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DEVELOPING A COMPUTER MODEL AND ITS APPLICATION
IN EVALUATING FORWARD CLEANER SEQUENCES

Submitted in Partial Fulfilment
of Class Requirements For Thesis 471

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March, 1982

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Abstract

The objective of this work was to establish a usable format for developing an idea into a working model and to verify that format by example.

The format is outlined as follows:

- Establish a need
- Set Objectives/Criteria
- Synthesis
- Analysis
- Selection
- Decision/Action
- Communication

The example used to verify the format was a comparison of various forward cleaner sequences to determine if an improvement could be made over the current cascade system. After completion of the model format, it was determined that an alpha/alpha cleaning system would prove more cost effective than a cascade system if it was run at feed consistencies greater than .55%. The incremental cleaning efficiency would allow for lower cost stocks to be used, thus defraying the increased capital costs. The overall application of the model format proved very effective.

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Introduction

The objective of this work was to establish a usable format for developing an idea into a working model and to verify that format by example. The concept of having an established format for developing an idea was meant not inhibit creativity but rather to channel creative thoughts into a valid format for business interpretation.

The short term objective of this work was to evaluate various forward cleaner sequences to determine if an improvement could be made over the current cascade system. In order to evaluate these sequences accurately, the model format again was applied, showing its effectiveness in various applications.

Whether a model format is applied that produces a computer model, a mechanical model or a paper and pen model, the same purpose and principles apply. An individual is usually trying to present an idea in a clear, concise manner, showing that the idea was well thought out, demonstrate the decision making process and establish the value of the idea. The model format outlined as follows helps to do all the above:

- Establish a need
- Set objectives/Criteria
- Synthesis
- Analysis
- Selection
- Decision/Action
- Communication

The following work will detail the model format and demonstrate one of its applications.

BACKGROUND/THEORETICAL

DISCUSSION

What is a Model?

The earliest use of the word "model" denoted a set of architects' plans.(4) Models were also constructed as a means of illustrating "elementary" mathematics(4). A model was made (of a square for example) and used as a physical demonstration of the fact which it illustrates. Early models provided tangible objects to bring reality into the symbolic world of mathematics. Any figure drawn on paper as a tangible aid to understanding could be justifiably called a model.

Why use a Model?

A model is often used to illustrate a "real-life" situation when a large number of variables are under consideration or when common sense dictates.

The type of model under consideration in this paper is not a model of an already proven fact, but a model of a new system design. This type of model will aid in ;

- illustrating an idea for something new or different
- solving a problem and getting an answer in a satisfactory or useful form.
- making a decision by choosing between two or more alternatives.

When designing a system (and a model of that system) several terms must be defined to avoid misunderstanding.

System - A system is a set of components arranged to perform some wanted operation(s). A complex system performing one operation may be composed of many single systems, each with one input and one output that when combined, achieve the whole operation.

Design - A design is the work of a human mind or minds to coordinate separate parts or acts to produce a result. Design always involves the following information:

1. Information in the form of facts and data
2. Information in the form of patterns and relations between the items of 1.
3. Information processing using 1 & 2.

System Design/Modeling Steps

The first step in any design is getting an idea. The original idea is worked over, modified and worked over again until several ideas are available for consideration. Before going further, it is necessary to choose the best proposal. The second step is to set objectives for the design.

Objectives and goals guide and limit the design work. Objectives and goals can be classified as follows:

1. MUSTS - The set of performance and other requirements that must be met.
2. MUST NOTS - The set of constraints stating what the system must not exceed.
3. WANTS - These are not hard and fast requirements.
4. DON'T WANTS - Exactly what the words say.

Tolerance is the amount of variation that can be accepted in input and output information. Objectives, goals and tolerances must be identified and accepted before work proceeds further.

Step three is identifying the environment. The environment consists of everything outside the system that either affects the performance or is affected by the operation, or both. A designer must carefully consider all of the effects of environment upon the design. For a sizable system, the conceivable number of inputs and outputs may be extremely large. In practice a designer must select those effects believed to be most important thus dividing the possible interactions into those which are known to be important and those which can be safely neglected.

Synthesis is next and is the first real step of design work. Synthesis involves finding any collection of objects that can perform all the wanted functions and meet all of the requirements of the specifications. All available information on the objects proposed for use must be organized and classified. Hopefully there will be several tentative collections that promise to do the job. The next step is analysis.

In system design, analysis means that any tentative collection must be studied and checked to make certain that it meets all of the objectives. At this point, repeatedly using the synthesis and analysis steps, an optimum design is developed.

After analysis comes selection. There should be more than one collection available that will meet the objectives and the best alternative must be selected. Some times a choice between alternatives is clear-cut based on the objectives and rules previously established and sometimes a choice must be made on the basis of minor differences.

Once a selection is made, a decision is aimed at what action to take and how to effectively communicate the results of the work.

A model, along this vein, may be a paper and pencil reproduction of the system design or it may be a hands-on working representation. A model should provide information that may have been overlooked originally and help identify any mistakes that have been made.

The information gained from the model may require rethinking of the entire design problem. A different collection of elements to meet the requirements may be needed and occasionally (but not often) objectives must be changed.

At this point, it can be seen that the system design and modeling steps will be repeated until the design selection and the model are in agreement with the set objectives and tolerances. The next portion of this paper will demonstrate the applications of the modeling steps in system design and selection. A summary of these steps is as follows:

1. A need or a problem exists
 - All available information related to the problem must be gathered.
2. Objectives and tolerances must be set
 - Musts, Must-Nots
 - Wants, Don't Wants
 - Environment must be considered and requirements established
3. Synthesis - collection that performs wanted functions.
 - All available information related to the objects in the collection must be gathered.
4. Analysis - Double check, optimum design
5. Selection - Review solution vs. initial objectives
6. Decision/Action
7. Communication of Results

APPLICATION OF MODELING STEPS

Need

A question was raised by Scott Paper Company as to whether or not a forward cleaner system could be developed for use with secondary fiber slurries that was more cost effective than the cascade system predominant in the pulp and paper industry.

Information Related to the Problem:

In order to reduce the processing costs associated with a forward cleaner system one must optimize yield, cleaning efficiency, water consumption and equipment costs. A system that could yield more fiber for a given input, provide cleaner pulp, use less water or require fewer cleaners than a cascade system would help fill the need to be more cost efective. A cascade system using 3" cleaners is assumed satisfactory unless an improved design can be developed.

Objectives/Tolerances

Musts: - Consist of on-the-market 3" centrifugal cleaners

- Cost no more than \$250,000
- Have a yield as high as or higher than a cascade system
- Provide a pulp as clean as or cleaner than a cascade system

Wants:*- Accept consistency .4% or greater

- 80% minimum yield
- Cleaning efficiencies 50%

* See Appendix II for details of yield and cleaning efficiency calculations.

Environment:

- Stock being fed to the cleaners is at 80-90°F (1), .55-.65% consistency, 30-50 ppm dirt count.
- Pressure drops between feed to accept lines will be 40 psig (1).
- All dilution water will be a closed system @ .01% consistency.

These conditions are considered representative of desired operating conditions. Figure 1 displays the known relationship between feed consistency and thickening factor for 3" forward cleaners. This relationship was experimentally determined at an earlier date. (See Appendix III).

Figure 2 displays the known relationship between feed consistency and cleaning efficiency. This relationship was experimentally determined at an earlier date. (See Appendix III).

FIGURE 1

FEED CONSISTENCY VS. THICKENING FACTOR FOR 3" CENTRIFUGAL CLEANERS

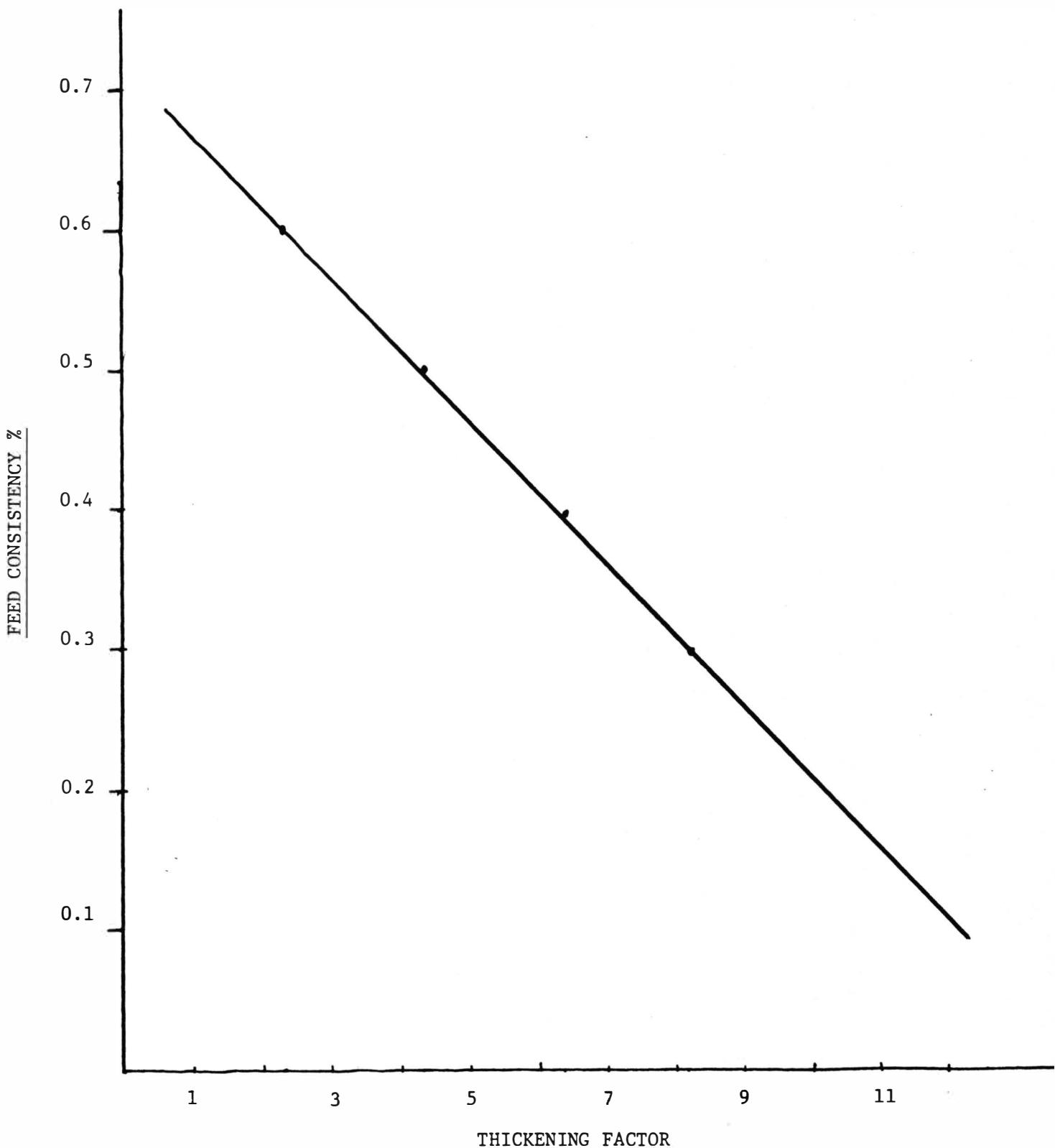
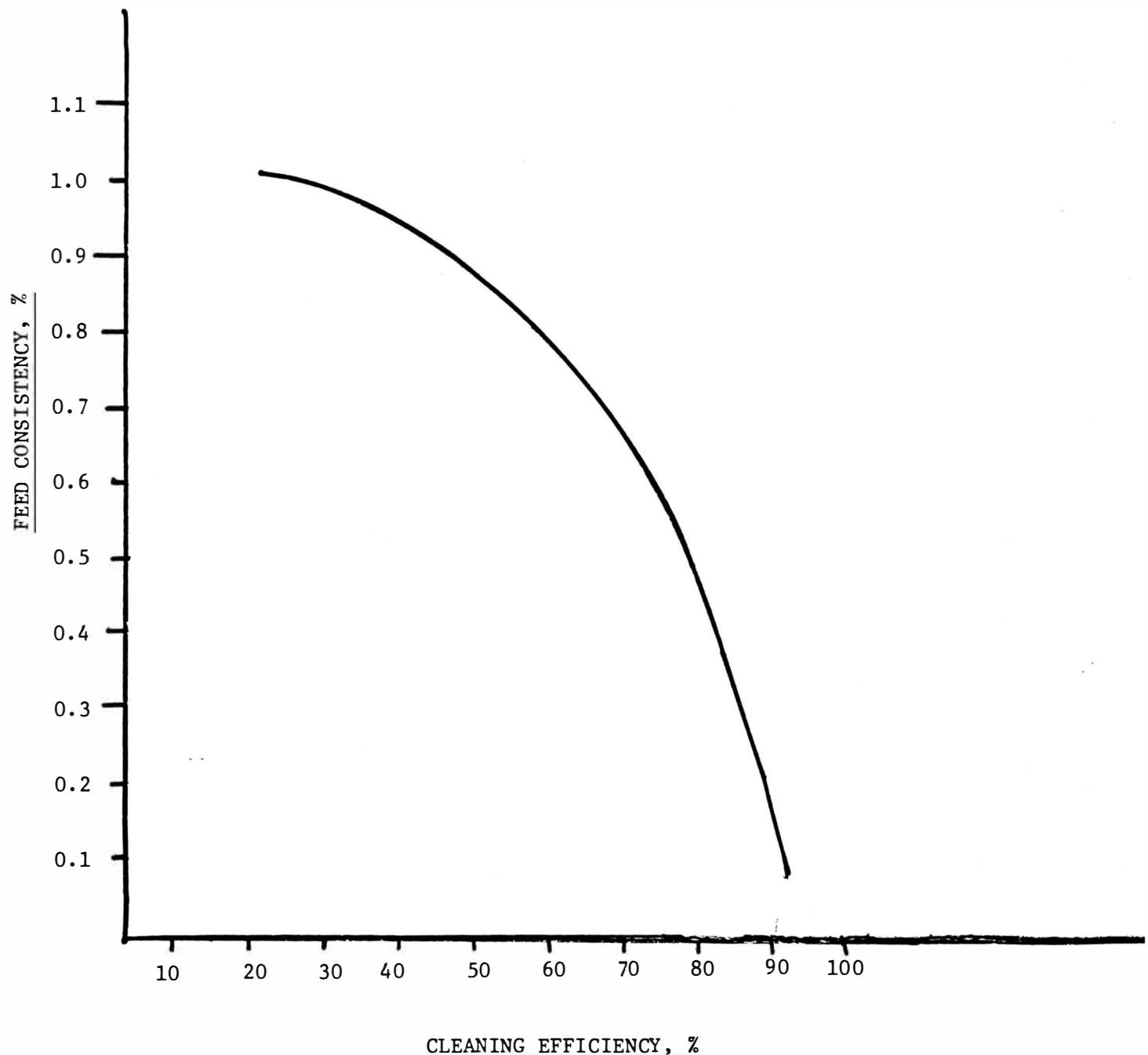


FIGURE 2

FEED CONSISTENCY VS. CLEANING
EFFICIENCY - (30-50 PPM DIRT IN FEED)

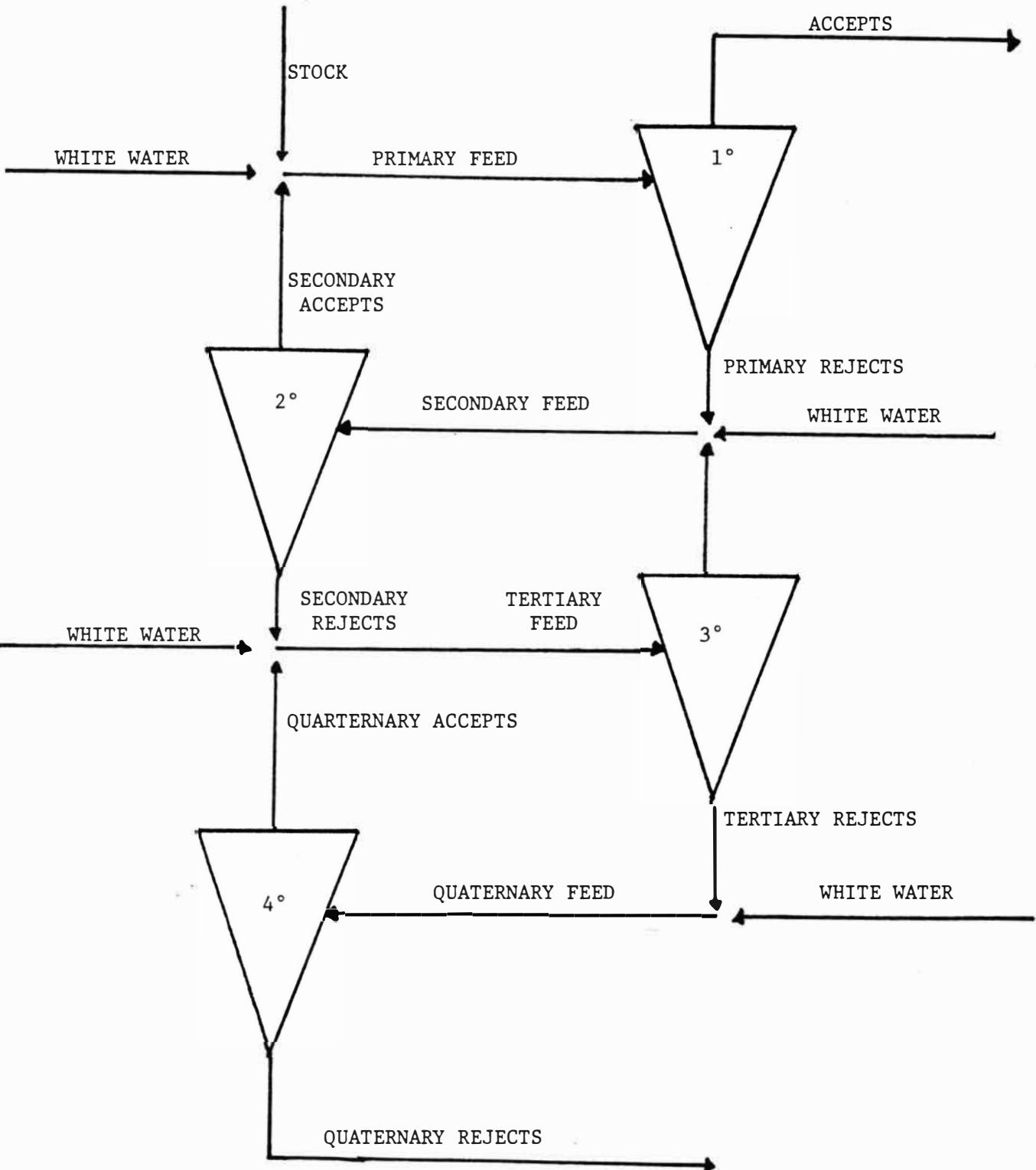


CLEANING EFFICIENCY, %

Synthesis

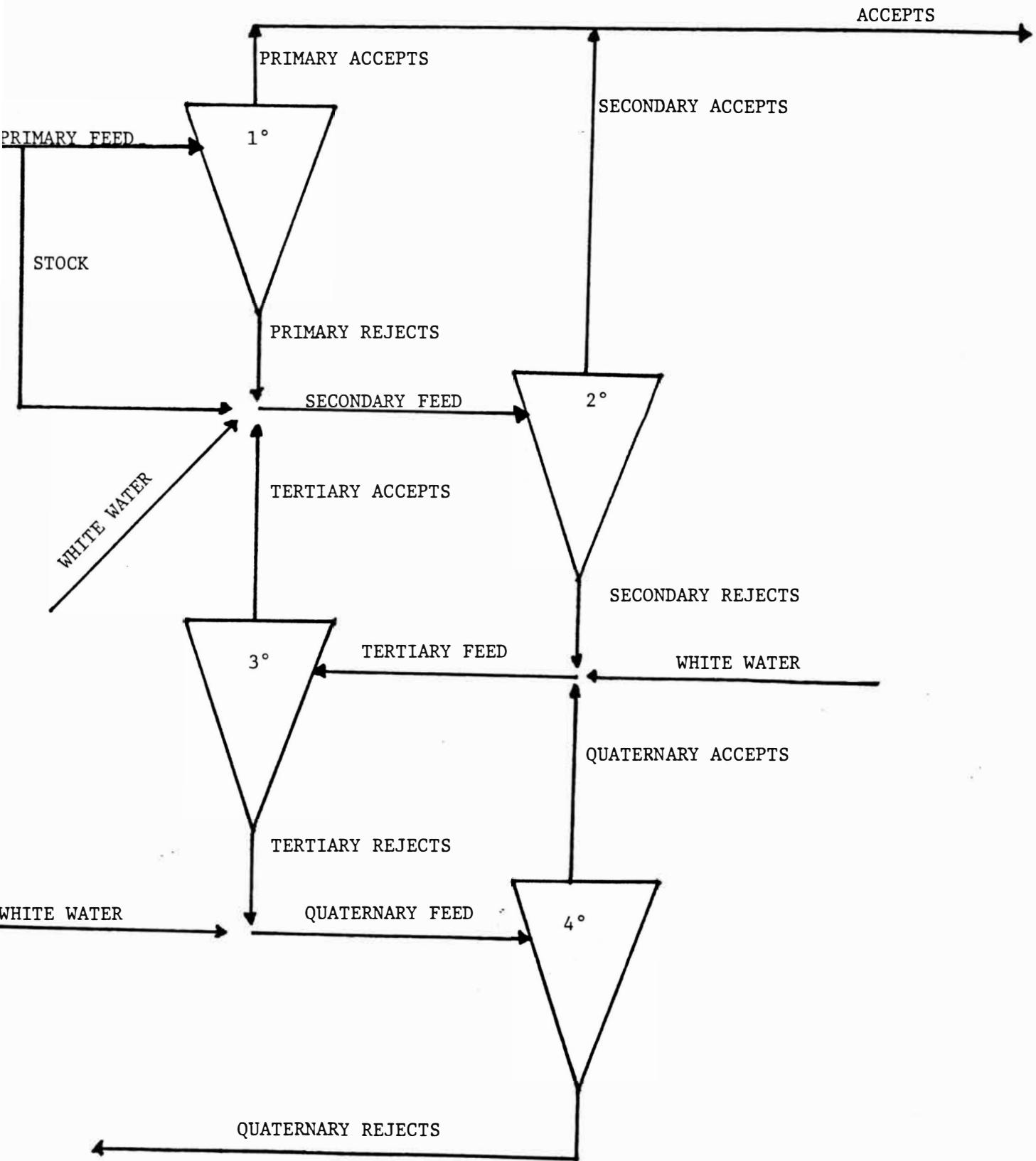
Collection 1

Collection 1 demonstrates the popular 4 stage cascade system that will be modeled for comparison to and evaluation against other collections.



