COMPARATIVE STUDY OF COST INDICES ON THE COST ESTIMATION OF A PALM OIL REFINERY AND FRACTIONATION PLANT

BY

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DECLARATION

I hereby declare that this work was carried out by me and it is a record of my research work. It has not been presented in any previous application for a higher degree. All the sources of information are duly acknowledged by means of references.

NFW .... 15/9/05 ....

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CERTIFICATION

This thesis entitled "Comparative of Cost Indices on the cost estimation of a Palm Oil Refinery and Fractional Plant", by Ngubi Fredericks Wirsiy meets the regulation governing the award of degree of Master of Engineering (M. Eng. Chem.) at Federal University of Technology, Minna and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to the memory of my late maternal grand parents: Yaya Maria Ntang née Ba'ty and Yerimah Jisi Mathias Balon, and also to all those who had never and may likely not have any work dedicated to their memory, and finally to my yet unborn children.

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NOMENCLATURE

CCT	Current cost of a piece of equipment (₦)
HCT	Historical cost of a piece of equipment (₦)
CIT	Current cost index of a piece of equipment (no units)
HIT	Historical cost index of a piece of equipment (no units)
TT	Total cost of a number of an equipment unit (₦)
HCA	Historical cost of equipment A (₦)
HCB	Historical cost of equipment B (₦)
QA	Capacity of equipment A (either in m, m^2, m^3, m^3/s)
QB	Capacity of equipment B (either in m, m^2, m^3, m^3/s)
QAH	Historical capacity of equipment A (m, m^2, m^3, m^3/s)
QAC	Current capacity of equipment A (m, m^2, m^3, m^3/s)
CIA	Current cost index of equipment A (no units)
HIA	Historical cost index of equipment A (no units)
PECT	Delivered purchased equipment cost (₦)
CCi	Current cost of equipment I (₦)
FCAPN	Fixed capital investment (₦)
F_i	Direct cost factors used in computation of fixed capital investment (multiplying factors for the estimation of cost of piping, instrumentation, buildings delivered purchased equipment installation, electrical equipment and materials, yard improvements, service facilities and land) (no units).
f_j	Indirect cost factors used in calculating the fixed capital investment or multiplying factors for estimation of indirect expenses such as engineering fee, contractors' fee, and contingencies) (no units).

F_I	$(1 + \Sigma f_j)$ (no units)
WCAPN	Working capital investment (₦)
TCAPN	Total capital investment (₦)
CINDEX	FORTRAN 77 source code representing the method of cost index
CINDEX.RES	Result or output file for CINDEX
CISCAL	FORTRAN 77 source code representing the method of cost index and scaling.
CISCAL.RES	Result file for CISCAL
SIX10R	FORTRAN 77 source code representing the Six-Tenths Factor Rule method.
SIX10R.RES	Result file for SIX10R.
E1	Slope of the correlating curve on the log-log cost plot. (variable exponent to which the ratio of equipment capacities was raised). (no units).

ABSTRACT

Studies were carried out towards the development of three overall robust and modular computer modules that could relate equipment cost fluctuation on the design of a Palm Oil Refinery and Fractionation Plant (PORFP) with intention for future use. Cost modules for each of the 27 major processing equipment of the PORFP were created, alongside those for computation of the delivered purchased equipment cost, fixed, working and total capital investments.

Three different cost estimation methods were used namely the methods of cost index, six-tenths factor rule and cost index and scaling.

Three FORTRAN source codes CINDEX, SIX10R and CISCAL were written to represent the 3 cost estimation methods above respectively. Cost data obtained in 1996 and cost indices for 1996 and 2002 were used as data to run the three overall robust modules: CINDEX, SIX10R and CISCAL. These were developed to relate equipment cost fluctuation to the design of PORFP using the three different costing methods, namely cost index, six-tenths factor rule and cost index and scaling methods respectively.

These modules were tested by comparing the cost of each piece of equipment in 2002 (the chosen current year) with those in 1996 (the chosen reference year) in order to determine the efficiency and performance of the modules. A summary of the delivered purchased equipment cost, fixed, working and total capital investments has been presented. Corresponding cost estimates obtained from the methods of six-tenths factor rule and cost index and scaling on the other one hand were similar, but significantly different in magnitude from that obtained from the method of cost index. For instance, the delivered purchase equipment of ₦20,174,510.00 computed by CINDEX was about ₦9,000,000.00 less than computed by SIX10R and CISCAL which stood at ₦30,734,920.00 and ₦29,235,930.00 respectively. Similarly, the fix capital investment

computed by CINDEX was ₦185,609,600.00 as opposed to ₦ 282,767,400.00 and ₦268,976,400.00 for SIX10R and CISCAL respectively. Likewise the working capital investment for CINDEX stood at ₦32,754,630.00 while those for SIX10R and CISCAL were ₦49,900130.00 and ₦47,466,430.00 respectively. Finally, the total capital investment computed by CINDEX, SIX10R and CISCAL were ₦218, 364,200.00, ₦ 22, 607,500.00 and ₦316, 442,900.00

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Palm oil is an edible oil derived from the fleshy mesocarp of the fruits of the oil palm tree, which is a perennial plant indigenous to tropical West Africa and South America (FAO/WHO, 1993). This plant produces edible oil (palm and kernel) in bigger quantities per unit area of land than any other plant. However, despite its commercial importance, it is not a well-known plant (Wood, 1987).

The principal oil palm of commerce is *Elaies guineensis*, which is in the same botanical tribe (Cocoinae) as the coconut. It is a tropical palm with a crown of pinnate fronds (leaves) on a thickened vascular stem with a single bud in the crown centre (Wood, 1987).

In ideal conditions, yields are above 30 tons of fresh fruit bunch/hectare with today's planting materials, poor soil texture or chemical characteristics, a relatively high proportion of gravel to concretions, and compaction all pull down the yield potential, but the palm is reasonably adapted and 15 – 30 tons per hectare may be obtained on less favourable soil, when climate is good (Foster, 1982).

Today, the oil palm is cultivated within this range of $\pm 10^{o}$ latitude in Africa, Indonesia, Malaysia, Papua New Guinea and Colombia for commerce. The vast bulk of oil obtained from the original stock is basically similar whether it is grown in Africa, South America or South East Asia.

Oil from the South American oil palm *Elaies oleifera* is noticeably different in fatty acid composition as shown in Table 1.1; and because of the high content of linoleic acid it is more desirable. However, the yield of the South American tree is substantially lower than that of trees from the *Elaies guineensis* stock and therefore, it is not at present grown commercially (Gunstone, 1987).

Table1: Percentage Fatty Acid Composition of Palm Oil

Fatty Acid	Codex (1)	Zaire Plantation (2)	Malaysia PORIM mean (3)	Columbia *Elaies oleifera*
12:0	< 1.2	0.12	0.2	-
14:0	0.5 – 5.9	1.02	1.1	Trace
16:0	32 – 59	45.5	44.0	22.9
16:1	< 0.6	0.10	0.1	1.3
18:0	1.5 – 8	5-90	4.5	1.0
18:1	27 – 52	34.6	39.2	54.8
18:2	5.0 – 14	11.8	10.1	20.0
18:3	< 1.5	0.29	0.4	-
20:0	< 1.0	0.36	0.4	-

Source: Gunstone, 1987.

1.2 PROBLEM STATEMENT

The reference year for historical equipment costs and cost indices was 1996, and the current year was 2002. It was required to estimate the current cost of each piece of equipment of the Palm Oil Refinery and Fractionation Plant, and hence the delivered purchased equipment cost, and subsequently, the fixed, working, and total capital investments, bearing in mind the changing economic conditions like inflation, deflation, technological advancements, and a host of other factors. The following cost data (Tables 1.2 and 1.3) obtained in 1996 were used in running the three FORTRAN cost modules namely CINDEX, SIX10R, and CISCAL to obtain the required cost estimates.

Table 1.1: Relevant Cost Data for the Units of the Palm Oil Refinery and Fractionation Plant as at 1996.

Piece of Equipment	Historical Cost (₦)	Capacity		Exponent
		A(1)	B(2)	(E1)
Calcium carbonate tank	78773	2 m^3	4 m^3	0.49
Mixing tank	78773	2 m^3	4 m^3	0.49
Phosphoric acid tank	98200	2.5 m^3	5 m^3	0.47
Drier	103537	3 m^3	6 m^3	0.47
Bleaching earth tank	104604	3 m^3	6 m^3	0.76
Continuous bleaching reactor	640436	3 m^3	6 m^3	0.49
Bernardinni filter	693806	15 m^2	30 m^2	0.54
Steel super filter	117413	0.2 m^3	0.4 m^3	0.66
Guard filter I	111596	2.5 m^3	5 m^3	0.66
Decanter	66712	3 m^3	6 m^3	0.66
Storage tank	105031	2.5 m^3	5 m^3	0.49
Deacrator/Drier	111649	2.5 m^3	5 m^3	0.49
Deodoriser	320218	3 m^3	6 m^3	0.66
FFA recuperator	98200	2.5 m^3	5 m^3	0.49
Preheating tank	104604	3 m^3	6 m^3	0.49
Vacuum system	393868	0.4 m^3	0.8 m^3	0.66
Screw worm	329825	10 m	20 m	0.99
Pump	200136	$9.5x10^{-3}$ m^3/s	$19.5x10^{-3}$ m^3/s	0.33
Tube and shell heat exchanger	1050316	14 m^2	28 m^2	0.66
Guard filter II	111596	0.0335 m^3	0.067 m^3	0.66
Crystalliser	144098	0.314 m^3	0.628 m^3	0.37
R.B.D. tank	104605	3 m^3	6 m^3	0.49
Cold water tank	96065	2.5 m^3	5 m^3	0.49
Warm water tank	96065	2.5 m^3	5 m^3	0.49
Welders' filter press	960654	9.29 m^2	18.58 m^2	0.66
Stearin tank	104605	3 m^3	6 m^3	0.47
Olein tank	104605	3 m^3	6 m^3	0.47

Chemical Plant Cost Index (1996) = 381.7

Chemical Plant Cost Index (2002) = 394.3

Table 1.2: Ratio Factors for Estimating Capital Investments Items Based on Delivered Equipment Cost.

ITEM	FACTOR
Direct costs	
Delivered purchased equipment	1.00
Purchased equipment installation	0.47
Instrumentation and controls	0.18
Piping (including services)	0.66
Building (including services)	0.18
Electrical (installed)	0.11
Yard improvements	0.10
Service facilities (installed)	0.70
Land	0.06
Indirect Costs	
Engineering and supervision	0.33
Construction expenses	0.41
Contractor's fees	0.21
Contingency	0.42

1.3 AIM AND OBJECTIVES

The aim of this work is to develop three computer modules that could relate equipment cost fluctuation to the design of a Palm Oil Refinery and Fractionation Plant with intention for future use.

The objectives of this study are to:

a. Create a cost module for each unit of the Palm Oil Refinery and Fractionation Plant.

b. Develop three overall robust modules for the same plant using three different costing methods.

1.4 SCOPE AND LIMITATIONS

This work is based on the design of the Société Camerounaise de Rafinnage – MAYA et Cie: a Palm Refinery and Fractionation Plant established in 1992 (in the Bonandale Industrial zone of Douala, the economic capital of Cameroon) with a refining capacity of 15,000m^3 per annum, whose pertinent design specifications (Table 1.2) were made use of to achieve the objectives of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 VEGETABLE OILS

2.1.1 Introduction

The McGraw-Hill Encyclopaedia of Science and Technology (1997) defines vegetables oils as edible, mixed glyceride oils derived from plants (fruit, leaves, seeds). Simply put, they are oils that are derived from plant sources. Examples are palm oil, corn oil, soybean oil, cotton seed oil, coconut oil, sesame oil to name but a few.

The largest sources of vegetable oils are annual plants such as soybeans, corn, cottonseed, and groundnuts. However, other sources are the oil-bearing perennials such as the oil palm, olive and coconut (Hui, 1996). Few annual plants are cultivated only for the oil, the castor plant being the only exception. Soybean or Canola is generally utilized for high protein feed production with the vegetable oil as a co-product.

The annual world production of vegetable oils is in excess of 59 million tons compared to the total world production for all fats and oils of 72.6 million metric tons for 1991 – 1992 (SO/OCs – 40, 1994). The world production of vegetable oils for 1991-1992 is shown in Table 2.1.

Table 2.1: World Production of Vegetable Oils for 1991-1992

Vegetable Oil	Metric Tons
Soya bean	16.80
Cotton seed	4.17
Groundnut	3.41
Sunflower seed	7.61
Rapeseed	9.11
Olive	2.14
Coconut	2.94
Palm Kernel	1.49
Palm	11.49
Total	59.14

2.1.2 Chemical Composition of Vegetable Oils.

Vegetable oils are made up of edible fats and oil which are basically esters of glycerol, $C_3H_5(OH)_3$, and various fatty acids, most of which have an even number of carbon atoms arranged in a long straight chain. They may be represented by the structural formula in Fig. 2.1, where R, R', and R'' represent the carbon chains of the fatty acid.

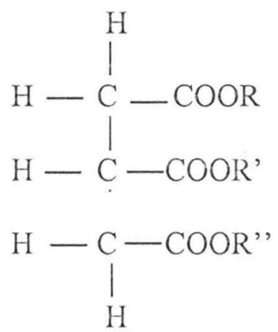


Fig. 2.1: Structural Formula of an Ester of Glycerol

The fatty acids may be saturated, that is, each carbon atom in the chain is linked by single bonds to other carbon atoms or to hydrogen atoms as in palmitic (hexadecanoic) acid, represented by structural formula Fig. 2.2, or they may be unsaturated, having one or more carbon atoms in the chain joined by two bonds as in oleic , linoleic and linolenic acids.

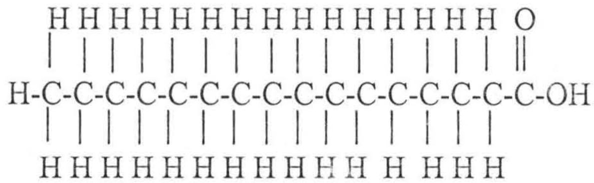


Fig. 2.2 : Structural formula of palmitic acid

Hydrogen, halogens, and other chemical reagents can be added to the double bonds of unsaturated acids to form saturated acids or derivatives. The most important saturated acids in edible fats are palmitic, with 16 carbon atoms; stearic with 18 carbon atoms; lauric with 12 carbon atoms; and butyric with 4 carbon atoms. Oleic acid having 18 carbon atoms and a double bond in the 9-carbon atom position can be represented by structural formula in Fig. 2.3. It is the most abundant unsaturated fatty acid.

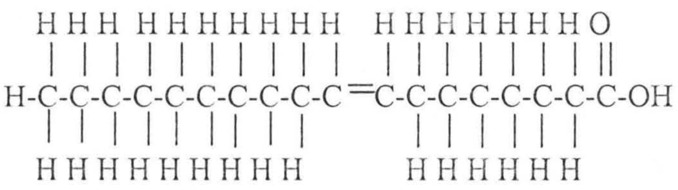


Fig. 2.3 : Structural formula of Oleic acid.

Acids having more than one double bond include linoleic acid, with 18 carbon atoms and two double bonds in the 9^{th} and 12^{th} positions; Linolenic acid, with 18 carbon atoms and three double bonds in the 9^{th}, 12^{th} and 15^{th} positions; and arachidoric acid, with 20 carbon atoms and four double bonds in the 5^{th}, 8^{th}, 11^{th}, and 14^{th} positions.

Fatty acids are distributed among the glycerides in a complex manner, which accounts for the wide variations in physical properties of fats. Only in a few oils, such as cocoa butter, are there a limited number of glycerides of specific configuration.

Non glyceride components, which are not saponified by alkali, constitute from about 0.5 to 2% of most fats. They include sterols, hydrocarbons (such as squalene), carotenoids, and fat-soluble vitamins. The tocopherols (one of which is vitamin E) function as antioxidants and delay the development of rancidity in fat.

2.1.3 Spoilage Factors.

Oxidation and hydrolysis are spoilage factors in the production and storage of edible fats and oils. Incipient oxidation may produce flavours characterised as grassy, buttery, beany or fishy. Rancidity is an advanced state of oxidative deterioration. Oxygen from the air first reacts with the unsaturated fatty acids at or adjacent to the double bonds to form hydrogen peroxides, which then decompose to yield aldehydes having the pungent odour and flavour of rancid fats. Oxidation is catalysed by light and metals such as copper or iron, and is accelerated by heat. Preventive measures include packaging in brown glass or metal containers. Use of nitrogen, an inert gas, in processing and packaging and addition of citric acid during processing to inactivate trace metals. Antioxidants are added to control to rancidity in fats deficient in naturally occurring antioxidants. Widely used antioxidants include nordihydroguiatic acid (NOGA), butylated hydroxytoluene (BHT), or propyl gallate. The more saturated fats and hydrogenated fats are less subject to oxidative deterioration. In processing or use, fats should never be in contact with equipment or utensils made of copper or copper-containing alloys.

Hydrolytic spoilage results only in fats in contact with moisture. With most fats hydrolysis does not noticeably affect the flavour, but butter becomes strong and cocoanut oil develops a soapy flavour. This type of spoilage may be catalysed by the enzymes present in other components of processed food product or enzymes liberated by microorganisms (McGraw-Hill Encyclopedia of Science and Technology, 1997)

2.1.4 Oils in Seed Tissues

Oils accumulate in seed tissues in discrete bodies, about 10μm oil bodies (Griffiths *et al,* 1988). The deposition follows defined kinetics depending upon the type of plant. Safflower cotyledons, for example, after a lag of 12 to 14 days after pollination, actively accumulate triglycerides for 8 to 10 more days. Almost 75% of the oil is laid down from 16 to 20 days after pollination. Each species varies in the time period for oil deposition and is influenced by hormones, factors affecting photosynthesis, cell division and expansion, and genetics of the tissue during development.

Microsomal membranes during the first phase of oil deposition are the most active at synthesizing triglycerides (Green, 1986). Preparations from the developing cotyledons contain all the necessary enzymes for the acylation of glycerol phosphate and assembly of the triacylglycerols.

2.1.5 Classification of Vegetation Oils.

Vegetable oils are classified by Iodine Value or Number into drying oils, semi-drying oils and non-drying oils. The conventional classification results in ten groups that are based on six vegetable oils for edible products, a conjugated acid group, and a hydroxy acid group.

The main vegetable oil categories are (Swern, 1979) are shown in Table 2.2.

Table 2.2: Classification of Vegetable Oils according to the Principal Fatty Acid Component.

Principal Fatty Acid	Oil Source
Lauric	Coconut oil, palm kernel oil and Babasu oil.
Palmitic	Palm oil.
Oleic	Olive, Canola, groundnut, high oleic sunflower and safflower oils.
Linoleic (medium)	Corn, cottonseed, Sesame and soybean.
Linoleic (high)	Sunflower and safflower oils.
Erutic	Rapeseed.

Source: Hui, 1996

A non-conventional classification of vegetable oils by characteristic fatty acid composition is more useful in today's market. These Characteristic Fatty Acids are: Lauric, Palmitic, Stearic, Oleic/Linoleic (delta linoleic, gamma linoleic), lenolenic, erutic, confectionary, specialty oils, conjugated acid oils and hydroxy acid oils (Hui, 1996)

Classification by the characteristic fatty acids that are present permits the inclusion of the genetically modified oils where the characteristic fatty acid may be altered. An example would be regular lower oil versus high oleic sunflower oil.

The largest source for oil is the annual plants such as corn, groundnuts, rapeseed and sunflower. These oils are produced in the temperate climatic regions (Sonntag, 1979). The perennial oil-bearing trees (Coconut, palm, Olive, tung) are grown in tropical regions.

2.1.6 Commercial Utilisation of Vegetable Oils.

Previously, shortenings were the most consumed oil products in the United States of America. However, now salad and cooking oil are the main products consumed as shown in Table 2.3. The U.S. consumer has become more health conscious with the promotion of polyunsaturated and monounsaturated fatty acid oils. In Europe, margarine is the major product made out of vegetable oil, while in Africa it is mostly used in its basic unprocessed form as cooking oil.

The type of oils consumed also differs with the part of the world considered. Olive oil for instance is preferred in the Mediterranean. Soybean, corn and cottonseed oils are dominant in the U.S.A, while groundnut oil is the major oil for most of Europe. In Eastern Europe and the Orient, rapeseed, sesame and sunflower oils are the major oils consumed. In Western Europe, rapeseed and low-erutic acid rapeseed are the most important oil crops. Both high and low-erutic acid rapeseed oils are produced for food and non-food applications. *Crambe abyssinica*, as a source of erutic and behemic acid, may be used as substitutes for rapeseed in North America. In Africa and South-East Asia, palm oil is produced in great quantities.

Table 2.3: Vegetable oils used for edible products by use, United States, 1986/87 – 1992/93

	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
Baking or Frying	5257	5430	5319	5724	5793	5702	5960
Fats	1973	1909	1869	2117	2168	2173	2186
Margarine	6351	6521	6205	6262	6222	6536	6374
Salad or cooking oil	348	310	330	290	368	351	439
Other edible oils	13947	14175	13719	14383	14491	14765	14969
Total edible							

Source: FAO TRADE YEARBOOK, 1993[1a], a = millions of pounds

2.2 PALM OIL

2.2.1 Definition

Palm oil is an edible oil derived from the fatty mesocarp of the oil palm fruit. In the unprocessed form palm oil is reddish-brown or orange-red in colour and it has a semi-solid consistency at ambient temperature. (Hui, 1996)

The history of palm oil can be traced back to the days of the Egyptian Pharaohs 5000 years B.C. The oil palm, however, is a native of West Africa. It was introduced to Malaysia at the start of the 20th century and commercially produced in 1917. Today, Malaysia's oil palm plantations cover 40% of its cultivated land and Malaysia has become the world's largest producer and exporter of palm oil with nearly 60% of the total world production. Other production is in West and Central Africa, principally Nigeria, Cote d'Ivoire, Zaire and Cameroon. Indonesia has also embarked on a massive oil plantation program, and having a much bigger land base, it is expected to catch up soon with Malaysia. Limited quantities are produced in Brazil, Central and South America. Much of the oil is exported to continental Europe, England and Japan.

The palm fruit has an active lipase that hydrolysis the oil during harvesting and handling resulting in very high free fatty acid content in the crude oil. Palm oil's distinctive orange-red colour is due to the presence of carotene. The major carotenoids in crude palm oil are alpha carotene (186μg/g) and beta-carotene (356μg/g) (Bhagaran and Padmanabhan, 1992). Gamma, beta and delta tocotrienols are also present. The oil can be bleached by hydrogenation to the normal yellow colour of vegetable oils.

Palm oil has nearly equal concentrations of saturated and unsaturated fatty acids, 85% of triglycerides of palm oil contain an unsaturated fatty acid at the 2 carbon position of the glycerol backbone.

2.2.2 Chemical and Physical Properties of Palm Oil

Palm oil, like all oils and fats, is made up mostly of glyceridic materials in small or trace quantities. It is this chemical composition that defines the chemical and physical characteristics of palm oil, which in turn will determine the suitability of the oil in various processes and applications.

2.2.2.1 Chemical Properties of Palm Oil

Triglycerides and Fatty Acid Composition

Triglycerides form the major component and bulk of the glyceridic material present in palm oil with small amounts of monoglycerides and diglycerides, which are artefacts of the extraction process. The fatty acid chains present in the palm oil triglycerides could vary in the number of carbons present in the chain (chain length) and in structure (presence of double bonds, i.e., unsaturation).

It is the variation in the structure and number of carbons in these fatty acid chains that largely defines the chemical and physical properties of palm oil.

The chain lengths of the fatty acids present in the triglycerides of palm oil fall within a narrow range from 12 to 20 carbon atoms. About 50% of the fatty acids present in palm oil are saturated and about 50% are unsaturated. This even balance between saturation and unsaturation determines the Iodine value of the oil (about 53) and confers some stability against oxidation to the oil as compared to other vegetable oils. The three fatty acids in the triglycerides could be represented by the multitude of fatty acids naturally known to be found in palm oil from various species of the plant. The different placement of fatty acids attached to the glycerol molecule can lead to a large number of different triglycerides.

Knowledge about the detailed structures of the triglycerides present in palm oil is important because they define some of the physical characteristics of the oil. The melting points of triglycerides are dependent on the structures and composition of the component acids present. They also affect the crystallisation behaviour of the oil. The semi solid nature of the palm oil at room temperature has been attributed to the presence of oleo-disaturated fraction.

As mentioned previously, partial glycerides are artifacts of the extraction process, especially the stages prior to sterilisation. Oil obtained from unbruised sterilised fruits shows trace levels of partial glycerides. Random analyses of samples of refined palm oil, palm olein, and palm stearin have shown the presence of about 2% of 1,2 – diglycerides and about 4% of 1,3 – diglycerides with trace amounts of monoglycerides (Hui, 1996). These partial glycerides are important as they are known to affect the crystallisation behaviour of the oil.

Minor Components

The carotenoids, tocopherols sterols and phosphatides, triterpenic, and aliphatic alcohols form the minor components of palm oil. Though present in less than 1% altogether in palm oil, never the less, they play a significant role in the stability and refinability of the oil, in addition to increasing the nutritive value of the oil.

Crude palm oil contains between 500 - 700 ppm of carotenoids, mainly in the form of α-and β- carotenes, the precursor of vitamin A. Unless extracted prior to refining, these carotenoids are thermally destroyed during the deodorisation stage in order to produce the desired colour for refined oil. In crude palm oil, the presence of these carotenoids appears to offer some oxidative protection to the oil through a mechanism where they are oxidized prior to the triglycerides.

Crude palm oil contains tocopherols and tocotrienols in the range of 600-1000ppm. Refined palm oil retains about 50% of these products. Tocophenols and tocotrienols are antioxidants and provide some natural oxidative protection to the oil.

In terms of sterols, palm oil contains far less cholesterol than many vegetable oils, usually in the range of 13 – 18 ppm. The low cholesterol levels in crude palm oil and palm olein are further reduced to even lower levels upon refining. This low cholesterol level together with the antithrombotic and anticarcinogenic properties of some of the carotenoids, tocophenols and tocotrienols present add further to the nutritive value of palm oil and palm oil fractions.

Table 2.4 summarises the inherent chemical properties of Malaysia palm oil.

Table 2.4: Inherent Chemical Properties of Malaysian Palm Oil.

Chemical Characteristics	Mean	Range
Saponification value (MgKOH/g Oil	195.7	190.1-201.7
Unsaponifiable matter (%)	0.51	0.15 – 0.99
Iodine value (Wijs)	52.9	50.6 – 55.1
Slip melting point (^{o}C)	34.2	30.8 – 37.6

Source: Hui, 1996.

2.2.2.2 Physical Properties of Palm Oil

Apparent density is an important parameter from the commercial point of view since it is used for volume to weight conversions. It can also be used as a purity indicator.

The solid fat content (in percent) of oil is a measure of the amount of solid fat present in the oil at any one temperature. It is measured by means of wide-line nuclear magnetic resonance (NMR) spectrometry after a standard tempering procedure for the samples.

The solid present in the oil at any one temperature is due to the process of crystallisation occurring in the oil as a consequence of its chemical properties. The different molecular triglyceride structures with their differing chemical characteristics manifests their physical states at different temperatures, thus imparting certain crystallisation and melting behaviour to the oil. These thermally associated processes can be followed by means of differential scanning calorimetry (DSC).

Considering thermal characteristics, it can be seen that palm oil can be separated under controlled thermal conditions into two components, i.e. a solid (stearin) and a liquid (olein) fractions. This fractionation process can be effected either in the dry form in the presence of a detergent or solvent. The method employed to a certain extent, determines some of the chemical and physical properties of the oleins and stearins produced, especially the stearins. By varying the fractionation methods and conditions used, a range of stearins with differing chemical and physical properties could be produced, yet keeping the chemical and physical properties of the oleins to within a very narrow range of values.

Under normal fractionation conditions, soft stearins and oleins with cloud points in the range of 8 to 10°C are produced. Where required, fractionation conditions could be specifically altered to produce stearin or olein of a desired specification for specialised application, but within the domain of the composition of palm oil. For example, stearins of differing Iodine Values (IV) ranging from the hard (IV of about 20) to soft (IV of about 50) could be produced. For more specialised usage such as in the confectionary industry, a more desired specific type of stearin is required or desired, a double fractionation process is used.

2.2.3 Palm Oil Trade

Although many countries are involved in the production of palm oil, only a few are net exporters of the commodity. The net exporting countries are those where the oil palm can grow well to make it viable to produce the oil for export. Malaysia and Indonesia are the major net exporters of palm oil, accounting for more than 90% of the total exports of palm oil, while other exporters have only a small share, each accounting for not more than 3% of the total export (Hui, 1996).

Crude palm oil used to be the main form of export in the past. With the establishment of refineries especially in Malaysia during the mid- 1970s and 1980s, refined palm oil products have replaced the crude as the main form of palm oil export. A wide range of processed or semi processed products are exported, and these include the different fractions of processed palm oil known as palm olein (liquid) and palm stearin (solid). The availability of refineries also lead to the production of specialty fats products aimed at the confectionary markets.

Most major buyers of palm oil products use the NIOP or FOSFA contracts to secure their palm oil supplies. Other major buyers such as India, Pakistan and China have their own trading specifications. Palm oil prices are quoted in the terminal markets such as Rotterdam, New York, and Kuala Lumpur. There is a future market for palm oil in Kuala Lumpur, and it is actively used as the reference point for price determination. A network of brokers and dealers are involved in facilitating trade in palm oil products. In addition, some major multinational buyers have established their buying offices in the producing countries (Hui,1996). Sellers also participate in responding to tenders called by a number of importing countries for the supply of palm oil. In this way, palm oil has been exported through many different channels and mechanisms to suit consumer needs.

Trade is facilitated by the existence of bulking installations at the major ports of loading for the export of the palm oil products. Codes of practice for handling and shipment of palm oil have been formulated by the international trade association to ensure that the quality of the oil is protected. For example, the trading contracts such as FOSFA and NIOP stipulate that the previous cargoes of the ship carrying palm oil must not be any from the list of banned substances. Efforts are made to continuously upgrade the quality of palm oil products through improvements in standards, and these are discussed at international forums such as Codex Alimentarius meetings. Many mills and refineries are also adopting the ISO 9000 to provide quality assurance for the products that they export.

The major importers of palm oil used to be the developed countries of the

European Economic Community (EEC), the United States, and Japan. They accounted for about 75% of the imports of palm oil in the early 1970s. With the increasing exports of refined palm oil products, many developing countries, which did not have refining capacities, were able to export processed palm oil for direct consumption with minimal or no further refining. This helped to expand the market for palm oil in the developing countries. By the end of 1980s, the developing countries had become the major consumers of palm oil accounting for 75% of the import trade (Hui,1996). While the import share of palm oil by the developed countries had decline to about 25% the actual volume consumed by them has continued to expand. This reflects the competitiveness of palm oil for all types of end uses both in the developed and developing countries.

Many countries are facing chronic shortages of oils and fats due to shortfall in the domestic production in the face of increasing population and income (Hui, 1996). For these countries, the relative availability of palm oil provides a convenient source of supply. Because of the rapidly expanding supply of palm oil, its price has been very competitive. For the last 30 years, palm oil has been selling at a discount compared to the other major oils in the world market, but prices of palm oil are highly correlated with those of the other oils. This suggests that the market acknowledges the high degree of substitutability of other oils and fats by palm oil.

The versatility of palm oil in terms of its presentation of various sub products and the wide range of technical properties increase the competitiveness of palm oil to the consumers. Palm oil has become the major oil among the imported oils in most countries. Even countries that are net exporters of oils and fats, such as the United States, are importing palm oil in substantial quantities. For these countries palm oil can provide certain technical advantages in some end uses, and palm oil usage gives better margins of profits compared to the use of locally available oils and fats. (Hui, 1996).

2.3 CRUDE PALM OIL PROCESSING AND FRACTIONATION.

2.3.1 The Quality of Crude Palm Oil.

The quality of crude palm oil is determined by the levels of impurities in the oil. These fall into two groups according to their effect on the oil:

1. Hydrolytic, e.g. moisture, insoluble impurities, free fatty acids, partial glycerides, enzymes.
2. Oxidative, e.g. oxidative products, trace metals, and pigments.

Phosphatids are emulsifiers and so hinder the separation of oil and water phases in the chemical refining process. If they are not removed prior to physical refining they char at high temperatures employed, giving the oil brown colour. The phosphatids are broadly separated into hydratable and non-hydratable types. As the name implies, hydratable phosphatids can be removed by treatment with water, while the non-hydratable compounds which are salts or co-ordination compounds of calcium and magnesium primarily with phosphatidic acid, can only be rendered insoluble in the oil by use of chemical reagents, the most commonly used being phosphoric acid (H_3PO_4). Carbohydrates, pectins and glucosides increase the viscosity of the oil with a consequent detrimental effect on refining and fractionation efficiency (Hui, 1996).

As far as the quality of the crude oil is concerned, the oil palm fruit mesocarp contains important enzyme system: the lipases responsible for hydrolytic splitting of the triglycerides, the lipoxygenase enzymes which catalyses oxidation of the fatty acid chains, and the phosphorylases which cause increase in the phosphatide level.

Palm oil is extracted by a process, which involves considerable contact of the oil with water at temperatures around 90°C. Although part of the plant is constructed from stainless steel, the greater part is of mild steel, so the risk of iron contamination and copper in any form should be prevented. The carotene content is included because it is a good indicator of the bleachability of the oil. Low levels of carotene suggest that the oil will be difficult to bleach because of the formation of coloured condensation products (Young, 1987).

2.3.2 Physical and Chemical Refining

Crude palm oil extracted commercially from the fresh fruit bunches contains a small but variable amount of undesirable components and impurities. These include some mesocarp fibres, moisture and insolubles, free fatty acids, phospholipids, trace metals, oxidation products, and odoriferous substances. As a result palm oil is normally refined to a bland, stable product before it is used for direct consumption or for formulation of edible product. In Africa, however, crude palm oil is often consumed in the crude form (Hui, 1996).

Two methods namely physical refining and chemical refining are available for refining crude palm oil. They differ basically in the manner in which the free fatty acids are removed. Physical refining has become the major processing route because of its cost effectiveness, efficiency, and simple effluent treatment (Swoboda, 1985). Both processes are able to produce refined, bleached and deodorised (RBD) palm oil of desirable quality and stability suitable for edible purposes (Kheiri, 1985).

2.3.2.1 Physical Refining

Physical refining was introduced to palm oil processing in 1973 (Young, 1981). Its unique feature is that the deacidification, deodorisation and thermal decomposition of carotenoids are accomplished in one process in a stainless steel deodoriser. It is continuous processing consisting of a two-step operation of pretreatment followed by a steam distillation (Howes *et al*, 1993).

Pretreament.

Pretreatment refers to the initial degumming of crude palm oil with concentrated phosphoric acid and subsequent adsorptive cleansing with bleaching clay. Crude palm oil is dosed with phosphoric acid (80-85% concentration) at a rate 0.05-0.2% (of the feed oil), heated to 90 ° -110°C, and given a residence time of 15 –30 minutes before passing to the bleacher where bleaching earth is added as slurry. The earth required ranges from 0.8 to 2.0%, depending on the quality of the crude palm oil.

The purpose of the phosphoric acid is to precipitate the non-hydratable phosphatids while the functions of the earth are four-fold (Young, 1981):

1. to adsorb the undesirable impurities such as trace metals, moisture and insolubles and part of the carotenoids and other pigments,
2. to reduce the oxidation products,
3. to adsorb the phospholipids precipitated by the phosphoric acid, and
4. to remove any excess phosphoric acid present in the oil after degumming. The final residual colour of the pretreated oil alone is unimportant as the role of the bleaching earth is not so much to remove the colour but more critically in its ability to act as an adsorptive cleansing agent (Wilhems, 1985). Complete removal of residual phosphoric acid in the bleaching stage is also critical as any "slip through" can result in rapid rise of free fatty acid content and colour of the RBD oil (Swoboda, 1985; Howes *et al*, 1993; Hui, 1996). As a further assurance a suitable quantity of calcium carbonate is often added after dosing of the bleaching earth to the degummed oil, to help neutralise the residual

phosphoric acid (Jacobsberg, 1983). The principal stages in the refining of crude palm oil are shown in Table 2.5.

Table 2.5: Principal Stages in the Refining of Crude palm oil.

Stage	Principal Impurities Reduced or Removed
Degumming	Phospholipids, trace metals, pigments.
Neutralisation	Fatty acids, phospholipids, pigments, oil insolubles, water solubles.
Washing	Soap.
Drying	Water.
Bleaching	Pigments, oxidation products, trace metals, traces of soap.
Filtration	Spent bleaching earth.
Deodorisation	Fatty acids mono- and diglycerides, oxidation products, pigment decomposition products.
Physical Refining	Fatty acids, mono-, and diglycerids, oxidation products, pigment decomposition products.
Polishing	Removal of trace oil insolubles.

Bleaching is carried out under a vacuum of 20 – 25 mmHg and at a temperature of 95 – 110°C with retention time of 30 – 45 min (Lim, 1984). The slurry containing the oil is then filtered to recover clear, light orange coloured pre-treated oil. Usually a small amount of diatomaceous earth is used to precoat the filter leaves to improve the filtration process. As a quality precaution, the filtered oil is polished through another security filter bag in series, to trap any earth particles that escape through the first filter. This is essential as the presence of spent earth particles in the pretreated oil reduces the oxidative stability of the final RBD oil (Jacobsberg, 1983). The spent earth from the filter normally contains about 20 – 40% oil, and this is the major source of oil loss in the refining process.

The pretreatment process can be carried out in batch, semi continuous, or continuous equipment, and the filters used are either plate and frame presses or vertical or horizontal pressure filters with vertical stainless steel filter screens.

Deodorisation.

The pretreated oil is then ready for deacidification and deodorization. It is first deaerated, followed by heating to 240° – 270°C in an external heat exchanger before pumping into the deodoriser, which is kept under a vacuum of 2 – 5 mmHg. Traditionally thermal fluids are commonly used as the heating medium. However, to eliminate the risk of possible contamination of refined oil with thermal fluids, a superheated high-pressure steam is now commonly being used, especially in new plants.

Temperatures above 270°C are to be avoided to minimize loss of neutral oil, tocopherols/tocotrienols, and also the possibility of isomerisation and undesirable thermo chemical reactions (Lim et al, 1984).

Under such reactions and with the help of stripping steam, the free fatty acids, which were still present in the pretreated oil, are distilled together with the more volatile odoriferous and oxidative products such as aldehydes and ketones, which otherwise, would impart undesirable odour and taste to the oil. At the same time the residual carotenoids present are thermally decomposed, and the end result is the production of a light coloured, bland RBD oil. To maximise the recovery of thermal energy, the hot deodorised oil is heat exchanged against incoming pretreated oil to be cooled down to a temperature of 120 –150°. Further cooling is effected by water down to 55 –60° C prior to storage. Antioxidant and citric acid, if required, are dosed into the RBD oil at this stage.

2.3.2.2 Chemical Refining

Also called caustic refining, chemical refining involves three stages namely gum conditioning and neutralization, bleaching and filtration, and deodorization.

Gum conditioning and neutralization.

Crude palm oil is heated to a temperature of 80-90°C. Phosphoric acid of 80 – 85% concentration is then dosed in at a rate of 0.05-0.2% (of feed oil). This serves to precipitate the phospholipids. After this, the degummed oil is further treated with caustic soda solution of about 4N (or 2Bé) concentration with calculated excess (based on free acid content of the crude oil of about 20%). The reaction between caustic soda and the free fatty acids in the degummed oil results in the formation of sodium soap, which is readily removed by a cenrtifugal separator. The lighter phase discharged consists mainly of neutralised oil containing 500 – 1000mg/Kg of soap and moisture while the heavy phase is mainly soap, insoluble impurities, gums and phosphatids, excess alkali, and a small quantity of oil loss through emulsification. As an excess of alkali is used, it is unavoidable that a slight loss of neutral oil through saponification also occurs.

The neutralised palm oil is then washed with 10-20% hot water to remove traces of soap still present. After another stage of centrifugal separation, the washed oil is then dried under vacuum to a moisture level below 0.05% (Hui, 1996).

Bleaching and Filtration

The neutralised palm oil is treated with bleaching earth in a similar manner, as that described in physical refining. However, in this case, the earth also removes traces of soap that are present.

Deodorisation

The neutralised and bleached oil is then channeled to the deodoriser in a similar manner to that in physical refining. This is subjected to distillation at a temperature of 240 –260°C and a vacuum of 2-5mmHg with direct steam injection. Under such conditions, residual free fatty acids, volatile oxidation products, and odoriferous materials are removed together with thermal decomposition of carotenoids. The final product, called neutralised, bleached and deodorised palm oil is then cooled down to 60° C and passed through polishing filter bags before pumping to the storage tanks.

2.3.3 Fractionation

2.3.3.1 General considerations

Oils and fats are mixtures of triglycerides, which because of their different fatty acid compositions, have melting points spanning the range from below –30°C to above +70°C, each having its own melting range. The melting range, which is measured by determining the solid fat content, limits the use of a particular oil or fat. Fractionation is thermo mechanical process by which the raw material is separated into two or more portions, which widens its use. Thermo mechanical separation processes include distillation and crystallisation. Distillation is commercially unsuitable for the fractionation of triglyceride mixtures because of their low vapour pressures and because of their relatively low stability at high temperatures. Separation can however be effected by crystallisation.

The triglyceride composition of palm oil includes substantial quantities of both low and high melting points triglycerides. The oil therefore lends itself to crystallisation by controlled cooling followed by separation to yield a liquid (olein) and a solid (stearin) phase.

The aim of single fractionation of palm oil is to produce an olein, which can be used as a partial replacement for liquid vegetable oils such as soybean oil. The stearin from this fractionation is used in margarine, shortening and frying fat production. If a double fractionation is carried out in which, for example, the olein from a first stage is recrystallised at a lower temperature, a second stearin and olein are obtained. The second stearin is known as palm mid-fraction. The temperature of the second stages of the process can be so chosen that the palm mid-fraction is enriched in the semi triglycerides which are important in the production of cocoa butter equivalents. The importance of fractionation in palm oil processing can be seen in that over 2 million tons of the oil were fractionated in 1983 out of a total world production of 6.4 million (FAO/WHO, 1993).

Edible oils and fats are polymorphic in their crystalline behaviour. When considering the crystallisation of palm oil, three forms are of importance,α, β`, β, which are of increasing stability in that order. The rate of crystallisation of the α form is greater than that of the β polymorph. If super cooling is carried out too rapidly, crystallisation of the α form occurs resulting in a mass of very small crystal. To obtain good separation of palm oil fractions, crystallisation is required in the β` crystals agglomerate into large aggregates that are firm and of uniform spherical size and give good filtration.

Crystallisation is affected by the non-triglycerides components of edible oils. Free fatty acids form eutectic mixtures with the triglycerides causing a softening of the consistency of the fat (Hui, 1996).

This feature is indicated by the solid content of palm olein after physical refining when the original palm oil is fractionated in the crude state.

As stated earlier, the monoglyceride content of palm oil is normally less than one percent. At this level, monoglycerides have a noticeable effect on crystallisation or separation, but Kolowski (1975) reported inhibition of crystallisation when working with an oil of 90% free fatty acid and 5.5% monoglyceride. Diglycerides, on the other hand, are or can be present in sufficient quantities in commercial oils to affect crystallisation. Their effect is caused by the formation of eutetic mixtures and by slowing down the transformation of α, to β\` form. This latter effect causes difficulties with filtration possible due to differences in size and shape of the crystals obtained (Hui, 1996).

Other impurities such as phosphatides, sugar and soap inhibit the process either by increasing the viscosity of the olein phase or making the crystal agglomerate slowly (Gunstone, 1987).

2.3.3.2 Process Description

There are three commercial methods for fractionating palm oil: dry, detergent, and solvent process.

2.3.3.2.1 Dry Fractionation

This is usually carried out semi continuously using neutralised, neutralised and bleached, or fully refined palm oil. It does not require the use of any chemicals or additives. The oil is kept homogenised at about 70°C to destroy any presence of crystal in order to induce crystallisation in a controlled manner during subsequent cooling. Crystal formation and growth occur as the oil is agitated and cooled using chilled-water circulation. The cooling program is controlled by setting the temperature differential between the oil and chilled-water, and also the time of cooling. When the temperature reaches the desired temperature, which is dependent on the quality of olein required (but usually about 20°C), the cooling is stopped and the thick partially crystallised mass is ready for filtration. The different filtration systems now used in the industry are drum, rotary filter and membrane filter, which actually is a filter press equipped with a membrane plate, is increasing used because it gives a higher yield of olein (about 70-75%) and a harder stearin compared to that of about 65% obtained from Florentine or rotary drum filters (Wong *et al*, 1993).

2.3.3.2.2 Solvent Fractionation.

This process is the most expensive because of solvent loss, solvent recovery equipment, much lower temperature requirement, and stringent safety features. The process involves the use of solvents such as hexane or acetone. The oil is first dissolved in the solvent followed by cooling to obtain the desired crystals. Cooling is affected by brine if very low temperature is required. The miscella containing the partially crystallised oil and solvent is then filtered under vacuum suction in an enclosed drum filter. The Olein miscella and the stearin miscella are then separately distilled to remove the solvent and recover the fractions. Yield of Olein is about 80%. The solvent process nowadays is only viable in the production of high value products such as cocoa butter equivalent or other specialty fats (Hui, 1996)

2.3.3.2.3 Double Fractionation.

Double fractionation is carried out for the production of palm olein with higher iodine value of about 60 or for the production of palm mid-fraction, which contains a high proportion of oleodipalmitin used for the production of palm based coca butter equivalent (Hui, 1996). Usually the first Olein obtained is recycled to the plant for further cooling, crystallisation and filtration. The second Stearin obtained is called palm mid-fraction. Special and skilful control of the crystallisation of both stages is critical in achieving the desired quality of the products.

2.4 DESIGN OF PALM OIL REFINERY AND FRACTIONATION PLANT

Unlike consumer goods and appliances which are bought directly and employed immediately, process equipment for the Palm Oil Refinery and Fractionation Plant must be custom designed or at least identified to some extent by a professional and installed by specialists. Therefore, the total plant cost which is a summation of the costs of the various unit equipment depends to a large extent on the design specifications of the various units, which make up the plant.

These specifications invariably involve the equipment capacities in terms of volume, materials of construction, which must resist corrosion if the substances to be handled are corrosive; pressures and temperatures for storage tanks; surface areas, volume, residence time, flow rates for reactors; filters and crystallizers, etc. Since the detailed design of the Palm Oil Refinery and Fractionation Plant is beyond the scope of this study, only the most pertinent design specifications like the surface areas and volumes of the various process equipment that shall be directly used in the cost estimation equations shall be stated here. Schematic diagrams of the major process equipment units of the Palm Oil Refinery and the Fractionation Plant are shown in Figures 2.4 and 2.5.

LEGEND

1	Crude Palm oil
2	Phosphoric acid
3	Calcium carbonate
4	Spent bleaching Earth
5	Unfiltered oil, water and bleaching Earth.
6	Condensate
503	Calcium carbonate tank
505	Mixing tank
534	Phosphoric Acid tank
504	Drier
535A	Bleaching Earth tank
622	Continuous bleaching

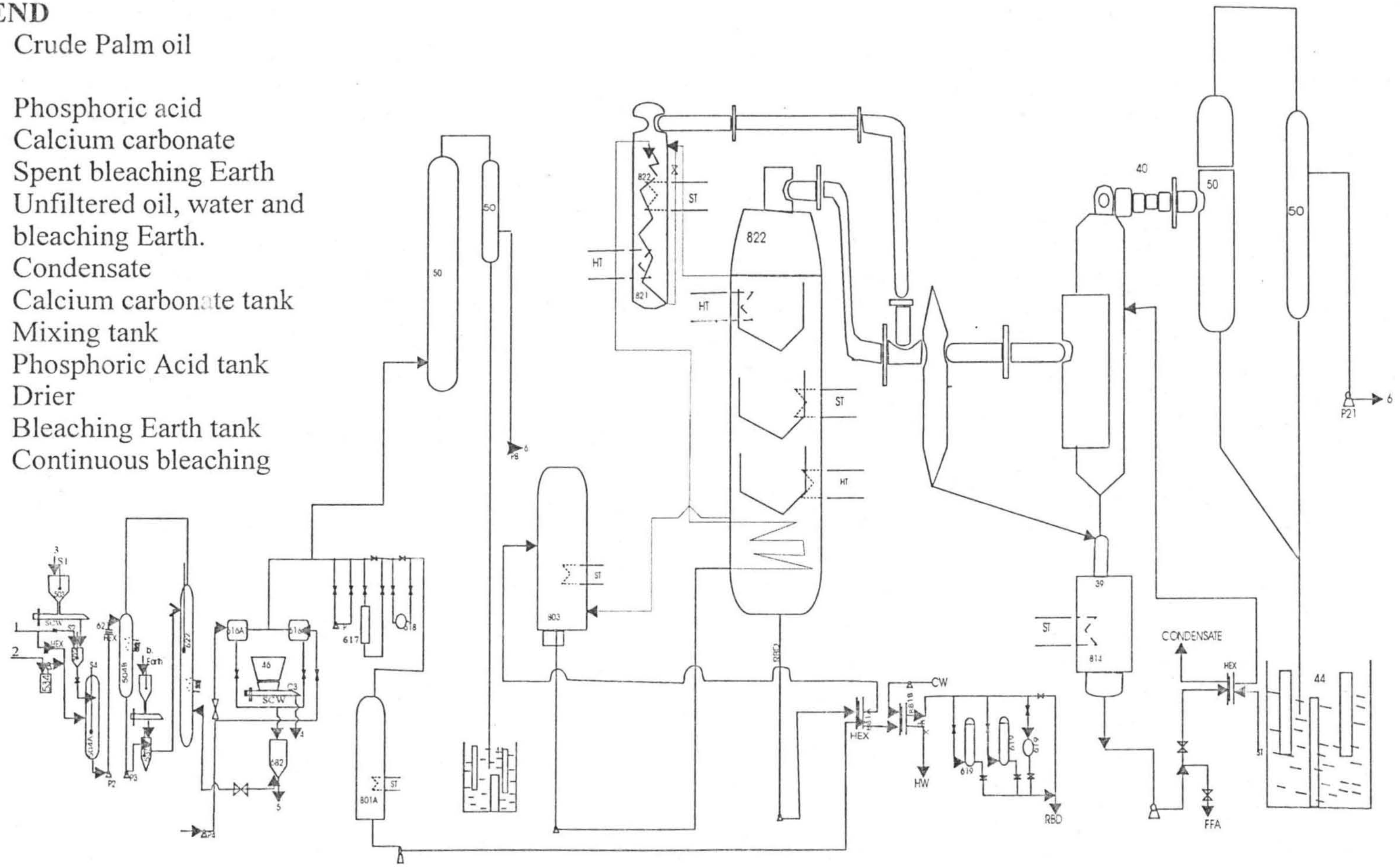


Fig. 2.4: SCHEMATIC DIAGRAM OF THE UNITS OF THE CRUDE PALM OIL REFINERY

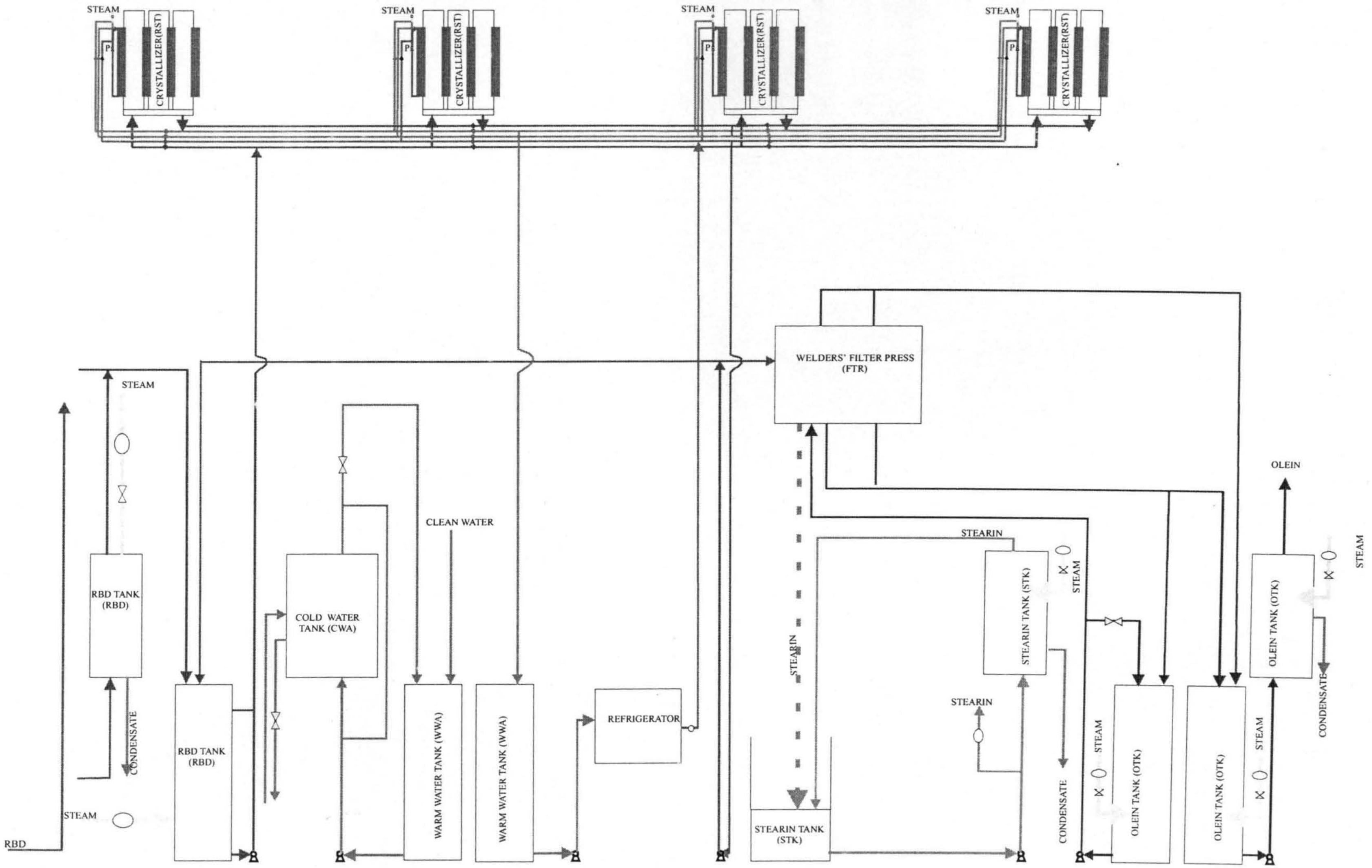


FIG. 2.5: SCHEMATIC DIAGRAM OF THE UNITS OF THE REFINED, BLEACHED AND DEODORIZED PALM OIL FRACTIONATION PLANT

2.4.1 Units of the Palm Oil Refinery

A summary of the most pertinent design specifications of the units of the refinery to be used in the cost estimation equations is given in Table 2.6.

