RESOURCE SUBSTITUTION: AUTOMATIC CASING AND STACKING VERSUS MANUAL CASING AND STACKING OF FLUID MILK PRODUCTS

by

James Edward Schad

Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute
in candidacy for the degree of

MASTER OF SCIENCE
in
Dairy Technology

August, 1963

Blacksburg, Virginia

TABLE OF CONTENTS

Page

DIAGRAMS

CHARTS

INTRODUCTION

Since the turn of the century, interest in mechanization of the dairy industry has grown (49). One of the best definitions of mechanization and automation is the definition given by Ripma. He states that mechanization is taking the "muscle" out of the operation, and automation is mechanization with the addition of controls enabling the piece of equipment to perform additional functions without the attendance of an operator (36).

One of the main factors which has resulted in this interest by management has been the necessity to become more efficient in attempts to remain competitive in the face of the price-cost squeeze. Some of the concomitant results of managerial decisions to bring about efficiency are: 1) progress, 2) reduction in labor cost, 3) increase in gallon-per-man-hour, and 4) improving the morale of the employees. The belief exists that the plants which produce less than 13,000 gallons per day are inefficient and cannot be automated. However, there are degrees of automation available to all plants for improving efficiency and cutting labor costs (37).

In recent years, changes in union contracts, resulting in ever-increasing labor costs, have given dairy operators incentive to automate. Unions have become aware of the fact that mechanization and automation are reducing the labor force in dairy plants. Many union contracts state that the labor force will not be reduced with the installation of more automatic equipment. This could prevent the increase in gallons-per-man-hour in many dairy plants.

Lack of accurate standards by which to measure costs frequently contribute to management's difficulty in determining the extent to which a plant should be mechanized and automated.

REVIEW OF LITERATURE

In the review of literature, the author has investigated three areas believed to be important in making the decision to utilize equipment in a dairy plant. These areas are: 1) plant personnel problems caused by automation, 2) plant layout, and 3) the question of whether to buy or lease. It is realized there is much more information pertaining to the above areas, however, material in this review of literature pertains only to this thesis problem.

Plant Personnel Problems Caused by Automation

The three main problems with which management may be confronted as a result of automation are:
1) employees resist job change, 2) employees are unhappy with job content, and 3) employees fear displacement (20). It is vital for management to establish and preserve good personnel relations, since the employees within a dairy plant are its most important asset (25)(26). Many of these problems are the result of sudden changes due to automation rather than gradual changes.

Another problem is the retention of unneeded workers. Probably one of the most important problems is the effect of unions on automation.

Product quality improvement can be made through modernization by improving adequate facilities for competent people to produce a high quality product. Cost reduction is attained through more efficient handling of the products before and after packaging.

The improvement of public relations by presenting to the public a plant of pleasing appearance, which leaves the customer with an image of efficiency and cleanliness, is important. This is, therefore, a powerful sales tool especially in markets where price is controlled and sales are heavily influenced by the public image (1).

When rebuilding an old plant or building a new plant, plans are made several years in advance. Many of the men employed, after plans for a new operation are initiated, are told that their positions may be temporary in view of the proposed shift to more automation. By the time the plant construction is well under way, a number of the older employees are retired, disabled, or have become incapacitated.

Therefore, what might have seemed at first a major problem will have dwindled to one of lesser importance (48).

Many of the new plants require only a third of the original work force. The personnel department may reduce the problem of unneeded personnel in the new plant through notification of new employees that their jobs may be temporary, and through the retirement of older employees (48). However, sometimes it may be desirable to retain certain employees because of their potential value in the future.

Displacement causes the most severe difficulty when viewed on a short-term basis. This is no comfort to the employee who suddenly loses his position, paycheck, and domestic and community prestige (20).

The older employee who is resistant to job change often is given the opportunity to be placed on another job within the plant, or is relieved of his duties with the company. When this occurs the personnel department may make an effort to locate another job for him in the community.

It is not unlikely that organized labor will sometimes freeze the productivity of its workers at a certain predetermined level (48). The tool that unions sometimes employ in the prevention of automation, is the attempt to attain contracts reducing the work load on each individual employee. This tends to force management to employ the same number of men as automation is introduced.

It behooves management, therefore, to exert every means possible through the building of better designed plants and the application of automation to raise the productivity of labor to higher levels (48). The fact that automation may displace an employee today is more real to him than the industrial or plant benefits of automation which will be his tomorrow (20)(48).

"A worker takes pride in his role on the work team. He gains a sense of satisfaction and security from familiarity with relation to the work cycle and to fellow workers" (25). The lack of job content is associated with unsatisfactory workmanship that sometimes appears in consumer goods produced by modern assembly line techniques (25).

The plant personnel requires a sympathetic and understanding approach before and during the introduction of automation if the plant is to achieve full advantage of automation (20)(26).

Seinwerth suggests ten steps as a partial solution for easing personnel problems of automation (20).

1) Proper timing of all steps for introducing and effecting change.

2) Full, timely, and complete communication of all facets of change to all persons involved and provision of opportunities for participation in two-way discussions.

3) Recognition of and allowances for prestige factors which involve name, titles, status factors, and includes washrooms, lounge facilities, etc.

4) Careful planning of working conditions including heat, light, ventilation, location, colors of paint.

5) An orderly and logical job evaluation system for evaluating job content and establishing rates of pay.

6) Attempts to maintain work team relationships and thus avoid such problems as the steel companies' "lonesome" pay bonus.

7) Departmental as well as plant seniority. With this arrangement the youngest people in point of service in the plant are those affected by layoffs or technological changes. This makes for an older group

who can perform many different jobs and who have excellent employment stability.

8) A liberal separation pay policy.

9) A non-contributory pension consideration for older employees whose jobs are eliminated by technological change, and who because of age, health, or other reasons, are unable to take other work to which their seniority would entitle them.

10) Full application of Unemployment Compensation Insurance and Federal Old Age and Survivors Insurance benefits when applicable.

Management's job today lies in the building of an effective secondary management team, and improving the one now in use. No championship team depends solely on the "first string" members; depth in an organization determines the lasting quality of the business (25).

From the beginning, a new employee reflects the attitudes and ideas of management. He is what he is taught, or not taught, in the organization (25).

Such training can be of two types: 1) that of a paramecium type in which the employee is allowed to drift along with the tide of in-plant operations, shifting for himself, and depending on the process of osmosis for the absorption of information, guidance, and education, or 2) an organized and planned program in which the employee has a charted course, with an objective, supervised by a qualified counselor (25).

Management's job today is one of selling rather than telling (25)(26). There is no panacea for personnel development. The desire for such a program, its plans, and the efforts exerted, must originate with management if it is to be successful (25).

Personnel leadership, experience, training, and attitudes, reflect in the products produced and the efficiency of such production (25). The human factors involved in automation are perhaps more complex than the mechanical and engineering factors (20).

During the past two decades, through fields of education, research, technology, and machine design, our industry has reduced the mechanics of milk production, processing, packaging, and delivery, from an art to a science (25)(26).

Milk plant automation has not yet reached the degree of perfection desired. The most efficient plants are processing 100 to 125 gallons-per-man-hour. A reasonable goal for the present is set at 200 gallons-per-man-hour (38).

As production per man-hour increases in one industry through the application of automation, there develops a need for similar application in other industries (48). Companies must modernize and continue to perfect efficiency through the application of automation if they are going to survive the highly competitive era that is ahead (47).

Boyce[1] in Bittel (16) points out that there is a belief that automation will destroy jobs, put people out of work, and create a recession or depression. He states in his reply that this thinking is a waste of time.

Many fear unemployment from automation because they are looking at only a segment and are not looking at the whole picture of automation (16).

If there are enough people employed to buy all of the goods and services being produced, the economy is in good condition. Demands of a rapidly growing population for industrial products will prevent any shrinkage in manufacturing employment. Changes in both products and processes to meet consumer demands for different or better products at lower prices are being

---

1. C. W. Boyce is Associate Editor of Factory.

made more rapidly than ever before. With each change, certain jobs, certain skills, and sometimes whole plants are made economically obsolete (16).

Today the total active labor force is 41% of the total population. Except for the war years, the average for the past 30 to 40 years was approximately 41%. Projected to 1975 this would be 41% of 220 million or about 90 million workers (16).

The years until 1975 will not be normal (16). Economic patterns and the age distribution of the population are changing drastically. Both of these factors will act to reduce the active labor force to far less than our old concept of normal (16).

Here is how Mr. Boyce figures it (16):

The bulk of the labor force is in the age group of 20 to 65 years. Those now living under the age of 45 will compose this labor force of 117 million in 1975. But mortality tables indicate 10 million will die before 1975, leaving a net increase of 15 million. In 1975, 23 million women will be in the child bearing ages of 20 to 35, compared with 18 million today. This reduces the labor force another five million. Still others will be "involuntary" dependents, physically or mentally incapable. Increased enrollments in school will cut the labor force further.

If immigration continues as it has in the past, it will add from two to three million additional workers to the labor force. The number under 20 will depend on the birth rate in the late 1950's, probably two million, discounting those in school under 20.

Looking at the figures in this manner, there would be an increase of 14 to 15 million in the work force in 1975. This means that there would be a labor force of 86 million in 1975, up 22 million from the present 64 million.

Automation will destroy 9 to 21 million jobs in the next 20 years if we are to raise our living standards at the present rate and also work shorter hours.

There are two alternatives: 1) continue to raise the living standard at the present rate allowing automation to make up the deficit of workers, or 2) slow our progress toward higher living standards with reduced automation.

Plant Layouts

Many plants constructed during the last ten years were designed so that automated equipment could be added gradually. Many of the older plants, however, are inefficient, not only due to the lack of automation, but also because of unsatisfactory plant layout and design. It is customary for the older plants to expand as the volume of business increases because of consolidation, mergers, and increased population in markets served. In many cases land area was not available for the expansion of existing plants according to an orderly and well-designed layout which results in an inefficient plant operation (48).

Allinson (1) states that the three basic aims in modernization of a milk plant are product quality improvement, cost reduction, and public relations.

The processing phase has, in general, kept pace with rising costs. Today, the mechanization of the processing phase is approaching automation (38).

The package handling phase of the dairy industry has only recently been introduced to mechanization through automatic case stackers, pallet loaders, and unloaders, casers, infloor conveyors, unstackers, and other pieces of machinery. The dairy plant handling system from filler to truck is divided into five parts. They are unloading empty cases and bottles, washing bottles and storing cases, filling containers, refrigerated storage, and loading trucks (38).

The jobs range from a one-man operation to the largest operation in the plant. The several parts must be properly related to each other in order to have an efficient plant. The capacities of each machine should be approximately equal so that a continuous flow of work is achieved (38).

Many plants have a relatively high handling cost in one or more parts of the package handling system. This results in reduced profits through overtime, excessive man-hours, low line efficiencies, and profit loss (38).

It is incumbent upon management to know what is occurring in each area of its package handling operation. The manager should know the efficiency of the equipment as well as its bottlenecks. Then a workable schematic layout should be planned to make the packaging routine smooth. The layout should be started where the most savings per man-hour can be realized (38).

The step by step system, recognizing bottlenecks in the operation, may take several years to complete. But each of the steps is in the direction of reduced plant handling cost.

There is ny way in which all plants with different individual bottlenecks can be grouped into one infallible layout which would yield the lowest man-hour requirements per day. Many mistakes are made in plant layouts, such as wasted space, minimum or lack of flexibility, excess movement necessary in production, crowded space, and poor accessibility (33).

Buy or Lease

The volume of milk in a plant does not always justify the expenditure for automated equipment. If the objective is a reduction in product loss, or labor cost, then various degrees of automation may be justified.

A one-step plan for automation is difficult because of the large investment involved. Normally, however, any firm can gradually add machinery. Definite objectives in bringing about automation will eventually save money and manpower. The company must decide the amount and type of equipment to buy (21).

The solution to this problem and the more complex problems that lie ahead depends upon the manager's access to facts and his skills in using them. With the facts in hand he can obey the three basic commands of cost evaluation (21): 1) locate and identify the costs, 2) measure alternate costs, and 3) compare actual and alternate costs.

Years ago accounting systems dictated that cost be spread out on a manpower basis. Today, because of technological changes, different bases must be used for comparisons (21).

The four typical problems related to mechanization are: 1) the calculation of system reliability. Storage space should be designed to take care of the percentage of time the equipment is down; 2) the control of possible scrap inventory; 3) the proper timing of the installation of automated equipment. Time will be lost in getting the machine installed and working properly, as well as product, carton, and direct and indirect man-hour losses which occur during the installation period. Highly mechanized systems involve many pieces of highly synchronized equipment. When one piece of equipment is not functioning the entire line process may be delayed; 4) the use of the break-even principle in comparing highly mechanized equipment with the present operation. Conventional operations might be able to perform beyond this point at no extra change in investment. This simply means that the degree of mechanization must not exceed its ability to produce a reasonable return (36).

Another aspect of automation to be considered is the pay-back time on investment. The pay-back time on investment should not be set too rigidly since the objectives will vary between investments. However, when a change of method is considered, such as automation, certain cost factors must be considered. If the life of the equipment is to be ten years, then the depreciation cost plus interest, repairs, taxes, insurance, and operating expenses, averages 20 to 22% of the annual investment. When a worker's annual wages and fringe benefits range from six to seven thousand dollars, then this would be equivalent to an investment of approximately 30 to 35 thousand dollars in automation (36).

If a corporation pays a 50% excess profit tax, only one-half of the savings over the 20 to 22% can be considered as a net gain. Therefore, a gross savings of at least 40% of the additional cost is necessary per year to pay out in five years. Most operators believe automation is worthwhile from the cost standpoint if the investment is returned in two and one-half or three years (36).

Once management begins to think in terms of automation, the question of lease or buy must be considered. A firm should carefully consider the cost before leasing. Each firm should weigh the advantages and disadvantages of leasing before making any definite decisions concerning the use of new equipment.