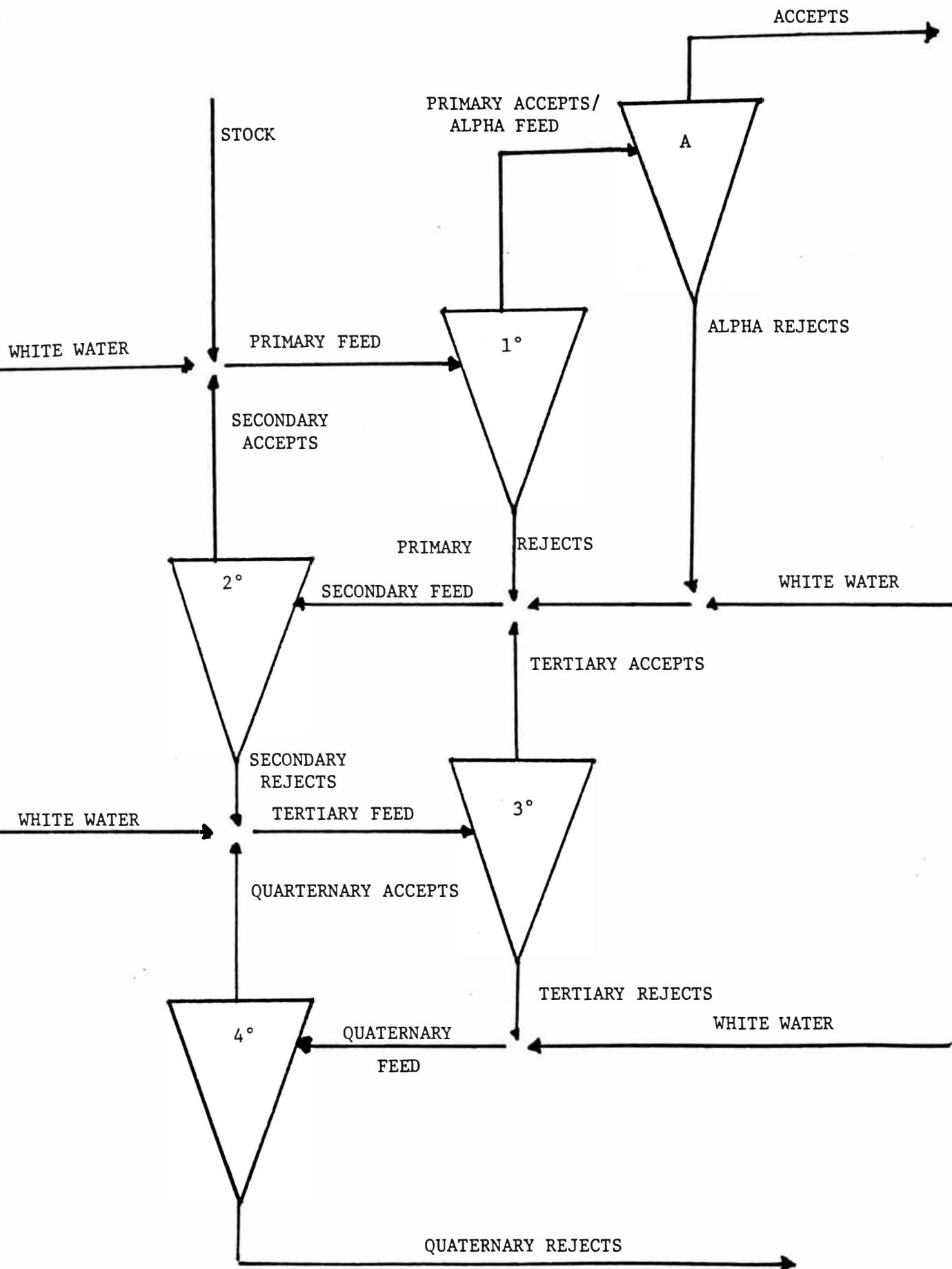
Collection 2

Collection two demonstrates a "split/feed - feed forward" system that is a possible alternative to the cascade system



COLLECTION 3

Collection 3 demonstrates an "alpha-alpha" system that is a possible alternative to the cascade system.



Analysis

Based on the objectives and tolerances listed previously, one must obtain the following information for each system:

- Total number of cleaners needed
- Gallons fed to system
- Gallons accepted from system
- Gallons rejected from system
- Tons of stock fed to system
- Tons accepted from system
- Tons rejected from system
- Dirt count entering the system
- Dirt count leaving the system
- Accepted stock consistency

With this information, total cost, space requirements, yield and cleaning efficiencies can be calculated and compared. To obtain this information a mass and flow balance must be performed on each system.

Because of the interaction between stages a series of equations representing the mass and flow splits must be performed in a loop sequence until there is no change in the system and thus it is balanced. To perform these equations by hand would require several hours per system for each set of conditions.

At this time, it was decided that a mathematical model that represented each collection and could be programmed into a computer/calculator should be developed. This would aid in the understanding of what actually happens with each collection and form a basic analysis structure for quick evaluation of future collections.

Development of these models follows the same steps as previously outlined:

- Define the problem
- Set objectives
- Synthesis
- Analysis
- Selection
- Action

The basic problem was a need for a computer program that would simulate each of the cleaner systems. When gathering pertinent information it was discovered that two such programs (for cascade systems) already existed, (2, 3).

The objectives set for these models are that they must be accurate, easy to apply and provide information in a usable format.

When synthesizing these models, the programs written previously by Mr. V. Kumar and Mr. K. J. Laurinolli (2, 3) were reviewed. Mr. Kumar's program is 100% accurate but the format can only be applied to a HP-97 calculator. Mr. Laurinolli's program is accurate to .00001/GPM, makes several assumptions as to thickening factors and is applicable only to a TI-59 calculator. It was decided at that time to apply several of the principles of Mr. Kumar's program with the format of Mr. Laurinolli's program to develop an accurate cascade flow balance that could be used with a TI-59 calculator (easily available to the author) or programmed in the FORTRAN language. The principles of this hybrid program, if successful, would then be applied to each of the other collections under consideration and they could then be balanced and evaluated under the same criteria.

The final algorithms for each collection are listed on the following pages. Details of the actual programming steps can be found in Appendix I.

MODEL SYNTHESIS

WITH ALGORITHMS

COLLECTION 1

NOMENCLATURE

Symbols

TF = Thickening Factor

T = B.D. tons per day

C = B.D. consistency (not %)

G = Gallons per minute

R = Reject rate by weight

Subscripts:

1 = Primary stage

2 = Secondary stage

3 = Tertiary stage

4 = Quaternary Stage

A = Accepts

F = Feed

R = Rejects

W = Dilution water

S = Initial thick stock

Input

TAA

C₁F

C₂F

C₃F

C₄F

R₁

R₂

R₃

R₄

TF₁

TF₂

TF₃

TF₄

C₁W

C₂W

C₃W

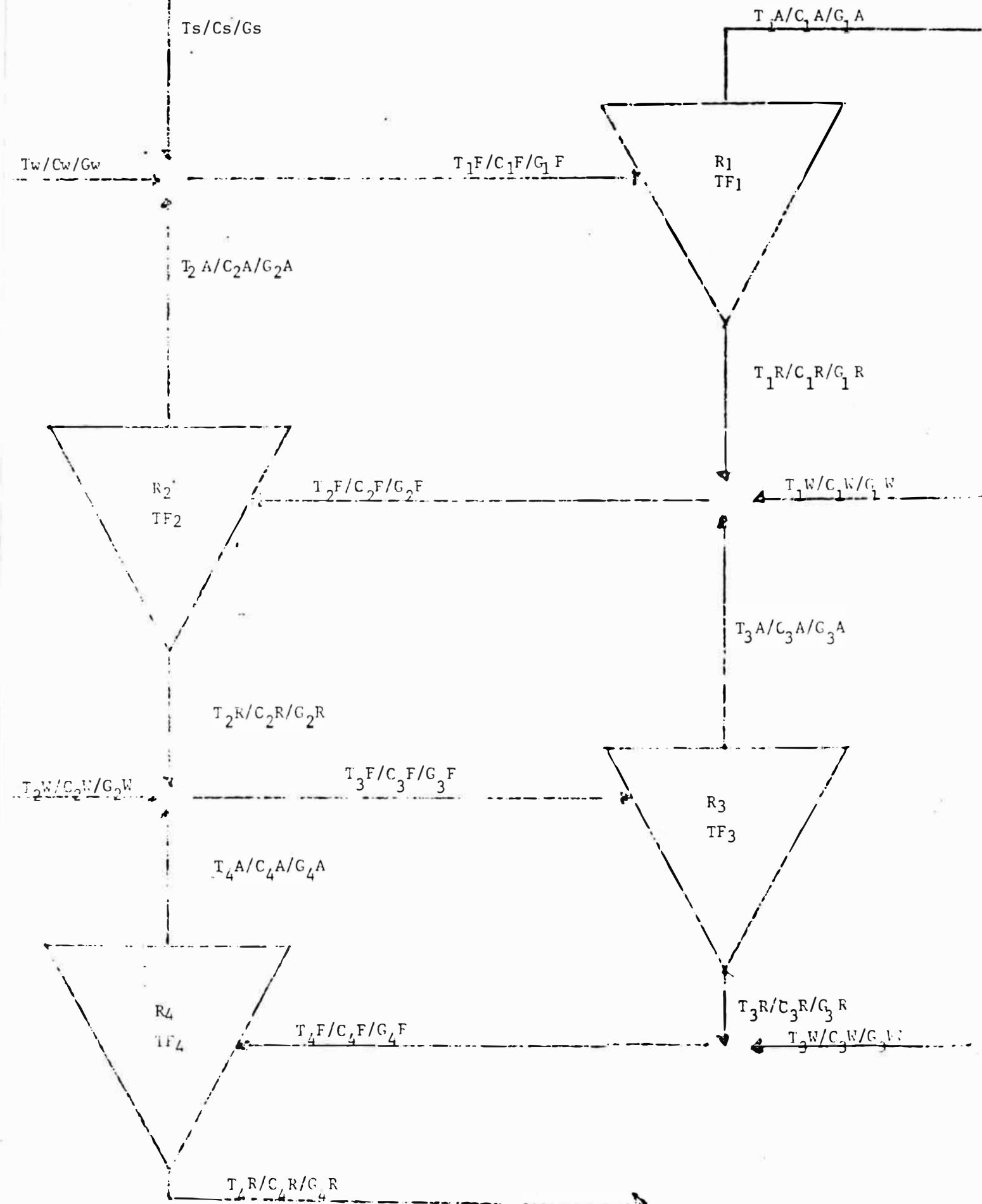
C₄W

CS

T₄R - initial

SYMBOL IDENTIFICATION

Collection I



$$1) \quad G_4 R = \frac{T_4 R}{C_4 R - 6.008}$$

$$2) \quad T_4 F = \frac{T_4 R}{R_4}$$

$$3) \quad G_4 F = \frac{T_4 F}{C_4 F - 6.008}$$

$$4) \quad G_4 A = G_4 F - G_4 R$$

$$5) \quad T_4 A = T_4 F - T_4 R$$

$$6) \quad C_4 A = \frac{T_4 A}{G_4 A - 6.008}$$

$$7) \quad C_3 R = C_3 F - T F_3$$

$$8) \quad \frac{(C_4 F - C_3 R) G_4 F}{(C_3 W - C_3 R)} = G_3 W$$

$$9) \quad G_3 R = G_4 F - G_3 W$$

$$10) \quad T_3 R = G_3 R C_3 R - 6.008$$

$$11) \quad T_3 W = G_3 W C_3 W - 6.008$$

$$12) \quad T_3 F = \frac{T_3 R}{R_3}$$

$$13) \quad G_3 F = \frac{T_3 F}{C_3 F - 6.008}$$

$$14) \quad T_3 A = T_3 F - T_3 R$$

$$15) \quad G_3 A = G_3 F - G_3 R$$

$$16) \quad C_3 A = \frac{T_3 A}{G_3 A - 6.008}$$

$$17) \quad C_2^R = C_2^F \cdot T F_2$$

$$18) \quad G_2^W = \frac{G_3^F (C_3^F - C_2^R) + G_4^A (C_2^R - C_4^A)}{(C_2^W - C_2^R)}$$

$$19) \quad G_2^R = G_3^F - G_2^W - G_4^A$$

$$20) \quad T_2^W = C_2^W \cdot G_2^W \cdot 6.008$$

$$21) \quad T_2^R = C_2^R \cdot G_2^R \cdot 6.008$$

$$22) \quad T_3^F = \frac{T_2^R}{R_2}$$

$$23) \quad G_2^F = \frac{T_2^F}{C_2^F \cdot 6.008}$$

$$24) \quad T_2^A = T_2^F - T_2^R$$

$$25) \quad G_2^A = G_2^F - G_2^R$$

$$26) \quad C_2^A = \frac{T_2^A}{G_2^A \cdot 6.008}$$

$$27) \quad C_1^R = C_1^F \cdot T F_1$$

$$28) \quad G_1^W = \frac{G_2^F (C_2^F - C_1^R) + G_3^A (C_1^R - C_3^A)}{C_1^W - C_1^R}$$

$$29) \quad G_1^R = G_2^F - G_3^A - G_1^W$$

$$30) \quad T_1^R = G_1^R \cdot C_1^R \cdot 6.008$$

$$31) \quad T_1^F = \frac{T_1^R}{R_1}$$

$$32) \quad G_1^F = \frac{T_1^F}{C_1^F \cdot 6.008}$$

$$33) \quad T_1^A = T_1^F - T_1^R$$

$$34) \quad G_1^A = G_1^F - G_1^R$$

$$35) \quad \frac{G_1^A - \text{Known}}{G_1^A - \text{Calculated}} = X$$

$$36) \quad G_4^R X = G_4^R \text{ Actual}$$

$$37) \quad G_4^R (\text{Actual}) C_4^R 6.008 = T_4^R$$

38) Repeat 1-37 until $X=1$ (Step 35)

$$39) \quad GW = \frac{G_1^F (C_1^F - CS) + G_2^A (CS - C_2^A)}{CW - CS}$$

$$40) \quad GS = G_1^F - G_2^A - GW$$

$$41) \quad TW = CW GW 6.008$$

$$42) \quad TS = CS GS 6.008$$

COLLECTION 2

NOMENCLATURE

Symbols

TF = Thickening factor

T = B.D. tons per day

C = B.D. consistency (not %)

G = Gallons per minute

R = Reject rate by weight

Pct = Percentage of feed flow that goes to primary stage

Subscripts:

1 = Primary stage

2 = Secondary stage

3 = Tertiary stage

4 = Quaternary Stage

A = Accepts

F = Feed

R = Rejects

W = Dilution water

S = Initial thick stock

Input

T₁A

C₁F

C₂F

C₃F

C₄F

R₁

R₂

R₃

R₄

TF₁

TF₂

TF₃

TF₄

C₁W

C₂W

C₃W

C₄W

CS

T₄R

Pct

$$1) \quad G_4 R = \frac{T_4 R}{C_4 R \cdot 6.008}$$

$$2) \quad T_4 F = \frac{T_4 R}{R_4}$$

$$3) \quad G_4 F = \frac{T_4 F}{C_4 F \cdot 6.008}$$

$$4) \quad G_4 A = G_4 F - G_4 R$$

$$5) \quad T_4 A = T_4 F - T_4 R$$

$$6) \quad C_4 A = \frac{T_4 A}{G_4 A \cdot 6.008}$$

$$7) \quad C_3 R = C_3 F \cdot T_3 F$$

$$8) \quad \frac{(C_4 F - C_3 R) \cdot G_4 F}{(C_3 W - C_3 R)} = G_3 W$$

$$9) \quad G_3 R = G_4 F - G_3 W$$

$$10) \quad T_3 R = G_3 R \cdot C_3 R \cdot 6.008$$

$$11) \quad T_3 W = G_3 W \cdot C_3 W \cdot 6.008$$

$$12) \quad T_3 F = \frac{T_3 R}{R_3}$$

$$13) \quad G_3 F = \frac{T_3 F}{C_3 F \cdot 6.008}$$

$$14) \quad T_3 A = T_3 F - T_3 R$$

$$15) \quad G_3 A = G_3 F - G_3 R$$

$$16) \quad C_3 A = \frac{T_3 A}{G_3 A \cdot 6.008}$$

$$17) \quad C_2^R = C_2^F \cdot T F_2$$

$$18) \quad G_2^W = \frac{G_3^F (C_3^F - C_2^R) + G_4^A (C_2^R - C_4^A)}{(C_2^W - C_2^R)}$$

$$19) \quad G_2^R = G_3^F - G_2^W - G_4^A$$

$$20) \quad T_2^W = C_2^W \cdot G_2^W \cdot 6.008$$

$$21) \quad T_2^R = C_2^R \cdot G_2^R \cdot 6.008$$

$$22) \quad T_3^F = \frac{T_2^R}{R_2}$$

$$23) \quad G_2^F = \frac{T_2^F}{C_2^F \cdot 6.008}$$

$$24) \quad T_2^A = T_2^F - T_2^R$$

$$25) \quad G_2^A = G_2^F - G_2^R$$

$$26) \quad C_2^A = \frac{T_2^A}{G_2^A \cdot 6.008}$$

$$27) \quad C_1^R = C_1^F \cdot T F_1$$

$$28) \quad G = G_2^F (C_2^F - C_2^W) + G_3^A (C_2^W - C_3^A)$$

$$29) \quad A = C_1^R + C_1^R (1 - pct) - C_2^W \cdot C_1^R - (1-pct) \\ \frac{R1 \quad Pct}{C_1^F \cdot R_1 \cdot Pct}$$

$$30) \quad G_1^R = G/A$$

$$31) \quad G_1^F = \frac{G_1^R \cdot C_1^R \cdot (1 - Pct)}{C1F \quad R1 \quad Pct}$$

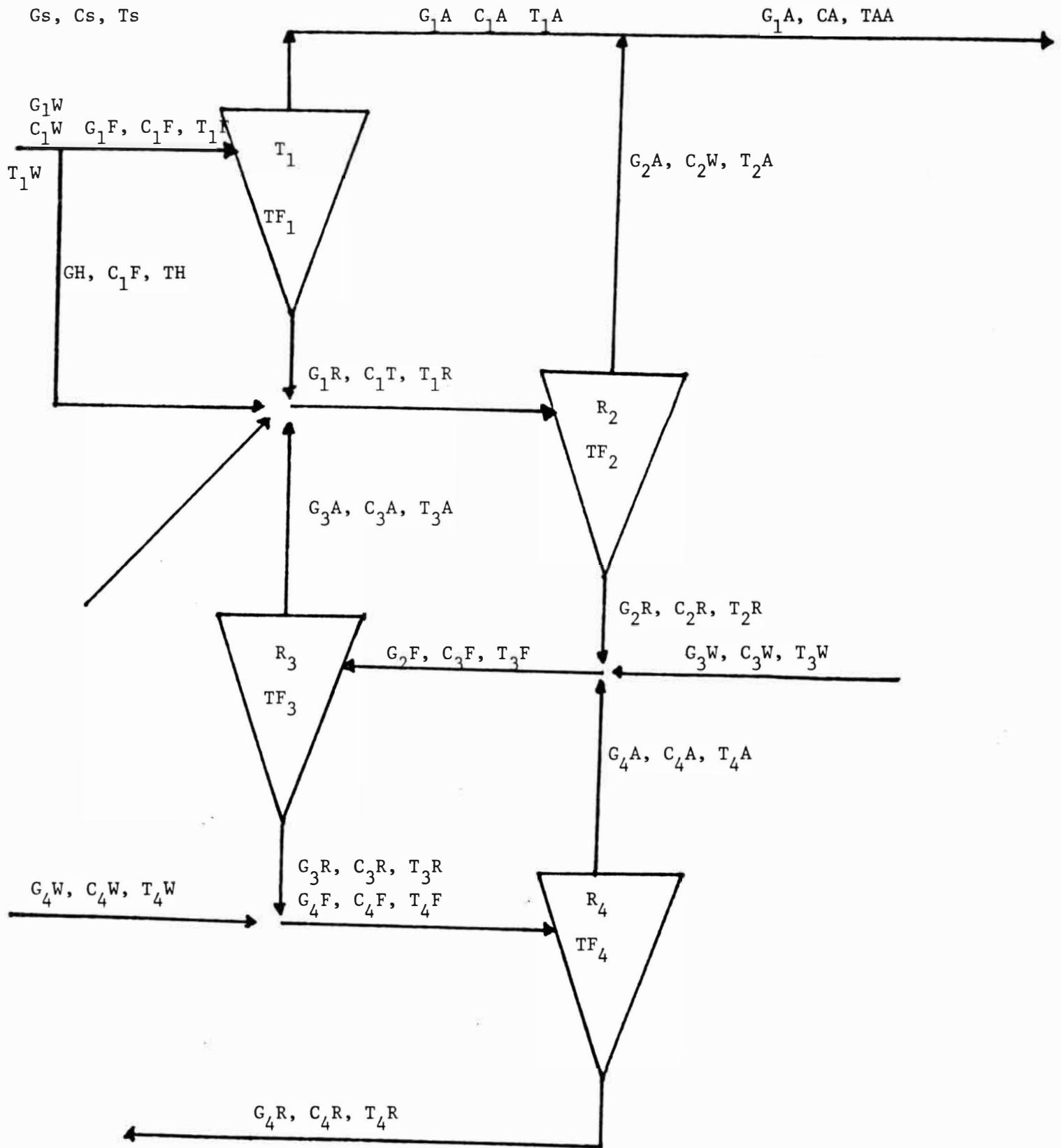
$$32) \quad G_2^W = G_2^F - G_1^R - G_{13}^H$$

