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USING THE TI-59 PROGRAMMABLE CALCULATOR TO ESTIMATE OPERATING COSTS AND HAULING RATES FOR BULK MILK ASSEMBLY

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PREFACE

This bulletin is an update of A.E. Research 79-18 published in September 1979. At that time the concept of using a programmable calculator to estimate bulk milk assembly costs was a new one which was unfamiliar conceptually and operationally to both handlers and haulers. In addition the availability and relative ease of access to different units (e.g., annual vs. average daily miles) of information was not known. The need for better information on hauling was nevertheless evident and a decision was made to prepare a simplified program with the expectation that with practice and experience a more suitable and easier to operate program could be developed in the future. The revised program is now available and is included in this bulletin. There are two major changes from the earlier program. First, the data entries have been put in forms which are more readily available for handlers and haulers. For example, route miles are now listed as daily rather than annual averages, the relief driver wage is incorporated in the average driver wage and is removed as a separate entry, and maintenance costs are entered as averages per mile rather than as a gradient. Because of these changes it has been necessary to change the data entry register numbers from those used in the previous program; care should be taken that the figures are placed in the appropriate registers. Second, tax savings to haulers from depreciation allowances and the investment tax credit are now incorporated in the program resulting in estimates of fixed and total costs which will be lower than if the same cost figures were run on the previous program.

A further addition has been made which consists of programming the calculations for determining a stop charge and hundredweight payments to haulers for costs incurred in pumping and transporting milk. The manual calculations for making these cost allocations were described in the original bulletin. This bulletin contains a description of using the program to make these calculations rapidly and without error.

INTRODUCTION AND PURPOSE

The New York State dairy industry is vitally dependent on an efficient and competitive transportation system for assembling and transporting milk from farms to processing plants. Much of the state's milk assembly operation is carried out by independent contract haulers who operate their own truck(s). The independent owner-operator has often proved the best as well as the lowest-cost option for accomplishing the hauling function. The use of a relatively large number of independent haulers over a wide range of route conditions does, however, create significant coordination needs for the participants. This publication is directed to assisting with one aspect of the coordination requirements; the determination of equitable hauling rates.

The rate paid to haulers for bulk milk assembly is, ideally, negotiated on a route-by-route basis. Typically in practice the request for a rate change is initiated by a hauler and justified on the basis of an increase in labor, fuel or other costs. But since many cost increases affect all haulers, what began as a request for a rate change by an individual hauler often becomes a concurrent request by all haulers. If the handler agrees to a rate increase while lacking specific information about the effect of the cost increase on individual routes, the increase is often applied as a flat, across-the-board adjustment. Such uniform rate changes in assembly systems with highly divergent route conditions tend to favor some haulers over others. As a result some assembly routes can be substantially more profitable than others, while the system as a whole is neither efficient nor equitable for either the dairymen or the haulers. A detailed knowledge of assembly costs is essential for operating an efficient system.

At the same time, rapidly rising transportation costs have placed the small contract hauler at a competitive disadvantage to larger operators as the management function becomes more critical. The small operator, who drives and maintains the truck, has less time available for analyzing the business. A quick means of

estimating changing route costs should prove an essential management tool during these inflationary times.

The purpose of this publication is to present a ready means of estimating the effect of a change in the cost of the one factor, like fuel, on overall operating costs. The resultant estimates are useful to both handlers and haulers. Handlers may use the estimates in planning for anticipated future cost changes. Haulers must keep track of costs to be sure that rates are sufficient to accumulate capital for timely replacement of the tank truck fleet. Together the estimates provide a common basis from which rate negotiations can be started.

The estimates are developed using economic engineering techniques by combining individual item costs, from fuel and tires to purchase price and maintenance, into uniform operating costs per unit of product, time and distance. These estimates may be broken out into fixed and variable cost components. To make the calculations speedy and accurate a TI-59 programmable calculator is used*(1). With its assistance the effect of a fuel price increase on total per mile costs, to mention one example, can be determined within seconds.

The program is kept relatively short by omitting much of the detail and special considerations which are a part of day-to-day operations. Thus the results should be viewed as approximations only. The estimates include operating costs only; other factors such as returns to management and risk are not included. The appropriate payments for management and risk vary widely from firm to firm so that no rule-of-thumb figure can be established. Allowances for these factors and other items specific to particular routes must be established during negotiations.