Leasing is another form of financing. The difference between leasing and renting is that leasing is for long-term use and renting is for short-term use (28).

The tax benefit is probably the greatest attraction to leasing. A straight lease with a leasing firm enables a company to deduct all of the payments as a 100% business operating expense. The company is not asked to follow the depreciation guidelines which might require waiting five or more years to depreciate a piece of equipment. However, tax collectors sometimes think that if the contract establishes an equity for the company, it will then be difficult to claim as a 100% business operating expense (47).

There are several reasons why businessmen lease (44):

1) Long-term financing is obtained without impairing the company's short-term credit.

2) The cost of equipment is paid out of earnings made during its use.

3) Leasing charges are legitimately deductible as operating expenses. This permits a company to dispose of equipment more realistically and replace it when business economics demands.

4) Long-term financing is obtained through leasing without diluting the equity of the owners.

5) Leasing protects a firm against possible early obsolescence of equipment.

Leasing makes it possible for a firm to obtain immediate use of new equipment. This enables the company to compete on an equal or superior basis with other dairy operators (28).

Leasing is a benefit to those dairies that are not of size to make use of public stock issues, bond issues, or institutional borrowing. It permits the use of bank financing for shorter term requirements (28).

The major disadvantages of leasing are loosely drawn agreements, unethical leasors, and disappointments in tax savings (47). Also at the end of the lease period the equipment is not owned by the company. This is only a disadvantage when, at the end of the lease, the used equipment is worth more than the additional profits earned as a result of leasing (44).

There are three types of companies that will not find leasing advantageous (44):

1) The company that has all of the working capital it needs, and does not require any new equipment.

2) Companies that earn less than 10% on working capital before taxes (4.8% after taxes) should not lease. It is not an advantage for such a company to pay a leasing company for the use of outside capital.

3) Marginal companies should not lease. Generally leasing firms will not lease equipment to any company if the value of the equipment is greater than 50% of the company's net worth.

Other cautions to consider are that most lease contracts start with high rents being gradually reduced as time passes. In the beginning the company can charge the higher rents against profits, cutting taxes; later the company will pay more taxes (47).

Most leasing firms discourage a conditional sale in a lease agreement because it means that the company may deduct only the regular depreciation on the equipment instead of taking a 100% business deduction each year. Leasing is a legitimate deduction as an operating expense, where the conditional sale is only deductible at the rates specified in the government depreciation tables (35).

Leasing cannot provide a firm with equipment unless it is able to demonstrate, usually by means of financial statements, that it is capable of fulfilling the lease obligations. It means that reasonable ratios between the various items of the financial statement should be shown (28).

Usually in a lease finance plan there is no down payment and the lease payments extend over a period of six years with the option to renew the lease each year. The renewal is usually based on the estimated residual value of the equipment at the end of the lease. Normally the renewal is based on from 5 to 10% of the original cost of the equipment (28).

Generally, in most lease agreements, maintenance and repairs are handled by the lessee, and the warranties given are settled between the seller and the lessee prior to leasing (35).

It has been stated that leasing is an expensive method of financing capital equipment. This conclusion is based on cost estimated considering the following factors (29):

1) The total amount of rental payments.

2) The total investment by purchase.

3) The difference in terms of dollars between ownership and rental.

4) The comparative cost of borrowing from a bank.

An illustration of this reasoning is shown on the question of leasing or purchasing a milk caser. The outright purchase price is approximately $12,500. The standard lease agreement is $18,100 and the conditional sale is $13,765. The difference in the standard lease agreement and the outright purchase price is $5,600. The comparative cost of borrowing from a bank and the tax advantage, if any, depending on the profit, have not been considered in this calculation.

Another illustration involves a company in which the equipment desired cost $100,000 based on the corporate tax rate at the time of purchase. After the equipment was fully depreciated, only $70,000 was retained by the company earning more than $25,000 per year. Due to technological changes the price of the equipment increased to $150,000. This firm was then confronted with the problem of raising the needed money (29).

A company utilizing equipment may ask how leasing can be a form of financing when it does not acquire the equipment. Dairies are not in the business of acquiring and eventually selling equipment. If they can realize its full use during its competitive life at a reasonable cost that permits them to make a profit consistent with their business, then the objective has been accomplished. A fairly priced lease of proper duration can help reach a profitable lease (28).

SCOPE OF INVESTIGATION

The broad purpose of this thesis is to analyze and develop a method for applying the break-even principle in comparing manual casing and stacking with automatic casing and stacking of fluid milk products. The break-even principle will be applied to models of casing and stacking equipment developed in this thesis.

PROCEDURE

Interview

Visits were made by the author to four dairy processing plants having automatic casers and stackers. The purpose was to learn the procedures involved in making the decision to install automatic casers and stackers.

Upon arrival at each plant, the visit was conducted in two parts in the following sequence:

A tour of the plant facilities was first completed to observe the equipment arrangement and to observe the methods and procedures which were being used in each plant. An additional benefit of the tour was that many of the questions included in the formal interview could be answered by observation and, therefore, reduced the length of the formal interview period.

The second part of the visit involved an interview with one or more persons in managerial positions in order to obtain detailed and specific information. In most plants, the bottling supervisor was included in a portion of the interview.

During the interview, routine questions were asked with respect to: 1) how the decision was made to install the automatic casers and stackers, 2) estimated physical life of the equipment, 3) depreciation period of the equipment, 4) number of units processed per day, 5) amount of down time due to malfunctions, 6) amount of maintenance required on the equipment, 7) environmental problems, such as moisture, with respect to the equipment, 8) number of employees in the operation before the installation of the casers and stackers, and the number of employees in the operation after the installation of the equipment, and 9) possible suggestions for improvement of the layout after having some experience with the equipment.

Development of Models

Upon analysis of these data, the combinations of filling equipment models were derived. The basis for this was the ratio of one-half gallon containers filled, compared to units filled on the quart fillers. A total of nine models as outlined below were submitted to the manager of each plant visited.

Model I consisted of two filling machines with manual casing and stacking of cartons. One filler has a capacity of 75 units per minute (quarts, pints, or one-half pints), the other 33 one-half gallon units per minute.

Model II included the same combination of filling equipment as Model I except that automatic casers and stackers were extended at the end of the filling machines.

Model III was comprised of the same combination of filling machines as Model I except that the automatic casers and stackers were located on the side of the filling machines.

Model IV consisted of three filling machines having manually cased and stacked cartons. Two fillers had a capacity of 75 units per minute (quarts, pints, or one-half pints), the other 75 one-half-gallon units per minute.

Model V was comprised of the same combination of filling machines as Model IV except a caser and stacker were extended at the end of the filling machines.

Model VI included the same combination of filling machines as Model IV except a caser and stacker were located on the side of the filling machines.

Model VII consisted of four filling machines with manual casing and stacking of cartons. Three fillers had a capacity of 75 units per minute (quarts, pints, or one-half pints), the other 75 one-half-gallon units per minute.

Model VIII was comprised of the same combination of filling machines as Model VII except three casers and stackers were used. One caser and stacker, by use of a bottle combiner, were attached to two 75 units per minute (quarts, pints, or one-half pints) filling machines. The remaining two filling machines each were used with a caser and stacker. All of these casers and stackers were extended at the end of the filling machines.

Model IX included the same pieces of equipment as Model VIII, except this model had the cases and stackers located to the side of the filling machines.

Questionnaire

A set of these models was sent to each dairy processor visited with an attached letter requesting that the models be evaluated with respect to:
1) number of men they would employ in each model, 2) each production personnel's title and job specification, 3) hourly wage to be paid each employee in the model, 4) any measures they thought would improve the model, and 5) their preference of the models containing the casers and stackers as to whether they preferred the casers and stackers located beside, or at the end of, the filling machines, assuming that adequate space was available and that such a layout posed no problems.

Analysis of the Questionnaire

With the exception of minor conveyor changes, most of the operators preferred the models having the casers and stackers extended at the end of the filling machines. This arrangement was preferred because less turns in the conveyors were required resulting in a slightly lower capital investment. Secondly, with less turns, there would be less wear on the conveying equipment. Thirdly, with the employee functions, any malfunctions of the casers and stackers could be easily observed.

Models to be Used in the Study

From the above comments, Models I and II, IV and V, and VII and VIII were used.

From these models, the fixed, variable, and total costs of the casing and stacking phase were obtained. The fixed, variable, and total costs of each combination of filling equipment (casing and stacking phase) of the manual and automatic methods were compared.

The break-even principle was used in obtaining the break-even point of the models based on cost and number of units produced or the point where total cost of the automated and that of the non-automated operations intersect.

Analytically the break-even point may be obtained by the following method.

At the break-even point the total cost for one model would be equal to the total cost for comparative model; i.e.,

$$TC_m = TC_a$$

where:

$$TC = FC + VC(x).$$

Then:

$$FC_m + VC_m(x) = FC_a + VC_a(x)$$

where:

m = manual casing and stacking models

a = automatic casing and stacking models

FC = fixed cost

VC = variable cost.

Let x equal the number of units at the break-even point, then

Models I and II

$$2.946 + .00069x = 35.330 + .00056x$$

$$.00069x - .00056x = 35.330 - 2.946$$

$$.00013x = 32.384$$

$$x = 2,491,077$$

Models IV and V

$$3.420 + .00064x = 52.941 + .00039x$$

$$.00064x - .00039x = 52.941 - 3.420$$

$$.00025x = 49.521$$

$$x = 198,084$$

Models VII and VIII

$$4.000 + .00088x = 54.421 + .00039x$$

$$.00088x - .00039x = 54.421 - 4,000$$

$$.00049x = 50.421$$

$$x = 102,900$$

Basic Assumptions

The basic cost data for these models was developed from information obtained from equipment suppliers, plant operators, and published reports. It was assumed that adequate space is available for the addition of case stacking equipment.

The efficiency of the models is 80% based on a study by Sharkey (42). The remaining 20% includes the time for maladjustments of the equipment, lack of product, lunch breaks, wash filler and change product, movement of cases to and from fillers, and miscellaneous items.

No remodeling costs are included in the comparison of these models because of the different changes that would be required in each individual plant and the geographic location of the plant.

Interest, insurance, taxes, and maintenance per year are based on the initial cost of the equipment installed. The percentages used would be higher if they were calculated on the basis of the average annual investment.

The depreciation of this type of equipment is based on an estimated economic life of ten years. This estimated life is used by the dairies visited and also was used in the published reports reviewed.

The economic studies reviewed assumed no scrap value. This is due to the fact that it is difficult to estimate the economic life of the equipment. This assumption of no salvage value gives a more conservative production cost estimate.

The daily costs are based on 260 operating days per year, each consisting of eight hour shifts. They were obtained from published reports and equipment suppliers.

RESULTS AND DISCUSSION

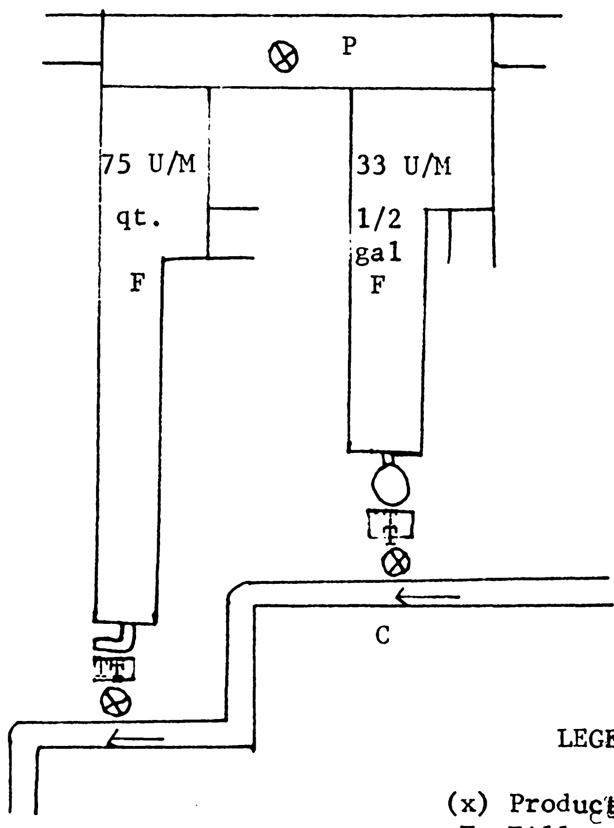
The cost data applied to the models on the following pages are approximate. These cost data would vary depending on the location of the dairy plant.

The break-even point of the comparative models was illustrated by two means. In the first instance, total cost and number of hours were used to determine the number of hours of operation required to break even for the two systems. In the second procedure the cost per unit was used in determining the total output at which the break-even point was obtained. These two methods give the identical break-even point since the cost per unit was determined by multiplying the output rate by the number of hours of operation.

Diagrams I and II illustrate the layouts for Models I and II, respectively, which were earlier described. The cost estimates determined for these models are presented on pages 41, 42, and 44, 45, 46, respectively.

With the introduction of full automation in the casing and stacking operation for this combination of fillers, the work crew was reduced from 3 to 2-1/4 men

DIAGRAM I



LEGEND

(x) Production Personnel
F Fillers
P Platform
T Tables
C Conveyor

SCALE 1/8" = 1 ft.

