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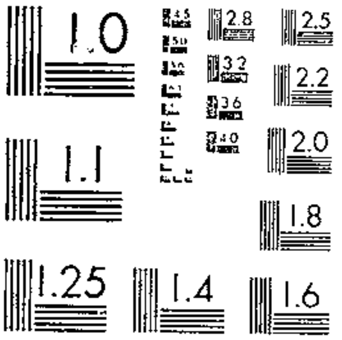

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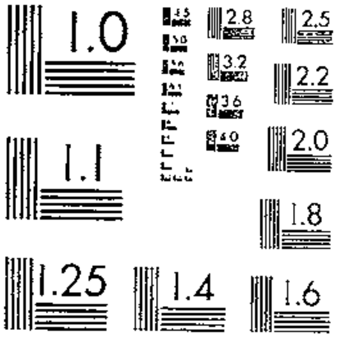

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Computer Simulation Of Potato Packinghouse Operations

An Interim Step

Technical Bulletin 1504

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

Preface

This publication discusses a computer simulation of packinghouse operations to help minimize potato marketing cost. The model is part of a major research project conducted to develop improved methods, equipment, operating procedures, and facilities for preparing potatoes for market.

The study was conducted under the general supervision of Joseph F. Herrick, Jr., formerly investigations leader, of the then Transportation and Facilities Research Division, Agricultural Research Service.

The computer program, which is the basis of this publication, was developed by the Industrial Engineering Department of North Dakota State University under contract between the University and the U.S. Department of Agriculture.

This work was performed at North Dakota State University at Fargo and at the Red River Valley Potato Research Center at East Grand Forks, Minn.

The authors gratefully acknowledge the cooperation of Don Peterson, Director at the North Dakota State University Computer Center.

Other publications previously issued for the potato industry are:

Potato Packinghouses—Guidelines for Plant Layout. U.S. Dept. Agr. Mktg. Res. Rpt. 975. April 1973.

Powered Bulk Scooping in Potato Storages. U.S. Dept. Agr. Mktg. Res. Rpt. 916. March 1971.

Bin Fronts for Potato Storages. U.S. Dept. Agr. Mktg. Res. Rpt. 893. July 1971.

Handling Potatoes from Storage to Packing Line—Methods and Costs. U.S. Dept. Agr. Mktg. Res. Rpt. 890. March 1971.

Lateral Pressures on Walls of Potato Storage Bins. U.S. Dept. Agr. ARS 52-32. June 1968.

Bulk Handling Spring Crop Potatoes from Harvester to Packing Line—Methods and Costs. U.S. Dept. Agr. Mktg. Res. Rpt. 761. November 1966.

Shell Ventilation Systems for Potato Storages in the Fall Crop Area. U.S. Dept. Agr. Mktg. Res. Rpt. 579. January 1963.

Storage of Fall-Harvested Potatoes in the Northeastern Late Summer Crop Area. U.S. Dept. Agr. Mktg. Res. Rpt. 370. February 1960.

Computer Simulation Of Potato Packinghouse Operations

An Interim Step

By Paul H. Orr, Kenneth A. Ebeling, Lewis A. Schaper and Thomas W. Serrin

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Computer Simulation Of Potato Packinghouse Operations

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By Paul H. Orr, Kenneth A. Ebeling, Lewis A. Schaper, and Thomas W. Serrin

Summary

An operative computer simulation model was developed as a research tool to assist in detailed studies of potato packinghouse operations. This development completes an important interim step in a procedure designed to expand the possibilities of packinghouse economic, engineering, and managerial research studies through the use of computer simulation. Research investigations to improve overall packinghouse performance can now be conducted with the controlled computer model rather than with the transient, uncontrolled real-life situations in packinghouses. Many more possibilities for improving equipment and operations can be explored rapidly and effectively with this approach.

Eight operations common to most potato packinghouses were modeled using a standard system simulation language. They are (1) receiving, (2) presizing, (3) pregrading, (4) washing and drying, (5) grading, (6) sprout inhibition or transfer, (7) sizing, and (8) packaging. The model simulates individual tuber characteristic, equipment function, and worker activities relationships to provide a logical description of each of these operations.

Synthesized packing line layout and example data were used for equipment sizing and sequencing and for demonstrating the logic of the model.

Introduction

Fruit and vegetable packing operations increasingly are being handled by fewer and larger, highly commercialized firms. With large-scale operations, the processing of fruits and vegetables for the fresh produce market has become quite complex in relationships among time, material, labor, equipment, and markets. Although these factors and their interactions are extremely important to good management, they are difficult to analyze.

Previous research efforts have been directed toward analyzing and improving individual items of equipment, individual processes, or isolated activities within the packinghouse. This often has required simplifying assumptions about the interactions of labor, machinery, and product. These interactions could result in process-efficient results that were not efficient for the packinghouse as a whole. A research tool was needed with which both the individual operations and that of the total system of operations could be analyzed simultaneously. Systems simulation models have been effective in analyzing similar industrial and agricultural processing systems.

The purpose of this study was to develop a simulation model of potato packinghouse operations that could then be used in detailed studies of packinghouse equipment and operations. Though the resulting simulation model is capable of accommodating a wide variety of pack-

[1] Paul H. Orr and Lewis A. Schaper, agricultural engineers, Red River Valley Potato Research Center, Agricultural Research Service, East Grand Forks, Minn.; Kenneth A. Ebeling and Thomas W. Serrin, respectively, assistant and associate professors, Industrial Engineering, North Dakota State University.

ing plant configurations, verification that it can predict actual plant performance under all possible operating conditions is extremely difficult and is beyond the scope of this study. Verification that the model will at least duplicate known operating conditions will be carried out in a subsequent study. The potato packinghouse model reported here has passed all known tests of reasonableness by researchers who are familiar with packinghouse operations.

Simulation Concepts

Simulation is a technique of analysis in which only the essential characteristics and relationships of some real system are formulated by numerical methods into a model that in operation behaves much like the real system.

The principal advantage of simulation in research is that a simulated model allows experimentation with a real system without interfering with the ongoing operation or without engaging in costly and difficult alterations in product layouts or schedules. Some such experimentation would not be possible with the real system itself. For example, a researcher can easily repeat tests that would otherwise take years to study in real life. Another major advantage is that the actual step-by-step development of a simulation model forces critical examination of the system being modeled. Knowledge obtained by this close scrutiny is invaluable not only to research work in the system but also to the managers and to supervisors of the real system itself.

The simulation model developed in this study is structurally based on a General Purpose Simulation System (GPSS) compiler that was developed for an IBM computer.[2] This GPSS compiler is designed to manipulate a class of problems that are characterized by blocks of common operations and flows among these blocks with intervening queues. The compiler language facilitates the formulation of block-flow diagrams of the model system and, at the same time, provides for detailed analysis of specific operations and equipment systems. The GPSS output is in numerical values which describe the status and performance of the system at any particular time.

Simulating Potato Packinghouse Operations

In general, the model simulates individual potato tubers being processed by individual items of equipment, some of which interface with the activities of workers. Tuber flow rate, equipment size and sequence, and worker assignments are based on a common packing line layout.

Individual tubers

Individual potato tubers are the basic units of the product being processed in the model. The model is concerned with the actual tuber-by-tuber response of packinghouse workers and machinery to the physical and biological characteristics of the potatoes during packing operations.

Individual tubers are simulated in terms of such physical characteristics as size, shape, weight, and appearance. The simulated unit is a tuber carrying these data and constitutes a transaction and each item of data is a parameter of the transaction. Each transaction (tuber) flows through the simulation routine carrying information about itself in specific parameters (major axis length, weight, and percent damage).

Each simulated tuber also is labeled with values representing such quality characteristics as disease incidence, mechanical damage, and smoothness. The model user identifies a distribution of possible values for each quality characteristic and enters these data as input. The simulation routine selects an appropriate value for each characteristic and labels each tuber accordingly.

Changes in these tuber characteristics during a simulation run not only describe the perform-

[2] Detailed information about this simulation system is provided in General Purpose Simulation System/360 User's Manual H20-0326-2, IBM, White Plains, N.Y. August 1969.

ance of the system being simulated but actually affect subsequent performance of the model. Hence, parameter values are provided as output at frequent intervals in the programs.

Equipment functions

Equipment functions are simulated as responses to the tuber size, shape, and weight information associated with each transaction. The simulation of machine functions includes such characteristics as machine size, shape, and operating speeds as well as interactions among such factors as speed with effectiveness. Tendencies of machines to inflict damage are simulated by adjusting the value of the damage parameters.

Overloads, odd-shaped tubers, and similar conditions can cause improper responses from equipment. Error terms are provided in the model to represent a machine's actual tendency to improperly perform its function when operating under abnormal conditions. The numerical levels of such errors and the error-causing factors must be identified and provided by the user.

Worker activities

The activities of workers are simulated as responses to information about the product being processed. For example, the grading operation is accomplished by simulating the response of each worker to the values found in those parameters representing quality of the potato tuber. These levels are compared with the levels required for the grade categories being packed. The sort is simulated by labeling each tuber with the number of the next machine designated to handle that grade.

Certain of the worker activities and machine-controlled operations are interfaced in the model. For example, in the operation, a machine fills containers that must be checked for weight and then adjusted by a worker. The model accumulates individual tubers until their combined weight approximates that required by the container. The worker responds by adding or subtracting tubers until the proper container weight is achieved.

Just as in simulating equipment, error terms are used to adjust worker performance to reflect the effects of product overloads, excessive operating speeds, and inadequate numbers of workers.

Complete packing line

The packing line layout shown in figure 1 was selected as the basic one to be modeled.[3] It represents types, sizes, and sequencing of equipment commonly encountered in Red River Valley packinghouses. The equipment required for sizing tubers by weight and packing them in boxes are not illustrated in the figure, but appropriate data to represent those items were included in simulating the packaging operations. The equipment shown represents a packing line capable of input rates of 400 to 500 hundredweights of potatoes per hour.

Description of the Model

The detail of the model, language selection, and computer limitations required the use of a sequential phased model rather than a single stage model. For this reason, as well as to permit comparing alternative designs of packing line equipment, the packinghouse operations were divided into eight sequential phases:

1. Receiving (1)[4]
2. Presizing (2)
3. Pregrading (3)
4. Washing and drying (4)
5. Grading (9)
6. Sprout inhibition or transfer (12)
7. Sizing (13)
8. Packaging (24)

Each phase of the model was developed to meet the following requirements:

(1) To incorporate the significant equipment design and operating factors.

(2) To determine the economic factors of equipment ownership and operation.

[3] Orr, P. H. Potato Packinghouses—Guidelines for Plant Layout. U.S. Dept. Agr. Market. Res. Rpt. 975, illus. 1973.

[4] Numbers in parentheses refer to numbered locations in figure 1 of the primary item of equipment for each operation.