Table 2.6: Summary of Design Specifications of the Palm Oil Refinery.

Piece of Equipment	Historical Design Specifications	Current Design specifications
Calcium Carbonate tank (503)	$2m^3$	$4m^3$
Mixing tank (505)	$2\ m^3$	$5\ m^3$
Phosphoric acid tank (534)	$2.5\ m^3$	$5\ m^3$
Drier (504)	$3\ m^3$	$6\ m^3$
Bleaching Earth tank (535)	$3\ m^3$	$6\ m^3$
Continuous bleaching Reactor (622)	$3\ m^3$	$6\ m^3$
Bernardinni filter (616)	$15\ m^2$	$30\ m^2$
Steel super filter (617)	$0.02\ m^3$	$0.04\ m^3$
Guard filter I (618)	$2.5\ m^3$	$5\ m^3$
Decanter (682)	$3\ m^3$	$6\ m^3$
Storage tank (801)	$2.5\ m^3$	$5\ m^3$
Deaerateor/Drier (803)	$2.5\ m^3$	$5\ m^3$
Deodorizer (822)	$3\ m^3$	$6\ m^3$
FFA Recuperator (814)	$2.5\ m^3$	$5\ m^3$
Preheating tank (821)	$3\ m^3$	$6\ m^3$
Vacuum system (50)	$0.4\ m^3$	$0.8\ m^3$
Screw worm (SCW)	10m	20m
Pump (PUM)	$9.5x10^{-3}\ m^3/s$	$19.5x10^{-3}\ m^3/s$
Tube and shell heat exchanger (HEX)	$14\ m^2$	$28\ m^2$
Guard Filter II (619)	$0.0335\ m^3$	$0.067\ m^3$

2.4.2 Units of the Fractionation Plant

A summary of the most pertinent design specifications of the units of the into account all factors, such as special technological advancement, or local conditions. The common index permits fairly accurate estimates if the time period involved is less than 10 years.

Many different types of cost Indices are published regularly. The most common of these Indices which can be used for estimating equipment costs are the Marshall and Swift Equipment Cost Index, and the Chemical Engineering Plant Cost Index. For the purpose of this work, the latter shall be used.

2.5.1 Chemical Engineering Plant Cost Index

Construction cost for chemical engineering plants form the basis of the Chemical Engineering Plant Cost Index. The four major components of this index are weighted by percentage in the following manner: equipment, machinery, and supports, 61; erection and installation labour, 22; buildings, materials, and labour, 7; and engineering and supervision, 10. The major component, equipment, is further subdivided and weighted as follows:

Fabricated equipment, 37; process machinery, 14; pipes, valves and fillings, 20; process instruments and control, 7; pumps and compressors, 7; electrical equipment and materials, 5; structural supports, paints, and instrumentation, 10. All index components are based on 1957-1959 = 100 (Peters and Timmerhaus, 1991).

CHAPTER THREE

METHODOLOGY

3.1 COSTING

It is an economic fact that the purchasing power of the monetary unit, no matter what the currency is, erodes and depreciates with time, and there is little if any reason, to suggest that this trend will change in the future. This depreciation in the value of money is termed inflation. Inflation is the rise in price level or a fall in the purchasing power, or the rate of increase in some national price level (Popper and Weismantel, 1970). The official rate of inflation is based on a specified mixture of goods required to maintain the standard of living of the average citizen. The annual rate of increase in cash outlay required to purchase this basket of goods is the official rate of inflation.

Due to inflation and other factors, the economic environment in which a chemical plant (e.g. the Palm Oil Refinery and fractionation plant) operates is a dynamic and not static one, and it undergoes continuous change. During the life of the plant, the demand for its products will change, as will the factors that determine its profitability, e.g. labour, raw materials, and utilities. The overall cost of establishing such a plant will equally change upwards, as the years slowly go by. One of the most important factors contributing to the changes above is inflation, which will also seriously affect the cost of equipment.

3.2 DEVELOPMENT OF COST EQUATIONS

3.2.1. Equipment Cost Estimation

Basically, three different methods of estimation of equipment costs of the Palm Oil Refinery and Fractionation Plant, have been used, namely the method of Cost Index, the Six-Tenth-Factor Rule Method, and method of Cost Index and Scaling.

3.2.1.1 The Method of Cost Index.

If the cost of each piece of equipment at sometime in the past is known, then the equivalent cost at the present time can be determined by multiplying the original or historical cost by the ratio of the present index value to the historical index value applicable when the historical cost was obtained (See Table 1.2 for cost data).

Let historical cost (original) cost of each equipment be HC, say; the historical cost index be HI; the current cost index be CI, and the current cost of the equipment be CC.

Therefore, the current cost of any equipment was given by the following equation:

$$CC = HC\ (CI/HI) \qquad \text{.................................3.1}$$

3.2.1.2 Six -Tenths Factor Rule Method

It is often necessary to estimate the cost of a piece of equipment when no cost data are available for the particular size of operational capacity in question. Good results can be obtained by using the logarithmic relation known as the six-tenth–factor rule; if the desired piece of equipment is similar to one of a different capacity for which the cost data are available. According to this rule, if the cost of a given equipment at one capacity is known, the cost of a desired similar unit with X times the capacity of the first equipment is approximately $(X)^{0.6}$ times the cost of the original equipment. (See Table 1.2 for the cost data).

Let HCB - historical cost of equipment B (desired)

HCA - historical cost of equipment A

QA - known capacity of equipment A

QB - capacity of equipment B

system can be extrapolated from the delivered cost of the major items of processing equipment (Rudd and Watson, 1968).

It has been observed that the cost of the other essential items needed to complete the process system can be correlated with the investment cost in major items of equipment, and the capital investment can be estimated by the application of experience factors to the base investment or delivered purchased equipment cost (Rudd and Watson, 1968).

Thus, the factored estimate equation below results. The experience factors f are obtained from a study of many similar processing systems. Values for the direct and indirect factors are given in Table 1.3

$$\text{FCAPN} = \left[PECT + \left(\Sigma f_i PEECT\right)\right] f_I \quad \text{...3.8}$$

Where $f_I = \left(1 + \Sigma f_i\right)$

3.2.4 Computation of the Total and Working Capital Investments.

Total capital investment consists of fixed capital and working capital investments.

The fixed-capital investment was taken as eighty five percent of the total capital investment, while the remaining fifteen percent became the working capital investment.

Thus, the total capital investment given by;

$$\text{TCAPN} = \text{FCAPN}/0.85 \quad \text{...3.9}$$

And, the working capital investment was given by:

$$\text{WCAPN} = 0.15*\text{TCAPN} \quad \text{...3.10}$$

3.3 DEVELOPMENT OF COMPUTER COST MODULES

Three computer programs namely CINDEX, CISCAL, and SIX10R were written in Waterloo FORTRAN, a dialect of FORTRAN 77. Each of the three programs was based on one of the three cost estimation methods discussed in Section 3.2. Each program computed the current cost of each major process equipment, the delivered purchased equipment cost, the fixed, working and total capital investments in Naira, of the Palm Oil Refinery and Fractionation Plant as at 2002.

3.3.1 Program CINDEX

This program represented the method of Cost Index. It is modular in nature and consists of thirty-one subroutines, each assigned a particular task.

The first subroutine called BEGIN read, validated, and printed the reference year for cost indices and opened an output file (CINDEX.RES) to store the results.

Each of the following twenty-seven subroutines computed the current cost of each of the twenty-seven major process equipment by means of Equation 3.1.

The twenty-ninth subroutine computed the delivered purchased equipment cost making use Equation 3.7.

The last-but-one subroutine computed the fixed capital investment using Equation 3.8.

Finally, the last subroutine computed the total and working capital investments by means of Equation 3.8 and Equation 3.9 respectively. The details are shown in the program flow chart in Fig. 3.1 and source code in Appendix A1.

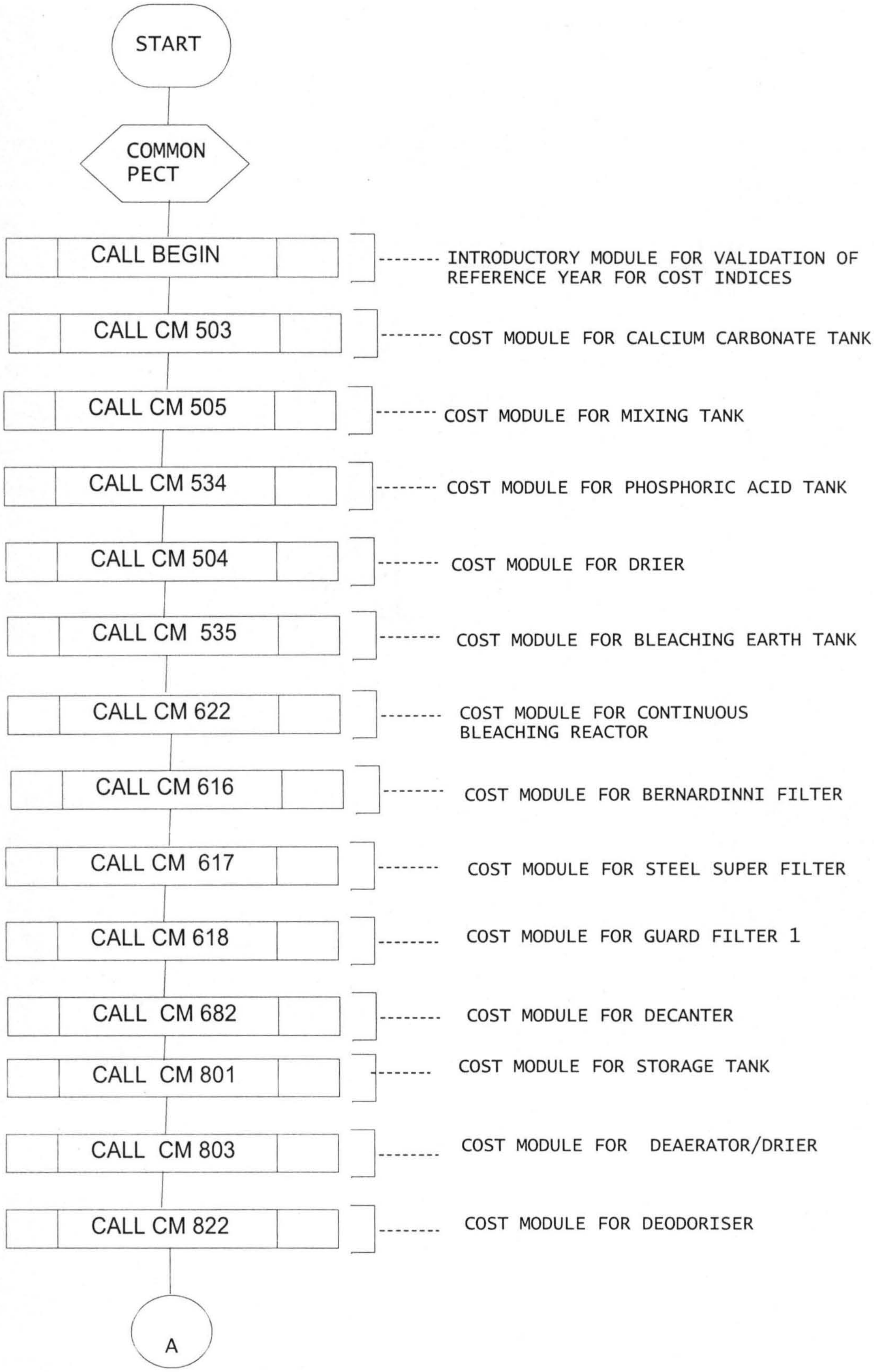
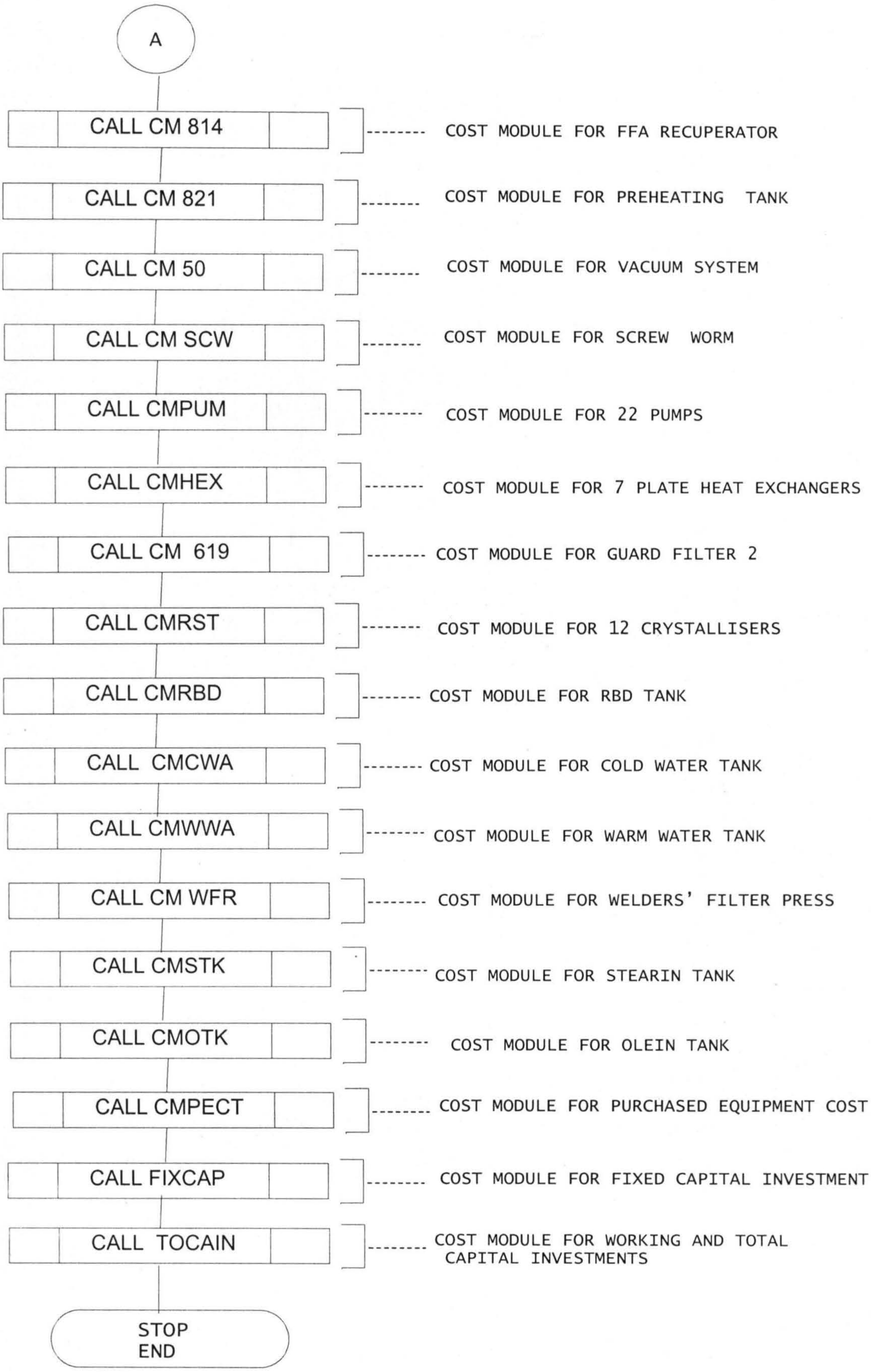


FIGURE 3.1: FLOW CHART FOR PROGRAM CINDEX (CINDEX MAIN MODULE)


A
CALL CM 814
COST MODULE FOR FFA RECUPERATOR
CALL CM 821
COST MODULE FOR PREHEATING TANK
CALL CM 50
COST MODULE FOR VACUUM SYSTEM
CALL CM SCW
COST MODULE FOR SCREW WORM
CALL CMPUM
COST MODULE FOR 22 PUMPS
CALL CMHEX
COST MODULE FOR 7 PLATE HEAT EXCHANGERS
CALL CM 619
COST MODULE FOR GUARD FILTER 2
CALL CMRST
COST MODULE FOR 12 CRYSTALLISERS
CALL CMRBD
COST MODULE FOR RBD TANK
CALL CMCWA
COST MODULE FOR COLD WATER TANK
CALL CMWWA
COST MODULE FOR WARM WATER TANK
CALL CM WFR
COST MODULE FOR WELDERS' FILTER PRESS
CALL CMSTK
COST MODULE FOR STEARIN TANK
CALL CMOTK
COST MODULE FOR OLEIN TANK
CALL CMPECT
COST MODULE FOR PURCHASED EQUIPMENT COST
CALL FIXCAP
COST MODULE FOR FIXED CAPITAL INVESTMENT
CALL TOCAIN
COST MODULE FOR WORKING AND TOTAL CAPITAL INVESTMENTS
STOP
END

3.3.2 Program SIX10R

This program represented the six-tenths factor rule and scaling method. It is also modularized, consisting of thirty-one subroutines, each assigned a particular task.

The first subroutine named FIRST read, validated, and printed the reference year for cost indices and opened an output file (SIX10R.RES) to store the results.

The following twenty-seven subroutines, each calculated the cost of one particular major process equipment making use of Equation 3.5.

The working of the remaining part of this program is similar to that of CINDEX. Details are shown in the flow chart in Fig. 3.2 and in the source code in Appendix B1.

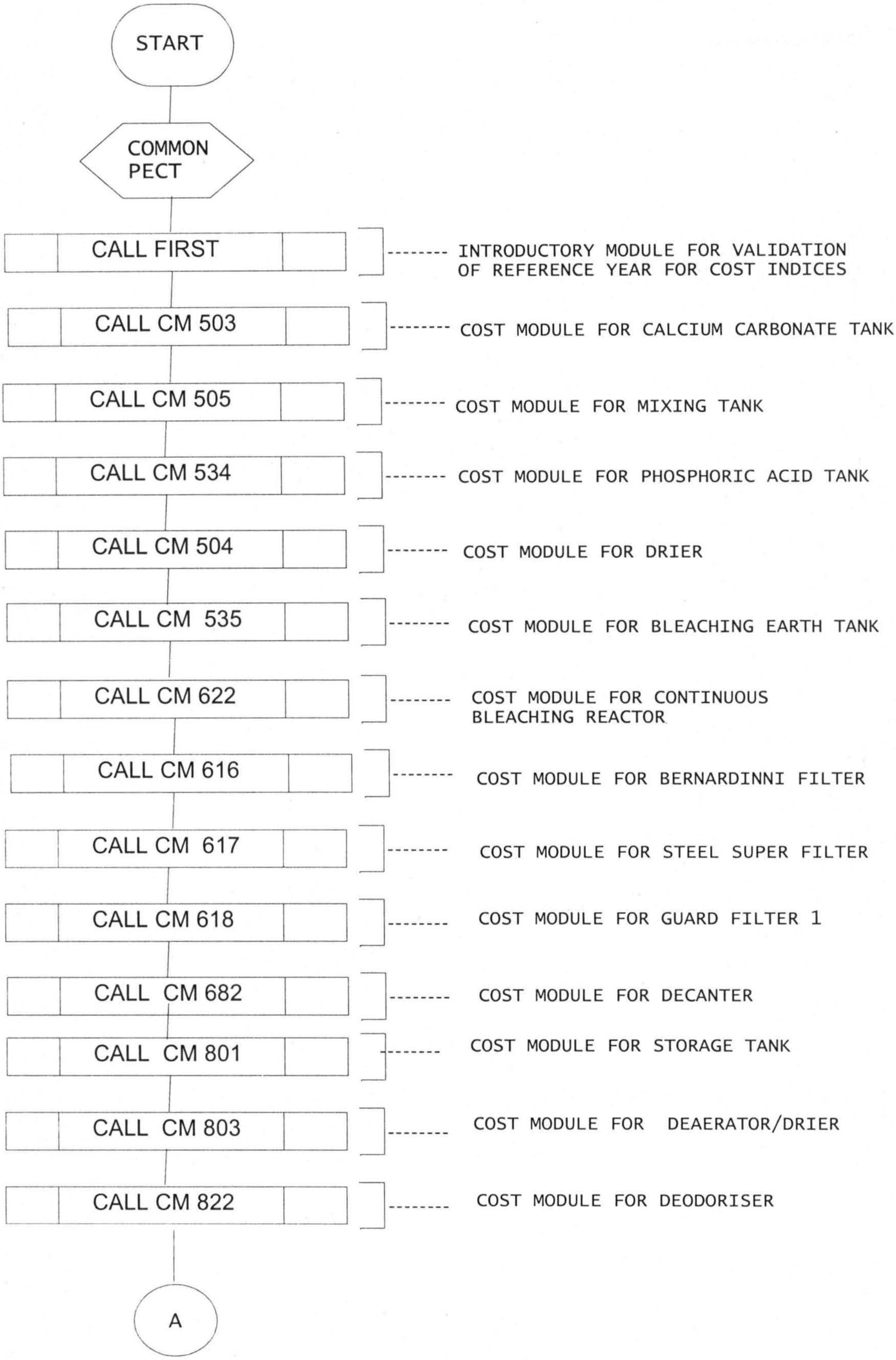
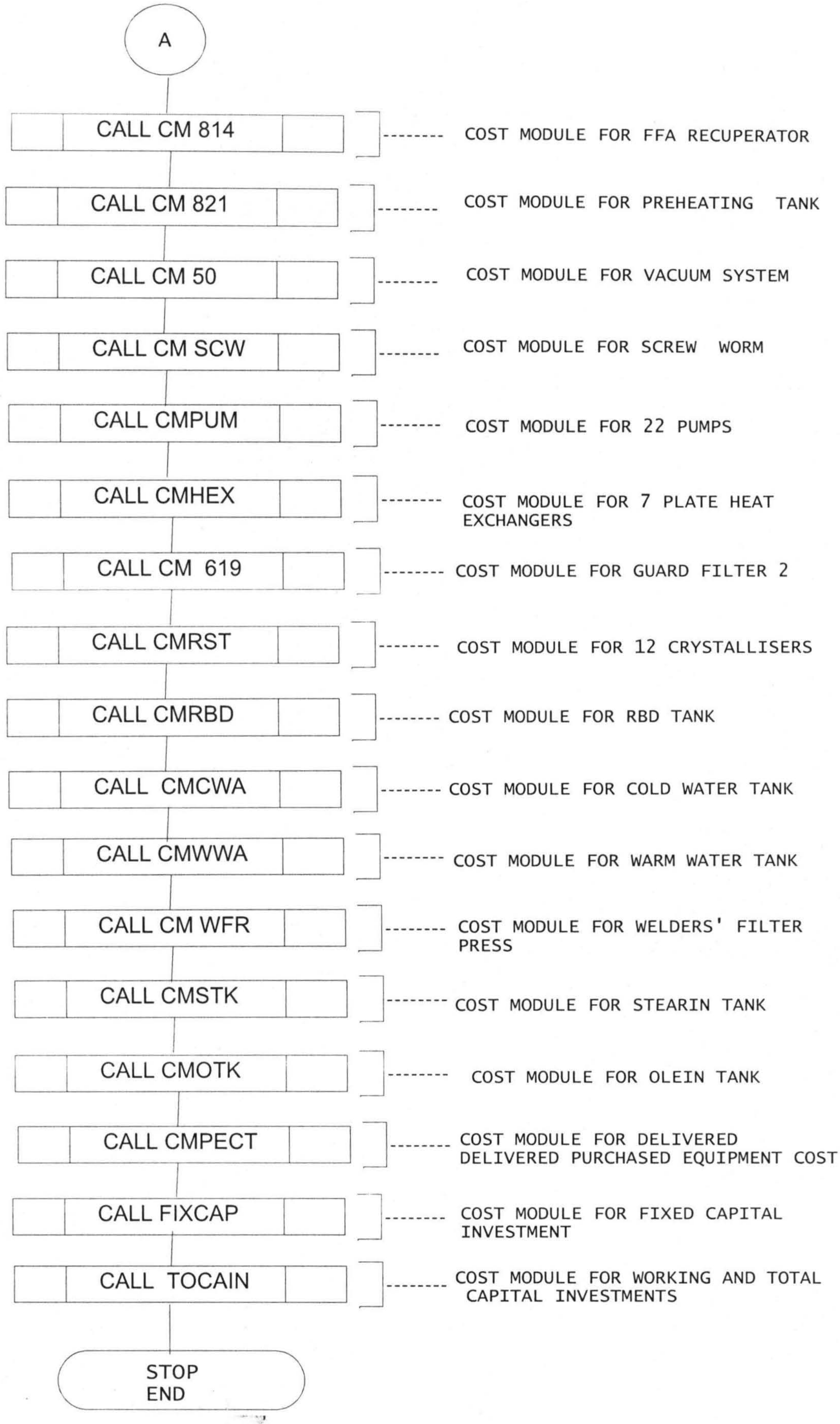


FIGURE 3.2: FLOWCHART FOR PROGRAM SIX10R (SIX10R MAIN MODULE)


A
CALL CM 814
COST MODULE FOR FFA RECUPERATOR
CALL CM 821
COST MODULE FOR PREHEATING TANK
CALL CM 50
COST MODULE FOR VACUUM SYSTEM
CALL CM SCW
COST MODULE FOR SCREW WORM
CALL CMPUM
COST MODULE FOR 22 PUMPS
CALL CMHEX
COST MODULE FOR 7 PLATE HEAT EXCHANGERS
CALL CM 619
COST MODULE FOR GUARD FILTER 2
CALL CMRST
COST MODULE FOR 12 CRYSTALLISERS
CALL CMRBD
COST MODULE FOR RBD TANK
CALL CMCWA
COST MODULE FOR COLD WATER TANK
CALL CMWWA
COST MODULE FOR WARM WATER TANK
CALL CM WFR
COST MODULE FOR WELDERS' FILTER PRESS
CALL CMSTK
COST MODULE FOR STEARIN TANK
CALL CMOTK
COST MODULE FOR OLEIN TANK
CALL CMPECT
COST MODULE FOR DELIVERED DELIVERED PURCHASED EQUIPMENT COST
CALL FIXCAP
COST MODULE FOR FIXED CAPITAL INVESTMENT
CALL TOCAIN
COST MODULE FOR WORKING AND TOTAL CAPITAL INVESTMENTS
STOP
END

3.3.3 Program CISCAL

This program represented the method of cost indices and scaling. It is equally modular in nature and consists of thirty-one subroutines, each handling a specialised task.

The first subroutine called START read, validated and printed the reference year for cost indices as well as opened the output file (CISCAL.RES) to store the results.

The following twenty-seven subroutines each computed the current cost of one particular major process equipment by means of Equation 3.6

The remaining part of this program worked in a similar way to CINDEX. Details are shown in the program flow chart in Fig. 3.3 and in the source code in Appendix C1.

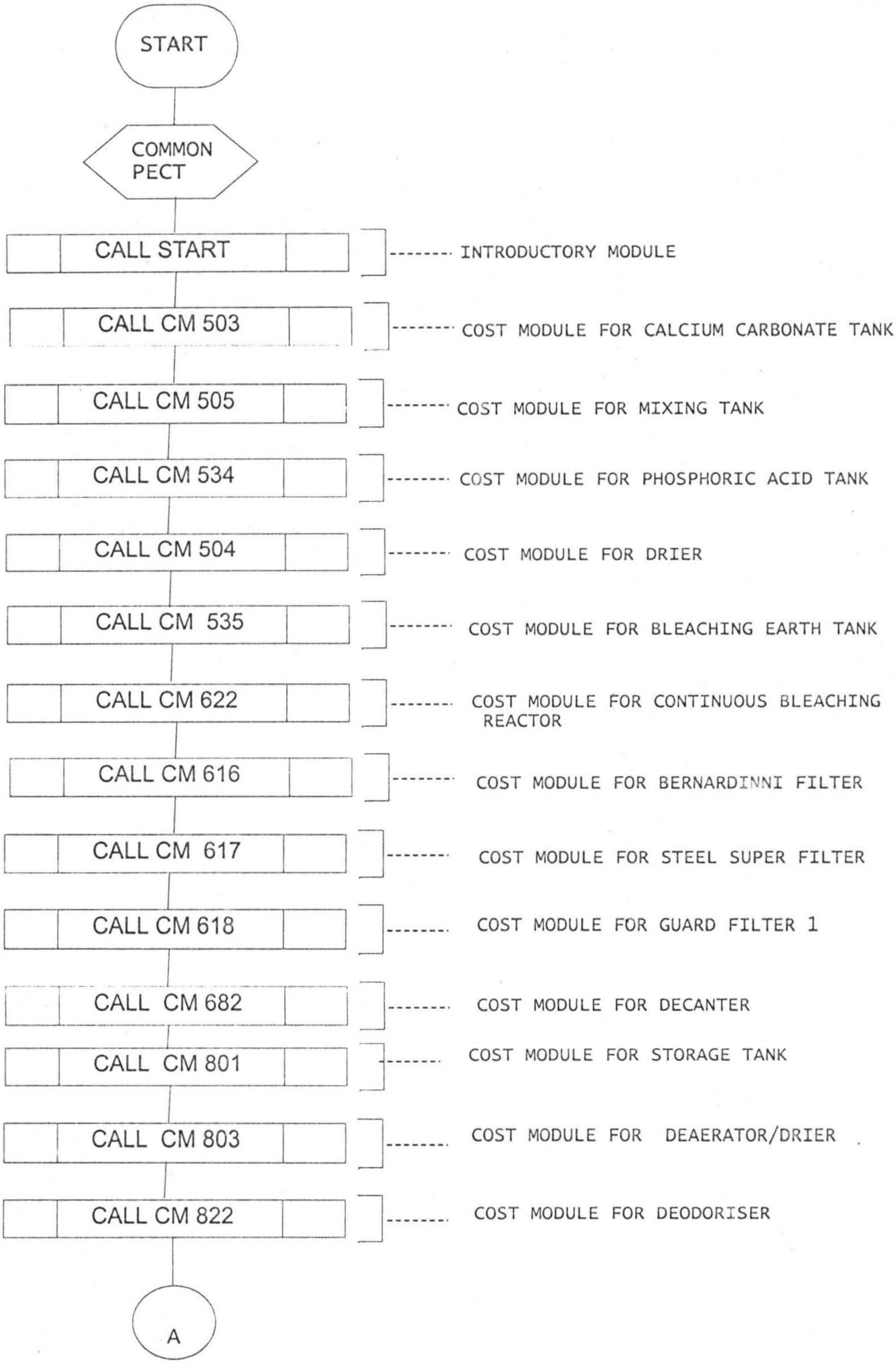
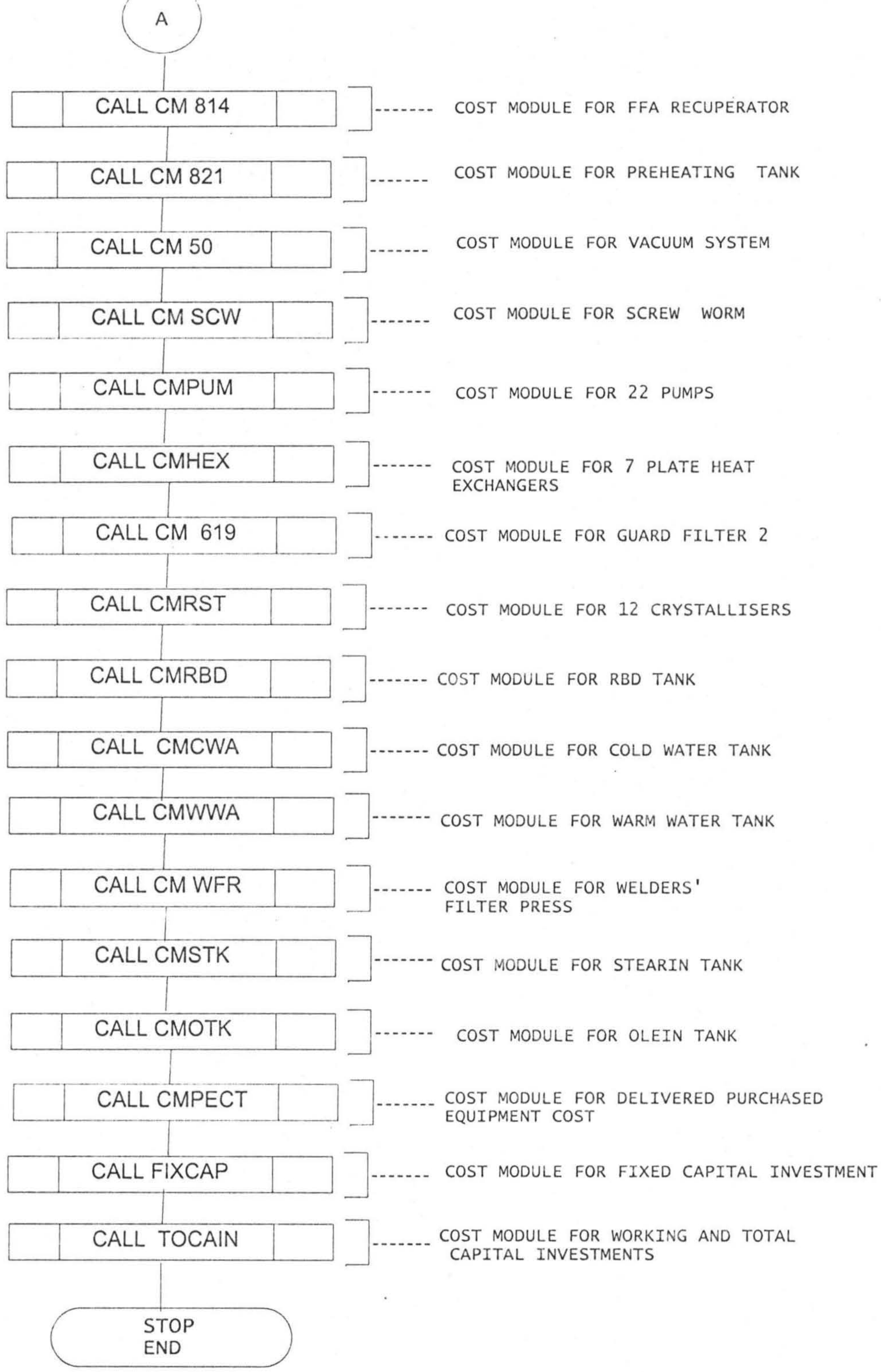


Fig. 3.3: FLOW CHART FOR PROGRAM CISCAL
(CISCAL MAIN MODULE)



Continuation of Fig. 3.3

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 RESULTS

The overall results for the methods of cost index, six-tenths factor rule, and cost index and scaling are shown in Tables 4.1, 4.2, and 4.3 respectively.

TABLE 4.1: Results for Cost Index Method.

The Reference year used is 1996.

The current year is 2002. Plant Capacity: 15,000m^3 per annum.

Name of Equipment	Cost of Equipment in 2002(₦).
Calcium Carbonate tank	813773.30
Mixing tank	813773.30
Phosphoric acid tank	101441.60
Drier	106954.80
Bleaching earth tank	108057.00
'Continuous bleaching Reactor	661576.90
One Bernardinni filter	716708.60
Two Bernardinni filters	1433417.00
Steel super filter	121288.80
Guard filter I	115279.80
Decanter	68914.17
Storage tank	108498.10
Deaerator/Drier	115334.50
Deodoriser	330788.40
FFA Recuperator	101441.60
Preheating tank	108057.00
Vacuum system	406869.60
Screw worm	340712.60
One pump	206742.50
Twenty-two pumps	4548336.00
One heat Exchanger	1084987.00
Seven heat Exchangers	7594910.00
One Guard filter II	115279.80
Two Guard filters II	230559.60
One Crystalliser	148854.70
Twelve Crystallisers	1786256.00
RBD Storage tank	108058.00
Cold water tank	99236.12
Warm water tank	99236.12
Welders' filter press	992365.30
Stearin tank	108058.00
Olein tank	108058.00
Two Olein tanks	216116.00
Delivered Purchased equipment cost	20174510.00
Fixed Capital Investments	185609600.00
Working Capital Investment	32754630.00
Total Capital Investment	218364200.00

Table 4.2: Results for Six-Tenths Factor Rule Method.

The Reference year used is 1996

The Current year is 2002. Plant Capacity: 30,000m^3 per annum.

Name of Equipment	**Cost of Equipment in 2002(₦).**
Calcium Carbonate tank	123338.90
Mixing tank	123338.90
Phosphoric acid tank	153756.70
Drier	162113.10
Bleaching earth tank	163783.80
Continuous bleaching Reactor	1002763.00
One Bernardinni filter	1086327.00
Two Bernardinni filters	2172654.00
Steel super filter	174914.70
Guard filter I	174731.50
Decanter	104454.40
Storage tank	164452.30
Deaerator/Drier	174814.50
Deodoriser	501381.50
FFA Recuperator	153756.70
Preheating tank	163783.80
Vacuum system	616699.00
Screw worm	681425.10
One pump	313363.10
Twenty-two pumps	6893988.00
One heat Exchanger	1644533.00
Seven heat Exchangers	11511730.00
One Guard filter II	174731.50
Two Guard filters II	349463.00
One Crystalliser	225621.50
Twelve Crystallisers	2707458.00
RBD Storage tank	163785.30
Cold water tank	150413.80
Warm water tank	150413.80
Welders' filter press	1504145.00
Stearin tank	163785.30
Olein tank	163785.30
Two Olein tanks	327570.70
Delivered Purchased equipment cost	30734920.00
Fixed Capital Investments	282767400.00
Working Capital Investment	49900130.00
Total Capital Investment	332667500.00

Table 4.3: Results for Cost Index and Scaling Method.

The Reference year used is 1996.

The current year is 2002. Plant Capacity: 30,000m^3 per annum.

Name of Equipment	Cost of Equipment in 2002(₦).
Calcium Carbonate tank	114284.30
Mixing tank	114284.30
Phosphoric acid tank	140507.70
Drier	148144.00
Bleaching earth tank	182993.50
Continuous bleaching Reactor	929148.30
One Bernardinni filter	1042075.00
Two Bernardinni filters	2084149.00
Steel super filter	190722.90
Guard filter I	182151.60
Decanter	108890.10
Storage tank	152379.60
Deaerator/Drier	161981.00
Deodoriser	522673.10
FFA Recuperator	142469.10
Preheating tank	151760.10
Vacuum system	642887.60
Screw worm	428280.30
One pump	259878.10
Twenty-two pumps	5717319.00
One heat Exchanger	1714369.00
Seven heat Exchangers	12000590.00
One Guard filter II	182151.60
Two Guard filters II	364303.20
One Crystalliser	192372.80
Twelve Crystallisers	2308473.00
RBD Storage tank	151761.50
Cold water tank	139373.70
Warm water tank	139373.70
Welders' filter press	1568019.00
Stearin tank	149672.20
Olein tank	149672.20
Two Olein tanks	299344.40
Delivered Purchased equipment cost	29235930.00
Fixed Capital Investments	268976400.00
Working Capital Investment	47466430.00
Total Capital Investment	316442900.00

Meanwhile, Table 4.4 gives a summary of the overall results for delivered purchased equipment cost, fixed capital investment, working capital investment, and total capital investment for the three methods in question in Naira.

Table 4.4: **A summary of the Delivered purchased equipment Cost, Fixed Capital, Working capital, and Total Capital Investments.**

Program	Delivered Purchased Equipment Cost (₦)	Fixed Capital Investment ₦)	Working Capital Investment (₦)	Total Capital Investment (₦)
Cost Index Method (CINDEX)	20,174,510.00	185,609,600.00	32,754,630.00	316,442,900.00
Six-Tenths Factor Rule Method (SIXIOR)	30,734,920.00	282,767,400.00	49,900,130.00	332,667,500.00
Cost Index and Scaling Method (CISCAL)	29,235,930.00	268,974,400.00	47,466,430.00	316,442,900.00

4.2 DISCUSSION OF RESULTS.

All the three cost estimation methods used, namely, the method of Cost Index represented by the program CINDEX, the Six-Tenths Factor Rule Method represented by the program SIX10R, and the method of Cost Index and Scaling represented by the program CISCAL, are equally reliable within a period of not more than ten years (Peters and Timmerhaus, 1991, Rudd and Watson, 1968). Since the period considered in this work is six years (from 1996 to 2002), it is well within the recommended period. The results discussed above are therefore, expected to be reliable.

Corresponding results shown in Table 4.2 and Table 4.3 are very similar, but differ considerably from corresponding results shown in Table 4.1. For instance, the Fixed Capital Investments in Table 4.2 and Table 4.3 are ₦ 282,767,400 and ₦268, 974,400 respectively differing only by ₦14,883,000; whereas the Fixed Capital Investment in Table 4.1 is ₦185, 609,600, differing by at least ₦ 83 million from those in Tables 4.2 and 4.3. This is so because both the Six-Tenths Factor Rule (Table 4.2) and the Cost Index and Scaling (Table 4.3) methods are cost estimation methods involving scaling of equipment capacities (Rudd and Watson, 1968) by a factor of two, whereas, the method of cost Index (Table 4.1) does not involve scaling.

4.2.1 Unit Equipment Cost

It is obvious from the results in Table 4.1, Table 4.2 and Table 4.3 that the cost estimate for each piece of equipment in the year 2002 is higher than that for the reference year 1996. This was in total agreement with the Chemical Engineering Plant Cost Index quoted as 381.7 and 394.3 for 1996 and 2002 respectively (www.Eng-tips.com, 2002), which showed an increase in the index. For instance a deodoriser which costed ₦320, 218.00 in 1996 was estimated to have cost ₦330, 778.40 in 2002. This represented an increase of ₦10, 560.40 (Table 4.1) over a period of six years from 1996 to 2002, a clear indication of the dynamic nature of the economic environment, meanwhile, for the same period of time, in Table 4.2 and Table 4.3 the estimated cost of a deodoriser in 2002 with twice the capacity of 1996 were ₦522,673.10 and ₦501,381.50 respectively. The difference between the cost of deodoriser in Table 4.2 and Table 4.3 is due to the fact that in the Cost Index and Scaling Method, the ratio of the current capacity to the historical capacity of the deodoriser was raised to a higher exponent (0.66), and in the Six-Tenths Factor Rule method, it was raised to the exponent 0.6 (Peters and Timmerhaus, 1991). The results in Table 4.1 on the one hand, and those of Table 4.2 and Table 4.3 on the other hand, is an indication that doubling the capacity of each equipment results in nearly doubling the investment in each equipment as the cost of a deodoriser in particular and in fact, the cost of every other equipment was almost doubled when the capacity was doubled. From the results obtained, it is amply clear that available past and current cost data can be used to compute future cost estimates, as well as past cost data have been used to compute current cost estimates (Peters and Timmerhaus, 1991 Rudd and Watson, 1968, Ulrich 1984)

4.2.2 Delivered Purchased Equipment Cost

The delivered purchased equipment cost of ₦20,174,510.00 computed by CINDEX (Table 4.1) was about ₦9,000,000.00 less than those computed by CISCAL (table 4.2) and SIX10R (Table 4.3) which stood at ₦29,235,930.00 and ₦30,734,920.00 respectively. The disparity in the results in Table 4.1 on the one hand, and those in Table 4.2 and Table 4.3 on the other hand, is brought about by the fact that both CISCAL and SIX10R are scale – ups by double the capacity for each equipment capacity in CINDEX. This has shown that for this particular plant, increasing the capacity of the entire plant two fold results in a fifty percent increase in the delivered purchase equipment cost. Here the effect of changes in cost and equipment capacity is clearly visible and significant and represented substantially by the nine million Naira difference.

4.2.3 Fixed Capital Investment

The fixed capital investment computed by CINDEX (Table 4.1, Table 4.4) was ₦185, 609,600.00 as opposed to ₦282, 767,400.00 and ₦268, 976,400.00 for SIX10R (Table 4.2 and Table 4.4) and (Table 4.3 and 4.4) respectively. Table 4.2 and Table 4.3 show estimates for a plant double the size of the plant whose cost estimates are displayed in Table 4.1. This adequately explains the disparity in the results.

The difference in the estimates computed by SIX10R (Table 4.2) and CISCAL (Table 4.3) stems from the fact that the ratio of the equipment capacities in CISCAL were raised to different exponents (Rudd and Watson, 1968) depending on the particular equipment; for instance, the exponents for continuous bleaching reactor and screw worm ware 0.49 and 0.99, whereas in SIX10R those ratios were raised to a common exponent which was 0.66 (Peters and Timmerhaus, 1991).

Comparing the fixed capital investment computed by CINDEX and CISCAL (Table 4.4), it was found that doubling the plant size resulted in about 45% increase in the fixed capital investment. When the fixed capital investment computed by CINDEX was compared with that estimated by SIX10R, a 52% increase in fixed capital investment was observed. These two comparisons have shown that doubling the plant size (capacity) does not necessarily result in doubling the fixed capital investment.

4.2.4 Working Capital Investment

The working capital investment computed by CINDEX (Table 4.1, Table 4.4) stood at ₦32,754,630.00 while those for SIX10R (Table 4.2, Table 4.4) and CISCAL (Table 4.3, Table 4.4) stood at ₦49,900,130.00 and ₦47,466,430.00 respectively. The extra investment required for SIX10R and CISCAL over CINDEX was 52.3% and 44.9% respectively. They were very reasonable since the plant capacities were doubled in CISCAL and SIX10R without a corresponding doubling of investment.

It should also be noted that SIX10R and CISCAL are made use of when the required cost data for the desired capacities are not entirely available, but the cost data for other capacities other than those required are.

4.2.5 Total Capital Investment

The total capital estimate computed by CINDEX, SIX10R and CISCAL (Table 4.4) were ₦218, 364,200.00, ₦ 322,667,500.00 and ₦ 316,442,900.00 respectively.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Three overall robust modules namely CINDEX, SIX10R, and CISCAL were developed that could relate equipment cost fluctuation to the design of a Palm Oil Refinery and Fractionation Plant using three different costing methods namely Cost Index, the Six-Tenths-Factor Rule, and Cost Index and Scaling methods respectively.

The modules were tested by comparing the cost of each piece of equipment in 2002 with those in 1996 in order to determine the efficiency and performance of the modules. Corresponding cost estimates obtained from the methods of Cost Index and Scaling and Six-Tenths Factor Rule are similar, but significantly different in magnitude from that of the method of Cost Index.

5.2 RECOMMENDATIONS

1. Further work remains to be done on the 'Comparative Study of Cost Indices on the Cost Estimation of the Palm Oil Refinery and Fractionation Plant'. For this work the researcher should work on his/her own design based on the prevailing local economic conditions.
2. More research needs to be done in the area of Cost Indices, i.e., to set up a database (electronic or otherwise) for local cost indices suitable to Nigerian economic environment in particular and African economic environment at large.

