000 0051   FLONE  10    0000        0051
0962   20 0000 0051   TWOAA  20    0000        0051
1117   75 0000 0050   SERFI  75    0000        0050
1162   37 5000 0053   THSFI  37    5000        0053
1328   50 0000 0053   FIVHD  50    0000        0053
1276   82 5000 0053   CONST  82    5000        0053
1753   00 0400 0000   CONTR  00    0400        0000
1669   55 5555 5555   FIVEA  55    5555        5555
1774   66 6666 6666   SIXAA  66    6666        6666
1400   00 0000 0058   FIVET  00    0000        0058
1450   10 0000 0052   TENNN  10    0000        0052
0882   60 0013 1718   FXCST  RAU   0013
1718   34 1450 1500          FDV   TENNN
1500   21 0000 1154          STU   0000
1154   60 0011 1768          RAU   0011
1768   21 0002 1606          STU   0002
1606   35 0008 1925          SLT   0008
1925   30 0008 1893          SRT   0008
1893   80 8003 1102          RAA   8003
1102   51 0050 1308          SXA   0050
1308   82 0010 1764          RAB   0010
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865 1764   53 2000 1874          SXB   0000 A
866 1874   60 0002 1857          RAU   0002
867 1857   30 4000 1879          SRT   0000 B
868 1879   21 0007 1560          STU   0007
869 1560   60 0012 1818          RAU   0012
870 1818   44 1924 1826          NZU              DEPRC
871 1924   33 0002 1929          FSB   0002
872 1929   46 1434 1826          BMI   TRDIN      DEPRC
873 1434   60 1079 1484   TRDIN  RAU   FLONE
874 1484   34 0013 1814          FDV   0013
875 1814   21 0003 1656          STU   0003
876 1656   60 0007 1811          RAU   0007
877 1811   80 8003 1670          RAA   8003
878 1670   51 0001 1876          SXA   0001
879 1876   65 8005 1837          RAL   8005
880 1837   20 0006 1610          STL   0006
881 1610   60 1079 1534          RAU   FLONE
882 1534   21 0004 1907          STU   0004
883 1907   82 0015 1864          RAB   0015       ROOTE
884 1864   60 0002 1358   ROOTE  RAU   0002
885 1358   33 1079 1706          FSB   FLONE
886 1706   39 0004 1204          FMP   0004
887 1204   21 0005 1408          STU   0005
888 1408   60 0003 1458          RAU   0003       DIVID
889 1458   34 0004 1254   DIVID  FDV   0004
890 1254   51 0001 1660          SXA   0001
891 1660   40 1458 1914          NZA   DIVID      ONNNN
892 1914   32 0005 1584   ONNNN  FAD   0005
893 1584   34 0002 1152          FDV   0002
894 1152   21 0004 1508          STU   0004
895 1508   53 0001 1868          SXB   0001
896 1868   42 1926 1727          NZB              FINSH
897 1926   65 0006 1861          RAL   0006
898 1861   80 8002 1864          RAA   8002       ROOTE
899 1727   60 0012 1918   FINSH  RAU   0012
900 1918   35 0008 1887          SLT   0008
901 1887   30 0008 1756          SRT   0008
902 1756   80 8003 1719          RAA   8003
903 1719   51 0050 1777          SXA   0050
904 1777   82 0010 1634          RAB   0010
905 1634   53 2000 1841          SXB   0000 A
906 1841   60 0012 1769          RAU   0012
907 1769   30 4000 1891          SRT   0000 B
908 1891   21 0007 1710          STU   0007
909 1710   80 8003 1819          RAA   8003
910 1819   60 0004 1760          RAU   0004
911 1760   51 0001 1869          SXA   0001
912 1869   40 1827 1877          NZA   MULTP      VALUE
913 1827   39 0004 1304   MULTP  FMP   0004
914 1304   51 0001 1810          SXA   0001
915 1810   40 1827 1877          NZA   MULTP      VALUE