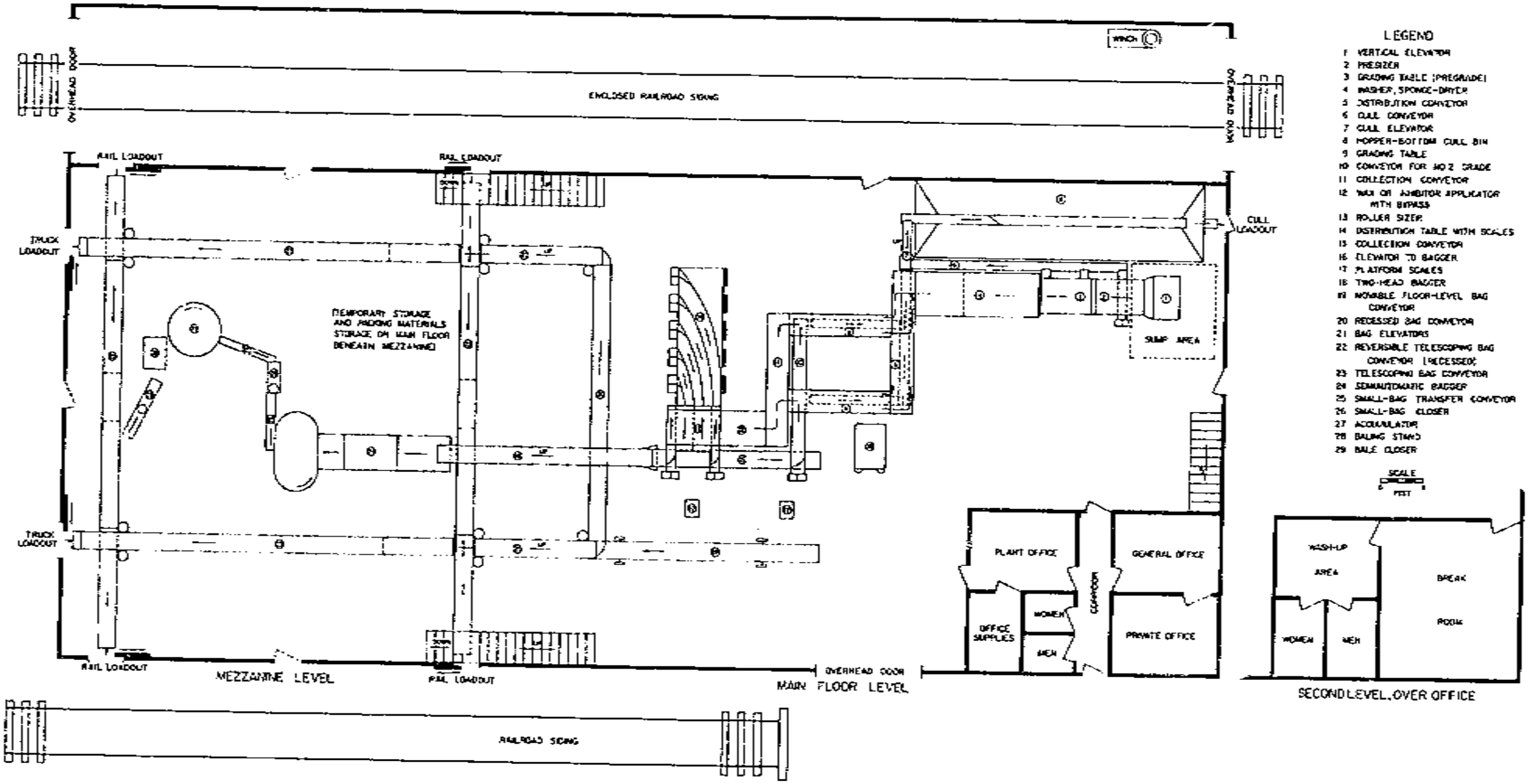


Figure 1.—Layout of packing line.

(3) To include labor and material factors.

(4) To permit the *tuber flow* transformation results of an earlier phase to be passed directly to the next sequential phase of the plant's operation.

(5) To allow flexibility in simulating the numerous alternatives available to the packinghouse manager.

(6) To provide for modifying or extending the model.

These criteria permit the user of the generalized model to study potato packing line performance. This is based on measures of finished product quality and economic return when supplied with detailed data on the operating configuration of a particular packing line.

Receiving operations

Receiving operations are simulated in phase 1 of the model which generates the individual tubers to be processed and simulates their transfer from a fully loaded flume to the packing line by a bucket-type vertical elevator.

The basic logic of this phase of the model is shown in figure 2. In this and subsequent diagrams *tuber flow* refers to the series of fundamental programmed steps of the simulation. *Initialization* refers to the procedure required for setting initial values of computer routines for entering processing equipment, characteristic data, and for generating other specific values required by the model. *Flow rate* refers to those procedures used to maintain statistics concerning categorial product flow rates, equipment and operation effectiveness, and operational costs. Each phase of the model has many more program steps than are shown in the diagrams. The steps shown represent fundamental logic and major portions of the actual computer programs.

Phase 1 requires the following data input to simulate operation of the elevator:

(1) The distance the potatoes are to be lifted, operating speed, and size and spacing of the buckets;

(2) The quantity (generally a probability distribution) of tubers of the type being processed that enter a bucket of a given size when the elevator is operating at a given speed; and

(3) Any interactions between number of tubers entering buckets, bucket size, and elevator operating speed.

The *initialization* procedure of phase 1 (fig. 2) is the routine that calculates bucket volume, elevator speed, and bucket loading data required by the *tuber flow* procedure. Then, as shown in the first three steps of *tuber flow* in figure 2, the model, using these data, "generates" properly sized and spaced elevator buckets, "advances" them the specified lift distance at the required speed, and "dumps" from each the proper number of tuber transactions. This process establishes the quantity, order, and rate of tubers flowing to the packing line.

The next step in the *tuber flow* procedure (fig. 2) is the "assignment" of numerical values into proper parameters of each tuber transaction generated at the elevator. The values assigned represent the level of certain physical characteristics of the tubers that are pertinent to packing line operations.

The following describes the contents of each tuber transaction parameter:

Parameter number	*Description of characteristics*
1	Number of the machine which just completed processing the tuber.
2	Number of the machine for which the tuber is scheduled next.
3	Size of the small axis of the tuber in tenths of an inch.
4	Size of the intermediate axis of the tuber in tenths of an inch.
5	Size of the large axis of the tuber in tenths of an inch.
6	Weight of the tuber in tenths of an ounce.
7	Smoothness of the tuber skin on a grading scale from 0 (rough) to 100 (smooth).
8	Smoothness of the tuber configuration on a grading scale from 0 to 100.
9	Total number of types of defects for this tuber.
10	The percent of the tuber surface that is covered by dirt.
11	The percent of the tuber skin that is freshly damaged.
12	The percent of the tuber that is destroyed by soft rot.
13	The percent of the tuber that is destroyed by dry rot.
14	The percent of the tuber that is destroyed by frost damage.
15	The density of Rhizoctonia spots on the tuber surface.
16	The percent of the tuber surface affected by greening.
17	The number of healed-over major cuts and bruises on the tuber.
18	The degree of sprout growth in ¼-inch increments.

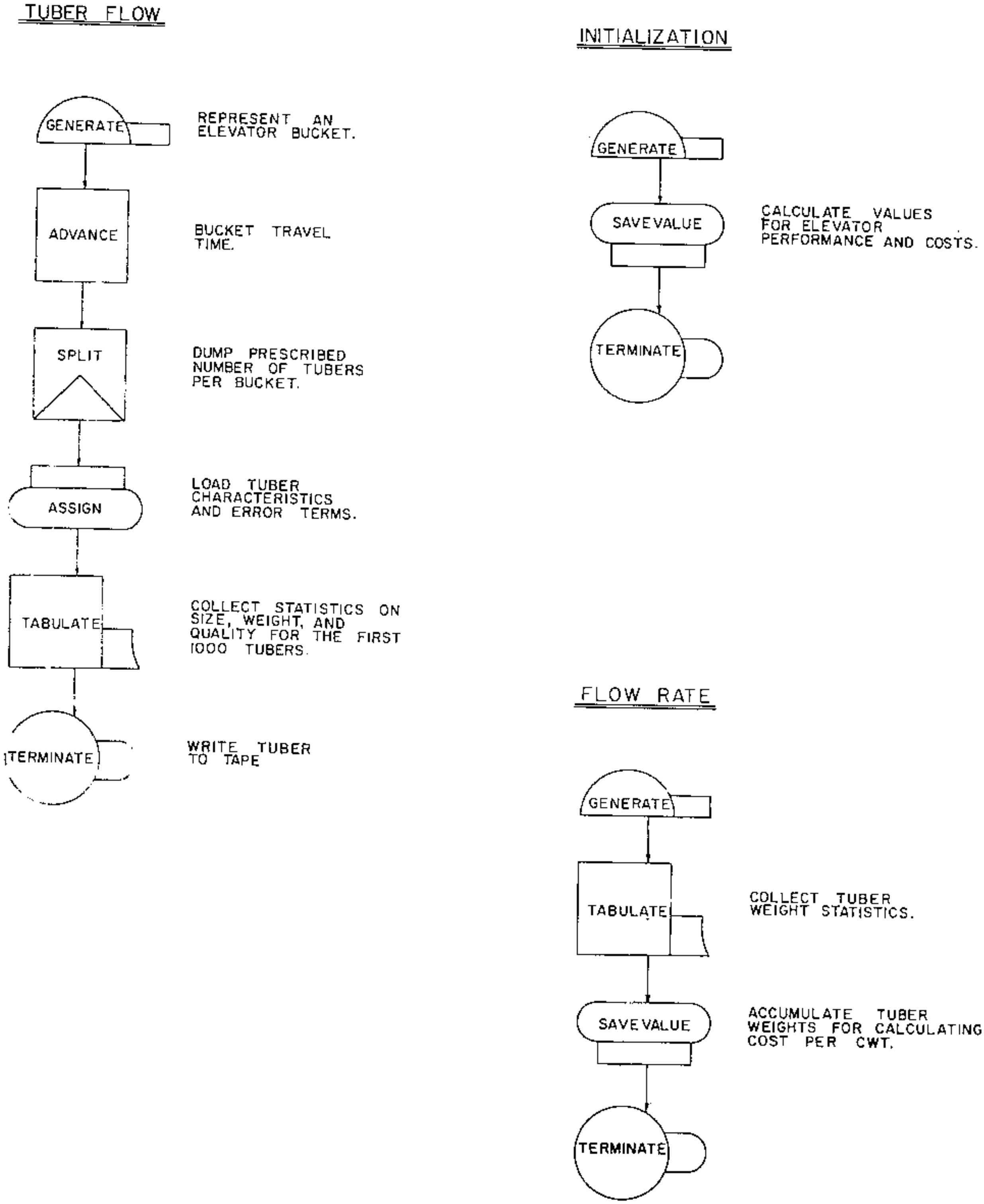


Figure 2.—Basic logic for receiving operations, phase 1.

The parameter values may be assigned directly based on storage bin sampling data or may be generated by the model from data input as probability distributions. If the latter are used, a specific value is randomly selected from each distribution and assigned to the proper parameter. This process establishes the physical appearance of each tuber transaction generated at the elevator. Some of these parameter values will be adjusted in subsequent phases of the model as packing line operations affect changes in the tubers.