- 33) $T_1 H = GH - C_1 F \quad 6.008$
 34) $T_1 R = G_1 R - C_1 R \quad 6.008$
 35) $T_2 W = G_2 W - C_2 W \quad 6.008$
 36) $T_1 F = T_1 R / R_1$
 37) $G_1 F = T_1 F / C_1 F \quad 6.008$
 38) $T_1 A = T_1 F - T_1 R$
 39) $TAA \text{ Calc.} = T_1 A + T_2 A$
 40) $X = TAA / TAA \text{ Calc.}$
 41) $T_4 R \text{ New} = T_4 R - X$
 42) $T_4 R = T_4 R \text{ New}$
 43) $G_1 A = G_1 F - G_1 R$
 44) $C_1 A = T_1 A / (G_1 A - 6.008)$
 45) $GS = G_1 F - (C_1 F - C_1 W + GH (C_1 F - C_1 W))$

 46) $G_1 W = GH - G_1 F - GS$
 47) $T_1 W = C_1 W - G_1 W - 6.008$
 48) $TS = GS - CS \quad 6.008$
 49) $GA = G_1 A + G_2 A$
 50) $CA = TAA / (GA - 6.008)$

SYMBOL IDENTIFICATION

COLLECTION 2



COLLECTION 3

NOMENCLATURE

Symbols

TF = Thickening factor

T = B.D. tons per day

C = B.D. consistency (not %)

G = Gallons per minute

R = Reject rate by weight

A = Alpha stage

Subscripts

1 = Primary stage

2 = Secondary stage

3 = Tertiary stage

4 = Quaternary Stage

A = Accepts

F = Feed

R = Rejects

W = Dilution water

S = Initial thick stock

Input

TAA

$C_1 F$

$C_2 F$

$C_3 F$

$C_4 F$

R_1

R_2

R_3

R_4

RA

TF_1

TF_2

TF_3

TF_4

TFA

$C_1 W$

$C_2 W$

$C_3 W$

$C_4 W$

CS

$T_4 R - \text{initial}$

C - Initial

$$1) \quad G_4 R = \frac{T_4 R}{C_4 R \ 6.008}$$

$$2) \quad T_4 F = \frac{T_4 R}{R_4}$$

$$3) \quad G_4 F = \frac{T_4 F}{C_4 F \ 6.008}$$

$$4) \quad G_4 A = G_4 F - G_4 R$$

$$5) \quad T_4 A = T_4 F - T_4 R$$

$$6) \quad C_4 A = \frac{T_4 A}{G_4 A \ 6.008}$$

$$7) \quad C_3 R = C_3 F \ TF_3$$

$$8) \quad \frac{(C_4 F - C_3 R) \ G_4 F}{(C_3 W - C_3 R)} = G_3 W$$

$$9) \quad G_3 R = G_4 F - G_3 W$$

$$10) \quad T_3 R = G_3 R \ C_3 R \ 6.008$$

$$11) \quad T_3 W = G_3 W \ C_3 W \ 6.008$$

$$12) \quad T_3 F = \frac{T_3 R}{R_3}$$

$$13) \quad G_3 F = \frac{T_3 F}{C_3 F \ 6.008}$$

$$14) \quad T_3 A = T_3 F - T_3 R$$

$$15) \quad G_3 A = G_3 F - G_3 R$$

$$16) \quad C_3 A = \frac{T_3 A}{G_3 A \ 6.008}$$

$$17) \quad C_2^R = C_2^F \cdot T F_2$$

$$18) \quad G_2^W = \frac{G_3^F (C_3^F - C_2^R) + G_4^A (C_2^R - C_4^A)}{(C_2^W - C_2^R)}$$

$$19) \quad G_2^R = G_3^F - G_2^W - G_4^A$$

$$20) \quad T_2^W = C_2^W \cdot G_2^W \cdot 6.008$$

$$21) \quad T_2^R = C_2^R \cdot G_2^R \cdot 6.008$$

$$22) \quad T_3^F = \frac{T_2^R}{R_2}$$

$$23) \quad G_2^F = \frac{T_2^F}{C_2^F \cdot 6.008}$$

$$24) \quad T_2^A = T_2^F - T_2^R$$

$$25) \quad G_2^A = G_2^F - G_2^R$$

$$26) \quad C_2^A = \frac{T_2^A}{G_2^A \cdot 6.008}$$

$$27) \quad C_1^R = C_1^F \cdot T F_1$$

$$28) \quad C = 0.5 \times C_1^R$$

$$29) \quad G = (G_2^F (C_2^F - C_1^R) + G_3^A (C_1^R - C_3^A)) / (C - C_1^R)$$

$$30) \quad T = G \times C \times 6.008$$

$$31) \quad G_1^R = G_2^F - G - G_3^A$$

$$32) \quad T_1^R = G_1^R \times C_1^R \times 6.008$$

$$33) \quad T_1^F = T_1^R / R_1$$

$$34) \quad T_1^A = T_1^F - T_1^R$$

$$35) \quad T R = T_1^A \times R A$$

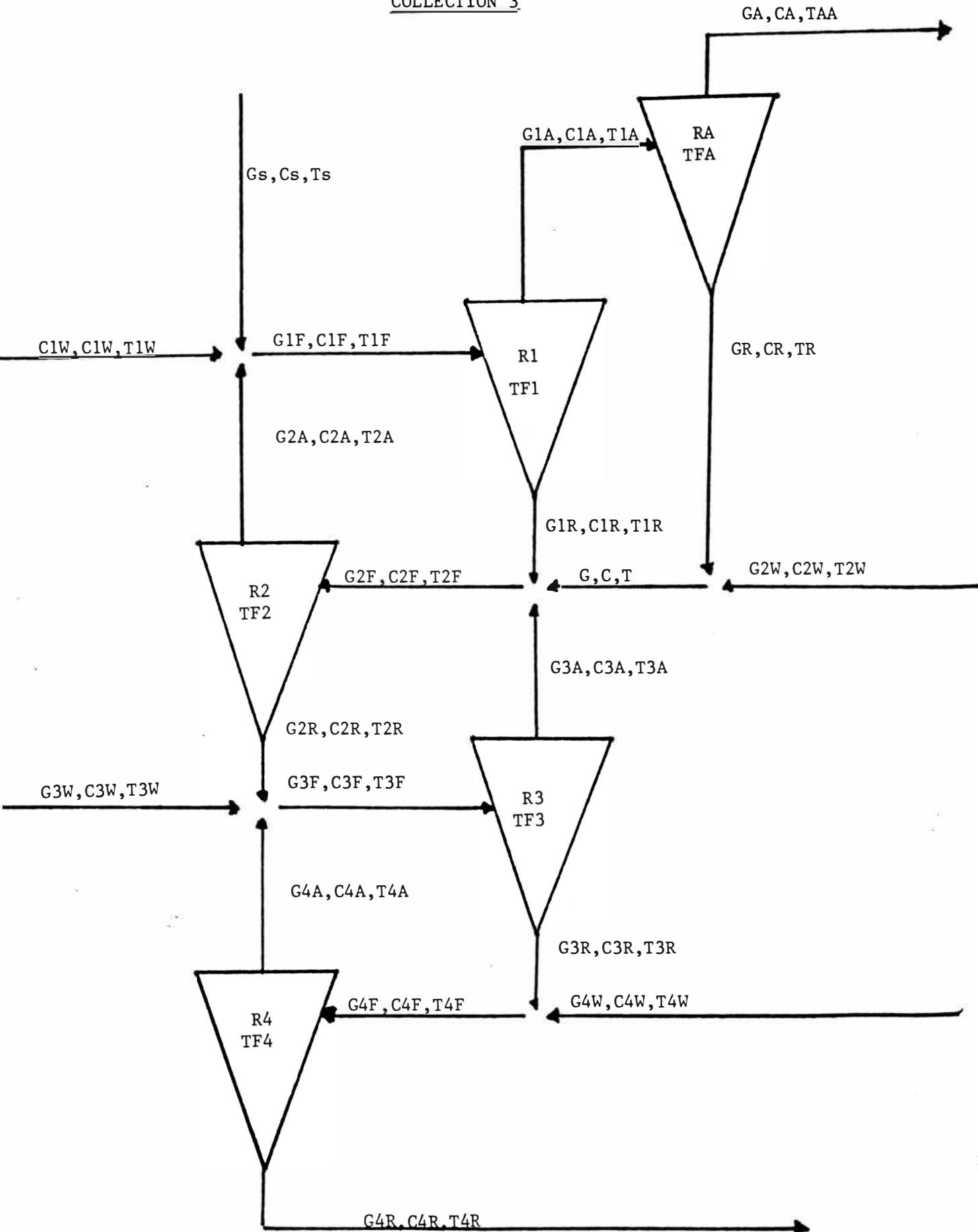
$$36) \quad G_1^F = T_1^F / (C_1^F \times 6.008)$$

$$37) \quad G_1^A = G_1^F - G_1^R$$

- 38) $C_1 A = T_1 A / (G_1 A \times 6.008)$
- 39) $CR = C_1 F \times TFA$
- 40) $GR = TR / (CR \times 6.008)$
- 41) $G_2 W = G - G_1 R$
- 42) $T_2 W = T - TR$
- 43) $TAA \text{ Calc.} = T_1 A - T_1 R$
- 44) $X = TAA / TAA \text{ Calc.}$
- 45) $T_4 R \text{ New} = T_4 R \times X$
- 46) $T_4 R = T_4 R \text{ New}$
- 47) $GA = G_1 A - G_1 R$
- 48) $CA = TA / (GA \times 6.008)$
- 49) $GS = G_1 F (C_1 W - C_1 F) + G_2 A \times (C_2 A - C_1 W) / (C_1 W - CS)$
- 50) $TS = GS \times CS \times 6.008$
- 51) $T_1 W = T_1 F - TS - T_2 A$
- 52) $G_1 W = T_1 W / (C_1 W \times 6.008)$

SYMBOL IDENTIFICATION

COLLECTION 3



Analysis

The following data was run through each collection:

	<u>Input 1</u>	<u>Input 2</u>	<u>Input 3</u>
TA, TAA	150	150	150
C ₁ F	.006	.0050	.005
C ₂ F	.0055	.005	.0045
C ₃ F	.005	.0045	.004
C ₄ F	.0045	.004	.0035
R ₁	.348	.348	.348
R ₂	.474	.474	.474
R ₃	.665	.665	.665
R ₄	.939	.939	.939
TF ₁	2.3	3.3	4.3
TF ₂	3.3	4.3	5.3
TF ₃	4.3	5.3	6.3
TF ₄	5.3	6.3	7.3
C ₁ W	.0001	.0001	.0001
C ₂ W	.0001	.0001	.0001
C ₃ W	.0001	.0001	.0001
C ₄ W	.0001	.0001	.0001
PPM	50	50	50
RA	.297	.297	.297
TFA	5.3	6.3	7.3
PCT	0.8	0.8	0.8
C =	0.1xCIR	0.1xCIR	0.1xCIR

The data previously determined to be necessary for evaluation (pg. 14) was assembled on the following pages. Detailed model results are in Appendix IV.

Analysis

Input 1

	Collection 1	Collection 2	Collection 3
Total number of cleaners	560	466	1158
Gallons fed to system	5629	6373	7596
Gallons accepted from system	5417	6142	7273
Gallons rejected from system	212	231	323
Tons fed to system	181	183	196
Tons accepted from system	150	150	150
Tons rejected from system	31	33	46
Dirt count fed stock (ppm)	50	50	50
Dirt count accepted stock (ppm)	38.4	37.7	36.8
Dirt count rejected stock (ppm)	102.5	100.4	148.9
Accepted stock consistency, %	.461	.406	.343
Yield, % (TS)	82.9	82.0	76.5
Cleaning efficiency, %	35.1	36.9	45.5
Total cost \$ (equipment)	140,580	150,760	209,820

Analysis

Input 2

	Collection 1	Collection 2	Collection 3
Total number of cleaners	605	513	1327
Gallons fed to system	6429	7263	8774
Gallons accepted from system	6228	7044	8442
Gallons rejected from system	201	219	331
Tons fed to system	181	183	200
Tons accepted from system	150	150	150
Tons rejected from system	31	33	50
Dirt count feed stock (ppm)	50	50	50
Dirt count accepted stock (ppm)	35.5	34.3	39.6
Dirt count rejected stock (ppm)	116	115	122.2
Accepted stock consistency, %	.401	.354	.296
Yield, % (TS)	82.9	82.0	75.0
Cleaning efficiency, %	40.0	42.6	50.8
Total cost \$ (equipment)	158,830	170,910	241,830

Analysis

Input 3

	Collection 1	Collection 2	Collection 3
Total number of cleaners	673	572	1528
Gallons fed to system	7240	8200	9962
Gallons accepted from system	7039	7983	9605
Gallons rejected from system	201	217	357
Tons fed to system	181	183	205
Tons accepted from system	150	150	150
Tons rejected from system	31	33	55
Dirt count fed stock (ppm)	50	50	50
Dirt count accepted stock (ppm)	33	32.3	36.1
Dirt count rejected stock (ppm)	126	124	115
Accepted stock consistency, %	.355	.313	.260
Yield, %	82.9	82.0	73.2
Cleaning efficiency, %	43.8	45.8	53.9
Total cost \$ (equipment)	178,447	192,600	275,640

Selection

When selecting a solution to the original need, one must review the initial criteria:

- Must:
- Consist of on-the-market 3" centrifugal cleaners
 - Have a yield as high as, or higher than, a cascade system
 - Provide a pulp at least 5% cleaner than a cascade system

- Must not:
- Exceed \$250,000

- Wants:
- Accept consistency .4% or greater
 - 75% minimum yield
 - 50% minimum cleaning efficiency

Yield

All collections exceed the 75% minimum yield except Collection 3, Input 3. Because feed consistencies are lowest, the cleaners are more efficient and reject more material thus lowering yield. Collections 1 and 2 do not appear to be as sensitive to consistency and yield losses.

The cascade system (Collection 1) shows 82.9% yield in each data case while the split feed-forward system (Collection 2) shows 82% of yield. One objective emphasized earlier was that yield must be greater than or equal to a cascade yield, in this case no yield of other collections met that criteria, but the less than one percent difference is within experimental error, thus Collection 1 and Collection 2 meet yield requirements.

Cleaning Efficiency

Only Collection 3 exceeds the 50% cleaning efficiency desired, while both Collections 2 and 3 exceed the efficiency of the cascade system, both Collection 3 is above the 50% minimum efficiency that is required.

Cost

Collection 3, Input 3 exceeds the \$250,000 limit and is, therefore, eliminated.

All other collections fall below the cost limit.

Comparison

Input 1

	<u>Cascade</u>	<u>Collection</u> <u>2</u>	<u>Collection</u> <u>3</u>
Yield	82.9	-1.0%	-6.4%
Cleaning efficiency	35.1	+1.8%	+10.4%
Cost	140,580	+6.8%	+33%
Acc. Cons. >.4%	Y	Y	N
		Choice	- Collection 3

Input 2

	<u>Cascade</u>	<u>Collection</u> <u>2</u>	<u>Collection</u> <u>3</u>
Yield	82.9	-1.0%	-7.9%
Cleaning efficiency	40.0	+2.6%	+10.8%
Cost	158,830	+7.1%	+34.3%
Acc. Cons. >.4%	Y	N	N
		Choice	- Collection 3

Input 3

	<u>Cascade</u>	<u>Collection</u> <u>2</u>	<u>Collection</u> <u>3</u>
Yield	82.9	-1.0%	-9.7%
Cleaning efficiency	43.8	+2.0%	+10.1%
Cost	178,447	+7.3%	+35.3%
Acc. Cons. >.4%	N	N	N
		Choice	- Collection 1

The selection and recommendation in this case is that for new installations, Collection 3 would be the most acceptable. Also included is the stipulation that it be run at .6% primary feed consistency or higher.

The comparison shows that even though Collection 3 has a high capital cost, it is below the limits by \$40,000. The incremental cleaning efficiency should allow dirtier stocks to be processed. These dirtier stocks are cheaper than cleaner stocks and the lower pulp costs justify the capital costs. A pulp cost, lower by 25#/ton, would return the difference in capital costs in one year at 150 TPD of production. Also, as primary feed consistency increases the yield difference between the cascade system and Collection 3 decreases.

Decision/Action

The decision based on the information provided, is that Collection 3 would be a cost-effective substitute for a cascade system.

The action recommended at this point is to obtain a wider range of input data and evaluate further. The possibility of building a prototype should also be investigated.

Conclusions

The idea of using a model to help illustrate a point is not new but many applications in system design are as yet untried.

This paper presents one sequence of modeling steps and applies that sequence twice in an effort to solve a practical problem in system design. The conclusions reached are:

1. The modeling steps provide an orderly thought process for developing and evaluating a process system.
2. The steps can be applied in their entirety to single elements of a system thus building a complex system one step at a time.
3. The decision reached by following these modeling steps may propose a solution, and/or may also propose further analysis.
4. The forward cleaner sequences modeled in this paper were to be evaluated based on a set of criteria and given input data. From this evaluation a decision was reached that an "Alpha-Alpha" cleaning sequence could be a cost effective replacement for the traditional cascade cleaner system.

5. The action step recommendations were to first expand the given input data base, then perform further analysis to either verify or disqualify the initial decision.