In past years it was common for rates to reflect the haulers out-of-pocket costs plus a premium for management and risk. This meant among other things that

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*The bracketed numbers refer to additional information on this point included with the footnotes on page 17 following the text.

haulers were compensated based on what they actually paid for their turck. During periods of relatively stable prices this approach proved adequate but problems began to appear when replacement truck prices started moving up sharply. The hauler who had to replace his truck with a much more expensive new one found that he had no accumulated reserves to use to allow purchase at the higher price and had to drop out of the industry. One solution to this situation would be to raise the rate whenever a new truck is purchased. This would, however, not be equitable and would provide a strong incentive for all haulers to buy new equipment! A second and preferable procedure is to provide on going payments with which the hauler may build some equity for the time when a replacement must be purchased. A reasonable improvement in equity should be assured if the rates are periodically adjusted to reflect the "current replacement" of a similar vechicle. This "replacement cost" approach is used in this bulletin. It will generally give a good approximation to the long term costs faced by a hauler but may not be appropriate in some cases, such as a route which would not be economical once the present truck wears out (2).

Data requirements for the program are substantial. In some cases a considerable initial effort will be required to establish a system for collecting and updating the necessary information. If it is done properly this data collection procedure should lead to better record keeping and an improved understanding of the hauling system and the major factors influencing costs. If not, the estimates provided by the program will be inaccurate and misleading.

This report is organized as follows. The first section involves the estimation of hauling costs and includes a description of the basic program, an example application, suggested procedures for collecting data, and an overview of ways of adapting the model for a range of different conditions. The second section describes the use of the program to calculate stop charges and allocation of costs based on time, distance and volume. The program itself is included in the Appendix.

SECTION I

Estimating Hauling Costs

Steps for operating the TI-59 program are detailed in Figure 1. This figure also includes an example which may be run to check to see that the program has been typed in correctly. The data for the example have been developed from information supplied by a group of handlers and haulers in upstate New York and reasonably accurately represents aggregate cost conditions for that area for early 1980. These data do not, however, necessarily represent actual costs for any one specific route and are not indended to be used in any application of the program to an actual situation.

Definitions and Guidelines for Data Collection

The results of the program are, of course, only as good as the data which are entered by the user. A strict adherence to the definitions and collection guidelines listed below will help to assure that the program results are valid and compatible for cross-firm comparisons.

01. Average Daily Route Miles - Use the total average daily miles traveled from garage to garage. In the case where more miles are traveled one day than another, total the two days and divide by two.

    Ex. Day 1 - 75 miles
    Day 2 - 105 miles
    Total 180/2 = 90 Avg. miles per day

02. Average CWT Delivered Per Day - Use average daily deliveries over the entire year taking into consideration all routes and the flush period, if any.

03. Truck Costs - Truck are available with an extremely large selection of optional equipment from engines, axles and transmissions, down to radios, air conditioners and seats. To standardize cost estimates the specifications of a serviceable truck must be agreed upon by haulers and handlers. Examples of such specifications are listed in Figure 2. With these specifications, prices can be collected from cooperating new truck dealers. In most cases fleet prices will be assumed to apply.

    Truck investment costs are frequently lumpy with a large initial investment (down payment), a stream of interest and repayment costs and finally a return in the form of the salvage value (trade-in or scrap value). In order to make a nonuniform series of costs and returns comparable they are converted to an equivalent uniform annual series of payments (3).

Figure 1: Operating Instructions for Part I of the TI-59 Program

Entering the Program from Magnetic Cards:

Turn Claculator off. Turn calculator on.
Press Key 1. insert side 1
Press Key 2. insert side 2

DATA INPUT

Item*	Example Value	Press Key	Example Display	Your Value	Press Key	Your Display
Fixed Costs						
Average Daily Route Miles	110	STO 01	110		STO 01	
Average CWT Delivered Per Day	299	STO 02	299		STO 02	
Truck Chassis Cost ($)	46000	STO 03	46000		STO 03	
Chassis Expected Life (years)	7	STO 04	7		STO 04	
Chassis Salvage Value ($)	9200	STO 05	9200		STO 05	
Tank Cost ($)	18000	STO 06	18000		STO 06	
Tank Expected Life (years)	10	STO 07	10		STO 07	
Tank Salvage Value ($)	3600	STO 08	3600		STO 08	
Insurance	1400	STO 09	1400		STO 09	
Registration Fees	280	STO 10	280		STO 10	
Highway Tax	120	STO 11	120		STO 11	
Interest Rate	.12	STO 12	.12		STO 12	
Miscellaneous Costs	1000	STO 13	1000		STO 13	
Driver Hourly Wage ($/hr.)	7.50	STO 14	7.50		STO 14	
Hours/Day for Driver(s)	8	STO 15	8		STO 15	
Variable Costs						
Miles Per Gallon	5	STO 20	5		STO 20	
Fuel Cost ($/gallon)	1.10	STO 21	1.10		STO 21	
Cost New Tire	200	STO 22	200		STO 22	
Cost Recapped Tire	85	STO 23	85		STO 23	
Number of Tires	10	STO 24	10		STO 24	
Bias or Radial Ply Tires - Enter 1 if Radial, 0 if Bias	0	STO 25	0		STO 25	
Ton-Mile Tax Rate	.017	STO 26	.017		STO 26	
Annual Maintenance	600	STO 27	600		STO 27	
Average Annual Repair in $/Mile	.075	STO 28	.075		STO 28	
Miscellaneous Variable Costs	0	STO 29	0		STO 29	