In step five of the *tuber flow* procedure, data from the first 1,000 tubers generated are used to obtain parameter mean values and tuber size and weight distributions. These data as output indicate the general condition of the product, become a basis for evaluating product improvement by subsequent operations, and provide a check of proper tuber simulation by the model.

The final step in the *tuber flow* procedure (fig. 2) is the taping of all tuber transaction values along with other tuber sequencing and timing information for transfer to the next phase of the model.

In addition to providing elevator operating data (p. 3) to the *tuber flow* procedure, the *initialization* routine calculates equipment ownership and operating costs from the following data input:

(1) Initial cost,
(2) Estimated life,
(3) Salvage value,
(4) Interest rate,
(5) Tax rate,
(6) Insurance rate,
(7) Motor horsepower,
(8) Electric power rate, and
(9) Maintenance rate.

The *flow rate* routine, shown in figure 2, converts these total costs from the *initialization* routine to unit costs by maintaining statistics on tuber weights. The resulting data output is annual ownership costs plus operating costs in both dollars per hour and dollars per hundredweight.

Additionally, the *flow rate* routine provides a graphic output of the pattern of variation in the amount of product flowing to the packing line. The average flow rate and standard deviation is also output.

Whereas any data generated during a simulation run may be saved for output, certain information has been set up as standard output from each phase of the model. An example of the standard data output for phase 1—receiving operations—is shown in the appendix (Elevator report).

Presizing operations

Phase 2 models the presizing operations. To simulate the separation of undersize tubers from the main product flow by a screen-type presizer, phase 2 requires the following data input:

(1) The dimensions of the sizing surface and the size of the screen openings;
(2) The operating speed of the sizing screen;
(3) The effect of tuber shape and sizer overloading on sizing accuracy; and
(4) The relationship between tuber shape and tuber damage susceptibility.

As shown in the *tuber flow* portion of figure 3, phase 2 receives its simulated product flow by reading from tape the tuber transaction data stored there by phase 1. The *tuber flow* procedure interfaces with the *initialization* routine (fig. 3) to obtain data about the following: (1) the sizers operating speed, working capacity, and screen size, and (2) the relationships between the size of the tubers' axes and size of the screen openings.

Using *initialization* data, the model performs a series of tests (fig. 3). It compares data in parameters 4 (size of intermediate axis) and 5 (size of large axis) of each transaction to the size of the screen openings and the model checks machine loading data for the availability of screen openings.

Transactions are assigned the number of the next machine scheduled to process tubers passing across the sizer when they meet *one* of the following four conditions:

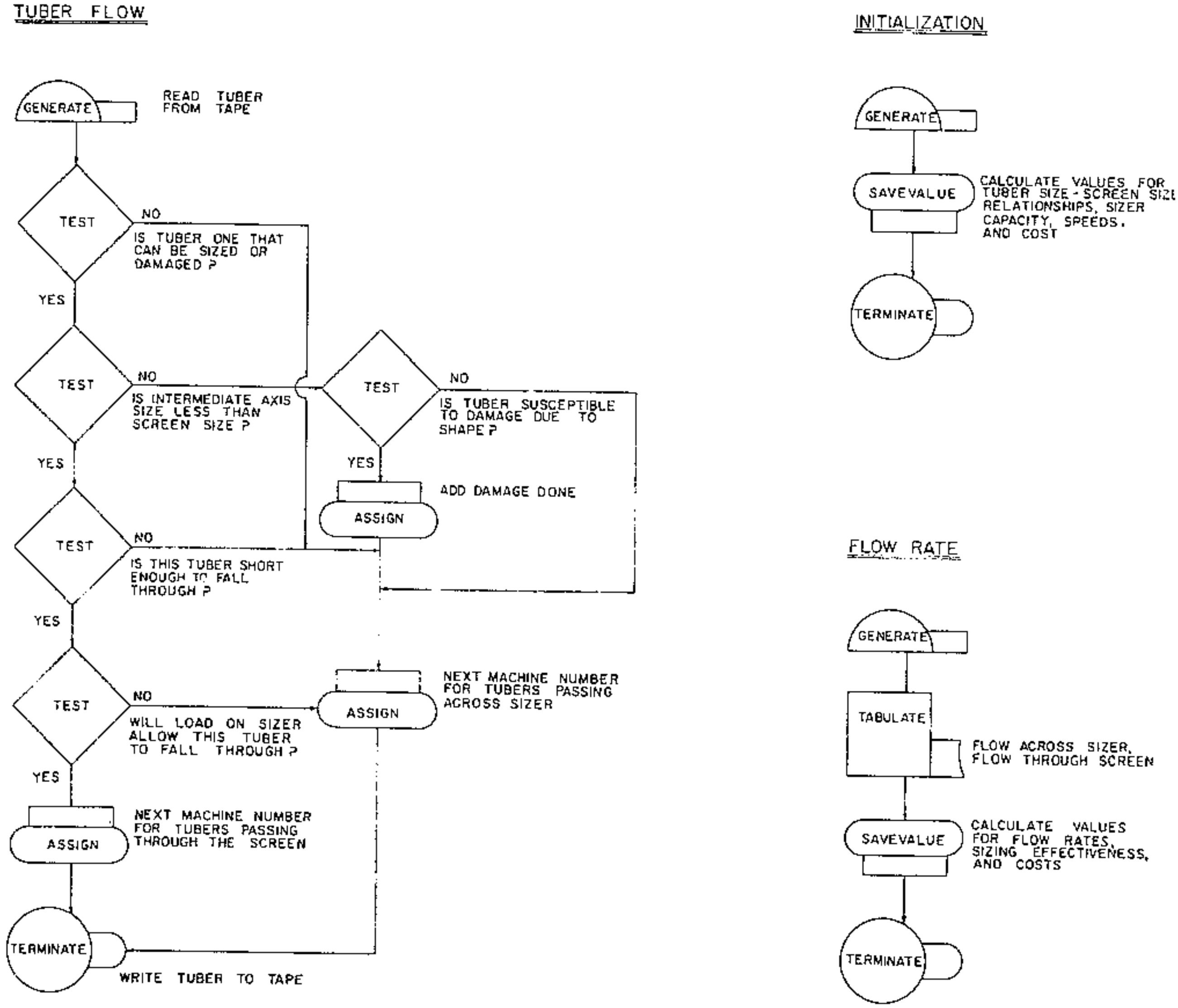


Figure 3.—Basic logic for presizer operations, phase 2.

(1) The tuber's intermediate axis is larger than the screen openings by more than a specified amount (for example, 20 percent) so that the tuber is too large to even partially enter the openings;

(2) The intermediate axis is larger than the screen openings (but by less than the above specified amount) so that the tuber is too large to pass through the screen, but partial entry resulting in damage may occur;

(3) The intermediate axis is smaller than the screen openings and the tuber should pass through, but the tuber's large axis is greater by a given amount which allows it to span the opening; or

(4) The intermediate axis is smaller than the screen openings, and the tuber should pass through; however, the product load on the screen leaves no openings available.

The above four conditions correspond to the NO pathways exiting from the test blocks at the left in figure 3. The additional test block to the right in the *tuber flow* procedure determines if damage should be assigned to those tubers slightly larger than screen openings. This test is accomplished by comparing the tuber's large axis size with the screen openings.

When the large axis is greater by a given amount (for example, 100 percent), the tuber simply spans the opening and is undamaged; if the large axis is smaller than the given amount, the tuber will orient itself to enter the opening and will be damaged. The amount of damage assigned is determined from operating speed and agitation data supplied by the *initialization* routine.

Transactions are assigned the number of the next machine to process the undersize if they meet *all* of the following conditions:

(1) The tuber's intermediate axis is smaller than the screen openings so that the tuber may pass through;

(2) The tuber's large axis is less than a given amount greater than the screen openings so that the tuber may orient itself to pass through; and

(3) The load on the sizer screen is such that openings are available.

The above conditions correspond to the requirements of the YES pathways through the series of test block at the left in figure 3.

Thus, by the process illustrated, the entire product flow is separated into two categories and assigned next machine numbers. Finally, all tuber transaction data are written to tape for transfer to the next phase of the model.

During the simulation in phase 2, cost data are continuously processed and maintained by the *initialization* and *flow rate* routines. Input requirements and standard output concerning costs are similar to those of phase 1 (p. 7). An example of the standard output of presizing is shown in the appendix (Presizing table report).

Pregrading operations

Pregrading is the removal of the more obvious cull tubers from the main product flow at an early stage in the packing process. This operation that involves inspectors handpicking cull tubers from a roller-type grading table is simulated in phase 3. Phase 3 requires the following data input:

(1) The length and width of the grading surface;

(2) The translational and rotational speeds of the grading rollers;

(3) The number of inspectors and their standard time for removing a tuber; and

(4) The coded values representing the tight interpretation of cull grade specifications.

Figure 4 illustrates the meanings of the "tight" and "loose" interpretation of the grade specifications for simulation purposes. The usual cost data input are required (p. 7) plus an hourly labor charge for inspectors.

Figure 5 illustrates the basic logic for the pregrading operations. The *tuber flow* procedure reads from the tape the tuber transaction data stored there by phase 2 and determines (by machine number codes) which tubers are scheduled for the pregrading operations.

The model determines whether or not a tuber is a cull by comparing the cull grade specifications to the data in parameter numbers 11 (fresh damage), 12 (soft rot), 13 (dry rot), 14 (frost damage), 16 (greening), and 17 (major cuts) of the incoming transactions. Additionally, an interface with the *initialization* routine provides table loading information and inspector capacity data.

Transactions are assigned the number of the next machine scheduled to process tubers passing across the pregrading table when they meet *one* of the following conditions:

(1) The tuber is not a cull for pregrading purposes because its quality is higher than the tight cull specifications at the upper grade level (fig. 4);

(2) The tuber may not be obvious as a cull because its quality may range between the upper and lower tight cull specifications, and it is not detected because of table overloading; or

(3) The tuber is obviously a cull because its quality is lower than the tight specification at the lower grade level, but it is carried past the inspectors before they can remove it.

These conditions correspond to the YES pathways leaving the first and third test blocks and the NO pathways through the inspector availability gates of figure 5.

Transactions are assigned the number of the next machine scheduled for cull tubers when they meet *all* of the following conditions:

(1) The tuber's quality is poorer than the tight cull specifications at the upper grade level;

(2) The table is not excessively loaded so the cull tuber is detectable; and

(3) An inspector is available to remove the tuber before it is carried across the grading table.