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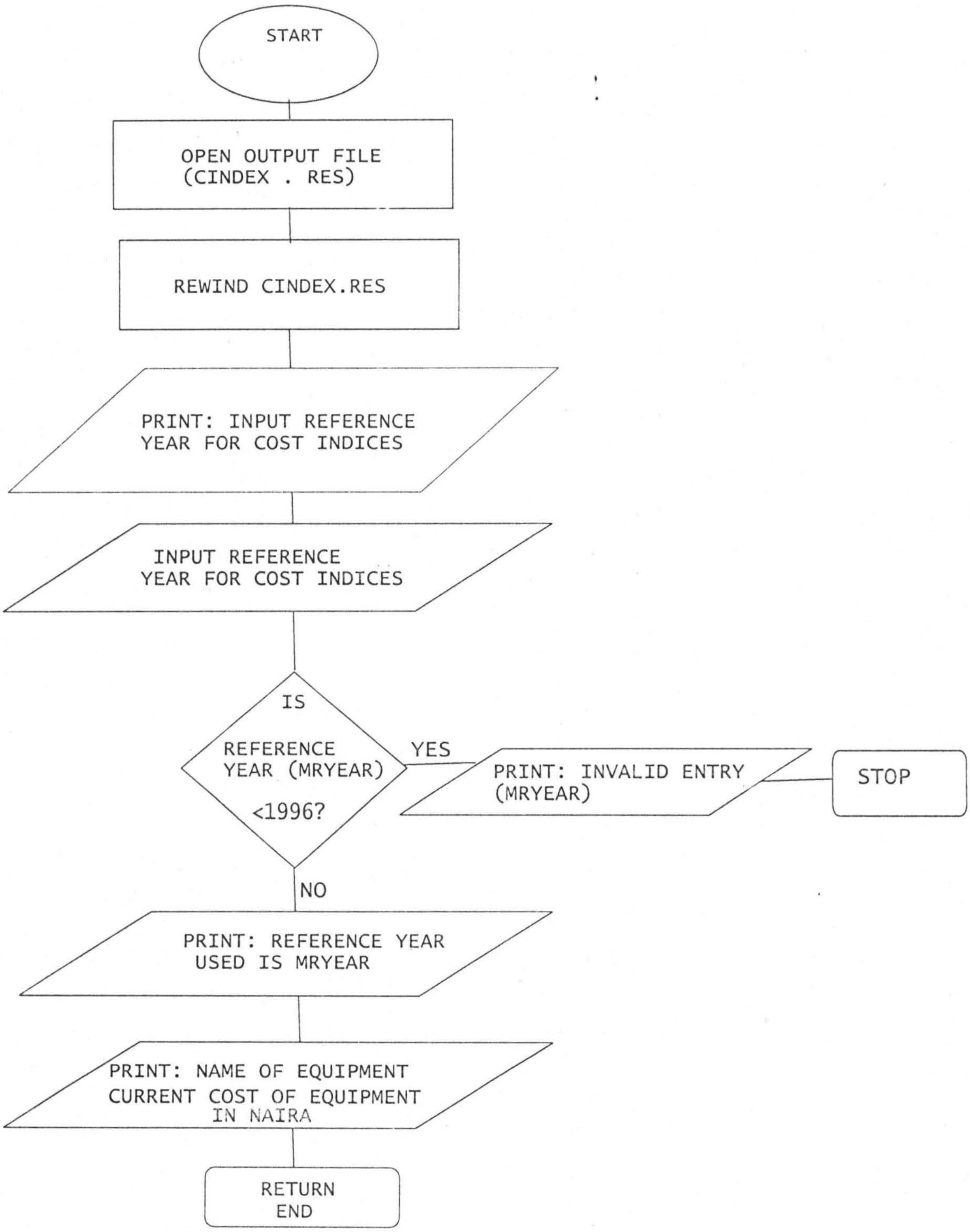
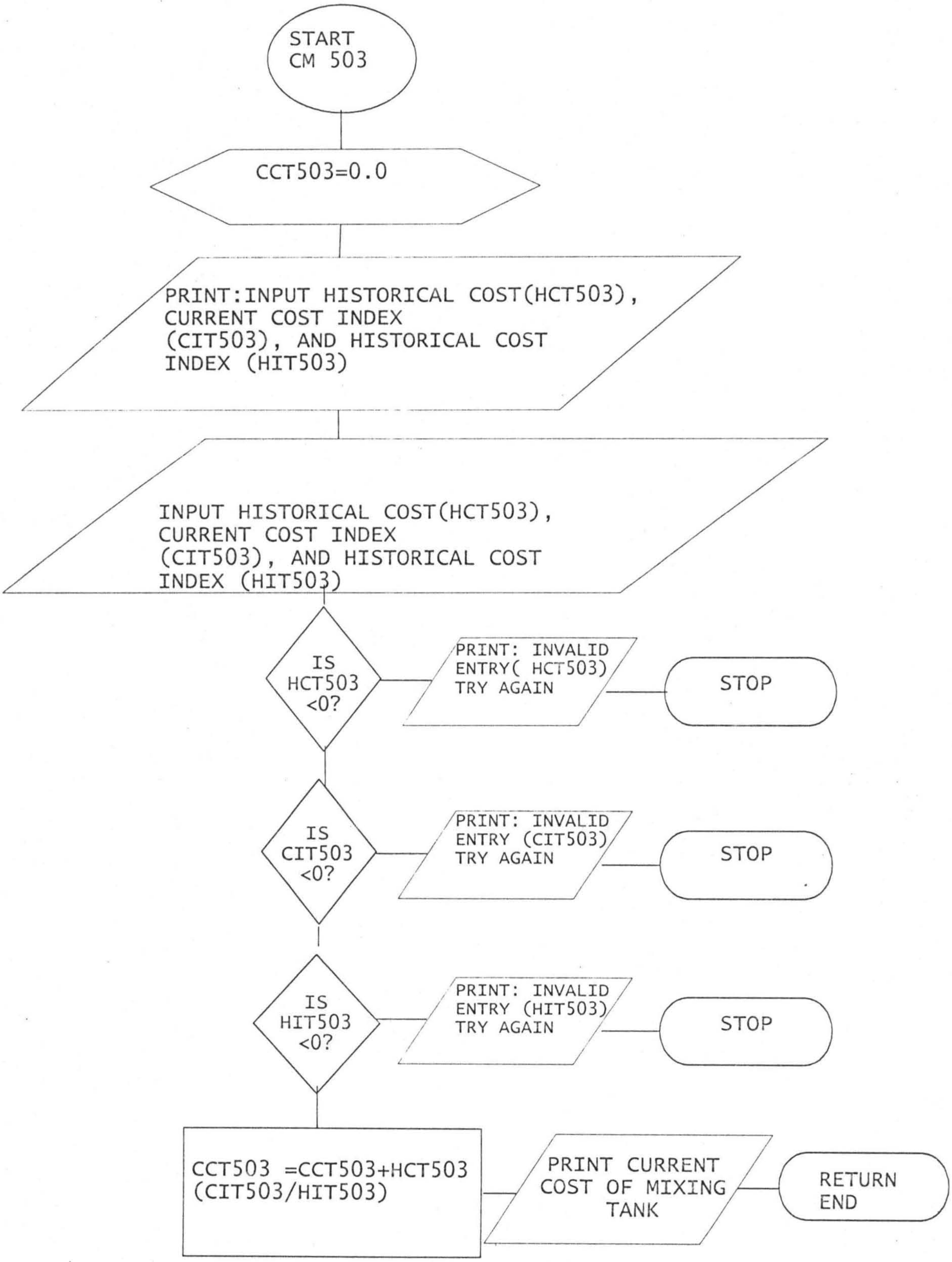
APPENDIX A1
Subroutine Flow Chart for Program CINDEX

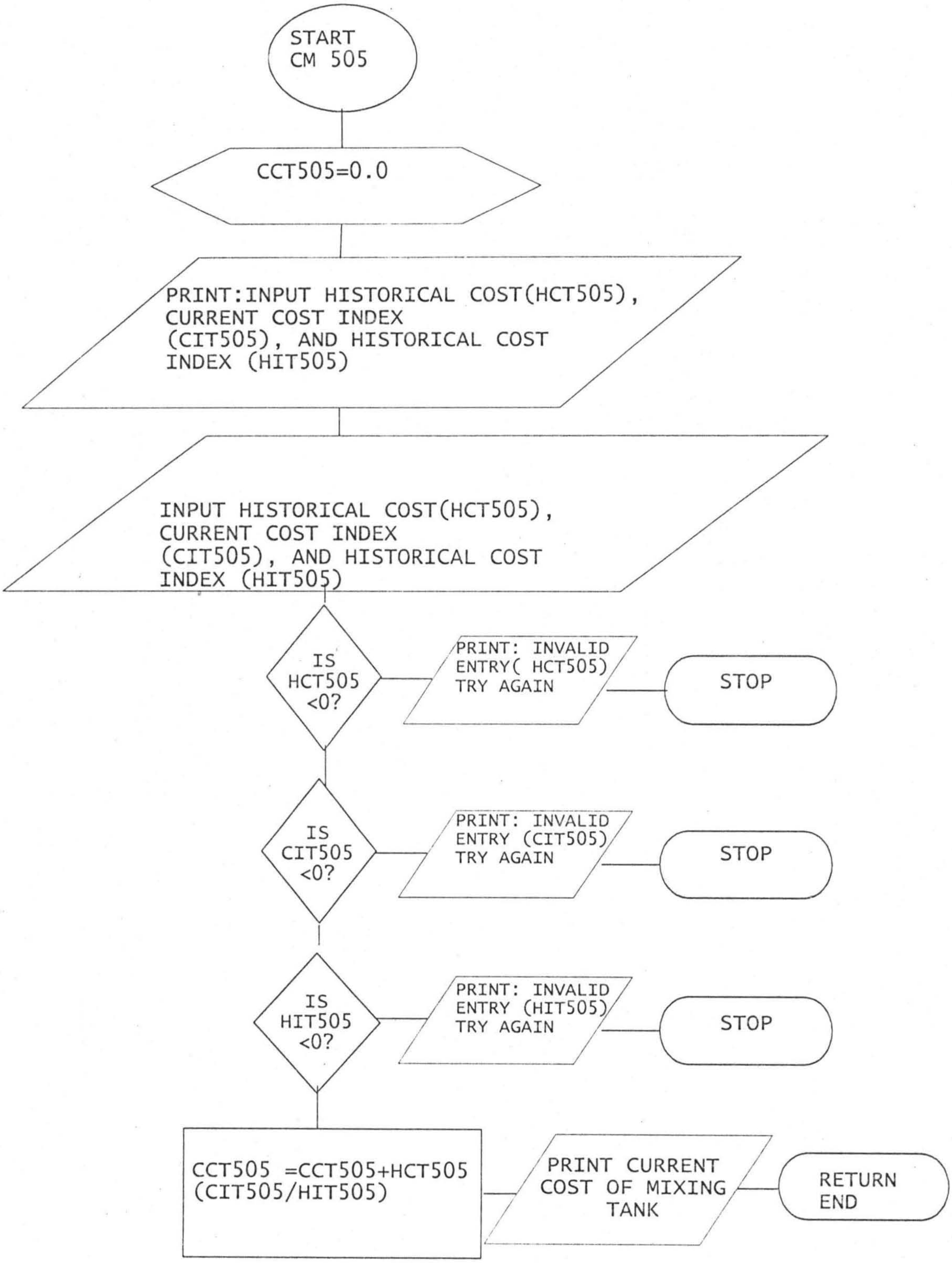
INTRODUCTORY MODULE FOR VALIDATION OF
REFERENCE YEAR FOR COST INDICES



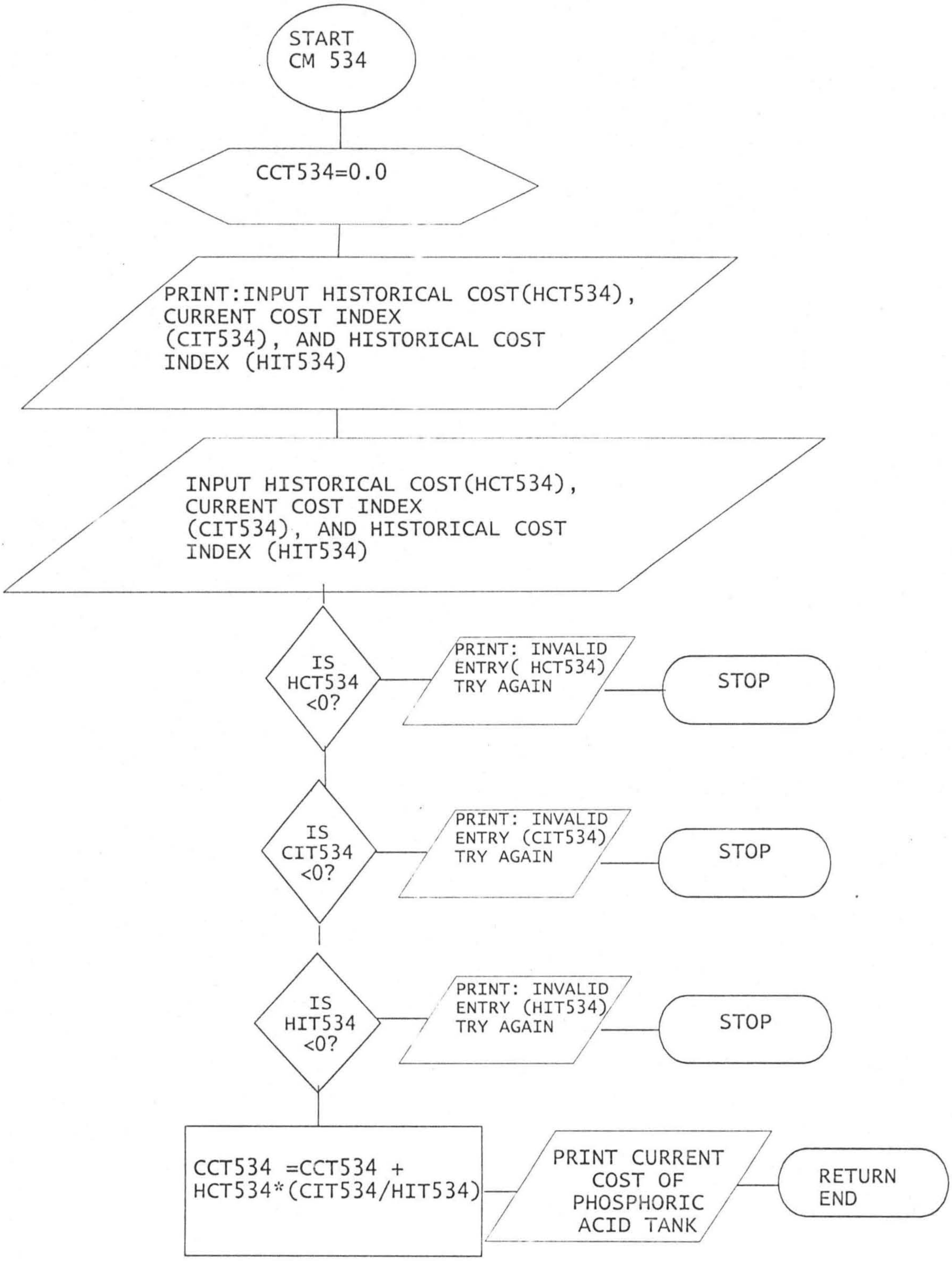
CALCULATION OF CURRENT COST OF CALCIUM CARBONATE TANK



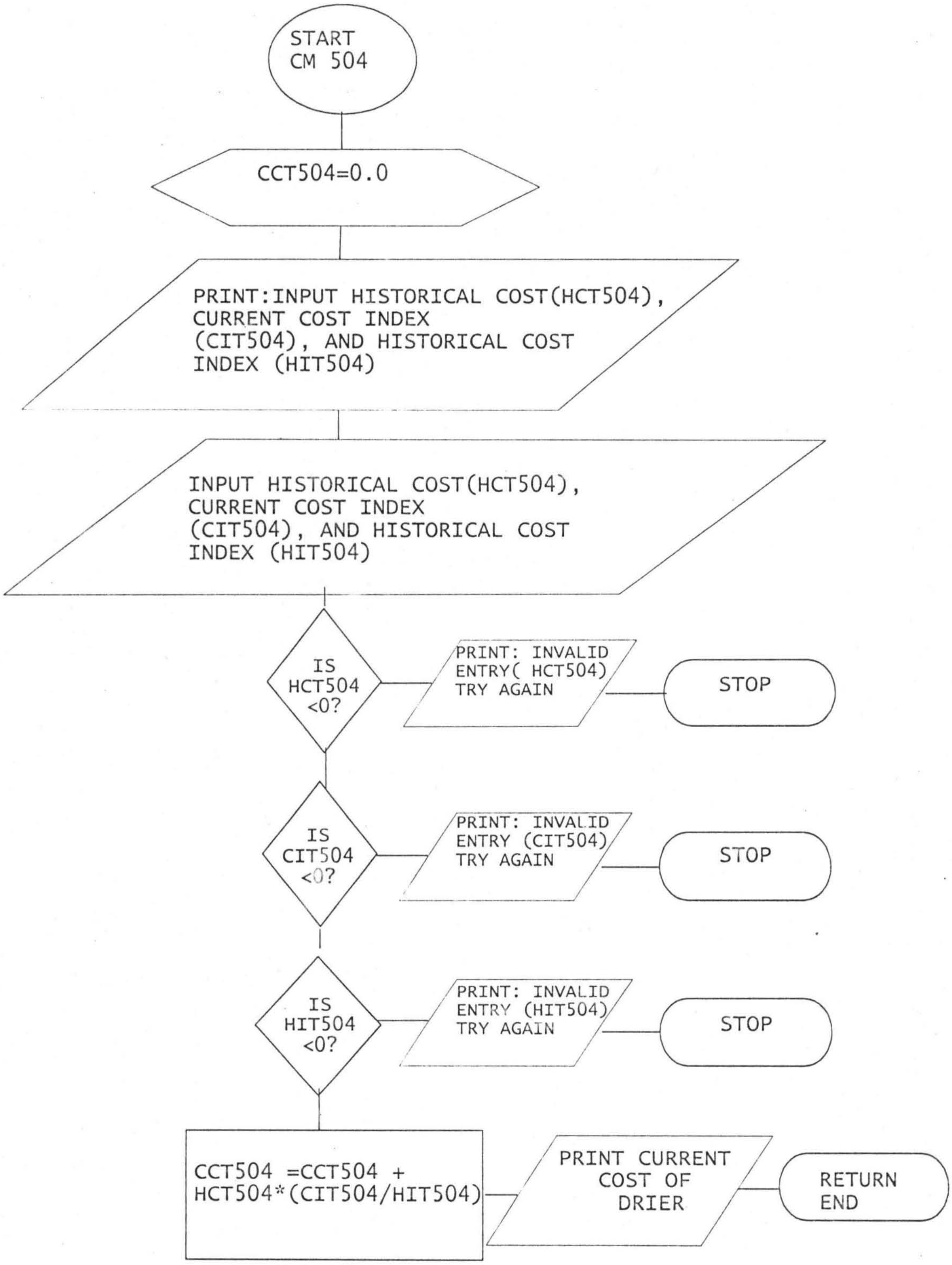
CALCULATION OF CURRENT COST OF MIXING TANK



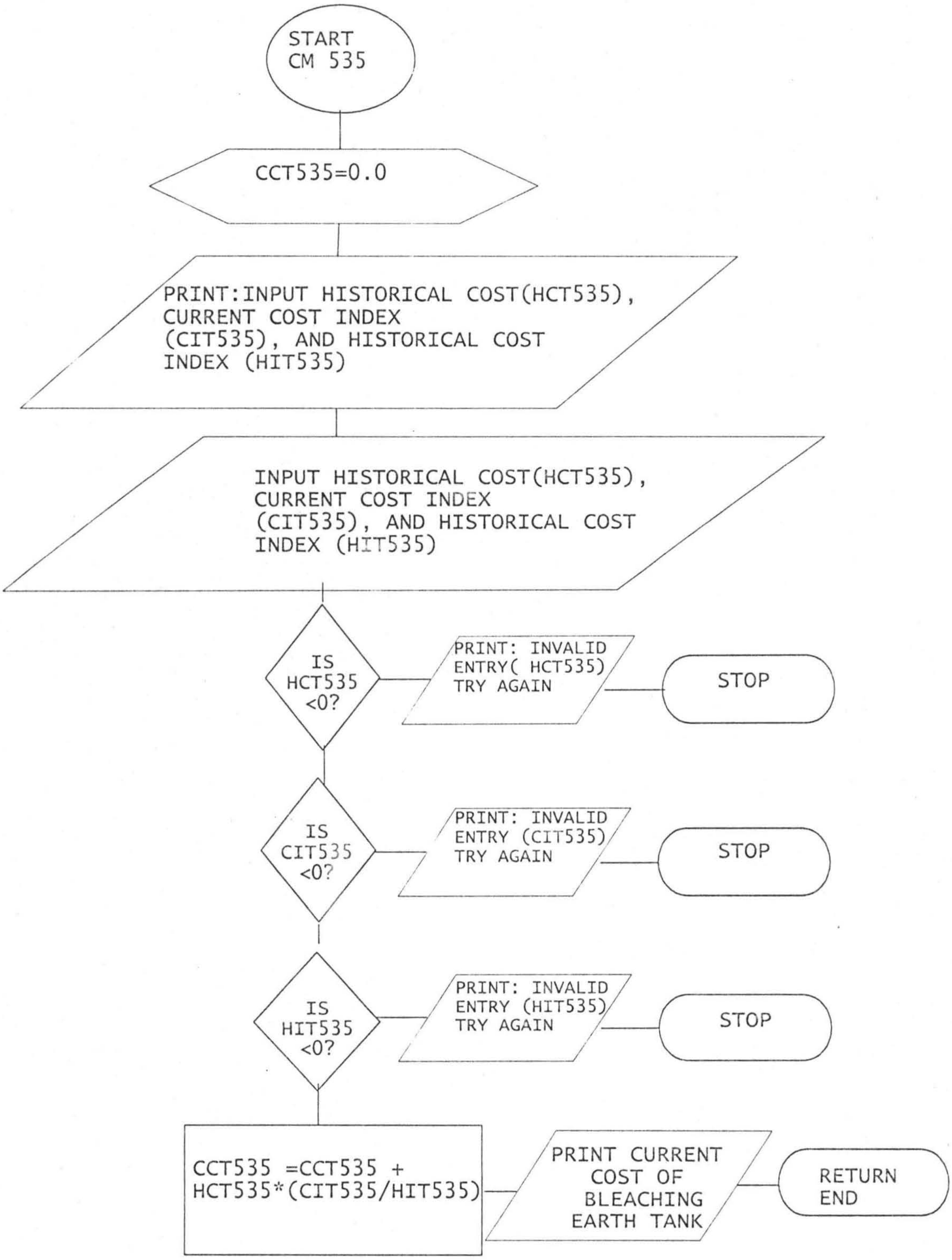
CALCULATION OF CURRENT COST OF PHOSPHORIC ACID TANK



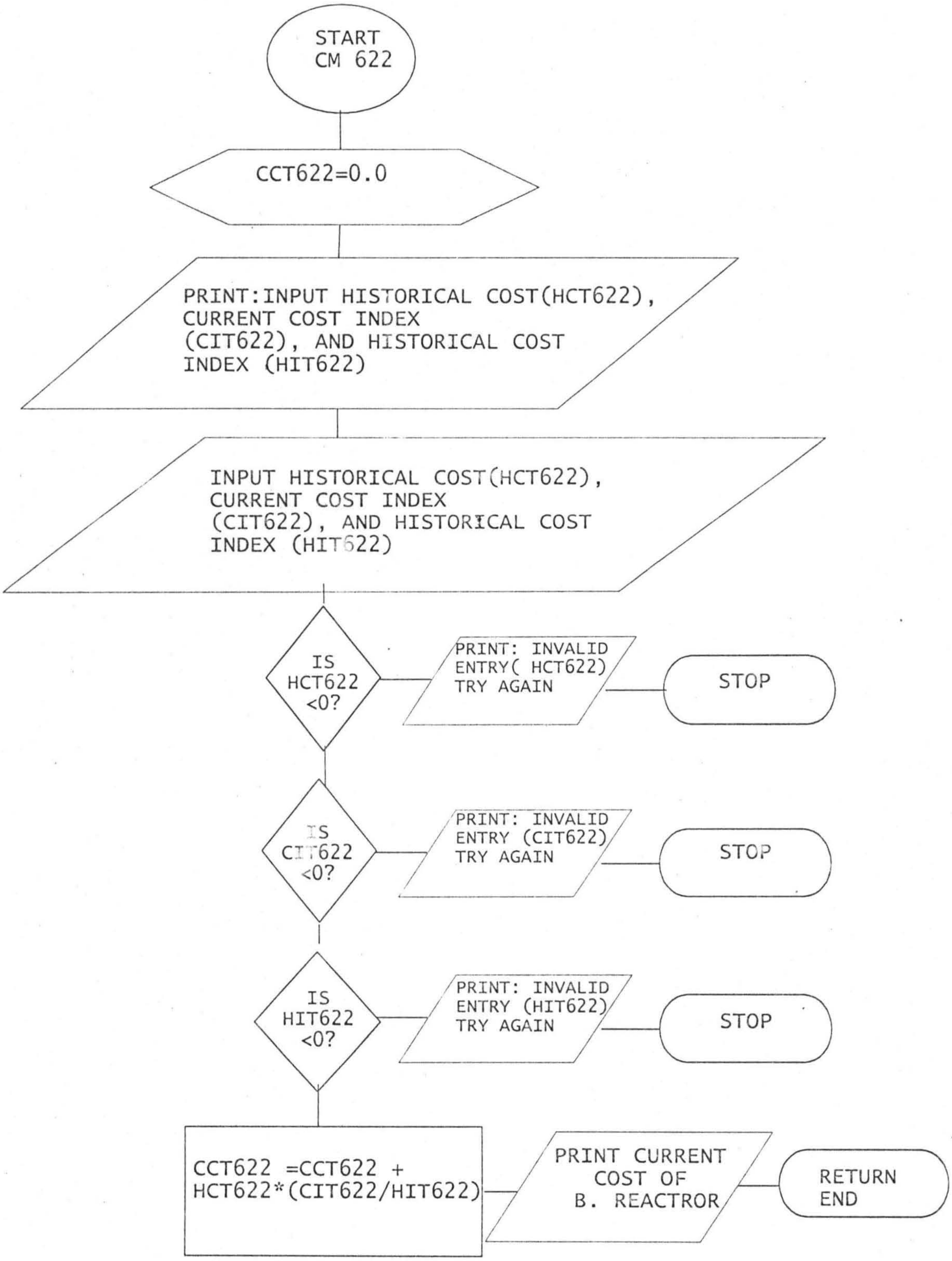
CALCULATION OF CURRENT COST OF DRIER



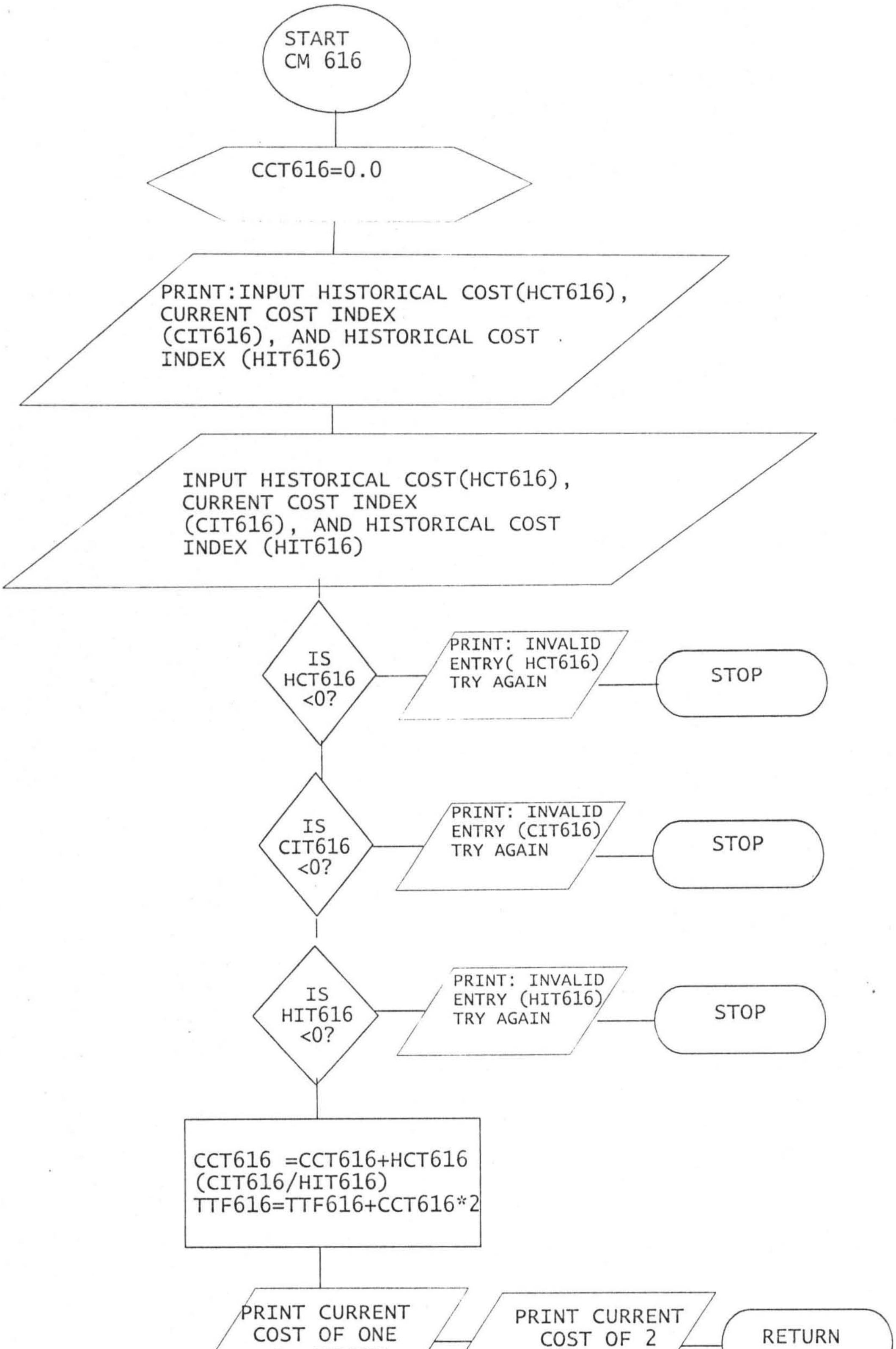
CALCULATION OF CURRENT COST OF BLEACHING EARTH TANK



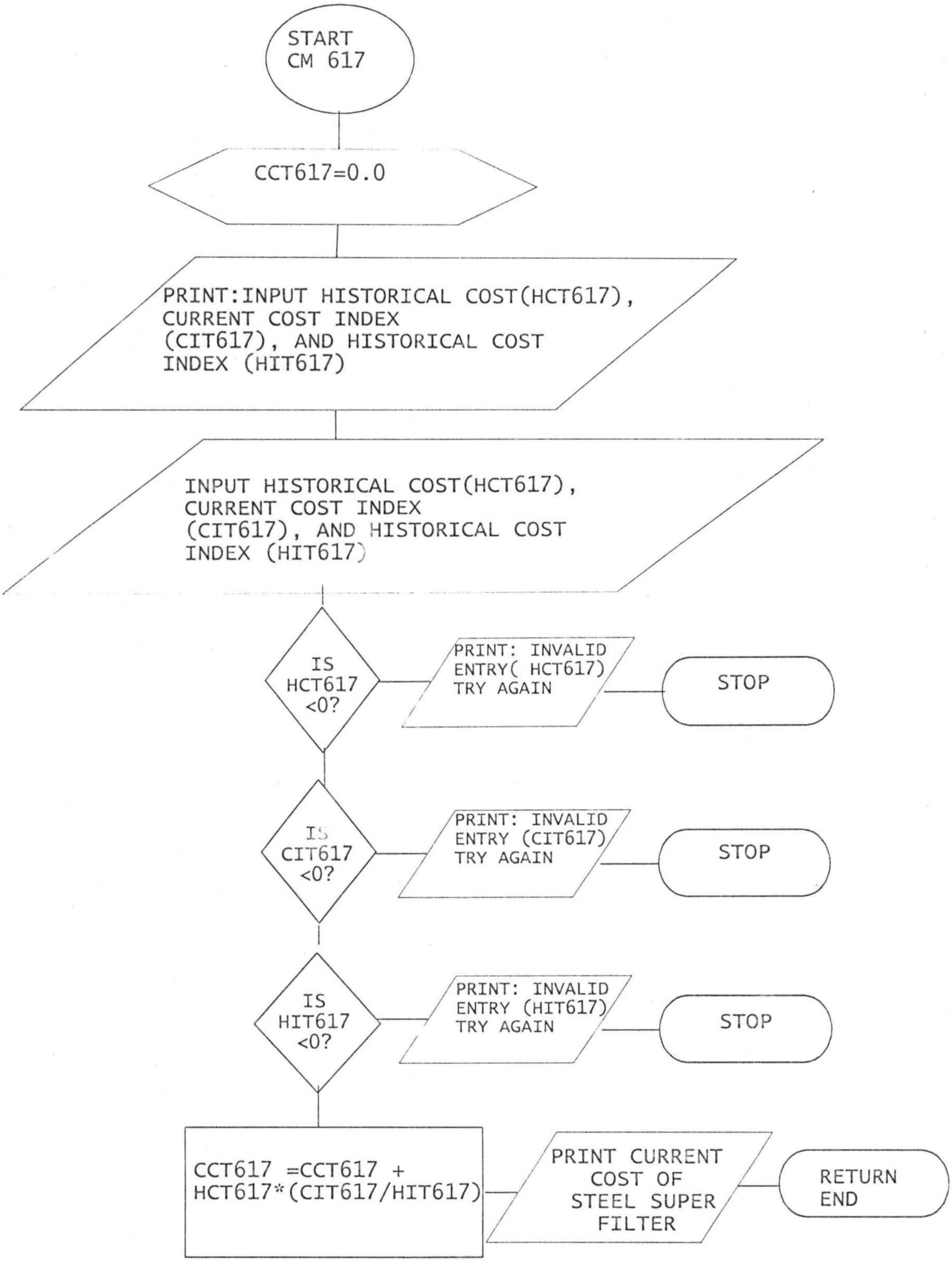
CALCULATION OF CURRENT COST OF CONTINUOUS BLEACHING REACTOR



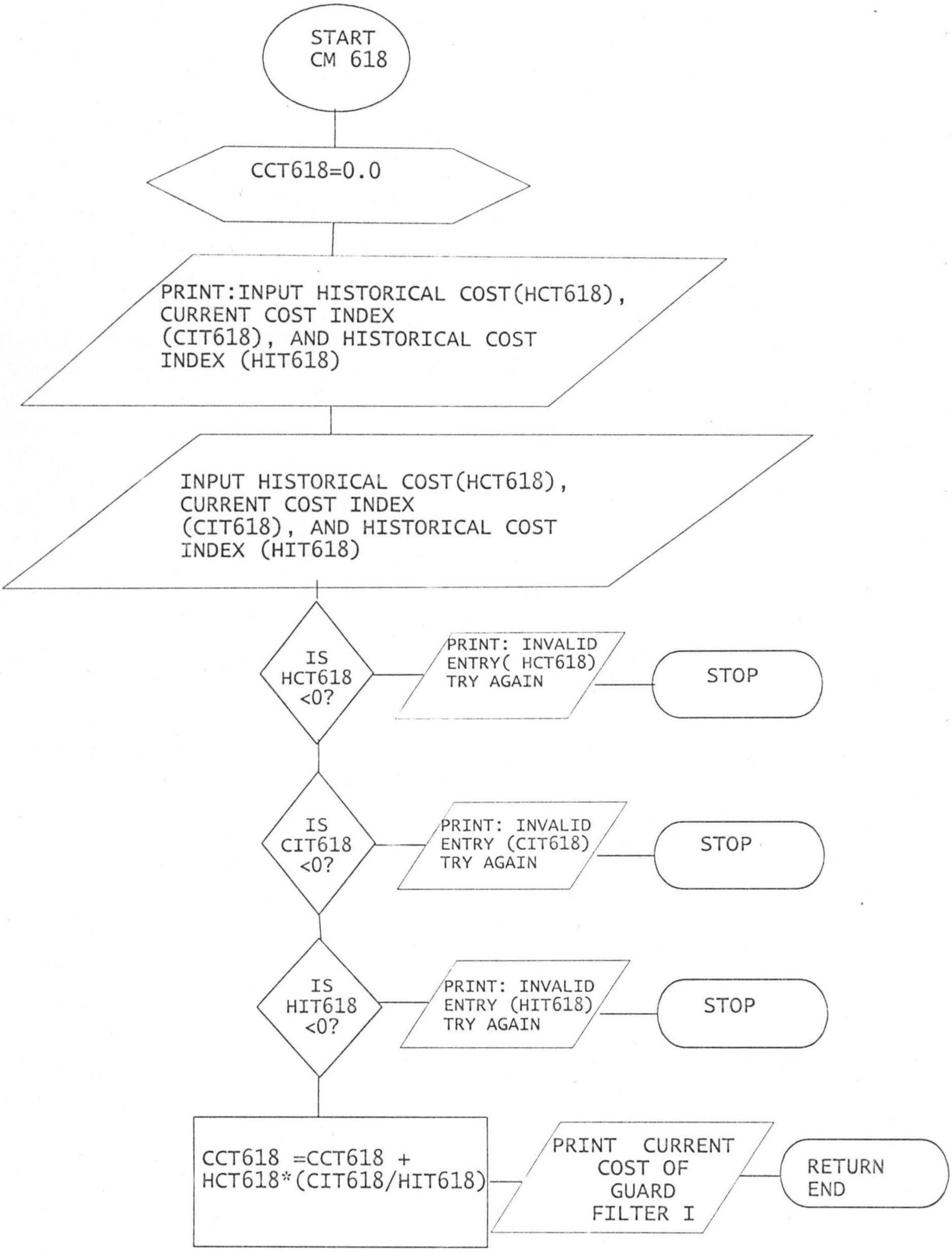
CALCULATION OF CURRENT COST OF TWO BERNARDINNI FILTER



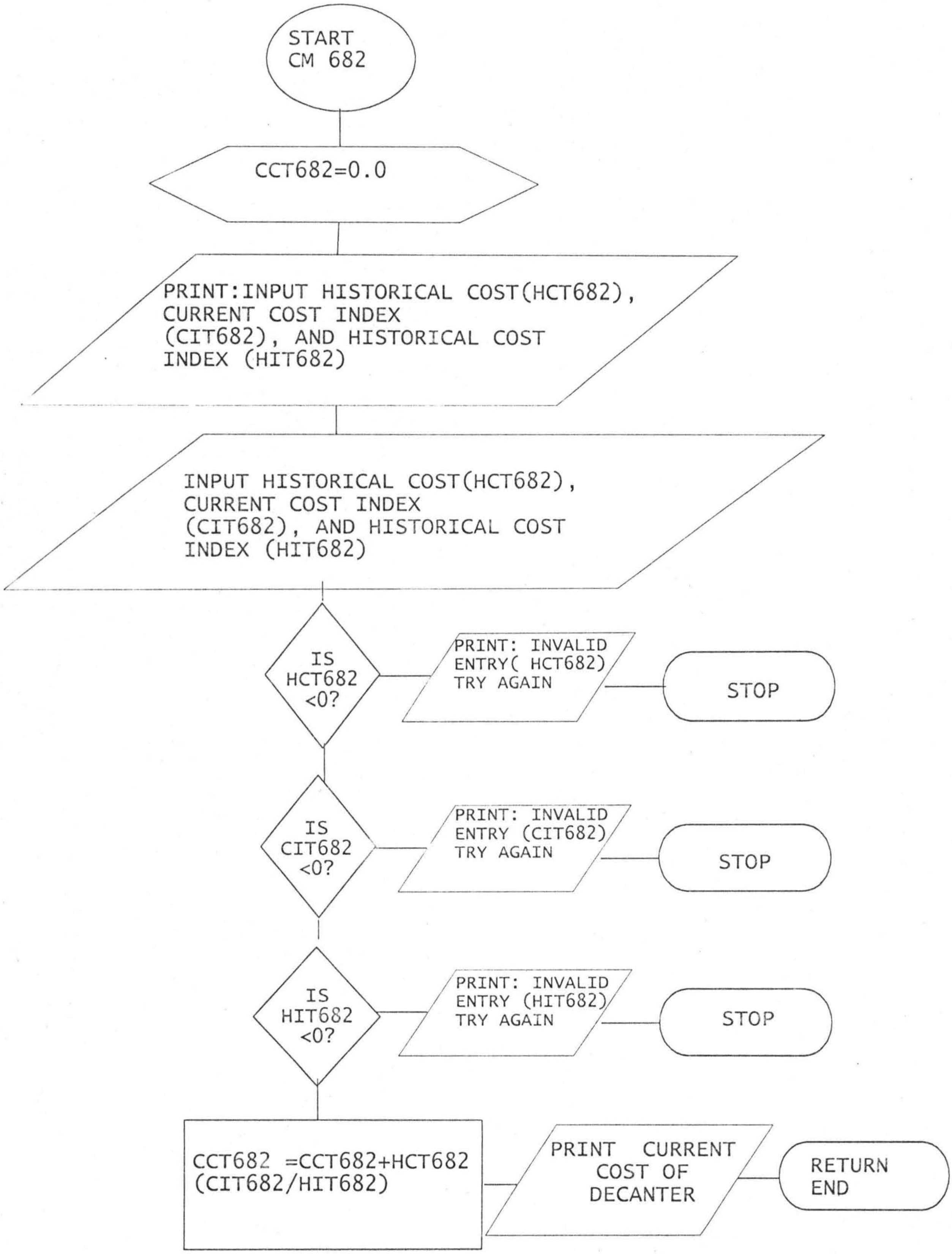
CALCULATION OF CURRENT COST OF STEEL SUPER FILTER



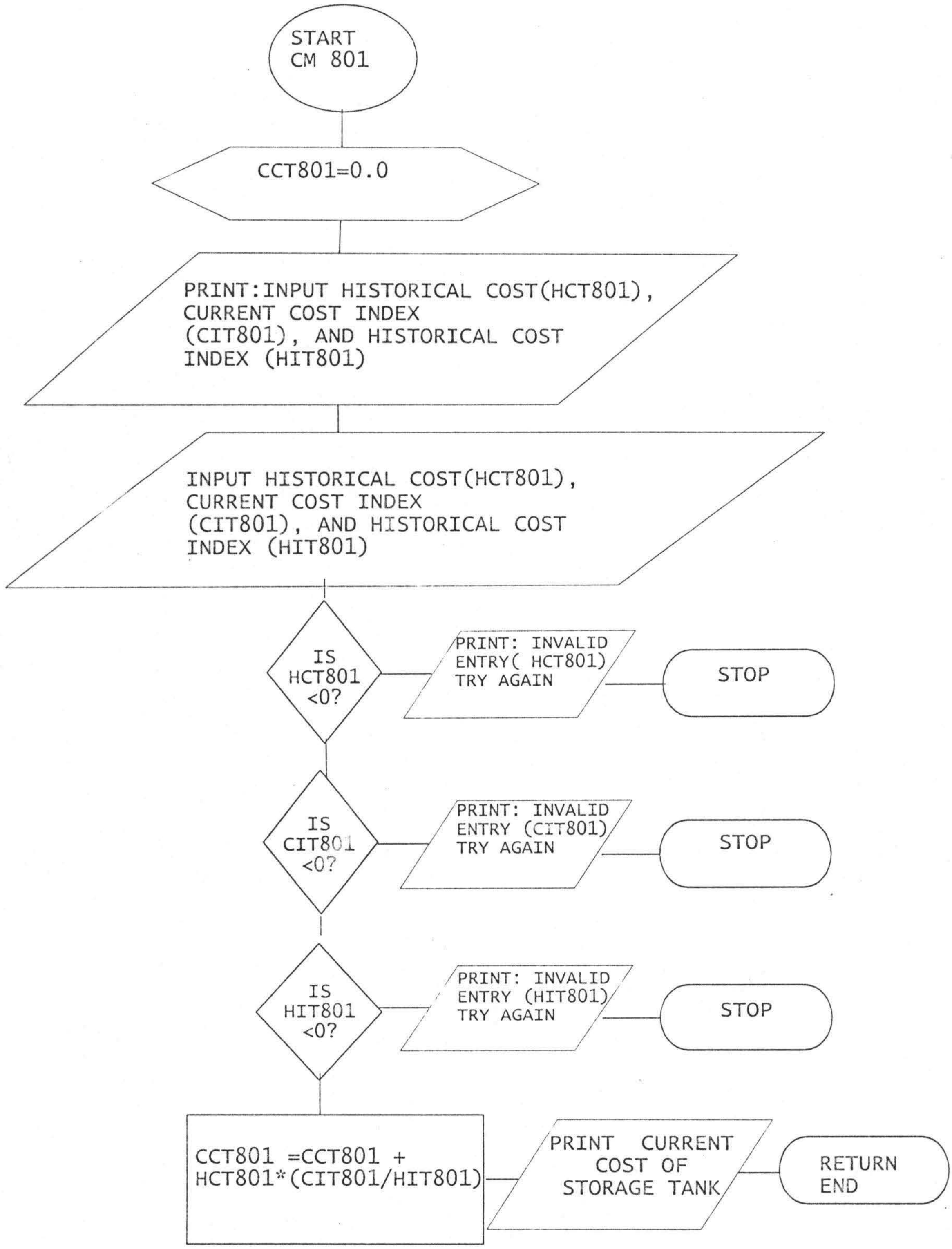
CALCULATION OF CURRENT COST OF GUARD FILTER I



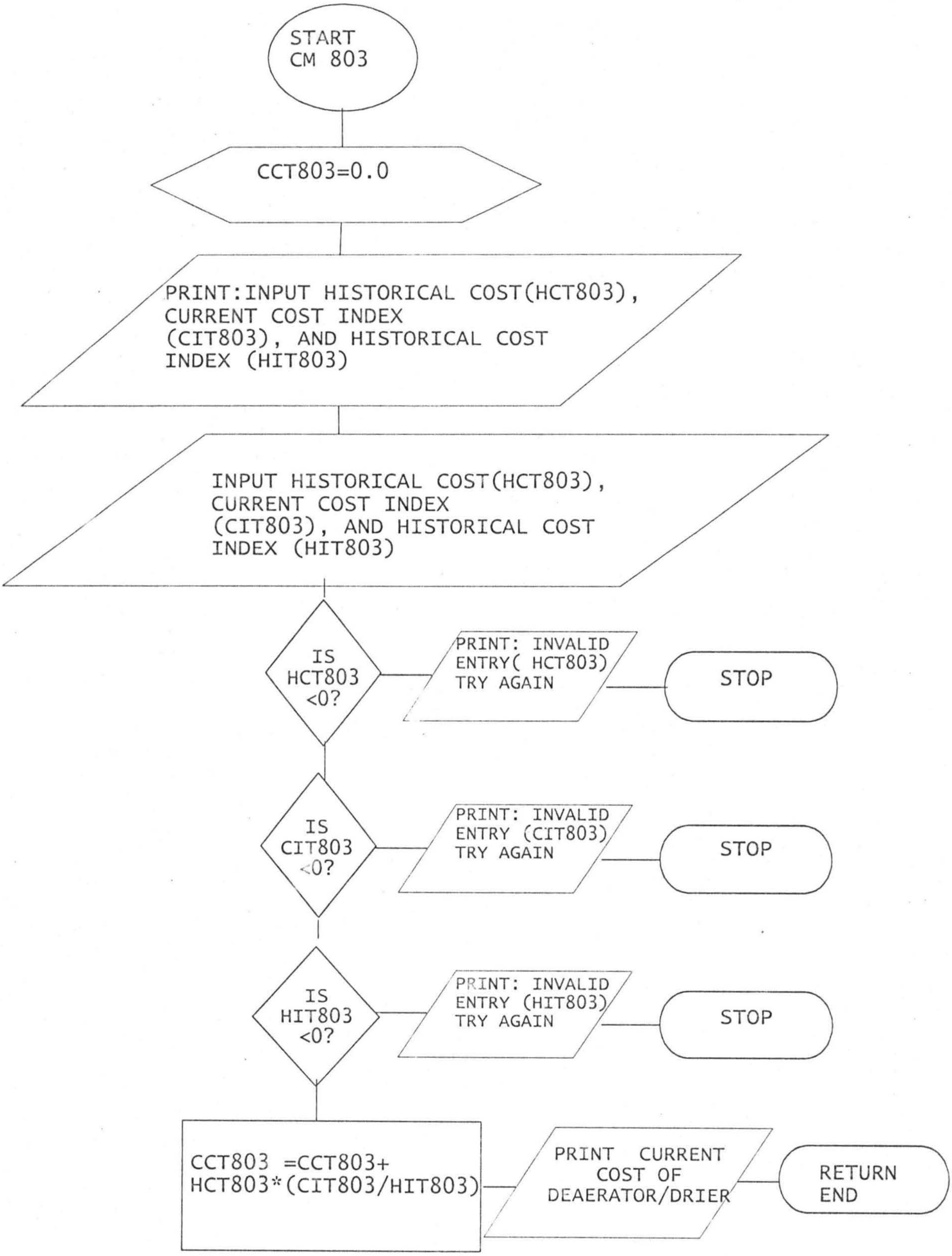
CALCULATION OF CURRENT COST OF DECANTER



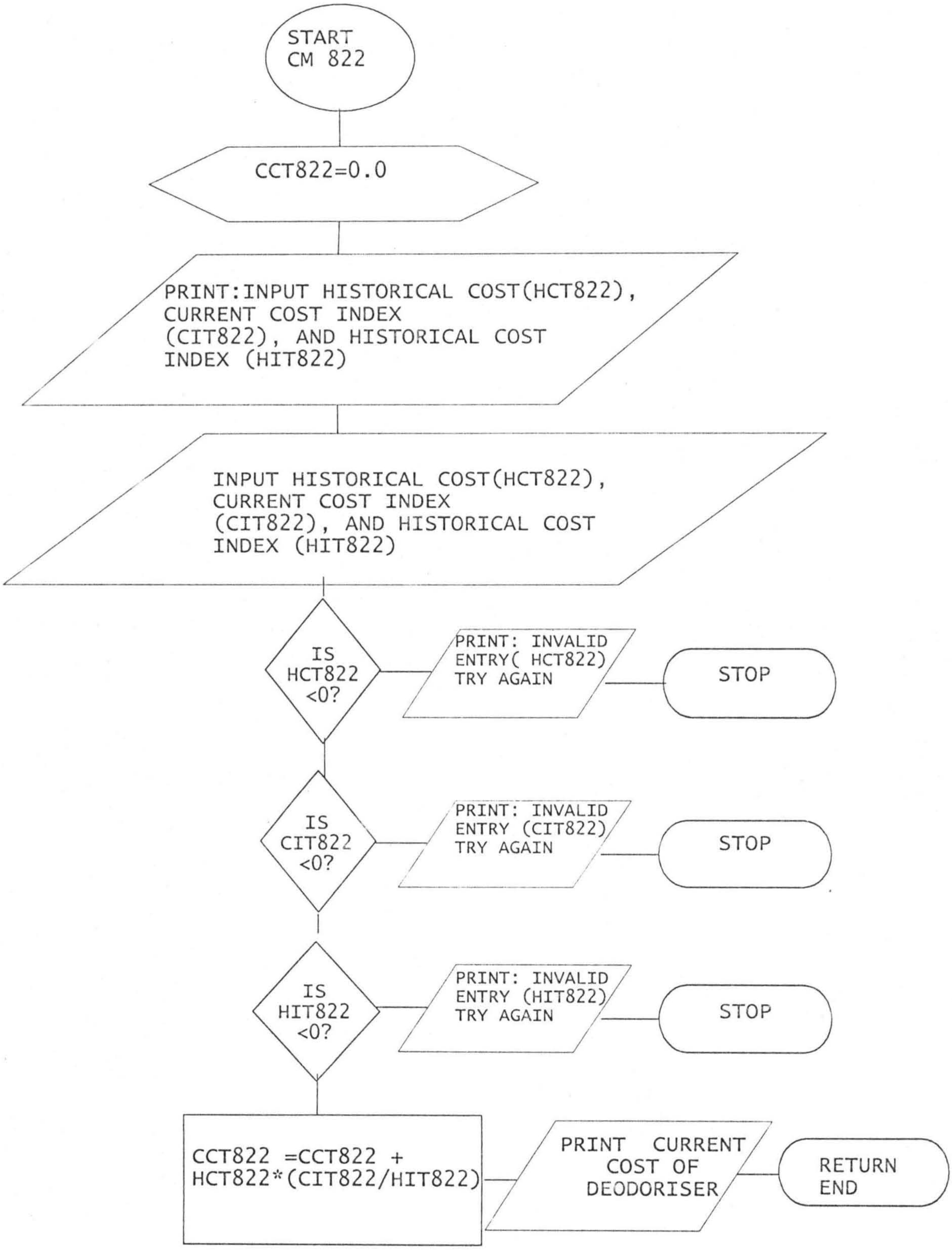
CALCULATION OF CURRENT COST OF STORAGE TANK



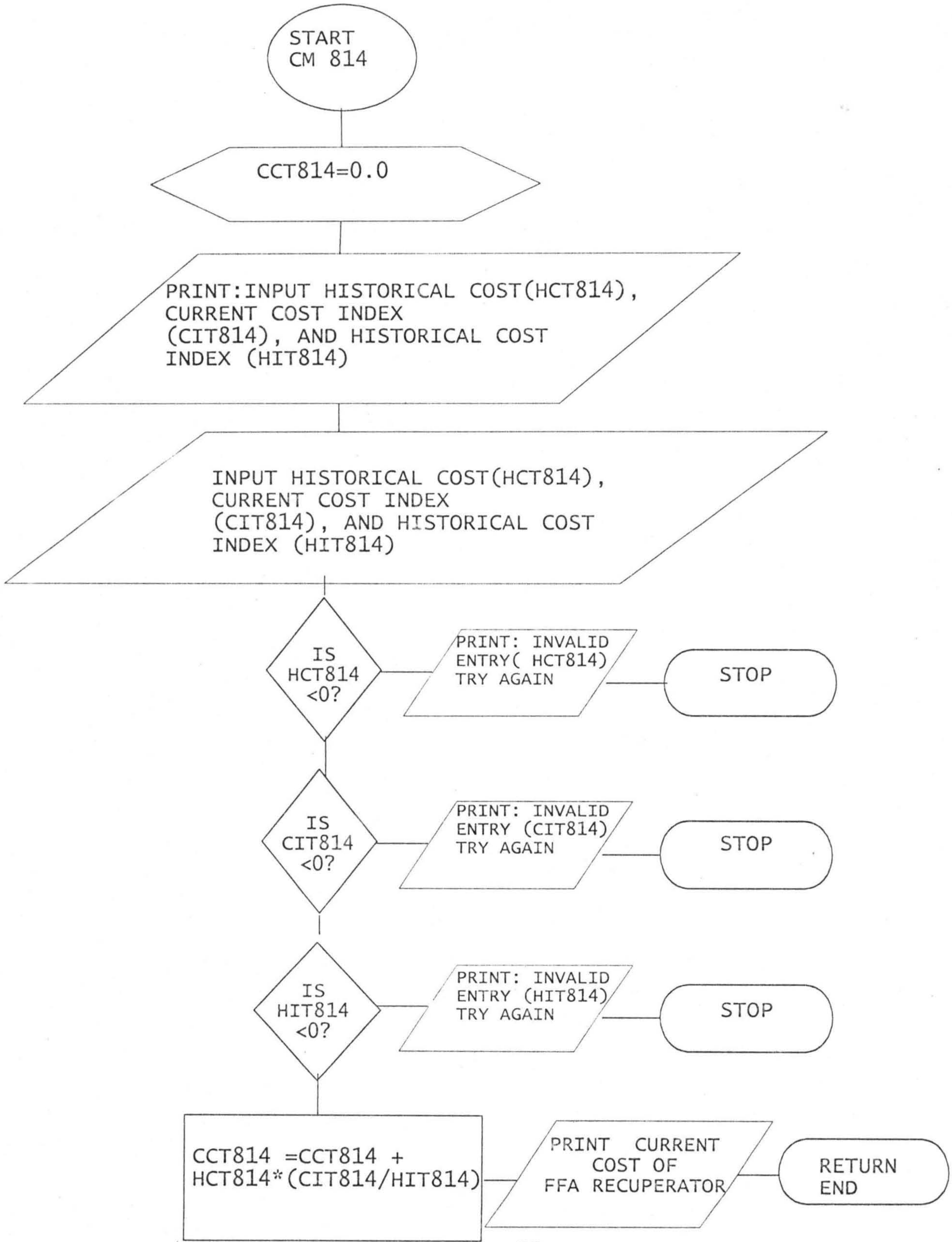
CALCULATION OF CURRENT COST OF DEAERATOR/DRIER



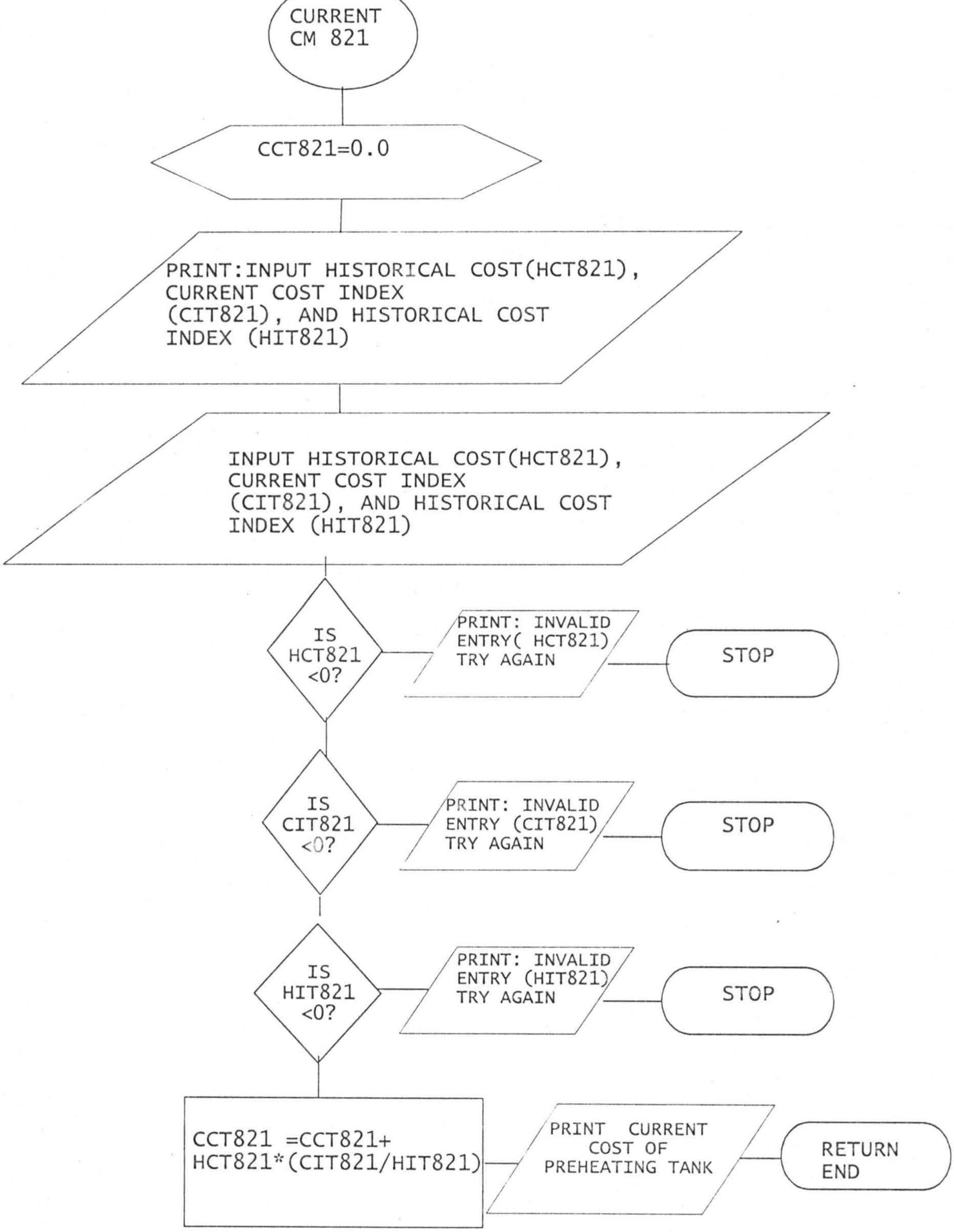
CALCULATION OF CURRENT COST OF DEODORISER