OUTPUT

Press Key	Value Output	Example Display	Your Display
A	Total Annual Fixed Costs (TFC)	33885.96	
R/S	TFC/Mile	.844	
R/S	TFC/CWT	.310	
R/S	TFC/Minute	.193	
B	Total Annual Variable Costs (TVC)	15033	
R/S	Total Annual Costs (TC)**	48919.88	
R/S	TC/CWT	.448	
R/S	TC/Mile	1.22	
R/S	TVC/CWT	.138	
R/S	TVC/Mile	.374	

*Definitions of these terms and suggested sources of information are included in the following section.

**TC = TFC + TVC.

Figure 2: Truck Specificaitons: Single Chassis

Specifications for a Single Chassis Truck
Suitable for a 4,000 Gallon, Farm Pickup Truck

Cab:	151" conventional	
Wheel base:	Approx. 218"	
Engine:	Detroit diesel - 671 N	Engine heater
	Low oil pressure warning	Vertical exhaust
	Spin-on oil filter	Luberfiner - 750
	Spin-on water filter	Farr air cleaner
	Plastic fan blade	Delco Remy H.D. alternator
	Jake brake	Ammeter
Clutch:	14" double disc	
Transmission:	Fuller R.T.O. 915	
Rear Axle:	Timken 38,000# 4:44 ratio	
Suspension:	Hendrickson spring & saddle mount.	Extended leaf, 50" aluminum beam
Front Axle:	Rockwell FL 901 - 18,000 lb., Shepard power steering	
Brakes:	S-Cam. Rear - 16 1/2" x 7 8" dia.	
	Front - 16 1/2" x 5"	
	Hand valve for all wheels	
	Front wheel limiting valve	
	Alcohol kit	
Tires:	Front - General high miler - 11:00 x 20	
	Rear - General D.C.L. 10:00 x 20	
Other Options:	Double frame or frame reinforcement	
	Dual 50 gal. step tanks	
	Stemco hubs	
	Tow hooks, fron and rear	
	Bostrom Viking driver seat	
	Passenger seat	
	Air horn	
	Electric wiper motor	
	Radiator shutters	
	West Coast mirrors	

Source: Dennis R. Lifferth and Walter C. Wasserman, Milk Transportation and Processing: Analysis of Alternative Milk Marketing Systems USDA Farmer Cooperative Service, mimeograph, undated, p. 139.

04. Truck Life - The expected number of miles of service would be available from service managers. Dividing this figure by the annual route miles will give the expected life in years.

05. Truck Salvage Value - This figure will perhaps be one of the more difficult to estimate accurately. Dealers can give a good indication of what a particular five year old truck is worth today. This, however, will not necessarily indicate future salvage values since new truck prices have been rising rapidly in recent years, carrying used and junk truck prices up with them. The problem of estimating future salvage values is therefore one of projecting the rate of inflation for this equipment. Individual judgment must be used. A 20% of replacement cost rule-of-thumb is being used by some individuals in the industry.

06 & 07. Tank Cost and Tank Life - Available from the suppliers. Annual costs are calculated in the same manner as truck costs (see above).

08. Tank Salvage Value - Use current scrap metal values which have remained relatively constant over time, or if tanks are rehabilitated, use expected net value.

09. Insurance - Annual rates for liability and cargo, available from insurance agents and brokers. A standardized policy should be used. Such a policy might include $300,000 - $500,000 liability, collision for the value of the truck with $200 - $500 deductible and cargo coverage in case of upset. Some states, like New York, mandate other coverage.

10. Registration Fees - Annual fees available from the New York State Department of Motor Vehicles or comparable department in other states.

11. Highway Tax - Listed in New York State Department of Taxation and Finance Highway Tax Law Bulletin, October 1, 1974, or similar bulletins from other states, and in Federal tax codes. The tax should be calculated on an annual basis.