916 1877   39 0013 1919   VALUE  FMP   0013
917 1919   21 0000 1826          STU   0000       DEPRC
918 1826   60 0016 1927   DEPRC  RAU   0016
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919	1927	44	1684	1734		NZU	SINKF	STLIN
920	1684	60	0013	1720	SINKF	RAU	0013	
921	1720	33	0000	1878		FSB	0000	
922	1878	21	0002	1806		STU	0002	
923	1806	60	0007	1911		RAU	0007	
924	1911	80	8003	1770		RAA	8003	
925	1770	51	0001	1928		SXA	0001	
926	1928	60	0016	1580		RAU	0016	
927	1580	34	0966	1820		FDV	ONEHD	
928	1820	32	1079	1856		FAD	FLONE	
929	1856	21	0004	1558		STU	0004	INCRE
930	1558	39	0004	1354	INCRE	FMP	0004	
931	1354	51	0001	1860		SXA	0001	
932	1860	40	1558	1870		NZA	INCRE	
933	1870	21	0001	1404		STU	0001	
934	1404	33	1079	1906		FSB	FLONE	
935	1906	21	0003	1608		STU	0003	
936	1608	60	0016	1630		RAU	0016	
937	1630	34	0966	1920		FDV	ONEHD	
938	1920	34	0003	1454		FDV	0003	
939	1454	39	0002	1202		FMP	0002	
940	1202	21	9001	1910		STU	9001	
941	1910	65	8007	1680		RAL	8007	
942	1680	20	0008	1730		STL	0008	
943	1730	60	0015	1780		RAU	0015	
944	1780	35	0008	1249		SLT	0008	
945	1249	30	0008	1830		SRT	0008	
946	1830	11	0911	1880		SUP	FIFIV	
947	1880	44	1784	1834		NZU	SIMPL	COMPO
948	1784	82	0000	1941	SIMPL	RAB	0000	FIGUR
949	1834	60	0015	1930	COMPO	RAU	0015	
950	1930	35	0001	1937		SLT	0001	
951	1937	30	0001	1943		SRT	0001	
952	1943	32	0968	1545		FAD	ZEROA	
953	1545	21	0015	1884		STU	0015	
954	1884	82	0001	1941		RAB	0001	FIGUR
955	1941	69	0013	1934	FIGUR	LDD	0013	
956	1934	24	0005	1658		STD	0005	
957	1658	60	0007	1338		RAU	0007	
958	1338	80	8003	1446		RAA	8003	
959	1446	88	0001	1252		RAC	0001	
960	1252	60	0002	1708		RAU	0002	
961	1708	34	0003	1504		FDV	0003	
962	1504	21	0002	1758		STU	0002	
963	1758	60	0001	1808		RAU	0001	
964	1808	33	0004	1388		FSB	0004	
965	1388	39	0002	1302		FMP	0002	
966	1302	32	0000	1438		FAD	0000	
967	1438	21	0003	1858		STU	0003	
968	1858	32	0005	1488		FAD	0005	
969	1488	34	0962	1538		FDV	TWOAA	
970	1538	39	0015	1588		FMP	0015	
971	1588	34	0966	1638		FDV	ONEHD	
972	1638	21	0009	1688		STU	0009	

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1688  59 2000 1595          SXC   2000
1595  48 1148 1299          NZC          STOWN
1148  88 0001 1908          RAC   0001   INTER
1908  60 0003 1738   INTER  RAU   0003
1738  21 0005 1788          STU   0005
1788  65 8007 1597          RAL   8007
1597  20 0006 1838          STL   0006
1838  60 0004 1888          RAU   0004   BACKK
1888  39 0004 1554   BACKK  FMP   0004
1554  59 0001 1938          SXC   0001
1938  48 1888 1492          NZC   BACKK
1492  21 0003 1542          STU   0003
1542  60 0001 1592          RAU   0001
1592  33 0003 1642          FSB   0003
1642  39 0002 1352          FMP   0002
1352  32 0000 1692          FAD   0000
1692  21 0003 1742          STU   0003
1742  32 0005 1792          FAD   0005
1792  34 0962 5963          FDV   TWOAA   1963 B
1964  32 0009 1963    1964  FAD   0009    1963
1963  39 0015 1842    1963  FMP   0015
1842  34 0966 1892          FDV   ONEHD
1892  32 0009 1942          FAD   0009
1942  21 0009 1394          STU   0009
1394  65 0006 1444          RAL   0006
1444  88 8002 1604          RAC   8002
1604  58 0002 1494          AXC   0002
1494  51 6000 1201          SXA   6000
1201  40 1654 1544          NZA          LASTT
1654  59 0001 1550          SXC   0001
1550  60 0007 1594          RAU   0007