APPENDIX I

PROGRAM DETAILS

C PROGRAM BALANCE 1

C C IMPLICIT INTEGER*2 (1-N)
IMPLICIT REAL*2 (A-H)
IMPLICIT REAL*8 (D-Z)

C C INTEGER*4 INPUTNAM(18)

C REAL*8 INPUT(18)

C LOGICAL MAX(19), MIN(19)
REAL*8 INMAX(19), INMIN(19)

C C LOGICAL TRACE
INTEGER*1 IRESP

C EQUIVALENCE (INPUT(1), T1A)
EQUIVALENCE (INPUT(2), C1F)
EQUIVALENCE (INPUT(3), C2F)
EQUIVALENCE (INPUT(4), C3F)
EQUIVALENCE (INPUT(5), C4F)
EQUIVALENCE (INPUT(6), R1)
EQUIVALENCE (INPUT(7), R2)
EQUIVALENCE (INPUT(8), R3)
EQUIVALENCE (INPUT(9), R4)
EQUIVALENCE (INPUT(10), TF1)
EQUIVALENCE (INPUT(11), TF2)
EQUIVALENCE (INPUT(12), TF3)
EQUIVALENCE (INPUT(13), TF4)
EQUIVALENCE (INPUT(14), C1W)
EQUIVALENCE (INPUT(15), C2W)
EQUIVALENCE (INPUT(16), C3W)
EQUIVALENCE (INPUT(17), C4W)
EQUIVALENCE (INPUT(18), CS)

C C DATA FACTOR / 6.008 /

0018.000
0019.000
0020.000
0021.000
0022.000
0023.000
0024.000
0025.000
0026.000
0027.000
0028.000
0029.000
0030.000
0031.000
0032.000
0033.000
0034.000
0035.000
0036.000
0037.000
0038.000
0039.000
0040.000
0041.000
0042.000
0043.000
0044.000
0045.000
0046.000
0047.000
0048.000
0049.000
0050.000
0051.000
0052.000
0053.000
0054.000
0055.000
0056.000
0057.000
0058.000
0059.000
0060.000

```

C DATA XMAX / 1.000001 /
C DATA XMIN / .999999 /
C
C NOTE THAT T4R ALSO HAS LIMITS (INDEX = 19 FOR THESE LOOKUPS...)
C DATA MAX / .FALSE. , 17* TRUE. , .FALSE. /
C
C NEGATIVE ENTRIES ARE NEVER ALLOWED, REGARDLESS OF EXISTENCE
C OF A SPECIFIED MINIMUM VALUE
C DATA MIN / 5 * .TRUE. , 18 * .FALSE. , .TRUE. /
C
C DATA INMAX / 0 , 4 * 0.3 , 4* 1.0 , 4* 100.0 , 4* 0.01 , 1.0 , 0 /
C DATA INMIN / 1.0 , 4* 0.001 , 13* 0.0 , 1.0 /
C
C DATA INPUTNAM / 'T1A', 'C1F', 'C2F', 'C3F', 'C4F', 'R1', 'R2', 'R3',
C 'R4', 'TF1', 'TF2', 'TF3', 'TF4', 'C1W', 'C2W', 'C3W', 'C4W', 'CS' /
C
C DO 10 IA=1,18
C
11 WRITE ('CRT', 1001) INPUTNAM(IA)
1001 FORMAT (' PLEASE ENTER THE VALUE OF ', A4, ' ')
C
1002 READ ('KYB', 1002) INPUT(IA)
1002 FORMAT (F12.4)
C
IF (INPUT(IA).LT.0.0) GO TO 12
IF (MIN(IA).AND.INPUT(IA).LT.INMIN(IA)) GO TO 12
IF (MAX(IA).AND.INPUT(IA).GT.INMAX(IA)) GO TO 13
C
GO TO 10
C
12 WRITE ('CRT', 1030)
1030 FORMAT (' *** VALUE IS BELOW MINIMUM. PLEASE RE-ENTER... ')
C
GO TO 11
C
13 WRITE ('CRT', 1031)
1031 FORMAT (' *** VALUE IS ABOVE MAXIMUM. PLEASE RE-ENTER... ')
C
GO TO 11
C
10 CONTINUE
C
IA = 19
C
21 WRITE ('CRT', 1003)
1003 FORMAT (' PLEASE ENTER THE ASSUMED INITIAL VALUE OF T4R... ')

```

0063.00
0064.00
0065.00
0066.00
0067.00
0068.00
0069.00
0070.00
0071.00
0072.00
0073.00
0074.00
0075.00
0076.00
0077.00
0078.00
0079.00
0080.00
0081.00
0082.00
0083.00
0084.00
0085.00
0086.00
0087.00
0088.00
0089.00
0090.00
0091.00
0092.00
0093.00
0094.00
0095.00
0096.00
0097.00
0098.00
0099.00
0100.00
0101.00
0102.00
0103.00
0104.00
0105.00
0106.00
0107.00
0108.00
0109.00
0110.00
0111.00
0112.00
0113.00
0114.00
0115.00
0116.00
0117.00
0118.00
0119.00
0120.00

```

C      IF (T4RINIT.LT.0.0) GO TO 22          0123.00
C      IF (MIN(IA).AND.T4RINIT.LT.INMIN(IA)) GO TO 22 0124.00
C      IF (MAX(IA).AND.T4RINIT.GT.INMAX(IA)) GO TO 23 0125.00
C
C      GO TO 30                                0126.00
C
C      22 WRITE ('CRT',1030)                   0127.00
C
C      GO TO 21                                0128.00
C
C      23 WRITE ('CRT',1031)                   0129.00
C
C      GO TO 21                                0130.00
C
C      30 WRITE ('CRT',1005)                   0131.00
C      1005 FORMAT ('DO YOU WISH TO TRACE THE ITERATIONS... ') 0132.00
C
C      READ ('KYB',1008) IRESP                0133.00
C      1008 FORMAT (A1)                         0134.00
C
C      IF (IRESP.EQ.'Y') TRACE = TRUE.        0135.00
C
C      WRITE ('CRT',1004)                      0136.00
C      1004 FORMAT ('/ THANK YOU... ')          0137.00
C
C      T4R = T4RINIT                          0138.00
C
C
C      20 CONTINUE                            0139.00
C
C      T4F = T4R / R4                         0140.00
C
C      G4F = T4F / (C4F * FACTOR)             0141.00
C
C      C4R = C4F * TF4                        0142.00
C
C      G4R = T4R / (C4R * FACTOR)             0143.00
C
C      G4A = G4F - G4R                        0144.00
C
C      T4A = T4F - T4R                        0145.00
C
C      C4A = T4A / (G4A * FACTOR)             0146.00
C
C      C3R = C3F * TF3                        0147.00
C
C      G4W = ((C4F-C3R)*G4F) / (C4W-C3R)    0148.00
C
C      G3R = G4F - G4W                        0149.00
C
C      T4W = G4W * C4W * FACTOR              0150.00
C
C      T3R = G3R * C3R * FACTOR              0151.00
C
C      T3F = T3R / R3                        0152.00
C
C
C
C

```

```

C   G3A = G3F - G3R          0183.00
C   T3A = T3F - T3R          0184.00
C   C3A = T3A / (G3A * FACTOR) 0185.00
C   C2R = C2F * TF2          0186.00
C   G2R = ((G3F * (C3F - C3W)) + G4A * (C3W - C4A)) / (C2R - C3W) 0187.00
C   G3W = G3F - G4A - G2R      0188.00
C   T2R = G2R * C2R * FACTOR  0189.00
C   T3W = G3W * C3W * FACTOR  0190.00
C   T2F = T2R / R2            0191.00
C   G2F = T2F / (C2F * FACTOR) 0192.00
C   T2A = T2F - T2R          0193.00
C   G2A = G2F - G2R          0194.00
C   C2A = T2A / (G2A * FACTOR) 0195.00
C   C1R = C1F * TF1          0196.00
C   G1R = ((G2F * (C2F - C2W)) + G3A * (C2W - C3A)) / (C1R - C2W) 0197.00
C   G2W = G2F - G1R - G3A      0198.00
C   T1R = G1R * C1R * FACTOR  0199.00
C   T2W = G2W * C2W * FACTOR  0200.00
C   T1F = T1R / R1            0201.00
C   G1F = T1F / (C1F * FACTOR) 0202.00
C   GS = ((G1F * (C1F - C1W)) + G2A * (C1W - C2A)) / (GS - C1W) 0203.00
C   G1W = G1F - GS - G2A      0204.00
C   TS = GS * CS * FACTOR    0205.00
C   T1W = G1W * C1W * FACTOR  0206.00
C   T1ACALC = T1F - T1R       0207.00
C   X = T1A / T1ACALC        0208.00
C   T4RNEW = T4R * X          0209.00
C   IF (.NOT. TRACE) GO TO 80 0210.00
C   WRITE ('CRT',1000) X,T4RNEW 0211.00

```

C 80 IF (X.LT.XMAX AND X.GT.XMIN) GO TO 90
C T4R = T4RNEW
C GO TO 20
C
C 90 WRITE ('CRT',1007)
1007 FORMAT (' ITERATIONS COMPLETE ')
C G1A = G1F - G1R
C C1A = T1A / (G1A * FACTOR)
C
C CONSOLIDATE RESULTS FOR PRINTOUT
C CSX = CS * 100.0
C C1FX = C1F * 100.0
C C1AX = C1A * 100.0
C C1RX = C1R * 100.0
C C1WX = C1W * 100.0
C C2FX = C2F * 100.0
C C2AX = C2A * 100.0
C C2RX = C2R * 100.0
C C2WX = C2W * 100.0
C C3FX = C3F * 100.0
C C3AX = C3A * 100.0
C C3RX = C3R * 100.0
C C3WX = C3W * 100.0
C C4FX = C4F * 100.0
C C4AX = C4A * 100.0
C C4RX = C4R * 100.0
C C4WX = C4W * 100.0
C
C 1009 WRITE ('PTR',1009)
1009 FORMAT (15X,'STOCK')//)
C
C WRITE ('PTR',1010) TS,CSX,G3

10X, 'GPM' //F12.37)

C C

1011 WRITE ('PTR', 1011)
C
1012 FORMAT (15X, 'PRIMARY STAGE')
C
1013 WRITE ('PTR', 1012)
C
1014 FORMAT (3X, 'FEED')
C
1015 WRITE ('PTR', 1013)
C
1016 FORMAT (3X, 'ACCEPTS')
C
1017 WRITE ('PTR', 1014)
C
1018 FORMAT (3X, 'REJECTS')
C
1019 WRITE ('PTR', 1015)
C
1020 FORMAT (3X, 'WHITEWATER')
C
1021 WRITE ('PTR', 1016)
C
1022 FORMAT (15X, 'SECONDARY STAGE')
C
1023 WRITE ('PTR', 1017)
C
1024 WRITE ('PTR', 1018)
C
1025 FORMAT (3X, 'FEED')
C
1026 WRITE ('PTR', 1019)
C
1027 FORMAT (3X, 'ACCEPTS')
C
1028 WRITE ('PTR', 1020)
C
1029 FORMAT (3X, 'REJECTS')
C
1030 WRITE ('PTR', 1021)
C
1031 FORMAT (15X, 'TERTIARY STAGE')
C
1032 WRITE ('PTR', 1022)
C
1033 FORMAT (3X, 'FEED')
C
1034 WRITE ('PTR', 1023)
C
1035 FORMAT (3X, 'ACCEPTS')
C
1036 WRITE ('PTR', 1024)
C
1037 FORMAT (3X, 'REJECTS')
C
1038 WRITE ('PTR', 1025)
C
1039 FORMAT (15X, 'QUARTER STAGE')
C
1040 WRITE ('PTR', 1026)
C
1041 FORMAT (3X, 'FEED')
C
1042 WRITE ('PTR', 1027)
C
1043 FORMAT (3X, 'ACCEPTS')
C
1044 WRITE ('PTR', 1028)
C
1045 FORMAT (3X, 'REJECTS')
C
1046 WRITE ('PTR', 1029)
C
1047 FORMAT (15X, 'FIFTH STAGE')
C
1048 WRITE ('PTR', 102A)
C
1049 FORMAT (3X, 'FEED')
C
1050 WRITE ('PTR', 102B)
C
1051 FORMAT (3X, 'ACCEPTS')
C
1052 WRITE ('PTR', 102C)
C
1053 FORMAT (3X, 'REJECTS')
C
1054 WRITE ('PTR', 102D)
C
1055 FORMAT (15X, 'SIXTH STAGE')
C
1056 WRITE ('PTR', 102E)
C
1057 FORMAT (3X, 'FEED')
C
1058 WRITE ('PTR', 102F)
C
1059 FORMAT (3X, 'ACCEPTS')
C
1060 WRITE ('PTR', 1030)
C
1061 FORMAT (15X, 'SEVENTH STAGE')
C
1062 WRITE ('PTR', 1031)
C
1063 FORMAT (3X, 'FEED')
C
1064 WRITE ('PTR', 1032)
C
1065 FORMAT (3X, 'ACCEPTS')
C
1066 WRITE ('PTR', 1033)
C
1067 FORMAT (3X, 'REJECTS')
C
1068 WRITE ('PTR', 1034)
C
1069 FORMAT (15X, 'EIGHTH STAGE')
C
1070 WRITE ('PTR', 1035)
C
1071 FORMAT (3X, 'FEED')
C
1072 WRITE ('PTR', 1036)
C
1073 FORMAT (3X, 'ACCEPTS')
C
1074 WRITE ('PTR', 1037)
C
1075 FORMAT (3X, 'REJECTS')
C
1076 WRITE ('PTR', 1038)
C
1077 FORMAT (15X, 'NINTH STAGE')
C
1078 WRITE ('PTR', 1039)
C
1079 FORMAT (3X, 'FEED')
C
1080 WRITE ('PTR', 103A)
C
1081 FORMAT (3X, 'ACCEPTS')
C
1082 WRITE ('PTR', 103B)
C
1083 FORMAT (3X, 'REJECTS')
C
1084 WRITE ('PTR', 103C)
C
1085 FORMAT (15X, 'TENTH STAGE')
C
1086 WRITE ('PTR', 103D)
C
1087 FORMAT (3X, 'FEED')
C
1088 WRITE ('PTR', 103E)
C
1089 FORMAT (3X, 'ACCEPTS')
C
1090 WRITE ('PTR', 103F)
C
1091 FORMAT (3X, 'REJECTS')
C
1092 WRITE ('PTR', 1040)
C
1093 FORMAT (15X, 'ELEVENTH STAGE')
C
1094 WRITE ('PTR', 1041)
C
1095 FORMAT (3X, 'FEED')
C
1096 WRITE ('PTR', 1042)
C
1097 FORMAT (3X, 'ACCEPTS')
C
1098 WRITE ('PTR', 1043)
C
1099 FORMAT (3X, 'REJECTS')
C
1100 WRITE ('PTR', 1044)
C
1101 FORMAT (15X, 'TWELFTH STAGE')
C
1102 WRITE ('PTR', 1045)
C
1103 FORMAT (3X, 'FEED')
C
1104 WRITE ('PTR', 1046)
C
1105 FORMAT (3X, 'ACCEPTS')
C
1106 WRITE ('PTR', 1047)
C
1107 FORMAT (3X, 'REJECTS')
C
1108 WRITE ('PTR', 1048)
C
1109 FORMAT (15X, 'THIRTEEN STAGE')
C
1110 WRITE ('PTR', 1049)
C
1111 FORMAT (3X, 'FEED')
C
1112 WRITE ('PTR', 104A)
C
1113 FORMAT (3X, 'ACCEPTS')
C
1114 WRITE ('PTR', 104B)
C
1115 FORMAT (3X, 'REJECTS')
C
1116 WRITE ('PTR', 104C)
C
1117 FORMAT (15X, 'FOURTEEN STAGE')
C
1118 WRITE ('PTR', 104D)
C
1119 FORMAT (3X, 'FEED')
C
1120 WRITE ('PTR', 104E)
C
1121 FORMAT (3X, 'ACCEPTS')
C
1122 WRITE ('PTR', 104F)
C
1123 FORMAT (3X, 'REJECTS')
C
1124 WRITE ('PTR', 104G)
C
1125 FORMAT (15X, 'FIFTEEN STAGE')
C
1126 WRITE ('PTR', 104H)
C
1127 FORMAT (3X, 'FEED')
C
1128 WRITE ('PTR', 104I)
C
1129 FORMAT (3X, 'ACCEPTS')
C
1130 WRITE ('PTR', 104J)
C
1131 FORMAT (3X, 'REJECTS')
C
1132 WRITE ('PTR', 104K)
C
1133 FORMAT (15X, 'SIXTEEN STAGE')
C
1134 WRITE ('PTR', 104L)
C
1135 FORMAT (3X, 'FEED')
C
1136 WRITE ('PTR', 104M)
C
1137 FORMAT (3X, 'ACCEPTS')
C
1138 WRITE ('PTR', 104N)
C
1139 FORMAT (3X, 'REJECTS')
C
1140 WRITE ('PTR', 104O)
C
1141 FORMAT (15X, 'SEVENTEEN STAGE')
C
1142 WRITE ('PTR', 104P)
C
1143 FORMAT (3X, 'FEED')
C
1144 WRITE ('PTR', 104Q)
C
1145 FORMAT (3X, 'ACCEPTS')
C
1146 WRITE ('PTR', 104R)
C
1147 FORMAT (3X, 'REJECTS')
C
1148 WRITE ('PTR', 104S)
C
1149 FORMAT (15X, 'EIGHTEEN STAGE')
C
1150 WRITE ('PTR', 104T)
C
1151 FORMAT (3X, 'FEED')
C
1152 WRITE ('PTR', 104U)
C
1153 FORMAT (3X, 'ACCEPTS')
C
1154 WRITE ('PTR', 104V)
C
1155 FORMAT (3X, 'REJECTS')
C
1156 WRITE ('PTR', 104W)
C
1157 FORMAT (15X, 'NINETEEN STAGE')
C
1158 WRITE ('PTR', 104X)
C
1159 FORMAT (3X, 'FEED')
C
1160 WRITE ('PTR', 104Y)
C
1161 FORMAT (3X, 'ACCEPTS')
C
1162 WRITE ('PTR', 104Z)
C
1163 FORMAT (3X, 'REJECTS')
C
1164 WRITE ('PTR', 104AA)
C
1165 FORMAT (15X, 'TWENTY STAGE')
C
1166 WRITE ('PTR', 104AB)
C
1167 FORMAT (3X, 'FEED')
C
1168 WRITE ('PTR', 104AC)
C
1169 FORMAT (3X, 'ACCEPTS')
C
1170 WRITE ('PTR', 104AD)
C
1171 FORMAT (3X, 'REJECTS')
C
1172 WRITE ('PTR', 104AE)
C
1173 FORMAT (15X, 'TWENTYONE STAGE')
C
1174 WRITE ('PTR', 104AF)
C
1175 FORMAT (3X, 'FEED')
C
1176 WRITE ('PTR', 104AG)
C
1177 FORMAT (3X, 'ACCEPTS')
C
1178 WRITE ('PTR', 104AH)
C
1179 FORMAT (3X, 'REJECTS')
C
1180 WRITE ('PTR', 104AI)
C
1181 FORMAT (15X, 'TWENTYTWO STAGE')
C
1182 WRITE ('PTR', 104AJ)
C
1183 FORMAT (3X, 'FEED')
C
1184 WRITE ('PTR', 104AK)
C
1185 FORMAT (3X, 'ACCEPTS')
C
1186 WRITE ('PTR', 104AL)
C
1187 FORMAT (3X, 'REJECTS')
C
1188 WRITE ('PTR', 104AM)
C
1189 FORMAT (15X, 'TWENTYTTHREE STAGE')
C
1190 WRITE ('PTR', 104AN)
C
1191 FORMAT (3X, 'FEED')
C
1192 WRITE ('PTR', 104AO)
C
1193 FORMAT (3X, 'ACCEPTS')
C
1194 WRITE ('PTR', 104AP)
C
1195 FORMAT (3X, 'REJECTS')
C
1196 WRITE ('PTR', 104AQ)
C
1197 FORMAT (15X, 'TWENTYTFOUR STAGE')
C
1198 WRITE ('PTR', 104AR)
C
1199 FORMAT (3X, 'FEED')
C
1200 WRITE ('PTR', 104AS)
C
1201 FORMAT (3X, 'ACCEPTS')
C
1202 WRITE ('PTR', 104AT)
C
1203 FORMAT (3X, 'REJECTS')
C
1204 WRITE ('PTR', 104AU)
C
1205 FORMAT (15X, 'TWENTYTFOIVE STAGE')
C
1206 WRITE ('PTR', 104AV)
C
1207 FORMAT (3X, 'FEED')
C
1208 WRITE ('PTR', 104AW)
C
1209 FORMAT (3X, 'ACCEPTS')
C
1210 WRITE ('PTR', 104AX)
C
1211 FORMAT (3X, 'REJECTS')
C
1212 WRITE ('PTR', 104AY)
C
1213 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1214 WRITE ('PTR', 104AZ)
C
1215 FORMAT (3X, 'FEED')
C
1216 WRITE ('PTR', 104BA)
C
1217 FORMAT (3X, 'ACCEPTS')
C
1218 WRITE ('PTR', 104CA)
C
1219 FORMAT (3X, 'REJECTS')
C
1220 WRITE ('PTR', 104DA)
C
1221 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1222 WRITE ('PTR', 104EA)
C
1223 FORMAT (3X, 'FEED')
C
1224 WRITE ('PTR', 104FA)
C
1225 FORMAT (3X, 'ACCEPTS')
C
1226 WRITE ('PTR', 104GA)
C
1227 FORMAT (3X, 'REJECTS')
C
1228 WRITE ('PTR', 104HA)
C
1229 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1230 WRITE ('PTR', 104IA)
C
1231 FORMAT (3X, 'FEED')
C
1232 WRITE ('PTR', 104JA)
C
1233 FORMAT (3X, 'ACCEPTS')
C
1234 WRITE ('PTR', 104KA)
C
1235 FORMAT (3X, 'REJECTS')
C
1236 WRITE ('PTR', 104LA)
C
1237 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1238 WRITE ('PTR', 104MA)
C
1239 FORMAT (3X, 'FEED')
C
1240 WRITE ('PTR', 104NA)
C
1241 FORMAT (3X, 'ACCEPTS')
C
1242 WRITE ('PTR', 104OA)
C
1243 FORMAT (3X, 'REJECTS')
C
1244 WRITE ('PTR', 104PA)
C
1245 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1246 WRITE ('PTR', 104QA)
C
1247 FORMAT (3X, 'FEED')
C
1248 WRITE ('PTR', 104RA)
C
1249 FORMAT (3X, 'ACCEPTS')
C
1250 WRITE ('PTR', 104SA)
C
1251 FORMAT (3X, 'REJECTS')
C
1252 WRITE ('PTR', 104TA)
C
1253 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1254 WRITE ('PTR', 104UA)
C
1255 FORMAT (3X, 'FEED')
C
1256 WRITE ('PTR', 104VA)
C
1257 FORMAT (3X, 'ACCEPTS')
C
1258 WRITE ('PTR', 104WA)
C
1259 FORMAT (3X, 'REJECTS')
C
1260 WRITE ('PTR', 104XA)
C
1261 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1262 WRITE ('PTR', 104YA)
C
1263 FORMAT (3X, 'FEED')
C
1264 WRITE ('PTR', 104ZA)
C
1265 FORMAT (3X, 'ACCEPTS')
C
1266 WRITE ('PTR', 104AA)
C
1267 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1268 WRITE ('PTR', 104AB)
C
1269 FORMAT (3X, 'FEED')
C
1270 WRITE ('PTR', 104AC)
C
1271 FORMAT (3X, 'ACCEPTS')
C
1272 WRITE ('PTR', 104AD)
C
1273 FORMAT (3X, 'REJECTS')
C
1274 WRITE ('PTR', 104AE)
C
1275 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1276 WRITE ('PTR', 104AF)
C
1277 FORMAT (3X, 'FEED')
C
1278 WRITE ('PTR', 104AG)
C
1279 FORMAT (3X, 'ACCEPTS')
C
1280 WRITE ('PTR', 104AH)
C
1281 FORMAT (3X, 'REJECTS')
C
1282 WRITE ('PTR', 104AI)
C
1283 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1284 WRITE ('PTR', 104AJ)
C
1285 FORMAT (3X, 'FEED')
C
1286 WRITE ('PTR', 104AK)
C
1287 FORMAT (3X, 'ACCEPTS')
C
1288 WRITE ('PTR', 104AL)
C
1289 FORMAT (3X, 'REJECTS')
C
1290 WRITE ('PTR', 104AM)
C
1291 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1292 WRITE ('PTR', 104AN)
C
1293 FORMAT (3X, 'FEED')
C
1294 WRITE ('PTR', 104AO)
C
1295 FORMAT (3X, 'ACCEPTS')
C
1296 WRITE ('PTR', 104AP)
C
1297 FORMAT (3X, 'REJECTS')
C
1298 WRITE ('PTR', 104AQ)
C
1299 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1300 WRITE ('PTR', 104AR)
C
1301 FORMAT (3X, 'FEED')
C
1302 WRITE ('PTR', 104AS)
C
1303 FORMAT (3X, 'ACCEPTS')
C
1304 WRITE ('PTR', 104AT)
C
1305 FORMAT (3X, 'REJECTS')
C
1306 WRITE ('PTR', 104AU)
C
1307 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1308 WRITE ('PTR', 104AV)
C
1309 FORMAT (3X, 'FEED')
C
1310 WRITE ('PTR', 104AW)
C
1311 FORMAT (3X, 'ACCEPTS')
C
1312 WRITE ('PTR', 104AX)
C
1313 FORMAT (3X, 'REJECTS')
C
1314 WRITE ('PTR', 104AY)
C
1315 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1316 WRITE ('PTR', 104AZ)
C
1317 FORMAT (3X, 'FEED')
C
1318 WRITE ('PTR', 104BA)
C
1319 FORMAT (3X, 'ACCEPTS')
C
1320 WRITE ('PTR', 104CA)
C
1321 FORMAT (3X, 'REJECTS')
C
1322 WRITE ('PTR', 104DA)
C
1323 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1324 WRITE ('PTR', 104EA)
C
1325 FORMAT (3X, 'FEED')
C
1326 WRITE ('PTR', 104FA)
C
1327 FORMAT (3X, 'ACCEPTS')
C
1328 WRITE ('PTR', 104GA)
C
1329 FORMAT (3X, 'REJECTS')
C
1330 WRITE ('PTR', 104HA)
C
1331 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1332 WRITE ('PTR', 104IA)
C
1333 FORMAT (3X, 'FEED')
C
1334 WRITE ('PTR', 104JA)
C
1335 FORMAT (3X, 'ACCEPTS')
C
1336 WRITE ('PTR', 104KA)
C
1337 FORMAT (3X, 'REJECTS')
C
1338 WRITE ('PTR', 104LA)
C
1339 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1340 WRITE ('PTR', 104MA)
C
1341 FORMAT (3X, 'FEED')
C
1342 WRITE ('PTR', 104NA)
C
1343 FORMAT (3X, 'ACCEPTS')
C
1344 WRITE ('PTR', 104OA)
C
1345 FORMAT (3X, 'REJECTS')
C
1346 WRITE ('PTR', 104PA)
C
1347 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1348 WRITE ('PTR', 104QA)
C
1349 FORMAT (3X, 'FEED')
C
1350 WRITE ('PTR', 104RA)
C
1351 FORMAT (3X, 'ACCEPTS')
C
1352 WRITE ('PTR', 104SA)
C
1353 FORMAT (3X, 'REJECTS')
C
1354 WRITE ('PTR', 104TA)
C
1355 FORMAT (15X, 'TWENTYTFOUNE STAGE')
C
1356 WRITE ('PTR', 104UA)
C
1357 FORMAT (3X, 'FEED')
C
1358 WRITE ('PTR', 104VA)
C
1359 FORMAT (3X, 'ACCEPTS')
C
1360 WRITE ('PTR', 104WA)
C
1361 FORMAT (3X, 'REJECTS')