12. Interest Rate - The interest rate reflects the value and cost of capital tied up in the truck and tank over their service lives. For this program the yield for industrial bonds rated "A" is suggested for use (4). This rate is available in major newspapers or by telephoning local banks.

13. Miscellaneous Fixed Costs - These costs should include annual garaging, bookkeeping, heat, office, and other expenses which are necessary to operate the milk hauling business. These items are likely to differ from operator to operator so that the actual costs should be used if available. Other fixed costs which do not fit into the above categories may also be included here. A lease contract on trucks or tanks may be included here on an annual cost basis. See the following section for several examples.

14. Drivers' Wages - The average hourly wage rate including fringe benefits should be used. If a significant number of drivers are unionized the rate stipulated in the contract may be used. Wages should include the value of all fringe benefits and payroll taxes. If the drivers are not unionized or a significant number are independent owner-operators, then the prevailing local rate (including fringes) must be used. In a situation where there is

more than one driver during the day and the hourly rates are different, use a weighted average hourly rate:

Ex. Driver 1 - $ 7.40/hr. x 8 hrs. = $ 60
Driver 2 - $10.00/hr. x 7 hrs. = $ 70
$130 ÷ 15 hrs. = $8.67/hr.

Relief driver wages should be included in calculating the average rate.

15. Hours/Day for Driver - An eight-hour day may be assumed unless information from the hauler or contract specifications indicate that a different length of day should be used.

20. Fuel Consumption in MPG - Available from operators or as estimates from truck dealers.

21. Fuel Cost ($/Gallon) - Use average local pump prices.

22 & 23. Cost of New Tire and Cost of Recapped Tire - Use fleet prices collected from local dealer (5).

24. Number of Tires - Part of the specifications under (03) above.

25. Type of Tire (Bias Ply or Radial) - Indicate most common type of tire used by pressing 0 for bias ply or 1 for radials (6).

26. Ton-Mile Tax Rate - Rates are listed in the New York State Department of Taxation and Finance Truck Mileage Tax and Fuel. Use Tax bulletin, Regulations 21, April 1, 1970, or similar publicaitons for other states. If fuel is bought outside the state of operation a fuel use tax must also be paid (not included in program).

27. Annual Periodic Maintenance - This figure includes oil, chassis lubrication, filters, plugs and points (if necessary). This cost is available from local service stations and can be calculated on an annual basis according to expected mileage and service intervals recommended by the manufacturer.

28. Average Annual Repair Cost Per Mile - Repair costs are among the most difficult costs to determine. The rate would be best determined for several trucks over more than one year. Repair costs should include parts and labor on an annual basis divided by annual miles driven. If field data are not available applicable cost information may be collected from fleet service managers with similar type hauls.

29. Miscellaneous Variable Cost - To be used for items related to operating the truck but included elsewhere. Examples included mileage based rental rates for the truck or tank.

After punching in all these values you can easily check to see that the correct numbers were entered by punching in the following sequence of steps:

SBR
CLR
RST
INV
2nd LST

This will cause the calculator to print out a list of values stored in each register beginning with the first. These numbers can be checked with the values you intended to enter. In case of an error simply press the correct figure and STO --. To stop the list once it is running simply press R/S.

ADAPTING THE MODEL FOR DIFFERENT CONDITIONS

The basic program applies to the simplest possible bulk hauling situation; the hauler follows one or more route per day using self-owned equipment. This section contains explanations for adapting the basic program for different conditions such as leased rather than owned equipment. The changes include straightforward modifications in the input data and increase in complexity up to permanent changes in the program itself. The following examples indicate how several kinds of changes may be made. They should be used as guidelines for other modifications of the program to meet specific user requirements.

Changing Constants Incorporated in the Program: Tire Life

To keep the user supplied data inputs down to a reasonable number, several values are stored internally in the program as "constants." Examples are tire life and tax rates. The stored values, however, may not be appropriate for all routes and would need to be changed; routes with many hills and curves, for example, may give tire life below the assumed averages. These changes may be made by following the examples below.

Example: Tire Life

On a rough, curvey route a hauler finds that radial tires last on average only 90,000 miles rather than the 100,000 miles assumed. To make the adjustment the proper program location must first be found and the following changes made:

Press	Display	Object
GTO 243	---	Locate part of program requiring change
LRN	243 004	Put calculator in mode to make changes
23	244 00	Insert new number which reduces life by 10,000 miles. (The calculator automatically shows you the next step, not the one you have just completed. To see it push BST - you should get 243 03).
LRN		Return to operating mode

The way this change works is to reduce 40,000 to 30,000; pushing 3 replaces the 4. The 30,000 is the difference in mileage of a radial over the 80,000 miles assumed for a bias ply. The new total is thus 90,000 rather than 100,000 miles.