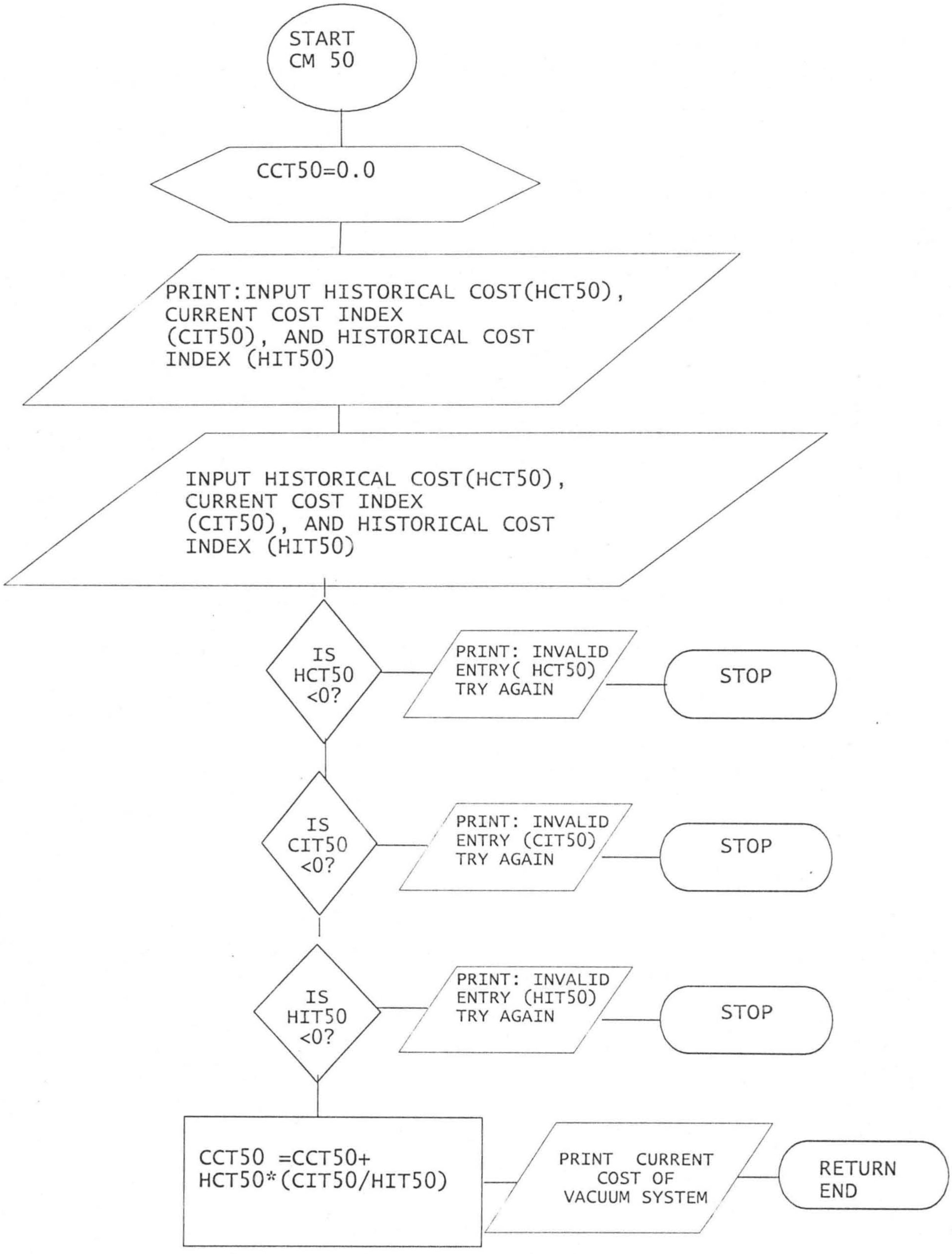
CALCULATION OF CURRENT COST OF FFA RECUPERATOR



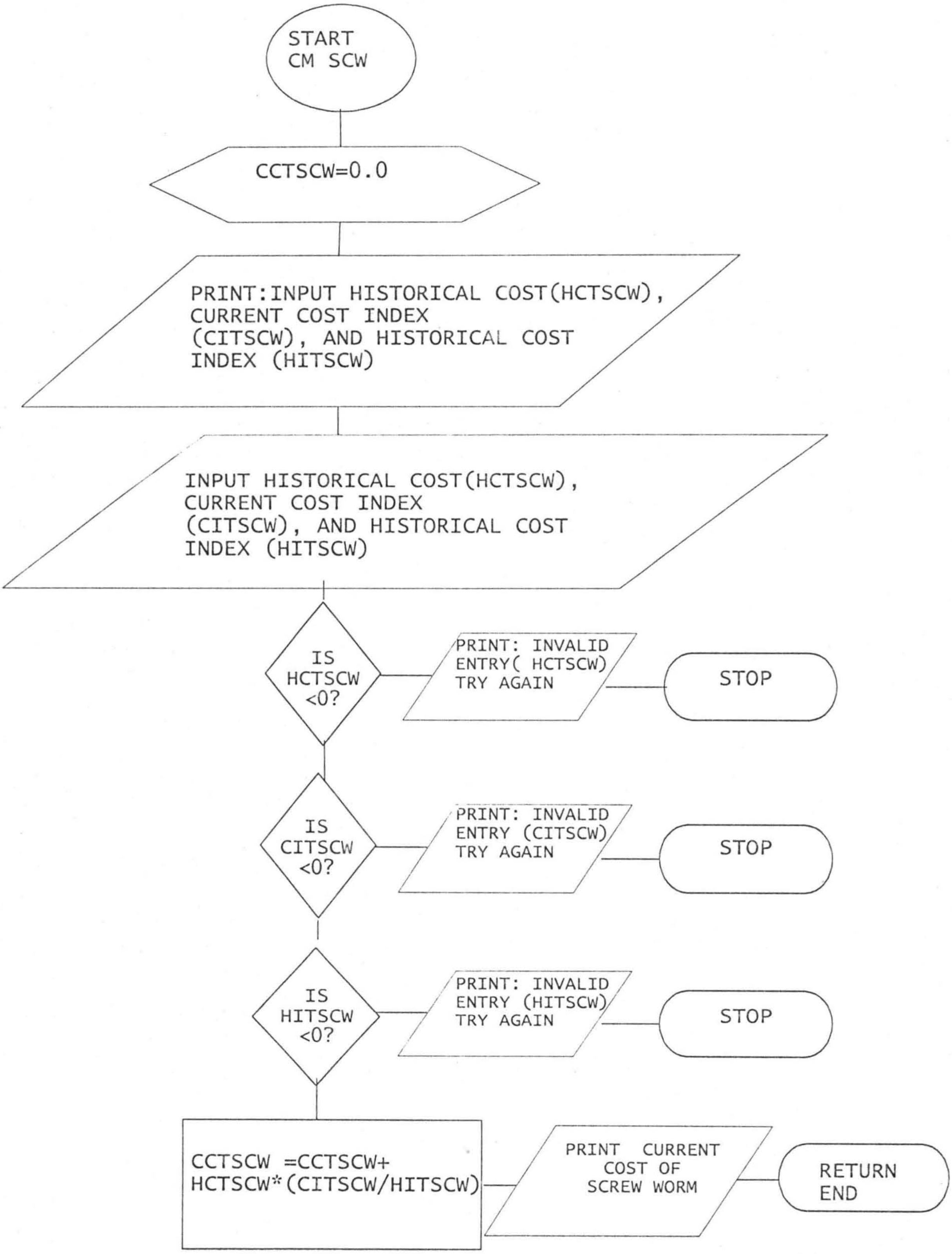
CALCULATION OF CURRENT COST OF PREHEATING TANK



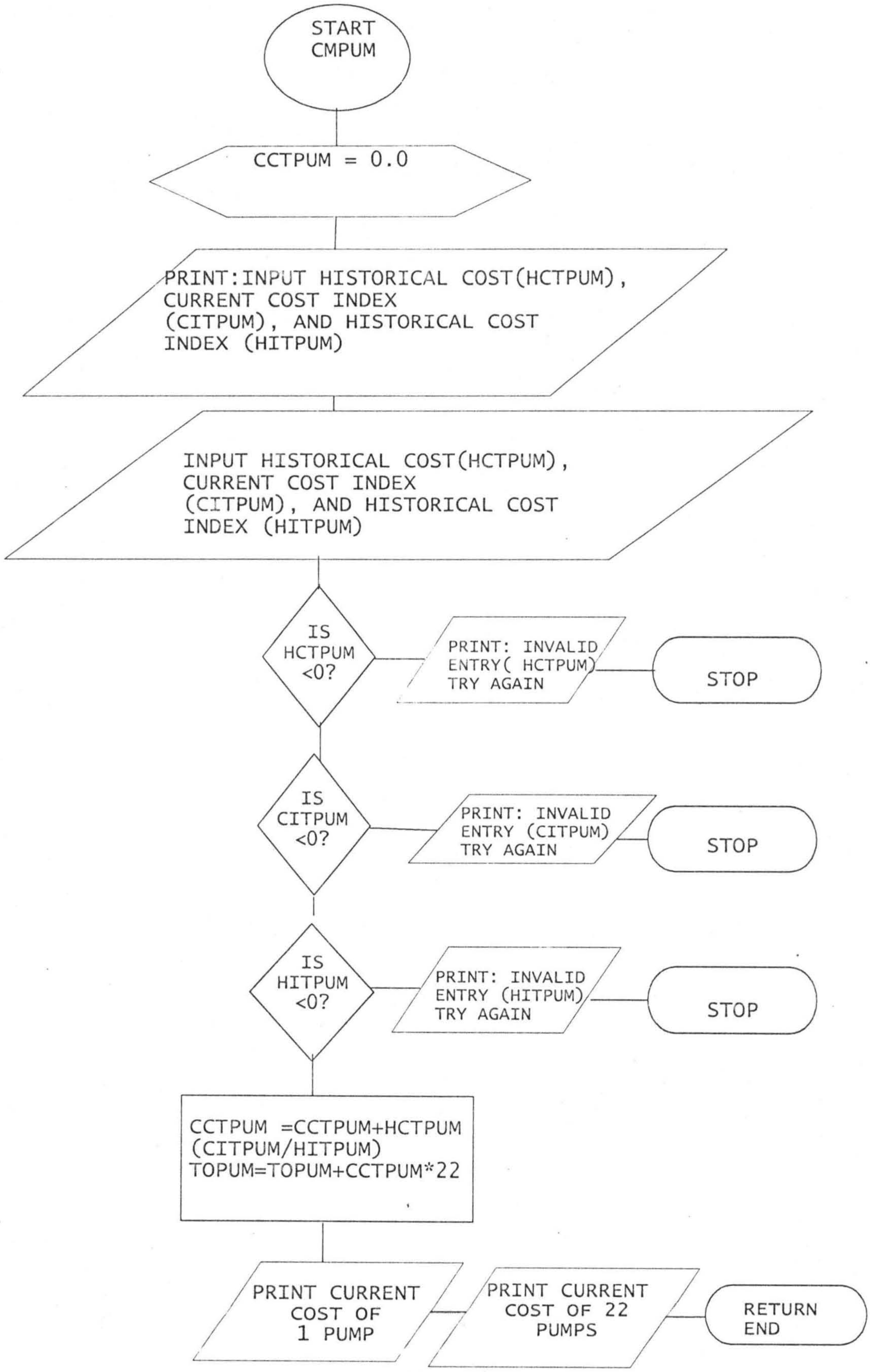
CALCULATION OF CURRENT COST OF VACUUM SYSTEM



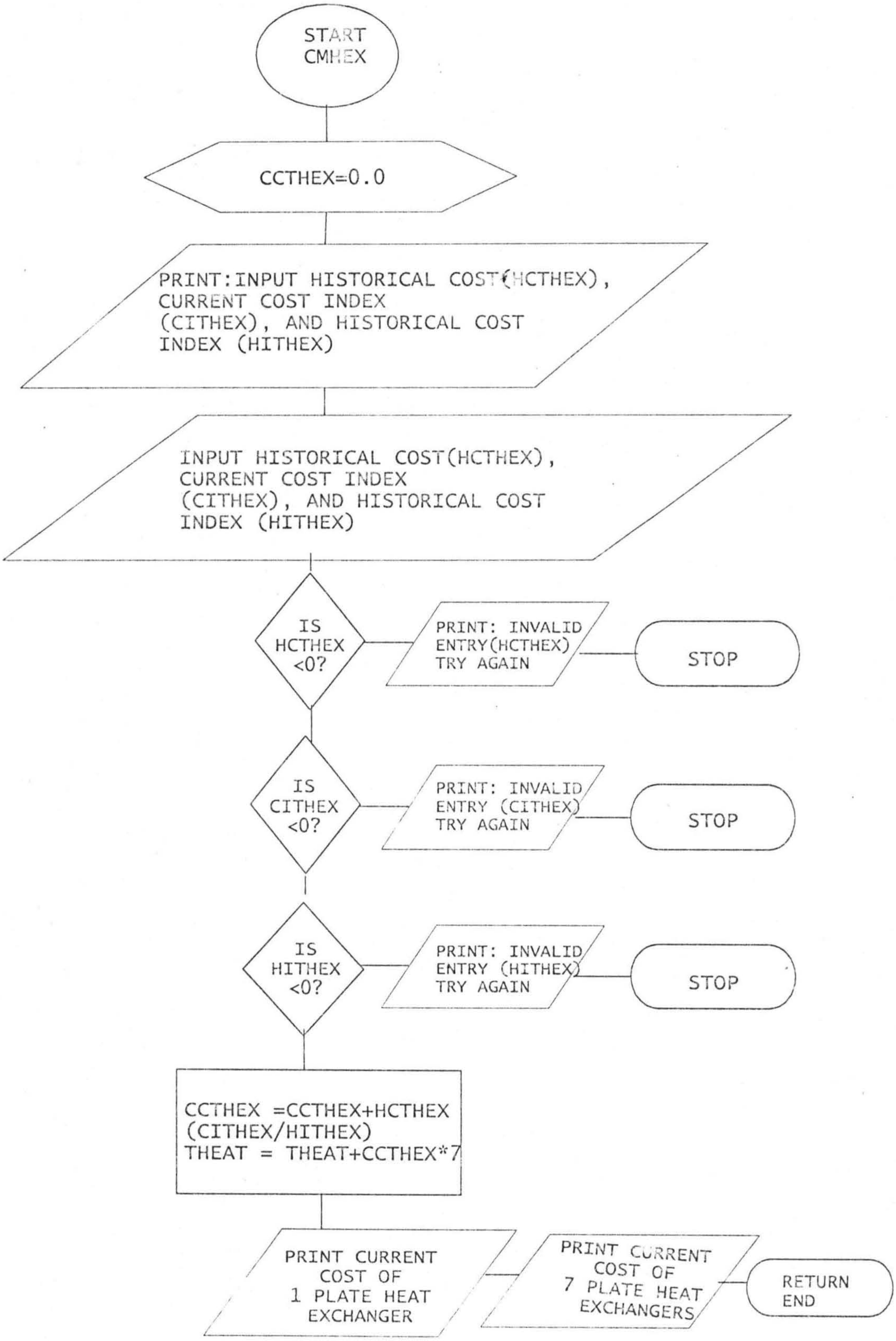
CALCULATION OF CURRENT COST OF SCREW WORM



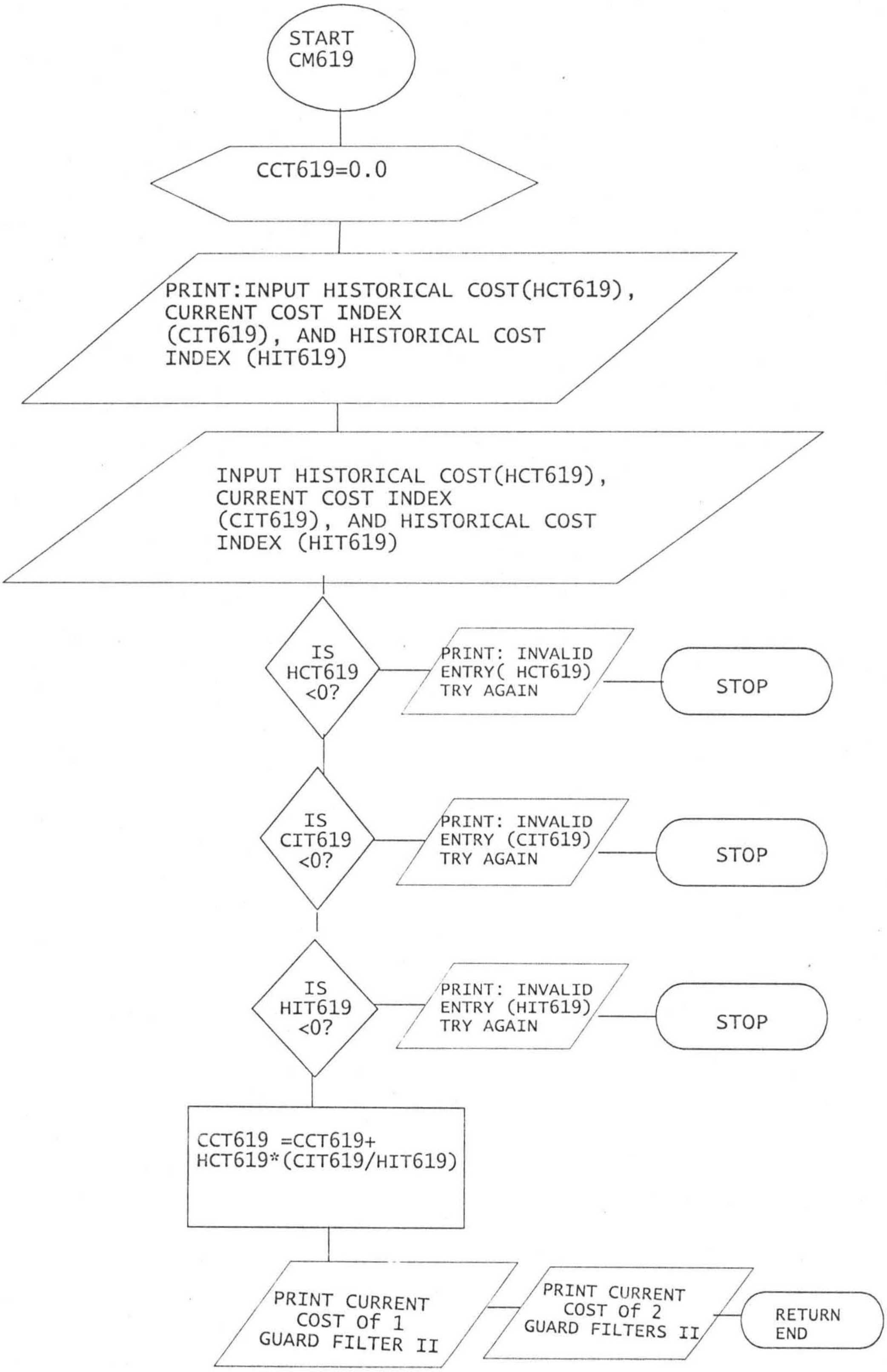
CALCULATION OF CURRENT COST OF 22 PUMPS



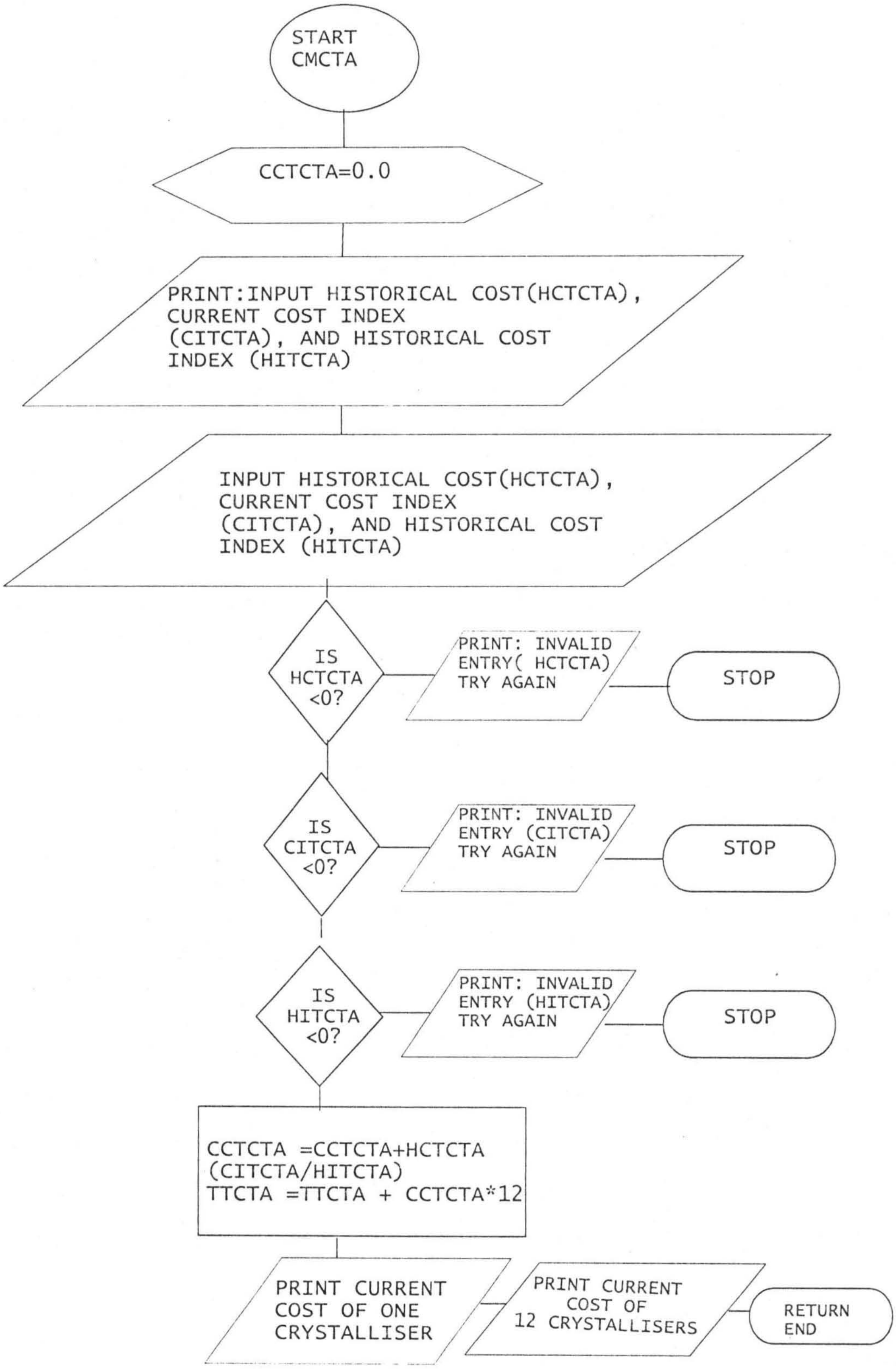
CALCULATION OF CURRENT COST OF 7 PLATE HEAT EXCHANGERS



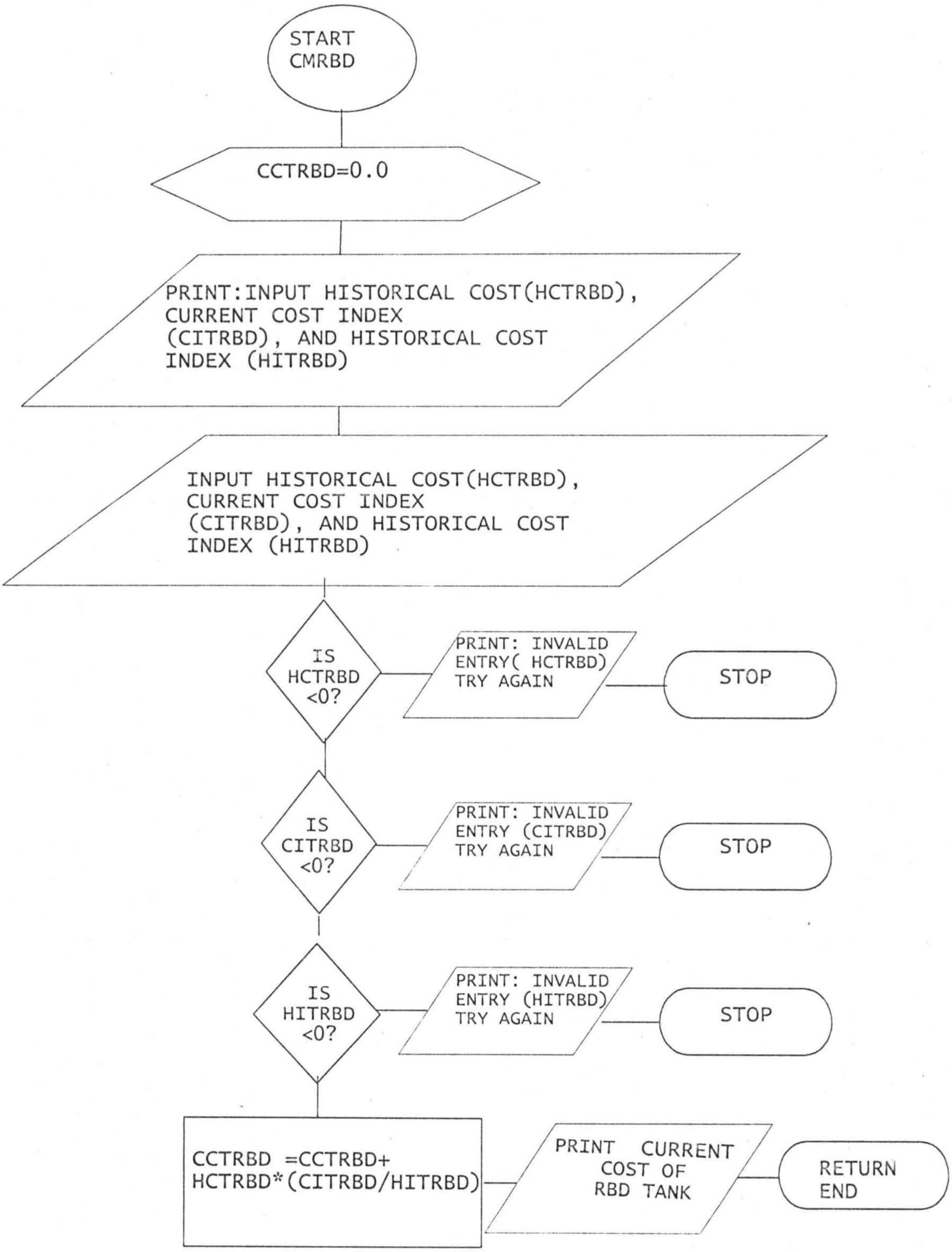
CALCULATION OF CURRENT COST OF GUARD FILTER II



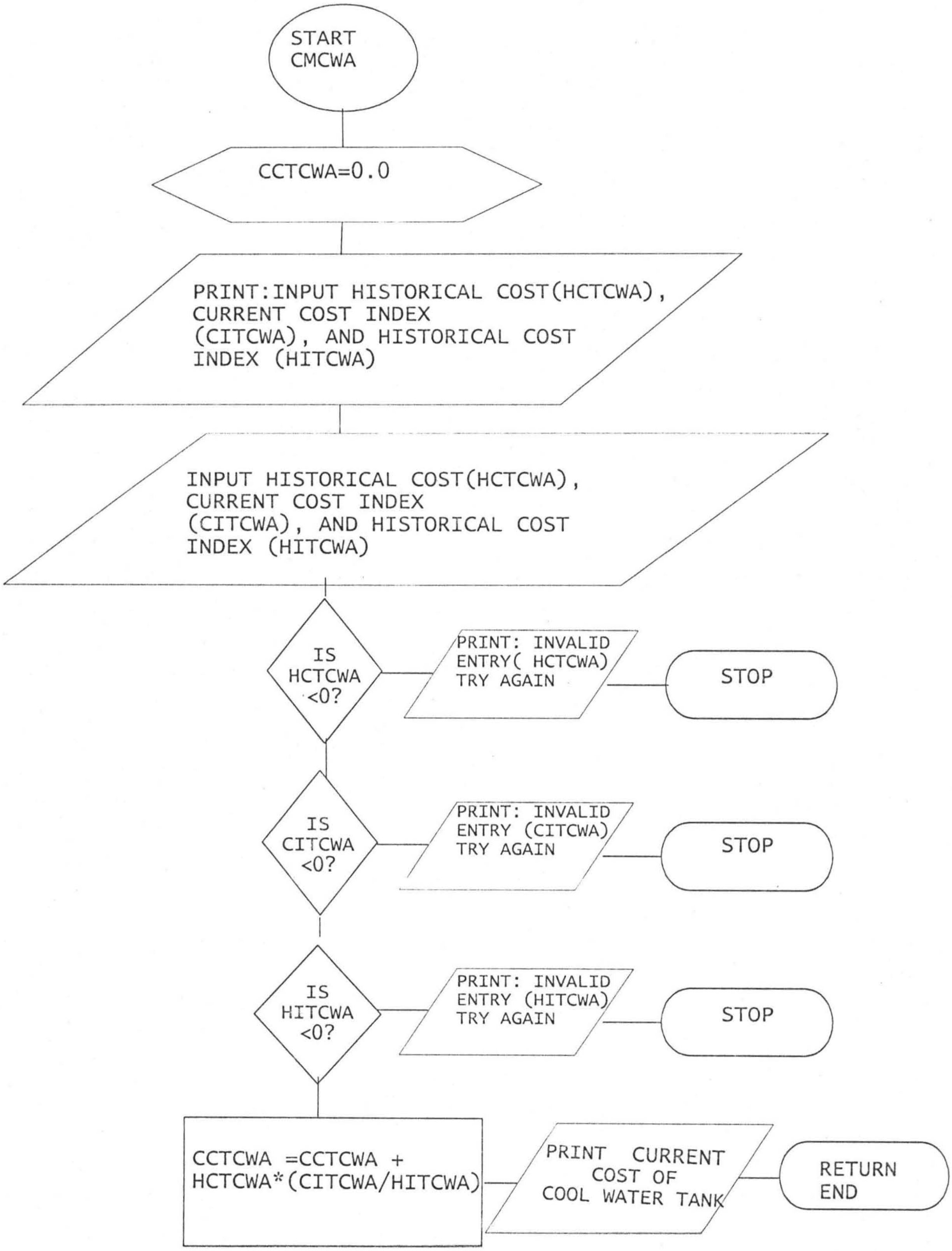
CALCULATION OF CURRENT COST OF 12 CRYSTALLISERS



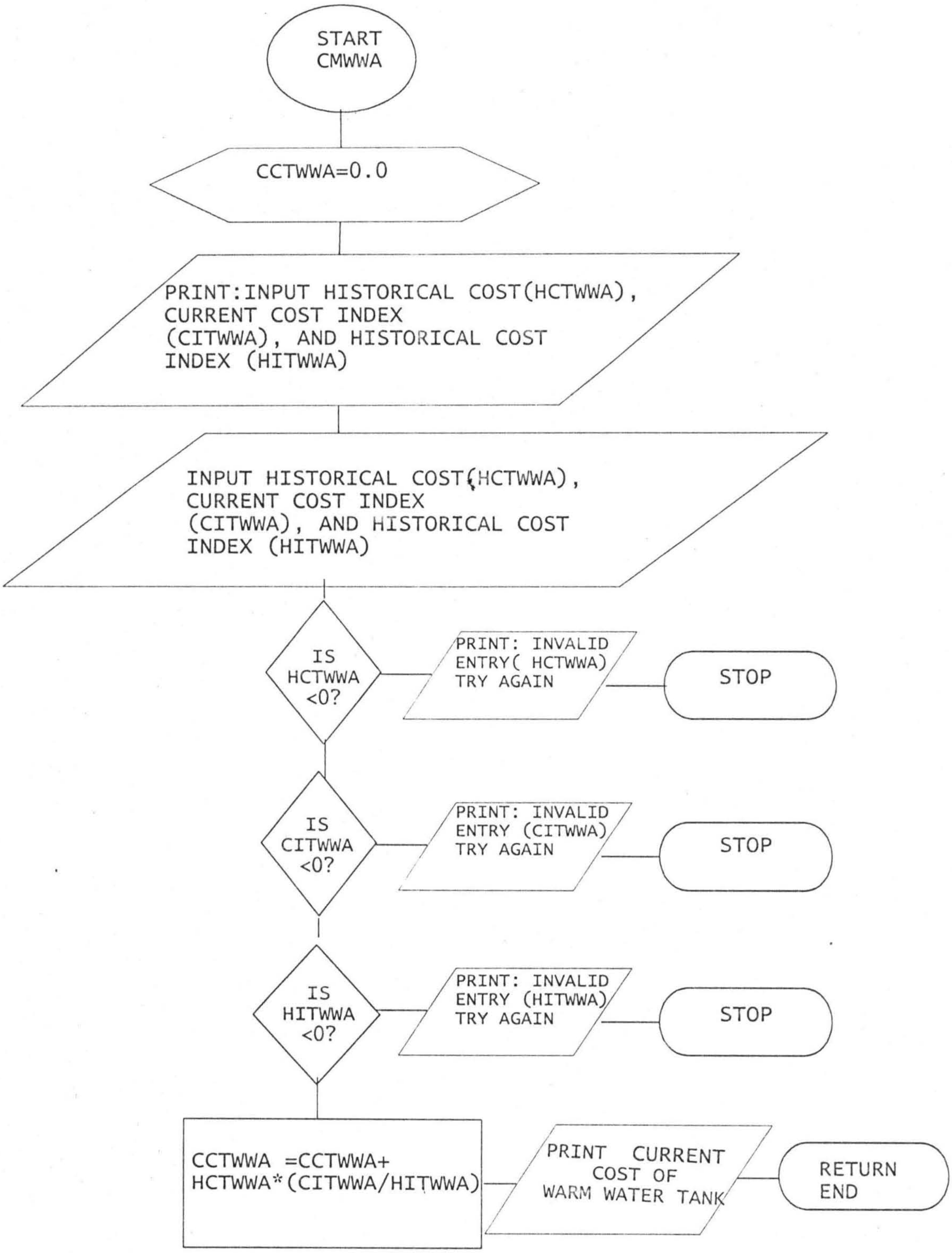
CALCULATION OF CURRENT COST OF RBD TANK



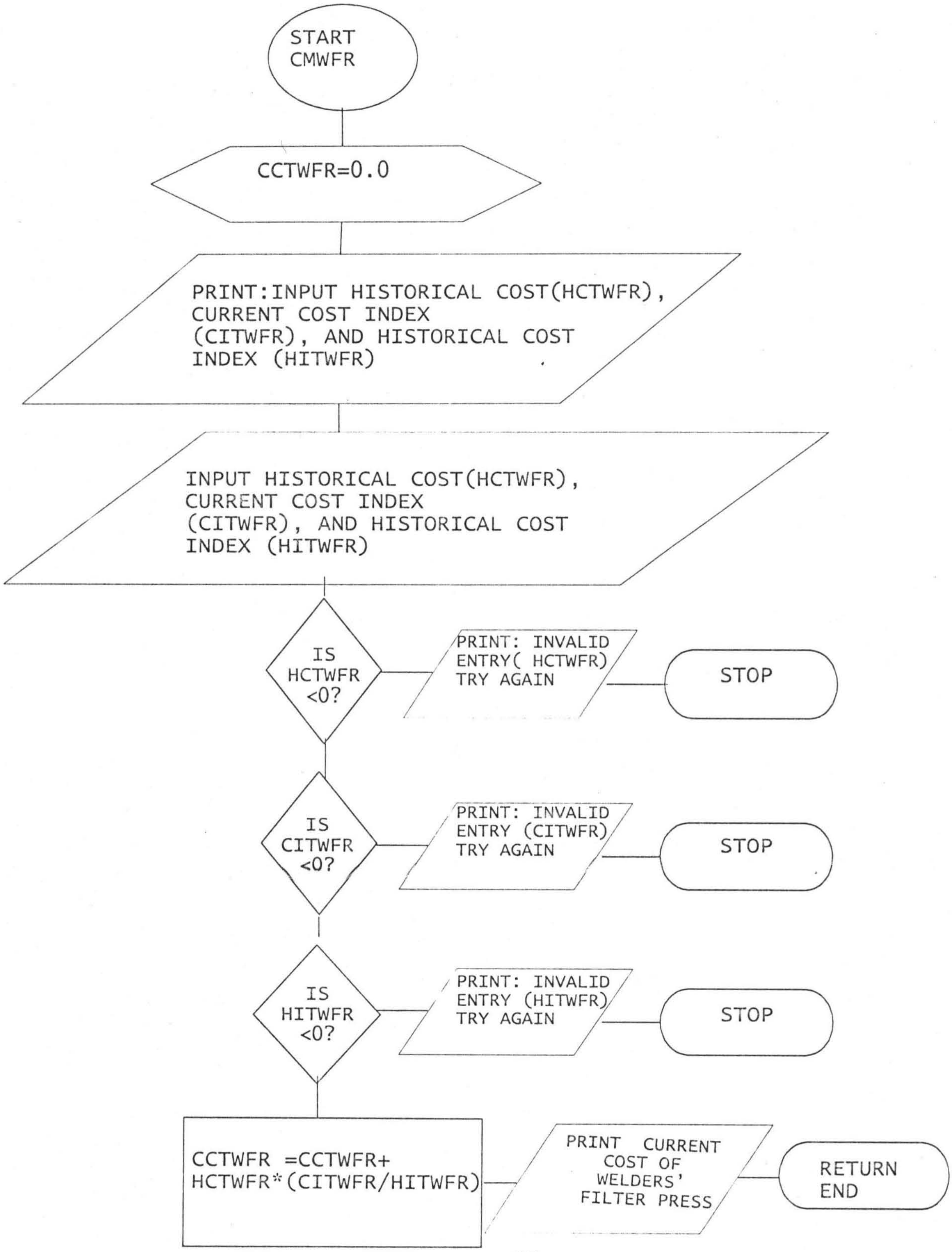
CALCULATION OF CURRENT COST OF COOL WATER TANK



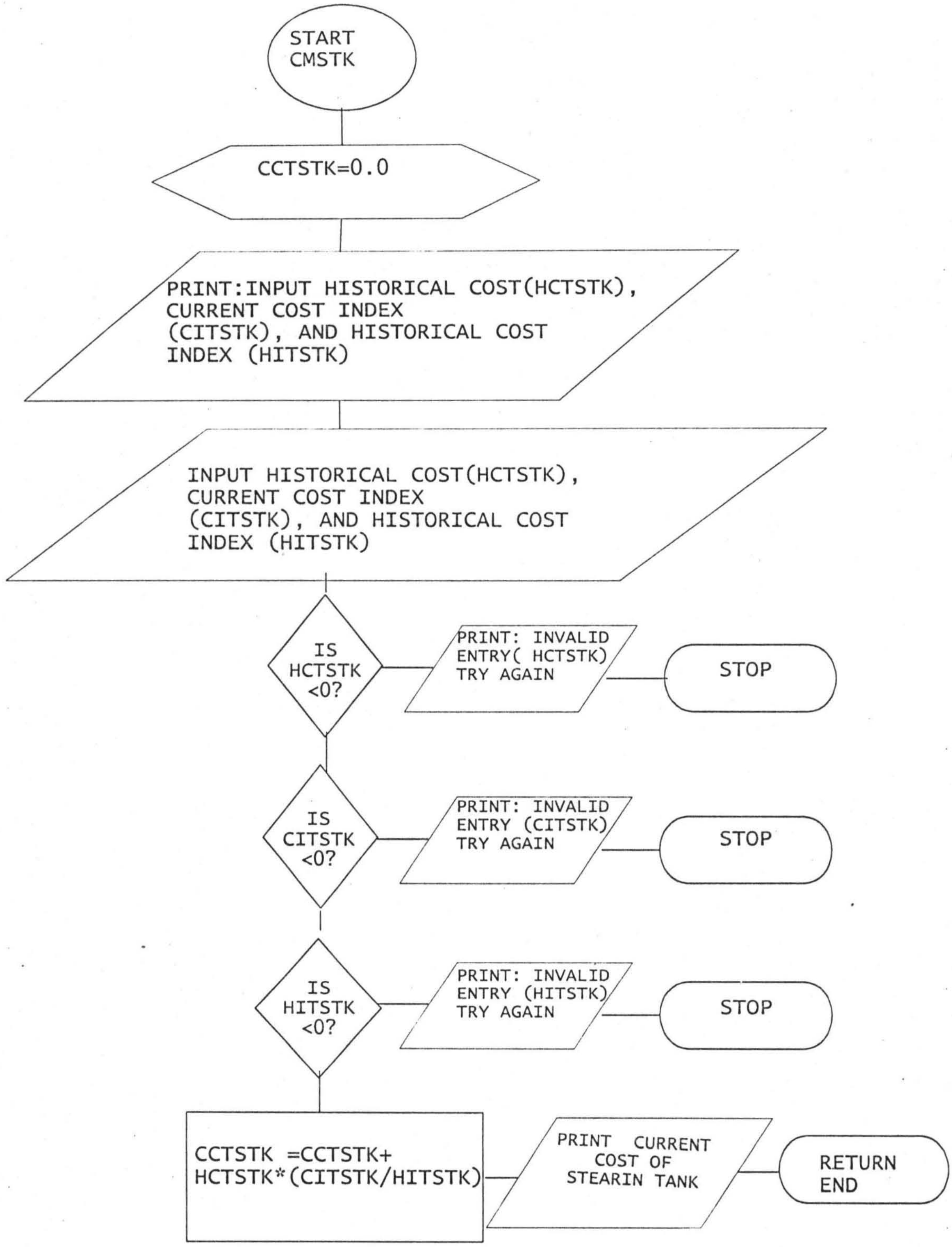
CALCULATION OF CURRENT COST OF WARM WATER TANK



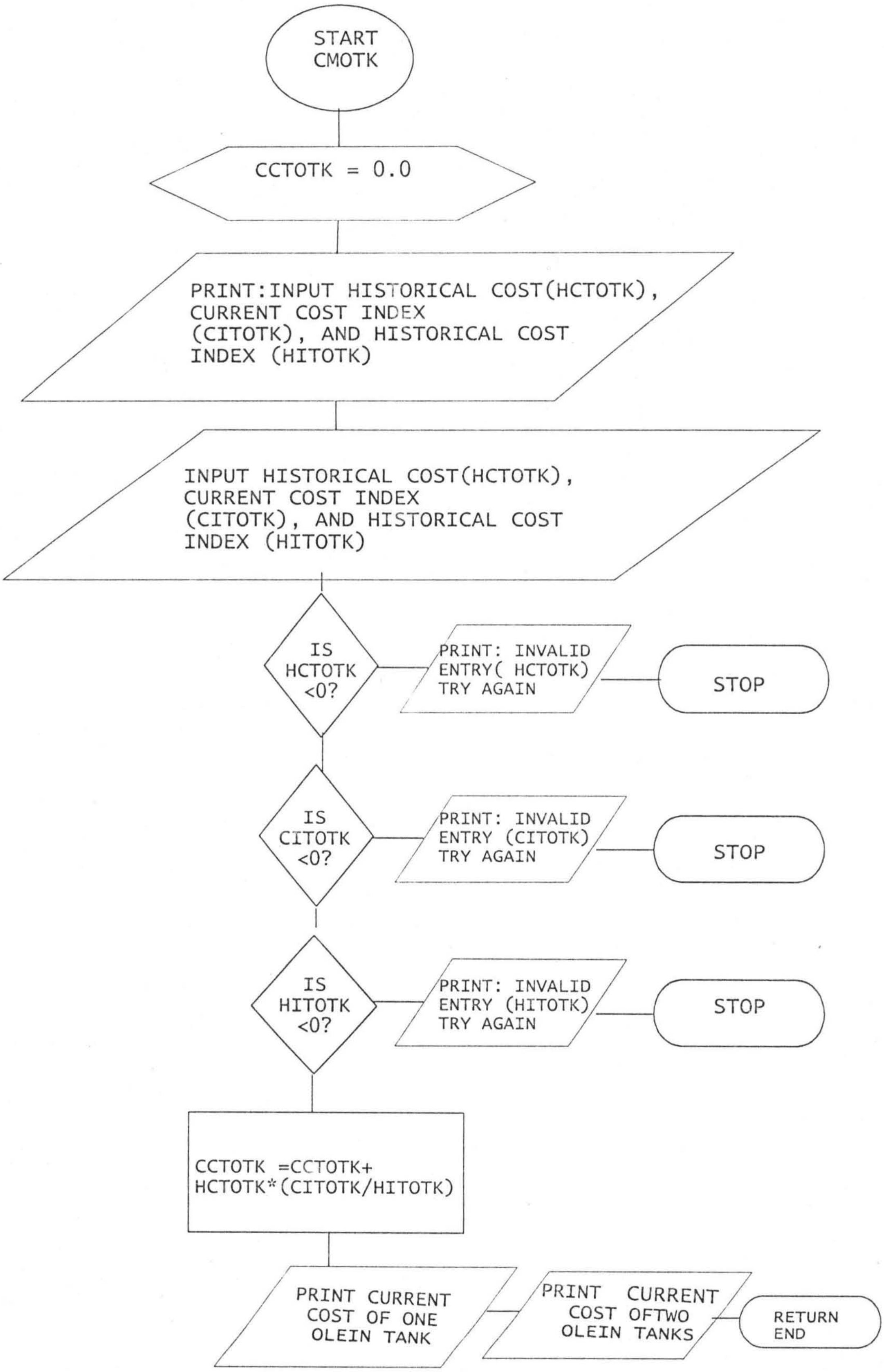
CALCULATION OF CURRENT COST OF WELDERS' FILTER PRESS



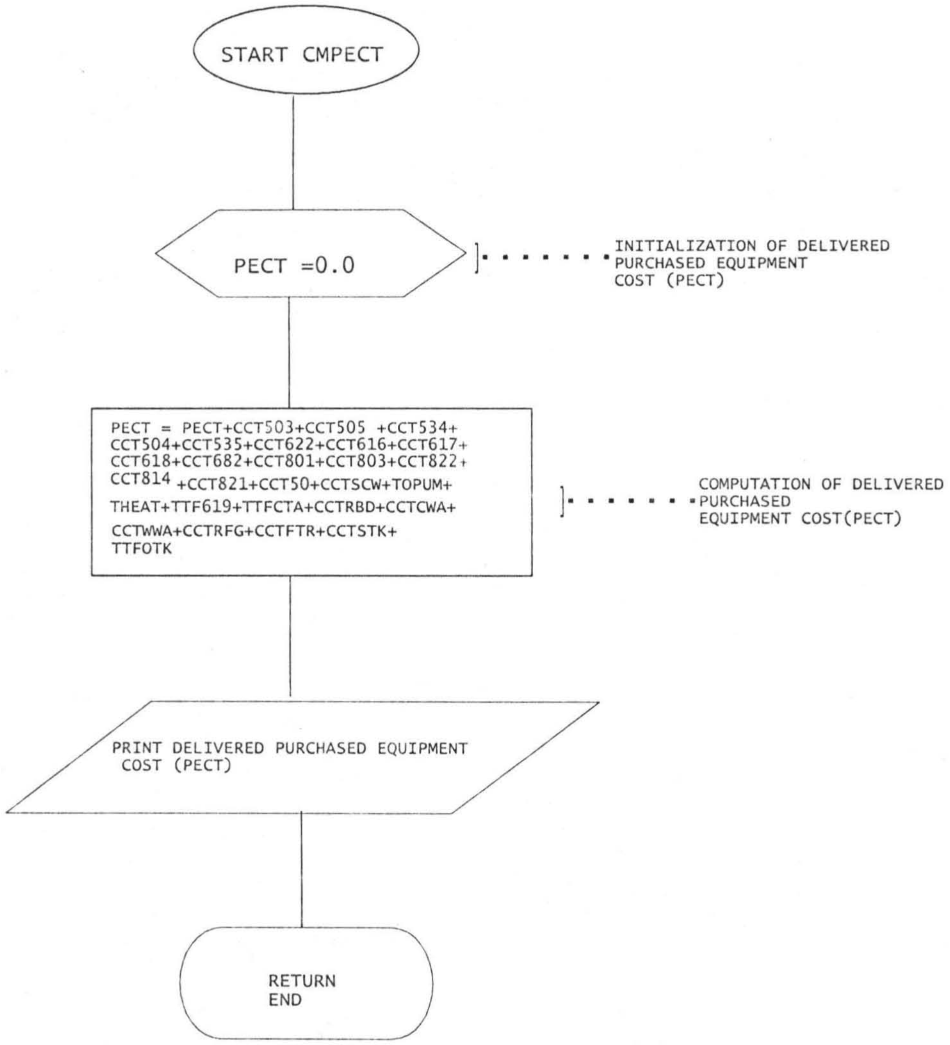
CALCULATION OF CURRENT COST OF STEARIN TANK



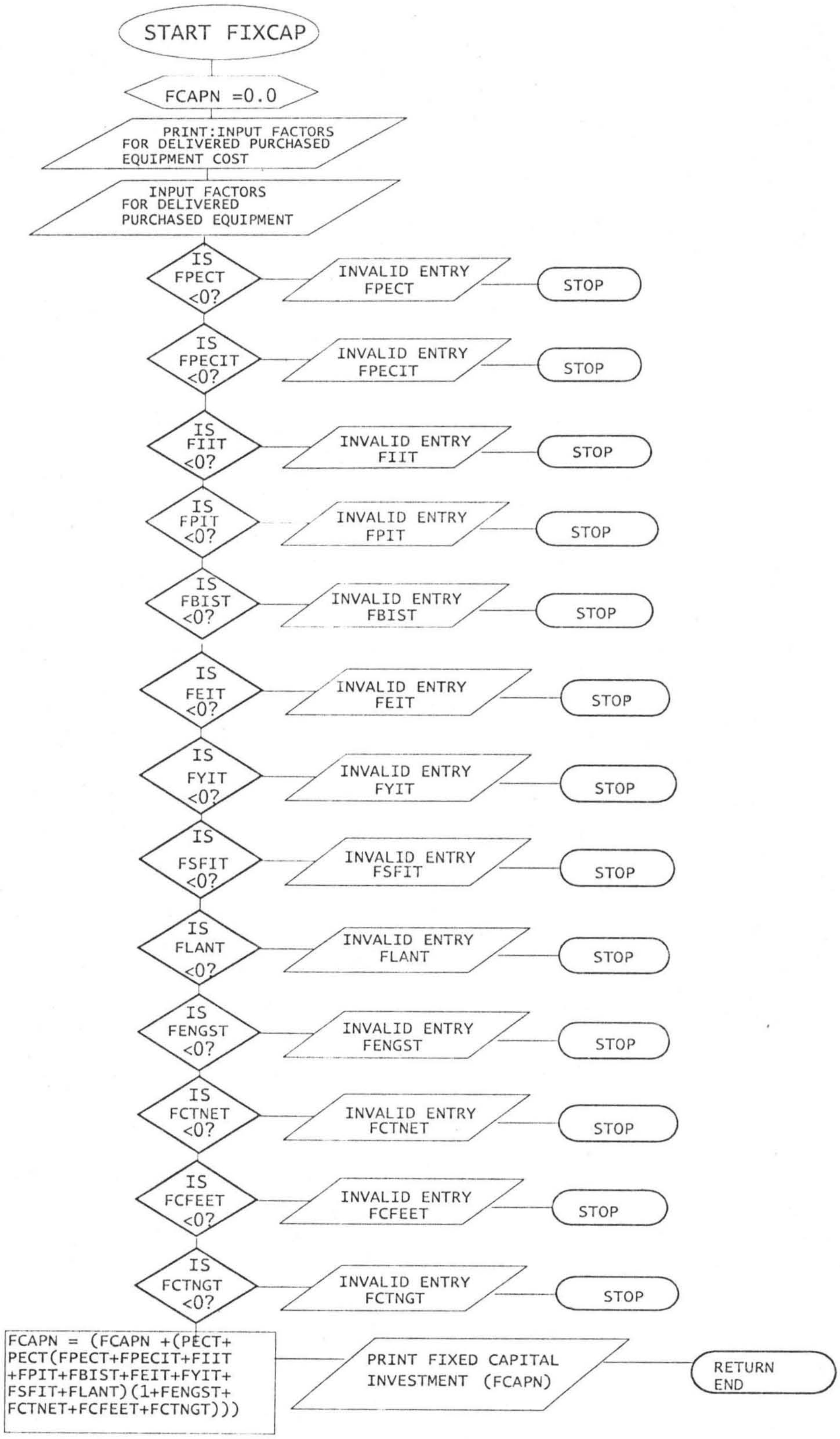
CALCULATION OF CURRENT COST OF OLEIN TANK