WRITE ('PTR', 1013)
C WRITE ('PTR', 1010) T3A, C3AX, G3A
C WRITE ('PTR', 1014)
C WRITE ('PTR', 1010) T3R, C3RX, G3R
C
C WRITE ('PTR', 1015)
C WRITE ('PTR', 1010) T3W, C3WX, G3W
C
C
C
4011 WRITE ('PTR', 4011)
4011 FORMAT (//15X, 'QUARTENARY STAGE'//)
C WRITE ('PTR', 1012)
C WRITE ('PTR', 1010) T4F, C4FX, G4F
C WRITE ('PTR', 1013)
C WRITE ('PTR', 1010) T4A, C4AX, G4A
C WRITE ('PTR', 1014)
C WRITE ('PTR', 1010) T4R, C4RX, G4R
C
C WRITE ('PTR', 1015)
C WRITE ('PTR', 1010) T4W, C4WX, G4W
C
C
C
1020 WRITE ('CRT', 1020)
1020 FORMAT ('/ FINISHED/')

C
STOP
END

\$IFT ABORT ABEND
\$ALLOCATE 20000
\$CATALOG
ASSIGN4 CRT=UT
ASSIGN4 KYB=UT
ASSIGN2 PTR=SLO, 999
CATALOG BALANCE U NOM
\$DEFNAME ABEND
\$EOJ
\$\$

0382.00
0363.00
0364.00
0365.00
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0415.00

C PROGRAM BALANCE 2
C
C IMPLICIT INTEGER*2 (1--N)
C IMPLICIT REAL*8 (A-H)
C IMPLICIT REAL*8 (O-Z)
C
C INTEGER*4 INPUTNAM(19)
C
C REAL*8 INPUT(19)
C
C LOGICAL MAX(20), MIN(20)
C REAL*8 INMAX(20), INMIN(20)
C
C LOGICAL TRACE
C INTEGER*1 IRESP
C
C EQUIVALENCE (INPUT(1), TAG)
C EQUIVALENCE (INPUT(2), C1F)
C EQUIVALENCE (INPUT(3), C2F)
C EQUIVALENCE (INPUT(4), C3F)
C EQUIVALENCE (INPUT(5), C4F)
C EQUIVALENCE (INPUT(6), R1)
C EQUIVALENCE (INPUT(7), R2)
C EQUIVALENCE (INPUT(8), R3)
C EQUIVALENCE (INPUT(9), R4)
C EQUIVALENCE (INPUT(10), TF1)
C EQUIVALENCE (INPUT(11), TF2)
C EQUIVALENCE (INPUT(12), TF3)
C EQUIVALENCE (INPUT(13), TF4)
C EQUIVALENCE (INPUT(14), C1W)
C EQUIVALENCE (INPUT(15), C2W)
C EQUIVALENCE (INPUT(16), C3W)
C EQUIVALENCE (INPUT(17), C4W)
C EQUIVALENCE (INPUT(18), CS)
C
C EQUIVALENCE (INPUT(19), PCT)

0019.00
0020.00
0021.00
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0059.00
0060.00

```

C DATA FACTOR / 6.008 /
C
C DATA XMAX / 1.000001 /
C DATA XMIN / .999999 /
C
C NOTE THAT T4R ALSO HAS LIMITS (INDEX = 20 FOR THESE LOOKUPS... )
C
C DATA MAX / .FALSE. , 18* .TRUE. , .FALSE. /
C
C NEGATIVE ENTRIES ARE NEVER ALLOWED, REGARDLESS OF EXISTENCE
C OF A SPECIFIED MINIMUM VALUE
C
C DATA MIN / 5 * .TRUE. , 17 * .FALSE. , 1* .TRUE. /
C
C DATA INMAX / 0 , 4 * 0.1 , 4* 1.0 , 4* 100.0 , 4* 0.01, 2*01.0, 0/0078.00
C
C DATA INMIN / 1.0 , 4* 0.001 , 13* 0.0 , .0001, 1.0 /
C
C
C DATA INPUTNAM / 'T1A', 'T1F1', 'T2F1', 'COP', 'C4P', 'R1', 'R2', 'R3',
C   'R4', 'TF1', 'TF2', 'TF3', 'TF4', 'C1W', 'C2W', 'C3W', 'C4W', 'CS' /
C   'PCT' /
C
C DO 10 IA=1,19
C
11 WRITE ('CRT',1001) INPUTNAM(IA)
1001 FORMAT (' PLEASE ENTER THE VALUE OF ',A4,' ')
C
READ ('KYB',1002) INPUT(IA)
1002 FORMAT (F12.4)
C
IF (INPUT(IA) LT 0.0) GO TO 12
IF (MIN(IA) AND INPUT(IA).LT. INMIN(IA)) GO TO 12
IF (MAX(IA).AND. INPUT(IA).GT. INMAX(IA)) GO TO 13
C
GO TO 10
C
12 WRITE ('CRT',1030)
1030 FORMAT (' *** VALUE IS BELOW MINIMUM, PLEASE RE-ENTER... ')
C
GO TO 11
C
13 WRITE ('CRT',1031)
1031 FORMAT (' *** VALUE IS ABOVE MAXIMUM, PLEASE RE-ENTER... ')
C
GO TO 11
C
10 CONTINUE
C
IA = 20
C
21 WRITE ('CRT',1003)

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1003 FORMAT (' PLEASE ENTER THE ASSUMED INITIAL VALUE OF T4R... ')      0121. 00
C
C     READ ('KYB', 1002) T4RINIT                                         0122. 00
C
C     IF (T4RINIT.LT.0.0) GO TO 22                                         0123. 00
C     IF (ININ(IA).AND.T4RINIT.LT.INMIN(IA)) GO TO 22                      0124. 00
C     IF (MAX(IA).AND.T4RINIT.GT.INMAX(IA)) GO TO 23                      0125. 00
C
C     GO TO 30                                                       0126. 00
C
C     22 WRITE ('CRT', 1030)                                              0127. 00
C
C     GO TO 21                                                       0128. 00
C
C     23 WRITE ('CRT', 1031)                                              0129. 00
C
C     GO TO 21                                                       0130. 00
C
C     30 WRITE ('CRT', 1005)                                              0131. 00
1005 FORMAT (' DO YOU WISH TO TRACE THE ITERATIONS... ')                  0132. 00
C
C     READ ('KYB', 1008) IRESP                                           0133. 00
1008 FORMAT (A1)                                                       0134. 00
C
C     IF (IRESP.EQ.'Y') TRACE = .TRUE.                                     0135. 00
C
C     WRITE ('CRT', 1004)                                              0136. 00
1004 FORMAT ('/ THANK YOU ')                                             0137. 00
C
C     T4R = T4RINIT                                         0138. 00
C
C
C     20 CONTINUE                                              0139. 00
C
C     T4F = T4R / R4                                              0140. 00
C
C     G4F = T4F / (C4F * FACTOR)                                         0141. 00
C
C     C4R = C4F * TFF                                              0142. 00
C
C     G4R = T4R / (C4R * FACTOR)                                         0143. 00
C
C     G4A = G4F - G4R                                              0144. 00
C
C     T4A = T4F - T4R                                              0145. 00
C
C     C4A = T4A / (G4A * FACTOR)                                         0146. 00
C
C     C3R = C3F * TFB                                              0147. 00
C
C     G4W = ((C4F-C3R)*G4F) / (C4W-C3R)                                0148. 00
C
C     G3R = G4F - G4W                                              0149. 00
C
C     T4W = G4W * C4U * FACTOR                                         0150. 00
C
C     T3R = G3R * C3R * FACTOR                                         0151. 00
C
C
C     21 CONTINUE                                              0152. 00
C
C     T4R = T4R + T4W                                              0153. 00
C
C
C     22 CONTINUE                                              0154. 00
C
C     T4F = T4R / R4                                              0155. 00
C
C     G4F = T4F / (C4F * FACTOR)                                         0156. 00
C
C     C4R = C4F * TFF                                              0157. 00
C
C     G4R = T4R / (C4R * FACTOR)                                         0158. 00
C
C     G4A = G4F - G4R                                              0159. 00
C
C     T4A = T4F - T4R                                              0160. 00
C
C     C4A = T4A / (G4A * FACTOR)                                         0161. 00
C
C     C3R = C3F * TFB                                              0162. 00
C
C     G4W = ((C4F-C3R)*G4F) / (C4W-C3R)                                0163. 00
C
C     G3R = G4F - G4W                                              0164. 00
C
C     T4W = G4W * C4U * FACTOR                                         0165. 00
C
C     T3R = G3R * C3R * FACTOR                                         0166. 00
C
C
C     23 CONTINUE                                              0167. 00
C
C     T4R = T4R + T4W                                              0168. 00
C
C
C     24 CONTINUE                                              0169. 00
C
C     T4F = T4R / R4                                              0170. 00
C
C     G4F = T4F / (C4F * FACTOR)                                         0171. 00
C
C     C4R = C4F * TFF                                              0172. 00
C
C     G4R = T4R / (C4R * FACTOR)                                         0173. 00
C
C     G4A = G4F - G4R                                              0174. 00
C
C     T4A = T4F - T4R                                              0175. 00
C
C     C4A = T4A / (G4A * FACTOR)                                         0176. 00
C
C     C3R = C3F * TFB                                              0177. 00
C
C     G4W = ((C4F-C3R)*G4F) / (C4W-C3R)                                0178. 00
C
C     G3R = G4F - G4W                                              0179. 00
C
C     T4W = G4W * C4U * FACTOR                                         0180. 00

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C T3F = T3R / R3 0181. 00
C G3F = T3F / (G3F * FACTOR) 0182. 00
C G3A = G3F - G3R 0183. 00
C T3A = T3F - T3R 0184. 00
C C3A = T3A / (G3A * FACTOR ) 0185. 00
C C2R = C2F * TF2 0186. 00
C G2R = ((G3F * (G3F - G3W)) + G4A * (G3W - G4A)) / (C2R - C3W) 0187. 00
C G3W = G3F - G4A - G2R 0188. 00
C T2R = G2R * C2R * FACTOR 0189. 00
C T3W = G3W * G3W * FACTOR 0190. 00
C T2F = T2R / R2 0191. 00
C G2F = T2F / (C2F * FACTOR) 0192. 00
C T2A = T2F - T2R 0193. 00
C G2A = G2F - G2R 0194. 00
C C2A = T2A / (G2A * FACTOR) 0195. 00
C C1R = C1F * TF1 0196. 00
C G = (G2F*(C2F-C2W)+G2A*(C2W-G2A)) 0197. 00
C A = (C1R+(C1R*(1-PCT))/((R1*PCT)-(C2W*(C1R*(1-PCT)/(C1F*R1*PCT)))) 0198. 00
C G1R = G / A 0199. 00
C GH = (G1R*C1R*(1-PCT)) / (C1F*R1*PCT) 0200. 00
C G2W = G2F - G1R - G3A - GH 0201. 00
C TH = GH * C1F * FACTOR 0202. 00
C T1R = G1R * C1R * FACTOR 0203. 00
C T2W = G2W * C2W * FACTOR 0204. 00
C T1F = T1R / R1 0205. 00
C G1F = T1F / (C1F * FACTOR) 0206. 00
C T1A = T1F - T1R 0207. 00
C TAACALC = T1A + T2A 0208. 00
C X = TAA / TAACALC 0209. 00
C T4RNEW = T4R * X 0210. 00
C C C C C
IF (.NOT. TRACE) GO TO 80 0211. 00
0212. 00
0213. 00
0214. 00
0215. 00
0216. 00
0217. 00
0218. 00
0219. 00
0220. 00
0221. 00
0222. 00
0223. 00
0224. 00
0225. 00
0226. 00
0227. 00
0228. 00
0229. 00
0230. 00
0231. 00
0232. 00
0233. 00
0234. 00
0235. 00
0236. 00
0237. 00
0238. 00
0239. 00
0240. 00

```

```

C      WRITE ('CRT', 1006) X, T4RNEW          0241.00
1006 FORMAT (' RATIO IS ',F12.5, 'X, 'NEW T4R IS ',F14.6) 0242.00
C      80 IF (X.LT.XMAX .AND. X.GT.XMIN) GO TO 90 0243.00
C      T4R = T4RNEW                         0244.00
C      GO TO 20                            0245.00
C
C      90 WRITE ('CRT', 1007)                0246.00
1007 FORMAT (' ITERATIONS COMPLETE ...') 0247.00
C      G1A = G1F - G1R                      0248.00
C
C      C1A = T1A / (G1A * FACTOR)           0249.00
C      GS = (G1F*(C1F-C1W)+GH*(C1F-C1W))/ (CS-C1W) 0250.00
C      G1W = GH - G1F - GS                  0251.00
C      T1W = C1W * G1W * FACTOR            0252.00
C      TS = GS * CS * FACTOR              0253.00
C      GA = G1A + G2A                     0254.00
C      CA = TAA / (GA * FACTOR)            0255.00
C
C      CONSOLIDATE RESULTS FOR PRIN1S01    0256.00
C      CSX = CS * 100.0                    0257.00
C      C1FX = C1F * 100.0                  0258.00
C      C1AX = C1A * 100.0                  0259.00
C      C1RX = C1R * 100.0                  0260.00
C      C1WX = C1W * 100.0                  0261.00
C      C2FX = C2F * 100.0                  0262.00
C      C2AX = C2A * 100.0                  0263.00
C      C2RX = C2R * 100.0                  0264.00
C      C2WX = C2W * 100.0                  0265.00
C      C3FX = C3F * 100.0                  0266.00
C      C3AX = C3A * 100.0                  0267.00
C      C3RX = C3R * 100.0                  0268.00
C      C3WX = C3W * 100.0                  0269.00
C      C4FX = C4F * 100.0                  0270.00
C      C4AX = C4A * 100.0                  0271.00
C      C4RX = C4R * 100.0                  0272.00
C      C4WX = C4W * 100.0                  0273.00
C
C      1008 FORMAT (' RATIO IS ',F12.5, 'X, 'NEW T4R IS ',F14.6) 0274.00
C      80 IF (X.LT.XMAX .AND. X.GT.XMIN) GO TO 90 0275.00
C      T4R = T4RNEW                         0276.00
C      GO TO 20                            0277.00
C
C      90 WRITE ('CRT', 1007)                0278.00
1007 FORMAT (' ITERATIONS COMPLETE ...') 0279.00
C      G1A = G1F - G1R                      0280.00
C
C      C1A = T1A / (G1A * FACTOR)           0281.00
C      GS = (G1F*(C1F-C1W)+GH*(C1F-C1W))/ (CS-C1W) 0282.00
C      G1W = GH - G1F - GS                  0283.00
C      T1W = C1W * G1W * FACTOR            0284.00
C      TS = GS * CS * FACTOR              0285.00
C      GA = G1A + G2A                     0286.00
C      CA = TAA / (GA * FACTOR)            0287.00
C
C      CONSOLIDATE RESULTS FOR PRIN1S01    0288.00
C      CSX = CS * 100.0                    0289.00
C      C1FX = C1F * 100.0                  0290.00
C      C1AX = C1A * 100.0                  0291.00
C      C1RX = C1R * 100.0                  0292.00
C      C1WX = C1W * 100.0                  0293.00
C      C2FX = C2F * 100.0                  0294.00
C      C2AX = C2A * 100.0                  0295.00
C      C2RX = C2R * 100.0                  0296.00
C      C2WX = C2W * 100.0                  0297.00
C      C3FX = C3F * 100.0                  0298.00
C      C3AX = C3A * 100.0                  0299.00
C      C3RX = C3R * 100.0                  0300.00

```

C CAX = CA * 100.0 0301.00
C WRITE ('PTR', 1009) 0302.00
1009 FORMAT (15X, 'STOCK') 0303.00
C WRITE ('PTR', 1010) TS, CSX, GS 0304.00
1010 FORMAT (10X, 'T-PD' //, F12.3 / 0305.00
10X, 'CONS.' //, F12.3 / 0306.00
10X, 'GPM' //, F12.3 / 0307.00
C WRITE ('PTR', 1011) 0308.00
1011 FORMAT (//15X, 'PRIMARY STAGE') 0309.00
C WRITE ('PTR', 1012) 0310.00
1012 FORMAT (3X, 'FEED') 0311.00
C WRITE ('PTR', 1013) 0312.00
1013 FORMAT (3X, 'ACCEPTS') 0313.00
C WRITE ('PTR', 1014) 0314.00
1014 FORMAT (3X, 'REJECTS') 0315.00
C WRITE ('PTR', 1015) 0316.00
1015 FORMAT (3X, 'WHITE WATER') 0317.00
C WRITE ('PTR', 1010) TIW, CIW, GIW 0318.00
C C WRITE ('PTR', 2011) 0319.00
2011 FORMAT (//15X, 'SECONDARY STAGE') 0320.00
C WRITE ('PTR', 1012) 0321.00
C WRITE ('PTR', 1010) T2F, C2Fx, G2F 0322.00
C WRITE ('PTR', 1013) 0323.00
C WRITE ('PTR', 1010) T2A, C2Ax, G2A 0324.00
C WRITE ('PTR', 1014) 0325.00
C WRITE ('PTR', 1010) T2R, C2Rx, G2R 0326.00
C WRITE ('PTR', 1015) 0327.00
C WRITE ('PTR', 1010) T2W, C2Wx, G2W 0328.00
C 0329.00
C 0330.00
C 0331.00
C 0332.00
C 0333.00
C 0334.00
C 0335.00
C 0336.00
C 0337.00
C 0338.00
C 0339.00
C 0340.00
C 0341.00
C 0342.00
C 0343.00
C 0344.00
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C 0355.00
C 0356.00
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C 0358.00
C 0359.00
C 0360.00

C
C
C
3011 WRITE ('PTR', 3011)
FORMAT (//15X, 'TERTIARY STAGE'//)
C
WRITE ('PTR', 1012)
C
WRITE ('PTR', 1010) T3F, C3FX, G3F
C
WRITE ('PTR', 1013)
C
WRITE ('PTR', 1010) T3A, C3AX, G3A
C
WRITE ('PTR', 1014)
C
WRITE ('PTR', 1010) T3R, C3RX, G3R
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
4011 WRITE ('PTR', 4011)
FORMAT (//15X, 'QUARTERNARY STAGE'//)
C
WRITE ('PTR', 1012)
C
WRITE ('PTR', 1010) T4F, C4FX, G4F
C
WRITE ('PTR', 1013)
C
WRITE ('PTR', 1010) T4A, C4AX, G4A
C
WRITE ('PTR', 1014)
C
WRITE ('PTR', 1010) T4R, C4RX, G4R
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
5011 WRITE ('PTR', 5011)
FORMAT (//15X, 'SYSTEM ACCEPTS'//)
WRITE ('PTR', 1010) TAA, CAX, GA
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
1020 WRITE ('CRT', 1020)
FORMAT (/, ' FINISHED')
C
STOP
END
\$IFT ABORT ABEND
\$ALLOCATE 20000
\$CATALOG

ASSIGN4 CRT=UT
ASSIGN4 KYB=UT
ASSIGN2 PTR=SLO, 999
CATALOG BALANCE2 U NBM
\$DEFNAME ABEND
\$EOJ
\$\$

0421. 000
0422. 000
0423. 000
0424. 000
0425. 000
0426. 000
0427. 000

C PROGRAM BALANCE3

C IMPLICIT INTEGER*4

C IMPLICIT REAL*8

C IMPLICIT REAL*4

C INTEGER*4 INPUT(20)

C REAL*8 INPUT(20)

C LOGICAL MAYBE(1000)

C REAL*8 INPUT(1000)

C LOGICAL TRACE

C INTEGER*1 IRG

C EQUIVALENCE INPUT(1),IRG

C EQUIVALENCE INPUT(2),IRG

C EQUIVALENCE INPUT(3),IRG

C EQUIVALENCE INPUT(4),IRG

C EQUIVALENCE INPUT(5),IRG

C EQUIVALENCE INPUT(6),IRG

C EQUIVALENCE INPUT(7),IRG

C EQUIVALENCE INPUT(8),IRG

C EQUIVALENCE INPUT(9),IRG

C EQUIVALENCE INPUT(10),IRG

C EQUIVALENCE INPUT(11),IRG

C EQUIVALENCE INPUT(12),IRG

C EQUIVALENCE INPUT(13),IRG

C EQUIVALENCE INPUT(14),IRG

C EQUIVALENCE INPUT(15),IRG

C EQUIVALENCE INPUT(16),IRG

C EQUIVALENCE INPUT(17),IRG

C EQUIVALENCE INPUT(18),IRG

C EQUIVALENCE INPUT(19),IRG

C EQUIVALENCE INPUT(20),IRG

0019
0020
0021
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0059
0060

C C DATA FACTOR / 5 32 6

C C DATA MAX / 9 5555 5
DATA MIN / 5 5555 5

C C NOTE THAT TAB 4 IS FOR LIBRARY INDEXES OF THE ENTRY LOOKUP
C C DATA MAX / 5 FALSE, 1.5 TRUE & 1.6875

C C NEGATIVE ENTRIES ARE NEVER INCLUDED. PREDICATION OF EXISTENCE
C C OF A SPECIFIED ELEMENT VALUE.