If this change is to be permanent it may be stored on a magnetic card by following these steps:

Press 1 2nd WRT - insert card, turn over
Press 2 2nd WRT - insert card

If the display number does not flash the program has been transferred properly.

Incorporating Different Operating Characteristics: Leased Equipment

If equipment is leased rather than owned the lease rate may be included in register 13 or 29, or if the lease includes both fixed and variable aspects both may be used. (If all equipment is leased with a service contract an interest rate - register 12 - still must be entered for the program to operate.) A fixed rental rate should be entered in register 3. If the rate is established on a monthly basis it must be adjusted to reflect the actual annual fee (7). Rates which vary according to distance or other factors should be included as a variable cost in register 29. Costs which are variable by the mile must be multiplied by total annual miles or, if the tank payment is based on the volume of milk delivered, by the cwt. delivered. Instructions for inserting into the program new instructions for calculating variable costs per mile and similar changes are described following the example.

Example

A hauler signs a seven-year lease for a bulk tank which includes a $1,500 nonrefundable payment plus one-half cent per hundredweight delivered.

There are two steps needed to incorporating these new conditions. First, the initial payment is a partial payment for the tank and should be treated as any other cost by inserting the payment, $1,500, into register 06 with the life

established at 7 years placed in register 07. Second, the cwt rental rate must be multiplied by hundred pounds delivered to determine the rental fee. Average daily pounds delivered is stored in register 02 which must be multiplied by 365 to calculate the annual total. These steps can be accomplished as follows:

Press	Display	Function Performed
GTO 275	---	Locate appropriate place in the program
LRN	275 95	Put in learn mode
2nd INS	275 00	Clear space (this instruction moves all the following steps ahead by one place)
x	276 95	Multiply rate times capacity (the calculator automatically advances you by one step so that you do not see what was just inserted)
2nd INS	276 00	Clear space
RCL	277 95	Recall average daily cwt delivered
2nd INS	277 00	Clear space
2	278 95	Completes RCL command
2nd INS	278 00	Clear space
x	279 95	Multiply by 365 to give annual value
2nd INS	279 00	Clear space
3	280 95	Begin inserting 365
2nd INS	280 00	Clear space
6	281 95	
2nd INS	281 00	Clear space
5	282 95	
LRN	---	Exit learn mode

When using this modification it is important that register 29 is not used for anything but the rental rate. If it is the entire value stored in this register will be treated as the rental rate, leading to a substantial overestimate of the cost.

If this change is to be permanent it may be stored on a magnetic card by following these steps:

Press 1 2nd WRT - insert card, turn over
Press 2 2nd WRT - insert card

If the display number is not flashing, the program was transferred properly.

SECTION II

Determining Hauling Rates from the Program Estimates

Hauling costs may be divided into three categories - on-farm, travel, and volume - based on where they are incurred. These categories take account of variable costs of travel (fuel, tires and maintenance) and the fixed costs of the tank, truck, insurance and the scheduled driver. Fixed costs including labor are substantial, comprising approximately two-thrids of total assembly route costs, and must be allocated across a full day's activities on a cost per minute basis.

On-farm costs are fixed costs which include the time required to perform routine chores at each stop. These chores include hooking up, agitating the milk, sampling, and rinsing the farm tank. The driver's personal time for lunch and rest breaks is also included with the on-farm costs.

Travel or mileage costs include both fixed and variable cost segments. The variable costs are related to the miles traveled while the fixed costs include the proportionate share of the overhead costs for the time the truck is traveling. The final category, volume costs, involves pumping time at the farm and plant.

These three components of the hauler rate are summarized in Figure 3 below. For completeness, this figure also indicates how the producer rate is related to hauler payments. Producers are assessed in a slightly different fashion than the haulers are paid so that there is not a direct pass-through of each cost item, as shown in the Figure.

Figure 3: Cost Components Included in the Hauler Rate and Producer Payment

Hauler Rate	Route Costs	Producer Rate
Stop Payment	On-farm labor, excluding pumping time, plus share of fixed cost, plus waiting and personal time	Stop Charge
Mileage Payment	Transport (garage to first farm, last farm to plant and plant to garage) cost	Location Differential
	Assembly (first to last farm) costs plus share of fixed cost and labor	
Volume Payment	Plant pumping and wash time plus farm pumping time	Volume Change

Steps for making these calculations using the TI-59 program are outlined in Figure 4.