Cost Estimate of Model I

Investment in Equipment Ready for Operation

9 ft. double chain at $10.00 per ft.[4]	$ 90.00
25 ft. straight conveyor at $35.00 per ft.[4]	875.00
3, 90° turns at $280.00 ea.[3]	840.00
2 case stops at $75.00 ea.[3]	150.00
1, 2-h.p. drive unit with take-up[3]	1,250.00
1 lub. dispenser[3]	90.00
2 tables at $15.00 ea.	30.00
All cost in connection with equipment	$ 3,325.00
Installation cost - 20% of initial investment	665.00
Total equipment investment	$ 3,990.00

Estimate of Annual Fixed Cost of the Operation

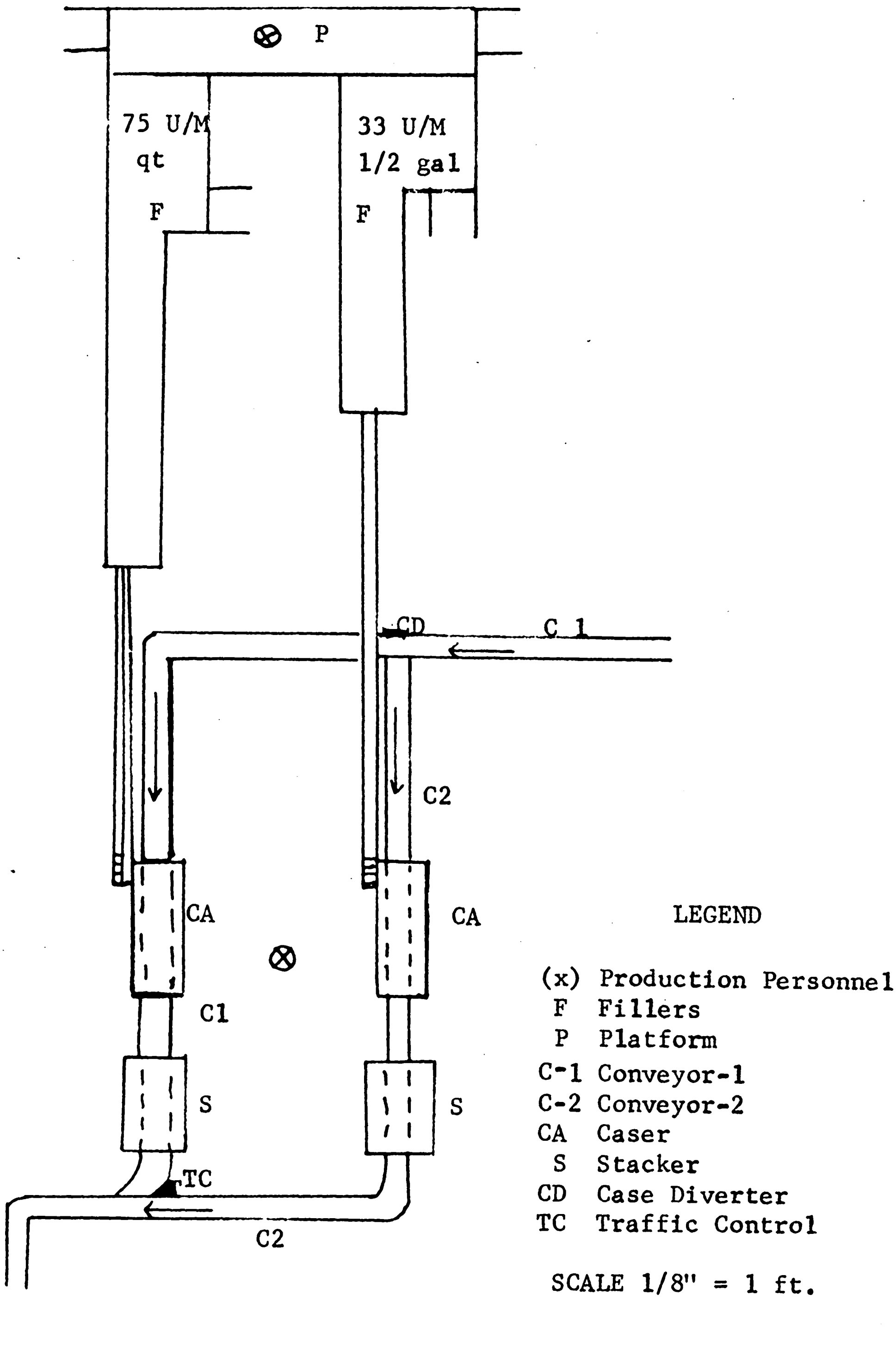
Depreciation - 10 year depreciation life[7]	$ 399.00	
Interest - 3% of initial equipment cost[7]	119.70	
Insurance - 1% of initial equipment cost[7]	39.90	
Taxes - 1.2% of initial equipment cost[7]	47.88	
Maintenance - 4% of initial equipment cost[7]	159.60	
Total annual fixed cost	$ 766.08	
Total daily fixed cost[5]		$ 2.946

Estimate of Hourly Cost of Operation

2 assistant operators at $1.70 per hour	$ 3.400	
2 h.p. electrical requirement for conveyor motors at $0.02 kw-hr[2] (1 h.p. .746w-hr)[6]	.030	
lubricant - $0.125 per hour based on 8 hour day[1]	.125	
Total hourly variable cost		$ 3.555

1. Actual cost value obtained from Cherry-Burrell Corp., Pittsburgh, Penn.
2. Appalachian Power Co., Roanoke, Va.
3. Approximate price quoted by Cherry-Burrell Corp., Cedar Rapids, Iowa.
4. Approximate estimated price quoted by the Planning Department, Pure-Pak Division of Excello Corp., Detroit, Mich.
5. Based on 260 operating days of 8 hour shifts.
6. Farrall, A. W., Dairy Engineering, Second Edition, 1958.
7. The Economic Feasibility of Additional Milk Manufacturing Facilities in North Carolina, Agricultural Economics Information Series No. 99, Department of Agricultural Economics, North Carolina State College, Raleigh, N. C., February 1963.

DIAGRAM II


P
75 U/M
qt
F
33 U/M
1/2 gal
F
CD
C 1
C2
CA
CA
C1
S
S
TC
C2
LEGEND
(x) Production Personnel
F Fillers
P Platform
C-1 Conveyor-1
C-2 Conveyor-2
CA Caser
S Stacker
CD Case Diverter
TC Traffic Control
SCALE 1/8" = 1 ft.

Cost Estimate of Model II

Investment in Equipment Ready for Operation

35 ft. double chain at \$10.00 per ft.[6]	\$ 350.00
47 ft. straight conveyor at \$35.00 per ft.[6]	1,995.00
2 automatic casers at \$10,000.00 ea.[7]	20,000.00
2 automatic stackers at \$4,500.00 ea.[8]	9,000.00
1 conveyor "Y"[4]	500.00
1 conveyor "T"[4]	425.00
3, 90° turns at \$318.00 ea.[4]	954.00
1 traffic control[4]	335.00
1 case diverter[4]	950.00
2, 2-h.p. drive units with take-up at \$1,400.00 ea.[4]	2,800.00
1 central lub. control[4]	375.00
2 lub. dispensers at \$115.00 ea.[4]	230.00
5 bottle conveyor legs at \$38.00 ea.[3]	190.00
33 ft. top track bottle conveyor at \$45.00 per ft.[3]	1,485.00
1, 3/4-h.p. bottle conveyor drive unit[3]	150.00
1 air dryer at 100 cfm at 100 psi 1/3 of \$400.00[5]	133.34
All cost in connection with equipment	\$ 39,872.34
Installation cost - 20% of initial investment	7,974.47
Total equipment investment	\$ 47,846.81

Estimate of Annual Fixed Cost of the Operation

Depreciation - 10 year depreciation life	$ 4,784.681	
Interest - 3% of initial equipment cost[10]	1,435.404	
Insurance - 1% of initial equipment cost[10]	478.468	
Taxes - 1.2% of initial equipment cost[10]	574.162	
Maintenance - 4% of initial equipment cost[10]	1,913.872	
Total annual fixed cost	$ 9,186.587	
Total daily fixed cost[9]		$ 35.333

Estimate of Hourly Cost of Operation

1 assistant operator at $1.70 per hour	$ 1.700	
1/4 maintenance man at $2.10 per hour	.525	
4, 3/4-h.p. electrical requirement for conveyor motors at $0.02 kw-hr[2]	.071	
14 h.p. electrical or equivalent requirement for 2 casers and stackers	.209	
lubricant - $0.125 per hour per system[1]	.250	
drying agent - $0.01 for 18,000 cf air[5]	.003	
clean-up - at $1.70 per hour-4 pieces at 10 minutes per piece ($1.132 per day)	.142	
Total hourly variable cost		$ 2.900

1. Actual cost value obtained from Cherry-Burrell Corp., Pittsburgh, Penn.
2. Appalachian Power Co., Roanoke, Va.
3. Approximate price quoted by Ampro Division of Yorde Machine Products, Columbus, Ohio.
4. Approximate price quoted by Cherry-Burrell Corp., Cedar Rapids, Iowa.
5. Approximate price quoted by Frank Howell Co., Richmond, Va.
6. Approximate price quoted by the Planning Department, Pure-Pak Division of Excello Corp., Detroit, Mich.
7. Average price quoted by four caser manufacturers.
8. Average price quoted by three stacker manufacturers.
9. Based on 260 operating days with 8 hour shifts.
10. The Economic Feasibility of Additional Milk Manufacturing Facilities in North Carolina, Agricultural Economics Information Series No. 99, Department of Agricultural Economics, North Carolina State College, Raleigh, N. C., February 1963.

while investment increased by about $44,000. As a result of these changes fixed costs increased from $2.95 to $35.33 per day. However, variable costs per hour declined from $3.56 to $2.90.

The determination of the break-even point between Models I and II is illustrated in Chart I using the total cost of the operations. The cost per unit is used in Chart II to show the break-even point of these models.

In Charts I and II, the break-even point of the comparative models did not occur within a 24 hour period because the automated equipment operated below its rated capacity in order to synchronize with the lower output of the filling equipment. Operating the equipment at this lower rate for longer hours was not a potential for reducing cost below the cost of the non-automated system since the fixed cost per unit is not reduced sufficiently to obtain a break-even point at this output.

The operating conditions underlying these two models indicate that it was undesirable for the operator of Model I to consider all of the automated equipment used in Model II. There was a .0655-cent cost per unit difference at eight hours of operation

CHART I

Determination of Break Even Point Using Total Cost (TC)
and Fixed Cost (FC) for Models I and II