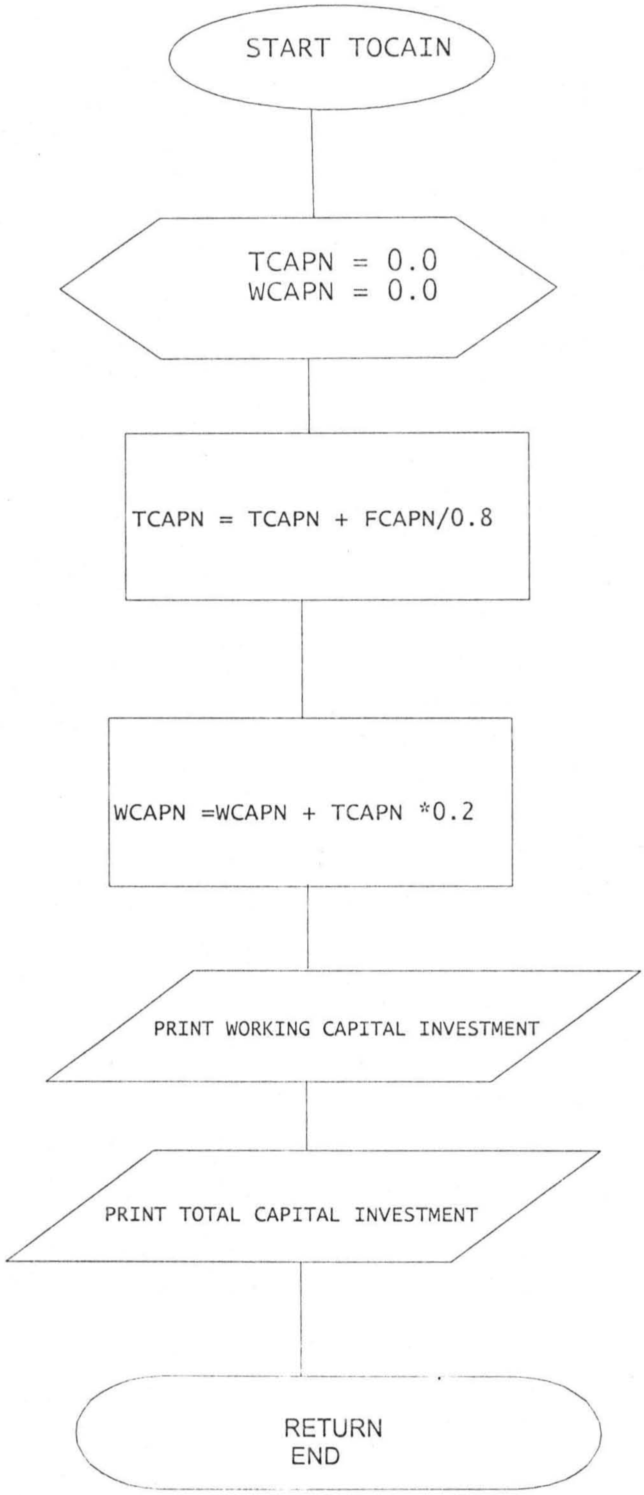
COMPUTATION OF PURCHASED EQUIPMENT COST



CALCULATION OF FIXED CAPITAL INVESTMENT



COMPUTATION OF WORKING AND TOTAL CAPITAL INVESTMENTS



APPENDIX A2: Program CINDEX Representing The Cost Index Method

```
      PROGRAM CINDEX
      INTEGER CUYEAR
      COMMON PECT
C This program computes the Current cost of Palm Oil Refinery and
C Fractionation Plant making use of Cost Indices to account for
C fluctuation in the cost of equipment due to inflation, Government
C regulation, type and size of equipment, location of the plant,
C operating time and rate of production, and a host of other factors.
C
C  AUTHOR:          NGUBI FREDERICKS WIRSIY
C  MAT. NO.:        M. ENG./SEET/573/2000/2001
C  COURSE TITLE:    M.ENG PROJECT WORK
C  COURSE CODE:     CEE 623
C  PROJECT TITLE:   EFFECT OF COST FLUCTUATION ON THE DESIGN OF A PALM
C                   OIL REFINERY AND FRACTIONATION INDUSTRY
C  SUPERVISOR:      DR. K.R.ONIFADE
C  LANGUAGE:        FORTRAN 77
C  DATE:            5 MAY,2002
C
C  FILES:           CINDEX.LST,CINDEX.RES
C  ARRAYS           NONE
C

C   SECTION FOR DEFINITION OF SUBROUTINES
C
C  BEGIN                    INTRODUCTORY MODULE
C  CM503                    COST MODULE FOR CaCO3 TANK
C  CM505                    COST MODULE FOR MIXING TANK
C  CM534                    COST MODULE FOR PHOSPHORIC ACID TANK
C  CM504                    COST MODULE FOR DRIER
C  CM535                    COST MODULE FOR BLEACHING EARTH TANK
C  CM622                    COST MODULE FOR CONTINUOUS BLEACHING REACTOR
C  CM616                    COST MODULE FOR BERNARDINNI FILTER
C  CM617                    COST MODULE FOR STEEL SUPER FILTER
C  CM618                    COST MODULE FOR GUARD FILTER I
C  CM682                    COST MODULE FOR DECANTER
C  CM801                    COST MODULE FOR STORAGE TANK
C  CM803                    COST MODULE FOR DEAERATOR/DRIER
C  CM822                    COST MODULE FOR DEODORISER
C  CM814                    COST MODULE FOR FFA RECUPERATOR
C  CM821                    COST MODULE FOR PREHEATING TANK
C  CM50                     COST MODULE FOR VACUMM SYSTEM
C  CMSCW                    COST MODULE FOR SCREW WORM
C  CMPUM                    COST MODULE FOR PUMPS
C  CMHEX                    COST MODULE FOR HEAT EXCHANGERS
C  CM619                    COST MODULE FOR GUARD FILTER II
C  CMRST                    COST MODULE FOR CRYSTALLISER
C  CMRBD                    COST MODULE FOR RBD TANK
C  CMCWA                    COST MODULE FOR COLD WATER TANK
C  CMWWA                    COST MODULE FOR WARM WATER TANK
C  CMWFR                    COST MODULE FOR WELDERS' FILTER PRESS
C  CMSTK                    COST MODULE FOR STEARIN TANK
C  CMOTK                    COST MODULE FOR OLEIN TANK
C  CMPECT                   COST MODULE FOR DELIVERED PURCHASED
C                           EQUIPMENT COST
C  FIXCAP                   COST MODULE FOR FIXED CAPITAL INVESTMENT
C  TOCAIN                   COST MODULE FOR WORKING & TOTAL CAPITAL
INVESTMENTS
```

```
      PRINT*,'Input Current year for Cost Indices (CUYEAR)'
      READ(*,*)MRYEAR,CUYEAR
      IF(MRYEAR.LT.1996)THEN
         PRINT10,'INVALID ENTRY:',MRYEAR,'TRY AGAIN!'
   10    FORMAT(/,10X,A,1X,I5,2X,A)
         STOP
      ELSE
         WRITE(*,13)'APPENDIX A2:Results for Program CINDEX,'
         WRITE(*,15)'Representing the Cost Index Method'
         WRITE(2,13)'Appendix A:Results for Program CINDEX,'
         WRITE(2,15)'representing the Cost Index Method'
         WRITE(*,20)'The Reference Year used is:',MRYEAR
         WRITE(2,20)'The Reference Year used is:',MRYEAR
         WRITE(*,22)
         WRITE(2,22)
         WRITE(*,25)'The Current Year is:',CUYEAR
         WRITE(2,25)'The Current Year is:',CUYEAR
         WRITE(*,27)
         WRITE(2,27)
   13    FORMAT(/,12X,A)
   15    FORMAT(12X,A)
   20    FORMAT(/,22X,A,4X,I5)
   22    FORMAT(22X,27('-'),5X,4('-'))
   25    FORMAT(/,22X,A,11X,I5)
   27    FORMAT(22X,20('-'),12X,4('-'))
      ENDIF
      CONTINUE
      WRITE(*,40)'Name of Equipment','Cost of Equipment in 2002 (Naira)'
      WRITE(2,40)'Name of Equipment','Cost of Equipment in 2002 (Naira)'
   40 FORMAT(/,11X,A,17X,A)
      WRITE(*,50)
      WRITE(2,50)
   50 FORMAT(11X,17('-'),17X,33('-'))
      RETURN
      END

C                   VARIABLES
C  CM                              Cost Module
C  For instance CM503 stands for Cost Module for equipment 503 which is
C the CaCO3 tank, etc...

C  CCT                             Current Cost of  equipment
C  HCT                             Historical Cost of equipment
C  CIT                             Current cost Index of equipment
C  HIT                             Historical cost Index of equipment
C
C  For instance,CCT503,HCT503,CIT503 and HIT503 stand for Current Cost
of
C  CaCO3 tank, Historical Cost of CaCO3 tank,Current cost Index of CaCO3
C  tank, Historical cost Index of CaCo3 tank designated 503.


      SUBROUTINE CM503(CCT503,HCT503,CIT503,HIT503)
C Subroutine CM503 calculates the Current cost of CaCO3 Tank.
      CCT503=0.0
      PRINT1,'Input historical Cost (HCT503),',
     $'Current Cost index (CIT503),',
     $'and historical Cost index (HIT503) of Calcium Carbonate Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT503,CIT503,HIT503
```

```
C
C SECTION FOR COMPUTING THE INDIVIDUAL EQUIPMENT COSTS
C
      PECT=0
      CALL BEGIN(NRYEAR,CUYEAR)
      CALL CM503(CC503,HC503,CI503,HI503)
      CALL CM505(CC505,HC505,CI505,HI505)
      CALL CM534(CC534,HC534,CI534,HI534)
      CALL CM504(CC504,HC504,CI504,HI504)
      CALL CM535(CC535,HC535,CI535,HI535)
      CALL CM622(CC622,HC622,CI622,HI622)
      CALL CM616(TTF616,CC616,HC616,CI616,HI616)
      CALL CM617(CC617,HC617,CI617,HI617)
      CALL CM618(CC618,HC618,CI618,HI618)
      CALL CM682(CC682,HC682,CI682,HI682)
      CALL CM801(CC801,HC801,CI801,HI801)
      CALL CM803(CC803,HC803,CI803,HI803)
      CALL CM822(CC822,HC822,CI822,HI822)
      CALL CM814(CC814,HC814,CI814,HI814)
      CALL CM821(CC821,HC821,CI821,HI821)
      CALL CM50(CC50,HC50,CI50,HI50)
      CALL CMSCW(CCSCW,HCSCW,CISCW,HISCW)
      CALL CMPUM(TOPUMS,CCPUM,HCPUM,CIPUM,HIPUM)
      CALL CMHEX(THEATS,CCHEX,HCHEX,CIHEX,HIHEX)
      CALL CM619(CC619,HC619,CI619,HI619,TTF619)
      CALL CMRST(CCRST,HCRST,CIRST,HIRST,TTCCTA)
      CALL CMRBD(CCRBD,HCRBD,CIRBD,HIRBD)
      CALL CMCWA(CCCWA,HCCWA,CICWA,HICWA)
      CALL CMWWA(CCWWA,HCWWA,CIWWA,HIWWA)
      CALL CMWFR(CCFTR,HCFTR,CIFTR,HIFTR)
      CALL CMSTK(CCSTK,HCSTK,CISTK,HISTK)
      CALL CMOTK(CCOTK,HCOTK,CIOTK,HIOTK,TTFOTK)
C
C  SECTION FOR COMPUTING DELIVERED PURCHASED EQUIPMENT COST
C
C
      CALL CMPECT(PECT,CC503,CC505,CC534,CC504,CC535,CC622,TTF616,
     $CC617,CC618,CC682,CC801,CC803,CC822,CC814,CC821,CC50,CCSCW,
     $TOPUMS,THEATS,TTF619,TTCCTA,CCRBD,CCCWA,CCWWA,CCFTR,CCSTK,
     $TTFOTK)

C     SECTION FOR COMPUTING THE FIXED CAPITAL INVESTMENT
C
      CALL FIXCAP(FCAPIN,PECT,FPEC,FPECI,FII,FPI,FBIS,FEI,FYI,FSFI,FLAN
     $,FENGS,FCTNE,FCFEE,FCTNG)
C
C     SECTION FOR COMPUTING THE WORKING & TOTAL CAPITAL INVESTMENTS
C
      CALL TOCAIN(FCAPIN,TCAPIN,WCAPIN)
      STOP
      END

C
C    SECTION FOR SUBROUTINES
C

      SUBROUTINE BEGIN(MRYEAR,CUYEAR)
      INTEGER CUYEAR
      OPEN(2,FILE='CINDEX.RES')
      REWIND(2)
      PRINT*,'Input Reference year for Cost Indices (MRYEAR)'
```

```
      IF(HCT503.LE.0)THEN
          PRINT5,'Invalid Entry (HCT503) :',HCT503,'Try Again!'
    5     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(CIT503.LE.0)THEN
          PRINT10,'Invalid Entry (CIT503) :',CIT503,'TRY AGAIN!'
   10     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(HIT503.LE.0)THEN
          PRINT15,'Invalid Entry (HIT503) :',HIT503,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula calculate the cost of Calcium Carbonate Tank.
         CCT503=CCT503+HCT503*(CIT503/HIT503)
         WRITE(*,20)' CaCO3 Tank ','N', CCT503
         WRITE(2,20)' CaCO3 Tank ','N', CCT503
   20    FORMAT(/,10X,A,T54,A,F15.2)
         ENDIF
         RETURN
         END


      SUBROUTINE CM505(CCT505,HCT505,CIT505,HIT505)
      CCT505=0.0
C Subroutine CM505 calculates the current cost of Mixing Tank
      PRINT5,'Input historical cost (HCT505),',
     $'current cost index (CIT505),',
     $'and historical cost+ index (HIT505) of Mixing Tank'
    5 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT505,CIT505,HIT505
      IF(HCT505.LE.0)THEN
           PRINT15,'Invalid Entry (HCT505) :',HCT505,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
      ELSEIF(CIT505.LE.0)THEN
           PRINT25,'Invalid Entry (CIT505) :',CIT505,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
      ELSEIF(HIT505.LE.0)THEN
           PRINT35,'Invalid Entry (HIT505) :',HIT505,'!'
  35       FORMAT(/,1X,A,1X,F15.2,1X,A)
      ELSE
           CCT505=CCT505+HCT505*(CIT505/HIT505)
           WRITE(*,45)'Mixing Tank ','N', CCT505
           WRITE(2,45)'Mixing Tank ','N', CCT505
   45      FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM534(CCT534,HCT534,CIT534,HIT534)
      CCT534=0.0
C Subroutine CM534 calculates the Current cost of Phosphoric Acid Tank
      PRINT1,'Input historical cost (HCT534),',
     $'Current cost index (CIT534),',
     $'historical cost index (HIT534) of Phosphoric Acid Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT534,CIT534,HIT534
      IF(HCT534.LE.0)THEN
           PRINT5,'Invalid Entry (HCT534) :',HCT534,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
```

```
      ELSEIF(CIT534.LE.0)THEN
           PRINT15,'Invalid Entry (CIT534) :',CIT534,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
      ELSEIF(HIT534.LE.0)THEN
           PRINT25,'Invalid Entry (HIT534) :',HIT534,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
        CCT534=CCT534+HCT534*(CIT534/HIT534)
        WRITE(*,35)' Phosphoric Acid Tank ','N',CCT534
        WRITE(2,35)' Phosphoric Acid Tank ','N',CCT534
   35   FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

        SUBROUTINE CM504(CCT504,HCT504,CIT504,HIT504)
C Subroutine CM504 calculates the Current cost of Drier.
        CCT504=0.0
        PRINT1,'Input historical cost (HCT504),',
     $'Current cost index (CIT504),',
     $'historical cost index (HIT504) of Drier'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT504,CIT504,HIT504
      IF(HCT504.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT504) :',HCT504,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT504.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT504) :',CIT504,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT504.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT504) :',HIT504,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT504=CCT504+HCT504*(CIT504/HIT504)
         WRITE(*,35)'Drier','N', CCT504
         WRITE(2,35)'Drier','N', CCT504
   35    FORMAT(/,10X,A,T54,A,1X,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM535(CCT535,HCT535,CIT535,HIT535)
C Subroutine CM535 calculates the Current cost of Bleaching Earth Tank
      CCT535=0.0
      PRINT1,'Input historical cost (HCT535),',
     $'Current cost index (CIT535),',
     $'historical cost index (HIT535) of Bleaching Earth Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT535,CIT535,HIT535
      IF(HCT535.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT535) :',HCT535,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT535.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT535) :',CIT535,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
```

```
      ELSEIF(HIT535.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT535) :',HIT535,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT535=CCT535+HCT535*(CIT535/HIT535)
         WRITE(*,35)'Bleaching Earth Tank ','N',CCT535
         WRITE(2,35)'Bleaching Earth Tank ','N',CCT535
   35    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM622(CCT622,HCT622,CIT622,HIT622)
C Subroutine CM622 calculates the Current cost of continuous Bleaching
Reactor.
      CCT622=0.0
      PRINT1,'Input historical cost (HCT622),',
     $'Current cost index (CIT622),',
     $'historical cost index (HIT622) of continuous Bleaching Reactor'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT622,CIT622,HIT622
      IF(HCT622.LE.0)THEN
        PRINT5,'INVALID ENTRY (HCT622) :',HCT622,'TRY AGAIN!'
    5   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(CIT622.LE.0)THEN
        PRINT15,'INVALID ENTRY (CIT622) :',CIT622,'TRY AGAIN!'
   15   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(HIT622.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT622) :',HIT622,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT622=CCT622+HCT622*(CIT622/HIT622)
         WRITE(*,23)'Continuous Bleaching Reactor ','N',CCT622
         WRITE(2,23)'Continuous Bleaching Reactor ','N',CCT622
   23    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM616(TTF616,CCT616,HCT616,CIT616,HIT616)
C Subroutine CM616 calculates the Current cost of two Bernardinni
Filters.
      CCT616=0.0
      TTF616=0.0
      PRINT1,'Input historical cost (HCT616),',
     $'Current cost index (CIT616),',
     $'historical cost index (HIT616) of Bernardinni Filter'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT616,CIT616,HIT 616
      IF(HCT616.LE.0)THEN
          PRINT5,'INVALID ENTRY (HCT616) :',HCT616,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT616.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT616) :',CIT616,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
```

```
      ELSEIF(HIT616.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT616) :',HIT616,'TRY AGAIN!'
 25      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT616=CCT616+HCT616*(CIT616/HIT616)
         WRITE(*,27)'1 Bernardini Filter','N',CCT616
         WRITE(2,27)'1 Bernardini Filter','N',CCT616
 27      FORMAT(/,10X,A,T54,A,F15.2)
         TTF616=TTF616 + CCT616*2
         WRITE(*,27)'2 Bernardini Filters','N',TTF616
         WRITE(2,27)'2 Bernardini Filters','N',TTF616
 29      FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM617(CCT617,HCT617,CIT617,HIT617)
C  Subroutine CM617 calculates the Current cost of steel super Filter.
      CCT617=0.0
      PRINT1,'Input historical cost (HCT617),',
     $'Current cost index (CIT617),',
     $'historical cost index (HIT617) of steel super Filter'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT617,CIT617,HIT617
      IF(HCT617.LE.0)THEN
        PRINT5,'INVALID ENTRY (HCT617) :',HCT617,'TRY AGAIN!'
  5     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(CIT617.LE.0)THEN
        PRINT15,'INVALID ENTRY (CIT617) :',CIT617,'TRY AGAIN!'
 15     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(HIT617.LE.0)THEN
        PRINT25,'INVALID ENTRY (HIT617) :',HIT617,'TRY AGAIN!'
 25     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSE
        CCT617=CCT617+HCT617*(CIT617/HIT617)
        WRITE(*,31)'Steel Super Filter','N', CCT617
        WRITE(2,31)'Steel Super Filter','N', CCT617
 31     FORMAT(/,10X,A,T54,A,F15.2)
        ENDIF
        RETURN
        END

      SUBROUTINE CM618(CCT618,HCT618,CIT618,HIT618)
C Subroutine CM618 calculates the Current cost of Guard Filter I.
      CCT618=0.0
      PRINT1,'Input historical cost (HCT618),',
     $'Current cost index (CIT618),',
     $'historical cost index (HIT618) of Guard Filter I'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT618,CIT618,HIT618
      IF(HCT618.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT618) :',HCT618,'TRY AGAIN!'
  5      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT618.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT618) :',CIT618,'TRY AGAIN!'
 15      FORMAT(/,1X,A,1X,F15.2,1X,A)
```

```
         STOP
      ELSEIF(HIT618.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT618) :',HIT618,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C The following Formula calculates the Current cost of Guard Filter I.
         CCT618=CCT618+HCT618*(CIT618/HIT618)
         WRITE(*,35)'Guard Filter I ','N', CCT618
         WRITE(2,35)'Guard Filter I ','N', CCT618
   35    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM682(CCT682,HCT682,CIT682,HIT682)
C Subroutine CM682 calculates the Current cost of Decanter.
      CCT682=0.0
      PRINT1,'Input historical cost (HCT682),',
     $'Current cost index (CIT682),',
     $'historical cost index (HIT682) of Decanter'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT682,CIT682,HIT682
      IF(HCT682.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT682) :',HCT682,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT682.LE.0)THEN
         PRINT15,'INVALID ENTRY (CCT682) :',CCT682,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT682.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT682) :',HIT682,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT682=CCT682+HCT682*(CIT682/HIT682)
         WRITE(*,39)'Decanter','N', CCT682
         WRITE(2,39)'Decanter','N', CCT682
   39    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM801(CCT801,HCT801,CIT801,HIT801)
C Subroutine CM801 calculates the Current cost of Storage Tank .
      CCT801=0.0
      PRINT1,'Input historical cost (HCT801),',
     $'Current cost index (CIT801),',
     $'historical cost index (HIT801) of Storage Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT801,CIT801,HIT801
      IF(HCT801.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT801) :',HCT801,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT801.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT801) :',CIT801,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT801.LE.0)THEN
```

```
         PRINT25,'INVALID ENTRY (HIT801) :',HIT801,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT801=CCT801+HCT801*(CIT801/HIT801)
         WRITE(*,35)'Storage Tank ','N', CCT801
         WRITE(2,35)'Storage Tank ','N', CCT801
   35    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM803(CCT803,HCT803,CIT803,HIT803)
C Subroutine CM803 calculates the Current cost of Dearator/Drier.
      CCT803=0.0
      PRINT1,'Input historical cost (HCT803),',
     $'Current cost index (CIT803),',
     $'historical cost index (HIT803) of Deaerator/Drier'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT803,CIT803,HIT803
      IF(HCT803.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT803) :',HCT803,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT803.LE.0)THEN
         PRINT15,'INVALID ENTRY (CCT803) :',CIT803,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT803.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT803) :',HIT803,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT803=CCT803+HCT803*(CIT803/HIT803)
         WRITE(*,35)'Dearator/Drier','N', CCT803
         WRITE(2,35)'Dearator/Drier','N', CCT803
   35    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM822(CCT822,HCT822,CIT822,HIT 822)
C Subroutine CM calculates the Current cost of Deodoriser.
      CCT822=0.0
      PRINT1,'Input historical cost (HCT822),',
     $'Current cost index (CIT822),',
     $'historical cost index (HIT822) of Deodoriser'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT822,CIT822,HIT822
      IF(HCT822.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT822) :',HCT822,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT822.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT822) :',CIT822,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT822.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT822) :',HIT822,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
```

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      ELSE
         CCT822=CCT822+HCT822*(CIT822/HIT822)
         WRITE(*,53)'Deodoriser','N', CCT822
         WRITE(2,53)'Deodoriser','N', CCT822
   53    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM814(CCT814,HCT814,CIT814,HIT814)
C Subroutine CM814 calculates the Current cost of  FFA Recuperator.
      CCT814=0.0
      PRINT1,'Input historical cost (HCT814),',
     $'Current cost index (CIT814),',
     $'historical cost index (HIT814) of FFA Recuperator'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT814,CIT814,HIT814
      IF(HCT814.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT814) :',HCT814,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT814.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT814) :',CIT814,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT814.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT814) :',HIT814,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT814=CCT814+HCT814*(CIT814/HIT814)
         WRITE(*,57)'FFA Recuperator','N', CCT814
         WRITE(2,57)'FFA Recuperator','N', CCT814
   57    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM821(CCT821,HCT821,CIT821,HIT821)
C Subroutine CM821 calculates the Current cost of Preheating Tank.
      CCT821=0.0
      PRINT1,'Input historical cost (HCT821),',
     $'Current cost index (CIT821),',
     $'historical cost index (HIT821) of Preheating Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT821,CIT821,HIT821
      IF(HCT821.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCT821) :',HCT821,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT821.LE.0)THEN
         PRINT15,'INVALID ENTRY (CIT821) :',CIT821,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT821.LE.0)THEN
         PRINT25,'INVALID ENTRY (HIT821) :',HIT821,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCT821=CCT821+HCT821*(CIT821/HIT821)
         WRITE(*,35)'Preheating Tank','N', CCT821
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        WRITE(2,35)'Preheating Tank','N', CCT821
   35   FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM50(CCT50,HCT50,CIT50,HIT50)
C Subroutine CM50 calculates the Current cost of Vacuum System.
      CCT50=0.0
      PRINT1,'Input historical cost (HCT50),',
     $'Current cost index (CIT50),',
     $'historical cost index (HIT50) of Vacuum System'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
       READ(*,*)HCT50,CIT50,HIT50
      IF(HCT50.LE.0)THEN
          PRINT5,'INVALID ENTRY (HCT50) :',HCT50,'TRY AGAIN!'
    5     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(CIT50.LE.0)THEN
          PRINT15,'INVALID ENTRY (CIT50) :',CIT50,'TRY AGAIN!'
   15     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(HIT50.LE.0)THEN
          PRINT25,'INVALID ENTRY (HIT50) :',HIT50,'TRY AGAIN!'
   25     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSE
          CCT50=CCT50+HCT50*(CIT50/HIT50)
          WRITE(*,65)'Vacuum System','N', CCT50
          WRITE(2,65)'Vacuum System','N', CCT50
   65     FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMSCW(CCTSCW,HCTSCW,CITSCW,HITSCW)
C Subroutine CMSCW calculates the Current cost of Screw Worm.
      CCTSCW=0.0
      PRINT1,'Input historical cost (HCTSCW),',
     $'Current cost index (CITSCW),',
     $'historical cost index (HITSCW) of Screw Worm'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTSCW,CITSCW,HITSCW
      IF(HCTSCW.LE.0)THEN
        PRINT5,'INVALID ENTRY (HCTSCW) :',HCTSCW,'TRY AGAIN!'
    5   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(CITSCW.LE.0)THEN
        PRINT15,'INVALID ENTRY (CITSCW) :',CITSCW,'TRY AGAIN!'
   15   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(HITSCW.LE.0)THEN
        PRINT25,'INVALID ENTRY (HITSCW) :',HITSCW,'TRY AGAIN!'
   25   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSE
        CCTSCW=CCTSCW+HCTSCW*(CITSCW/HITSCW)
        WRITE(*,35)'Screw Worm','N', CCTSCW
        WRITE(2,35)'Screw Worm','N', CCTSCW
   35   FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
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      RETURN
      END

      SUBROUTINE CMPUM(TOPUM,CCTPUM,HCTPUM,CITPUM,HITPUM)
C Subroutine CMPUM calculates the Current cost of 22 Pumps.
      CCTPUM=0.0
      TOPUM=0.0
      PRINT1,'Input historical cost(HCTPUM),',
     $'Current cost index(CITPUM),',
     $'historical cost index of one Pump(HITPUM)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTPUM,CITPUM,HITPUM
      IF(HCTPUM.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCTPUM) :',HCTPUM,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITPUM.LE.0)THEN
         PRINT15,'INVALID ENTRY (CITPUM) :',CITPUM,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITPUM.LE.0)THEN
         PRINT25,'INVALID ENTRY (HITPUM) :',HITPUM,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCTPUM=CCTPUM+HCTPUM*(CITPUM/HITPUM)
         WRITE(*,35)'One Pump','N', CCTPUM
         WRITE(2,35)'One Pump','N', CCTPUM
   35    FORMAT(/,10X,A,T54,A,F15.2)
         TOPUM=TOPUM+CCTPUM*22
         WRITE(*,75)'22 Pumps','N',TOPUM
         WRITE(2,75)'22 Pumps','N',TOPUM
   75    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMHEX(THEAT,CCTHEX,HCTHEX,CITHEX,HITHEX)
C Subroutine CMHEX calculates the Current cost of 7 Plate Heat
Exchangers.
      CCTHEX=0.0
      THEAT=0.0
      PRINT1,'Input historical cost (HCTHEX),',
     $'Current cost index (CITHEX),',
     $'historical cost index (HITHEX) of one Heat Exchanger'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTHEX,CITHEX,HITHEX
      IF(HCTHEX.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCTHEX) :',HCTHEX,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITHEX.LE.0)THEN
         PRINT15,'INVALID ENTRY (CITHEX) :',CITHEX,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITHEX.LE.0)THEN
         PRINT25,'INVALID ENTRY (HITHEX) :',HITHEX,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCTHEX=CCTHEX+HCTHEX*(CITHEX/HITHEX)
```

```
        WRITE(*,35)'One Heat Exchanger','N', CCTHEX
        WRITE(2,35)'One Heat Exchanger','N', CCTHEX
   35   FORMAT(/,10X,A,T54,A,F15.2)
        THEAT=THEAT+CCTHEX*7
        WRITE(*,45)'7 Heat Exchangers','N',THEAT
        WRITE(2,45)'7 Heat Exchangers','N',THEAT
   45   FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM619(CCT619,HCT619,CIT619,HIT619,TT619)
C Subroutine CM619 calculates the Current cost of two Guard
C Filters(2nd set).
      CCT619=0.0
      TT619=0.0
      PRINT1,'Input historical cost (HCT619),',
     $'Current cost index (CIT619),',
     $'historical cost index (HIT619) of one Guard Filter II'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT619,CIT619,HIT619
      IF(HCT619.LE.0)THEN
        PRINT5,'INVALID ENTRY (HCT619) :',HCT619,'TRY AGAIN!'
    5   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(CIT619.LE.0)THEN
        PRINT15,'INVALID ENTRY (CIT619) :',CIT619,'TRY AGAIN!'
   15   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(HIT619.LE.0)THEN
        PRINT25,'INVALID ENTRY (HIT619) :',HIT619,'TRY AGAIN!'
   25   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSE
        CCT619=CCT619+HCT619*(CIT619/HIT619)
        WRITE(*,35)'One Guard Filter II','N',CCT619
        WRITE(2,35)'One Guard Filter II','N',CCT619
   35   FORMAT(/,10X,A,T54,A,F15.2)
        TT619=TT619+CCT619*2
        WRITE(*,45)'2 Guard Filters II','N',TT619
        WRITE(2,45)'2 Guard Filters II','N',TT619
   45  FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMRST(CCTCTA,HCTCTA,CITCTA,HITCTA,TTCTA)
C Subroutine CMRST calculates the Current cost of 12 Crystallisers .
      CCTCTA=0.0
      TTCTA=0.0
      PRINT1,'Input historical cost (HCTCTA),',
     $'Current cost index (CITCTA),',
     $'historical cost index (HITCTA) of single Crystalliser'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTCTA,CITCTA,HITCTA
      IF(HCTCTA.LE.0)THEN
        PRINT5,'INVALID ENTRY (HCTCTA) :',HCTCTA,'TRY AGAIN!'
    5   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(CITCTA.LE.0)THEN
        PRINT15,'INVALID ENTRY (CITCTA) :',CITCTA,'TRY AGAIN!'
```

```
 15     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(HITCTA.LE.0)THEN
        PRINT25,'INVALID ENTRY (HITCTA) :',HITCTA,'TRY AGAIN!'
 25     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSE
        CCTCTA=CCTCTA+HCTCTA*(CITCTA/HITCTA)
        WRITE(*,35)'One Crystalliser','N', CCTCTA
        WRITE(2,35)'One Crystalliser','N', CCTCTA
 35     FORMAT(/,10X,A,27X,A,F15.2)
        TTCTA=TTCTA+CCTCTA*12
        WRITE(*,45)'Twelve Crystallisers','N',TTCTA
        WRITE(2,45)'Twelve Crystallisers','N',TTCTA
 45     FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMRBD(CCTRBD,HCTRBD,CITRBD,HITRBD)
C Subroutine CMRBD calculates the Current cost of RBD Storage Tank.
      CCTRBD=0.0
      PRINT1,'Input historical cost (HCTRBD),',
     $'Current cost index (CITRBD),',
     $'historical cost index (HITRBD) of RBD Storage Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTRBD,CITRBD,HITRBD
      IF(HCTRBD.LE.0)THEN
        PRINT5,'INVALID ENTRY (HCTRBD) :',HCTRBD,'TRY AGAIN!'
  5     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(CITRBD.LE.0)THEN
        PRINT15,'INVALID ENTRY (CITRBD) :',CITRBD,'TRY AGAIN!'
 15     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(HITRBD.LE.0)THEN
         PRINT25,'INVALID ENTRY (HITRBD) :',HITRBD,'TRY AGAIN!'
 25      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
        CCTRBD=CCTRBD+HCTRBD*(CITRBD/HITRBD)
        WRITE(*,35)'RBD Storage Tank','N',CCTRBD
        WRITE(2,35)'RBD Storage Tank','N',CCTRBD
 35     FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMCWA(CCTCWA,HCTCWA,CITCWA,HITCWA)
C Subroutine CMCWA calculates the Current cost of cold Water Tank.
      CCTCWA=0.0
      PRINT1,'Input historical cost (HCTCWA),',
     $'Current cost index (CITCWA),',
     $'historical cost index (HITCWA) of Cold Water Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTCWA,CITCWA,HITCWA
      IF(HCTCWA.LE.0)THEN
        PRINT5,'INVALID ENTRY (HCTCWA) :',HCTCWA,'TRY AGAIN!'
  5     FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
      ELSEIF(CITCWA.LE.0)THEN
```

```
         PRINT15,'INVALID ENTRY (CITCWA) :',CITCWA,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITCWA.LE.0)THEN
      PRINT25,'INVALID ENTRY (HITCWA) :',HITCWA,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCTCWA=CCTCWA+HCTCWA*(CITCWA/HITCWA)
         WRITE(*,105)'Cold Water Tank','N', CCTCWA
         WRITE(2,105)'Cold Water Tank','N', CCTCWA
  105    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMWWA(CCTWWA,HCTWWA,CITWWA,HITWWA)
C Subroutine CMWWA calculates the Current cost of Warm Water Tank.
      CCTWWA=0.0
      PRINT1,'Input historical cost (HCTWWA),',
     $'Current cost index (CITWWA),',
     $'historical cost index (HITWWA) of Warm Water Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTWWA,CITWWA,HITWWA
      IF(HCTWWA.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCTWWA) :',HCTWWA,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITWWA.LE.0)THEN
         PRINT15,'INVALID ENTRY (CITWWA) :',CITWWA,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITWWA.LE.0)THEN
         PRINT25,'INVALID ENTRY (HITWWA) :',HITWWA,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCTWWA=CCTWWA+HCTWWA*(CITWWA/HITWWA)
         WRITE(*,35)'Warm Water Tank','N', CCTWWA
         WRITE(2,35)'Warm Water Tank','N', CCTWWA
   35    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END
      SUBROUTINE CMWFR(CCTFTR,HCTFTR,CITFTR,HITFTR)
C Subroutine CMWFR calculates the Current cost of
C Welders' filter Press
      CCTFTR=0.0
      PRINT1,'Input historical cost (HCTFTR),',
     $'Current cost index (CITFTR),',
     $'historical cost index (HITFTR) of Welders'' Filter Press'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTFTR,CITFTR,HITFTR
      IF(HCTFTR.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCTFTR) :',HCTFTR,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITFTR.LE.0)THEN
         PRINT15,'INVALID ENTRY (CITFTR) :',CITFTR,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
```

```
      ELSEIF(HITFTR.LE.0)THEN
         PRINT25,'INVALID ENTRY (HITFTR) :',HITFTR,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCTFTR=CCTFTR+HCTFTR*(CITFTR/HITFTR)
         WRITE(*,35)'Welders'' Filter Press','N',CCTFTR
         WRITE(2,35)'Welders'' Filter Press','N',CCTFTR
   35    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMSTK(CCTSTK,HCTSTK,CITSTK,HITSTK)
C Subroutine CMSTK calculates the Current cost of Stearin tank.
      CCTSTK=0.0
      PRINT1,'Input historical cost (HCTSTK),',
     $'Current cost index (CITSTK),',
     $'historical cost index (HITSTK) of Stearin Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTSTK,CITSTK,HITSTK
      IF(HCTSTK.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCTSTK) :',HCTSTK,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITSTK.LE.0)THEN
         PRINT15,'INVALID ENTRY (CITSTK) :',CITSTK,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITSTK.LE.0)THEN
         PRINT25,'INVALID ENTRY (HITSTK) :',HITSTK,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
         CCTSTK=CCTSTK+HCTSTK*(CITSTK/HITSTK)
         WRITE(*,35)'Stearin Tank','N', CCTSTK
         WRITE(2,35)'Stearin Tank','N', CCTSTK
   35    FORMAT(/,10X,A,T54,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMOTK(CCTOTK,HCTOTK,CITOTK,HITOTK,TTOTK)
C Subroutine CMOTK calculates the Current cost of 2 Olein tanks.
      CCTOTK=0.0
      TTOTK=0.0
      PRINT1,'Input historical cost (HCTOTK),',
     $'Current cost index (CITOTK),'
     $'historical cost index (HITOTK) of Olein Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTOTK,CITOTK,HITOTK
      IF(HCTOTK.LE.0)THEN
         PRINT5,'INVALID ENTRY (HCTOTK) :',HCTOTK,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITOTK.LE.0)THEN
         PRINT15,'INVALID ENTRY (CITOTK) :',CITOTK,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITOTK.LE.0)THEN
         PRINT25,'INVALID ENTRY (HITOTK) :',HITOTK,'TRY AGAIN!'
```

```
  25      FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSE
          CCTOTK=CCTOTK+HCTOTK*(CITOTK/HITOTK)
          WRITE(*,35)'Olein Tank','N', CCTOTK
          WRITE(2,35)'Olein Tank','N', CCTOTK
  35      FORMAT(/,10X,A,33X,A,F15.2)
          TTOTK=TTOTK+CCTOTK*2
          WRITE(*,45)'Two Olein Tanks','N',TTOTK
          WRITE(2,45)'Two Olein Tanks','N',TTOTK
 45       FORMAT(/,10X,A,T54,A,F15.2)
       ENDIF
       RETURN
       END
C
       SUBROUTINE CMPECT(PECT,CCT503,CCT505,CCT534,CCT504,CCT535,CCT622,
      $TT616,CCT617,CCT618,CCT682,CCT801,CCT803,CCT822,CCT814,CCT821,
      $CCT50,CCTSCW,TOPUM,THEAT,TT619,TTCTA,CCTRBD,CCTCWA,CCTWWA,
      $CCTFTR,CCTSTK,TTOTK)
C SUBROUTINE CMPECT COMPUTES THE DELIVERED DELIVERED PURCHASED
C EQUIPMENT COST
C
       PECT=0
C The Delivered Purchased Equipment cost is obtained by summing the
C calculated Current costs of all equipment as shown in the following
C arithmetic expression.
       PECT=PECT+CCT503+CCT505+CCT534+CCT504+CCT535+CCT622+TT616+CCT617
      $+CCT618+CCT682+CCT801+CCT803+CCT822+CCT814+CCT821+CCT50+CCTSCW
      $+TOPUM+THEAT+TT619+TTCTA+CCTRBD+CCTCWA+CCTWWA+CCTFTR
      $+CCTSTK+TTOTK
       WRITE(*,5)'Delivered Purchased Equipment cost is :','N',PECT
       WRITE(2,5)'Delivered Purchased Equipment cost is :','N',PECT
     5 FORMAT(//,10X,A,T56,A,F15.2)
       WRITE(*,10)
       WRITE(2,10)
    10 FORMAT(T56,16('-'))
       RETURN
       END

       SUBROUTINE FIXCAP(FCAPN,PECT,FPECT,FPECIT,FIIT,FPIT,FBIST,FEIT,
      $FYIT,FSFIT,FLANT,FENGST,FCTNET,FCFEET,FCTNGT)
C Subroutine CITCAP calculates the current cost of Fixed Capital
Investment
       FCAPN=0.0
       PRINT1,'Input factors for Purchased Equipment (FPECT),',
      $'Purchased Equipment installation (FPECIT),',
      $'Instrumentation (installed) (FIIT),',
      $'Piping (Installed) (FPIT),',
      $'Buildings (includimg services) (FBIST),',
      $'Electrical (Intsalled) (FEIT),',
      $'Yard Improvements (FYIT),',
      $'Service facilities (installed) (FSFIT),',
      $'Land (FLANT),',
      $'Engineering and Supervision (FENGST),',
      $'Construction Expenses (FCTNET),',
      $'Contractors''fee (FCFEET),',
      $'Contingency (FCTNGT)'
     1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,
      $/,1X,A,/,1X,A,/,1X,A/,1X,A,/,1X,A)
       READ(*,*)FPECT,FPECIT,FIIT,FPIT,FBIST,FEIT,FYIT,FSFIT,FLANT,
      $FENGST,FCTNET,FCFEET,FCTNGT
```

```
      IF(FPECT.LE.0.OR.FPECT.GT.1)THEN
         PRINT5,'INVALID ENTRY (FPECT) :',FPECT,'TRY AGAIN!'
 5       FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FPECIT.LE.0.OR. FPECIT.GE.1)THEN
         PRINT15,'INVALID ENTRY (FPECIT) :',FPECIT,'TRY AGAIN!'
 15      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FIIT.LE.0.OR. FIIT.GE.1)THEN
         PRINT25,'INVALID ENTRY (FIIT) :',FIIT,'TRY AGAIN!'
 25      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FPIT.LE.0.OR. FPIT.GE.1)THEN
         PRINT35,'INVALID ENTRY (FPIT) :',FPIT,'TRY AGAIN!'
 35      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FBIST.LE.0.OR. FBIST.GE.1)THEN
         PRINT45,'INVALID ENTRY (FBIST) :',FBIST,'TRY AGAIN!'
 45      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FEIT.LE.0.OR. FEIT.GE.1)THEN
         PRINT55,'INVALID ENTRY (FEIT) :',FEIT,'TRY AGAIN!'
 55      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FYIT.LE.0.OR. FYIT.GE.1)THEN
         PRINT65,'INVALID ENTRY (FYIT) :',FYIT,'TRY AGAIN!'
 65      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FSFIT.LE.0.OR. FSFIT.GE.1)THEN
         PRINT75,'INVALID ENTRY (FSFIT) :',FSFIT,'TRY AGAIN!'
 75      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FLANT.LE.0.OR. FLANT.GE.1)THEN
         PRINT85,'INVALID ENTRY (FLANT) :',FLANT,'TRY AGAIN!'
 85      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FENGST.LE.0.OR. FENGST.GE.1)THEN
         PRINT95,'INVALID ENTRY (FENGST) :',FENGST,'TRY AGAIN!'
 95      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FCTNET.LE.0.OR. FCTNET.GE.1)THEN
         PRINT105,'INVALID ENTRY (FCTNET) :',FCTNET,'TRY AGAIN!'
105      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FCFEET.LE.0.OR. FCFEET.GE.1)THEN
         PRINT115,'INVALID ENTRY (FCFEET) :',FCFEET,'TRY AGAIN!'
115      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FCTNGT.LE.0.OR. FCTNGT.GE.1)THEN
         PRINT125,'INVALID ENTRY (FCTNGT) :',FCTNGT,'TRY AGAIN!'
125      FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSE
         FCAPN=(FCAPN+(PECT+ PECT*(FPECT+FPECIT+FIIT+FPIT+FBIST
     $   +FEIT+FYIT+FSFIT+FLANT)*(1+FENGST+FCTNET+FCFEET+FCTNGT)))
         WRITE(*,135)'Fixed Capital Investment is :','N',FCAPN
         WRITE(2,135)'Fixed Capital Investment is :','N',FCAPN
135      FORMAT(//,10X,A,T56,A,F15.2)
         WRITE(*,145)
         WRITE(2,145)
145      FORMAT(T56,16('-'))
```