C C DATA MIN / 5 32 6

C C DATA INMAX / 0 3.402 8E+38 1.0 3.402 8E+38 -4.9E-311 0 1.174E-38 7/0078

C C DATA INMIN / 1.0E-31 0 3.402 8E+38 1.0 3.402 8E+38 7/0079

C C DATA INPUTNAM / 88 1000 7350 500 300 150 / 81 150 150 150 150 150 / 81 150 150 150 150 /
1001 1002 1003 1004 1005 1006 1007 / 72 150 150 150 150 150 150 / 72 150 150 150 150 150 150 / 72 150 150 150 150 / 0084
10085 10086 10087 10088 10089 10090 10091 10092 10093 10094 10095 10096 10097 10098 10099 10100 10101 10102 10103 10104 10105 10106 10107 10108 10109 10110 10111 10112 10113 10114 10115 10116 10117 10118 10119 10120

C C DO 10 IA=1 20

C C 10 WRITE ('CRT', 1001) IA, T1, T2, T3, T4, T5, T6, T7, T8, T9
1001 FORMAT (1X, 'IA = ', I3, 1X, 10(1X, F8.4))

C C READ (5, 1002) IA
1002 FORMAT (I3)

C C IF IA .NE. 0 THEN
10 CONTINUE
10 IF IA>1A .NE. 0 THEN
10 IA=IA-1

C C GO TO 10

C C 12 WRITE ('CRT', 1003) IA, T1, T2, T3, T4, T5, T6, T7, T8, T9, PREP1
1003 FORMAT (1X, 'IA = ', I3, 1X, 10(1X, F8.4))

C C GO TO 14

C C 13 WRITE ('CRT', 1004) IA, T1, T2, T3, T4, T5, T6, T7, T8, T9, REL1
1004 FORMAT (1X, 'IA = ', I3, 1X, 10(1X, F8.4))

C C GO TO 11

C C 10 CONTINUE

C C IA = 21

C C 21 WRITE ('CRT', 1005) IA, T1, T2, T3, T4, T5, T6, T7, T8, T9, PREP2
1005 FORMAT (1X, 'IA = ', I3, 1X, 10(1X, F8.4))

```

C READ CKYB1, IUNIT, T4RINIT
C
C IF (T4RINIT .LT. 0.0) GO TO 27
C IF (MIN(IA) .NEQ. T4RINIT .OR. MAX(IA) .NEQ. T4RINIT) GO TO 28
C
C GO TO 30
C
C 22 WRITE ('CRT'), 1000
C
C GO TO 21
C
C 23 WRITE ('CRT'), 1001
C
C GO TO 21
C
C 30 WRITE ('CRT'), 000
C 1003 FORMAT (' DO YOU WISH TO TRACE THE PROGRAM?')
C
C READ CKYB1, IUNIT, T4RINIT
C 1008 FORMAT (A1)
C
C IF (IRESP.EQ.'Y') TRACE = .TRUE.
C
C WRITE ('CRT'), 004
C 1004 FORMAT ('X', TRACE, 0D0)
C
C T4R = T4RINIT
C
C
C 20 CONTINUE
C
C T4F = T4R * R4
C
C G4F = T4F * (C4F + FACTOR)
C
C C4A = C4F * CFA
C
C T4R = T4R / (C4F + FACTOR)
C
C G4A = G4F - C4A
C
C T4A = T4F - G4A
C
C C4A = T4A / (C4A + FACTOR)
C
C CBR = C3F * T4A
C
C G4W = ((C4F+C3F)*G4F) / (C4W+CBR)
C
C G3R = G4F - G4W
C
C T4W = G4W * R4 * FACTOR
C
C TCR = G3R + T4W * FACTOR
C
C T3F = T3R / R4

```

$G2F = T2F / (G2A + \text{FACT})$
 $G3A = G2F + G2R$
 $T2A = T2F + G2R$
 $G3R = T2A / (G2A + \text{FACT})$
 $G2P = G2F + T1F$
 $G2R = (G2P * G2A) / (G2A + G2P)$
 $T1R = G2F + G2A + G2P$
 $T2W = G2R * G2A * G2P$
 $T2F = T2R / (G2A + G2P)$
 $T2A = T2F + T2R$
 $G2A = G2F + G2R$
 $G2A = T2A / (\text{FACT} + G2A)$
 $C1R = C1F + T1F$
 $C = 1 - C1R$
 $G = (G2F * (C2A + \text{FACT})) / (T1R + G2A + G2P)$
 $T = G * C * T1R$
 $G1R = G2F + G2P$

 $T1R = G1R + G2P + \text{FACT}$

 $T1F = T1R / T1A$
 $T1A = T1F + T1R$
 $T1F = T1A * F$
 $G1F = T1F / (\text{FACT} + G1A)$
 $G1A = G1F + G1R$
 $C1A = T1A / (\text{FACT} + G1A)$
 $CR = C1A + G1A$
 $GP = TR / (G1A + \text{FACT})$
 $G2R = G - CR$
 $T2W = G2R * G2A * \text{FACT}$

62 TA4CALC = T4A * G2P
 $X = T4A / (\text{FACT} + G2P)$
 $TA4NEW = T4A * X$
 $IP = \text{NOT}(TA4 < 0.0001)$

0181, 00
 0182, 00
 0183, 00
 0184, 00
 0185, 00
 0186, 00
 0187, 00
 0188, 00
 0189, 00
 0190, 00
 0191, 00
 0192, 00
 0193, 00
 0194, 00
 0195, 00
 0196, 00
 0197, 00
 0198, 00
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 0212, 00
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 0224, 00
 0225, 00
 0226, 00
 0227, 00
 0228, 00
 0229, 00
 0230, 00
 0231, 00
 0232, 00
 0233, 00
 0234, 00
 0235, 00
 0236, 00
 0237, 00
 0238, 00
 0239, 00
 0240, 00

```

C      WRITE( CCR7, 90 ) G1A, GS
1006 FORMAT( 1X, A, 1X, F10.2, 1X, F10.2, 1X, F10.2 )
C      WRITE( CCR7, 90 ) T1F, TS, T1W, GS
8006 FORMAT( 1X, A, 1X, F10.2, 1X, F10.2, 1X, F10.2, 1X, F10.2 )
C      IF ( X .LT. XMA ) GO TO 1007
C      T4R = T4RNEW
C      GO TO 20
C
C      90 WRITE( CCR7, 97 )
1007 FORMAT( 1X, A, 1X, F10.2, 1X, F10.2 )
C      GA = G1A - GR
C      CA = TAA / ( C8 * FACTOR )
C      GS = ((G1F + G1W + C1F) * GAA + GAA * TAA) * FACTOR + GS
      TS = GS * C8 * FACTOR
      T1W = T1F - TS - TAA
      G1W = T1W / ( C1W * FACTOR )
C      CONSOLIDATE RESULTS FROM PREVIOUS
C      CSX = GS * 100.0
C      C1FX = C1F * 100.0
C      C1AX = C1A * 100.0
C      C1RX = C1R * 100.0
C      C1F = C1W
C      C2FX = C2F * 100.0
C      C2AX = C2A * 100.0
C      C2RX = C2W * 100.0
C      C3FX = C3F * 100.0
C      C3AX = C3A * 100.0
C      C3RX = C3W * 100.0
C      C4FX = C4F * 100.0
C      C4AX = C4A * 100.0
C      C4RX = C4R * 100.0

```

C CMAX = C4W + 1000
C CMAX = CA + 1000
C CARX = CR + 1000
C
C WRITE ('PTR', 1009)
1009 FDPMAT (15%, 1000, 0)
C
C WRITE ('PTR', 1010), TS, 05X, G5
1010 FORMAT (10X, 1F12.3, 1F12.3,
10X, 1F12.3, 1F12.3)
C
C WRITE ('PTR', 1011), TS, 05X, G5
1011 FORMAT (1/15%, 1F12.3, 1F12.3)
C
C WRITE ('PTR', 1012)
1012 FORMAT (3X, 'FIELD')
C
C WRITE ('PTR', 1013), TS, 05X, G5
1013 FORMAT (3X, 1A, 1F12.3)
C
C WRITE ('PTR', 1014), TS, 05X, G5
1014 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1015), TS, 05X, G5
1015 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1016), TS, 05X, G5
1016 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1017), TS, 05X, G5
1017 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1018), TS, 05X, G5
1018 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1019), TS, 05X, G5
1019 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1020), TS, 05X, G5
1020 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1021), TS, 05X, G5
1021 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1022), TS, 05X, G5
1022 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1023), TS, 05X, G5
1023 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1024), TS, 05X, G5
1024 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1025), TS, 05X, G5
1025 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1026), TS, 05X, G5
1026 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1027), TS, 05X, G5
1027 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1028), TS, 05X, G5
1028 FORMAT (3X, 1F12.3)
C
C WRITE ('PTR', 1029), TS, 05X, G5
1029 FORMAT (3X, 1F12.3)

```
      WRITE ('/PTR', 1011) 'DATA-FILE-NAME'
C
C
      WRITE ('/PTR', 3011)
      3011 FORMAT ('//15X, 16E1.0E0, 10E0')
      WRITE ('/PTR', 1012)
      WRITE ('/PTR', 1013) 'CBF-CODE-SEGMENT'
      WRITE ('/PTR', 1014)
      WRITE ('/PTR', 1015) 'Data-Block-Size'
      WRITE ('/PTR', 1016)
      WRITE ('/PTR', 1017) 'Total-Block-Size'
      WRITE ('/PTR', 1018)
      WRITE ('/PTR', 1019) 'Data-Block-Size'
      WRITE ('/PTR', 101A) 'Total-Block-Size'
      .
      .
      .
      WRITE ('/PTR', 4011)
      4011 FORMAT ('//15X, 16E1.0E0, 10E0')
      WRITE ('/PTR', 4012)
      WRITE ('/PTR', 4013) 'CBF-CODE-SEGMENT'
      WRITE ('/PTR', 4014)
      WRITE ('/PTR', 4015) 'Data-Block-Size'
      WRITE ('/PTR', 4016) 'Total-Block-Size'
      WRITE ('/PTR', 4017)
      WRITE ('/PTR', 4018) 'Data-Block-Size'
      WRITE ('/PTR', 4019) 'Total-Block-Size'
      WRITE ('/PTR', 401A) 'Data-Block-Size'
      WRITE ('/PTR', 401B) 'Total-Block-Size'
      WRITE ('/PTR', 401C)
      WRITE ('/PTR', 401D)
      WRITE ('/PTR', 401E)
      WRITE ('/PTR', 401F)
      WRITE ('/PTR', 401G)
      WRITE ('/PTR', 401H)
      WRITE ('/PTR', 401I)
      WRITE ('/PTR', 401J)
      WRITE ('/PTR', 401K)
      WRITE ('/PTR', 401L)
      WRITE ('/PTR', 401M)
      WRITE ('/PTR', 401N)
      WRITE ('/PTR', 401O)
      WRITE ('/PTR', 401P)
      WRITE ('/PTR', 401Q)
      WRITE ('/PTR', 401R)
      WRITE ('/PTR', 401S)
      WRITE ('/PTR', 401T)
      WRITE ('/PTR', 401U)
      WRITE ('/PTR', 401V)
      WRITE ('/PTR', 401W)
      WRITE ('/PTR', 401X)
      WRITE ('/PTR', 401Y)
      WRITE ('/PTR', 401Z)
```

1020 FORMATTED

C
STOP
END
\$IFT ABORT ABEND
\$ALLOCATE BUSSO
\$CATALOG
ASSIGNA OPT=UT
ASSIGNA PPR=UT
ASSIGNB PTP=SLO, EBC
CATALOG BALANCES UPA, M
\$DEPMNAME ABEND
\$END
+\$

0415 000
0420 000
0421 000
0422 000
0423 000
0424 000
0425 000
0426 000
0427 000
0428 000
0429 000
0430 000
0431 000
0432 000

PROGRAMMER Diane Krumwiede

DATE 10/81

PROGRAMMER Diane Krumwiede

DATE 10/81

TI Programmable
Coding Form

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
0		26	Quat. Acc TPD			29		27		Sto 36	Tert Acc TPD
1						x					
2		:				RCL					
3						7					
4						x					
5		RCL		22		RCL					
6		25				20					
7		x				=					
8		RCL				STO					
9		20				31					
10		)				RCL					
11		=				30					
12		STO	Quat. ACC Cons.			x					
13		27				RCL					
14		RCL		23		28					
15		04				x					
16		x				RCL					
17		RCL				20					
18		12				=					
19		=				STO					
20		STO	Tert Reg Cons.			32					
21		28				x					
22		(				RCL					
23						28					
24		RCL				x					
25		05				RCL					
26		-				08					
27		RCL				=					
28		28				STO					
29		)				32					
30		x				x					
31		RCL				RCL					
32		22				04					
33		)				x					
34		)				RCL					
35		:				20					
36		(=					
37		RCL				STO					
38		17				34					
39		-				x					
40		RCL				RCL					
41		28				08					
42)				=					
43		=				STO					
44		STO	Quat. NW			30					
45		29	GPM	26		=					
46		RCL				STO					
47		22				35					
48		-				RCL					
49		RCL				33					
50		29				-					
51		=				RCL					
52		STO	Quat. NW			32					
53		30	GPM			x					
54		RCL				RCL					
55		)				37					
56		Tert. Rej				=					
57		GPM				STO					
58						34					
59						x					
60						RCL					
61						35					
62						-					
63						RCL					
64						37					
65						=					
66						STO					
67						34					
68						x					
69						RCL					
70						35					
71						-					
72						RCL					
73						37					
74						=					
75						STO					
76						34					
77						x					
78						RCL					
79						35					
80						-					
81						RCL					
82						37					
83						=					
84						STO					
85						34					
86						x					
87						RCL					
88						35					
89						-					
90						RCL					
91						37					
92						=					
93						STO					
94						34					
95						x					
96						RCL					
97						35					
98						-					
99						RCL					

MERGED CODES

62	10	Ind	72	STO	14	83	GTO	15
63	11	Ind	73	RCL	14	84	DS	14
64	Dg	Ind	74	SUM	14	92	MM	SR

TEXAS INSTRUMENTS
INCORPORATED

TITLE Cleaner Balance 1 PAGE 3 OF 5 TI Programmable
 PROGRAMMER Done Krumwiede DATE 10/81 Coding Form

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
20	28			6	X			42	>		
1	-			7	RCL			7)		
2	RCL			8	20			8	+		
3	16			9	)			9	(
4	)			10	=			10	RCC		
5	=			11	STO		Sec Feed	11	35		
6	STO		Sec Reg.	12	+4		GPM	12	X		
7	39			13	RCL			13	(
8	RCL			14	43			14	RCL		
9	34			15	-			15	15		
33 0	-			16	RCL			16	-		
1	RCL			17	41			17	RCL		
2	25			18	=			18	37		
3	-			19	STO		Sec Acc	19)		
4	RCL			20	45		TPD	20)		
5	39			21	RCL			21	37		
6	=			22	44			22	37		
7	STO		Tert WW	23	RCL			23	37		
8	40		GPM	24	39			24	37		
9	RCL			25	=			25	37		
34 0	38			26	STO		Sec Acc	26	37		
1	X			27	46		GPM	27	37		
2	RCL			28	RCL			28	37		
3	39			29	45			29	37		
4	Y			30	-			30	37		
5	RCL			31	RCL			31	37		
6	20			32	45			32	37		
7	=			33	-			33	37		
8	STO		Sec Reg	34	RCL			34	37		
9	41		TPD	35	46			35	37		
35 0	RCL			36	X			36	37		
1	40			37	RCL			37	37		
2	X			38	20			38	37		
3	RCL			39	)			39	37		
4	16			40	=			40	37		
5	X			41	STO		Sec Acc	41	37		
6	RCL			42	47		Cons.	42	37		
7	20			43	RCL			43	37		
8	=			44	02			44	37		
9	STO		Tert WW	45	X			45	37		
36 0	42		TPD	46	RCL			46	37		
1	RCL			47	10			47	37		
2	41			48	=			48	37		
3	-			49	STO		Prim Reg	49	37		
4	RCL			50	48		cons.	50	37		
5	07			51	X			51	37		
6	=			52	RCL			52	37		
7	STO		Sec Feed	53	44			53	37		
8	43		TPD	54	X			54	37		
9				55	C			55	37		
37 0				56	RCL			56	37		
1	-			57	03			57	37		
2	(			58	-			58	37		
3	RCL			59	RCL			59	37		
4	03			60	IS			60	37		

MERGED CODES

62 Pgm	Ind	72 STO	Ind	83 GTO	1
63 Inv	Ind	73 RCL	Ind	84 Inv	1
64 Prg	Ind	74 SUM	Ind	92 INV	SWR

TEXAS INSTRUMENTS
INCORPORATED



PROGRAMMER Diane Krumwiede

DATE 10/81

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
1	0	50				(		59			
1	1	X				RCL		-			
2		RCL				18		50			
3		IS				-		60			
4		X				RCL					x = T
5		RCL		53		14					598
6		20				)					RCL
7		=				=					19
8		STO	Sec WW			STO	STOCK GPM				X
9		52	TPD			55					RCL
48	0	RCL				RCL					60
1		51				54					=
2		÷									STO
3		RCL		54							19
4		06									NewQuat
5		=									Reg Rate
6		STO	Prim Feed								GTO
7		53	TPD								103
8											RCL
9											54
49		÷									-
1		(									RCL
2		RCL									49
3		02									=
4		X									STO
5		RCL		55							61
6		20									RCL
7		)									01
8		=									÷
9		STO	Prim Feed								(
50		54	GPM								RCL
1											61
2											X
3											RCL
4		X									20
5		(		56)
5		RCL									=
7		02									STO
6		-									62
9		RCL									ADV
51	0	14									ADV
1		)									OP
2		+									OO
3		RCL									3
4		46									5
5		X									1
6		(		57							7
7		RCL									OP
8		14									01
9		-									1
52		RCL									MERGED CODES
1		47									62 PUP IND 72 STO IND 83 GTO RD
2		)									63 INC IND 73 RCL IND 84 INC IND
3		;									64 INV IND 74 SUM IND 92 INV SBR
4											

TEXAS INSTRUMENTS
INCORPORATED

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
13	0	3									
1	1										
2	6										
3	0										
4	0										
5	1										
6	5										
7	1										
8	3										
9	OP										
14	0	62									
1	3										
2	5										
3	1										
4	6										
5	0										
6	0										
7	0										
8	4										
9	0										
15	0	0									
1	OP										
2	03										
3	ADV										
4	ADV										
5	0D										
6	65										
7	ADV										
8	ADV										
9	ADV										
0											
1											
2											
3											
4											
5											
6											
7											
8											
9											
0											
1											
2											
3											
4											
5											
6											
7											
8											
9											
0											
1											
2											
3											
4											