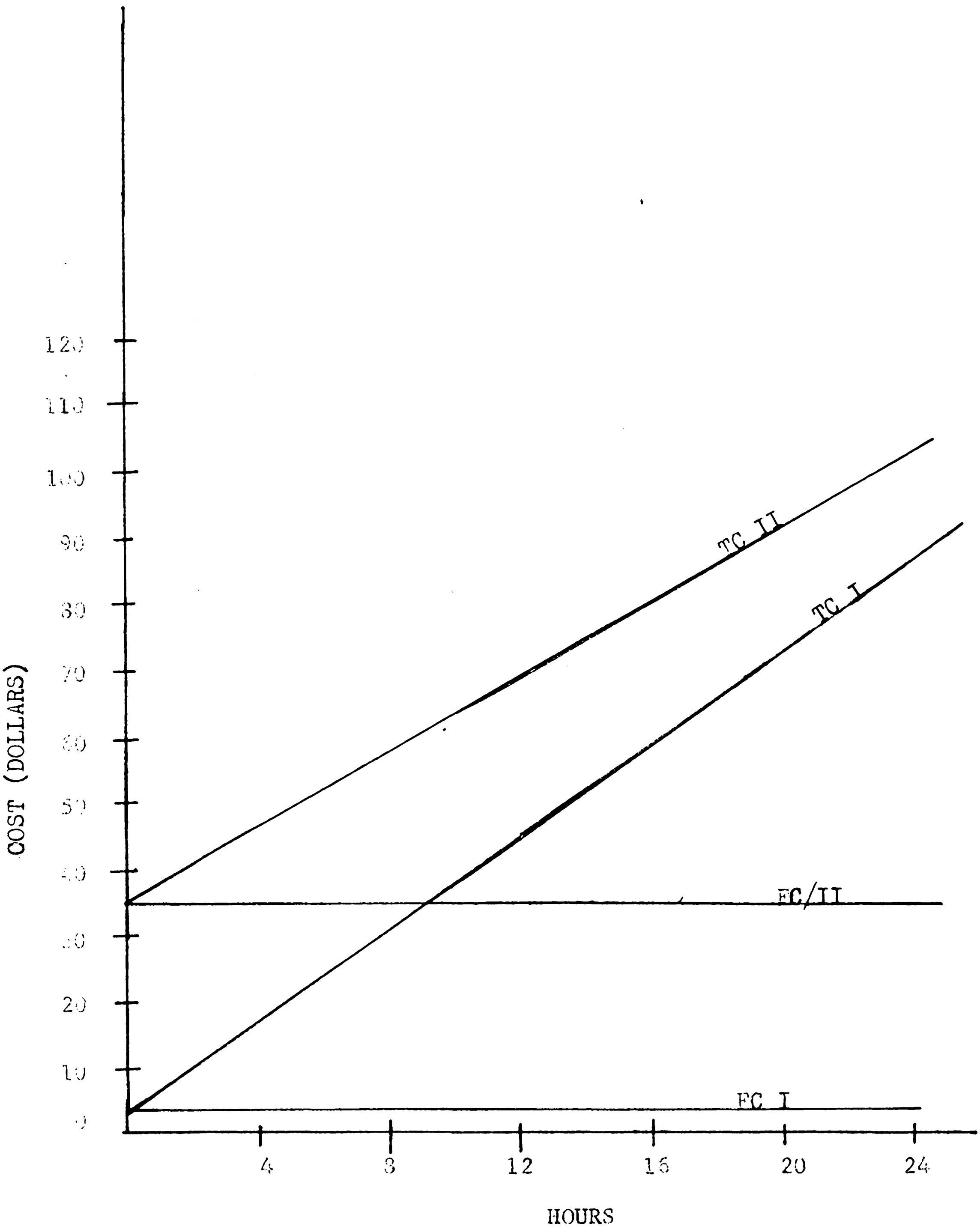
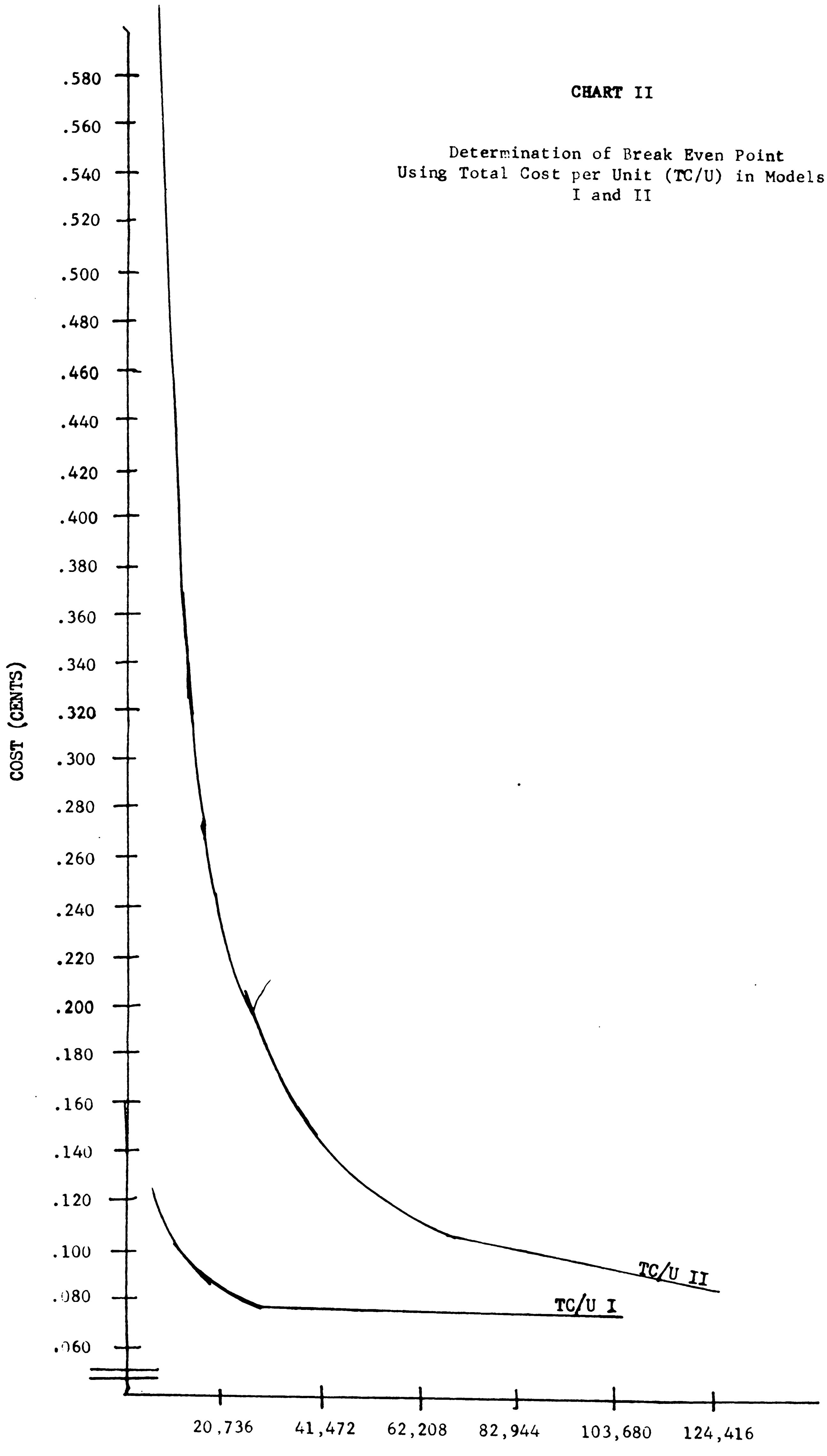


CHART II

Determination of Break Even Point
Using Total Cost per Unit (TC/U) in Models
I and II



and a difference of .0264-cent cost per unit at 16 hours of operation favoring the non-automated model. This does not rule out the desirability for the operator of Model I to consider some of the components of automation to reduce the cost of the casing and stacking phase. The desirability of smaller plants considering partial automation is supported by Ripma (36)(37)(38).

The alternative plans concerning automation for Model I are limited to a plant which has one one-half gallon filling machine and one quart, pint, or one-half pint filling machine. An alternative plan was to install an automatic caser on the 75 units per minute quart, pint, or one-half pint filling machine, but manually case the output of the one-half gallon filling machine. The employee manually casing the units from the one-half gallon filling machine would also be responsible for any malfunctions of the automatic caser.

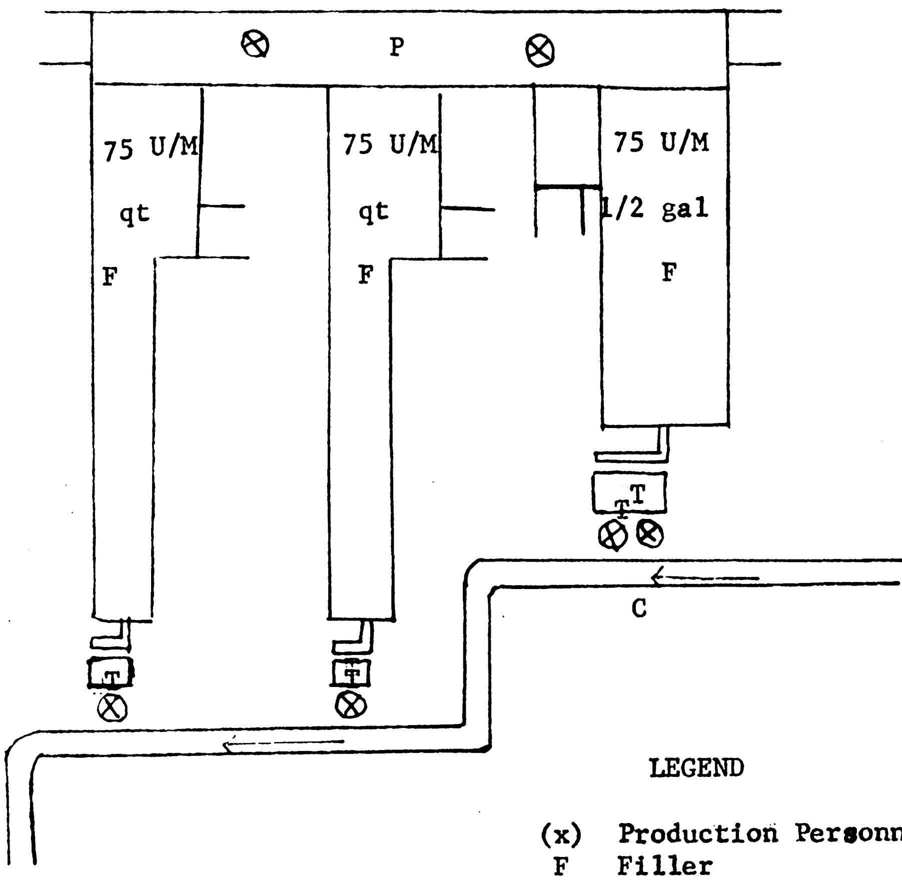
This plan would eliminate one man from the operation in Model I, resulting in one man operating the fillers and one man manually casing the one-half gallon cartons and correcting the maladjustments of the automatic caser. The results in terms of investment would be a $10,000 increase for Model I instead of a $40,000 increase as would occur in Model II with all of the components installed.

This limited automation would bring the break-even point within the range of output a dairy plant of this size could attain. The break-even point of this alternate model would be at 68,146 units. Additional pieces of equipment, such as an additional automatic caser or case stacker, would not be feasible because of the increased equipment investment as compared to Model I. A stacker would result in mixed stacks of cases. Another caser would not reduce the number of employees in the operation.

Diagrams III and IV illustrate the layout for Models IV and V, respectively, which has been described earlier. The cost estimates for these models are shown on pages 53, 54, and 56, 57, 58, respectively.

With the introduction of full automation in the casing and stacking operation for this combination of fillers, the work crew was reduced from 6 to 3-3/4 men while investment increased by about $68,000. As a result of these changes fixed costs increased from $3.42 to $52.94 per day. However, variable costs per hour declined from $6.96 to $4.26.

DIAGRAM III



LEGEND

(x) Production Personnel
F Filler
P Platform
C Conveyor
T Table

SCALE 1/8" = 1 ft.

Cost Estimate of Model IV

Investment in Equipment Ready for Operation

8 ft. double chain at $10.00 per ft.[4]	$	80.00
38 ft. straight conveyor at $35.00 per ft.[4]		1,330.00
3, 90° turns at $280.00 ea.[3]		840.00
1, 2-h.p. drive unit with take-up[3]		1,250.00
1 lub. dispenser[3]		90.00
3 tables at $15.00 ea.		45.00
3 case stops at $75.00 ea.[3]		225.00
All cost in connection with equipment	$	3,860.00
Installation cost - 20% of initial investment		772.00
Total equipment investment	$	4,632.00

Estimate of Annual Fixed Cost of the Operation

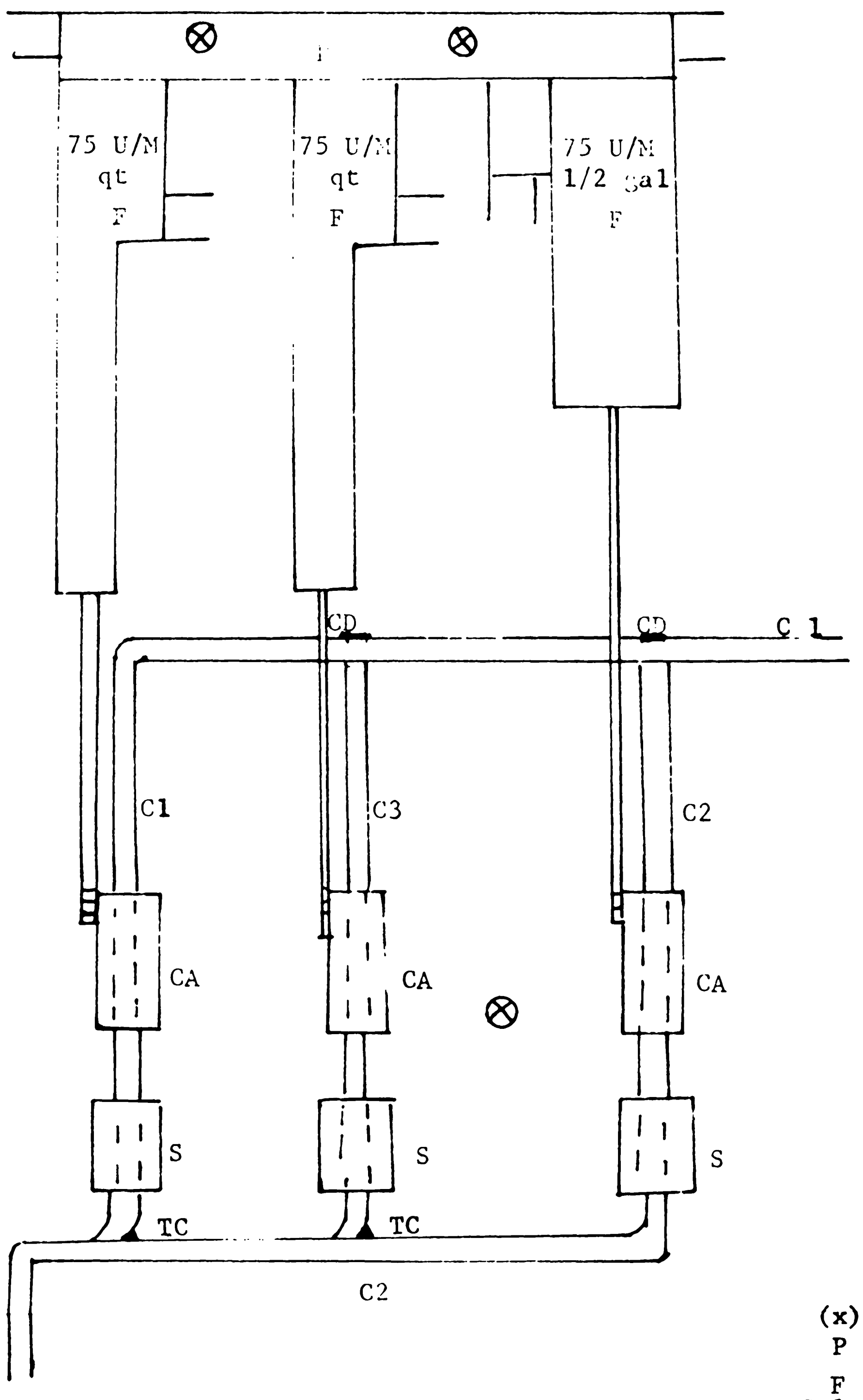
Depreciation - 10 year depreciation life	$	463.20	
Interest - 3% of initial equipment cost[6]		138.96	
Insurance - 1% of initial equipment cost[6]		46.32	
Taxes - 1.2% of initial equipment cost[6]		55.58	
Maintenance - 4% of initial equipment cost[6]		185.28	
Total annual fixed cost	$	889.34	
Total daily fixed cost[5]			$ 3.420

Estimate of Hourly Cost of Operation

4 assistant operators at $1.70 per hour	$ 6.800	
2 h.p. electrical requirement for conveyor motors at $0.02 kw-hr[2]	.030	
lubricant - $0.125 per hour per system[1]	.125	
Total hourly variable cost		$ 6.955

1. Actual cost value from Cherry-Burrell Corp., Pittsburgh, Penn.
2. Appalachian Power Co., Roanoke, Va.
3. Approximate price quoted by Cherry-Burrell Corp., Cedar Rapids, Iowa.
4. Approximate estimated price quoted by the Planning Department, Pure-Pak Division of Excello Corp., Detroit, Mich.
5. Based on 260 operating days of 8 hour shifts.
6. The Economic Feasibility of Additional Milk Manufacturing Facilities in North Carolina, Agricultural Economics Information Series No. 99, Department of Agricultural Economics, North Carolina State College, Raleigh, N. C., February 1963.