This portion of the program uses estimates from the program described above and consequently cannot be run unless steps A and B have been run previously. The steps for this program are included in the Appendix beginning at 336.

Figure 4: Operating Instructions for Part II of the TI-59 Program After Running Part I:

	DATA INPUT					
Item	Example Value	Press Key	Example Display	Your Value	Press Key	Your Display
Number of Farm Stops	9	STO 30	9	_____	STO 30	_____

	OUTPUT		
Press Key	Value Output	Example Display	Your Display
C	Stop Payment	3.54	_____
R/S	Mileage Payment/Mile	.734	_____
R/S	Volume Payment/cwt	.071	_____

The procedure followed in the program can best be explained by manually running through the calculating it makes internally.

Item	Includes	Amount	
Stop Payment	On-farm labor time (excluding pumping time) plus share of waiting and personal time (8)	10	mns. per farm labor time
		x 9	no. farm stops
		90	
		+ 75	waiting and personal time
		165	total stop time
		x.193	FC/Mn (from Figure 1)
		31.84	total stop cost
		÷ 9	
		$3.54	stop payment
Mileage Payment	Assembly time plus mileage costs	480	total minutes in day
		-165	stop time
		-53.39	farm pump time (9)
		-27.18	plant pump time (10)
		- 30	wash time (11)
		204.42	total route time
		x.197	FC/Mn (from Figure 1)
		$39.59	time cost

Item	Includes	Amount	
		110	miles
		x.374	VC/mile
		$41.14	mileage cost
		41.14	
		33.66	
		$80.68	total cost
		÷110	miles
		.733	mileage payment/mile (12)
Volume Payment	Plant pumping and washing time plus on-farm pumping time	53.39	farm pump time (9)
		+27.18	plant pump time (10)
		+30.00	wash time (11)
		110.57	total volume time
		x.193	
		21.34	total volume cost
		÷299	cwt delivered
		.071	volume payment

CONCLUSIONS

The calculated hauling cost of 44½ cents per hundredweight must be used only as a base or guideline rate. There are numerous other factors that should be considered in arriving at an actual rate. The actual rate must include a return for hauler management and risk not included in the cost estimates as well as including differentials for specific route characteristics such as road conditions and grade. Thus each route or group of routes served by a hauler must be analyzed separately with the final rate determined through individual negotiations.

The procedure described above if properly implemented is a means of achieving a closer correlation between hauling rates and actual route costs. It should provide an incentive for both producers and haulers to improve efficiency in the milk assembly system and serve the long-run interests of all participants.

FOOTNOTES

1/ The program is readily transferable to another programming language such as that used on the HP-97 calculator. Some knowledge of programming is needed.

2/ More precisely the appropriate rate should fall somewhere between the replacement cost and the "actual" cost based on current equipment costs. The replacement cost figure is utilized here because there is often a substantial lag in incorporating replacement cost figures in the hauling rate. This lag is a result of the time necessary to assemble the cost figures and negotiate rates, which then remain in effect for a year. At the end of this period during a time when equipment costs are rising rapidly the rate is actually below the true replacement cost rate and is assumed to approximate the minimum rate needed to keep haulers in the industry.

3/ The Annual Equivalent Cost (AEC) formula used in the program is:

$$AEC = EC\,\frac{i(1+i)^n}{(1+i)^n-1} - SV\,\frac{i}{(1+i)^n-1}$$

EC - equipment cost
SV - salvage value at end of n^{th} year
i - interest rate

Source: Gerald W. Smith, Engineering Economy: Analysis of Capital Expenditures. Iowa State University press, Ames, 1968, p. 99.

For further information see Smith or another book on engineering economy.

From the equivalent cost must be subtracted the appropriate tax savings available to the hauler. These include an investment tax credit (14% is used in the program which includes 10% federal and 4% New York State). Also straightline depreciation tax savings are deducted (a rate of 20% is assumed). Straightline depreciation was chosen because it approximates the method used by many smaller firms. Its use will lead to an underestimate of tax savings and thus a small overestimate of the equivalent cost for firms with sufficiently high incomes which use an accelerated depreciation such as double declining balance. The 20% tax rate is considered to be a good estimate for the entire industry but may be an underestimate for some large or more profitable operations.

4/ With the annual equivalent cost figure the annuity represents partially debt servicing and partially an increase in equity. Thus over the life of the good the interest rate must represent, in different proportions, both the cost of borrowed capital and the value of equity to the owner. Typically for small operators equity has a higher opportunity cost than borrowed capital because the risk is greater, and it should receive a higher return. The interest payments from equity are, however, taxable while debt servicing costs are tax deductible so that the other tax rate for both is applicable. After these adjustments are made and the average rate for debt and equity is calculated the yield of industrial bonds rated "A" is assumed to be a good approximation to the true value.