1594  80 8003 1908          RAA   8003   INTER
1544  60 0003 1644   LASTT  RAU   0003
1644  32 0000 1694          FAD   0000
1694  34 0962 1744          FDV   TWOAA
1744  42 1647 1198          NZB   ADDII  DONTA
1647  32 0009 1198   ADDII  FAD   0009   DONTA
1198  39 0015 1794   DONTA  FMP   0015
1794  34 0966 1844          FDV   ONEHD
1844  32 0009 1894          FAD   0009
1894  21 0009 1944          STU   0009
1944  60 0007 1645          RAU   0007
1645  35 0002 1251          SLT   0002
1251  10 1400 1695          AUP   FIVET
1695  32 0968 1745          FAD   ZEROA
1745  21 0007 1795          STU   0007
1795  60 0009 1845          RAU   0009
1845  34 0007 1895          FDV   0007
1895  21 0009 1299          STU   0009   STOWN
1299  65 0008 1945   STOWN  RAL   0008
1945  88 8002 1704          RAC   8002
1704  60 0009 1496          RAU   0009
1496  32 9001 1546          FAD   9001
1546  21 9001 1754          STU   9001   TAXES
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1027	1734	60	0007	1596	STLIN	RAU	0007	
1028	1596	35	0002	1804		SLT	0002	
1029	1804	10	1400	1646		AUP	FIVET	
1030	1646	32	0968	1696		FAD	ZEROA	
1031	1696	21	0001	1854		STU	0001	
1032	1854	60	0013	1746		RAU	0013	
1033	1746	33	0000	1796		FSB	0000	
1034	1796	34	0001	1301		FDV	0001	
1035	1301	21	0002	1846		STU	0002	
1036	1846	21	9001	1904		STU	9001	
1037	1904	60	0015	1896		RAU	0015	
1038	1896	35	0008	1946		SLT	0008	
1039	1946	30	0008	1697		SRT	0008	
1040	1697	11	0911	1747		SUP	FIFIV	
1041	1747	44	1351	1402		NZU	ZIMPL	POUND
1042	1351	60	0013	1797	ZIMPL	RAU	0013	
1043	1797	32	0000	1847		FAD	0000	
1044	1847	34	0962	1897		FDV	TWOAA	
1045	1897	39	0015	1947		FMP	0015	
1046	1947	34	0966	1248		FDV	ONEHD	
1047	1248	32	9001	1298		FAD	9001	
1048	1298	21	9001	1754		STU	9001	TAXES
1049	1402	60	0015	1348	POUND	RAU	0015	
1050	1348	35	0001	1398		SLT	0001	
1051	1398	30	0001	1448		SRT	0001	
1052	1448	32	0968	1498		FAD	ZEROA	
1053	1498	21	0015	1548		STU	0015	
1054	1548	60	0013	1598		RAU	0013	
1055	1598	33	0002	1648		FSB	0002	
1056	1648	32	0013	1698		FAD	0013	
1057	1698	34	0962	1748		FDV	TWOAA	
1058	1748	21	0003	1798		STU	0003	
1059	1798	39	0015	1848		FMP	0015	
1060	1848	34	0966	1898		FDV	ONEHD	
1061	1898	21	0009	1948		STU	0009	
1062	1948	60	0007	1349		RAU	0007	
1063	1349	80	8003	1399		RAA	8003	
1064	1399	51	0001	1449		SXA	0001	
1065	1449	40	1452	1499		NZA	CYCLE	STASH
1066	1452	60	0003	1549	CYCLE	RAU	0003	
1067	1549	33	0002	1599		FSB	0002	
1068	1599	21	0003	1649		STU	0003	
1069	1649	32	0009	1699		FAD	0009	
1070	1699	39	0015	1749		FMP	0015	
1071	1749	34	0966	1799		FDV	ONEHD	
1072	1799	32	0009	1849		FAD	0009	
1073	1849	21	0009	1899		STU	0009	
1074	1899	51	0001	1949		SXA	0001	
1075	1949	40	1452	1600		NZA	CYCLE	
1076	1600	34	0001	1499		FDV	0001	STASH
1077	1499	32	9001	1650	STASH	FAD	9001	
1078	1650	21	9001	1754		STU	9001	TAXES
1079	1754	60	0014	1700	TAXES	RAU	0014	
1080	1700	39	0013	1750		FMP	0013	

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1081 1750   34 0966 1800          FDV  ONEHD
1082 1800   32 9001 1850          FAD   9001
1083 1850   21 9001 1900          STU   9001
1084 1900   34 0013 1401          FDV   0013
1085 1401   39 0966 1451          FMP  ONEHD
1086 1451   21 0022 0981          STU   0022      GIVEN
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VITA

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