Print:
READ
CARD 3

MERGED CODES

62	IN	IND	72	STO	MD	83	GTO	!
63	IN	IND	73	RCL	MD	84	DIS	IS
64	IN	IND	74	SUM	MD	92	INV	SBR

TEXAS INSTRUMENTS
INCORPORATED

Print Instructions-Prog 1 PAGE 1 OF 3 TI Programmable
PROGRAMMER Diane Krumwiede DATE _____ Coding Form

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
0		LBC				Prt	Flow	11		1	
1		A				RCL				5	
2		OP				O2				0	
3		GO				SBR				0	
4		3				SUM				OP	
5		6				Prf	%			O2	
6		3				SBR	Print:			SBR	
7		7				CLR	ACC.			LNX	
8		3				RCL				ADV	
9		2				O1				SBR	
10		1				Prf	TPD	12		CE	Feed.
11		5				RCL				RCL	
12		2				61				43	
13		6				Prf	Flow			PRT	TPD
14		OP				RCL				RCL	
15		O2				62				44	
16		OP	PRINT:			SBR				PRT	
17		05	STOCK			SUM				RCL	
18		ADV				Prf	%			03	
19		RCL				SBR				SBR	
20		57				X ZT	PRINT:	13		SUM	
21		PRT	TPD			RCL	RES			PRT	
22		RCL				51				SBR	
23		55				Prf	TPD			CLR	
24		Prf	Flow			RCL				RCL	
25		RCL				49				45	
26		18				Prf	Flow			Prf	
27		SBR				RCL				RCL	
28		SUM				48				46	
29		Prf	%			SBR				Prf	
30		ADV				SUM				RCL	
31		ADV				Prf				47	
32		ADV				SBR				SBR	
33		OP				SUM				SUM	
34		00				Prf				Prf	
35		3				RCL				48	
36		3				58				SBR	
37		3				Prf	TPD			Print: RES	
38		5				RCL				X ZT	
39		2				56				RCL	
40		4				Prf	Flow			49	
41		0				RCL				Prf	TPD
42		0				14				RCL	
43		OP				SBR				39	
44		O2				SUM				Prf	
45		SBR	Print			Prf				RCL	
46		LNX	PRI STAGE			ADV				38	
47		ADV				ADV				SBR	
48		SBR				ADV				SUM	
49		CE	FEED			OP				Prf	
50		RCL				00				40	
51		53				3				SBR	
52		Prf	TPD			6				Print -WW	
53		RCL				1				X	
54		54				7				Y	

MERGED CODES

62	Prf	Ind	72	STD	83	GTO
63	Ind	Ind	73	RCL	84	D
64	Prf	Ind	74	SUM	92	WW

TEXAS INSTRUMENTS
INCORPORATED

PROGRAMMER D. Krumwiede

DATE

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
1	RCL			1	X2T		Print: RET	27	PRT		%0
2	52			2	RCL			3	SBR		
3	Prt		TPD	3	32			4	CLR		PRINT: ACC
4	RCL			4	Prt		TPD	5	RCL		
5	50			5	RCL			6	26		
6	Prt		Flow	6	30			7	PRT		TPD
7	RCL			7	Prt		Flow	8	RCL		
8	15			8	RCL			9	25		
9	SBR			9	28			10	PRT		Flow
10	Sum			10	SBR			11	RCL		
11	Prt		%0	11	Sum			12	27		
12	ADV			12	Prt		Y0	13	SBR		
13	ADV			13	SBR		Print: WW	14	SUM		
14	ADV			14	YX			15	PRT		%0
15	a7			15	RCL			16	SBR		
16	00			16	42			17	XST		PRINT: RET
17	3			17	Prt		TPD	18	RCL		
18	7			18	RCL			19	19		
19	1			19	40			20	Prt		TPD
20	7			20	Prt		Flow	21	REL		
21	3			21	RCL			22	24		
22	5			22	40			23	PRT		ELC
23	0			23	Prt			24	RCL		
24	cP			24	ADV			25	23		
25	02			25	ADV			26	SBR		
26	SBR		Print: TER STAGE	26	OP			27	SUM		
27	LNB			27	00			28	Prt		Y0
28	ADV			28	3			29	SBR		PRINT: WW
29	SBR			29	4			30	YX		
30	CE		FEED	30	3			31	RCL		
31	RCL			31	4			32	29		TPD
32	33			32	3			33	PRT		Flow
33	Prt		TPD	33	5			34	RCL		
34	RCL			34	3			35	17		
35	34			35	7			36	SBR		
36	Prt		Flow	36	0			37	SUM		
37	RCL			37	C			38	PRT		Y0
38	D4			38	OP			39	CLR		
39	SBR			39	02			40	ADV		
40	Sum		Y0	40	SBR		PRINT: QRT STAGE	41	ADV		
41	Print SBR			41	LNX			42	LBL		
42	CL42		PRINT: ACC	42	ADV			43	LNX		STAGE
43	RCL			43	SBR			44	3		
44	36			44	CE			45	6		
45	Prt		TPD	45	RCL			46	3		
46	RCL			46	21			47	7		
47	35			47	PRT		TPD	48			
48	PRT		Flow	48	RCL			49			
49	RCL			49	22			50			
50	37			50	PRT		Flow	51			
51	SBR			51	RCL			52			
52	Sum			52	05			53			
53	Prt		Y0	53	SBR			54			
54	SBR			54	Sum			55			

MERGED CODES

62	10	IM	72	STO	10	83	G10	
63	10	IM	73	RCL	10	84	0	
64	10	IM	74	SUM	10	92	INV	SBR

TEXAS INSTRUMENTS
INCORPORATED

PROGRAMMER D.Krumwiede

DATE _____

TI Programmable
Coding Form

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
1		3				7					
1		2				2					
2		2				5					
3		1				0					
4		7				0					
5		OP		38		O					
6		03				O					
7		OP				OP					
8		05				O1					
9		RTN				OP					
330		LBL	FEED			05					
1		CG				RTN					
2		OD				LBL					
3		OO				Y*					
4		2		39		OP					
5		1				OO					
6		1				4					
7		7				3					
8		1				4					
9		7				3					
340		1				0					
1		6				0					
2		0				0					
3		0				0					
4		OP		40		0					
5		O1				OP					
6		OP				O1					
7		05				OP					
8		RTN				05					
9		LBL				RTN					
350		CLR	ACC			LAL					
1		OP				Sum					
2		OO				X					
3		1		41		1					
4		3				0					
5		1				0					
6		5				=					
7		1				RTN					
8		5				RTN					
9		6									
360		0									
1		0									
2		0									
3		OP									
4		O1									
5		OP									
6		05									
7		RTN									
8		LAL									
9		X2T	REG								
370		OP									
1		OO									
2		3									
3		5									
4		1									

MERGED CODES

62	PRM	IND	72	STO	40	83	GTO	..
63	INC	IND	73	RCL	40	84	RTN	..
64	DEC	IND	74	SUM	RTN	92	INV	SWR

TEXAS INSTRUMENTS
INCORPORATED

PROGRAMMER _____

DATE _____

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
3											
1			Repeat 00-408								
2			of Balance 1.								
4	12	RCL									
41	1C	44				66)				
4		X				7)	-				
5		(				8CL					
6		RCL				15)				
7		63				=					
8		-									
9		RCL			47	STO					
10		15				+9					
1		)				RCL					
2		+				49					
3		RCL				X					
4		35				RCL					
5		X			48	48					
6		(				X					
7		RCL				2					
8		15			48	5					
9		-				÷					
430		RCL				•					
1		37				(
2		)				RCL					
3		)				64					
4		÷				X					
5		(			49	RCL					
6		(			02	02)				
7		RCL			=	=					
8		48									
9		X				50					
440		•			50	50					
1		2			RCL	50					
2		5			44	-					
3		.				RCL					
4		÷				50	-				
5		RCL				RCL					
6		06				49					
7)				-					
8		-				RCL					
9		(				35					
450		RCL				=					
1		48									
2		X			51	STO					
3		RCL				51					
4		15				RCL					
5		X				49					
6		-				Y					
7		2				RCL					
8		5				48					
9		÷				X					
460		(				STO					
1		RCL				20					
2		02				=					
3		X									
4		RCL									
					52	PRIM REG.					
						-PD-					

MERGED CODES

62	Fxn	Ind	72	STO	Ind	83	GTO	Ind
63	Fxn	Ind	73	RCL	Ind	84	RTN	Ind
64	Ind	Ind	74	SUM	Ind	92	INTV	Ind

TEXAS INSTRUMENTS
INCORPORATED

PROGRAMMER _____

DATE _____

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
570		57	PRIM ACC			X		68		X	
1	RCL		TPD			(			RCL		
2		57				RCL			18		
3		+				02			Y		
4	RCL					-			RCL		
5		45				RCL			20		
6		=				14			=		
7	STO		System Acc	63		)			STO		NEUTR SENS
8		58	TPD			+ RCL			65		TPD
9	RCL					50			ADV		
580		01				X			ADV'		
1		.				(			OP		
2	RCL					RCL			00		
3		58				07			3		
4		=				-			5		
5	STO		X	64		RCL			1		
6		59				14			7		
7	RCL					)			0D		
8		59				)			01		
9		X = T				-			1		
590						(			3		
1	RCL					RCL			1		
2		19				18			6		
3		X				-			0		
4	RCL			65		RCL			0		
5		59				14			1		
6		=				)			5		
7	STO		New Quat			=			1		
8		19	Reg Rate			STO			3		
9	6T0					GPM	STOCK-GPM.	70	OP		
600		103				62			02		
1	RCL					RCL			3		
2		54				50			5		
3		-				+			1		
4	RCL					RCL			6		
5		49				56			0		
6		=				-			0		
7	STO		Prim ACC	66		RCL			0		
8		60	GPM			62			4		
9	RCL					=			0		
610		57				STO			0		
1		.				63			0		
2	(					RCL			OP		
3	RCL					63			03		
4		60				X			ADV		
5		X				RCL			ADV		
6	RCL			67		14			ADV		
7		26				Y			ADV		
8		)				RCL			ADV		
9		=				20			ADV		
620		STO	PRIM ACC			=			MERGED CODES		
1		61	CONS.			STO			72	STO	1d
2		(				64			73	RCL	1
3	RCL					RCL			74	SUM	11
4		56				62			83	GTD	1d
									63	GT	1d
									73	GT	1d
									84	GT	1d
									74	SUM	11
									92	INV	1d

TEXAS INSTRUMENTS
INCORPORATED

PROGRAMMER _____

CHANGES FROM 1 AS FOLLOWS

DATE _____

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
20	65		Replaces 57								
1											
2											
2	62		Repl 55								
4											
5											
6											
7											
8											
9											
50	55		Repl 53								
1											
2											
3											
54	56		Repl 54								
5											
6											
67	60		Repl 61								
8											
9											
70	61		Repl 62								
1											
2											
3											
4											
5											
6											
7											
78	52		Repl 51								
9											
0											
91	64		Repl 58								
2											
3											
24	63		Repl 56								
5											
6											
7											
8											
9											
0											
161	53		Repl 52								
2											
3											
164	51		Repl 50								
5											
6	Follows Rest of Prog. 1 exactly.										
7											
8											
9											
0											
1											
2											
3											
4											

MERGED CODES

62	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	72	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	83	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
63	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	73	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	84	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
64	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	74	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	92	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

TEXAS INSTRUMENTS
INCORPORATED

DATE _____

PROGRAMMER _____

TI Programmable
Coding Form

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
0	RCL	at 00-	408		RCL			52	RCL		
1	STO	of balance	1		06	=			57		
2									-		
3		0			50				RCL		
4		0			52				50		
5		5			RCL				=		
6	STO				52				STO		
7	49				-				58		
8	(				RCL				RCL		
9	RCL				53				53		
10	44				ADV				÷		
11	x				OP				(
12	(				OC				RCL		
13	03				7				58		
14	-				1				x		
15	RCL				OP				RC		
16	49				02				20		
17	)				07)		
18	+				05				=		
19	RCL				ADV				STO		
20	35				R/S				59		
21	x				STO				RCL		
22	(				54				59		
23	RCL				PRT				x		
24	49				R/S				RCL		
25	-				STO				55		
26	RCL				55				=		
27	37				PRT				STO		
28	)				ADV				60		
29					ADV				RCL		
30					ADV				56		
31	(				RCL				÷		
32	RCL				53				(
33	48				x				RC		
34	-				RCL				60		
35	RCL				54				x		
36	49				=				RCL		
37	)				STO				20		
38	=				56)		
39	STO				RCL				=		
40					54				STO		
41					=				61		
42					STO				RCL		
43					56				44		
44					RCL				-		
45					52				RCL		
46					÷				50		
47					(				50		
48					RCL				=		
49					02				35		
50					x						
51					RCL						
52					50						
53)						
54					=						
55											
56											
57											
58											
59											
60											
61											
62											
63											
64											

MERGED CODES

62	STO	Ind	72	STO	Ind	83	GTO	Ind
63	RET	Ind	73	RCL	Ind	84	END	Ind
64	QEQ	Ind	74	SUM	Ind	92	INV	SBR

TEXAS INSTRUMENTS
INCORPORATED

TITLE Cleaner Balance -3PAGE 2 OF 3TI Programmable
Coding Form

PROGRAMMER _____ DATE _____

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
570		=				66	Calc-Composite consistency	68		S8	
1	STO		Composite GPM		RCL				RCL		
2	62				49				61		
3	RCL				÷				=		
4	62				RCL				STO		ALPHA ACC
5	X				66				70		GPM
6	RCL			63				RCL			
7	49				STO				01		
8	X				67				÷		
9	RCL				RCL				(
580	20				67				70		
1	=				X=I				X		
2	STO		Composite TPD		649				RCL		
3	63								20		
4	RCL			64	RCL)		
5	62				49				=		
6	-				X				STO		ALPHA ACC
7	RCL				RCL				71		COD.
5	61				67				(
9	=				=				RCL		
590	STO		Sec WW		STO		New Composite Consistency	70	57		
1	64		GPM		49				X		
2	RCL				GTO				(
3	64				418				RCL		
4	Y				RCL				14		
5	RCL			65	53	-		-			
6	15				RCL				RCL		
7	Y				56	=			02		
8	RCL				=)		
9	20				STO				+		
600	=				68				RCL		
1	STO		Sec WW		RCL				46		
2	65		TPD		01				X		
3	(				÷				RCL		
4	RCL			66	RCL				47		
5	56				68	=			-		
6	+				STO				RCL		
7	RCL				69				14		
8	65				RCL)		
9	)				69				3		
610	;				X=I						
1	(				179				(
2	(								RCL		
3	RCL				RCL				14		
4	61				19)		
5	+				X				3		
6	RCL			67	RCL						
7	64				69	=			(
8	)								RCL		
9	X				STO		New Quat Rej. Rate		14		
620	RCL				19)		
1	20								84		

MERGED CODES

62	STO	46	72	STO	46	83	GTO
63	TPD	47	73	RCL	47	84	TPD



PROGRAMMER _____

DATE _____

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
0)									
1		=									
2	STO		Thick Stock								
3	72		GPM.								
4	RCL										
5	72										
6	X										
7	RCL										
8	18										
9	*										
0	RCL										
1	20										
2	=										
3	STO		Thick stock								
4	73		TPD								
5	RCL										
6	52										
7	-										
8	RCL										
9	13										
0	-										
1	RCL										
2	45										
3	=										
4	STO		Prim WW								
5	74		TPD.								
6	RCL										
7	74										
8	-										
9	RCL										
0	H										
1	X										
2	RCL										
3	Z0										
4)										
5	=										
6	STO		Primww								
7	75		GPM.								
8											
9											
0											
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PROGRAMMER

Changes from prog I as follows:

DATE

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
1		New	old.	2				10			Follow rest of
5 1	52		Repe 5 3	3				7			Prog I exactly.
2				3				8			
3				2				9			
5 4	57		Repe 54	3				10			
6 4	53		Repl 01	1				11			
6 7	58		Repe 61	3				12			
8				0				13			
9				0				14			
7 0	59		repl 62	OP				15			
8 1	50		repl 49	O2				16			
2				SBR			Print -	17			
3				LNX			ALPHA STAGE	18			
4				ADV				19			
5				SOR				20			
6				CE			Feed	21			
7				RCL				22			
8				53				23			
9				PRT			TPD	24			
0				RCL				25			
9 1	74		repl 58	58			flow	26			
2				PRT				27			
3				RCL				28			
4	75		repl 56	59				29			
5				SBR			%	30			
6				Sum			Print : ACC	31			
7				PT				32			
8				SBR				33			
9				CLR				34			
0				RCL				35			
16 1	65		repe 52	O1				36			
2				PRT				37			
3				RCL				38			
16 4	64		repe 50	70				39			
5				PRT				40			
6				RCL				41			
7				71				42			
8				SBR				43			
9				Sum				44			
0				PRT				45			
1				SBR				46			
2				XST				47			
3				RCL				48			
4				56				49			
5				PRT				50			
6				RCL				51			
7				61				52			
8				PRT				53			
9				RCL				54			
0				60				55			
1				SBR				56			
2				Sum				57			
3				PRT				58			
4				ADV				59			
								60			
								61			
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								97			
								98			
								99			
								100			

MERGED CODES

62	PRP	Ind	72	STD	On	83	GTO	Off
63	IC	Ind	73	RCL	Ind	84	RET	Off
64	RJ	Ind	74	SUM	Ind	92	MOV	SER

TEXAS INSTRUMENTS
INCORPORATED

APPENDIX II

YIELD, EFFICIENCY CALCULATIONS

Yield

Yield was calculated in the following manner:

$$\text{TPD Feed (thick stock)} + \text{TPD white water} = \text{TPD Accepted} \\ + \text{TPD Rejected.}$$

$$\frac{\text{TPD Accepted}}{\text{TPD (thick stock)} + \text{TPD (white water)}} \times 100 = \text{BD Yield}$$

Cleaning Efficiency

Cleaning efficiency for the system as a whole was calculated as follows:

$$(\text{TPD W1W X PPM Dirt}) \\ + (\text{TPD Feed X PPM Dirt}) = (\text{TPD Accepts X PPM Dirt}) + (\text{TPD Rejects} \\ \times \text{PPM Dirt})$$

$$\frac{\text{TPD Rejects X PPM Dirt}}{(\text{TPD WW X PPM Dirt}) + (\text{TPD Feed X PPM Dirt})} \times 100 = \text{Cleaning Efficiency}$$

This calculation was verified by performing a dirt balance around each stage.

APPENDIX III

BACKGROUND DATA

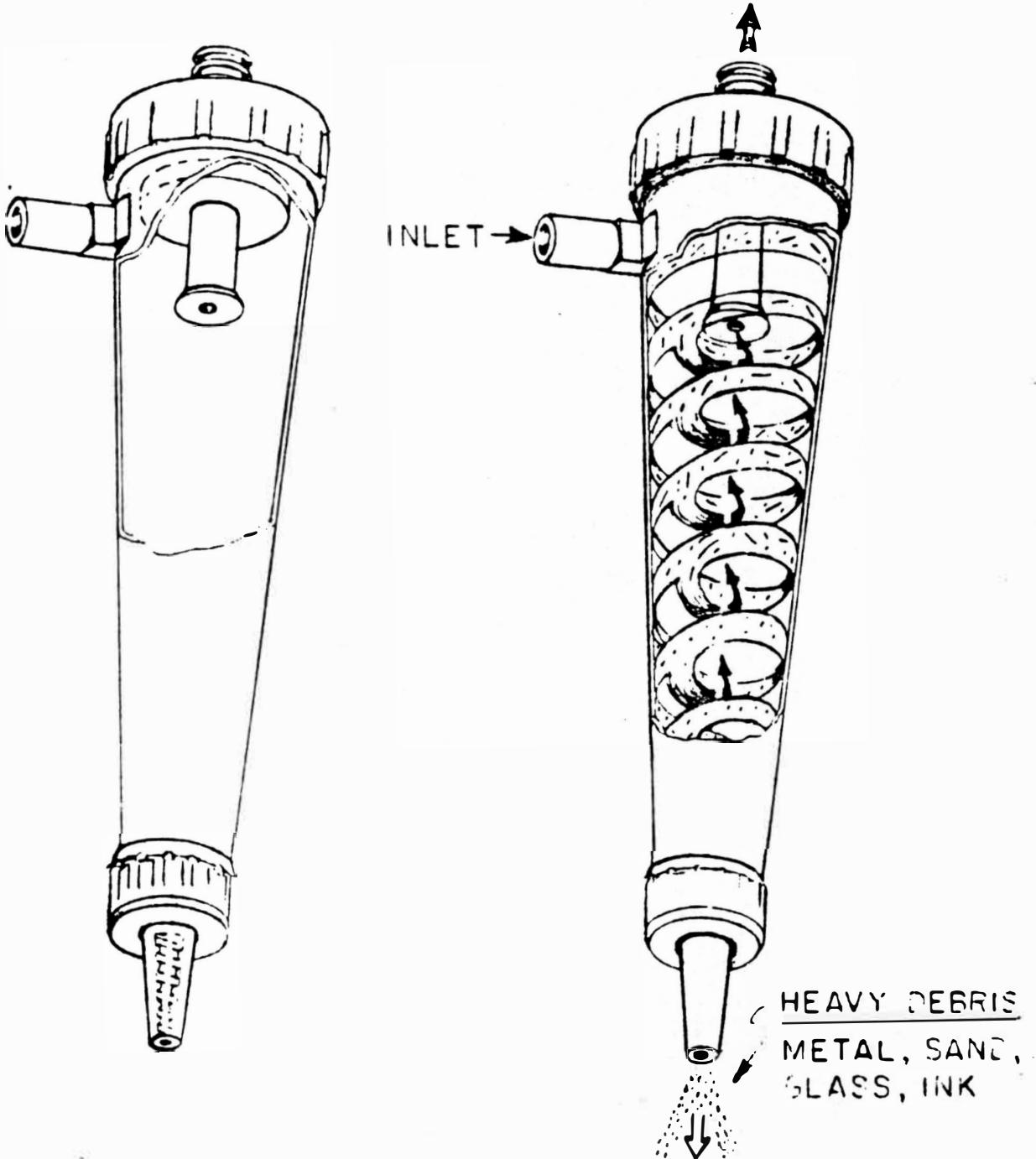
CLEANER PERFORMANCE

The following data was established through pilot plant experimentation with Bauer 3" centrifugal cleaners.