The diagramed pathways leading to the transfer block and out through the YES exits of the gate blocks represent all of these conditions being met in figure 5. Note that obvious culls are given special attention in the model because pregrading is the removal of obvious culls. Thus, the second test block transfers obvious culls directly to the attention of the inspectors

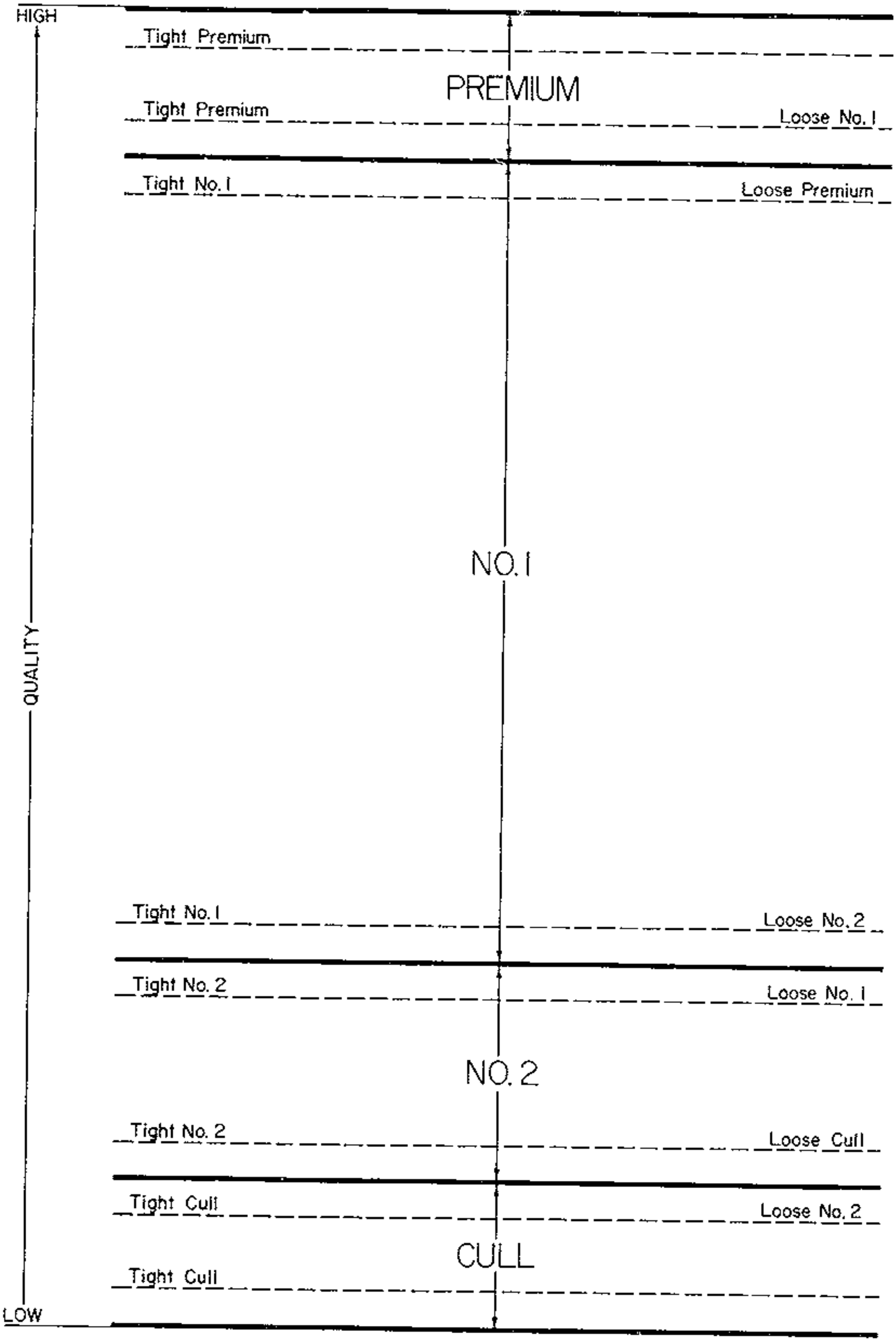


Figure 4.—Meaning of tight and loose grade specifications.

without being influenced by the table-loading block.

The series of blocks following each gate block simulates each inspector's capacity and availability for removing tubers based on standard removal times within 3 feet of grading-table length.

The phase 3 pregrading output data are similar to those of previous phases of the model—pertinent input items, economic information, and product flow rates. Additionally, phase 3 output provides such statistics concerning the utilization of inspectors and the effectiveness of the operation as culls missed, percent undergraded, and defects per tuber.

The final step is that of "writing to tape" each transaction with current information in the parameters after passing through this phase of the simulation.

Washing and drying operations

Phase 4 simulates the tuber washing and drying process as performed by a brush-type washer with water spray nozzles and a series of sponge rubber dryer rollers. Full implementation of this phase of the model was not achieved. Equipment and operating characteristics include the type, number, and spacing of nozzles; the type, number, and size of brushes; the width of rollers and their rotational speed; and water pressure, tuber damage, and product load effects. A simplified version of phase 4 was developed, but no description of the logic will be listed.

Grading operations

Grading operations are modeled in phase 5. As with pregrading, the grading operations involve inspectors working at a roller-type grading table. However, in this phase, more inspectors are accommodated, two side-by-side grading tables are utilized, and a fourway classification of product is accomplished. In this simulation, the four product classes are, in descending order of external quality, premium, No. 1, No. 2, and cull.

Phase 5 requires the same data input as phase 3 (p. 9) including all grade level specifications (fig. 4).

The *tuber flow* procedure for simulating the grading operations, as shown in figure 6, begins by reading transaction data from the prepared tape and determining which tubers are scheduled for grading. Then a "transfer" block divides the total product flowing to the grading operations into two equal parts representing the flows to two equal grading table operations of a packinghouse. At this point, transactions flowing to one of the grading tables in the model are terminated. This assures that the total number of transactions in process at one time, in this phase, will not exceed the limits of the computer's compiler.

This termination and later reproduction of tuber transactions assumes, in both the real and simulated grading operations, that the probability of a particular tuber in a cross section of the product flow being located at a particular point in that cross section is equal for all points in the cross section, and that the results of parallel grading table operations are alike for each table.

The next step, "tabulate," in the *tuber flow* procedures of figure 6, results in a tabulation of incoming tubers according to their next machine number asignments as determined by the subsequent series of tests and transfers. The tabulation serves as a benchmark for evaluating the effectivenes of grading operations in this phase. A tuber's grade and next machine assignment are determined through a series of test blocks. These compare coded values of grade specifications with the coded values contained in parameters number 7 (smoothness), 8 (configuration), 11 (fresh damage), 12 (soft rot), 13 (dry rot), 14 (frost damage), 15 (Rhizoctonia), 16 (greening), 17 (major cuts), and 18 (sprouts).

The first test block (fig. 6) determines which tubers have one or more quality factors lower than the "loose No. 2—tight cull" specifications (fig. 4) and routes them (via the YES pathway) to the block that assigns the number of the next machine scheduled to handle culls. The remaining portion of the *tuber flow* passes (via the NO pathway) to the next test block.

The second test determines which of these

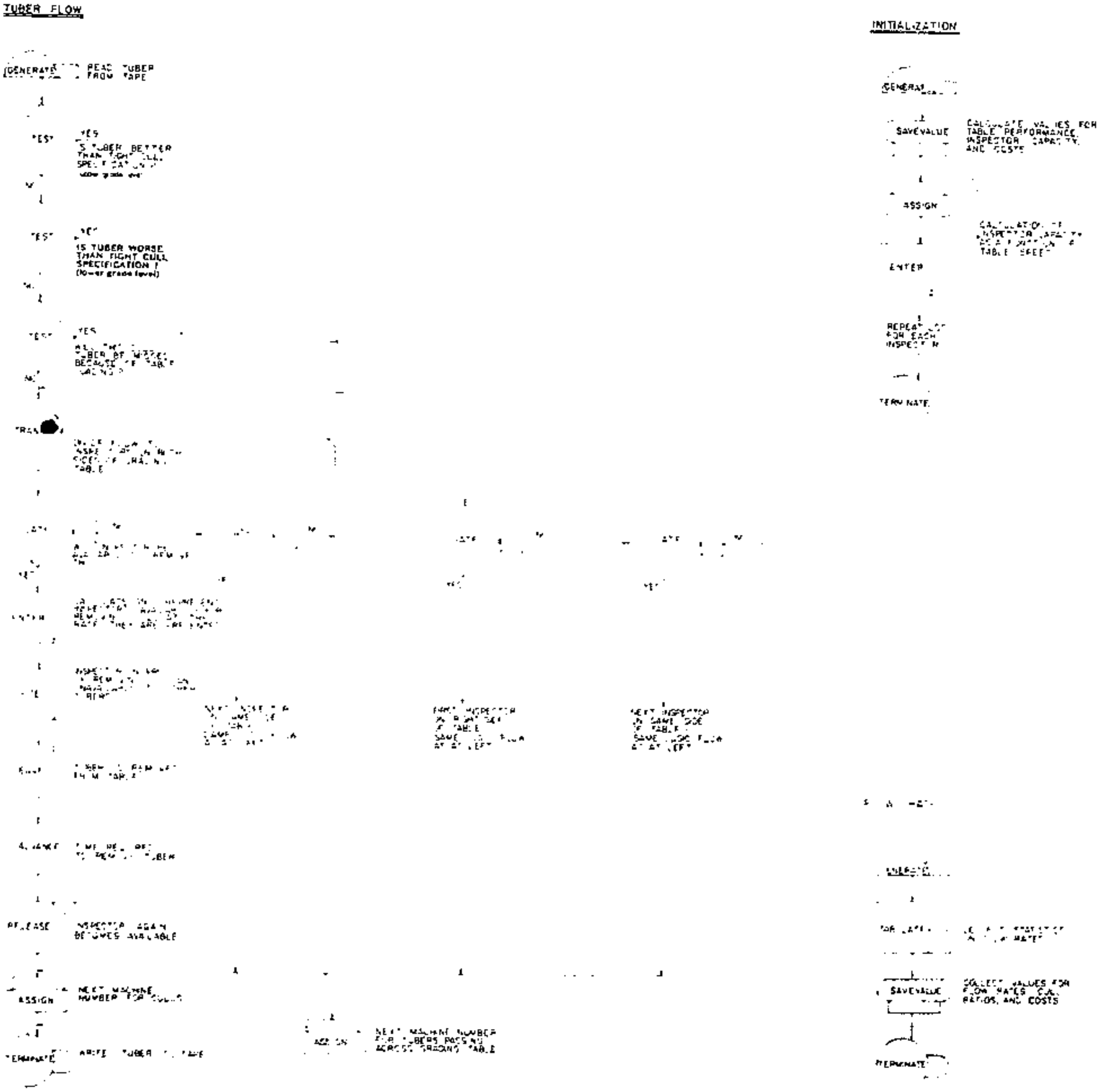


Figure 5.—Basic logic for pregrading operations, phase 3.

tubers have quality values lower than the "tight No. 2—loose cull" requirements (YES) and routes them to a transfer block. The transfer block divides the transaction flow in this pathway into two equal flows—tubers in one flow are assigned the number of the next machine scheduled to handle No. 2's; t hers in the other flow are assigned the number of the next machine scheduled to handle culls.

Those tubers that have better quality than required at the second test block take the NO route to the third test block. In this third test, those transactions having quality levels better than "tight premium—loose No. 1" specifications pass along the YES route to be assigned the number of the next machine scheduled to handle premiums.