DIAGRAM IV



LEGEND

(x) Production Personnel
P Platform
F Filler
C-1 Conveyor-1
C-2 Conveyor-2
C-3 Conveyor-3
CA Caser
S Stacker
CD Case Diverter
TC Traffic Control

SCALE 1/8" = 1 ft.

Cost Estimate of Model V

Investment in Equipment Ready for Operation

53 ft. double chain at $10.00 per ft.[6]	$ 530.00
85 ft. straight conveyor at $35.00 per ft.[6]	2,975.00
3 automatic casers at $10,000.00 ea.[7]	30,000.00
3 automatic stackers at $4,500.00 ea.[8]	13,500.00
2 conveyor "Y"'s at $500.00 ea.[4]	1,000.00
2 conveyor "T"'s at $425.00 ea.[4]	850.00
3, 90° turns at $318.00 ea.[4]	954.00
2 case diverters at $950.00 ea.[4]	1,900.00
2 case traffic controls at $335.00 ea.[4]	670.00
1, 1-h.p. drive unit with take-up[4]	1,260.00
2, 2-h.p. drive units with take-up at $1,310.00 ea.[4]	2,620.00
1 central lub. control[4]	375.00
3 lub. dispensers at $115.00 ea.[4]	345.00
47 ft. top track bottle conveyor at $45.00 per ft.[3]	2,115.00
1, 3/4-h.p. bottle conveyor drive unit[3]	150.00
7 bottle conveyor legs at $38.00 ea.[3]	266.00
1 air dryer - 250 cfm at 100 psi 1/3 of $700.00[5]	233.34
All cost in connection with equipment	$ 59,743.34
Installation cost - 20% of initial investment	11,948.67
Total equipment investment	$ 71,692.01

Estimate of Annual Fixed Cost of the Operation

Depreciation - 10 year depreciation life	$ 7,169.201	
Interest - 3% of initial equipment cost[10]	2,150.760	
Insurance - 1% of initial equipment cost[10]	716.920	
Taxes - 1.2% of initial equipment cost[10]	860.304	
Maintenance - 4% of initial equipment cost[10]	2,867.680	
Total annual fixed cost	$ 13,764.865	
Total daily fixed cost[9]		$ 52.941

Estimate of Hourly Cost of Operation

1 assistant operator at $1.70 per hour	$ 1.700	
3/4 maintenance man at $2.10 per hour	1.575	
5, 3/4-h.p. electrical requirement for conveyor motors at $0.02 kw-hr.[2]	.086	
21 h.p. electrical or equivalent requirement for 3 casers and stackers	.313	
lubricant - $0.125 per hour per system[1]	.375	
drying agent - $0.01 for 18,000 cf air[5]	.004	
clean-up at $1.70 per hour-6 pieces at 10 minutes per piece	.212	
Total hourly variable cost		$ 4.265

1. Actual cost value obtained from Cherry-Burrell Corp., Pittsburgh, Penn.
2. Appalachian Power Co., Roanoke, Va.
3. Approximate price quoted by the Ampro Division of Yorde Machine Products, Columbus, Ohio.
4. Approximate price quoted by Cherry-Burrell Corp., Cedar Rapids, Iowa.
5. Approximate price quoted by the Frank Howell Co., Richmond, Va.
6. Approximate price quoted by the Planning Department, Pure-Pak Division of Excello Corp., Detroit, Mich.
7. Average price quoted by four caser manufacturers.
8. Average price quoted by three stacker manufacturers.
9. Based on 260 operating days with 8 hour shifts.
10. The Economic Feasibility of Additional Milk Manufacturing Facilities in North Carolina, Agricultural Economics Information Series No. 99, Department of Agricultural Economics, North Carolina State College, Raleigh, N. C., February 1963.

It was observed that the break-even point of Models IV and V occurred at 18-1/2 hours of operation based on an eight hour shift with no overtime. If Model V was considered at 16 hours of operation, there would be a cost difference of .0373-cent cost per unit favoring Model IV. If the models were operated 22 hours per day, there would be a .0407-cent cost difference per unit favoring Model V.

The break-even point of 18-1/2 hours would be difficult for many dairy operators to obtain. Plants operating within the range of 16 to 20 hours per day might find overtime pay for the extra hours a more acceptable alternative. If overtime was paid for all hours worked in addition to 16 hours per day, a new break-even point would be obtained. The new break-even point would occur at a lower output since the overtime pay would have a greater impact on Model IV than Model V.

An alternate plan of automation for Model IV would be the illustration of the type supported by Craumer (17). In this plan, two of the 75 units per minute quart, pint, or one-half pint filling machines supplied cartons for an automatic caser and stacker.

CHART III

Determination of Break Even Point Using
Total Cost (TC) and Fixed Cost (FC)
For Models IV and V

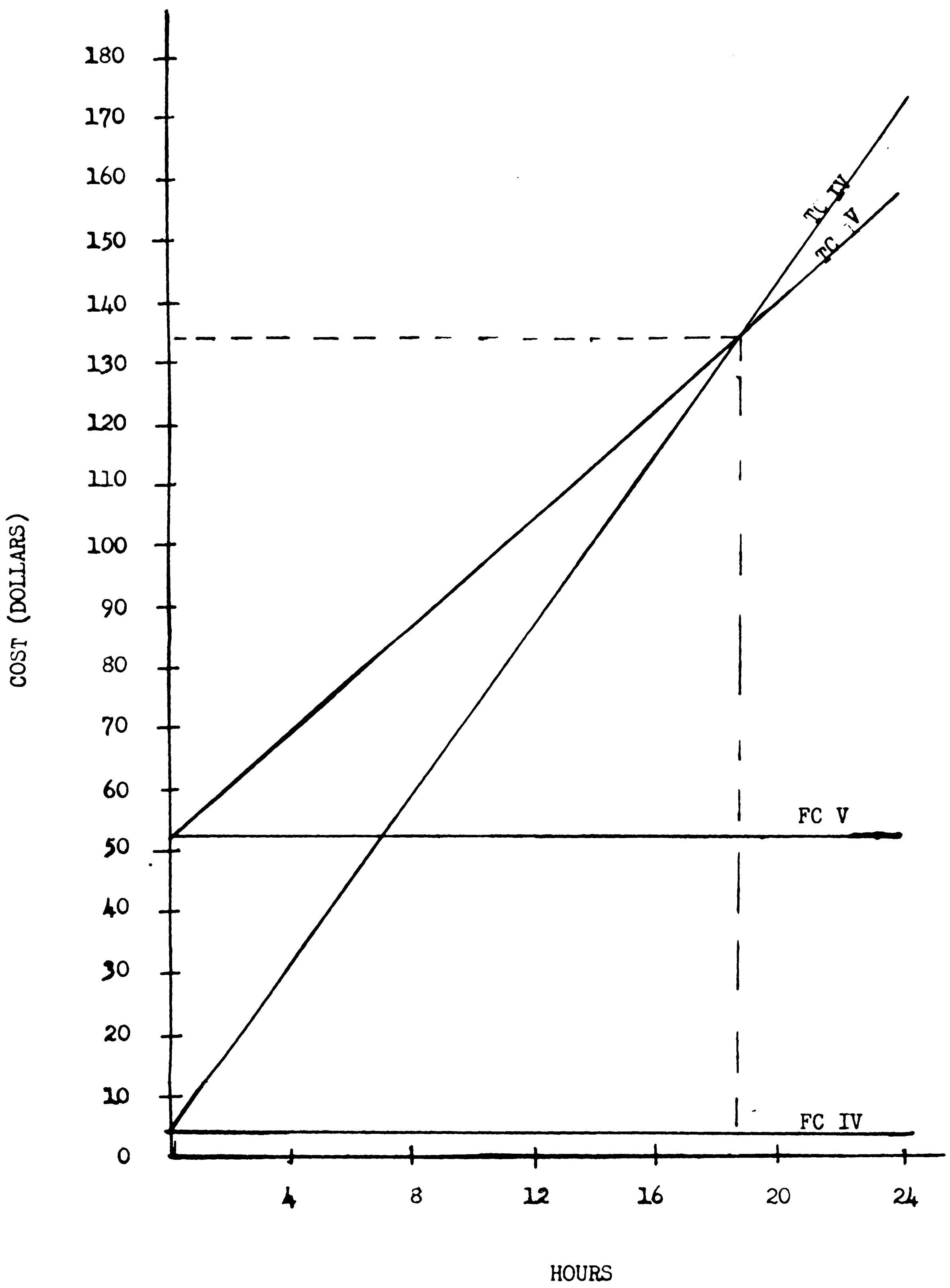
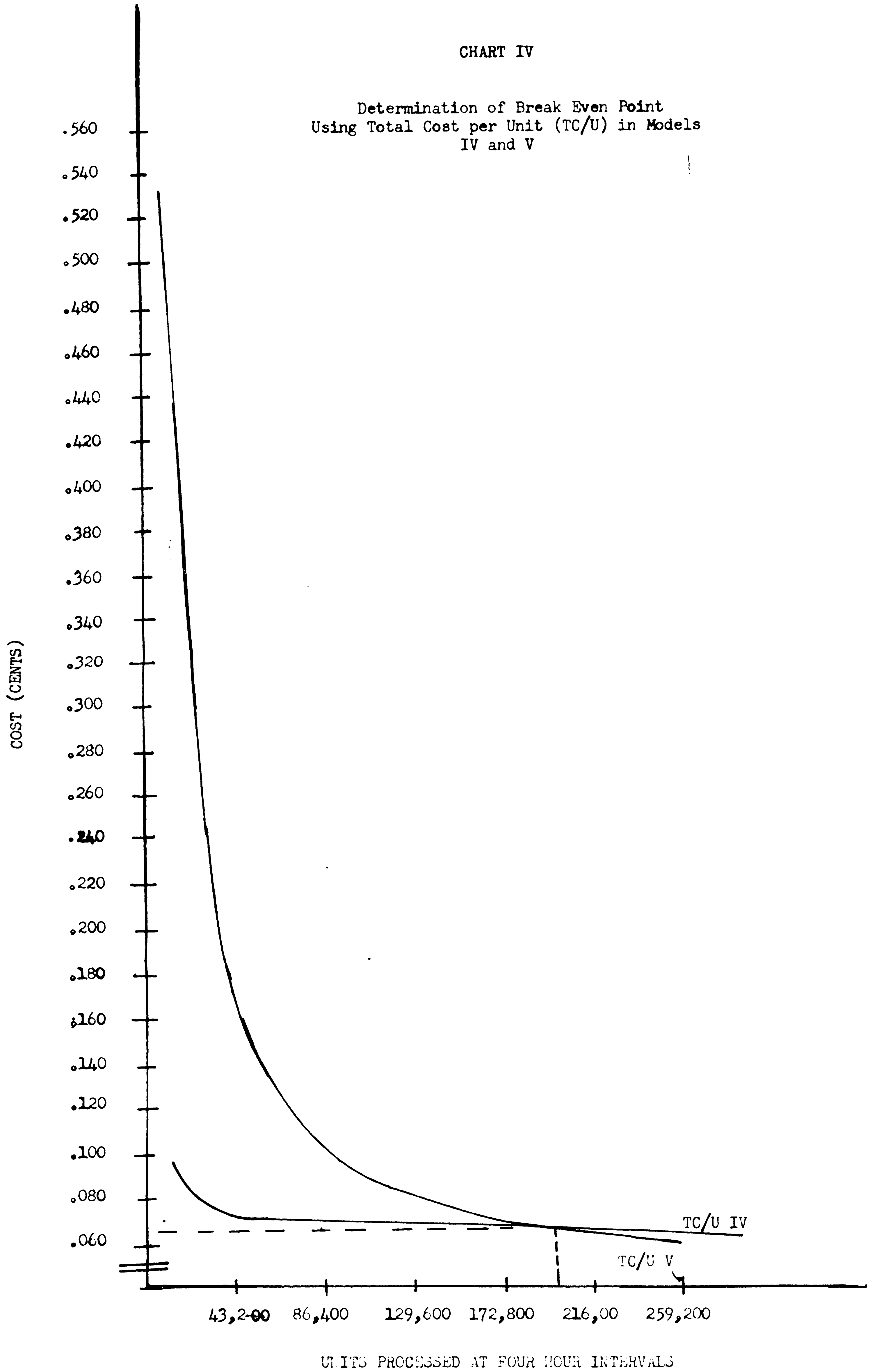