```
      ENDIF
      RETURN
      END

      SUBROUTINE TOCAIN (FCAPN,TCAPN,WCAPN)
C Subroutine TOCAIN calculates the current Working Capital
Investment(WCAPN)
C and Total capital Investment(TCAPN).
      TCAPN=0
      WCAPN=0
C Total capital investment is a Summation of the fixed and working
C capital Investment
C The working capital Investment will be taken as 15% of the Total
C Capital Investment,hence  the Fixed Capital Investment will be 85%
C of the Total Capital Investment
      TCAPN=TCAPN+FCAPN/0.85
      WCAPN=WCAPN+TCAPN*0.15
      WRITE(*,10)'Working Capital Investment is :','N',WCAPN
      WRITE(2,10)'Working Capital Investment is :','N',WCAPN
   10 FORMAT(//,10X,A,T56,A,F15.2)
      WRITE(*,20)
      WRITE(2,20)
   20 FORMAT(T56,16('-'))
      WRITE(*,30)'Total Capital Investment is :','N',TCAPN
      WRITE(2,30)'Total Capital Investment is :','N',TCAPN
   30 FORMAT(//,10X,A,T56,A,F15.2)
      WRITE(*,40)
      WRITE(2,40)
   40 FORMAT(T56,16('-'))
      WRITE(*,50)
      WRITE(2,50)
   50 FORMAT(T56,16('-'))
      RETURN
      END
```

APPENDIX A3: Results for Program CINDEX, Representing the Cost Index Method.

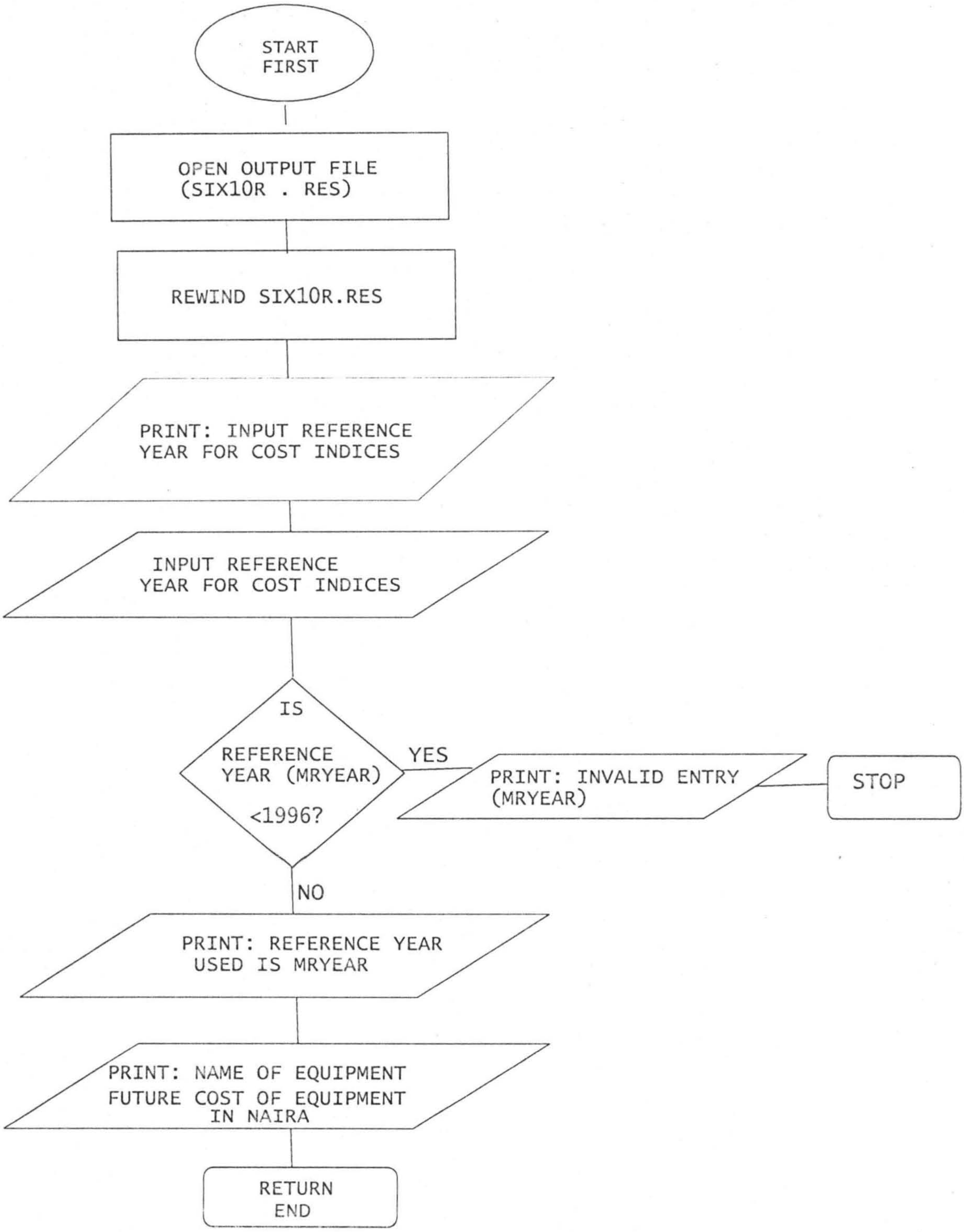
The Reference Year used is:	1996
The Current Year is:	2002

Name of Equipment		Cost of Equipment in 2002(₦)
CaCO3 Tank	N	81373.30
Mixing Tank	N	81373.30
Phosphoric Acid Tank	N	101441.60
Drier	N	106954.80
Bleaching Earth Tank	N	108057.00
Continuous Bleaching Reactor	N	661576.90
1 Bernardini Filter	N	716708.60
2 Bernardini Filters	N	1433417.00
Steel Super Filter	N	121288.80
Guard Filter I	N	115279.80
Decanter	N	68914.17
Storage Tank	N	25948.19
Dearator/Drier	N	115334.50
Deodoriser	N	330788.40
FFA Recuperator	N	101441.60
Preheating Tank	N	108057.00
Vacuum System	N	406869.60
Screw Worm	N	340712.60
One Pump	N	206742.50
22 Pumps	N	4548336.00
One Heat Exchanger	N	1084987.00
7 Heat Exchangers	N	7594910.00
One Guard Filter II	N	115279.80
2 Guard Filters II	N	230559.60

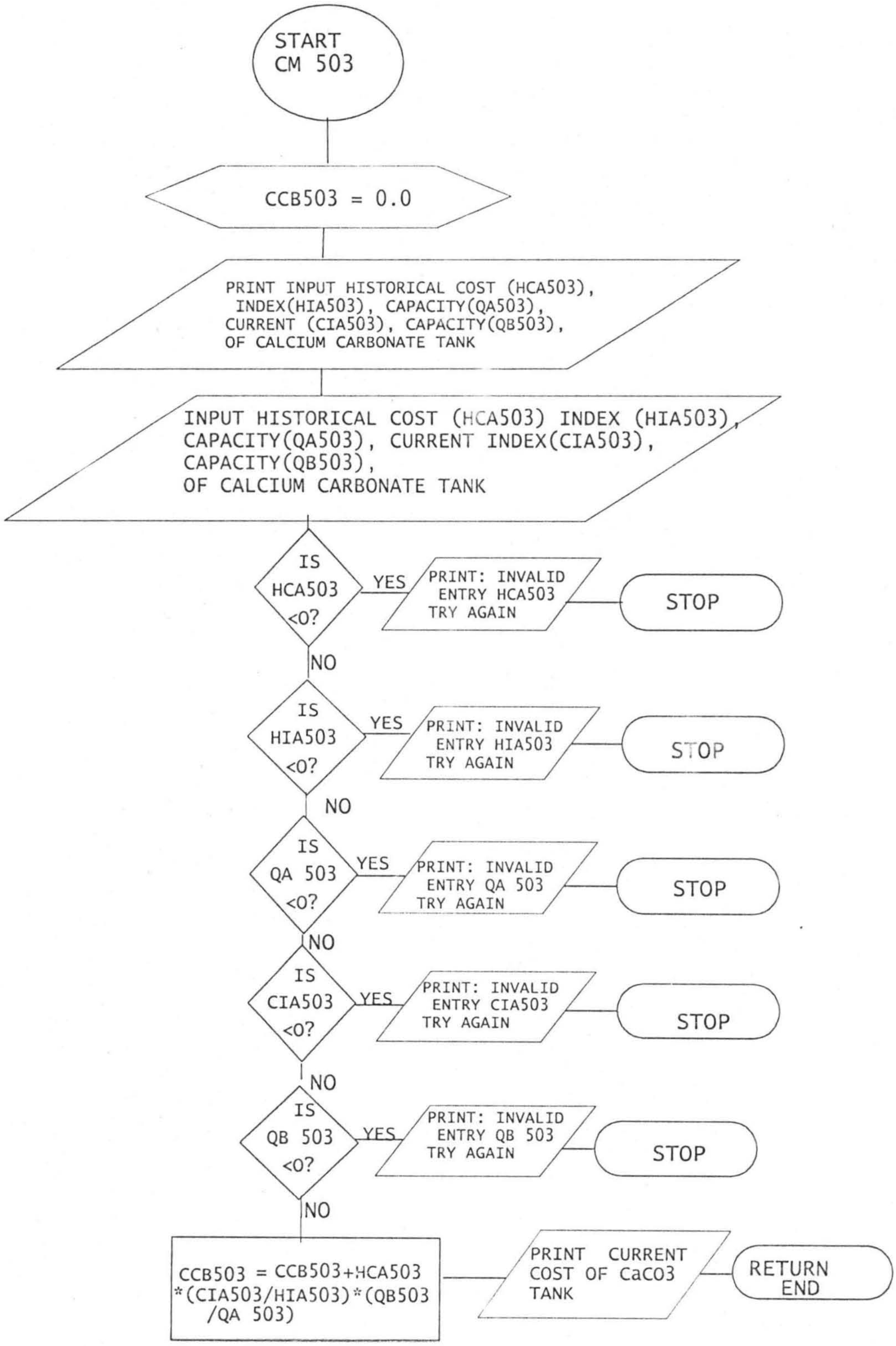
APPENDIX B1

Subroutine Flowchart for Program SIX10R

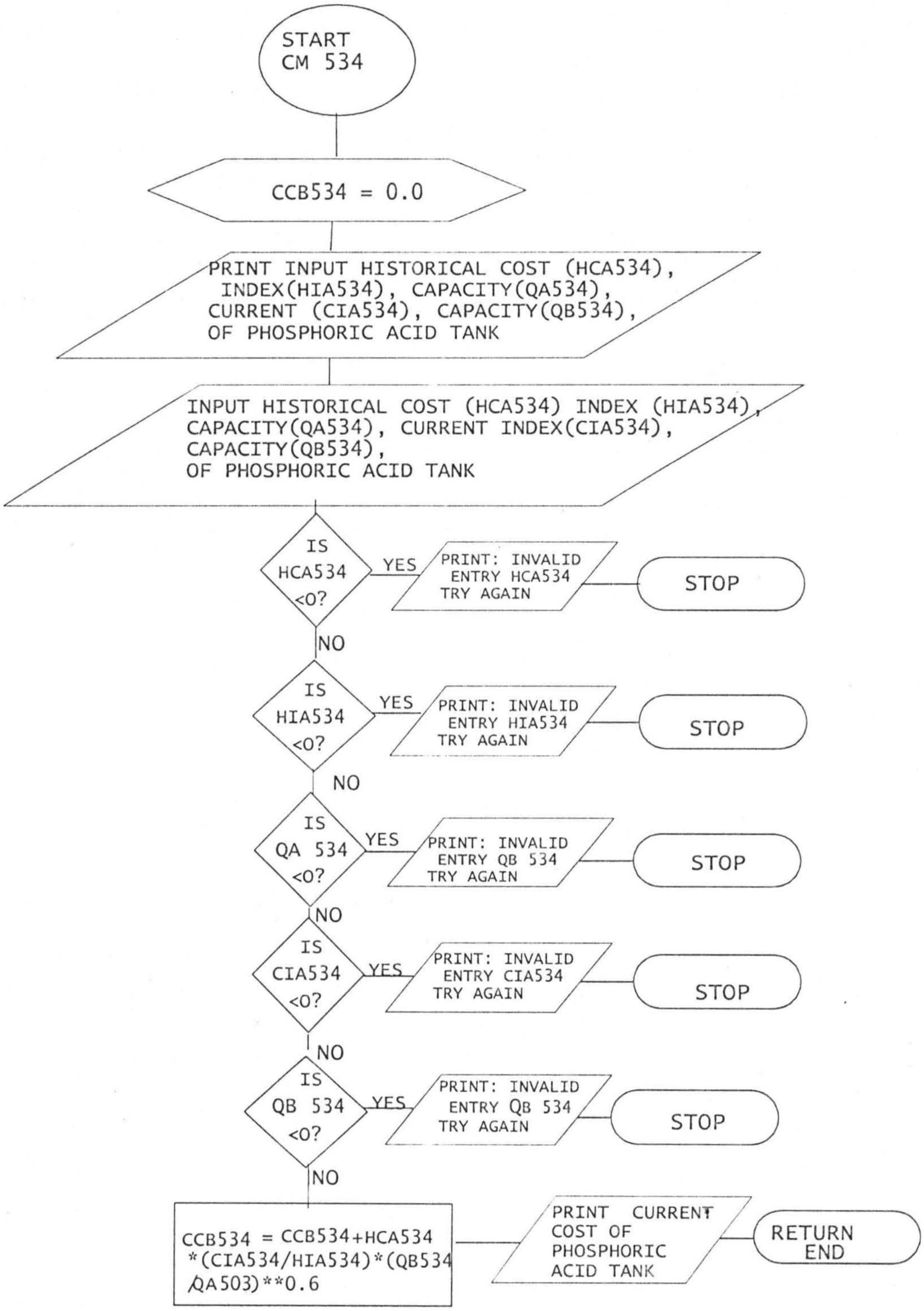
INTRODUCTORY MODULE FOR VALIDATION OF
REFERENCE YEAR FOR COST INDICES



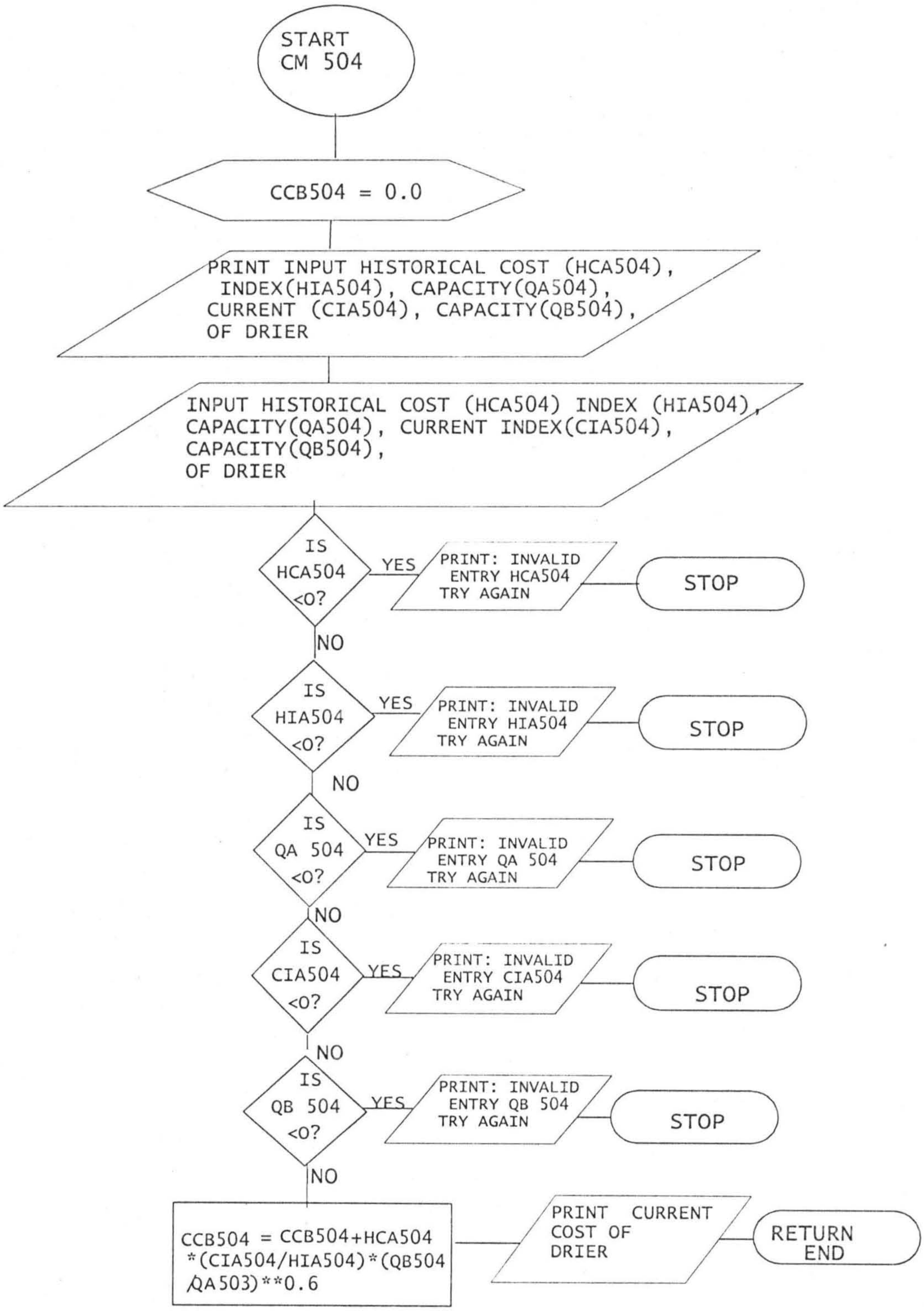
COMPUTATION OF CURRENT COST OF CALCIUM CARBONATE TANK



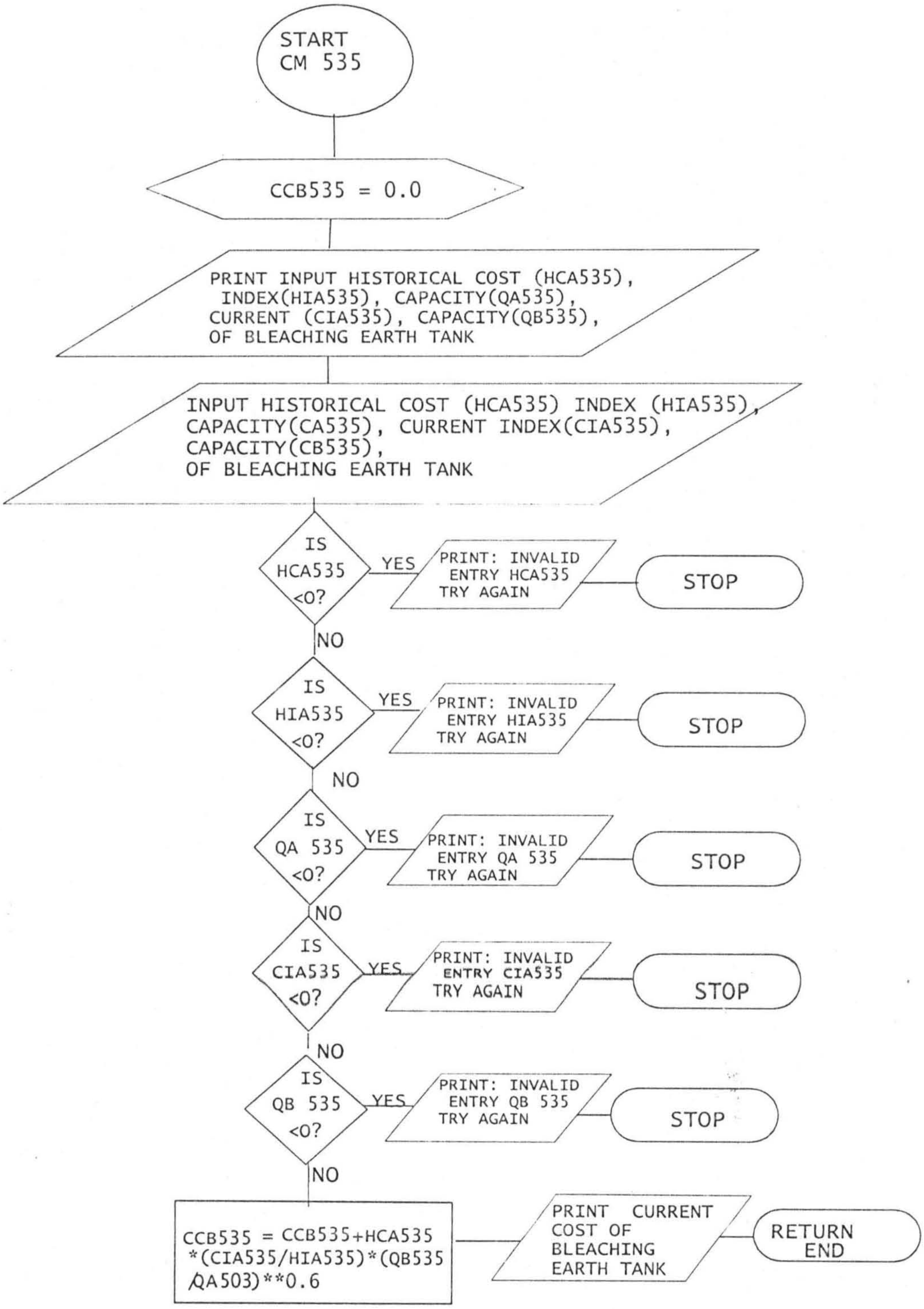
COMPUTATION OF CURRENT COST OF PHOSPHORIC ACID TANK



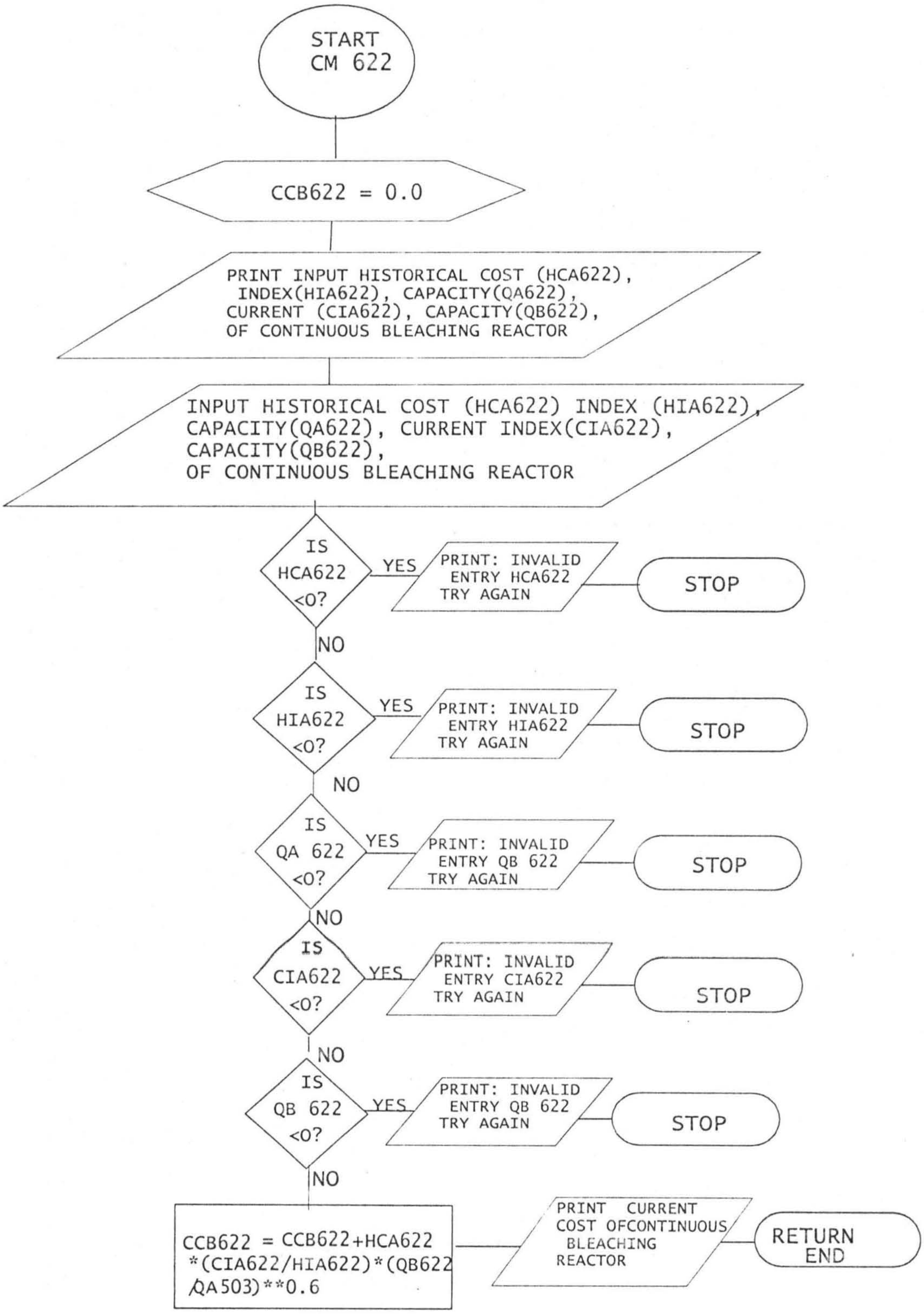
COMPUTATION OF CURRENT COST OF DRIER



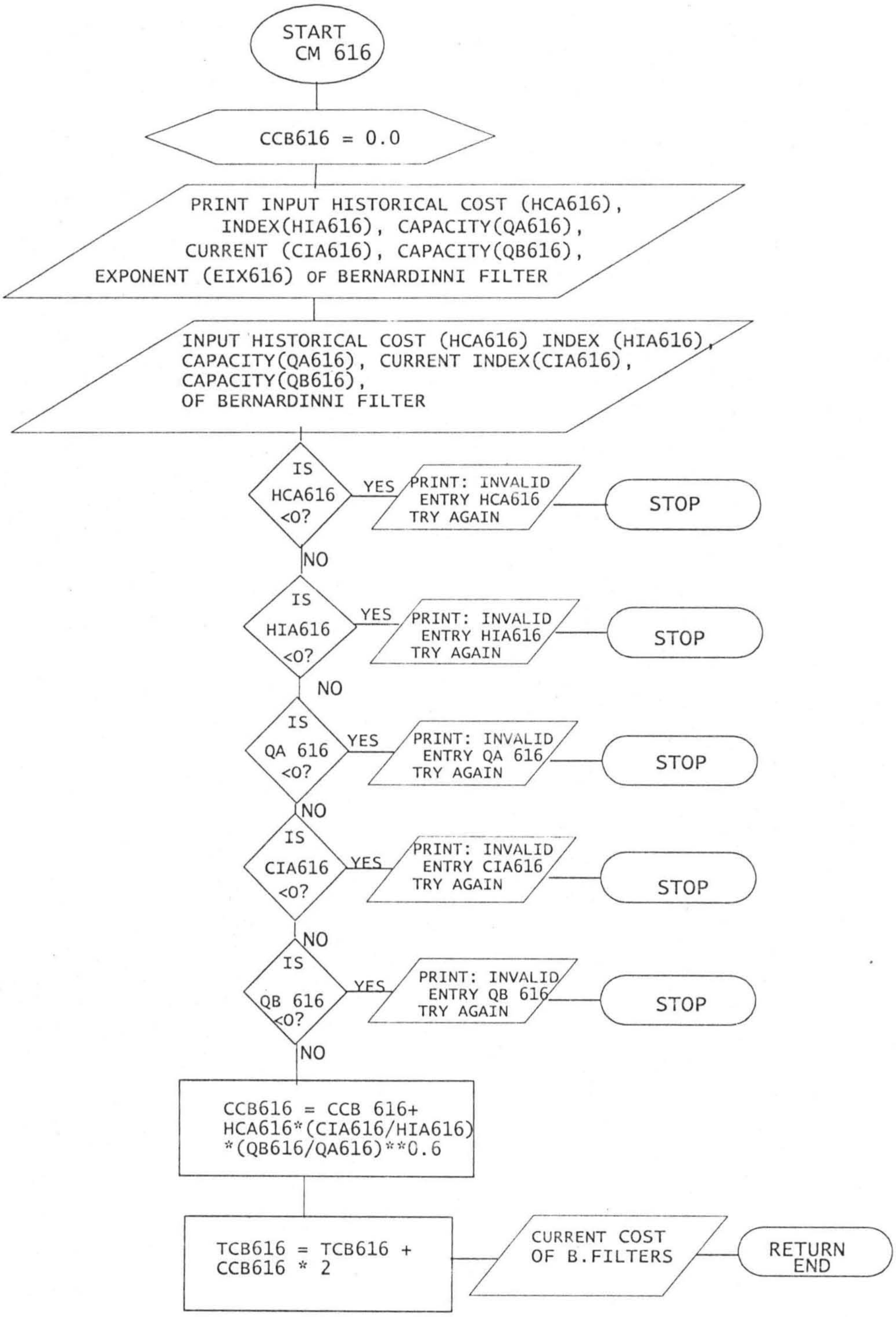
COMPUTATION OF CURRENT COST OF BLEACHING EARTH TANK



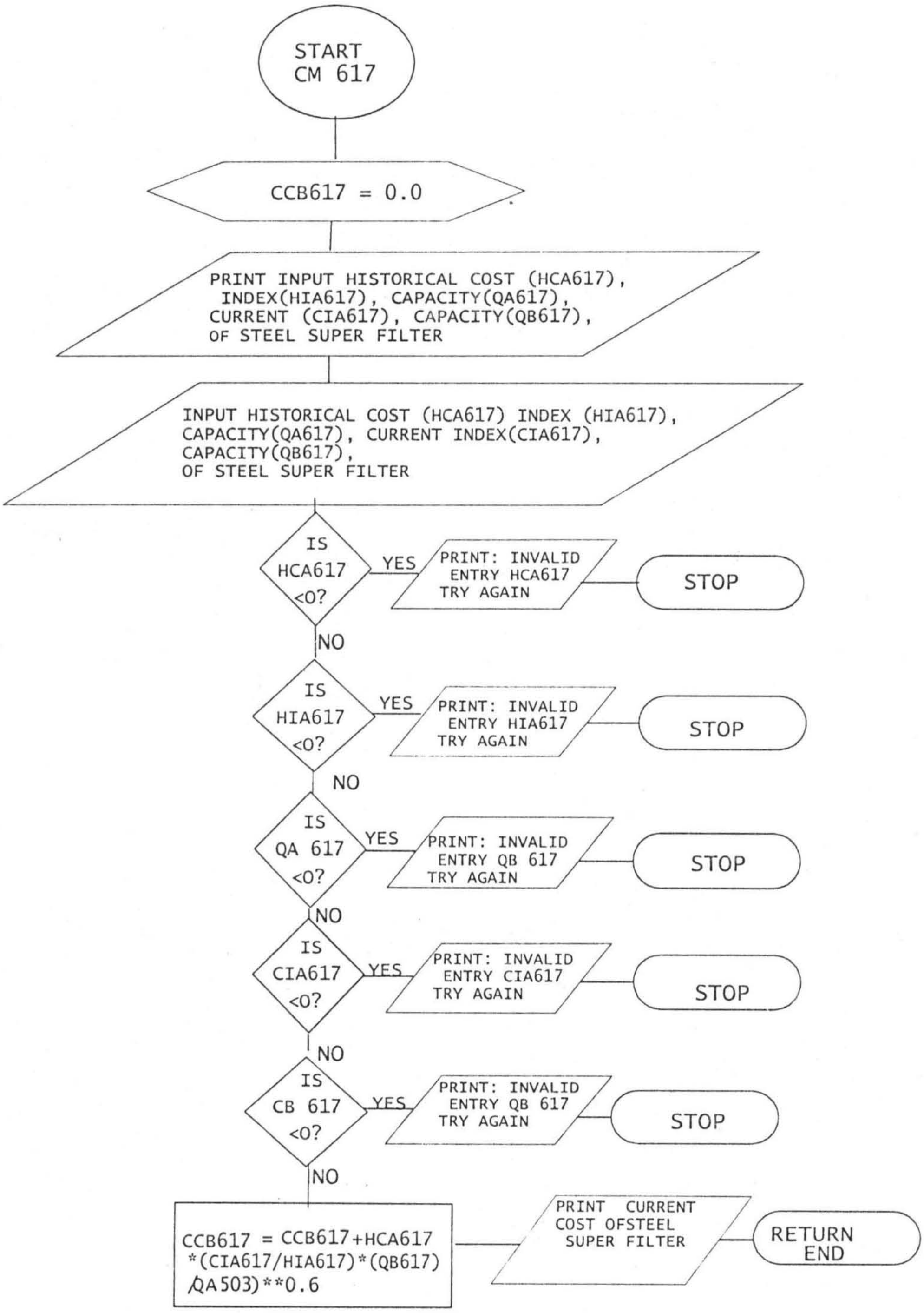
COMPUTATION OF CURRENT COST OF CONTINUOUS BLEACHING REACTOR



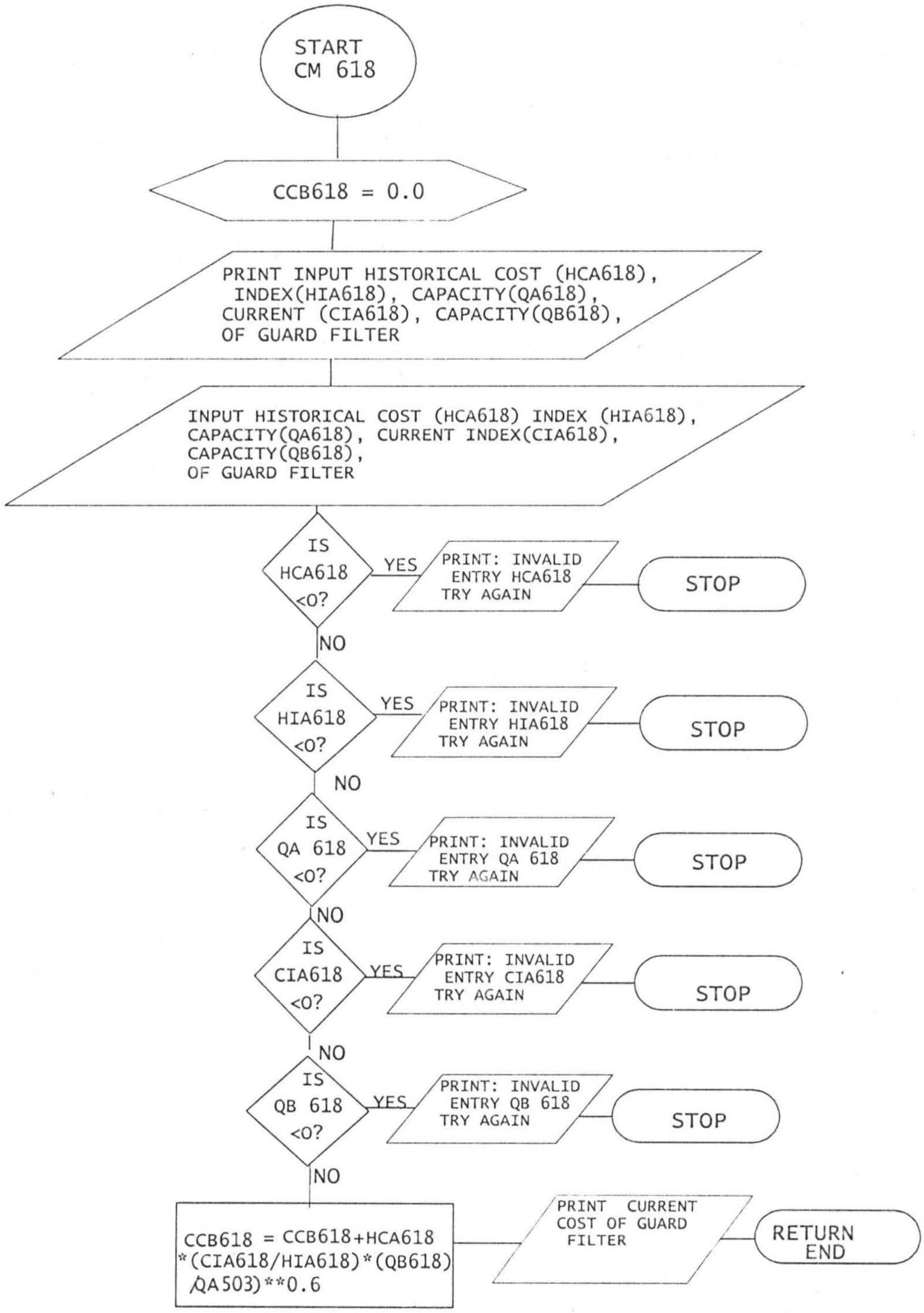
COMPUTATION OF CURRENT COST OF TWO BERNARDINNI FILTERS



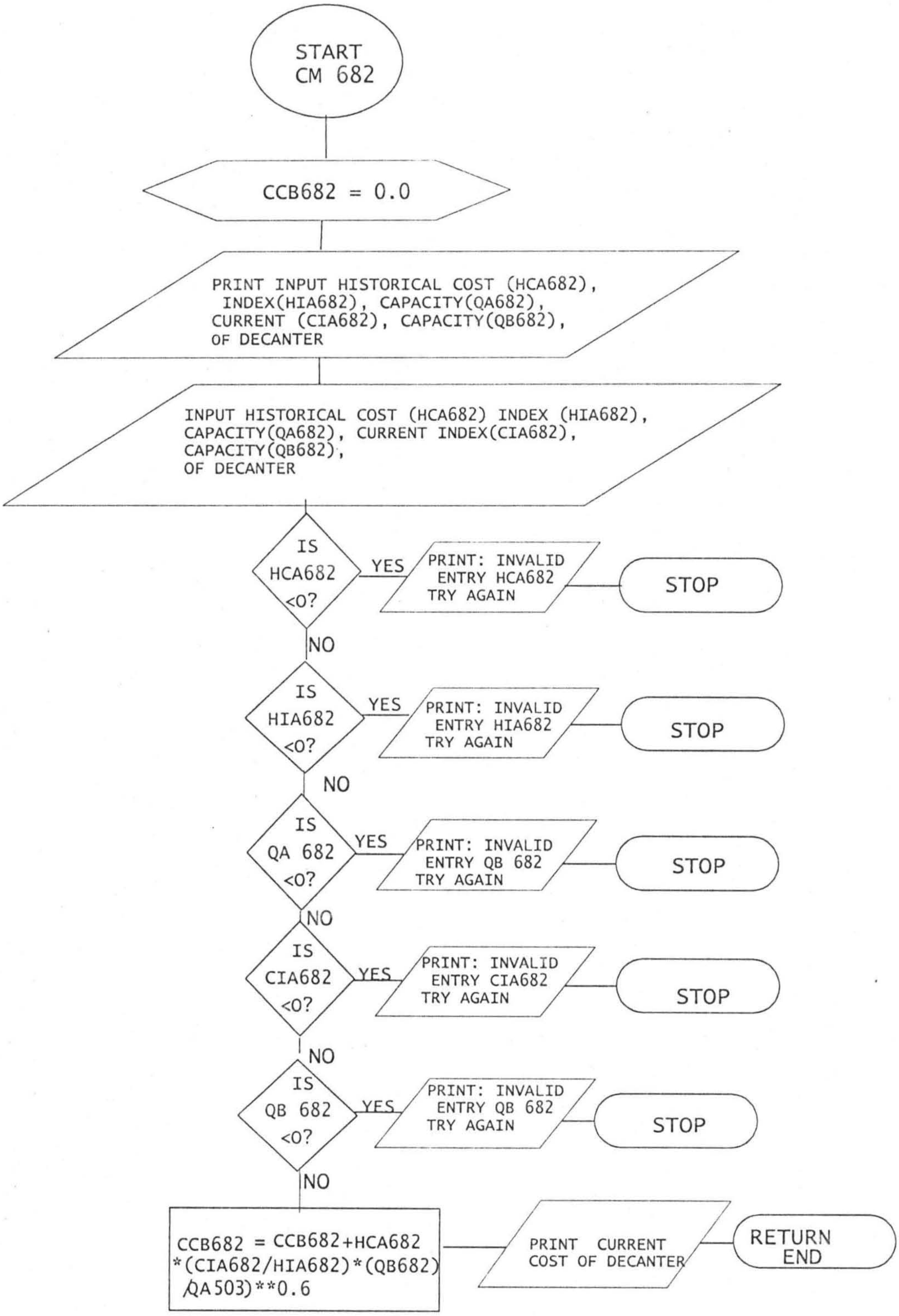
COMPUTATION OF CURRENT COST OF STEEL SUPER FILTER



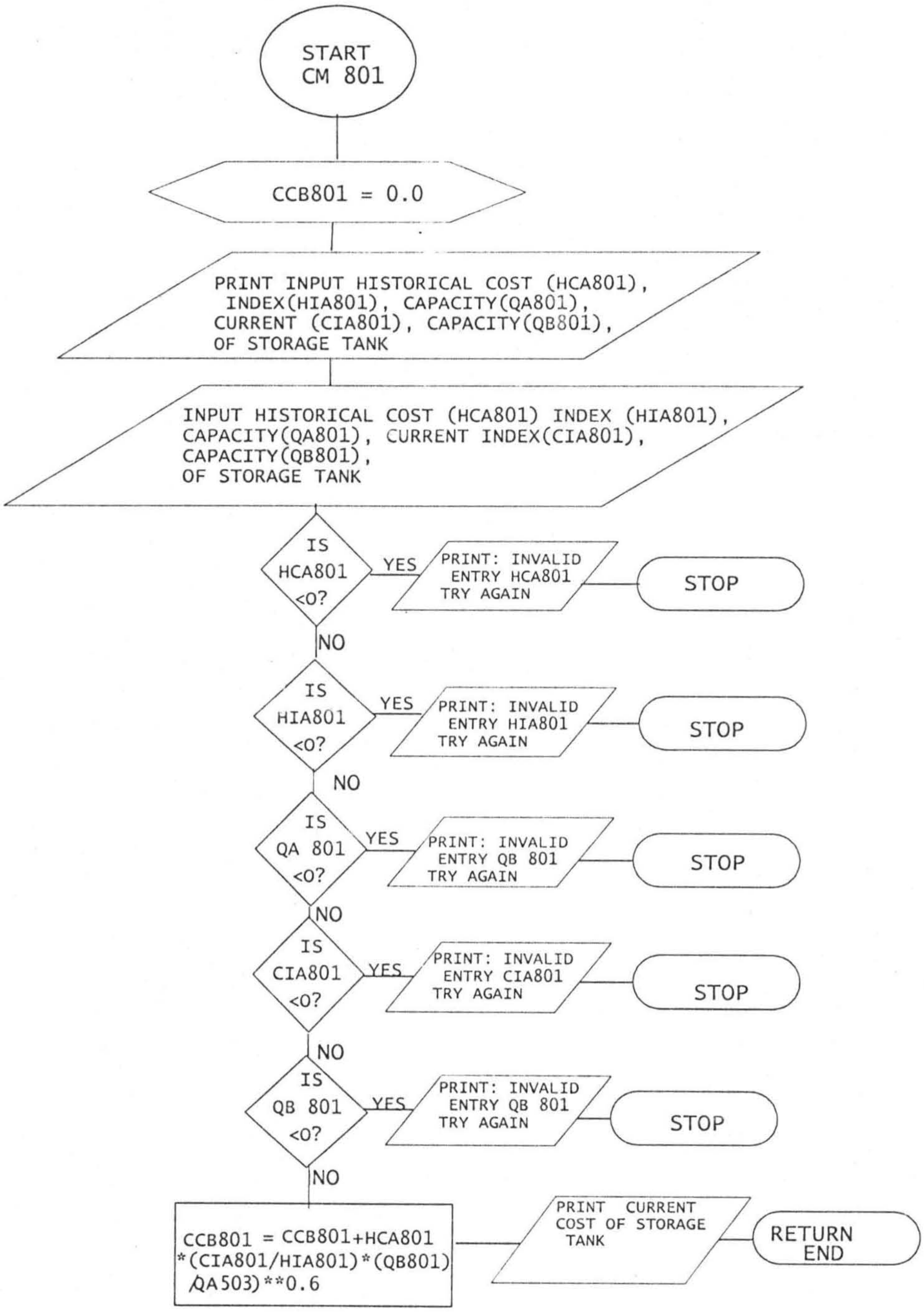
COMPUTATION OF CURRENT COST OF GUARD FILTER



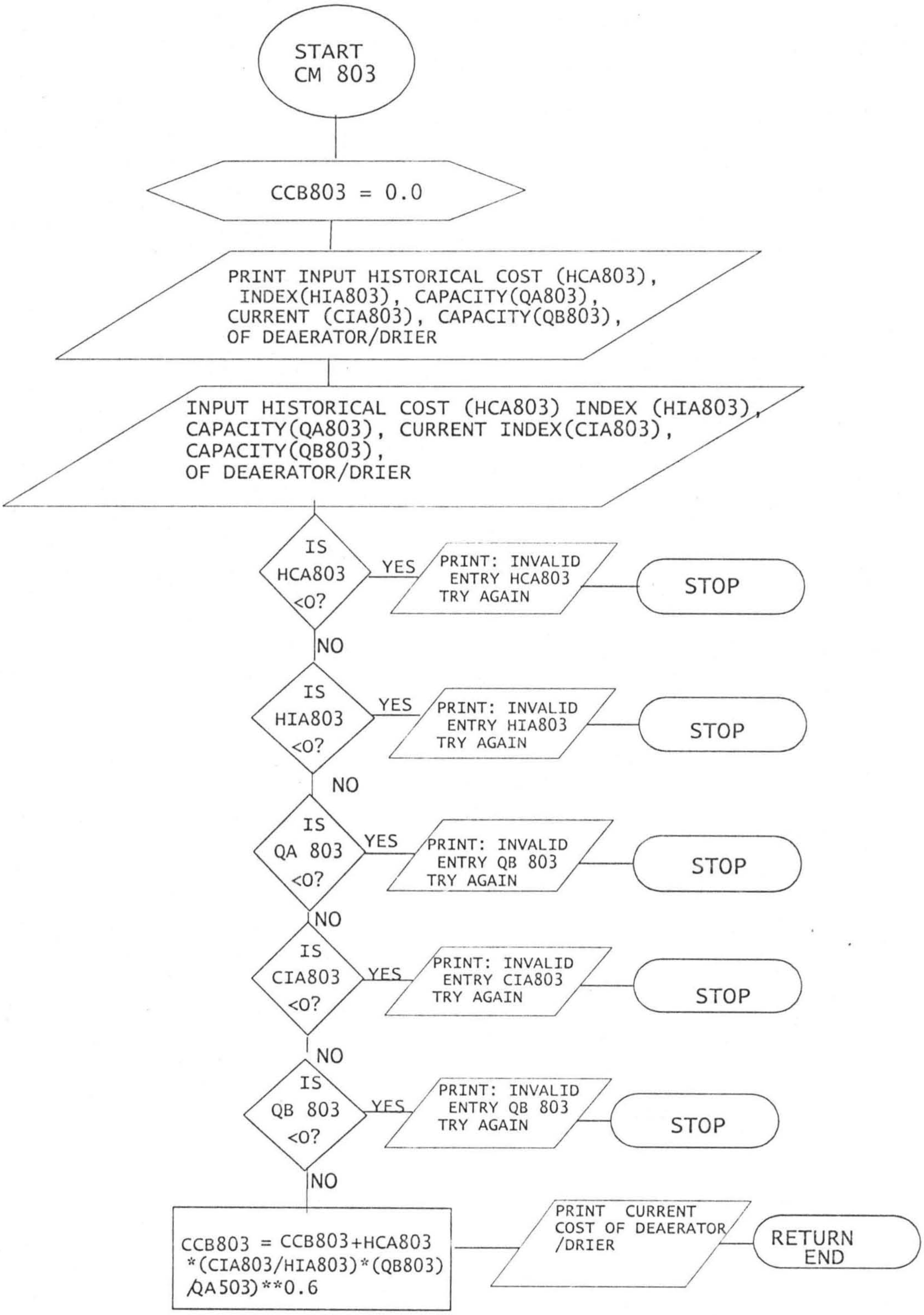
COMPUTATION OF CURRENT COST OF DECANTER



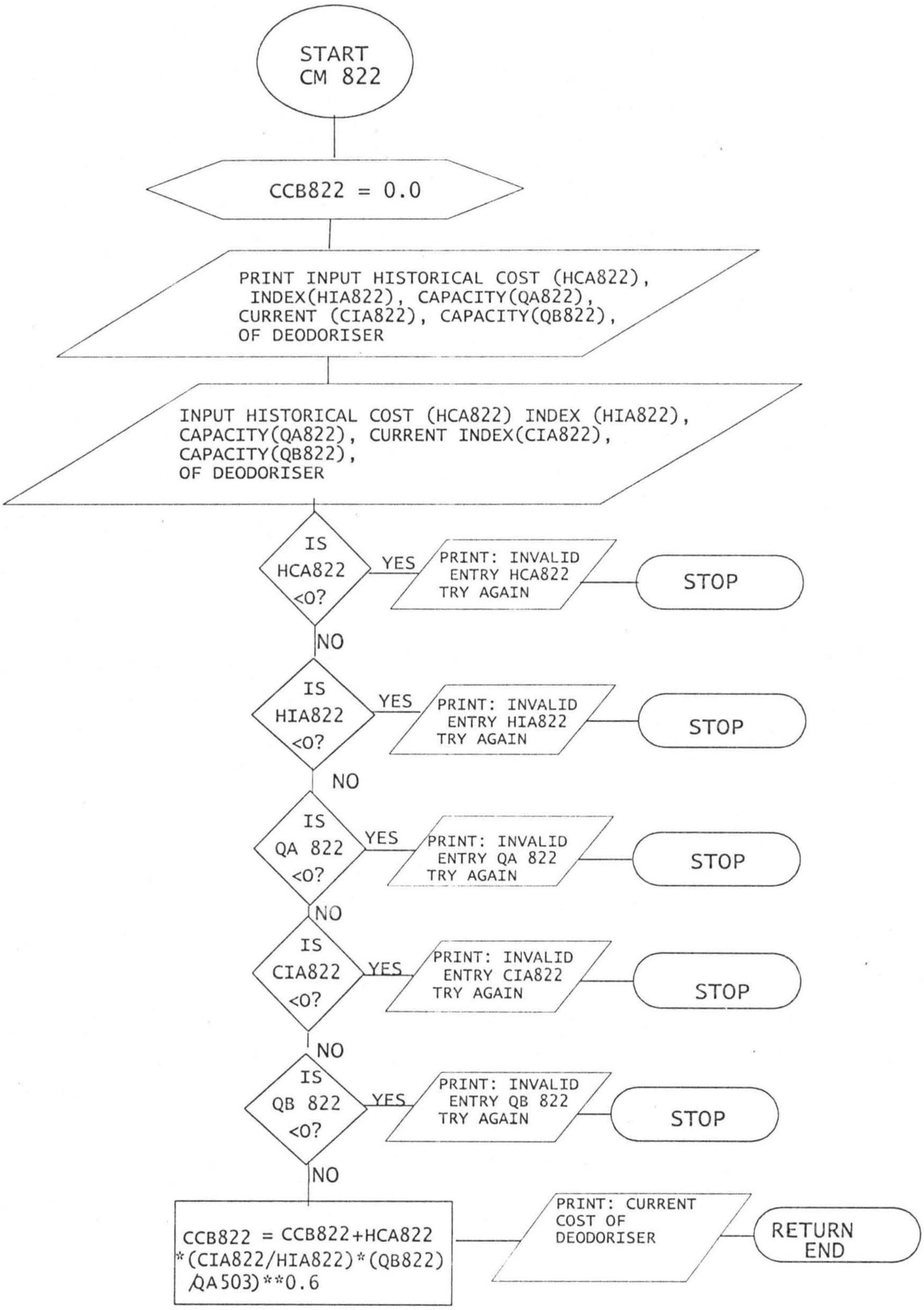
COMPUTATION OF CURRENT COST OF STORAGE TANK



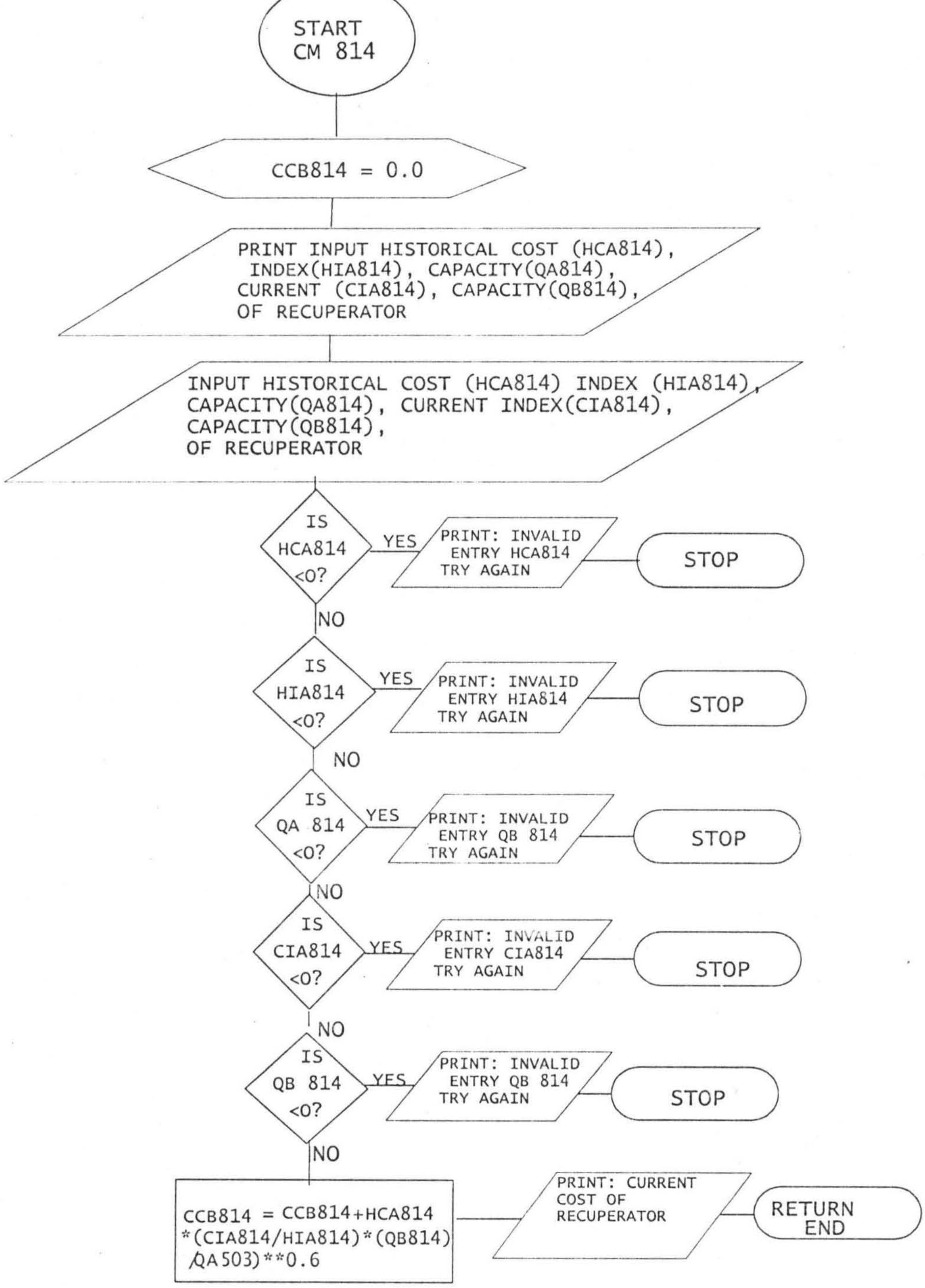
COMPUTATION OF CURRENT COST OF DEAERATOR/DRIER



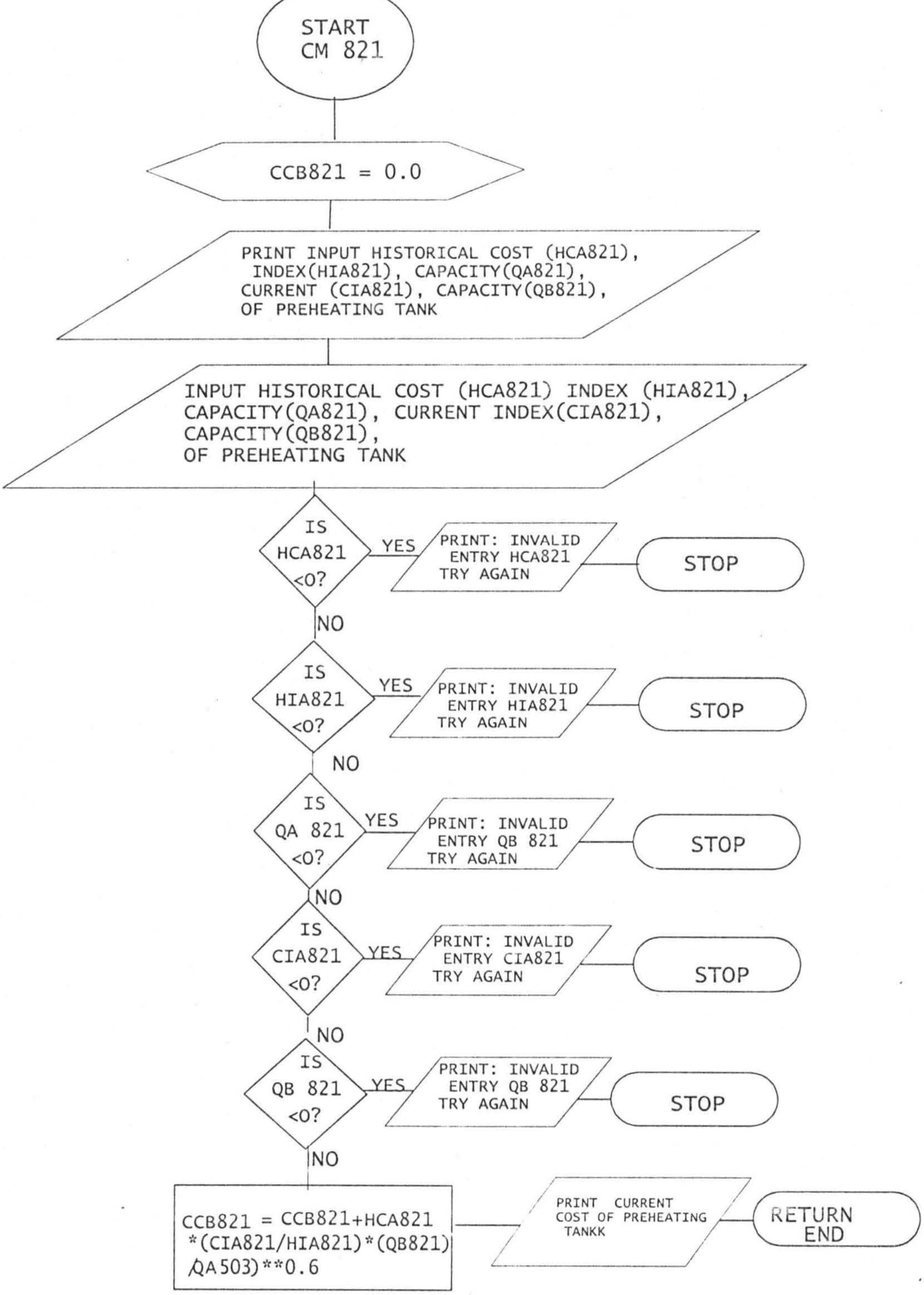
COMPUTATION OF CURRENT COST OF DEODORISER



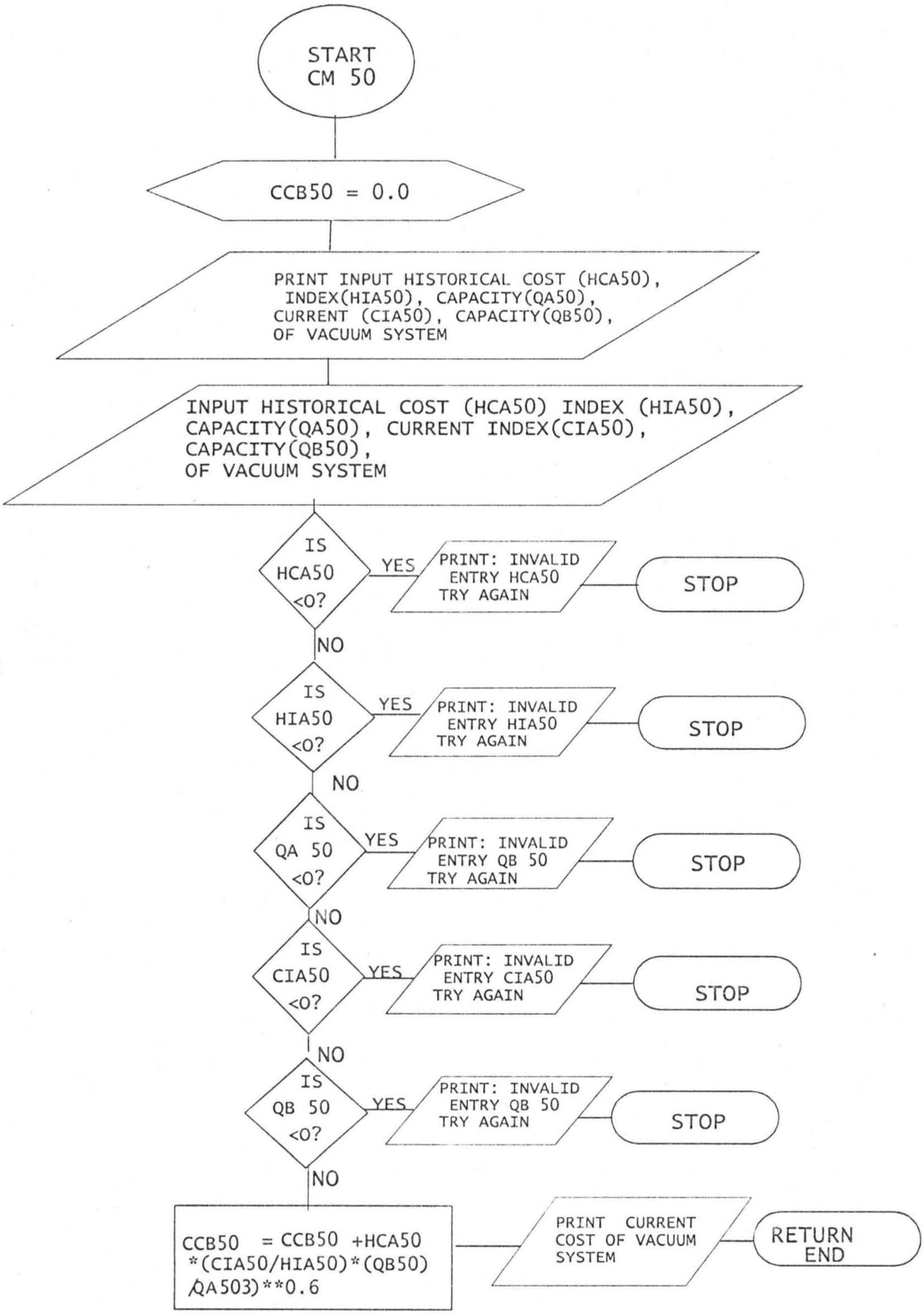
COMPUTATION OF CURRENT COST OF RECUPERATOR



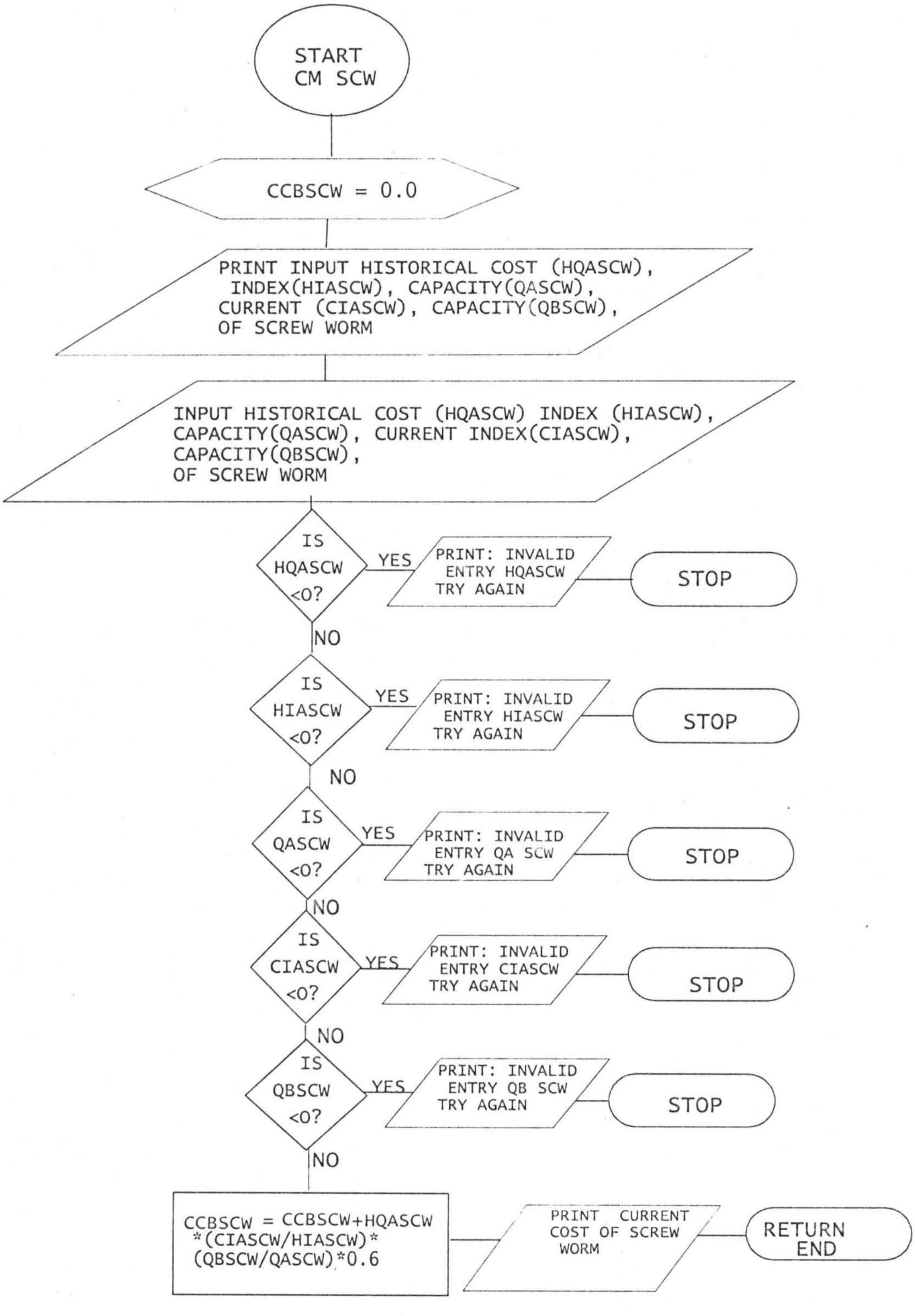
COMPUTATION OF CURRENT COST OF PREHEATING TANK



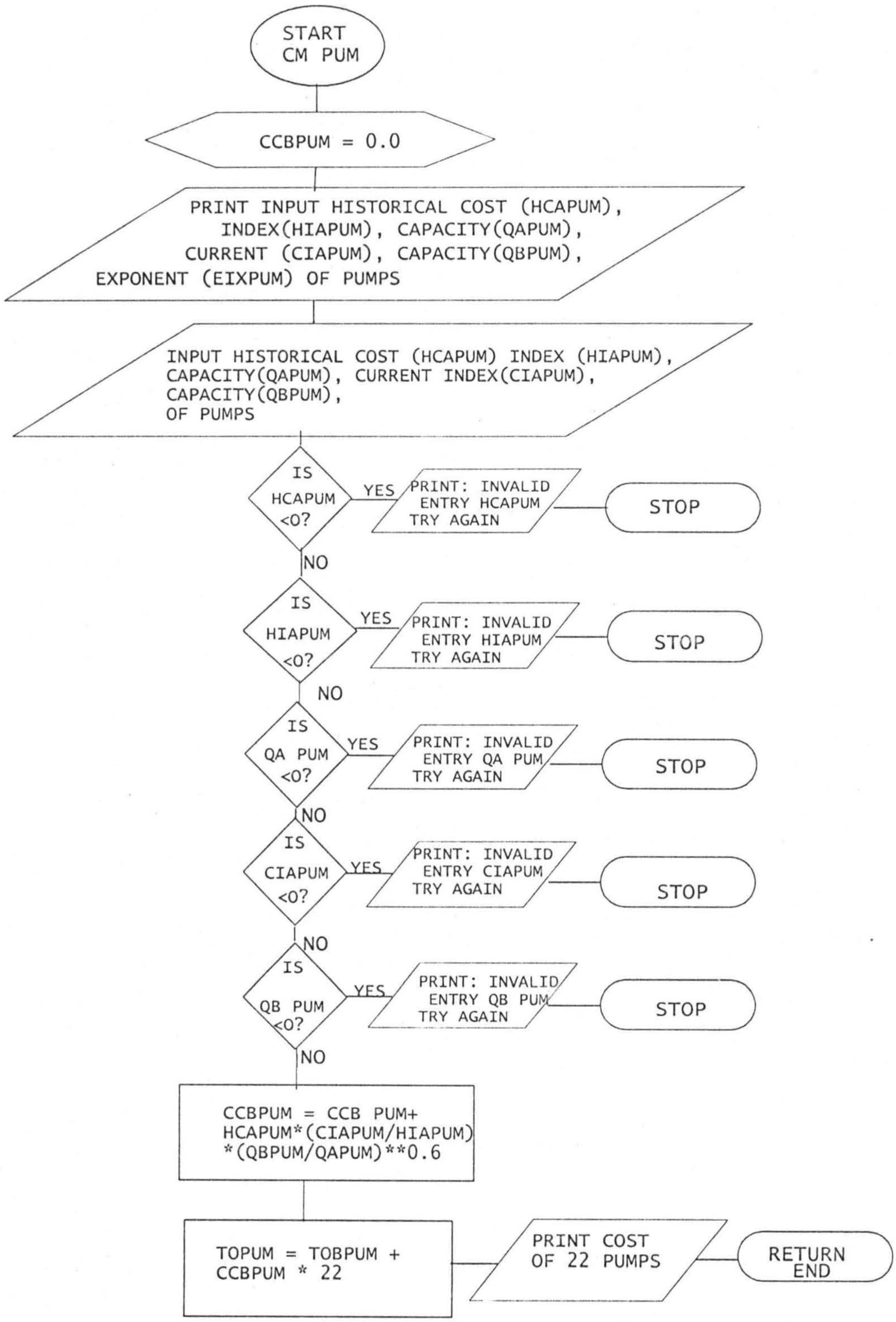
COMPUTATION OF CURRENT COST OF VACUUM SYSTEM



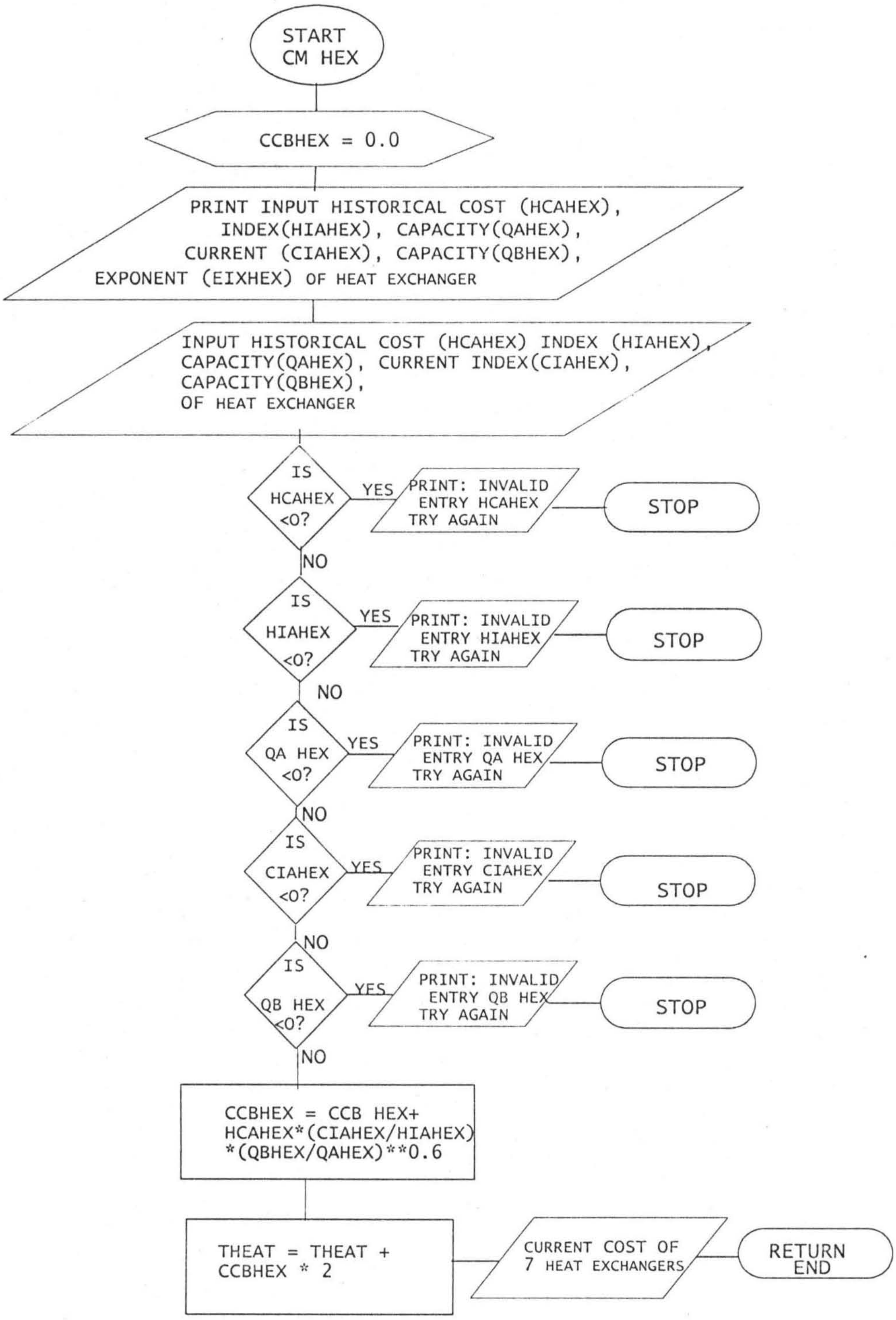
COMPUTATION OF CURRENT COST OF SCREW WORM



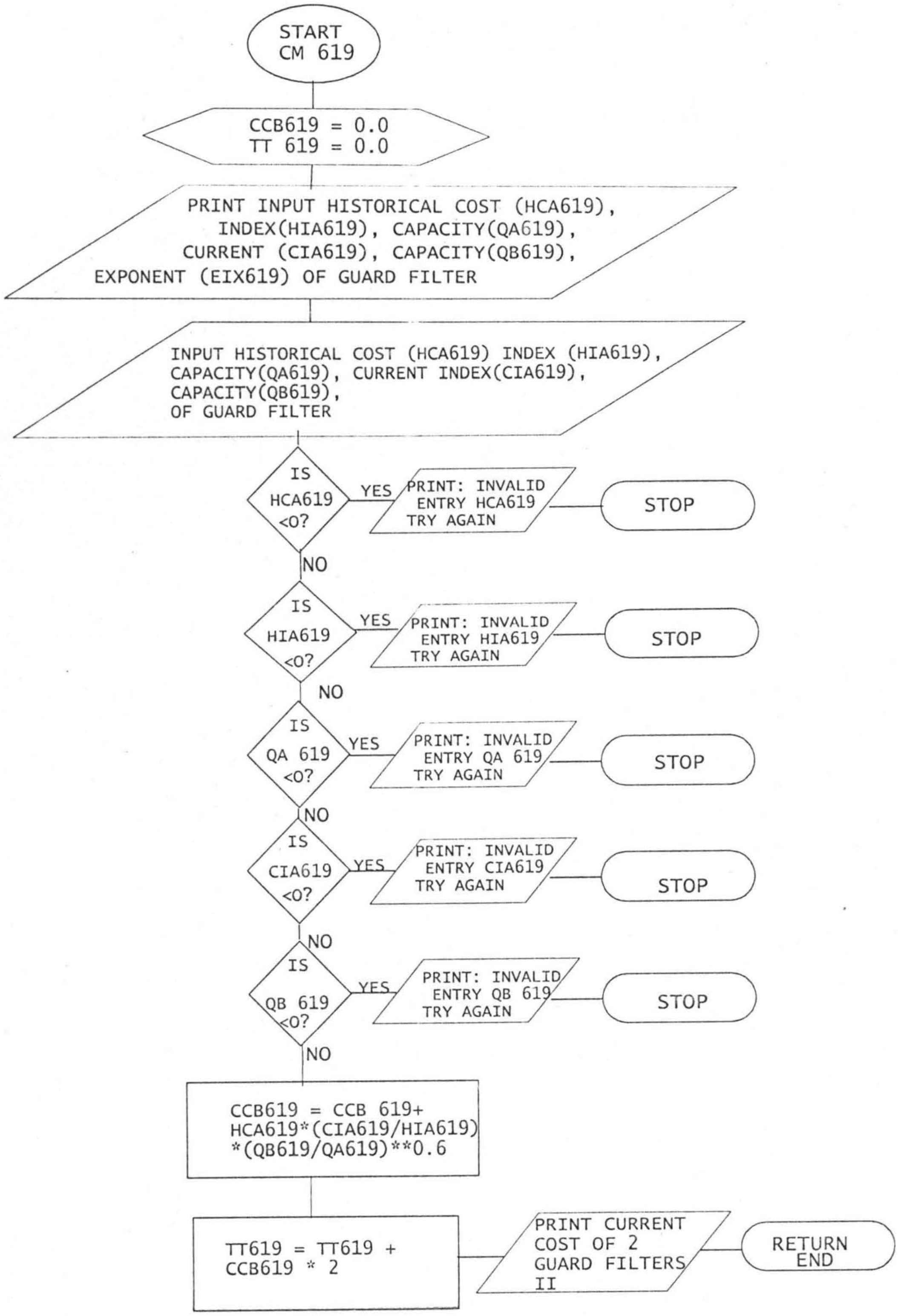
COMPUTATION OF CURRENT COST OF PUMPS



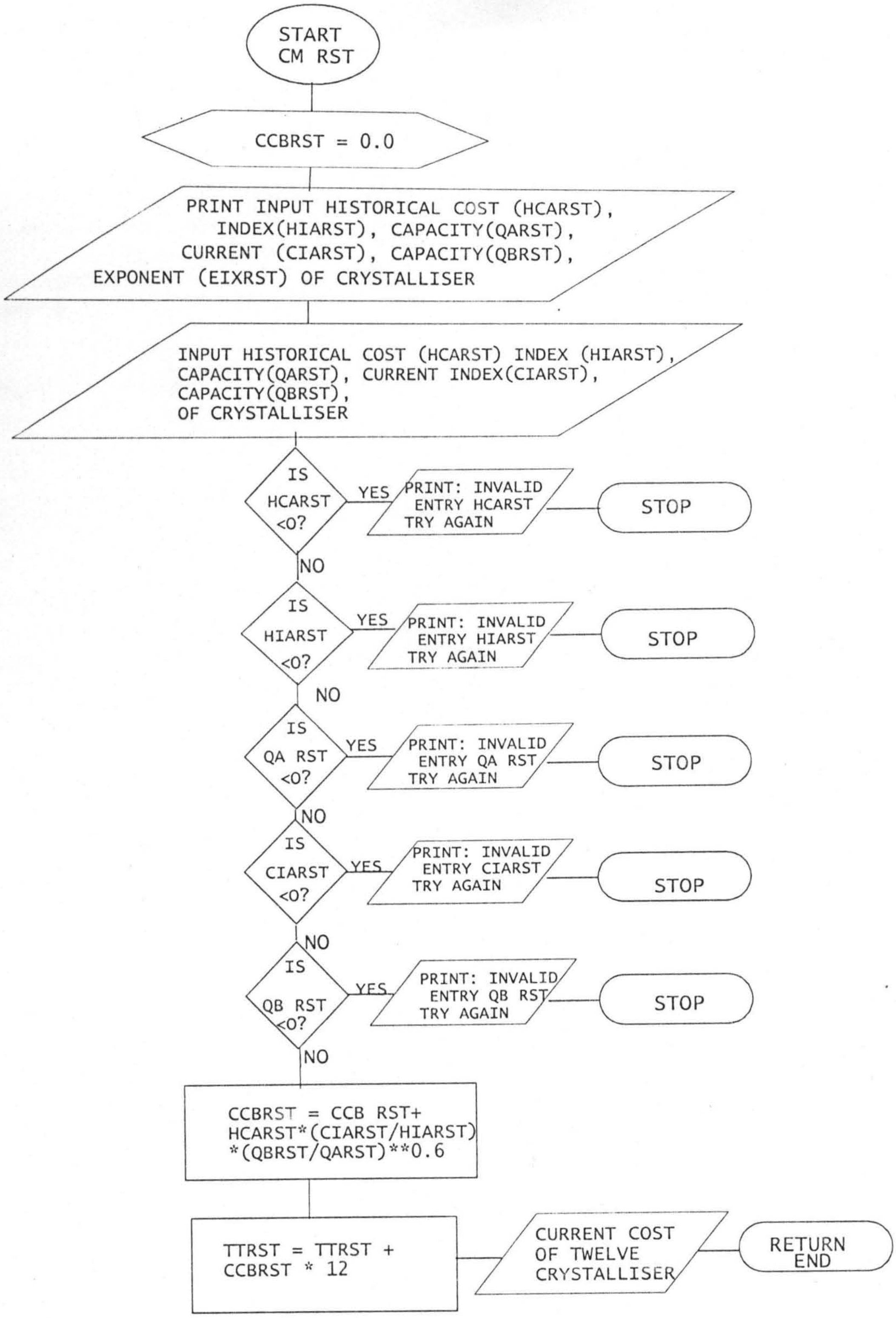
COMPUTATION OF CURRENT COST OF SEVEN HEAT EXCHANGERS



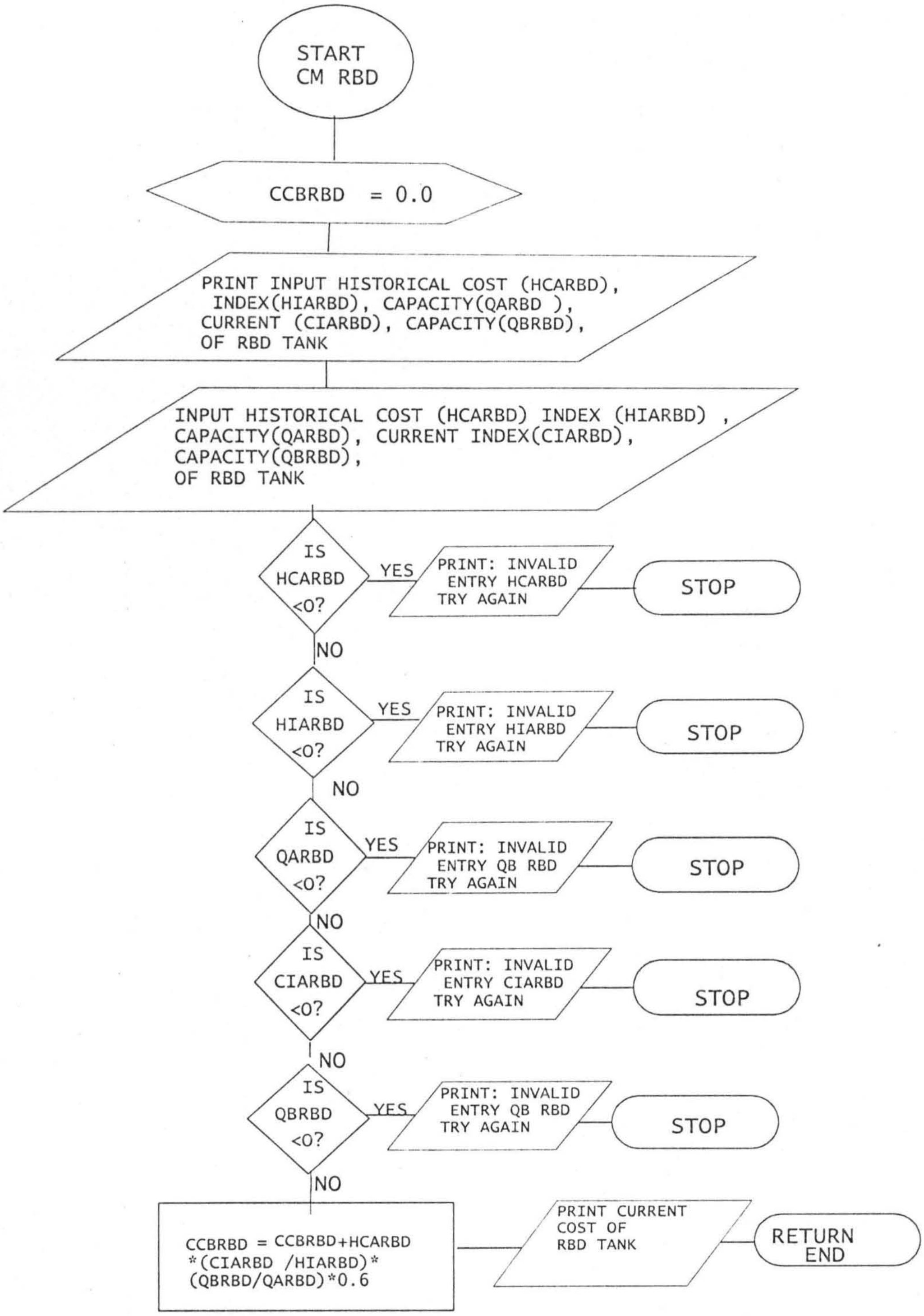
COMPUTATION OF CURRENT COST OF TWO GUARD FILTERS II



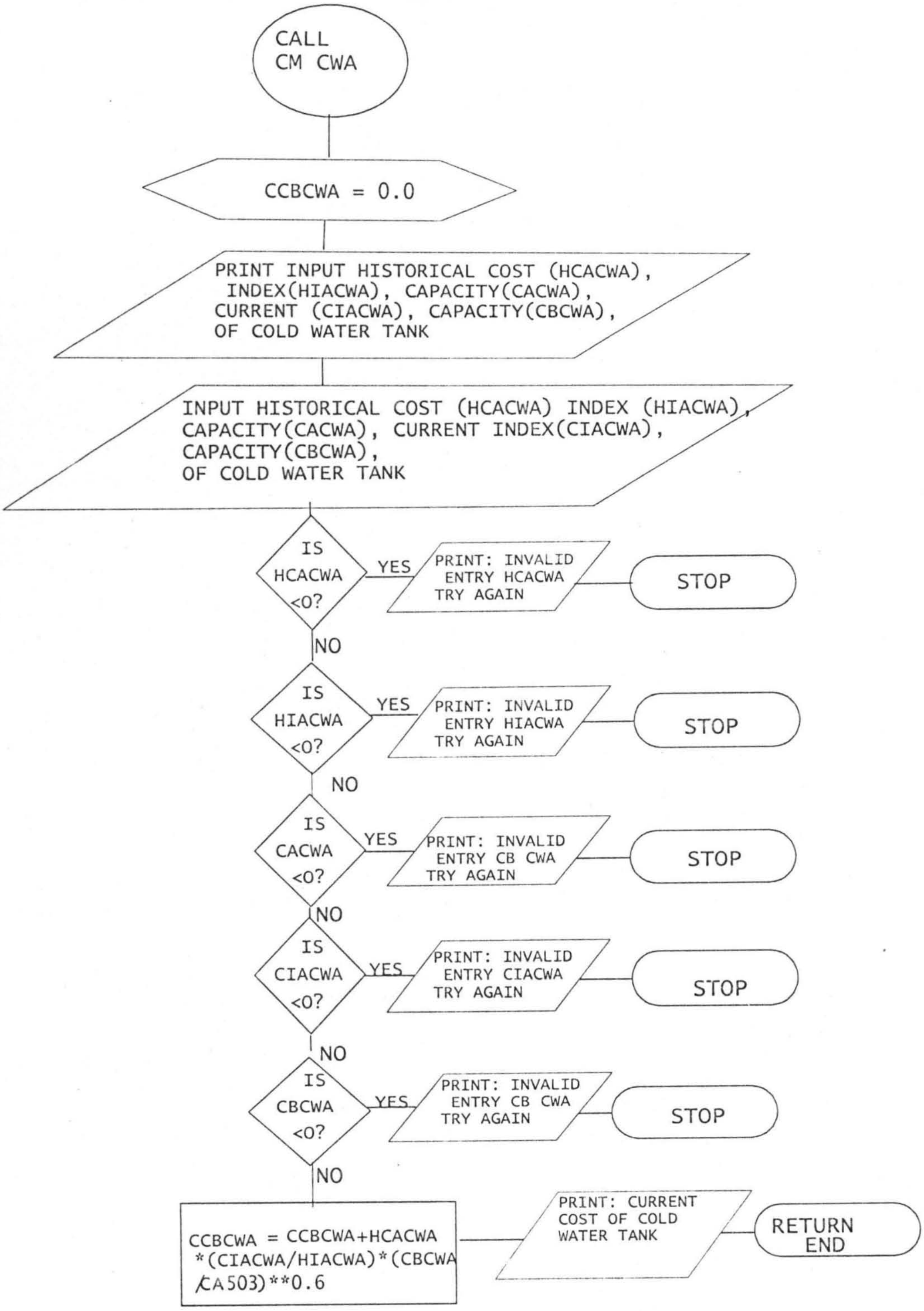
COMPUTATION OF CURRENT COST OF 12 CRYSTALLISERS



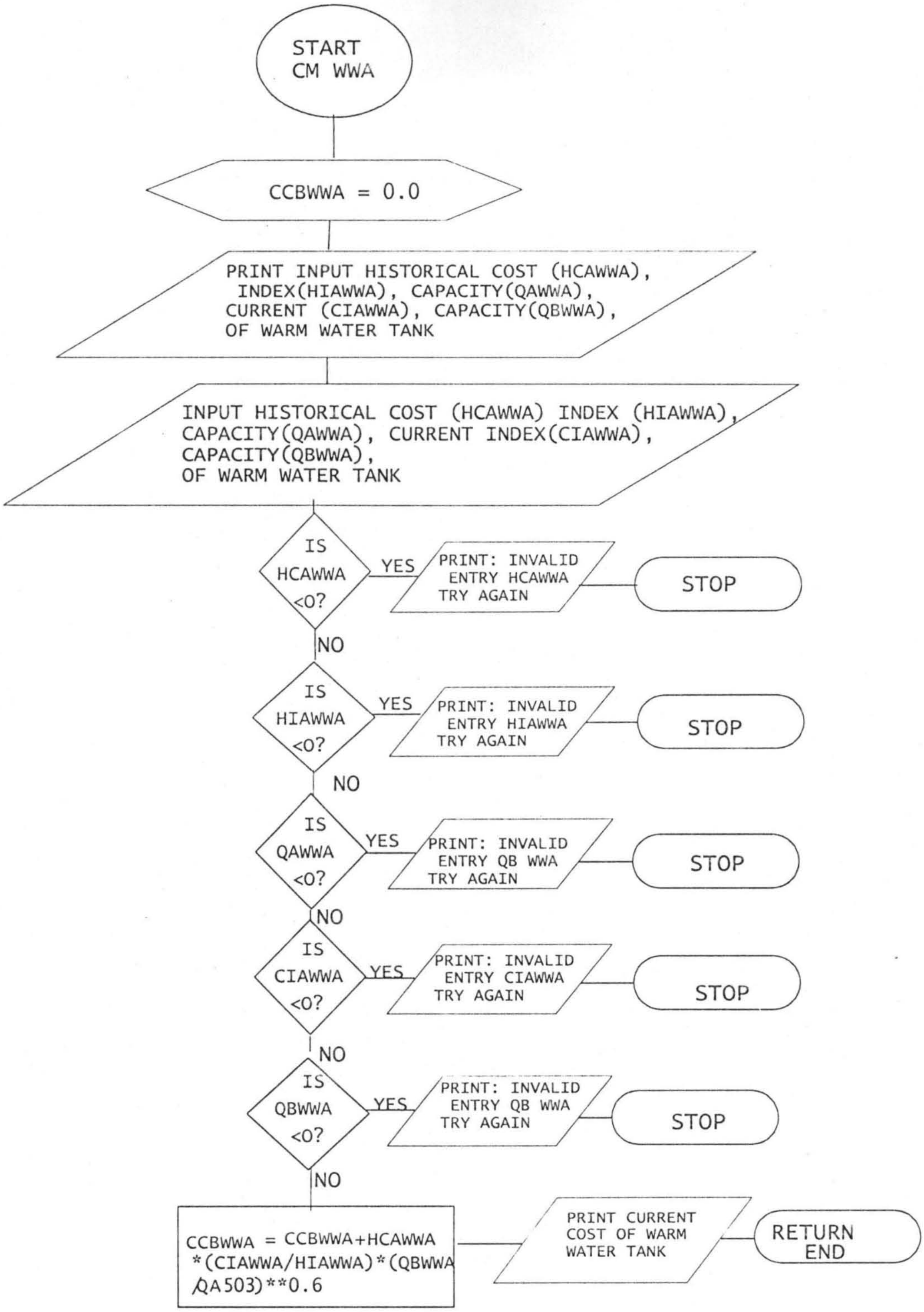
COMPUTATION OF CURRENT COST OF RBD TANK



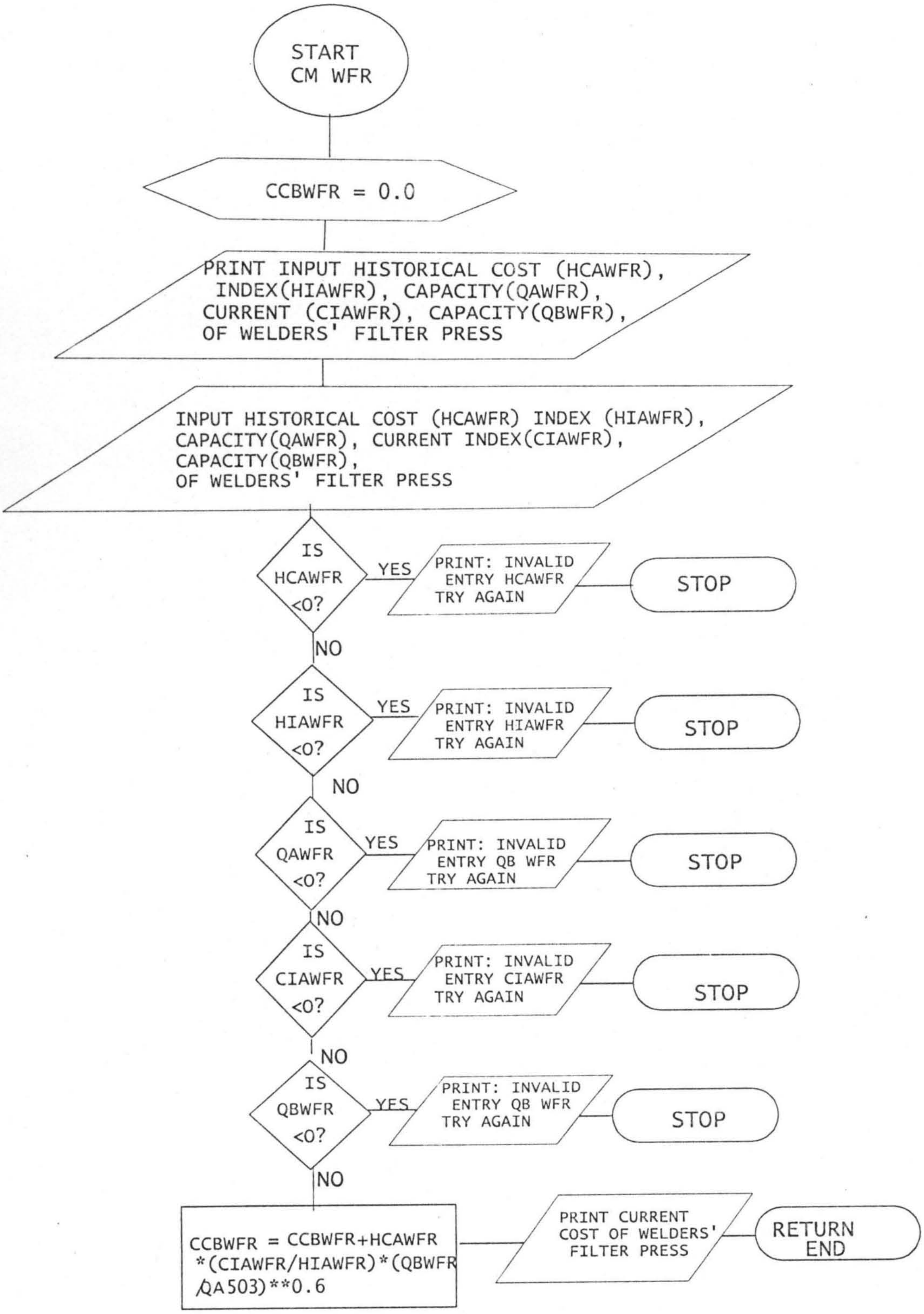
COMPUTATION OF CURRENT COST OF COLD WATER TANK



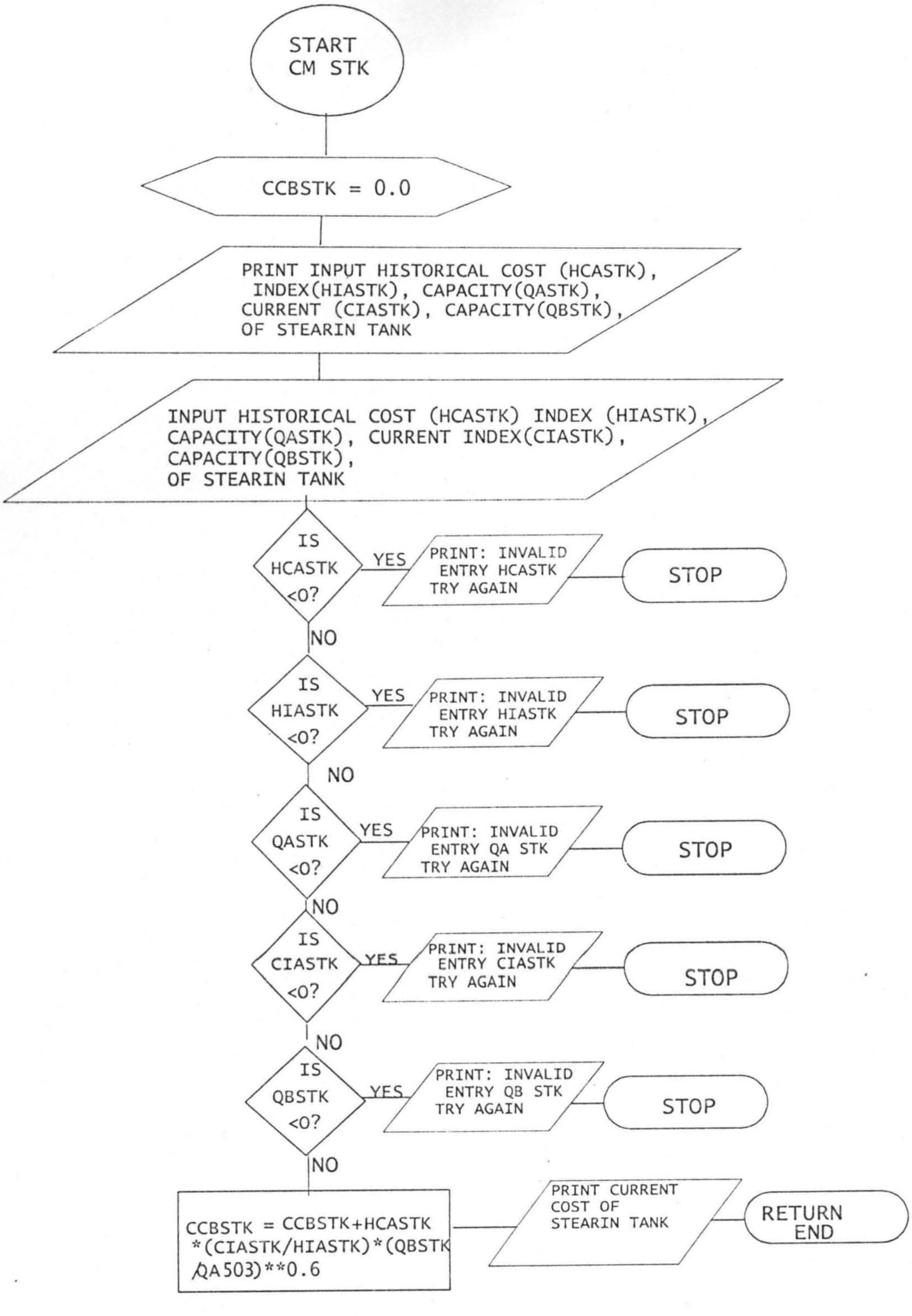
COMPUTATION OF CURRENT COST OF WARM WATER TANK



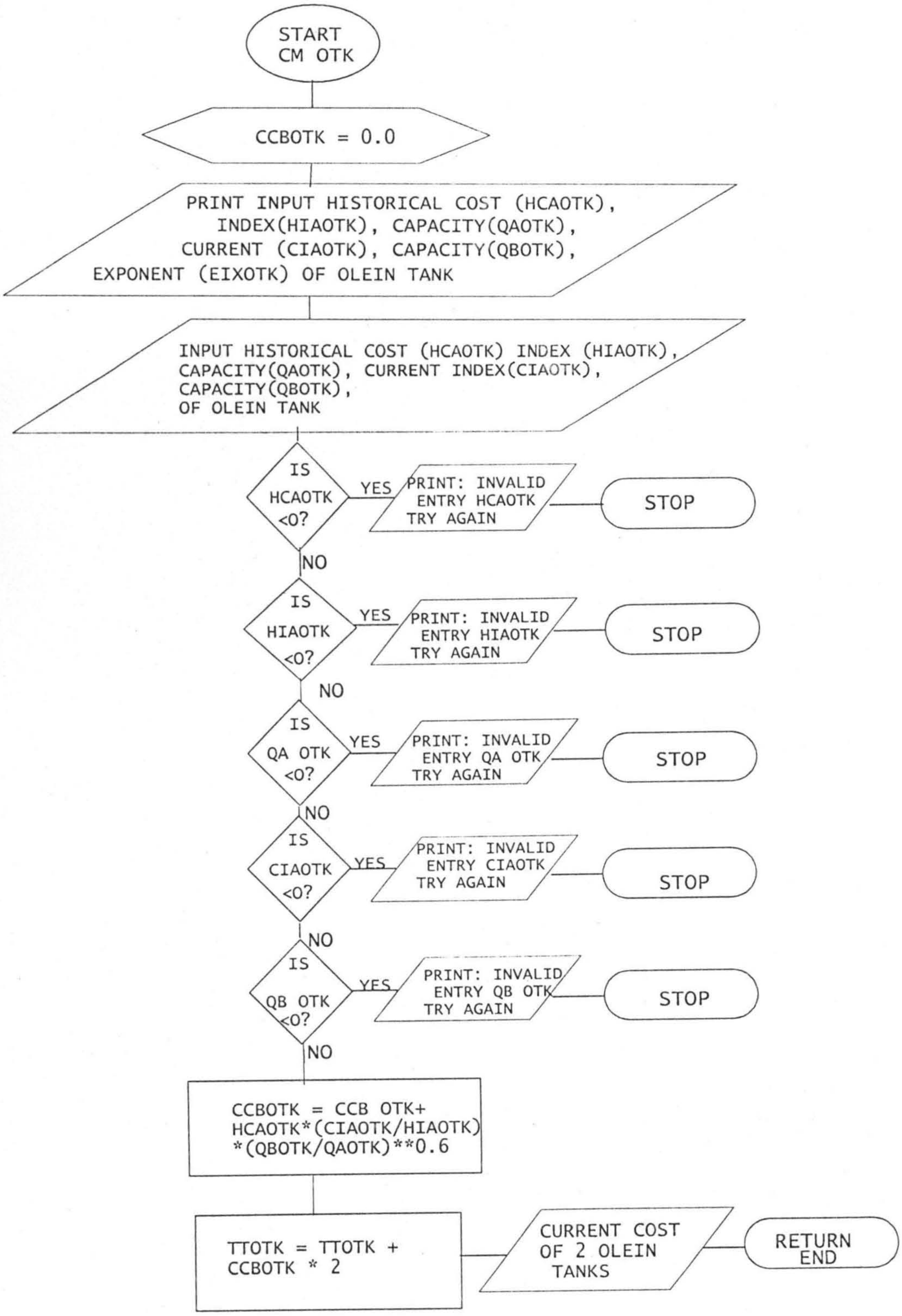
COMPUTATION OF CURRENT COST OF WELDERS' FILTER PRESS



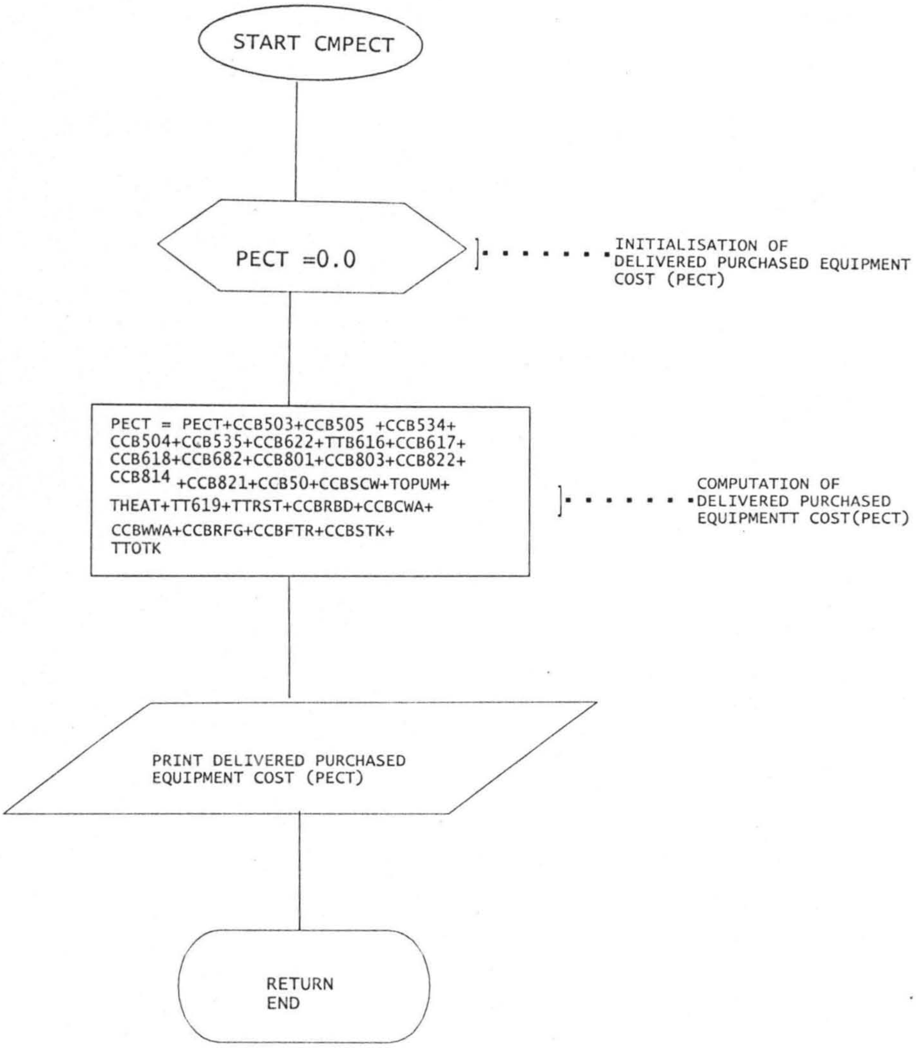
COMPUTATION OF CURRENT COST OF STEARIN TANK



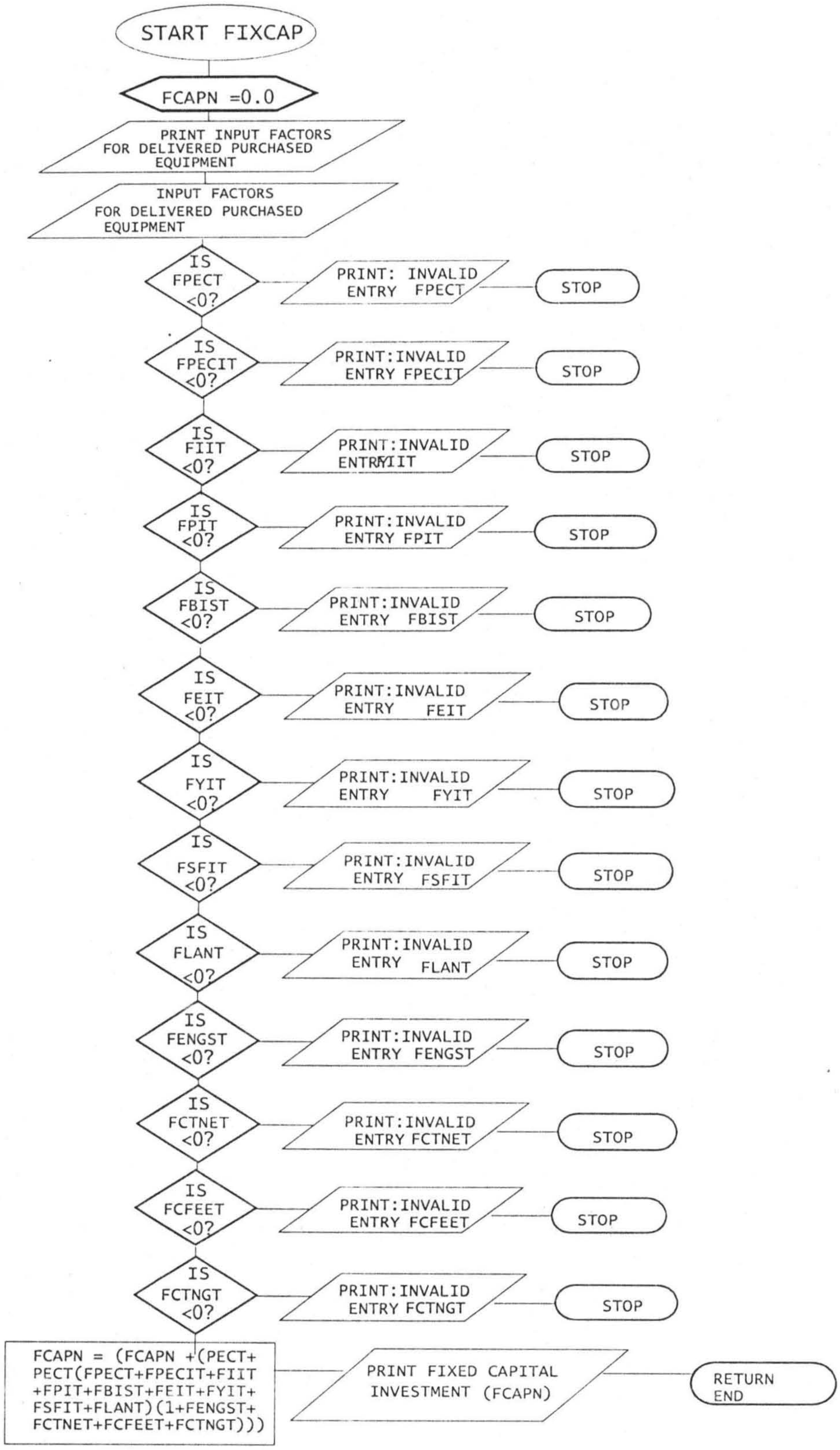
COMPUTATION OF CURRENT COST OF TWO OLEIN TANKS



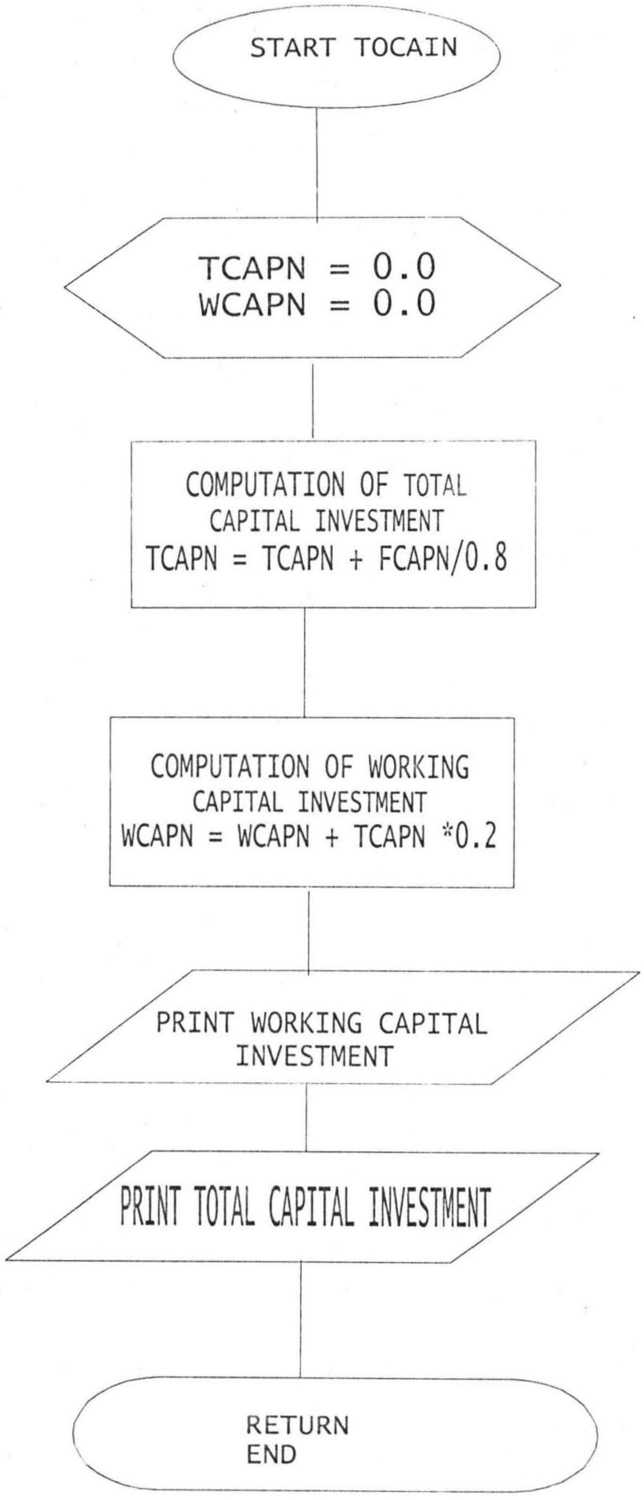
COMPUTATION OF THE DELIVERED PURCHASED EQUIPMENTT COST



COMPUTATION OF THE FIXED CAPITAL INVESTMENT



COMPUTATION OF WORKING AND TOTAL CAPITAL INVESTMENTS



APPENDIX B2: Program SIX10R Representing The Six-Tenths Factor Rule Method.