The fourth test block receives the transac-

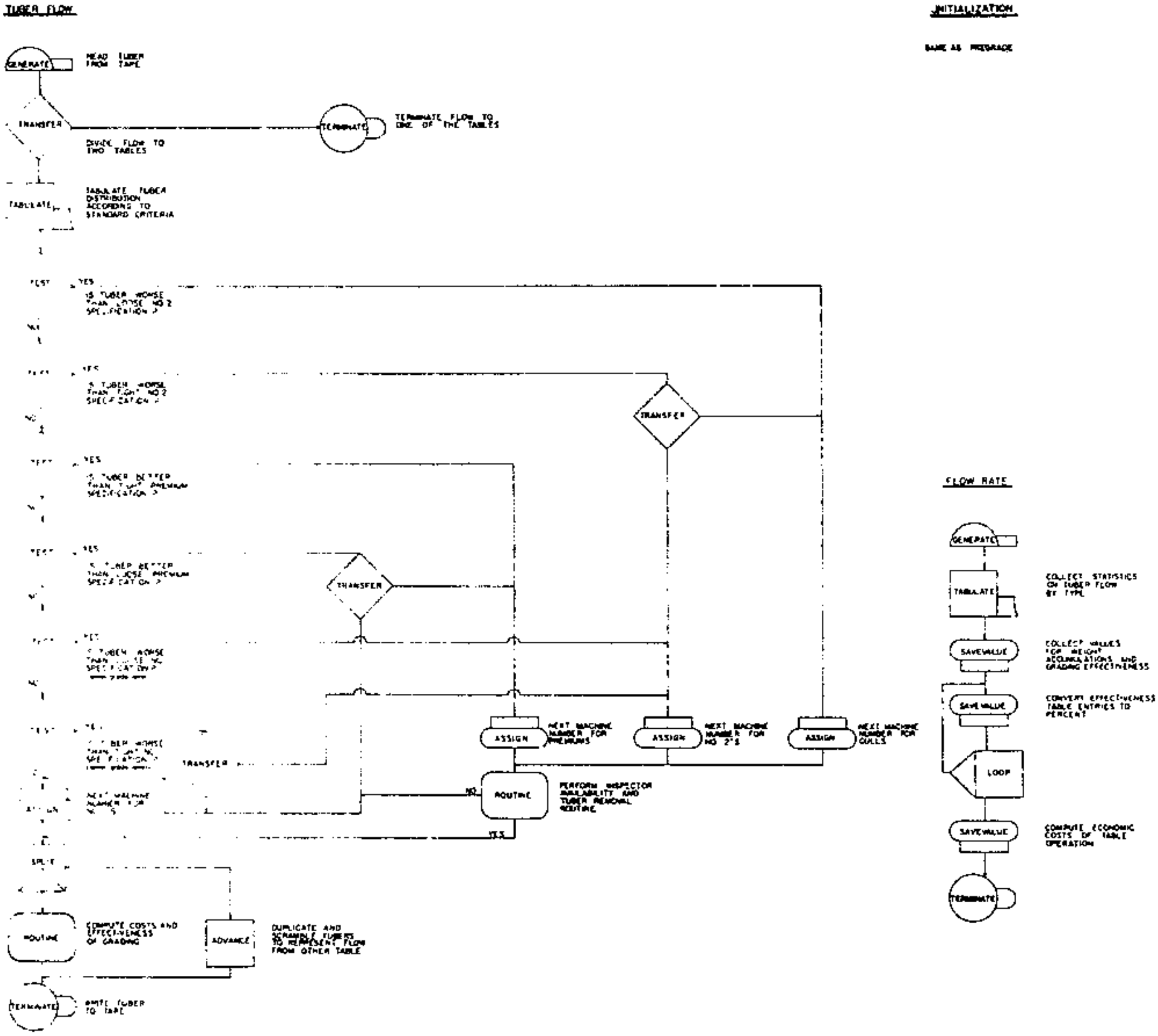


Figure 6.—Basic logic for grading operations, phase 5.

tions in the NO flow from the third test (now reduced to those with better quality than the "tight No. 2—loose cull" level but less than the "tight premium—loose No. 1" level). The fourth test analyzes the tubers for better quality than the "loose premium—tight No. 1" level and routes such tubers to be "transferred" and "assigned" (in the manner of the second test) the respective numbers of the next machines handling premiums or No. 1's.

The remaining tubers follow the NO pathway to the fifth test block that, again, approaches quality from the low side by directing tubers worse than the "loose No. 1—tight No. 2" level along the YES route to be assigned the number of the next machine scheduled for No. 2's.

The NO pathway accepts the remaining flow from the test block and routes the transactions to the sixth test. This test determines which of those tubers remaining are lower in quality than the "tight No. 1—loose No. 2" level and routes them to be "transferred" equally and "assigned" the respective numbers of the next machines handling No. 1's or No. 2's.

The tubers remaining after this sixth test are those between the "loose premium—tight No. 1" and "tight No. 1—loose No. 2." These follow the NO pathway to be assigned the number of the next machine scheduled to handle No. 1 tubers. This completes the assignment of all tubers by grade and provides data for the tuber distribution table of the initial "tabulate" block.

All tubers labeled culls, No. 2's, or premiums are to be removed from the grading table by the inspectors; the No. 1's are not. The inspector availability routine of figure 6 is the same as that of the pregrading operations (fig. 5) except that up to six inspectors are accommodated at each grading table. By interfacing with the *initialization* and *flow rate* routines, the availability of each inspector for tuber removal is continuously monitored.

If none of the inspectors can accomplish tuber removal as the tuber travels the length of the table, the transaction follows the NO route from the inspector availability routine, and the tuber is reassigned the number of the next machine scheduled to handle No. 1's. If an inspector is available as determined by the routine, the transaction takes the YES pathway from the routine and retains its same next machine number just assigned after the preceding test block procedure. Reassigned machine numbers reflect improper grading that is indicated in the effectiveness statistics of output data.

The "split" and "advance" routines next in the logic diagram replace those transactions that would have been processing on the second grading table if they had not been terminated at the start of this phase. This replacement is done by duplicating the transactions and by scrambling them with the grading-table flow that was actively simulated. The resulting *tuber flow* represents the combined output of the two grading tables being modeled. Then all transaction data are recorded on tape as the final step of phase 5.

An example of output data from phase 5 is shown in the appendix (Grading table report). Other itemizations of specific data in GPSS coded form are provided as output but are not included with the appendix material. The total output provides a means of evaluating grading effectiveness, labor utilization, and operating costs under various input conditions.

As in all phases, the *initialization* and *flow rate* routines are instrumental in calculating, accumulating, and converting data for interacting with the *tuber flow* procedure and for providing output statistics.

Sprout inhibition or transfer

Some packing lines utilize an item of equipment that applies a sprout inhibiting material to the potatoes; others do not. The equipment normally has a bypass belt that allows for simply transferring the tubers around the inhibition unit to the next operation. Only the transfer operation was modeled in phase 6. This required only a simple economic statistics model that will not be described further in this report.

Sizing operations

Phase 7 simulates the sizing operations of an expanding-pitch, roller-type sizer. The sizing machine arranges the *tuber flow* into an approximate array from smallest to largest tubers according to their small axis size. This is done by simultaneously expanding the interroller spacing and by translating the rollers across the sizing surface. When the interroller space becomes larger than the small axis of the tuber, the tuber passes between the rollers and down through the sizing surface. Dividers beneath the surface separate the array of falling tubers into several categories; each contains approximately the desired range of tuber sizes.

To simulate this operation, phase 7 requires the following data input:

(1) The dimensions of the sizing surface;

(2) The number and spacings of the rollers at the sizing surface;

(3) The translational speed of the rollers;

(4) The number and settings of the size category divisions beneath the rollers; and

(5) The probability of occurrence and severity levels for tuber damage.

The usual data input for calculating the economic portion of the simulation is required also. There is no labor input in this phase.

Figure 7 illustrates the basic logic for the sizer operations. *Initialization* and *flow rate* routines are similar to previous phases and are not illustrated.

Phase 7 begins by receiving transaction data from tape. The first "assign" block loads values into a matrix representing the sizing roller settings and interroller spacing at the sizing surface. The second "assign" block similarly prepares a matrix representing the divider size

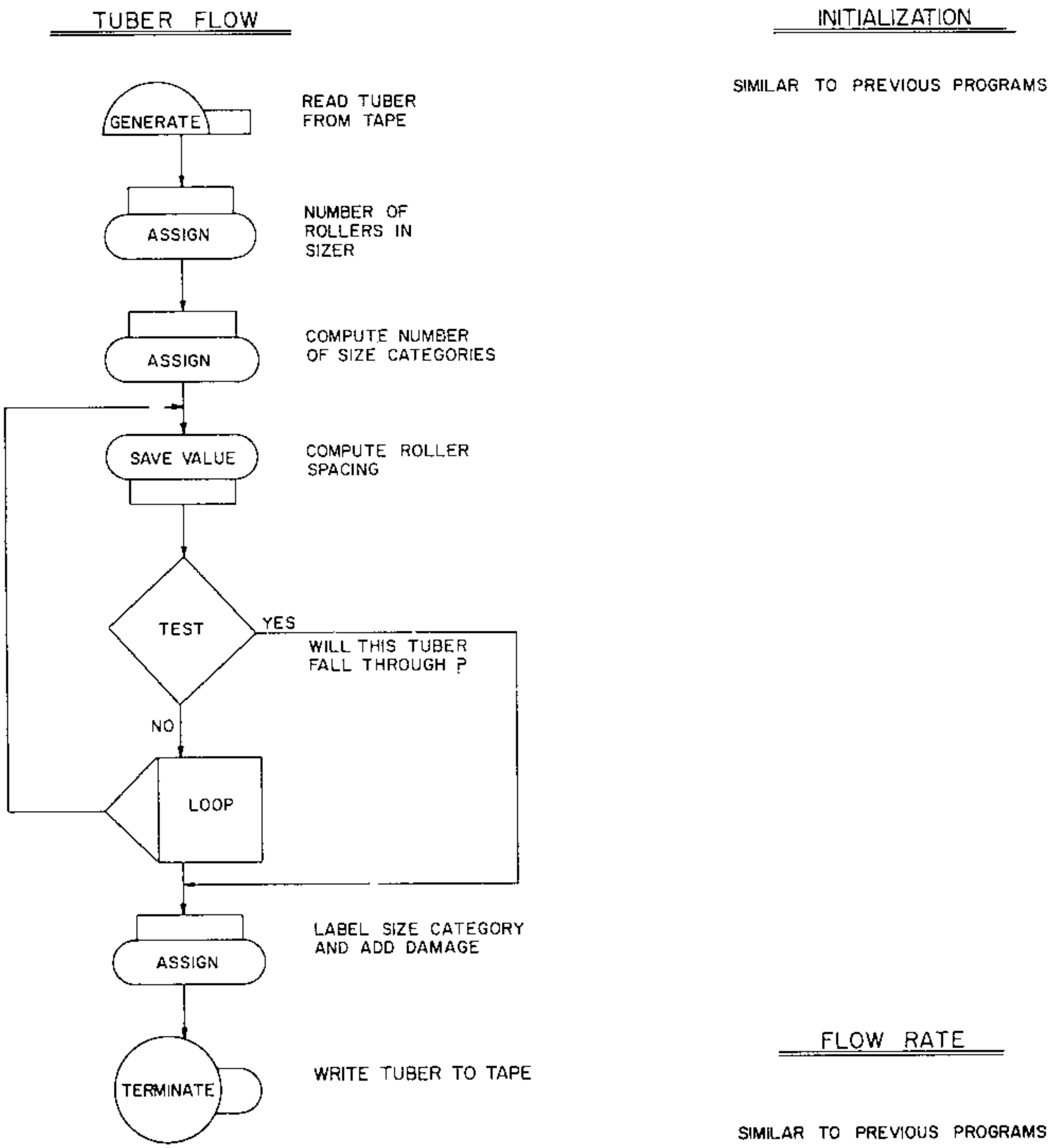


Figure 7.—Basic logic for sizer operations, phase 7.

categories and their associated range of interroller spaces from which each is to receive product.