CHART IV

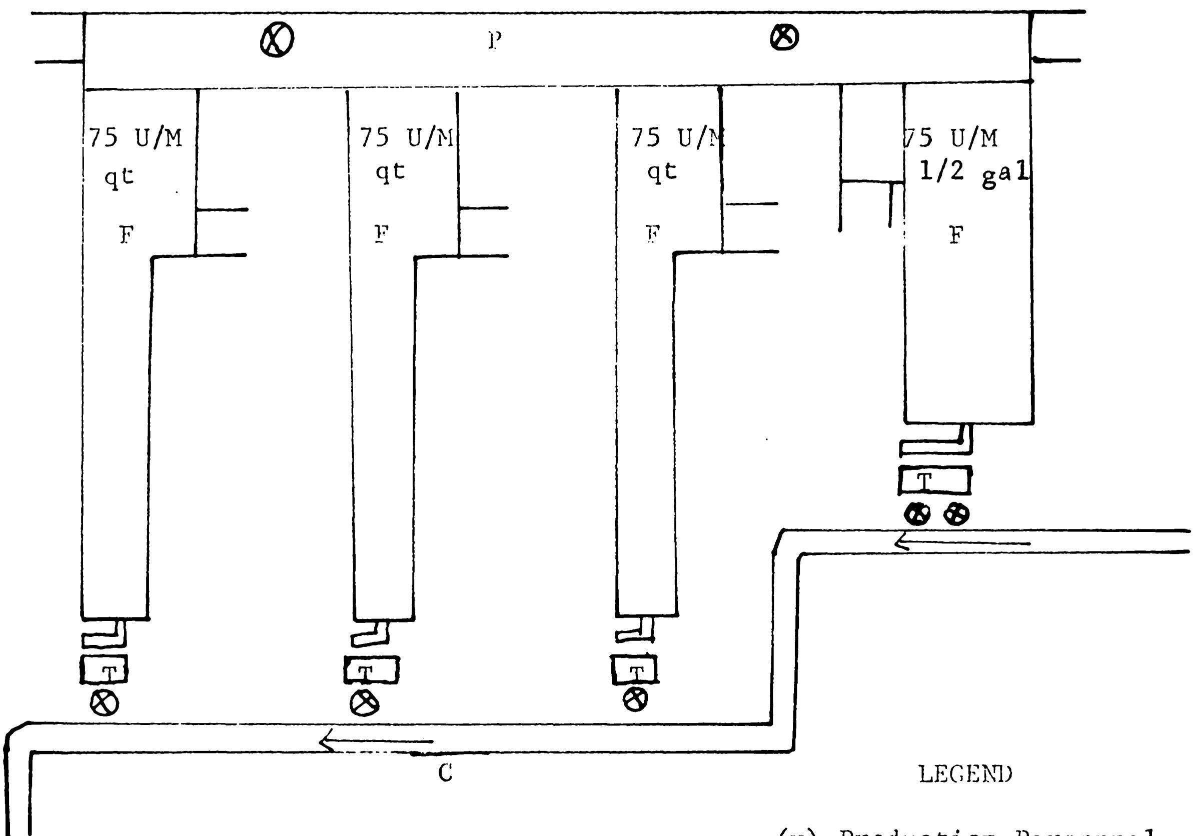
Determination of Break Even Point
Using Total Cost per Unit (TC/U) in Models
IV and V



The one-half gallon filler supplied cartons for another automatic caser and stacker. The processing schedule of the operation was planned so the two fillers supplying one automatic caser and stacker would fill the same size unit of the same product the major portion of the day. When the two fillers were used to fill cartons with different products, the casing operator would manually case and stack cartons utilizing a casing aid at one of the two fillers. He would also be responsible for eliminating the malfunctions of the two casers and with assistance from one of the filler operators to eliminate any major malfunctions which might occur. The plan would result in the employment of the same number of men as in Model V, but at a lower equipment investment of about $10,000. The new break-even point would be at an output of 175,760 units or slightly more than 16 hours of operation.

Diagrams V and VI illustrate the layouts for Models VII and VIII, respectively, which was explained earlier. The costs for these models are presented on pages 64, 65, and 67, 68, 69, respectively.

DIAGRAM V



LEGEND

(x) Production Personnel
P Platform
F Filler
T Table
C Conveyor

Cost Estimate of Model VII

Investment in Equipment Ready for Operation

9 ft. double chain at $10.00 per ft.[4]	$	90.00
51 ft. straight conveyor at $35.00 per ft.[4]		1,785.00
3, 90° turns at $280.00 ea.[3]		840.00
4 case stops at $75.00 ea.[3]		300.00
1, 3-h.p. drive unit with take-up[3]		1,260.00
1 lub. dispenser[3]		190.00
4 tables at $15.00 ea.		60.00
All cost in connection with equipment	$	4,525.00
Installation cost - 20% of initial investment		905.00
Total equipment investment	$	5,430.00

Estimate of Annual Fixed Cost of the Operation

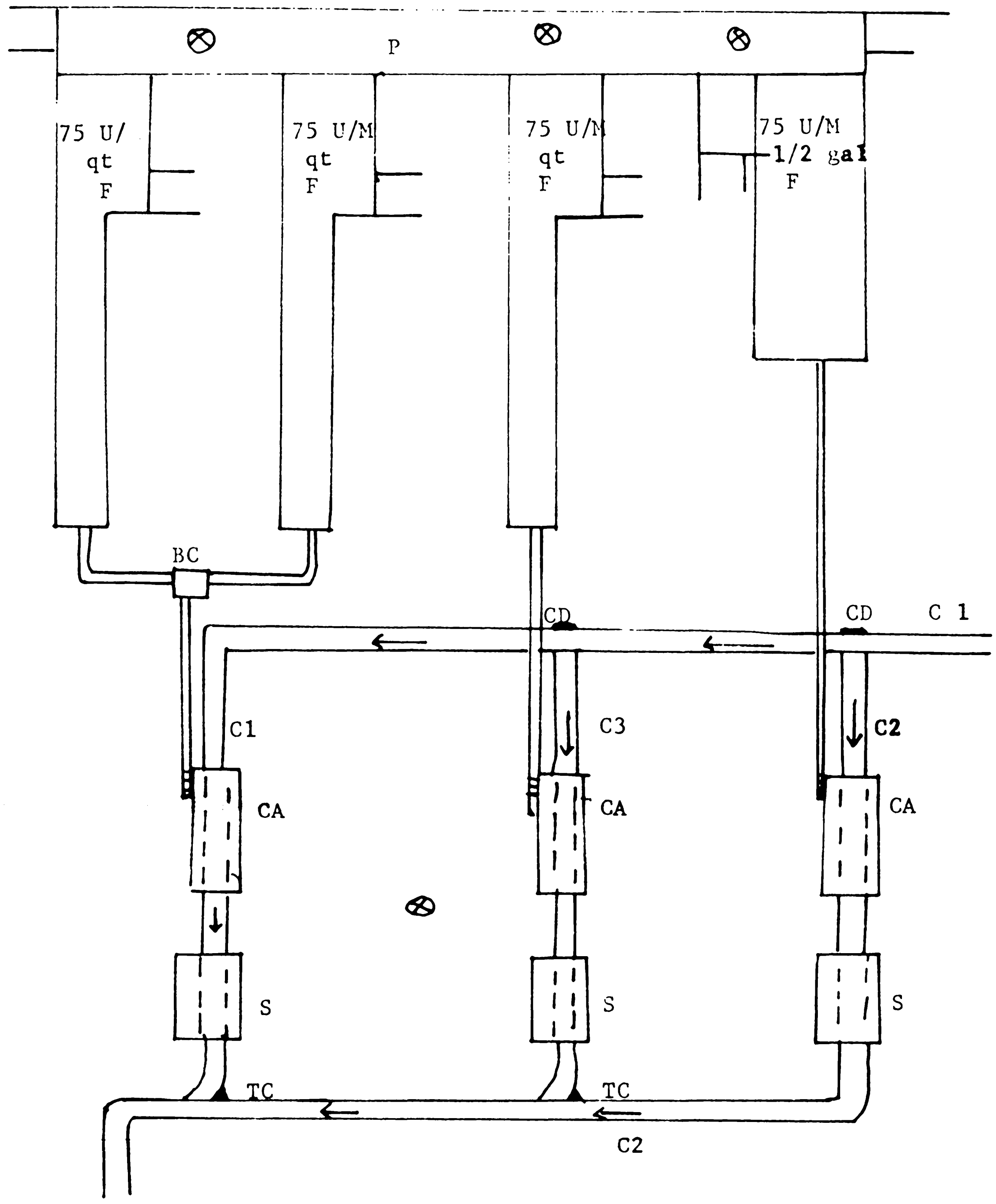
Depreciation - 10 year depreciation life	$	543.00	
Interest - 3% of initial equipment cost[6]		162.90	
Insurance - 1% of initial equipment cost[6]		54.30	
Taxes - 1.2% of initial equipment cost[6]		65.16	
Maintenance - 4% of initial equipment cost[6]		217.20	
Total annual fixed cost	$	1,042.56	
Total daily fixed cost[5]			$ 4.000

Estimate of Hourly Cost of Operation

5 assistant operators at $1.70 per hour	$ 8.500	
3 h.p. electrical requirement for conveyor motors at $0.02 kw-hr[2]	.045	
lubricant - $0.125 per hour per system[1]	.125	
Total hourly variable cost		$ 8.670

1. Actual cost value obtained from Cherry-Burrell Corp., Pittsburgh, Penn.
2. Appalachian Power Co., Roanoke, Va.
3. Approximate price quoted by Cherry-Burrell Corp., Cedar Rapids, Iowa.
4. Approximate estimated price quoted by the Planning Department, Pure-Pak Division of Excello Corp., Detroit, Mich.
5. Based on 260 operating days of 8 hour shifts.
6. The Economic Feasibility of Additional Milk Manufacturing Facilities in North Carolina, Agricultural Economics Information Series No. 99, Department of Agricultural Economics, North Carolina State College, Raleigh, N. C., February 1963.

DIAGRAM VI



LEGEND

(x) Production Personnel
P Platform
F Filler
C-1 Conveyor-1
C-2 Conveyor-2
C-3 Conveyor-3
CA Caser
S Stacker
BC Bottle Combiner
CD Case Diverter
TC Traffic Control

SCALE 1/8" = 1 ft.

Cost Estimate of Model VIII

Investment in Equipment Ready for Operation

60 ft. double chain conveyor at $10.00 per ft.[6]	$ 600.00
95 ft. straight conveyor at $35.00 per ft.[6]	3,325.00
3, 90° turns at $318.00 ea.[4]	954.00
2 conveyor "Y"'s at $500.00 ea.[4]	1,000.00
2 conveyor "T"'s at $425.00 ea.[4]	850.00
2 case diverters at $950.00 ea.[4]	1,900.00
2 case traffic controls at $335.00 ea.[4]	670.00
1, 1-h.p. drive unit with take-up[4]	1,260.00
2, 2-h.p. drive units with take-up at $1,310.00 ea.[4]	2,620.00
1 central lub. control[4]	375.00
3 lub. dispensers at $115.00 ea.[4]	345.00
3 automatic casers at $10,000.00 ea.[7]	30,000.00
3 automatic stackers at $4,500.00 ea.[8]	13,500.00
1, 3/4-h.p. bottle combiner[6]	550.00
1, 3/4-h.p. bottle conveyor drive unit[3]	150.00
58 ft. top track bottle conveyor at $45.00 per ft.[3]	2,610.00
2, 90° bottle conveyor turns at $45.00 ea.[3]	90.00
10 bottle conveyor legs at $38.00 ea.[3]	380.00
1 air dryer - 250 cfm at 100 psi 1/3 of $700.00[5]	233.34
All cost in connection with equipment	$ 61,412.34
Installation cost - 20% of initial investment	12,282.47
Total equipment investment	$ 73,694.81

Estimate of Annual Fixed Cost of the Operation

Depreciation - 10 year depreciation life	\$ 7,369.481	
Interest - 3% of initial equipment cost[10]	2,210.844	
Insurance - 1% of initial equipment cost[10]	736.948	
Taxes - 1.2% of initial equipment cost[10]	884.337	
Maintenance - 4% of initial equipment cost[10]	2,947.792	
Total annual fixed cost	\$ 14,149.402	
Total daily fixed cost		\$ 54.421

Estimate of Hourly Cost of Operation

1 assistant operator at \$1.70 per hour	\$ 1.700	
1 maintenance man at \$2.10 per hour	2.100	
6, 1/2-h.p. electrical requirement for conveyor motors at \$0.02 kw-hr[2]	.970	
21 h.p. electrical or equivalent requirement for 3 casers and stackers	.313	
lubricant - \$0.125 per hour per system[1]	.375	
drying agent - \$0.01 for 18,000 cf air[5]	.004	
clean-up at \$1.70 per hour - 6 pieces at 10 minutes per piece	.212	
Total hourly variable cost		\$ 5.674

1. Actual cost value obtained from Cherry-Burrell Corp., Pittsburgh, Penn.
2. Appalachian Power Co., Roanoke, Va.
3. Approximate price quoted by the Ampro Division of Yorde Machine Products, Columbus, Ohio.
4. Approximate price quoted by Cherry-Burrell Corp., Cedar Rapids, Iowa.
5. Approximate price quoted by Frank Howell Co., Richmond, Va.
6. Approximate price quoted by the Planning Department, Pure-Pak Division of Excello Corp., Detroit, Mich.
7. Average price quoted by four caser manufacturers.
8. Average price quoted by three stacker manufacturers.
9. Based on 260 operating days with 8 hour shifts.
10. The Economic Feasibility of Additional Milk Manufacturing Facilities in North Carolina, Agricultural Economics Information Series No. 99, Department of Agricultural Economics, North Carolina State College, Raleigh, N. C., February 1963.

With the introduction of full automation in the casing and stacking operation for this combination of fillers, the work crew was reduced from eight to five men, while investment increased by about $68,000. As a result of these changes, fixed costs increased from $4.00 to $54.42 per day. However, variable costs per hour declined from $12.67 to $5.67.

It is shown on Charts V and VI that the break-even point of these models was at some point above seven hours of operation per day. This corresponds to an output of 102,900 units with a cost of about .092 cents per unit. The cost difference between these two models would be .0097 cents per unit at six hours of operation in favor of Model VII. If the models were operated 12 hours, there would be a cost difference of .0195 cents per unit favoring Model VIII. The total cost of Model VII increased at a more rapid rate than for the other models using manual casing and stacking because of the increased number of employees required. When the equipment was operated near its rated capacity for a reasonable period of time, as in Model VIII, even though the fixed cost was quite high, the unit cost was reasonably low.