```
      PROGRAM SIX10R
      INTEGER CUYEAR
      COMMON PECT
C This program calculates the current cost of Palm Oil Refinery and
C Fractionation Plant making use of Six-Tenths Factor Rule method to
C account for fluctuation in the cost of equipment due to inflation,
C Government regulation, type and size of equipment, location of the
C plant, operating time and rate of production, and a host of other
C factors.
C
C  AUTHOR:          NGUBI FREDERICKS WIRSIY
C  MAT. NO.:        M. ENG./SEET/573/2000/2001
C  COURSE TITLE:    M.ENG PROJECT WORK
C  COURSE CODE:     CEE 623
C  PROJECT TITLE:   EFFECT OF COST FLUCTUATION ON THE DESIGN OF A PALM
C                   OIL REFINERY AND FRACTIONATION INDUSTRY
C  SUPERVISOR:      DR. K.R.ONIFADE
C  LANGUAGE:        FORTRAN 77
C  DATE:            5 MAY,2002
C
C  FILES:           SIX10R.LST,SIX1OR.RES
C  ARRAYS           NONE
C
C   SECTION FOR DEFINITION OF SUBROUTINES IN MAIN ROUTINE
C
C  FIRST                  INTRODUCTORY MODULE
C  CM503                  COST MODULE FOR CaCO3 TANK
C  CM505                  COST MODULE FOR MIXING TANK
C  CM534                  COST MODULE FOR PHOSPHORIC ACID TANK
C  CM504                  COST MODULE FOR DRIER
C  CM535                  COST MODULE FOR BLEACHING EARTH TANK
C  CM622                  COST MODULE FOR CONTINUOUS BLEACHING
C                         REACTOR
C  CM616                  COST MODULE FOR BERNARDINNI FILTER
C  CM617                  COST MODULE FOR STEEL SUPER FILTER
C  CM618                  COST MODULE FOR GUARD FILTER I
C  CM682                  COST MODULE FOR DEQANTER
C  CM801                  COST MODULE FOR STORAGE TANK
C  CM803                  COST MODULE FOR DEAERATOR/DRIER
C  CM822                  COST MODULE FOR DEODORISER
C  CM814                  COST MODULE FOR FFA RECUPERATOR
C  CM821                  COST MODULE FOR PREHEATING TANK
C  CM50                   COST MODULE FOR VACUUM SYSTEM
C  CMSCW                  COST MODULE FOR SCREW WARM
C  CMPUM                  COST MODULE FOR PUMPS
C  CMHEX                  COST MODULE FOR HEAT EXCHANGERS
C  CM619                  COST MODULE FOR GUARD FILTER 2
C  CMRST                  COST MODULE FOR CRYSTALLISERS
C  CMRBD                  COST MODULE FOR RBD TANK
C  CMCWA                  COST MODULE FOR COLD WATER TANK
C  CMWWA                  COST MODULE FOR WARM WATER TANK
C  CMWFR                  COST MODULE FOR WELDERS' FILTER PRESS
C  CMSTK                  COST MODULE FOR STEARIN TANK
C  CMOTK                  COST MODULE FOR OLEIN TANK
C  CMPECT                 COST MODULE FOR DELIVERED PURCHASED
C                         EQUIPMENT COST
C  FIXCAP                 COST MODULE FOR FIXED CAPITAL INVESTMENT
```

```
C  TOQAIN                        COST MODULE FOR WORKING & TOTAL CAPITAL
C                                INVESTMENTS
C
C SECTION FOR COMPUTING THE INDIVIDUAL EQUIPMENT COST
C
      PECT=0
      CALL FIRST(NRYEAR,CUYEAR)
      CALL CM503(HC503A,HI503A,CI505A,Q503A,Q503B,CC503B)
      CALL CM505(HC505A,HI505A,CI505A,Q505A,Q505B,CC505B)
      CALL CM534(HC534A,HI534A,CI534A,Q534A,Q534B,CC534B)
      CALL CM504(HC504A,HI504A,CI504A,Q504A,Q504B,CC504B)
      CALL CM535(HC535A,HI535A,CI535A,Q535A,Q535B,CC535B)
      CALL CM622(HC622A,HI622A,CI622A,Q622A,Q622B,CC622B)
      CALL CM616(HC616A,HI616A,CI616A,Q616A,Q616B,CC616B,TF616B)
      CALL CM617(HC617A,HI617A,CI617A,Q617A,Q617B,CC617B)
      CALL CM618(HC618A,HI618A,CI618A,Q618A,Q618B,CC618B)
      CALL CM682(HC682A,HI682A,CI682A,Q682A,Q682B,CC682B)
      CALL CM801(HC801A,HI801A,CI801A,Q801A,Q801B,CC801B)
      CALL CM803(HC803A,HI803A,CI803A,Q803A,Q803B,CC803B)
      CALL CM822(HC822A,HI822A,CI822A,Q822A,Q822B,CC822B)
      CALL CM814(HC814A,HI814A,CI814A,Q814A,Q814B,CC814B)
      CALL CM821(HC821A,HI821A,CI821A,Q821A,Q821B,CC821B)
      CALL CM50(HC50A,HI50A,CI50A,Q50A,Q50B,CC50B)
      CALL CMSCW(HCSCWA,HISCWA,CISCWA,QASCW,QSCWB,CCBSCW)
      CALL CMPUM(TOPUMS,HCPUMA,HIPUMA,CIPUMA,QPUMA,QPUMB,CCPUMB)
      CALL CMHEX(THEATS,HCHEXA,HIHEXA,CIHEXA,QHEXA,QHEXB,CCHEXB)
      CALL CM619(TTX619,HC619A,HI619A,CI619A,Q619A,Q619B,CC619B)
      CALL CMRST(TTXRST,HCRSTA,HIRSTA,CIRSTA,QRSTA,QRSTB,CCRSTB)
      CALL CMRBD(HCRBDA,HIRBDA,CIRBDA,QRBDA,QRBDB,CCRBDB)
      CALL CMCWA(HCCWAA,HICWAA,CICWAA,QCWAA,QCWAB,CCCWAB)
      CALL CMWWA(HCWWAA,HIWWAA,CIWWAA,QWWAA,QWWAB,CCWWAB)
      CALL CMFTR(HCFTRA,HIFTRA,CIFTRA,QFTRA,QFTRB,CCFTRB)
      CALL CMSTK(HCSTKA,HISTKA,CISTKA,QSTKA,QSTKB,CCSTKB)
      CALL CMOTK(TTXOTK,HCOTKA,HIOTKA,CIOTKA,QOTKA,QOTKB,CCOTKB)
C
C The Delivered purchased equipment cost is obtained by summing the
C calculated current costs of all equipment.
C
C   SECTION FOR COMPUTING THE DELIVERED PURCHASED EQUIPMENT COST (PECT).
C
C
      CALL CMPECT(PECT,CC503B,CC505B,CC534B,CC504B,CC535B,CC622B,
     $TF616B,CC617B,CC618B,CC682B,CC801B,CC803B,CC822B,CC814B,
     $CC821B,CC50B,CCBSCW,TOPUMS,THEATS,TTX619,TTXRST,CCRBDB,CCCWAB,
     $CCWWAB,CCFTRB,CCSTKB,TTXOTK)