A heavily printed bleached kraft stock was defibered with 1% NaOH and 140°F water. This stock was chosen primarily because cleaning efficiency is easy to determine, but also because fiber length, and ash content are somewhat in the middle of the extremes for available market fiber.

A pressure drop of 40 psig was recommended by the manufacturer. A temperature of 80-90°F was chosen as a representative process temperature, again due to the manufacturers' recommendations.

ACCEPTED STOCK



RAW DATA

Consistencies vs. Thickening Factor

Primary Stage

T.F.	Feed <u>Consistency</u>	Reject <u>Consistency</u>	Accept <u>Consistency</u>
4.73	.52	2.46	.41
5.10	.60	3.06	.47
3.00	.68	2.04	.52
2.82	.61	1.72	.51
3.17	.70	2.22	.41
4.80	.47	2.26	.51
3.86	.50	1.93	.44
3.34	.56	1.87	.52
2.96	.48	1.42	.29
2.93	.45	1.32	.32
2.13	.46	.98	.26
2.23	.52	1.16	.60
3.62	.93	3.37	.65
•			
\bar{x} = 3.438	.575	1.985	.455
SD = .949	.13	.705	.116
Var = .831	0.17	.459	.012

Secondary Stage

T.F.	<u>Feed Consistency</u>	<u>Reject Consistency</u>	<u>Accept Consistency</u>
4.96	.47	2.436	.11
3.60	.94		.15
4.2	.65		.35
6.69	.35	2.588	.19
4.40	.57		.18
6.14	.50	2.540	.28
5.76	.37		.21
5.65	.49	2.507	.29
6.58	.36	2.579	.19
5.75	.28	2.506	.16
3.93	.30	2.346	.09
3.29	.34	2.290	.22
5.84	.57		.12
\bar{x} = 5.138	.476	2.375	.195
SD = 1.144	.18	.729	.076
Var = 1.208	.03	.490	.005

Tertiary Stage

T.F.	<u>Feed Consistency</u>	<u>Reject Consistency</u>	<u>Accept Consistency</u>
5.55	.20	1.11	.07
5.57	.51	2.84	.03
4.92	.39	1.92	.20
12.62	.24	3.03	.11
6.48	.33	2.14	.30
7.58	.36	2.23	.12
6.62	.45	2.98	.14
3.00	.90	2.70	.43
5.48	.29	1.59	.08
5.55	.20	1.11	.09
3.53	.30	1.06	.10
7.15	.13	.93	.10
6.76	.29	1.96	.21
\bar{x} = 6.216	.309	2.00	.152
SD = 2.334	.109	.794	.109
Var = 5.027	.011	.581	.012

APPENDIX IV

BALANCED SYSTEM

RESULTS, ALL COLLECTIONS

ALL DATA INPUTS

RAW DATA

Feed Consistency vs. Cleaning Efficiency (30-50 PPM)

Primary Stage

<u>Feed Consistency</u>	<u>PPD Dirt Feed</u>	<u>Reject Rate</u>	<u>PPM Dirt Rejects</u>	<u>Cleaning Efficiency %</u>
.52	32	21.5	187	77.5
.60	35	25.6	185	74.0
.68	42	31.6	195	68.0
.61	45	23.3	265	73.0
.70	47	50.8	139	66.5
.47	50	80.9	77	80.0
.50	33	15.5	271	78.5
.56	36	9.9	485	75.0
.48	42	49.7	107	79.0
.45	48	38.1	156	81.0
.46	46	59.2	97	80.5
.52	34	36.1	122	77.5
.93	35	37.3	230	41.0

$\bar{X} = .575$ 40.4 34.8 194 59.8

Secondary Stage

<u>Feed Consistency</u>	<u>PPM Dirt Feed</u>	<u>Reject Rate</u>	<u>PPM Dirt Rejects</u>	<u>Cleaning Efficiency %</u>
.47	177	80.2	319	80
.35	175	22.8	913	84
.50	185	32.7	770	78.5
.49	255	46.1	1975	78
.36	129	51.0	302	83.5
.28	67	45.8	170	86.0
.30	261	72.8	419	85.5
.34	375	39.0	1131	85.0
$\bar{X} = .476$	203	47.5	744	57.4

Tertiary Stage

<u>Feed Consistency</u>	<u>PPM Dirt Feed</u>	<u>Reject Rate</u>	<u>PPM Dirt Rejects</u>	<u>Cleaning Efficiency %</u>
.20	310	69.4	507	88
.51	298	95.1	402	78
.39	460	54.4	1025	82.5
.24	280	56.2	569	87.5
.33	199	10.6	2208	85.0
.36	315	70.5	535	83.5
.45	320	72.3	546	81.0
.90	410	62.1	1375	48.0
.20	377	76.3	259	90
.22	365	60.4	687	88
.30	402	73.6	639	85.5
.13	354	25.9	1502	91.0
.29	332	30.9	1264	85.0
$\bar{X} = .309$		340	66.5	886
				57.7

RAW DATA

Feed Consistency vs. Reject Rate

Primary Stage

<u>Feed Consistency</u>	<u>Reject Rate %</u>
.52	21.5
.60	25.6
.68	31.6
.61	23.3
.70	50.8
.47	80.9
.50	15.5
.56	9.9
.48	49.7
.45	38.1
.46	59.2
.52	36.1
.93	37.3

Secondary Stage

Feed Consistency

Reject Rate %

.47	80.2
.35	22.8
.50	32.7
.49	46.1
.36	51.0
.28	45.8
.30	72.8
.34	39.0

\bar{X} = .476
SD = .18
Var = .03

47.4

Tertiary Stage

<u>Feed Consistency</u>	<u>Reject Rate %</u>
.20	69.4
.51	95.1
.39	54.4
.24	56.2
.33	10.6
.36	70.5
.45	72.3
.90	62.1
.29	76.3
.20	60.4
.30	73.6
.13	25.9
.29	30.9

\bar{X} = .309 66.5
SD = .109
Var = .011

COLLECTION 1

Results for Input 1

STOCK

TPD	177. 775
CONS.	2. 300
GPM	1286. 507

PRIMARY STAGE

FEED	TPD	230. 061
	CONS.	600
	GPM	6382. 084

ACCEPTS	TPD	150. 000
	CONS.	461
	GPM	5416. 447

REJECTS	TPD	80. 061
	CONS.	1. 380
	GPM	965. 637

WHITEWATER	TPD	1. 560
	CONS.	010
	GPM	2596. 279

TERTIARY STAGE

FEED	TPD	47. 798
	CONS.	500
	GPM	1591. 155

ACCEPTS	TPD	16. 012
	CONS.	198
	GPM	1345. 081

REJECTS	TPD	31. 786
	CONS.	2. 150
	GPM	246. 074

WHITEWATER	TPD	. 112
	CONS.	010
	GPM	187. 177

SECONDARY STAGE

FEED	TPD	96. 439
	CONS.	550
	GPM	2918. 501

ACCEPTS	TPD	50. 727
	CONS.	338
	GPM	2499. 298

REJECTS	TPD	45. 712
	CONS.	1. 815
	GPM	419. 203

WHITEWATER	TPD	. 365
	CONS.	010
	GPM	607. 783

QUARTENARY STAGE

FEED	TPD	32. 357
	CONS.	450
	GPM	1196. 814

ACCEPTS	TPD	1. 974
	CONS.	033
	GPM	984. 775

REJECTS	TPD	30. 383
	CONS.	2. 385
	GPM	212. 039

WHITEWATER	TPD	. 571
	CONS.	010
	GPM	950. 740

COLLECTION 2

Results for Input 1

STOCK		TERTIARY STAGE	
TPD	179.615	FEED	51.956
CONS.	2.300		.500
GPM	1299.825		1729.560
PRIMARY STAGE		ACCEPTS	
FEED		TPD	17.405
TPD	145.492	CONS.	.197
CONS.	.600	GPM	
GPM	4036.067		1468.160
ACCEPTS		REJECTS	
TPD	94.861	TPD	34.551
CONS.	.461	CONS.	2.200
GPM	3425.393	GPM	261.399
REJECTS		WHITE WATER	
TPD	50.631	TPD	.122
CONS.	1.380	CONS.	.010
GPM	610.675	GPM	203.348
QUARTENARY STAGE			
WHITE WATER		FEED	
TPD	2.250	TPD	35.175
CONS.	.010	CONS.	.450
GPM	3745.259	GPM	1301.056
SECONDARY STAGE		ACCEPTS	
FEED		TPD	2.146
TPD	104.827	CONS.	.033
CONS.	.550	GPM	1070.546
GPM	3172.353	REJECTS	
ACCEPTS		TPD	33.030
TPD	55.139	CONS.	2.385
CONS.	.368	GPM	230.508
GPM	2716.687	WHITE WATER	
REJECTS		TPD	.625
TPD	49.688	CONS.	.010
CONS.	1.815	GPM	1039.656
GPM	455.665	SYSTEM ACCEPTS	
WHITE WATER		TPD	150.000
TPD	.051	CONS.	.406
CONS.	.010	GPM	6142.080
GPM	84.501		

COLLECTION 3

U.S. T.O.
Results for Input 2

TERTIARY STAGE

	FEED	TPD CONS. GPM	72.708 500 2420.381
STOCK	ACCEPTS	TPD CONS. GPM	24.357 198 2046.066
TPD CONS. GPM	REJECTS	TPD CONS. GPM	46.351 2.150 374.315
248.002 2.300 1794.720			

PRIMARY STAGE

FEED	WHITEWATER	TPD CONS. GPM	171 010 284.724
TPD CONS. GPM		TPD CONS. GPM	
327.257 600 9078.355		TPD CONS. GPM	

ACCEPTS	QUARTENARY STAGE	TPD CONS. GPM	49.220 450 1820.531
TPD CONS. GPM		TPD CONS. GPM	
213.371 461 7704.760		TPD CONS. GPM	

REJECTS	FEED	TPD CONS. GPM	46.217 2.385 322.543
TPD CONS. GPM		TPD CONS. GPM	
113.895 1.380 1373.595		TPD CONS. GPM	

WHITEWATER	ACCEPTS	TPD CONS. GPM	3.002 063 1497.987
TPD CONS. GPM		TPD CONS. GPM	
2.052 010 3481.635		TPD CONS. GPM	

SECONDARY STAGE

FEED	ALPHA STAGE	TPD CONS. GPM	213.371 461 7704.760
TPD CONS. GPM		TPD CONS. GPM	
146.698 550 4439.469		TPD CONS. GPM	

ACCEPTS	FEED	TPD CONS. GPM	150.000 343 7273.003
TPD CONS. GPM		TPD CONS. GPM	
77.163 338 3801.800		TPD CONS. GPM	

REJECTS	ACCEPTS	TPD CONS. GPM	63.371 024 431.757
TPD CONS. GPM		TPD CONS. GPM	
69.535 1.815 637.669		TPD CONS. GPM	

WHITEWATER	REJECTS	TPD CONS. GPM	667 010 1446.216
TPD CONS. GPM		TPD CONS. GPM	
.353 .010 588.051		TPD CONS. GPM	

WHITEWATER

TPD CONS. GPM	667 010 1446.216
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COLLECTION 1

Results for Input 2

STOCK

TPD	177. 509
CONS.	2. 300
GPM	1284. 585

PRIMARY STAGE

FEED

TPD	230. 061
CONS.	. 550
GPM	6962. 273

ACCEPTS

TPD	150. 000
CONS.	. 401
GPM	6228. 070

REJECTS

TPD	80. 061
CONS.	. 1. 815
GPM	734. 203

WHITEWATER

TPD	1. 690
CONS.	. 010
GPM	2813. 625

TERTIARY STAGE

FEED

TPD	47. 981
CONS.	. 450
GPM	1774. 720

ACCEPTS

TPD	16. 074
CONS.	. 172
GPM	1552. 043

REJECTS

TPD	31. 908
CONS.	. 2. 385
GPM	222. 677

WHITEWATER

TPD	. 160
CONS.	. 010
GPM	265. 962

SECONDARY STAGE

FEED

TPD	96. 695
CONS.	. 500
GPM	3218. 889

ACCEPTS

TPD	50. 862
CONS.	. 296
GPM	2864. 063

REJECTS

TPD	45. 834
CONS.	. 2. 150
GPM	354. 826

WHITEWATER

TPD	. 560
CONS.	. 010
GPM	932. 643

QUARTENARY STAGE

FEED

TPD	32. 589
CONS.	. 400
GPM	1356. 046

ACCEPTS

TPD	. 1. 988
CONS.	. 029
GPM	1153. 931

REJECTS

TPD	30. 601
CONS.	. 2. 520
GPM	202. 115

WHITEWATER

TPD	. 681
CONS.	. 010
GPM	1133. 369

COLLECTION 2

Results for Input 2

STOCK			TERTIARY STAGE		
TPD	179. 318		TPD	52. 027	
CONS.	2. 300		CONS.	. 450	
GPM	1297. 674		GPM	1924. 348	
PRIMARY STAGE			ACCEPTS		
FEED	145. 475		TPD	17. 429	
TPD	. 550		CONS.	. 172	
CONS.			GPM	1682. 896	
GPM	4402. 478		REJECTS		
ACCEPTS	94. 850		TPD	34. 598	
TPD	. 401		CONS.	. 385	
CONS.			GPM	241. 451	
GPM	3938. 217		WHITE WATER		
REJECTS	50. 625		TPD	. 173	
TPD	. 815		CONS.	. 010	
CONS.			GPM	288. 386	
GPM	464. 261		QUARTENARY STAGE		
WHITE WATER	2. 527		FEED	35. 336	
TPD	. 010		TPD	. 400	
CONS.			CONS.		
GPM	4205. 424		GPM	1470. 376	
SECONDARY STAGE			ACCEPTS		
FEED	104. 848		TPD	2. 156	
TPD	. 500		CONS.	. 029	
CONS.			GPM	1251. 220	
GPM	3490. 276		REJECTS		
ACCEPTS	55. 150		TPD	33. 181	
TPD	. 296		CONS.	. 520	
CONS.			GPM	219. 156	
GPM	3105. 534		WHITE WATER		
REJECTS	49. 698		TPD	. 738	
TPD			CONS.	. 010	
CONS.	2. 150		GPM	1228. 924	
CONS.			SYSTEM ACCEPTS		
GPM	364. 742		TPD	150. 000	
WHITE WATER	146		CONS.	. 354	
TPD	. 010		GPM		
CONS.			7043. 751		
GPM	242. 499				

COLLECTION 3

COLLECTION 3
Results for Input 2

TERTIARY STAGE

STOCK	FEED	TPD	78. 756
TPD	CONS.	. 450	
CONS.	GPM	2912. 987	
GPM			
241. 698	ACCEPTS	TPD	26. 383
2. 300	CONS.	. 172	
1749. 104	GPM	2547. 490	
	REJECTS	TPD	52. 372
		CONS.	. 385
		GPM	365. 497
PRIMARY STAGE	WHITEWATER	TPD	. 262
FEED		CONS.	. 010
TPD	TPD	GPM	
CONS.	CONS.	GPM	436. 545
GPM	GPM		

ACCEPTS	QUARTENARY STAGE	
TPD	TPD	53. 490
CONS.	CONS.	. 400
GPM	GPM	2225. 786
REJECTS	ACCEPTS	
TPD	TPD	3. 263
CONS.	CONS.	. 029
GPM	GPM	1894. 038
WHITEWATER	REJECTS	
TPD	TPD	50. 227
CONS.	CONS.	. 520
GPM	GPM	331. 748
2. 075		
0. 010		
3453. 545		
SECONDARY STAGE		

FEED	ALPHA STAGE	
TPD	TPD	213. 371
CONS.	CONS.	. 401
GPM	GPM	8859. 274
ACCEPTS	ACCEPTS	
TPD	TPD	150. 000
CONS.	CONS.	. 296
GPM	GPM	8441. 623
REJECTS	REJECTS	
TPD	TPD	63. 371
CONS.	CONS.	. 025
GPM	GPM	417. 651
WHITEWATER	WHITEWATER	
TPD	TPD	1. 118
CONS.	CONS.	. 010
GPM	GPM	1860. 286
. 765		
0. 010		
1273. 889		

COLLECTION 1

Results for Input 3

STOCK

TPD	177.229
CONS.	2.300
GPM	1282.560

PRIMARY STAGE

FEED	
TPD	200.000
CONS.	2.300
GPM	7656.560

ACCEPTS	
TPD	150.000
CONS.	2.300
GPM	7030.696

REJECTS	
TPD	50.001
CONS.	2.150
GPM	615.804

WHITEWATER	
TPD	1.870
CONS.	010
GPM	2112.850

TERTIARY STAGE

FEED	
TPD	48.119
CONS.	400
GPM	2000.292

ACCEPTS	
TPD	18.120
CONS.	350
GPM	1790.730

REJECTS	
TPD	31.889
CONS.	2.520
GPM	211.352

WHITEWATER	
TPD	1.194
CONS.	010
GPM	211

SECONDARY STAGE

FEED	
TPD	94.866
CONS.	450
GPM	3563.595

ACCEPTS	
TPD	50.962
CONS.	260
GPM	3263.091

REJECTS	
TPD	45.924
CONS.	2.385
GPM	320.494

WHITEWATER	
TPD	1.705
CONS.	010
GPM	1172.851

QUATERNARY STAGE

FEED	
TPD	32.809
CONS.	350
GPM	1560.275

ACCEPTS	
TPD	2.001
CONS.	026
GPM	1259.576

REJECTS	
TPD	30.808
CONS.	2.556
GPM	230.690

WHITEWATER	
TPD	1.610
CONS.	010
GPM	1249.620

COLLECTION 2

Results for Input 3

TERTIARY STAGE			
	FEED	TPD CONS. GPM	52.084 400 2167.292
STOCK			
TPD CONS. GPM	176.963 2.300 1295.110		
PRIMARY STAGE			
FEED			
TPD CONS. GPM	145.457 500 4642.124		
ACCEPTS			
TPD CONS. GPM	94.838 355 4450.250		
REJECTS			
TPD CONS. GPM	50.619 2.150 391.874		
WHITE WATER			
TPD CONS. GPM	2.858 010 4757.545		
QUARTENARY STAGE			
	FEED	TPD CONS. GPM	35.513 350 1686.859
ACCEPTS			
TPD CON CONS. GPM	2.166 .025 1471.621		
REJECTS			
TPD CONS. GPM	33.347 2.555 217.238		
WHITE WATER			
TPD CONS. GPM	.877 .010 1460.089		
SECONDARY STAGE			
FEED			
TPD CONS. GPM	104.870 .450 3878.913		
ACCEPTS			
TPD CONS. GPM	55.162 .260 3532.006		
REJECTS			
TPD CONS. GPM	49.709 2.385 346.907		
WHITE WATER			
TPD TPD CONS. GPM	203 .010 337.985		
SYSTEM ACCEPTS			
		TPD CONS. GPM	150.000 .313 7982.256

COLLECTION 3

Results for Input 3

TERTIARY STAGE

FEED		TPD	85. 611
		CONS.	. 400
STOCK		GPM	3562. 362
ACCEPTS		TPD	28. 690
TPD	234. 550	CONS.	. 150
CONS.	2. 300	GPM	3186. 335
GPM	1697. 376	REJECTS	
PRIMARY STAGE		TPD	56. 931
FEED		CONS.	. 2. 520
TPD	327. 257	GPM	376. 027
CONS.	500	WHITEWATER	
GPM	10894. 026	TPD	. 344
ACCEPTS		CONS.	. 010
TPD	213. 371	GPM	573. 262
CONS.	. 355	QUARTENARY STAGE	
GPM	10012. 370	FEED	
REJECTS		TPD	58. 373
TPD	113. 885	CONS.	. 350
CONS.	2. 150	GPM	2775. 965
GPM	881. 656	ACCEPTS	
WHITEWATER		TPD	3. 561
TPD	2. 037	CONS.	. 025
CONS.	. 010	GPM	2418. 892
GPM	3391. 117	REJECTS	
SECONDARY STAGE		TPD	54. 812
FEED		CONS.	. 2. 555
TPD	172. 375	GPM	357. 073
CONS.	. 450	ALPHA STAGE	
GPM	6375. 741	FEED	
ACCEPTS		TPD	213. 371
TPD	90. 669	CONS.	. 355
CONS.	. 260	GPM	10012. 370
GPM	5805. 533	ACCEPTS	
REJECTS		TPD	150. 000
TPD	81. 706	CONS.	. 260
CONS.	. 385	GPM	9605. 017
GPM	570. 208	REJECTS	
WHITEWATER		TPD	63. 371
TPD	1. 142	CONS.	. 026
CONS.	. 010	GPM	407. 353
GPM	1900. 397	WHITEWATER	
TPD		TPD	1. 442
CONS.		CONS.	. 010
GPM		GPM	2399. 938

Literature Cited

- 1.) C. E. Bauer, Bulletin G-33, Combustion Engineering, Inc., 1976.
- 2.) Kumar, Vinod, TAPPI, 64 (4):145 (1981).
- 3.) Laurinolli, K. J., TAPPI, 63 (4):155 (1980).
- 4.) Wilson, Kra G. and Martvaun E., From Idea to Working Model, New York, Wiley, 1970.