5/ Tire costs are calculated assuming that an average carcass is retreadable once and that a bias ply carcass has a total service life of 60,000 miles and a radial a life of 100,000 miles. These are averages for all the tires on a truck since the actual mileage depends on which axle it is placed on as well as road conditions, etc.

6/ Operationally, this entry provides a "switch" which changes the base of the cost from 60,000 miles for bias ply tires to 100,000 miles for radials.

7/ Some leases require a substantial payment at the beginning of the contract. If this payment is nonrefundable it should be entered in register 3 or 7 as equipment cost. Even if the payment is refunded at the expiration of the lease the compounded interest figure over the period can be substantial. This amount too, should be entered as a cost.

8/ The figures for this example are based on a 1978 study of hauling routes in the New York State order area.

9/ On the farm milk is assumed to be pumped at the rate of 560 pounds/minute.

10/ At the plant milk is assumed to be pumped at the rate of 1,000 pounds/minute.

11/ A truck is assumed to be washed only once a day.

12/ Figures may not match exactly these in Figure 4 because of rounding error.

BULK MILK ASSEMBLY PROGRAM

```
000  76 LBL
001  11  A
002  53  (
003  43 RCL
004  03  03
005  65  ×
006  93  .
007  08  8
008  06  6
009  54  )
010  65  ×
011  71 SBR
012  89  π
013  75  -
014  43 RCL
015  05  05
016  65  ×
017  71 SBR
018  33 X²
019  75  -
020  93  .
021  02  2
022  65  ×
023  53  (
024  53  (
025  43 RCL
026  03  03
027  65  ×
028  93  .
029  08  8
030  06  6
031  75  -
032  43 RCL
033  05  05
034  54  )
035  55  ÷
036  43 RCL
037  07  07
038  54  )
039  85  +
040  53  (
041  43 RCL
042  06  06
043  65  ×
044  93  .
045  08  8
046  06  6
047  54  )
048  65  ×
049  71 SBR
050  89  π
051  75  -
052  43 RCL
053  08  08
054  65  ×
055  71 SBR
056  33 X²
057  75  -
058  93  .
059  02  2
060  65  ×
061  53  (
062  53  (
063  43 RCL
064  06  06
065  65  ×
066  93  .
067  08  8
068  06  6
069  75  -
070  43 RCL
071  08  08
072  54  )
073  55  ÷
074  43 RCL
075  07  07
076  54  )
077  85  +
078  43 RCL
079  09  09
080  85  +
081  43 RCL
082  10  10
083  85  +
084  43 RCL
085  11  11
086  85  +
087  43 RCL
088  13  13
089  85  +
090  43 RCL
091  14  14
092  65  ×
093  03  3
094  06  6
095  05  5
096  65  ×
097  43 RCL
098  15  15
099  95  =
100  42 STO
101  50  50
102  99 PRT
103  91 R/S
104  43 RCL
105  50  50
106  55  ÷
107  71 SBR
108  35 1/X
109  95  =
110  99 PRT
111  91 R/S
112  43 RCL
113  50  50
114  55  ÷
115  53  (
116  43 RCL
117  02  02
118  65  ×
119  03  3
120  06  6
121  05  5
122  54  )
123  95  =
124  99 PRT
125  91 R/S
126  43 RCL
127  50  50
128  55  ÷
129  53  (
130  43 RCL
131  15  15
132  65  ×
133  02  2
134  01  1
135  09  9
136  00  0
137  00  0
138  54  )
139  95  =
140  99 PRT
141  42 STO
142  41  41
143  91 R/S
144  76 LBL
145  89  π
146  53  (
147  53  (
148  43 RCL
149  12  12
150  65  ×
151  71 SBR
152  34 ΓX
153  54  )
154  55  ÷
155  53  (
156  43 RCL
157  49  49
158  75  -
```

```
159   01   1
160   54   )
161   54   )
162   92 INV SBR
163   76 LBL
164   33 X²
165   53   (
166   43 RCL
167   12   12
168   55   ÷
169   53   (
170   43 RCL
171   49   49
172   75   -
173   01   1
174   54   )
175   54   )
176   92 INV SBR
177   76 LBL
178   34 ΓX
179   53   (
180   53   (
181   01   1
182   85   +
183   43 RCL
184   12   12
185   54   )