Next the series of "savevalue-test-loop" blocks cycles (NO pathway) the incoming tuber transaction. Also, they compute the proper roller spacing, and compare the tuber's small axis (parameter 3) with roller spacing. In addition, they increment the roller matrix until the interroller space is large enough for the tuber to fall through (YES pathway).

Each transaction eventually takes the YES pathway and assigns a code representing the size category through which it passed. If tuber damage is applicable, it is also represented in this final "assign" block of figure 7. A formula that includes a probability of occurrence function and a severity level is referenced in assigning abrasion damage, which occurs when tubers pass between the pairs of sizing rollers. A similar formula that additionally includes the effect of tuber weight is referenced in assigning damage to tubers that drop onto the size category dividers beneath the sizing surfaces. Damage adjustment is an addition to the value in parameter 11 (fresh damage) of each affected transaction.

Standard data output from phase 7 consists of input values, *flow rates*, and economic statistics common to all phases of this model. However, *flow rates* and costs are allocated to each size category. Distributions of small and intermediate axes sizes are given because the tubers were arrayed on the basis of small axis size, but they must be marketed on the basis of intermediate axis size. As in all phases of this model, many other data are easily available by simple program statement additions.

The final step in the logic is "writing to tape" all of the current data carried by each transaction for transfer to the packaging phase of the model.

Packaging operations

Packaging operations are the most important and extensive activities performed in most packinghouses. The washing, grading, and sizing operations are performed primarily to prepare the potatoes for packaging. Likewise, phase 8 is paramount in this model with preceding phases preparing the product for this packaging phase.

Four basic forms of packinghouse product output are simulated in this phase. They are:

(1) Large bags,
(2) Bulk,
(3) Consumer packages, and
(4) Institutional packages.

Large bags refer to those packs typified by 100-pound burlap bags of potatoes that are packed by workers at a distribution table. **Bulk** refers to those potatoes that are not packaged at all before leaving the packinghouse. Bulk potatoes are simply conveyed loose to holding hoppers or directly to railroad cars or highway trucks which become the container. **Consumer packages** refers to such small bags of potatoes as the 5- to 20-pound bags that are commonly filled by semiautomatic bagging machines. **Institutional packages** refers to boxes of potatoes (usually 50 pounds) that are required to meet both count and weight standards per pack and that are packed at a weight-type sizing machine.

This phase provides for the simulation of *tuber flow* from any of the product categories assigned in previous phases. The flow may be to any of 9 bulk stations, 15 large-bag packing stations, a semiautomatic small-bag filling operation, or an institutional sizing-boxing operation.

To simulate the packing operations, phase 8 requires the following input data:

(1) The number and types of packaging stations in use;

(2) The types and sizes of containers being packed including the capacity of "bulk" containers;

(3) The tuber weight range, tuber size range (intermediate axis), and container fill weights desired for each type of container being filled;

(4) The worker assignments and standard times for replacing the various filled containers with empty ones and for closing filled containers;

(5) Basic equipment and labor cost items for calculating the economic portions of this phase; and

(6) Specific information about the rotary packaging machine including number of filling heads, width of the feeder belt, and their respective speeds.

The basic logic of this phase of the model is shown in figure 8. The additional block-flow diagram in this figure illustrates the logic for the simulation of the rotary-type, semiautomatic small-bag filling machine.

As shown in the diagram, phase 8 accepts the taped tuber transactions from phase 7 and performs four tests which determine each transaction's proper pathway through the *tuber flow* procedure. The tests are for large bags, bulk containers, consumer packages, or institutional boxes. These tests simply compare the "size category" codes assigned in phase 7 or the next machine codes (for No. 2's and others) assigned in other phases to the individual packaging station identification codes of phase 8.

Tuber transactions that are assigned to the large-bag packing operations (YES on first test block—fig. 8) enter a "statistical routine." This routine block in the diagram represents a series of computations, compilations, and presentations of data concerning off-specification tubers, numbers of tubers and bags packed per station, and worker utilization at each bag-filling and closing station. As in previous phases, interactions with the *flow rate* routine of figure 8 are required whenever development is occurring of such statistical data.

The next step in the large bag portion of the *tuber flow* procedure is an "enter" block which represents each bag being filled as storage. This block can accumulate tubers until the desired total fill weight is achieved. This enter block is paired with a "leave" block further along in the logic flow of figure 8.

The leave block represents the removal of the filled bag by a worker whose availability and need (bag full) to perform are checked by two intervening "test" blocks. All tubers in this portion of the procedure are "written to tape" via the NO pathways of these test blocks until both of the following conditions occur simultaneously: A worker is available to remove the filled bag and the bag receives a tuber that makes the total contents either equal or exceed the desired fill weight. When these conditions exist, the final tuber entering the filled bag follows the YES pathways from the test blocks and enters the "split" block.

In this split block, an exact copy is produced of the entering transaction. The original tuber transaction is written to tape to be saved as the single copy transaction follows the other route from the split block to "represent filled bag."

The first item of data "assigned" (fig. 8) to the parameters of this copy transaction is the total weight of the bag's contents. This weight is "removed" at the leave block to free the storage for the next empty bag and is "tabulated" as output data. The worker's activity in removing the filled bag and replacing it with an empty one is simulated by the "seize-advance-release" blocks in which a worker is obtained, confined to this activity for the standard time required, and then released for other tasks.

The filled container then may be delayed (queue) until a worker becomes available to close the bag (departs the queue). Just as with the simulation of a worker removing bags, the seize-advance-release blocks simulate the worker's activity in closing the bag. Then the copy transaction representing the filled bag is "terminated."

All large-bag filling stations are simulated continuously with this single path of logic both diagramatically in figure 8 and numerically in phase 8. This is accomplished through a matrix arrangement of bag station codes each of which may be referenced by the proper incoming transaction. Thus, continuously, hundreds of transactions may be processing through several bagging stations to containers being packed and closed by a number of workers just as tubers process in the real-life situation in a packinghouse.

Note in figure 8 that the basic logic for the institutional pack (boxes—test block) is almost identical to that for the large-bag packing stations. There is, however, an initial short routine that simulates the weight sizing operation before the box-filling logic. There is, also, no specific container closing logic because that operation occurs during the normal flow of filled boxes in process. All other blocks and flows are identical to the large-bag logic. Again, the matrix approach allows all boxing stations to be referred by the correct incoming transactions and simulated in this single-path logic.

The consumer *packaging unit flow logic* portion of figure 8 shows that the container closing

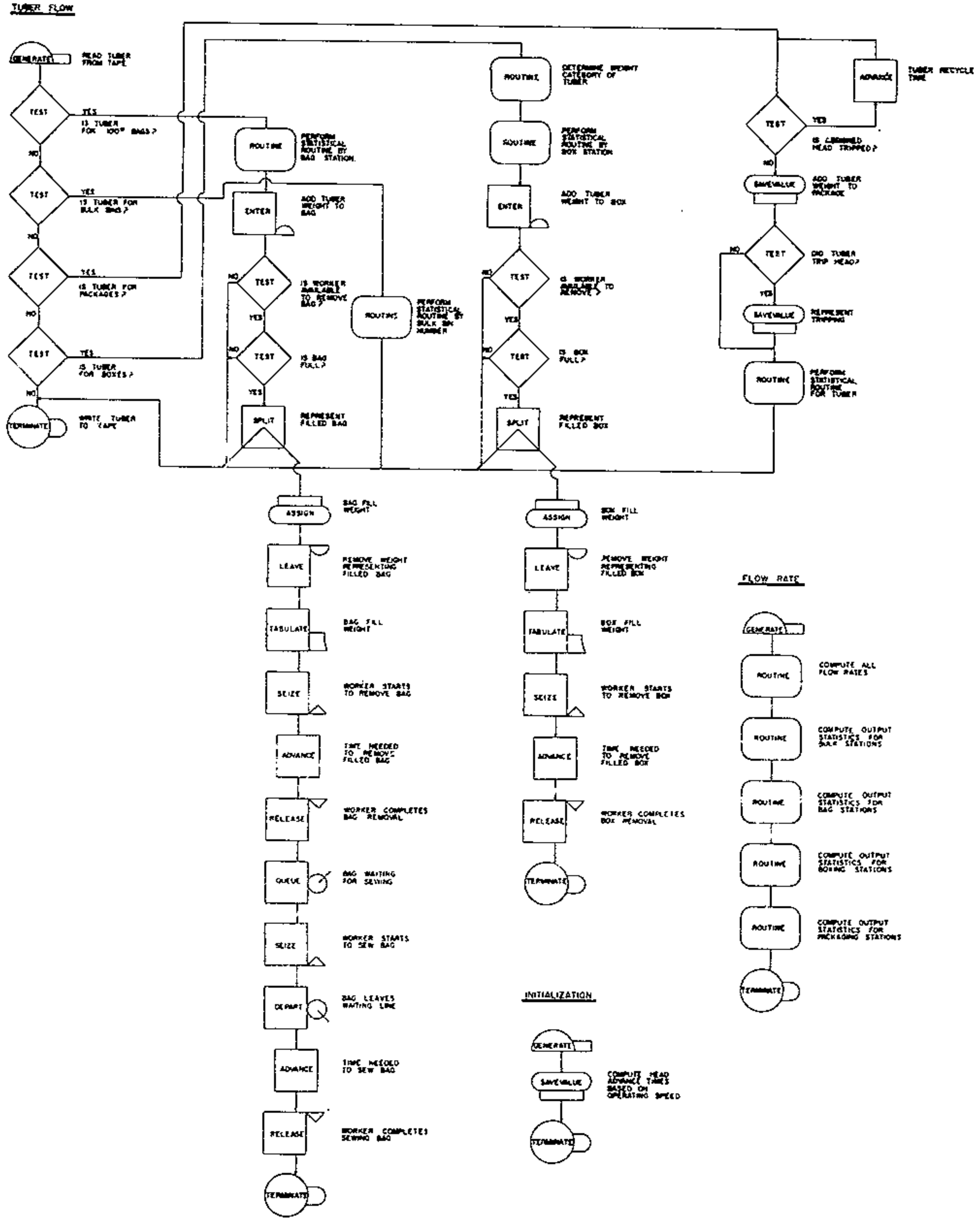


Figure 8.—Basic logic for packaging operations, phase 8.