CHART V

Determination of Break Even Point
Using Total Cost (TC) and Fixed
Cost (FC) for Models VII and VIII

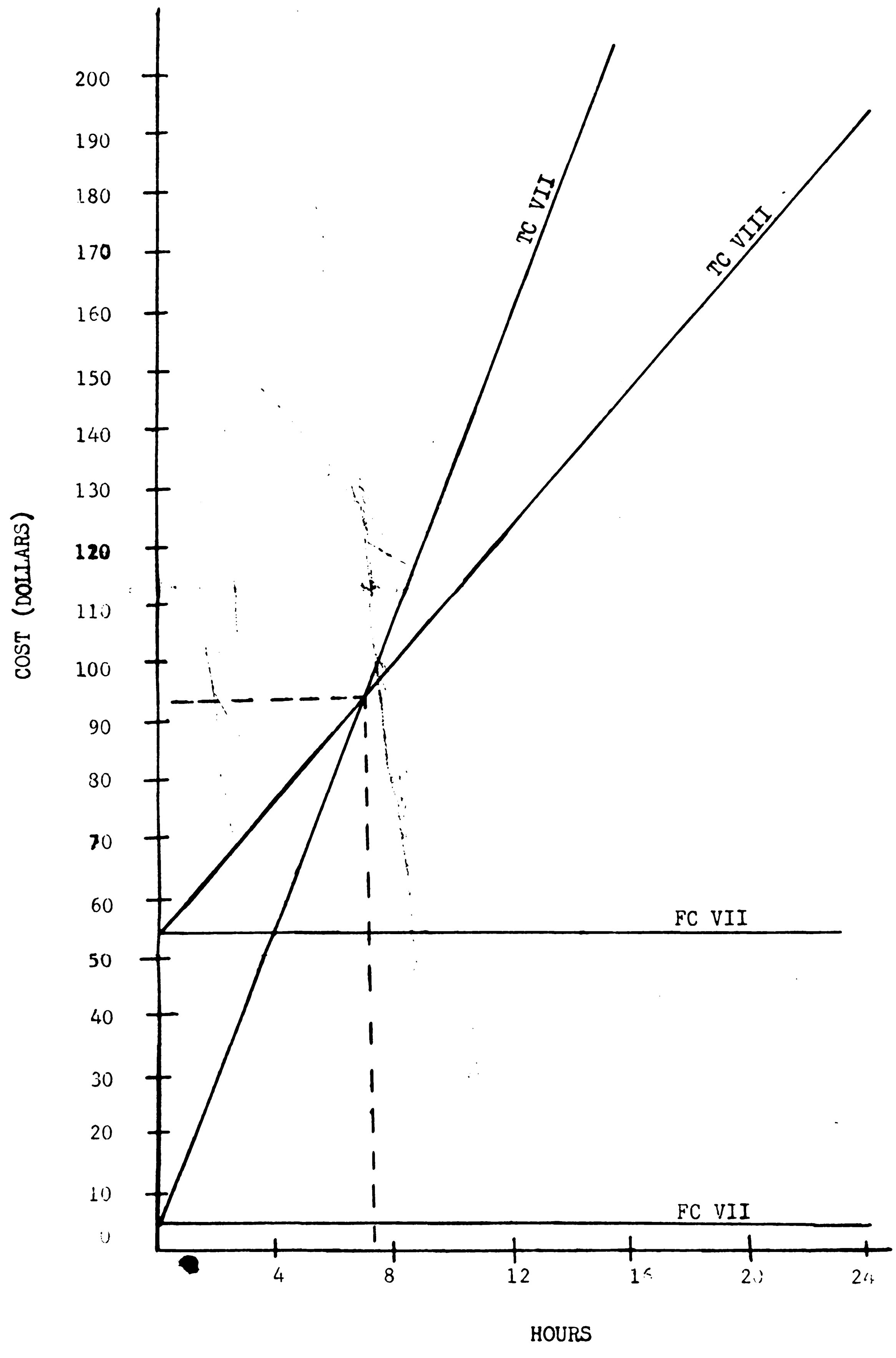
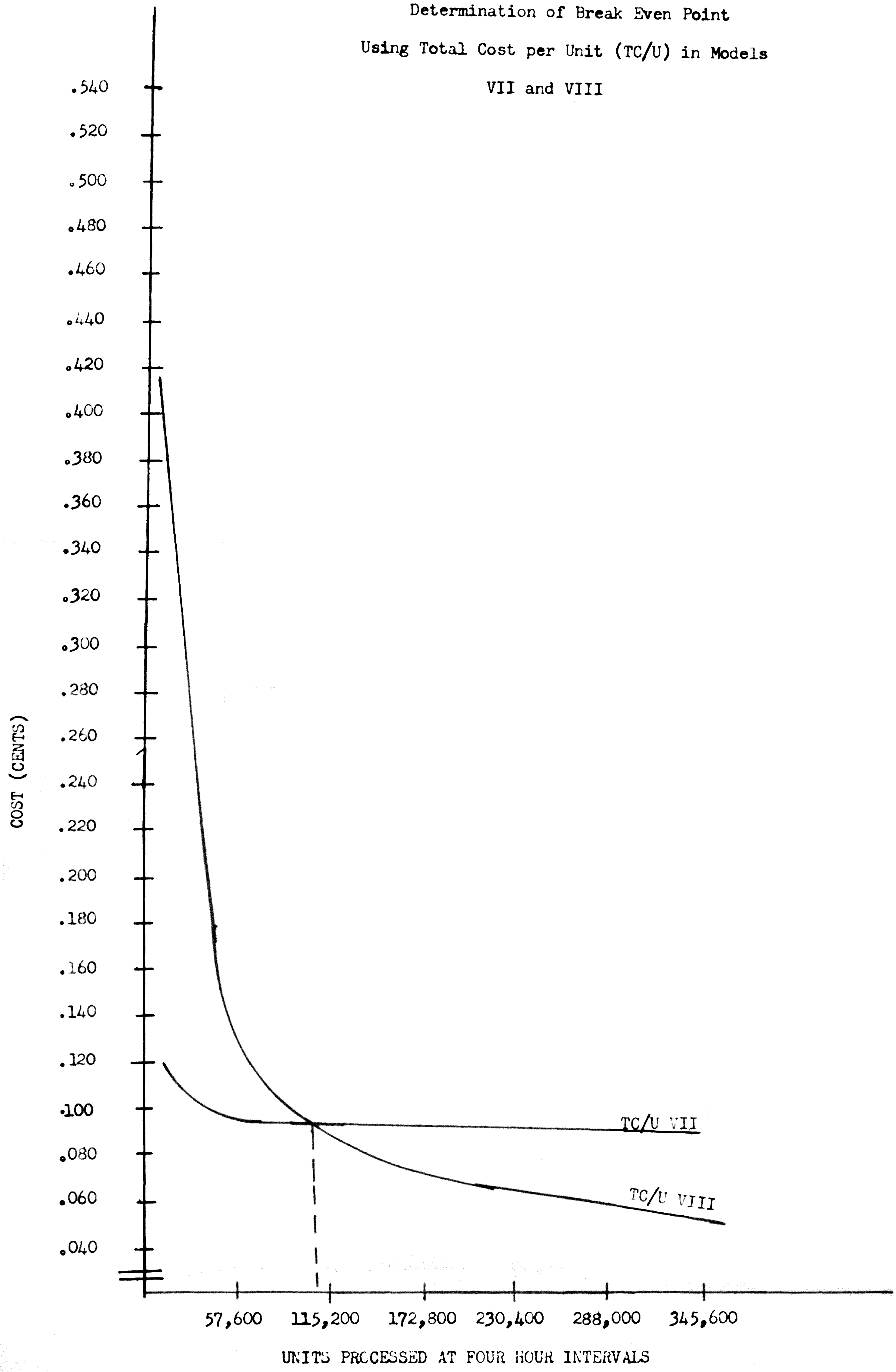


CHART VI

Determination of Break Even Point

Using Total Cost per Unit (TC/U) in Models

VII and VIII



In this illustration it was advisable for the operator to install the automated equipment if the equipment operated at or above seven hours per day.

SUMMARY AND CONCLUSIONS

The objective of this study was to determine the potential for reducing costs in milk plants by automation of the casing and stacking phase. As a basis for analysis in this study, three combinations of filling equipment were assumed and two models of the casing and stacking phases were constructed for each combination, one a manual operation, the other automated. The first combination was composed of two filling machines, one a quart filler, the other, a one-half gallon filler. The second filler combination consisted of two quart fillers and one one-half gallon filler. The final combination for which models were constructed, included three quart fillers and one one-half gallon filler.

A break-even point for Models I and II, which were associated with the two-filler combination, was not reached within a 24 hour operating period. This was an indication that it would be undesirable for the operator of Model I to consider all of the automated equipment used in Model II.

Under the conditions assumed for the automated model, an increased investment of $44,000 would result.

This would cause a cost difference of $7,058.22 per year based on an eight hour operating day in favor of the non-automated model. If the models were operated 16 hours per day, there would be a cost difference of $6,461.78 per year favoring the non-automated model.

An alternate plan of automation for Model I was the installation of an automatic caser on the quart filling machine, with manual casing and stacking of the units from the one-half gallon filling machine. This plan would result in a new break-even point at 64,146 units. It would also employ one less person than Model I with an equipment investment of only $10,000 more than Model I.

The break-even point for Models IV and V, illustrating the casing and stacking for the three filler combination, occurred at 198,084 units or at 18-1/2 hours of operation. This break-even point would be difficult for many dairy operators to obtain unless they were operating nearly 24 hours per day. The annual operating cost of the automated model would exceed the non-automated model by $7,280.26 when operated eight hours per day, or $1,685.06 per year when operated 16 hours per day.

An alternate plan using limited automation would provide for combining the output from the two quart filling machines so as to be cased and stacked by one automatic caser and stacker, and installing another automatic caser and stacker to handle the output of the one-half gallon filling machine. This would result in a new break-even point at 175,760 units or slightly more than 16 hours of operation with an increase of approximately $50,000 equipment investment instead of a $68,000 equipment investment as in Model V.

The break-even point of Models VII and VIII which were associated with the final combination of filling equipment occurred at 102,900 units or slightly above seven hours of operation. Compared to the non-automated model, there would be an operating cost savings of $1,440.92 annually based on an eight hour operating day, or $15,993.90 annually on a 16 hour day if all of the automated equipment were installed as in Model VIII.

It is apparent for these models that cost savings are not likely to be obtained by full automation within a reasonable length of time per operating day unless the casing and stacking equipment is utilized near its rated capacity.

ACKNOWLEDGMENTS

The author wishes to thank , head of the Department of Dairy Science, for the use of equipment and materials and for his helpful suggestions throughout the graduate program.

Sincere appreciation is expressed to his major professor, for his direction and guidance throughout the course of the graduate program. Without his invaluable criticisms, the preparation of this manuscript would have been impossible.

The author wishes to express his gratitude to and for their helpful criticisms and encouragement in the preparation of this manuscript.

The writer is grateful to:

and for their assistance in evaluating the models used in this study.

The author wishes to thank:

and for making

their company's equipment specifications available for use in this thesis.

He is very grateful to his father, for his advice throughout the graduate program.

The author wishes to acknowledge his wife, , and his mother, , for their encouragement during the graduate program.

He is also grateful to for typing the final manuscript and to for reproducing the diagrams and charts; and to a number of the other persons who have contributed toward the successful completion of this work.

BIBLIOGRAPHY

1. Allinson, W. L. Modernization of a 35,000 Gallon-per-day Milk Plant, 1962 Milk Foundation Convention Proceedings-Plant Section, p. 24, October 1962.

2. Anderson, P. J. Conveyor and Pallet Loader Cuts Handling 80%, Factory Management and Maintenance, 112, 2:98 1954.

3. Anonymous. Automatic Bottle Casing-By Air, Milk Dealer, 47, 4:46 1958.

4. Anonymous. Automatic Casing of Milk in Half-Gallon Paper Containers, Milk Dealer, 44, 1:66 1954.

5. Anonymous. Case Stackers that Really Stack Up, Milk Dealer, 47, 9:53 1958.

6. Anonymous. Automation for a Medium-Sized Dairy, American Milk Review, 23, 6:32 1961.

7. Anonymous. Automation for Special Milk Plants, Agricultural Marketing, 8, 1:8 1963.

8. Anonymous. Automation in Ice Cream Production at Boston Plant of H. P. Hood and Sons, Southern Dairy Products Journal, 68, 9:40 1960.

9. Anonymous. How to Get Exactly What You Need in Automatic Control Systems, Factory, 117, 3:70 1959.

10. Anonymous. How Much Can Industry Automate?, Factory Management and Maintenance, 117, 3:124 1959.

11. Anonymous. New Approach to Plant Efficiency, American Milk Review, 23, 2:66 1961.

12. Anonymous. Personnel Cost and Labor Efficiency, Southern Dairy Products Journal, 69, 3:27 1961.

13. Auerback, H. M. For Rent-Long Term Money, Milk Dealer, 50, 3:139 1961.

14. Bedford, J. How to Save Tax Dollars With New Depreciation Guidelines, Southern Dairy Products Journal, 73, 1:44 1963.

15. Bittel, L. R. How You Can Sell Modernization Ideas Up the Line, Factory Management and Maintenance, 116, 11:100 1958.

16. Bittel, L. R., Melden, M. G., and Rice, R. S. Practical Automation, 1957.

17. Craumer, W. A. Automatic Casing-By Vacuum, Milk Dealer, 48, 1:46 1958.

18. Hall, C. W. Automation for the Dairy Plant, Department of Agricultural Engineering, Michigan State University, Proceedings of 10th Annual National Dairy Engineering Conference-Michigan State University, 10:6, February 1962.