186   45 Y^x
187   43 RCL
188   04   04
189   54   )
190   42 STO
191   49   49
192   43 RCL
193   07   07
194   48 EXC
195   04   04
196   48 EXC
197   07   07
198   43 RCL
199   49   49
200   92 INV SBR
201   76 LBL
202   35 1/X
203   53   (
204   43 RCL
205   01   01
206   65   ×
207   03   3
208   06   6
209   05   5
210   54   )
```

```
211   92 INV SBR
212   76 LBL
213   12   B
214   71 SBR
215   35 1/X
216   55   ÷
217   43 RCL
218   20   20
219   65   ×
220   43 RCL
221   21   21
222   85   +
223   53   (
224   53   (
225   53   (
226   43 RCL
227   22   22
228   85   +
229   43 RCL
230   23   23
231   54   )
232   55   ÷
233   53   (
234   06   6
235   00   0
236   00   0
237   00   0
238   00   0
239   85   +
240   43 RCL
241   25   25
242   65   ×
243   04   4
244   00   0
245   00   0
246   00   0
247   00   0
248   54   )
249   54   )
250   65   ×
251   71 SBR
252   35 1/X
253   65   ×
254   43 RCL
255   24   24
256   54   )
257   85   +
258   43 RCL
259   26   26
260   65   ×
261   71 SBR
262   35 1/X
```

```
263   85   +
264   43 RCL
265   27   27
266   85   +
267   43 RCL
268   28   28
269   65   ×
270   71 SBR
271   35 1/X
272   85   +
273   43 RCL
274   29   29
275   95   =
276   42 STO
277   51   51
278   99 PRT
279   91 R/S
280   43 RCL
281   50   50
282   85   +
283   43 RCL
284   51   51
285   95   =
286   99 PRT
287   42 STO
288   53   53
289   91 R/S
290   43 RCL
291   53   53
292   55   ÷
293   53   (
294   03   3
295   06   6
296   05   5
297   65   ×
298   43 RCL
299   02   02
300   54   )
301   95   =
302   99 PRT
303   91 R/S
304   43 RCL
305   53   53
306   55   ÷
307   71 SBR
308   35 1/X
309   95   =
310   99 PRT
311   91 R/S
312   43 RCL
313   51   51
314   55   ÷
```

```
315  53  (
316  43  RCL
317  02  02
318  65  ×
319  03  3
320  06  6
321  05  5
322  54  )
323  95  =
324  99  PRT
325  91  R/S
326  43  RCL
327  51  51
328  55  ÷
329  71  SBR
330  35  1/X
331  95  =
332  99  PRT
333  42  STO
334  42  42
335  91  R/S
336  76  LBL
337  13  C
338  53  (
339  53  (
340  43  RCL
341  30  30
342  65  ×
343  01  1
344  00  0
345  85  +
346  07  7
347  05  5
348  54  )
349  65  ×
350  43  RCL
351  41  41
352  54  )
353  55  ÷
354  43  RCL
355  30  30
356  95  =
357  99  PRT
358  91  R/S
359  53  (
360  53  (
361  43  RCL
362  15  15
363  65  ×
364  06  6
365  00  0
366  75  -
```

```
367  53  (
368  43  RCL
369  30  30
370  65  ×
371  01  1
372  00  0
373  85  +
374  07  7
375  05  5
376  85  +
377  71  SBR
378  23  LNX
379  85  +
380  71  SBR
381  32  X↕T
382  85  +
383  03  3
384  00  0
385  54  )
386  54  )
387  65  ×
388  43  RCL
389  41  41
390  85  +
391  43  RCL
392  01  01
393  65  ×
394  43  RCL
395  42  42
396  54  )
397  55  ÷
398  43  RCL
399  01  01
400  95  =
401  99  PRT
402  91  R/S
403  53  (
404  53  (
405  71  SBR
406  23  LNX
407  85  +
408  71  SBR
409  32  X↕T
410  85  +
411  03  3
412  00  0
413  54  )
414  65  ×
415  43  RCL
416  41  41
417  54  )
418  55  ÷
```

```
419  43  RCL
420  02  02
421  95  =
422  99  PRT
423  91  R/S
424  76  LBL
425  23  LNX
426  53  (
427  53  (
428  43  RCL
429  02  02
430  65  ×
431  01  1
432  00  0
433  00  0
434  54  )
435  55  ÷
436  05  5
437  06  6
438  00  0
439  54  )
440  92  INV SBR
441  76  LBL
442  32  X↕T
443  53  (
444  53  (
445  43  RCL
446  02  02
447  65  ×
448  01  1
449  00  0
450  00  0
451  54  )
452  55  ÷
453  01  1
454  01  1
455  00  0
456  00  0
457  54  )
458  92  INV SBR
```