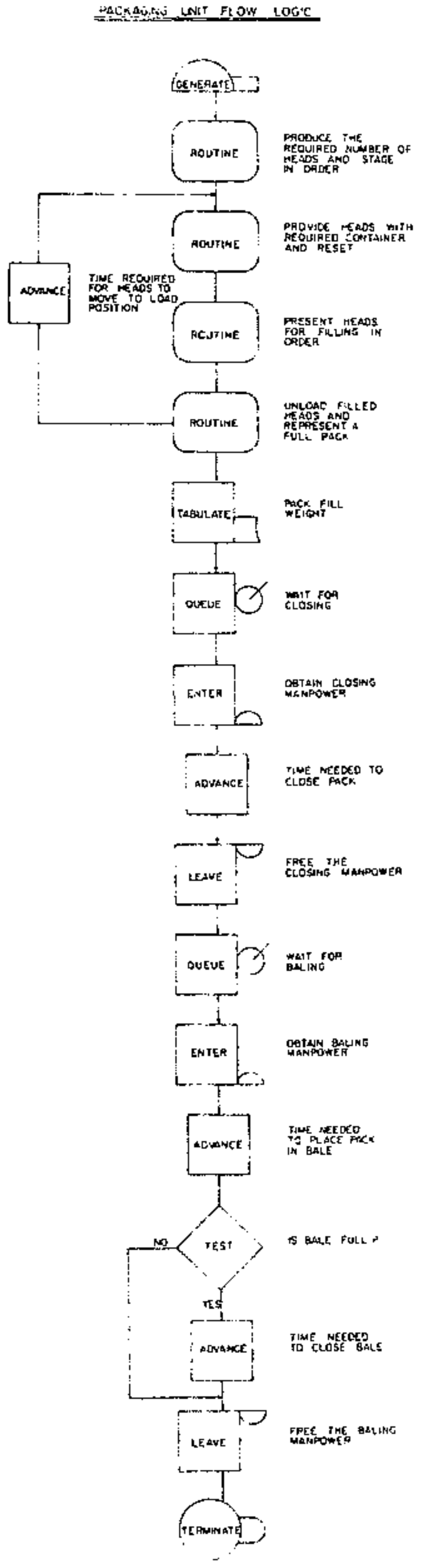


Figure 8 —Continued

and baling activities connected with this operation are simulated almost identically to those of the large bag and institutional pack operations. Note, though, that the operation of the rotary-type semiautomatic package filling machine requires some different logic steps.

The machine operation is given in the four routine blocks of the *packaging unit flow logic*. The first routine simulates and sequences the proper number of bag filling heads for the machine in use. The second simulates the attachment of an empty container and the resetting of tripped heads. The third interfaces with the *initialization* routine to represent the movement of each head past the feeder belt for bag filling and head tripping. The fourth simulates removal of the filled bags and represents full packages.

The *tuber flow* procedure of figure 8 for the consumer packages illustrates the product flow through the rotary packaging machine. This procedure is in constant interaction with the *packaging unit flow logic*. The test block determines if a bagging head is tripped; if YES, the tuber cannot enter it, and the tuber is recycled to the hopper to approach the heads via the feeder belt again; if NO, the tuber enters the package and its weight is added to the previous package weight. A second test block determines if the additional tuber weight was enough to approximate the desired package fill weight and trip the head; if NO, the statistical data are gathered and the tuber is "written to tape"; if YES, the tripping is simulated before "statistics gathering" and "writing to tape" occur.

Tuber transactions that flow to the bulk bins (test block, fig. 8) simply process through a statistics routine and are written to tape.

Output data are presented in special format for the four product categories of phase 8. Special output data for the large-bag category are shown in the appendix (Bag packaging). Similar data are output from phase 8 for the other three product categories. Additionally, GPSS standard output tables provide useful analysis information as in all phases of the model. The combined output data from the entire model provide data that are helpful in analyzing the performance of the individual operations and the total system.

Application of the Model

This model's tools are primarily for potato packinghouse research studies. Detailed investigations will be undertaken with the model to gain information about:

(1) Packinghouse equipment performance under abnormal or unusual operating conditions;

(2) Allocation of raw material and packaging costs under various combinations of packinghouse operations;

(3) Attainable quality levels under various raw product input conditions; and

(4) Alternative plant operating policies.

Results of these investigations will be reported in future publications.

The type of model described in this publication should be useful in research investigations of packinghouse operations for commodities that undergo market preparation activities similar to those in potato packinghouses. The basic concepts of the model should apply with details altered as necessary.

Appendix

Examples of output data from portions of the model are included here in computer print-out form.

****** INPUT DATA - TUBER CHARACTERISTICS
TUBER SIZE AND WEIGHT DISTRIBUTION

MATRIX HALFWORD SAVEVALUE 1

	COL. 1	2	3	4	5	6	7	8	9	10
ROW 1	0	0	0	0	0	0	0	0	0	0
2	0	47	0	0	0	0	0	0	47	2204
3	0	8	80	0	0	0	0	0	88	2206
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	108	0	0	0	0	0	108	2406
10	0	0	401	131	40	0	0	0	572	2408
11	0	0	71	99	8	0	0	0	179	2410
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	7	0	0	7	4608
35	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0
57	0	55	660	230	48	7	0	0	1000	0

FOOTNOTE

ROWS 1 TO 56 DETAILS TUBER AXIS SIZE BY COUNT
COLUMN 10 FIRST DIGIT REPRESENTS UPPER BOUND OF SMALL AXIS
SECOND DIGIT REPRESENTS UPPER BOUND OF INTER AXIS
3 + 4 DIGIT REPRESENTS UPPER BOUND OF LARGE AXIS
COLUMNS 1 TO 8 REPRESENTS UPPER BOUND OF TUBER WEIGHT IN MULTIPLES
OF TWO OUNCES
COLUMN 9 AND ROW 57 ARE THE RESPECTIVE CELL TOTALS

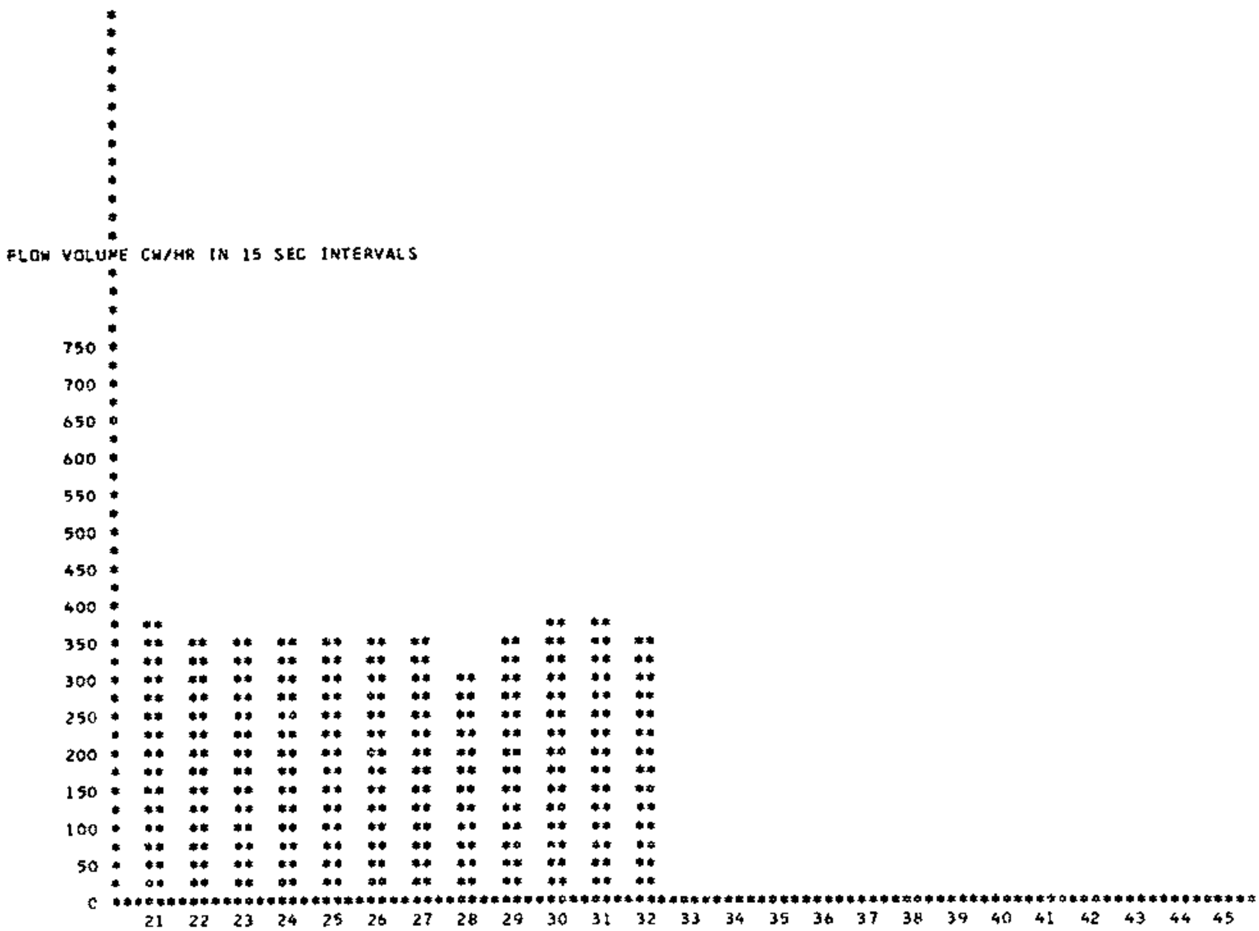
```
****** INPUT DATA - TUBER CHARACTERISTICS - CONTINUED-SAMPLE DATA
     AVERAGE TUBER SMALL AXIS SIZE       1.2 INCHES
     AVERAGE TUBER INTER AXIS SIZE       2.6 INCHES
     AVERAGE TUBER LARGE AXIS SIZE       6.9 INCHES
     AVERAGE TUBER WEIGHT                5.8 OUNCES
     AVERAGE TUBER SMOOTHNESS LEVEL    100.0              PERCENT SMOOTH          100.0%
     AVERAGE TUBER CONFIGURATION       100.0              PERCENT NOT DEFORMED    100.0%
     AVERAGE TUBER SOIL COVERING         -.0 % AREA       PERCENT CLEAN           100.0%
     AVERAGE TUBER SURFACE SKINNING       .2 % AREA       PERCENT NOT AFFECTED     95.3%
     AVERAGE TUBER SOFT ROT DAMAGE       1.0 % VOL        PERCENT NOT AFFECTED     99.0%
     AVERAGE TUBER DRY  ROT DAMAGE       1.7 % VOL        PERCENT NOT AFFECTED     84.2%
     AVERAGE TUBER FROST DAMAGE          2.5 % VOL        PERCENT NOT AFFECTED     95.3%
     AVERAGE TUBER RHIZOCTONIA DAMAGE    -.0 % AREA       PERCENT NOT AFFECTED    100.0%
     AVERAGE TUBER GREENING              1.1 % AREA       PERCENT NOT AFFECTED     95.4%
     AVERAGE TUBER SCARS                  .1 NUMBER       PERCENT NOT AFFECTED     96.1%
     AVERAGE TUBER SPROUTING FACTOR      -.0              PERCENT NOT AFFECTED    100.0%
     AVERAGE NO OF DEFECTS / TUBER        .3              PERCENT DEFECT FREE      69.4%


****** INPUT DATA - DECISION VARIABLES
     BUCKET SPACING IN INCHES             9
     BUCKET  WIDTH  IN INCHES             5
     BUCKET  DEPTH  IN INCHES             3
     BUCKET  LENGTH IN INCHES            48
     BUCKET OPERATING SPEED IN FPM       66
     ELEVATOR LIFT DISTANCE IN FEET      15


****** OUTPUT DATA - ELEVATOR OUTPUT STATISTICS
     NUMBER OF TUBERS LOADED           5000
     AVERAGE FLOW VOLUME IN CW/HR     364.7
     FLOW VOLUME STANDARD DEVIATION    17.5


****** ECONOMIC DATA
     INITIAL COST IN DOLLARS         4570.0
     ESTIMATED LIFE IN YEARS           15.0
     SALVAGE VALUE IN DOLLARS            .0
     INTEREST RATE IN PERCENT           7.0
     TAX RATE IN PERCENT                2.0
     INSURANCE RATE IN PERCENT          1.0
     POWER REQUIRED (HP)                5.0
     POWER COST IN CENTS PER KWH        2.0
     MAINTENANCE RATE IN PERCENT        1.0

     AVERAGE FLOW VOLUME CW/HR        364.7
     ANNUAL OVERHEAD COST IN DOLLARS  533.0
     OPERATING COST IN  CENTS  / HR   53.16
     OPERATING COST IN CENTS/CCW      14.60
```