19. Hoodes, D. Pinpointing Soft Spots in Costs, Factory, 117, 4:68 1959.

20. Hollinger, M. E. Automation, Southern Dairy Products Journal, 68, 8:20 1960.

21. Johnson, G. E. Better Decisions on Mechanizing, Factory, 117, 7:62 1959.

22. Johnson, G. R. Evaluating Materials Handling Techniques, American Milk Review, 24, 9:32 1962.

23. Juhrent, E. F. Demand Goes Up for Case Stackers, Milk Plant Monthly, 45, 9:14 1956.

24. Kiser, Mose. How We Streamlined Our Operation to Meet Rising Production Costs, Southern Dairy Products Journal, 70, 2:36 1962.

25. Kiser, W. R. Personnel Development in the Dairy Plant, Southern Dairy Products Journal, 69, 2:29 1961.

26. Kiser, W. R. Talk presented at the Dairy Manufacturing Conference, Virginia Polytechnic Institute, May 7, 1963.

27. Kluger, M. J., and Myrick, N. How to Use the Break-Even Point, American Milk Review, 19, 2:24 1957.

28. Lager, E. W. Taking the Mystery Out of Leasing-Part I, Milk Dealer, 50, 5:30 1961.

29. ibid. 50, 6:44 1961.

30. Meade, G. A. Automatic Casing....Versatile-Economic-Dependable, Milk Dealer, 49, 4:42 1960.

31. Merlin, D. Operations Speed Up with Automatic Caser, Milk Dealer, 48, 5:42 1959.

32. Moski, B. A., Jr. Cost Control Fundamentals, Factory Management and Maintenance, 106, 9:132 1948.

33. Muther, R. Getting Your Best Plant Layout, Factory, 117, 8:69 1959.

34. Nelson, J. P. Guidelines to Automation, Presented at the Dairy Plant Management Conference, Virginia Polytechnic Institute, May 16, 1961.

35. Peake, B. T., and Jones, C. I. Leasing Equipment for the Dairy Plant, Southern Dairy Products Journal, 69, 1:46 1961.

36. Ripma, G. G. Automation for the Medium Size Plant, Cherry-Burrell Corp., Products Sales Manager, Package Handling, Cedar Rapids, Iowa.

37. Ripma, G. G. Automation for the Small and Medium Plant, Southern Dairy Products Journal, 70, 5:52 1962.

38. Ripma, G. G. Step by Step Mechanization, Cherry-Burrell Corp., Product Sales Manager, Package Handling, Cedar Rapids, Iowa.

39. Roy, O. J. How to Automate Step by Step, Factory Management and Maintenance, 114, 7:140 1956.

40. Saal, H. 500,000 Pounds a Day Through Automation, American Milk Review, 24, 9:26 1962.

41. Schultze, R. B. How to Get the Most Out of Dollars Available for New Equipment, Factory Management and Maintenance, 110, 1:106 1952.

42. Sharkey, R. P. A Study of Labor Efficiency and Product Control, Southern Dairy Products Journal, 69, 4:33 1961.

43. Simmons, R. L. The Economics of Automation, Presented at the Dairy Plant Management Conference, Virginia Polytechnic Institute, May 16, 1961.

44. Sheridan, R. Leasing or Purchasing-A Comparison of Costs, American Milk Review, 22, 11:24 1960.

45. Spilman, H. A. Automation Equipment-Economic Factors That Must Be Considered When Planning to Install Automatic Equipment, Southern Dairy Products Journal, 69, 5:92 1961.

46. ibid. 69, 6:124 1961.

47. Stanbury, W. A. Your Dilemma: Lease or Buy? Factory Management and Maintenance, 116, 11:200 1958.

48. Tracy, P. H. Automation in Milk Plants, Southern Dairy Products Journal, 67, 11:120 1959.

49. United States Department of Agriculture, Agricultural Marketing Service-Transportation and Facilities Research Division, Layouts and Operating Criteria for Automation of Dairy Processing-Milk and Half-and-Half, Marketing Research Report No. 568, March 1963.

50. Uris, A. What You Can Do About Your Problem People, Factory Management and Maintenance, 111, 10:77 1958.

51. Wallace, C. L. How Fixed-Variable Cost Control Helps Produce Profits, Factory Management and Maintenance, 111, 6:126 1953.

52. Wray, J. D. How You Can Hit the High Cost of Handling in Maintenance, Factory, 117, 6:94 1959.

The vita has been removed from
the scanned document

APPENDIX

Model I

Hours (Operation)	Units at 80% Efficiency	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)	Total Cost/Unit (Cents)
1	5,184	2.946	3.555	6.501	.1254
2	10,368	2.946	7.110	10.056	.0969
3	15,552	2.946	10.665	13.611	.0875
4	20,736	2.946	14.220	17.166	.0827
5	25,920	2.946	17.775	20.720	.0799
6	31,104	2.946	21.333	24.279	.0780
7	36,288	2.946	24.885	27.831	.0766
8	41,472	2.946	28.440	31.386	.0756
9	46,656	2.946	31.995	34.941	.0748
10	51,840	2.946	35.550	38.496	.0742
11	57,024	2.946	39.105	42.051	.0737
12	62,208	2.946	42.660	45.606	.0733
13	67,392	2.946	46.215	49.161	.0729
14	72,576	2.946	49.770	52.716	.0726
15	77,760	2.946	53.325	56.271	.0723
16	82,944	2.946	56.880	59.826	.0721
17	88,128	2.946	60.435	63.381	.0719
18	93,312	2.946	63.990	66.954	.0717
19	98,496	2.946	67.545	70.491	.0715
20	103,680	2.946	71.100	74.046	.0714
21	108,864	2.946	74.655	77.601	.0713
22	114,048	2.946	78.210	81.156	.0712
23	119,232	2.946	81.765	84.711	.0710
24	124,416	2.946	85.320	88.266	.0709

1. Units are the combination of quarts, pints, one-half pints, and one-half gallons used in this study.

Model II

Hours (Operation)	Units at 80% Efficiency	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)	Total Cost/Unit (Cents)
1	5,184	35.333	2.900	38.233	.7370
2	10,368	35.333	5.800	41.133	.3966
3	15,552	35.333	8.700	44.033	.2831
4	20,736	35.333	11.600	46.933	.2263
5	25,920	35.333	14.500	49.833	.1922
6	31,104	35.333	17.400	52.733	.1695
7	36,288	35.333	20.300	55.633	.1533
8	41,472	35.333	23.200	58.533	.1411
9	46,656	35.333	26.100	61.433	.1316
10	51,840	35.333	29.000	64.333	.1240
11	57,024	35.333	31.900	67.233	.1179
12	62,208	35.333	34.800	70.133	.1127
13	67,392	35.333	37.700	73.033	.1083
14	72,576	35.333	40.600	75.933	.1046
15	77,760	35.333	43.500	78.833	.1013
16	82,944	35.333	46.400	81.733	.0985
17	88,128	35.333	49.300	84.633	.0960
18	93,312	35.333	52.200	87.533	.0938
19	98,496	35.333	55.100	90.433	.0918
20	103,680	35.333	58.000	93.333	.0900
21	108,864	35.333	60.900	96.233	.0883
22	114,048	35.333	63.800	99.133	.0869
23	119,232	35.333	66.700	102.033	.0855
24	124,416	35.333	69.600	104.933	.0843

Model IV

Hours (Operation)	Units at 80% Efficiency	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)	Total Cost/Unit (Cents)
1	10,800	3.420	6.955	10.375	.09606
2	21,600	3.420	13.910	17.330	.08023
3	32,400	3.420	20.865	24.285	.07495
4	43,200	3.420	27.820	31.240	.07231
5	54,000	3.420	34.775	38.195	.07073
6	64,800	3.420	41.730	45.150	.06967
7	75,600	3.420	48.685	52.105	.06892
8	86,400	3.420	55.640	59.060	.06835
9	97,200	3.420	62.595	66.015	.06791
10	108,000	3.420	69.550	72.970	.06756
11	118,800	3.420	76.505	79.925	.06728
12	129,600	3.420	83.460	86.880	.06704
13	140,400	3.420	90.415	93.835	.06683
14	151,200	3.420	97.370	100.970	.06677
15	162,000	3.420	104.325	107.745	.06650
16	172,800	3.420	111.280	114.700	.06637
17	183,600	3.420	118.235	121.655	.06626
18	194,400	3.420	125.190	128.610	.06615
19	205,200	3.420	132.145	135.565	.06606
20	216,000	3.420	139.100	142.520	.06598
21	226,800	3.420	146.055	149.475	.06590
22	237,600	3.420	152.010	156.430	.06583
23	248,400	3.420	159.965	163.385	.06577
24	259,200	3.420	166.920	170.340	.06571

Model V

Hours (Operation)	Units at 80% Efficiency	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)	Total Cost/Unit (Cents)
1	10,800	52.941	4.265	57.206	.5296
2	21,600	52.941	8.530	61.471	.2845
3	32,400	52.941	12.950	65.891	.2033
4	43,200	52.941	17.060	70.001	.1620
5	54,000	52.941	21.325	74.266	.1375
6	64,800	52.941	25.590	78.531	.1211
7	75,600	52.941	29.855	82.796	.1095
8	86,400	52.941	34.120	87.061	.1007
9	97,200	52.941	38.385	91.326	.0939
10	108,000	52.941	42.650	95.591	.0885
11	118,800	52.941	46.915	99.856	.0841
12	129,600	52.941	51.180	104.121	.0803
13	140,400	52.941	55.445	108.386	.0771
14	151,200	52.941	59.710	112.651	.0745
15	162,000	52.941	63.975	116.916	.0721
16	172,800	52.941	68.240	121.181	.0701
17	183,600	52.941	72.505	125.446	.0683
18	194,000	52.941	76.770	129.711	.0667
19	205,200	52.941	81.035	133.960	.0652
20	216,000	52.941	85.300	138.241	.0640
21	226,800	52.941	89.565	142.506	.0628
22	237,600	52.941	93.830	146.771	.0617
23	248,400	52.941	98.095	151.036	.0609
24	259,200	52.941	102.360	156.301	.0603

Model VII

Hours (Operation)	Units at 80% Efficiency	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)	Total Cost/Unit (Cents)
1	14,400	4.00	12.670	16.670	.1157
2	28,800	4.00	25.340	29.340	.1018
3	43,200	4.00	38.010	42.010	.0972
4	57,600	4.00	50.680	54.680	.0949
5	72,000	4.00	63.350	67.350	.0935
6	86,400	4.00	76.020	80.020	.0926
7	100,800	4.00	88.690	92.690	.0920
8	115,200	4.00	101.360	105.360	.0914
9	129,600	4.00	114.030	118.030	.0910
10	144,000	4.00	126.700	130.700	.0907
11	158,400	4.00	139.370	143.370	.0905
12	172,800	4.00	152.040	156.040	.0903
13	187,200	4.00	164.710	168.710	.0901
14	201,600	4.00	177.380	181.380	.0899
15	216,000	4.00	190.050	194.050	.0898
16	230,400	4.00	202.720	206.720	.0897
17	244,800	4.00	215.390	219.390	.0896
18	259,200	4.00	228.060	232.060	.0895
19	273,600	4.00	240.730	244.730	.0894
20	288,000	4.00	253.400	257.400	.0893
21	302,400	4.00	266.070	270.070	.0893
22	316,800	4.00	278.740	282.740	.0892
23	331,200	4.00	291.410	295.410	.0891
24	345,600	4.00	304.080	308.080	.0891

Model VIII

Hours (Operation)	Units at 80% Efficiency	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)	Total Cost/Unit (Cents)
1	14,400	54.421	5.674	60.095	.4173
2	28,800	54.421	11.348	65.769	.2283
3	43,200	54.421	17.027	71.448	.1653
4	57,600	54.421	22.696	77.117	.1338
5	72,000	54.421	28.370	82.791	.1149
6	86,400	54.421	34.044	88.465	.1023
7	100,800	54.421	39.718	94.139	.0934
8	115,200	54.421	45.397	99.818	.0866
9	129,600	54.421	51.066	105.487	.0813
10	144,000	54.421	56.740	111.161	.0771
11	158,400	54.421	62.414	116.835	.0737
12	172,800	54.421	68.088	122.509	.0708
13	187,200	54.421	73.762	128.183	.0684
14	201,600	54.421	79.436	133.857	.0663
15	216,000	54.421	85.110	139.531	.0645
16	230,400	54.421	90.784	145.205	.0630
17	244,800	54.421	96.458	150.879	.0616
18	259,200	54.421	102.132	156.553	.0603
19	273,600	54.421	107.060	161.481	.0590
20	288,000	54.421	113.480	167.901	.0582
21	302,400	54.421	119.154	173.575	.0573
22	316,800	54.421	124.828	179.249	.0565
23	331,200	54.421	130.503	184.923	.0558
24	345,600	54.421	136.176	190.597	.0551

Abstract

RESOURCE SUBSTITUTION: AUTOMATIC CASING
AND STACKING VERSUS MANUAL CASING AND
STACKING OF FLUID MILK PRODUCTS

by

James Edward Schad

A study was conducted to determine the break-even point of three comparative fluid milk casing and stacking operations.

The first comparative models consisted of two filling machines with the processed cartons manually cased and stacked, compared with automated casing and stacking, on a cost basis. The second comparative models consisted of three filling machines with the processed cartons cased and stacked as in the first comparative models. The third comparative models consisted of four filling machines with the processed cartons cased and stacked as in the first and second set of models.

The break-even point of the first comparative models was not reached within a 24 hour period based on 260 operating days per year. However, components

of automation in the packing handling phase of the fluid milk plant operation were considered.

The break-even point of the second comparative models was reached after 18-1/2 hours of operation. It is advisable for the operator of this combination of filling equipment to consider automation if he is operating the plant more than 18-1/2 hours per day. If this is not feasible, then those components of automation should be considered that would result in the greatest reduction in the packing handling costs of the processed milk.

The break-even point of the third comparative models was reached at slightly over seven hours of operation. The operator will realize a savings by installing the automated equipment if it is operated at or above seven hours per day.