FLOW VOLUME CW/HR IN 15 SEC INTERVALS
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45

>>>>>>>>>>> P R E S I Z I N G T A B L E R E P O R T <<<<<<<<

****** INPUT DATA - DECISION VARIABLES

SCREEN SIZE IN INCHES	2.0
TABLE LENGTH IN INCHES	48.0
TABLE WIDTH IN INCHES	48.0
OPERATING SPEED IN FPM	45.0
TUBER NO FOR THOSE REMOVED	11.0

****** OUTPUT DATA - EQUIPMENT EFFECTIVENESS

UNDERSIZED MISSED / REMAIN CT	8.8%
AVE INTER AXIS SIZE OF CUTGOING	2.7

DISTRIBUTION OF OUTGOING TUBER SKINNING

TABLE 3

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
6882	.268	1.292	1850.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	6527	94.84	94.8	5.1	-.000	-.207
5	192	2.78	97.6	2.3	18.599	3.659
10	163	2.36	100.0	.0	37.199	7.526

REMAINING FREQUENCIES ARE ALL ZERO

****** ECONOMIC DATA

INITIAL COST IN DOLLARS	1936.0
ESTIMATED LIFE IN YEARS	15.0
SALVAGE VALUE IN DOLLARS	200.0
INTEREST RATE IN PERCENT	7.0
TAX RATE IN PERCENT	2.0
INSURANCE RATE IN PERCENT	1.0
POWER REQUIRED (HP)	1.0
POWER COST IN CENTS PER KWH	2.0
MAINTENANCE RATE IN PERCENT	1.5
TOTAL AVE FLOW CW / HR	364.0
REMAIN AVE FLOW CW / HR	358.1
UNDERSIZED AVE FLOW CW / HR	6.6
ANNUAL OVERHEAD COST IN DOLLARS	222.0
OPERATING COST IN CENTS / HR	30.53
OPERATING COST IN CENTS/CCW	8.39
PERCENT OF WEIGHT REMOVED	1.6
RETAINED TUBER COST ALLOC C/CCW	8.24
REMOVED TUBER COST ALLOC C/CCW	.13

END

>>>>>>>>>>>>>> G R A D I N G   T A B L E   R E P O R T <<<<<<<<<<<

****** DECISION VARIABLES

TABLE LENGTH IN INCHES	120
TABLE WIDTH IN INCHES	39
NUMBER OF GRADERS USED	6
OPERATING SPEED IN FPM	25
LABEL CODE FOR PREMIUMS'	51
LABEL CODE FOR NO 1	70
LABEL CODE FOR NO 2	53
LABEL CODE FOR NO CULLS	10

GRADING CRITERIA

****** EQUIPMENT EFFECTIVENESS

TUBER CLASSIFICATION	INPUT TOTAL	% PREM	% NO 1	% NO 2	% CULL
PREM-CODED-51	168.7	82.4	86.3	.0	.0
NO 1-CODED-70	18.0	1.1	16.6	.0	.3
NO 2-CODED-53	10.2	.7	.0	4.2	5.3
CULL-CODED-10	25.5	.0	12.0	1.3	12.2
OUTPUT TOTAL	100.0	37.9	51.9	2.4	8.0

INSPECTOR UTILIZATION BY MAN NUMBER

FACILITY	AVERAGE UTILIZATION	NUMBER ENTRIES	AVERAGE TIME/TRAN
1	1.000	175	9.879
2	1.000	172	10.052
3	1.000	171	10.111
4	1.000	170	10.170
5	1.000	173	9.994
6	1.000	173	9.994

****** ECONOMIC DATA

INITIAL COST IN DOLLARS	3090.0
ESTIMATED LIFE IN YEARS	15.0
SALVAGE VALUE IN DOLLARS	300.0
INTEREST RATE IN PERCENT	7.0
TAX RATE IN PERCENT	2.0
INSURANCE RATE IN PERCENT	1.0
POWER REQUIRED (HP)	3.0
POWER COST IN CENTS PER KWH	2.0
MAINTENANCE RATE IN PERCENT	1.0
LABOR COST IN $ / MAN-HR	2.00

ANNUAL OVERHEAD COST IN DOLLARS	355.0
LABOR COST IN DOLLARS / HR	12.0
OPERATING COST IN CENTS / HR	35.37

COST ALLOCATIONS BY TUBER TYPE	CW PER HR	% BY WEIGHT	EQUIPMT C/CCW	LABOR C/CCW	TOTAL C/CCW
PREM-CODE-51	64.7	39.5	9.2	277.9	285.1
NO 1-CODE-70	89.6	53.6	11.4	386.9	398.4
NO 2-CODE-53	4.7	2.4	.5	17.3	17.8
CULL-CODE-10	9.9	5.4	1.1	38.9	40.1
TABLE TOTAL	166.0		21.[illegible]	7.2	14.4

```
****** BAG PACKAGING

MATRIX HALFWORD SAVEVALUE      1
```

	COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ROW 1	16160	16160	16160	16160	0	0	0	0	0	0	0	0	0	0	0
2	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0
3	1	2	3	2	0	0	0	0	0	0	0	0	0	0	0
4	16	16	16	16	0	0	0	0	0	0	0	0	0	0	0
5	16	16	16	16	0	0	0	0	0	0	0	0	0	0	0
6	73	72	53	74	0	0	0	0	0	0	0	0	0	0	0
7	1405	3126	1910	312	0	0	0	0	0	0	0	0	0	0	0
8	300	300	300	300	0	0	0	0	0	0	0	0	0	0	0
9	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
10	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0
11	400	400	400	400	0	0	0	0	0	0	0	0	0	0	0
12	20	20	20	20	0	0	0	0	0	0	0	0	0	0	0
13	60	60	60	60	0	0	0	0	0	0	0	0	0	0	0
14	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	60	60	60	60	0	0	0	0	0	0	0	0	0	0	0
17	90	90	90	90	0	0	0	0	0	0	0	0	0	0	0
18	0	1340	1195	0	0	0	0	0	0	0	0	0	0	0	0
19	130	60	200	190	0	0	0	0	0	0	0	0	0	0	0
20	150	1896	1365	160	0	0	0	0	0	0	0	0	0	0	0
21	230	2136	1965	190	0	0	0	0	0	0	0	0	0	0	0
22	3	22	19	3	0	0	0	0	0	0	0	0	0	0	0

```
FOOTNOTE
    COLUMN NUMBER REFERS TO BAG STATION NUMBER
    ROW 1 CONTAINS MINIMUM FILL WEIGHT IN TENTHS OF OZ.
    ROW 2 CONTAINS JERKER STANDARD TIME
    ROW 3 CONTAINS JERKER MAN NUMBER ASSIGNMENT
    ROW 4 CONTAINS SEW MAN NUMBER ASSIGNMENT
    ROW 5 CONTAINS STANDARD SEW TIME
    ROW 6 CONTAINS TUBER CODE NUMBER PACKED
    ROW 7 CONTAINS WORKING SPACE
    ROW 8 CONTAINS LABOR COST IN CENTS / HR
    ROW 9 CONTAINS BAG TYPE CODE
    ROW10 CONTAINS STATION EQUIP OPER COST IN CENTS / HR
    ROW11 CONTAINS STATION FIXED ANNUAL COST IN DOLLARS
    ROW12 CONTAINS LOWER SIZE LIMIT ON INTER AXIS
    ROW13 CONTAINS UPPER SIZE LIMIT ON INTER AXIS
    ROW14 CONTAINS NO OF TUBERS BELOW LOWER SIZE LIMIT
    ROW15 CONTAINS NO OF TUBERS ABOVE UPPER SIZE LIMIT
    ROW16 CONTAINS LOWER WEIGHT LIMIT IN TENTHS OF OZ.
    ROW17 CONTAINS UPPER WEIGHT LIMIT IN TENTHS OF OZ.
    ROW18 CONTAINS NO OF TUBERS BELOW LOWER WEIGHT LIMIT
    ROW19 CONTAINS NO OF TUBERS ABOVE UPPER WEIGHT LIMIT
    ROW20 CONTAINS NO OF DEFECTIVE TUBERS
    ROW21 CONTAINS TOTAL NO OF TUBERS LOADED
    ROW22 CONTAINS PERCENT OF TOTAL WEIGHT PACKED BY THIS STAT
```

BAG STATION NUMBER	MEAN FLOW RATE IN CW / HR	AVERAGE COST IN CENTS PER CW - PACKED
1	8.969	252
2	59.757	293
3	53.212	293
4	8.818	294
5	-.000	
6	-.000	
7	-.000	
8	-.000	
9	-.000	
10	-.000	
11	-.000	
12	-.000	
13	-.000	
14	-.000	
15	-.000	

BAG STATION NUMBER	AVERAGE FILL IN POUNDS
01	.00
02	-.00
03	-.00
04	.00
05	.00
06	.00
07	.00
08	.00
09	.00
10	.00
11	.00
12	.00
13	.00
14	.00
15	.00

JERKER MAN NUMBER	NO OF BAGS PACKED	JERKER UTILIZ-ATION
2	1	.020
3	1	.020

SEWING MAN NUMBER	NO OF BAGS SEWED	SEWING UTILIZ-ATION
16	2	.006

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END