C     SECTION FOR COMPUTING THE FIXED CAPITAL INVESTMENT(FCAPIN)
C
      CALL FIXCAP(FCAPIN,PECT,FPEC,FPECI,FII,FPI,FBIS,FEI,
     $FYI,FSFI,FLAN,FENGS,FCTNE,FCFEE,FCTNG)
C
C  SECTION FOR COMPUTING THE WORKING AND TOTAL CAPITAL INVESTMENTS
C  (WCAPIN & TCAPIN)
C
      CALL TOCAIN(FCAPIN,TCAPIN,WCAPIN)
      STOP
      END
```

```
C
C    SECTION FOR SUBROUTINES
C
      SUBROUTINE FIRST(MRYEAR,CUYEAR)
      INTEGER CUYEAR
      OPEN(2,FILE='SIX10R.RES')
      REWIND(2)
      PRINT*,'Input Reference year for Cost Indexes (MRYEAR)'
      PRINT*,'Input Current year for Cost Indexes (CUYEAR)'
      READ(*,*)MRYEAR,CUYEAR
      IF(MRYEAR.LT.1996)THEN
         PRINT10,'INVALID ENTRY:',MRYEAR,'TRY AGAIN!'
   10    FORMAT(/,10X,A,1X,I5,2X,A)
         STOP
      ELSE
         WRITE(*,13)'APPENDIX B2: Results for Program SIX10R,'
         WRITE(*,15)'Representing The Six-Tenths Factor Rule Method'
         WRITE(2,13)'APPENDIX B2: Results for Program SIX10R,'
         WRITE(2,15)'Representing The Six-Tenths Factor Rule Method'
         WRITE(*,20)'The Reference Year used is:',MRYEAR
         WRITE(2,20)'The Reference Year used is:',MRYEAR
         WRITE(*,20)'The Reference Year used is:',MRYEAR
         WRITE(2,20)'The Reference Year used is:',MRYEAR
         WRITE(*,22)
         WRITE(2,22)
         WRITE(*,25)'The Current Year is:',CUYEAR
         WRITE(2,25)'The Current Year is:',CUYEAR
         WRITE(*,27)
         WRITE(2,27)
   13    FORMAT(/,12X,A)
   15    FORMAT(12X,A)
   20    FORMAT(/,22X,A,4X,I5)
   22    FORMAT(22X,27('-'),5X,4('-'))
   25    FORMAT(/,22X,A,11X,I5)
   27    FORMAT(22X,20('-'),12X,4('-'))
      ENDIF
      CONTINUE
      WRITE(*,40)'Name of Equipment','Cost of Equipment in 2002 (Naira)'
      WRITE(2,40)'Name of Equipment','Cost of Equipment in 2002 (Naira)'
   40 FORMAT(/,10X,A,18X,A)
      WRITE(*,50)
      WRITE(2,50)
   50 FORMAT(10X,17('-'),18X,33('-'))
      RETURN
      END

C
C
C                   VARIABLES IN THE SUBROUTINES
C  CCB                            Current Cost of  equipment B
C  HCA                            Historic Cost of  equipment A
C  CIA                            Current  cost Index of equipment A
C  HIA                            Historic cost Index of equipment A
C  QA                             Historical Capacity of Equipment A
C  QB                             Current Capacity of Equipment B
C
C  For instance,CCB503,HCA503,CIA503,HIA503,QA503 and QB503 stand for
C  Current Cost of CaCO3 tank A, Historic Cost of CaCO3 tank A,Current
C  cost Index of CaCO3 tank A, Historic cost Index of CaCo3 tank A
C  Historical Capacity and Current capacity of CaCO3 tank A,designated
503.
```

```
      SUBROUTINE CM503(HCA503,HIA503,CIA503,QA503,QB503,CCB503)
C Subroutine CM503 calculates the current cost of CaCO3 Tank.
      CCB503=0.0
      PRINT1,'Input Historical Cost of CaCO3 Tank A (HCA503),',
     $'Historical Index of CaCO3 Tank A (HIA503),',
     $'current Index of CaCO3 Tank A (CIA503),',
     $'capacity of CaCO3 Tank A (QA503),',
     $'capacity of CaCO3 Tank B (QB503)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA503,HIA503,CIA503,QA503,QB503
      IF(HCA503.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA503) :',HCA503,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA503.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA503) :',HIA503,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA503.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA503) :',CIA503,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA503.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA503) :',QA503,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB503.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB503) :',QB503,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
       ELSE
C  The following formula is used for the calculation of the cost of
CaCO3 Tank
        CCB503=CCB503+HCA503*(CIA503/HIA503)*(QB503/QA503)**0.6
        WRITE(*,55)'CaCO3 Tank', 'N',CCB503
        WRITE(2,55)'CaCO3 Tank', 'N',CCB503
   55   FORMAT(/,10X,A,33X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM505(HCA505,HIA505,CIA505,QA505,QB505,CCB505)
C Subroutine CM505 calculates the current cost of Mixing Tank
      CCB505=0.0
      PRINT1,'Input Historical Cost (HCA505),',
     $'Historical Index of Mixing Tank A (HIA505),',
     $'current Index of Mixing Tank A (CIA505),',
     $'capacity of Mixing Tank A (QA505),',
     $'capacity of Mixing Tank B (QB505)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA505,HIA505,CIA505,QA505,QB505
      IF(HCA505.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA505):',HCA505,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA505.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA505) :',HIA505,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
```

```
      ELSEIF(CIA505.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA505) :',CIA505,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA505.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA505) :',QA505,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB505.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB505) :',QB505,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
       ELSE
C  The following formula is used for the calculation of the cost of
C  Mixing Tank.
        CCB505=CCB505+HCA505*(CIA505/HIA505)*(QB505/QA505)**0.6
        WRITE(*,55)'Mixing Tank', 'N',CCB505
        WRITE(2,55)'Mixing Tank', 'N',CCB505
   55   FORMAT(/,10X,A,32X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM534(HCA534,HIA534,CIA534,QA534,QB534,CCB534)
C Subroutine CM534 calculates the current cost of Phosphoric Acid Tank
      CCB534=0.0
      PRINT1,'Input Historical Cost of Phosphoric Acid Tank A(HCA534),',
     $'Historical Index of Phosphoric Acid Tank A (HIA534),',
     $'current Index of Phosphoric Acid Tank A (CIA534),',
     $'capacity of Phosphoric Acid Tank A (QA534),',
     $'capacity of Phosphoric Acid Tank B(QB534)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA534,HIA534,CIA534,QA534,QB534
      IF(HCA534.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA534) :',HCA534,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA534.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA534) :',HIA534,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA534.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA534) :',CIA534,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA534.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA534) :',QA534,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB534.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB534) :',QB534,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Phosphoric Acid Tank
        CCB534=CCB534+HCA534*(CIA534/HIA534)*(QB534/QA534)**0.6
        WRITE(*,55)'Phosphoric Acid Tank','N',CCB534
        WRITE(2,55)'Phosphoric Acid Tank','N',CCB534
   55   FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
```

```
      SUBROUTINE CM503(HCA503,HIA503,CIA503,QA503,QB503,CCB503)
C Subroutine CM503 calculates the current cost of CaCO3 Tank.
      CCB503=0.0
      PRINT1,'Input Historical Cost of CaCO3 Tank A (HCA503),',
     $'Historical Index of CaCO3 Tank A (HIA503),',
     $'current Index of CaCO3 Tank A (CIA503),',
     $'capacity of CaCO3 Tank A (QA503),',
     $'capacity of CaCO3 Tank B (QB503)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA503,HIA503,CIA503,QA503,QB503
      IF(HCA503.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCA503) :',HCA503,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIA503.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIA503) :',HIA503,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIA503.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIA503) :',CIA503,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QA503.LE.0)THEN
            PRINT35,'INVALID ENRTY (QA503) :',QA503,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QB503.LE.0)THEN
            PRINT45,'INVALID ENRTY (QB503) :',QB503,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
       ELSE
C  The following formula is used for the calculation of the cost of
CaCO3 Tank
        CCB503=CCB503+HCA503*(CIA503/HIA503)*(QB503/QA503)**0.6
        WRITE(*,55)'CaCO3 Tank', 'N',CCB503
        WRITE(2,55)'CaCO3 Tank', 'N',CCB503
   55   FORMAT(/,10X,A,33X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM505(HCA505,HIA505,CIA505,QA505,QB505,CCB505)
C Subroutine CM505 calculates the current cost of Mixing Tank
      CCB505=0.0
      PRINT1,'Input Historical Cost (HCA505),',
     $'Historical Index of Mixing Tank A (HIA505),',
     $'current Index of Mixing Tank A (CIA505),',
     $'capacity of Mixing Tank A (QA505),',
     $'capacity of Mixing Tank B (QB505)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA505,HIA505,CIA505,QA505,QB505
      IF(HCA505.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCA505):',HCA505,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIA505.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIA505) :',HIA505,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
```

```
      RETURN
      END
      SUBROUTINE CM504(HCA504,HIA504,CIA504,QA504,QB504,CCB504)
C Subroutine CM504 calculates the current cost of Drier
      CCB504=0.0
      PRINT1,'Input Historical Cost of Drier A (HCA504),',
     $'Historical Index of Drier A (HIA504),',
     $'current Index of Drier A (CIA504),',
     $'capacity of Drier A (QA504),',
     $'capacity of Drier B (QB504)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA504,HIA504,CIA504,QA504,QB504
      IF(HCA504.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA504) :',HCA504,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA504.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA504) :',HIA504,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA504.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA504) :',CIA504,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA504.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA504) :',QA504,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB504.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB504) :',QB504,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
       ELSE
C  The following formula is used for the calculation of the Cost of
Drier
        CCB504=CCB504+HCA504*(CIA504/HIA504)*(QB504/QA504)**0.6
        WRITE(*,55)'Drier', 'N',CCB504
        WRITE(2,55)'Drier', 'N',CCB504
   55   FORMAT(/,10X,A,38X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM535(HCA535,HIA535,CIA535,QA535,QB535,CCB535)
C Subroutine CM535 calculates the current cost of Bleaching Earth Tank
      CCB535=0.0
      PRINT1,'Input Historical Cost of Bleaching Earth Tank A(HCA535),',
     $'Historical Index of Bleaching Earth Tank A (HIA535),',
     $'current Index of Bleaching Earth Tank A (CIA535),',
     $'capacity of Bleaching Earth Tank A (QA535),',
     $'capacity of Bleaching Earth Tank B (QB535)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA535,HIA535,CIA535,QA535,QB535
      IF(HCA535.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA535) :',HCA535,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA535.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA535) :',HIA535,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
```

```
      ELSEIF(CIA505.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA505) :',CIA505,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA505.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA505) :',QA505,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB505.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB505) :',QB505,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
       ELSE
C The following formula is used for the calculation of the cost of
C Mixing Tank.
       CCB505=CCB505+HCA505*(CIA505/HIA505)*(QB505/QA505)**0.6
       WRITE(*,55)'Mixing Tank', 'N',CCB505
       WRITE(2,55)'Mixing Tank', 'N',CCB505
   55  FORMAT(/,10X,A,32X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM534(HCA534,HIA534,CIA534,QA534,QB534,CCB534)
C Subroutine CM534 calculates the current cost of Phosphoric Acid Tank
      CCB534=0.0
      PRINT1,'Input Historical Cost of Phosphoric Acid Tank A(HCA534),',
     $'Historical Index of Phosphoric Acid Tank A (HIA534),',
     $'current Index of Phosphoric Acid Tank A (CIA534),',
     $'capacity of Phosphoric Acid Tank A (QA534),',
     $'capacity of Phosphoric Acid Tank B(QB534)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA534,HIA534,CIA534,QA534,QB534
      IF(HCA534.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA534) :',HCA534,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA534.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA534) :',HIA534,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA534.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA534) :',CIA534,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA534.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA534) :',QA534,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB534.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB534) :',QB534,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C The following formula is used for the calculation of the Cost of
C Phosphoric Acid Tank
       CCB534=CCB534+HCA534*(CIA534/HIA534)*(QB534/QA534)**0.6
       WRITE(*,55)'Phosphoric Acid Tank','N',CCB534
       WRITE(2,55)'Phosphoric Acid Tank','N',CCB534
   55  FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
```

```
      RETURN
      END
      SUBROUTINE CM504(HCA504,HIA504,CIA504,QA504,QB504,CCB504)
C Subroutine CM504 calculates the current cost of Drier
      CCB504=0.0
      PRINT1,'Input Historical Cost of Drier A (HCA504),',
     $'Historical Index of Drier A (HIA504),',
     $'current Index of Drier A (CIA504),',
     $'capacity of Drier A (QA504),',
     $'capacity of Drier B (QB504)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA504,HIA504,CIA504,QA504,QB504
      IF(HCA504.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA504) :',HCA504,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA504.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA504) :',HIA504,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA504.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA504) :',CIA504,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA504.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA504) :',QA504,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB504.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB504) :',QB504,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
       ELSE
C  The following formula is used for the calculation of the Cost of
Drier
        CCB504=CCB504+HCA504*(CIA504/HIA504)*(QB504/QA504)**0.6
        WRITE(*,55)'Drier', 'N',CCB504
        WRITE(2,55)'Drier', 'N',CCB504
   55   FORMAT(/,10X,A,38X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM535(HCA535,HIA535,CIA535,QA535,QB535,CCB535)
C Subroutine CM535 calculates the current cost of Bleaching Earth Tank
      CCB535=0.0
      PRINT1,'Input Historical Cost of Bleaching Earth Tank A(HCA535),',
     $'Historical Index of Bleaching Earth Tank A (HIA535),',
     $'current Index of Bleaching Earth Tank A (CIA535),',
     $'capacity of Bleaching Earth Tank A (QA535),',
     $'capacity of Bleaching Earth Tank B (QB535)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA535,HIA535,CIA535,QA535,QB535
      IF(HCA535.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA535) :',HCA535,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA535.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA535) :',HIA535,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
```

```
      ELSEIF(CIA535.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA535) :',CIA535,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA535.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA535) :',QA535,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB535.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB535) :',QB535,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Bleaching Earth
        CCB535=CCB535+HCA535*(CIA535/HIA535)*(QB535/QA535)**0.6
        WRITE(*,55)'Bleaching Earth Tank','N',CCB535
        WRITE(2,55)'Bleaching Earth Tank','N',CCB535
   55   FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM622(HCA622,HIA622,CIA622,QA622,QB622,CCB622)
C Subroutine CM622 calculates the current cost of Continuous Bleaching
Reactor
      CCB622=0.0
      PRINT1,'Input Historical Cost of Continuous Bleaching Reactor
     $A (HCA622),',
     $'Historical Index of Continuous Bleaching Reactor A (HIA622),',
     $'current Index of Continuous Bleaching Reactor A (CIA622),',
     $'capacity of Continuous Bleaching Reactor A (QA622),',
     $'capacity of Continuous Bleaching Reactor B (QB622)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA622,HIA622,CIA622,QA622,QB622
      IF(HCA622.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA622) :',HCA622,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA622.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA622) :',HIA622,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA622.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA622) :',CIA622,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA622.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA622) :',QA622,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB622.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB622) :',QB622,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of theCost of
C  Continuous Bleaching Reactor
        CCB622=CCB622+HCA622*(CIA622/HIA622)*(QB622/QA622)**0.6
        WRITE(*,55)'Continuous Bleaching Reactor', 'N',CCB622
        WRITE(2,55)'Continuous Bleaching Reactor', 'N',CCB622
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55    FORMAT(/,10X,A,15X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM616(HCA616,HIA616,CIA616,QA616,QB616,CCB616,TFB616)
C Subroutine CM616 calculates the current cost of Bernardinni Filter
      CCB616=0.0
      TFB616=0.0
      PRINT1,'Input Historical Cost of Bernardinni Filter A (HCA616),',
     $'Historical Index of Bernardinni Filter A (HIA616),',
     $'current Index of Bernardinni Filter A (CIA616),',
     $'capacity of Bernardinni Filter A (QA616),',
     $'capacity of Bernardinni Filter B (QB616)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA616,HIA616,CIA616,QA616,QB616
      IF(HCA616.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA616) :',HCA616,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA616.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA616) :',HIA616,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA616.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA616) :',CIA616,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA616.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA616) :',QA616,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB616.LE.0)THEN
           PRINT45,'INVALID ENRTY  (QB616) :',QB616,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Bernardinni Filter
        CCB616=CCB616+HCA616*(CIA616/HIA616)*(QB616/QA616)**0.6
        TFB616=TFB616+CCB616*2
        WRITE(*,55)'One Bernardinni Filter', 'N',CCB616
        WRITE(2,55)'One Bernardinni Filter', 'N',CCB616
   55   FORMAT(/,10X,A,21X,A,F15.2)
        WRITE(*,59)'Two Bernardinni Filters','N',TFB616
        WRITE(2,59)'Two Bernardinni Filters','N',TFB616
   59   FORMAT(/,10X,A,20X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM617(HCA617,HIA617,CIA617,QA617,QB617,CCB617)
C Subroutine CM617 calculates the current cost of Steel Super Filter
      CCB617=0.0
      PRINT1,'Input Historical Cost of Steel Super Filter A (HCA617),',
     $'Historical Index of Steel Super Filter A (HIA617),',
     $'current Index of Steel Super Filter A (CIA617),',
     $'capacity of Steel Super Filter A (QA617),',
     $'capacity of Steel Super Filter B (QB617)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA617,HIA617,CIA617,QA617,QB617
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      IF(HCA617.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA617) :',HCA617,'TRY AGAIN!'
 5         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA617.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA617) :',HIA617,'TRY AGAIN!'
15         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA617.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA617) :',CIA617,'TRY AGAIN!'
25         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA617.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA617) :',QA617,'TRY AGAIN!'
35         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB617.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB617) :',QB617,'TRY AGAIN!'
45         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
       ELSE
C  The following formula is used for the calculation of the Cost of
C  Steel Super Filter
        CCB617=CCB617+HCA617*(CIA617/HIA617)*(QB617/QA617)**0.6
        WRITE(*,55)'Steel Super Filter', 'N',CCB617
        WRITE(2,55)'Steel Super Filter', 'N',CCB617
55      FORMAT(/,10X,A,25X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM618(HCA618,HIA618,CIA618,QA618,QB618,CCB618)
C Subroutine CM618 calculates the current cost of Guard Filter
      CCB618=0.0
      PRINT1,'Input Historical Cost of Guard Filter A (HCA618),',
     $'Historical Index of Guard Filter A (HIA618),',
     $'current Index of Guard Filter A (CIA61),',
     $'capacity of Guard Filter A (QA618),',
     $'capacity of Guard Filter B(QB618)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA618,HIA618,CIA618,QA618,QB618
      IF(HCA618.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA618) :',HCA618,'TRY AGAIN!'
 5         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA618.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA618) :',HIA618,'TRY AGAIN!'
15         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA618.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA618) :',CIA618,'TRY AGAIN!'
25         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA618.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA618) :',QA618,'TRY AGAIN!'
35         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB618.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB618) :',QB618,'TRY AGAIN!'
45         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
```

```
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Guard Filter
        CCB618=CCB618+HCA618*(CIA618/HIA618)*(QB618/QA618)**0.6
        WRITE(*,55)'Guard Filter', 'N',CCB618
        WRITE(2,55)'Guard Filter', 'N',CCB618
   55   FORMAT(/,10X,A,31X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM682(HCA682,HIA682,CIA682,QA682,QB682,CCB682)
C Subroutine CM682 calculates the current cost of Decanter
      CCB682=0.0
      PRINT1,'Input Historical Cost of Decanter A (HCA682),',
     $'Historical Index of Decanter A (HIA682),',
     $'current Index of Decanter A (CIA682),',
     $'capacity of Decanter A (QA682),',
     $'capacity of Decanter B (QB682)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA682,HIA682,CIA682,QA682,QB682
      IF(HCA682.LE.0)THEN
           PRINT5,'INVALID ENRTY  (HCA682):',HCA682,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA682.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA682) :',HIA682,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA682.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA682) :',CIA682,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA682.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA682) :',QA682,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB682.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB682) :',QB682,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Decanter.
        CCB682=CCB682+HCA682*(CIA682/HIA682)*(QB682/QA682)**0.6
        WRITE(*,55)'Decanter', 'N',CCB682
        WRITE(2,55)'Decanter', 'N',CCB682
   55   FORMAT(/,10X,A,35X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM801(HCA801,HIA801,CIA801,QA801,QB801,CCB801)
C Subroutine CM801 calculates the current cost of Storage Tank.
      CCB801=0.0
      PRINT1,'Input Historical Cost of Storage Tank A (HCA801),',
     $'Historical Index of Storage Tank A (HIA801),',
     $'current Index of Storage Tank A (CIA801),',
     $'capacity of Storage Tank A (QA801),',
     $'capacity of Storage Tank B (QB801)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
```

```
      READ(*,*)HCA801,HIA801,CIA801,QA801,QB801
      IF(HCA801.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCA801) :',HCA801,'TRY AGAIN!'
 5          FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIA801.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIA801) :',HIA801,'TRY AGAIN!'
 15         FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIA801.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIA801) :',CIA801,'TRY AGAIN!'
 25         FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QA801.LE.0)THEN
            PRINT35,'INVALID ENRTY (QA801) :',QA801,'TRY AGAIN!'
 35         FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QB801.LE.0)THEN
            PRINT45,'INVALID ENRTY (QB801) :',QB801,'TRY AGAIN!'
 45         FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Storage Tank
         CCB801=CCB801+HCA801*(CIA801/HIA801)*(QB801/QA801)**0.6
         WRITE(*,55)'Storage Tank', 'N',CCB801
         WRITE(2,55)'Storage Tank', 'N',CCB801
 55      FORMAT(/,10X,A,31X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM803(HCA803,HIA803,CIA803,QA803,QB803,CCB803)
C Subroutine CM803 calculates the current cost of Daerator/Drier
      CCB803=0.0
      PRINT1,'Input Historical Cost of  Daerator/Drier A (HCA803),',
     $'Historical Index of Daerator/Drier A (HIA803),',
     $'current Index of Daerator/Drier A (CIA803),',
     $'capacity of Daerator/Drier A (QA803),',
     $'capacity of Daerator/DrierB (QB803)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA803,HIA803,CIA803,QA803,QB803
      IF(HCA803.LE.0)THEN
            PRINT5,'INVALID ENRTY  (HCA803) :',HCA803,'TRY AGAIN!'
 5          FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIA803.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIA803) :',HIA803,'TRY AGAIN!'
 15         FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIA803.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIA803) :',CIA803,'TRY AGAIN!'
 25         FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QA803.LE.0)THEN
            PRINT35,'INVALID ENRTY (QA803) :',QA803,'TRY AGAIN!'
 35         FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QB803.LE.0)THEN
            PRINT45,'INVALID ENRTY (QB803) :',QB803,'TRY AGAIN!'
 45         FORMAT(/,1X,A,1X,F15.2,1X,A)
```

```
          STOP
        ELSE
C  The following formula is used for the calculation of the Cost of
C  Daerator/Drier
        CCB803=CCB803+HCA803*(CIA803/HIA803)*(QB803/QA803)**0.6
        WRITE(*,55)'Daerator/Drier', 'N',CCB803
        WRITE(2,55)'Daerator/Drier', 'N',CCB803
   55   FORMAT(/,10X,A,29X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM822(HCA822,HIA822,CIA822,QA822,QB822,CCB822)
C Subroutine CM822 calculates the current cost of Deodorizer.
      CCB822=0.0
      PRINT1,'Input Historical Cost of Deodorizer A (HCA822),',
     $'Historical Index of Deodorizer A (HIA822),',
     $'current Index of Deodorizer A (CIA822),',
     $'capacity of Deodorizer A (QA822),',
     $'capacity of Deodorizer B (QB822)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA822,HIA822,CIA822,QA822,QB822
      IF(HCA822.LE.0)THEN
          PRINT5,'INVALID ENRTY (HCA822) :',HCA822,'TRY AGAIN!'
    5     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(HIA822.LE.0)THEN
          PRINT15,'INVALID ENRTY (HIA822) :',HIA822,'TRY AGAIN!'
   15     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(CIA822.LE.0)THEN
          PRINT25,'INVALID ENRTY (CIA822) :',CIA822,'TRY AGAIN!'
   25     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(QA822.LE.0)THEN
          PRINT35,'INVALID ENRTY (QA822) :',QA822,'TRY AGAIN!'
   35     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSEIF(QB822.LE.0)THEN
          PRINT45,'INVALID ENRTY (QB822) :',QB822,'TRY AGAIN!'
   45     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
Deodorizer
        CCB822= CCB822+HCA822*(CIA822/HIA822)*(QB822/QA822)**0.6
        WRITE(*,55)'Deodorizer', 'N',CCB822
        WRITE(2,55)'Deodorizer', 'N',CCB822
   55   FORMAT(/,10X,A,33X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM814(HCA814,HIA814,CIA814,QA814,QB814,CCB814)
C Subroutine CM814 calculates the current cost of FFA Recuperator
      CCB814=0.0
      PRINT1,'Input Historical Cost of FFA Recuperator A (HCA814),',
     $'Historical Index of FFA Recuperator A (HIA814),',
     $'current Index of FFA Recuperator A (CIA814),',
     $'capacity of FFA Recuperator A (QA814),',
     $'capacity of FFA Recuperator B (QB814)'
```

```
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA814,HIA814,CIA814,QA814,QB814
      IF(HCA814.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA814) :',HCA814,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA814.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA814) :',HIA814,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA814.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA814) :',CIA814,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA814.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA814) :',QA814,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB814.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB814) :',QB814,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  FFA Recuperator
        CCB814=CCB814+HCA814*(CIA814/HIA814)*(QB814/QA814)**0.6
        WRITE(*,55)'FFA Recuperator', 'N',CCB814
        WRITE(2,55)'FFA Recuperator', 'N',CCB814
   55   FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM821(HCA821,HIA821,CIA821,QA821,QB821,CCB821)
C Subroutine CM821 calculates the current cost of Preheating Tank.
      CCB821=0.0
      PRINT1,'Input Historical Cost of Preheating Tank A (HCA821),',
     $'Historical Index of Preheating Tank A (HIA821),',
     $'current Index of Preheating Tank A (CIA821),',
     $'capacity of Preheating Tank A (QA821),',
     $'capacity of Preheating Tank B (QB821)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA821,HIA821,CIA821,QA821,QB821
      IF(HCA821.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA821) :',HCA821,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA821.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA821) :',HIA821,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA821.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA821) :',CIA821,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA821.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA821) :',QA821,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB821.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB821) :',QB821,'TRY AGAIN!'
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   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Preheating Tank
        CCB821=CCB821+HCA821*(CIA821/HIA821)*(QB821/QA821)**0.6
        WRITE(*,55)'Preheating Tank', 'N',CCB821
        WRITE(2,55)'Preheating Tank', 'N',CCB821
   55   FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM50(HCA50,HIA50,CIA50,QA50,QB50,CCB50)
C Subroutine CM50 calculates the current cost of VACUUM SYSTEM.
      CCB50=0.0
      PRINT1,'Input Historical Cost of VACUUM SYSTEM A (HCA50),',
     $'Historical Index of VACUUM SYSTEM A (HIA50),',
     $'current Index of VACUUM SYSTEM A (CIA50),',
     $'capacity of VACUUM SYSTEM A (QA50),',
     $'capacity of VACUUM SYSTEM B (QB50)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA50,HIA50,CIA50,QA50,QB50
      IF(HCA50.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCA50) :',HCA50,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIA50.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIA50) :',HIA50,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIA50.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIA50) :',CIA50,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QA50.LE.0)THEN
            PRINT35,'INVALID ENRTY (QA50) :',QA50,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QB50.LE.0)THEN
            PRINT45,'INVALID ENRTY (QB50) :',QB50,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  VACUUM SYSTEM
        CCB50=CCB50+HCA50*(CIA50/HIA50)*(QB50/QA50)**0.6
        WRITE(*,55)'VACUUM SYSTEM', 'N',CCB50
        WRITE(2,55)'VACUUM SYSTEM', 'N',CCB50
   55   FORMAT(/,10X,A,32X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMSCW (HCASCW,HIASCW,CIASCW,QASCW,QBSCW,CCBSCW)
C Subroutine CMSCW calculates the current cost of Screw Worm
      CCBSCW=0.0
      PRINT1,'Input HistoricalCost of Screw Worm A (HCASCW),',
     $'Historical Index of Screw Worm A (HIASCW),',
     $'current Index of Screw Worm A (CIASCW),',
     $'capacity of Screw Worm A (QASCW),',
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     $'capacity of Screw Worm B (QBSCW)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCASCW,HIASCW,CIASCW,QASCW,QBSCW
      IF(HCASCW.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCASCW) :',HCASCW,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIASCW.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIASCW) :',HIASCW,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIASCW.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIASCW) :',CIASCW,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QASCW.LE.0)THEN
            PRINT35,'INVALID ENRTY (QASCW) :',QASCW,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QBSCW.LE.0)THEN
            PRINT45,'INVALID ENRTY (QBSCW) :',QBSCW,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSE
C  The following formula is used for the calculation of the Cost
C  of Screw Worm.
        CCBSCW=CCBSCW+HCASCW*(CIASCW/HIASCW)*(QBSCW/QASCW)
        WRITE(*,55)'Screw Worm', 'N',CCBSCW
        WRITE(2,55)'Screw Worm', 'N',CCBSCW
   55   FORMAT(/,10X,A,33X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMPUM(TOPUM,HCAPUM,HIAPUM,CIAPUM,QAPUM,QBPUM,CCBPUM)
C Subroutine CMPUM calculates the current cost of 22 Pumps.
      CCBPUM=0.0
      TOPUM=0.0
      PRINT1,'Input Historical Cost of one Pump A (HCAPUM),',
     $'Historical Index of one Pump A (HIAPUM),',
     $'current Index of one Pump A (CIAPUM),',
     $'capacity of one Pump A (QAPUM),',
     $'capacity of one Pump B (QBPUM)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCAPUM,HIAPUM,CIAPUM,QAPUM,QBPUM
      IF(HCAPUM.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCAPUM) :',HCAPUM,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIAPUM.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIAPUM) :',HIAPUM,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIAPUM.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIAPUM) :',CIAPUM,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QAPUM.LE.0)THEN
            PRINT35,'INVALID ENRTY (QAPUM) :',QAPUM,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
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      ELSEIF(QBPUM.LE.0)THEN
           PRINT45,'INVALID ENRTY (QBPUM) :',QBPUM,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  one Pump is
        CCBPUM= CCBPUM+HCAPUM*(CIAPUM/HIAPUM)*(QBPUM/QAPUM)**0.6
        WRITE(*,55)'One Pump', 'N',CCBPUM
        WRITE(2,55)'One Pump', 'N',CCBPUM
   55   FORMAT(/,10X,A,35X,A,F15.2)
C  The following formula is used for the calculation of the Cost of
C  22 Pumps.
        TOPUM=TOPUM+CCBPUM*22
        WRITE(*,65)'Twenty two Pumps', 'N',TOPUM
        WRITE(2,65)'Twenty two Pumps', 'N',TOPUM
   65   FORMAT(/,10X,A,27X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMHEX(THEAT,HCAHEX,HIAHEX,CIAHEX,QAHEX,QBHEX,CCBHEX)
C Subroutine CMHEX calculates the current cost of 7 Plate Heat
Exchangers
      CCBHEX=0.0
      THEAT=0.0
      PRINT1,'Input Historical Cost of 1 Heat Exchanger A (HCAHEX),',
     $'Historical Index of 1 Heat Exchanger A (HIAHEX),',
     $'current Index of 1 Heat Exchanger A (CIAHEX),',
     $'capacity of 1 Heat Exchanger A(QAHEX),',
     $'capacity of 1 Heat Exchanger B (QBHEX)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCAHEX,HIAHEX,CIAHEX,QAHEX,QBHEX
      IF(HCAHEX.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCAHEX) :',HCAHEX,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIAHEX.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIAHEX) :',HIAHEX,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIAHEX.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIAHEX) :',CIAHEX,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QAHEX.LE.0)THEN
           PRINT35,'INVALID ENRTY (QAHEX) :',QAHEX,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QBHEX.LE.0)THEN
           PRINT45,'INVALID ENRTY (QBHEX) :',QBHEX,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  1 Heat Exchanger
        CCBHEX=CCBHEX+HCAHEX*(CIAHEX/HIAHEX)*(QBHEX/QAHEX)**0.6
        WRITE(*,55)'One Heat Exchanger', 'N',CCBHEX
        WRITE(2,55)'One Heat Exchanger', 'N',CCBHEX
   55   FORMAT(/,10X,A,25X,A,F15.2)
C  The following formula is used for the calculation of the Cost of
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C  7 Plate Heat Exchangers
        THEAT=THEAT+CCBHEX*7
        WRITE(*,65)'Seven Heat Exchangers', 'N',THEAT
        WRITE(2,65)'Seven Heat Exchangers', 'N',THEAT
   65   FORMAT(/,10X,A,22X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM619(TT619,HCA619,HIA619,CIA619,QA619,QB619,CCB619)
C Subroutine CM619 calculates the current cost of 2 Guard Filters
      CCB619=0.0
      TT619=0.0
      PRINT1,'Input Historical Cost of 1 Guard Filter II A(HCA619),',
     $'Historical Index of 1 Guard Filter II A (HIA619),',
     $'current Index of 1 Guard Filter II A (CIA619),',
     $'capacity of 1 Guard Filter II A (QA619),',
     $'capacity of 1 Guard Filter II B (QB619)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCA619,HIA619,CIA619,QA619,QB619
      IF(HCA619.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCA619) :',HCA619,'TRY AGAIN!'
    5      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIA619.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIA619) :',HIA619,'TRY AGAIN!'
   15      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIA619.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIA619) :',CIA619,'TRY AGAIN!'
   25      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QA619.LE.0)THEN
           PRINT35,'INVALID ENRTY (QA619) :',QA619,'TRY AGAIN!'
   35      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QB619.LE.0)THEN
           PRINT45,'INVALID ENRTY (QB619) :',QB619,'TRY AGAIN!'
   45      FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  1 Guard Filter
        CCB619=CCB619+HCA619*(CIA619/HIA619)*(QB619/QA619)**0.6
        WRITE(*,55)'One Guard Filter II', 'N',CCB619
        WRITE(2,55)'One Guard Filter II', 'N',CCB619
   55   FORMAT(/,10X,A,24X,A,F15.2)
C  The following formula is used for the calculation of the Cost of
C  2 Guard Filters
        TT619=TT619+CCB619*2
        WRITE(*,65)'Two Guard Filters II', 'N',TT619
        WRITE(2,65)'Two Guard Filters II', 'N',TT619
   65   FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMRST(TTRST,HCARST,HIARST,CIARST,QARST,QBRST,CCBRST)
C Subroutine CMRST calculates the current cost of 12 Crystallisers
      CCBRST=0.0
      TTRST=0.0
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      PRINT1,'Input Historical Cost of 1  A (HCARST),',
     $'Historical Index of 1  A (HIARST),',
     $'current Index of 1  A (CIARST),',
     $'capacity of 1  A (QARST),',
     $'capacity of 1  B (QBRST)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCARST,HIARST,CIARST,QARST,QBRST
      IF(HCARST.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCARST) :',HCARST,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIARST.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIARST) :',HIARST,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIARST.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIARST) :',CIARST,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QARST.LE.0)THEN
            PRINT35,'INVALID ENRTY (QARST) :',QARST,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QBRST.LE.0)THEN
            PRINT45,'INVALID ENRTY (QBRST) :',QBRST,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  1
        CCBRST=CCBRST+HCARST*(CIARST/HIARST)*(QBRST/QARST)**0.6
        WRITE(*,55)'One ', 'N',CCBRST
        WRITE(2,55)'One ', 'N',CCBRST
   55   FORMAT(/,10X,A,27X,A,F15.2)
C  The following formula is used for the calculation of the Cost of
C  12 s
        TTRST=TTRST+CCBRST*12
        WRITE(*,65)'Twelve s', 'N',TTRST
        WRITE(2,65)'Twelve s', 'N',TTRST
   65   FORMAT(/,10X,A,23X,A,F15.2)
        ENDIF
      RETURN
      END

      SUBROUTINE CMRBD(HCARBD,HIARBD,CIARBD,QARBD,QBRBD,CCBRBD)
C Subroutine CMRBD calculates the current cost of RBD Storage Tank
      CCBRBD=0.0
      PRINT1,'Input Historical Cost of RBD Storage Tank A (HCARBD),',
     $'Historical Index of RBD Storage Tank A (HIARBD),',
     $'current Index of RBD Storage Tank A (CIARBD),',
     $'capacity of RBD Storage Tank A (QARBD),',
     $'capacity of RBD Storage Tank B (QBRBD)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCARBD,HIARBD,CIARBD,QARBD,QBRBD
      IF(HCARBD.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCARBD) :',HCARBD,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIARBD.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIARBD) :',HIARBD,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
```

```
            STOP
        ELSEIF(CIARBD.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIARBD) :',CIARBD,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSEIF(QARBD.LE.0)THEN
            PRINT35,'INVALID ENRTY (QARBD) :',QARBD,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSEIF(QBRBD.LE.0)THEN
            PRINT45,'INVALID ENRTY (QBRBD) :',QBRBD,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSE
C  The following formula is used for the calculation of the Cost of
C  RBD Storage Tank
          CCBRBD=CCBRBD+HCARBD*(CIARBD/HIARBD)*(QBRBD/QARBD)**0.6
          WRITE(*,55)'RBD Storage Tank ', 'N',CCBRBD
          WRITE(2,55)'RBD Storage Tank ', 'N',CCBRBD
   55     FORMAT(/,10X,A,26X,A,F15.2)
        ENDIF
        RETURN
        END

        SUBROUTINE CMCWA(HCACWA,HIACWA,CIACWA,QACWA,QBCWA,CCBCWA)
C Subroutine CMCWA calculates the current cost of Cold Water Tank
        CCBCWA=0.0
        PRINT1,'Input Historical Cost of Cold Water Tank A (HCACWA),',
     $'Historical Index of Cold Water Tank A (HIACWA),',
     $'current Index of Cold Water Tank A (CIACWA),',
     $'capacity of Cold Water Tank A(QACWA),',
     $'capacity of Cold Water Tank B (QBCWA).'
      1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
        READ(*,*)HCACWA,HIACWA,CIACWA,QACWA,QBCWA
        IF(HCACWA.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCACWA) :',HCACWA,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSEIF(HIACWA.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIACWA) :',HIACWA,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSEIF(CIACWA.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIACWA) :',CIACWA,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSEIF(QACWA.LE.0)THEN
            PRINT35,'INVALID ENRTY (QACWA) :',QACWA,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSEIF(QBCWA.LE.0)THEN
            PRINT45,'INVALID ENRTY (QBCWA) :',QBCWA,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
        ELSE
C  The following formula is used for the calculation of the Cost of
C  Cold Water Tank
          CCBCWA=CCBCWA+HCACWA*(CIACWA/HIACWA)*(QBCWA/QACWA)**0.6
          WRITE(*,55)'Cold Water Tank', 'N',CCBCWA
          WRITE(2,55)'Cold Water Tank', 'N',CCBCWA
   55     FORMAT(/,10X,A,28X,A,F15.2)
```

```
      ENDIF
      RETURN
      END

      SUBROUTINE CMWWA(HCAWWA,HIAWWA,CIAWWA,QAWWA,QBWWA,CCBWWA)
C Subroutine CMWWA calculates the current cost of Warm Water Tank
      CCBWWA=0.0
      PRINT1,'Input Historical Cost of Warm Water Tank A (HCAWWA),',
     $'Historical Index of Warm Water Tank A (HIAWWA),',
     $'current Index of Warm Water Tank A (CIAWWA),',
     $'capacity of Warm Water Tank A (QAWWA),',
     $'capacity of Warm Water Tank B (QBWWA)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCAWWA,HIAWWA,CIAWWA,QAWWA,QBWWA
      IF(HCAWWA.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCAWWA) :',HCAWWA,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIAWWA.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIAWWA) :',HIAWWA,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIAWWA.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIAWWA) :',CIAWWA,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QAWWA.LE.0)THEN
            PRINT35,'INVALID ENRTY (QAWWA) :',QAWWA,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QBWWA.LE.0)THEN
            PRINT45,'INVALID ENRTY (QBWWA) :',QBWWA,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Warm Water Tank
        CCBWWA=CCBWWA+HCAWWA*(CIAWWA/HIAWWA)*(QBWWA/QAWWA)**0.6
        WRITE(*,55)'Warm Water Tank', 'N',CCBWWA
        WRITE(2,55)'Warm Water Tank', 'N',CCBWWA
   55   FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMFTR(HCAFTR,HIAFTR,CIAFTR,QAFTR,QBFTR,CCBFTR)
C Subroutine CMFTR calculates the current cost of Welders' Filter
C Press.
      CCBFTR=0.0
      PRINT1,'Input Historical Cost of Welders''s Filter Press A
     $(HCAFTR),',
     $'Historical Index of Welders''s Filter Press A (HIAFTR),',
     $'current Index of Welders''s Filter Press A (CIAFTR),',
     $'capacity of Welders''s Filter Press A (QAFTR),',
     $'capacity of Welders''s Filter Press B (QBFTR)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCAFTR,HIAFTR,CIAFTR,QAFTR,QBFTR
      IF(HCAFTR.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCAFTR) :',HCAFTR,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
```

```
      ELSEIF(HIAFTR.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIAFTR) :',HIAFTR,'TRY AGAIN!'
15         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIAFTR.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIAFTR) :',CIAFTR,'TRY AGAIN!'
25         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QAFTR.LE.0)THEN
           PRINT35,'INVALID ENRTY (QAFTR) :',QAFTR,'TRY AGAIN!'
35         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QBFTR.LE.0)THEN
           PRINT45,'INVALID ENRTY (QBFTR) :',QBFTR,'TRY AGAIN!'
45         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Welders' Filter Press
        CCBFTR=CCBFTR+HCAFTR*(CIAFTR/HIAFTR)*(QBFTR/QAFTR)**0.6
        WRITE(*,55)'Welders Filter Press','N',CCBFTR
        WRITE(2,55)'Welders Filter Press','N',CCBFTR
55      FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMSTK(HCASTK,HIASTK,CIASTK,QASTK,QBSTK,CCBSTK)
C Subroutine CMSTK calculates the current cost of Stearin Tank
      CCBSTK=0.0
      PRINT1,'Input Historical Cost of Stearin Tank A (HCASTK),',
     $'Historical Index of Stearin Tank A (HIASTK),',
     $'current Index of Stearin Tank A (CIASTK),',
     $'capacity of Stearin Tank A (QASTK),',
     $'capacity of Stearin Tank B (QBSTK)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCASTK,HIASTK,CIASTK,QASTK,QBSTK
      IF(HCASTK.LE.0)THEN
           PRINT5,'INVALID ENRTY (HCASTK) :',HCASTK,'TRY AGAIN!'
 5         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(HIASTK.LE.0)THEN
           PRINT15,'INVALID ENRTY (HIASTK) :',HIASTK,'TRY AGAIN!'
15         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(CIASTK.LE.0)THEN
           PRINT25,'INVALID ENRTY (CIASTK) :',CIASTK,'TRY AGAIN!'
25         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QASTK.LE.0)THEN
           PRINT35,'INVALID ENRTY (QASTK) :',QASTK,'TRY AGAIN!'
35         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSEIF(QBSTK.LE.0)THEN
           PRINT45,'INVALID ENRTY (QBSTK) :',QBSTK,'TRY AGAIN!'
45         FORMAT(/,1X,A,1X,F15.2,1X,A)
           STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  Stearin Tank
        CCBSTK=CCBSTK+HCASTK*(CIASTK/HIASTK)*(QBSTK/QASTK)**0.6
```

```
      WRITE(*,55)'Stearin Tank', 'N',CCBSTK
      WRITE(2,55)'Stearin Tank', 'N',CCBSTK
   55 FORMAT(/,10X,A,31X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMOTK(TTOTK,HCAOTK,HIAOTK,CIAOTK,QAOTK,QBOTK,CCBOTK)
C Subroutine CMOTK calculates the current cost of  2 Olein Tanks
      CCBOTK=0.0
      TTOTK=0.0
      PRINT1,'Input Historical Cost of 1 Olein Tank A (HCAOTK),',
     $'Historical Index of 1 Olein Tank A (HIAOTK),',
     $'current Index of 1 Olein Tank A (CIAOTK),',
     $'capacity of 1 Olein Tank A (QAOTK),',
     $'capacity of 1 Olein Tank B (QBOTK)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCAOTK,HIAOTK,CIAOTK,QAOTK,QBOTK
      IF(HCAOTK.LE.0)THEN
            PRINT5,'INVALID ENRTY (HCAOTK) :',HCAOTK,'TRY AGAIN!'
    5       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(HIAOTK.LE.0)THEN
            PRINT15,'INVALID ENRTY (HIAOTK) :',HIAOTK,'TRY AGAIN!'
   15       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(CIAOTK.LE.0)THEN
            PRINT25,'INVALID ENRTY (CIAOTK) :',CIAOTK,'TRY AGAIN!'
   25       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QAOTK.LE.0)THEN
            PRINT35,'INVALID ENRTY (QAOTK) :',QAOTK,'TRY AGAIN!'
   35       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSEIF(QBOTK.LE.0)THEN
            PRINT45,'INVALID ENRTY (QBOTK) :',QBOTK,'TRY AGAIN!'
   45       FORMAT(/,1X,A,1X,F15.2,1X,A)
            STOP
      ELSE
C  The following formula is used for the calculation of the Cost of
C  1 Olein Tank.
        CCBOTK=CCBOTK+HCAOTK*(CIAOTK/HIAOTK)*(QBOTK/QAOTK)**0.6
        WRITE(*,55)'One Olein Tank', 'N',CCBOTK
        WRITE(2,55)'One Olein Tank', 'N',CCBOTK
   55   FORMAT(/,10X,A,29X,A,F15.2)
C  The following formula is used for the calculation of the Cost of
C  2 Olein Tanks
        TTOTK=TTOTK+CCBOTK*2
        WRITE(*,65)'Two Olein Tanks', 'N',TTOTK
        WRITE(2,65)'Two Olein Tanks', 'N',TTOTK
   65   FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END
C
      SUBROUTINE CMPECT(PECT,CC503B,CC505B,CC534B,CC504B,CC535B,CC622B,
     $TT616B,CC617B,CC618B,CC682B,CC801B,CC803B,CC822B,CC814B,CC821B,
     $CC50B,CCSCWB,TOPUMS,THEATS,TT619B,TTRSTB,CCRBDB,CCCWAB,CCWWAB,
     $CCFTRB,CCSTKB,TTOTKB)
C Subroutine CMPECT computes the Purchased Equipment Cost.
C
```

```
        PRINT65,'INVALID ENTRY (FYIT) :',FYIT,'TRY AGAIN!'
 65     FORMAT(/,1X,A,1X,F15.1,1X,A)
        STOP
      ELSEIF(FSFIT.LE.0.OR. FSFIT.GE.1)THEN
        PRINT75,'INVALID ENTRY (FSFIT) :',FSFIT,'TRY AGAIN!'
 75     FORMAT(/,1X,A,1X,F15.1,1X,A)
        STOP
      ELSEIF(FLANT.LE.0.OR. FLANT.GE.1)THEN
        PRINT85,'INVALID ENTRY (FLANT) :',FLANT,'TRY AGAIN!'
 85     FORMAT(/,1X,A,1X,F15.1,1X,A)
        STOP
      ELSEIF(FENGST.LE.0.OR. FENGST.GE.1)THEN
        PRINT95,'INVALID ENTRY (FENGST) :',FENGST,'TRY AGAIN!'
 95     FORMAT(/,1X,A,1X,F15.1,1X,A)
        STOP
      ELSEIF(FCTNET.LE.0.OR. FCTNET.GE.1)THEN
        PRINT105,'INVALID ENTRY (FCTNET) :',FCTNET,'TRY AGAIN!'
105     FORMAT(/,1X,A,1X,F15.1,1X,A)
        STOP
      ELSEIF(FCFEET.LE.0.OR. FCFEET.GE.1)THEN
        PRINT115,'INVALID ENTRY (FCFEET) :',FCFEET,'TRY AGAIN!'
115     FORMAT(/,1X,A,1X,F15.1,1X,A)
        STOP
      ELSEIF(FCTNGT.LE.0.OR. FCTNGT.GE.1)THEN
        PRINT125,'INVALID ENTRY (FCTNGT) :',FCTNGT,'TRY AGAIN!'
125     FORMAT(/,1X,A,1X,F15.1,1X,A)
        STOP
      ELSE
        FCAPN=(FCAPN+(PECT+ PECT*(FPECT+FPECIT+FIIT+FPIT+FBIST
     $  +FEIT+FYIT+FSFIT+FLANT)*(1+FENGST+FCTNET+FCFEET+FCTNGT)))
        WRITE(*,135)'Fixed Capital Investment is :','N',FCAPN
        WRITE(2,135)'Fixed Capital Investment is :','N',FCAPN
135     FORMAT(//,10X,A,T56,A,F15.2)
        WRITE(*,145)
        WRITE(2,145)
145     FORMAT(T56,16('-'))
      ENDIF
      RETURN
      END

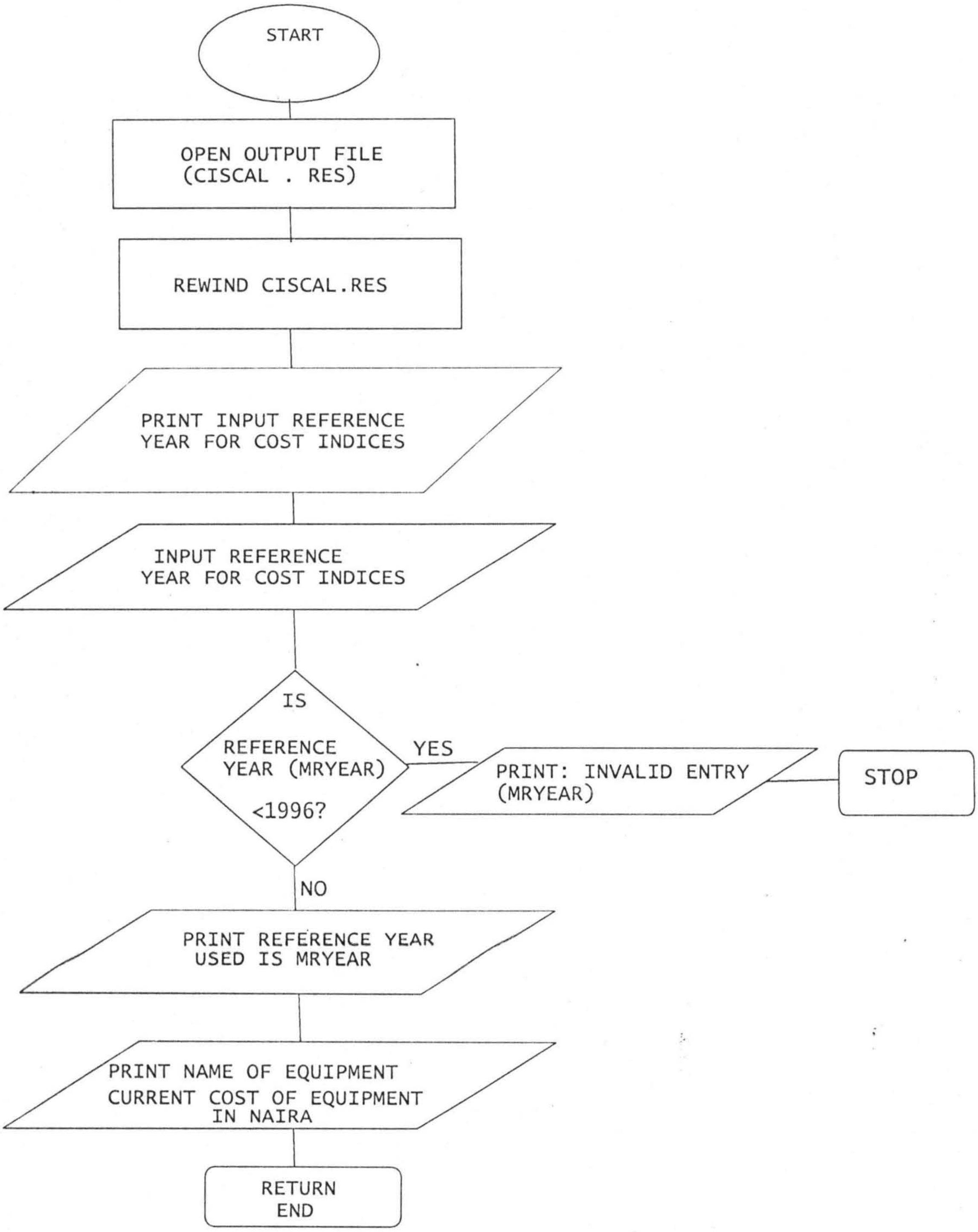
      SUBROUTINE TOCAIN (FCAPN,TCAPN,WCAPN)
C Subroutine TOCAIN calculates the current Working Capital
Investment(WCAPN)
C and Total capital Investment(TCAPN).
      TCAPN=0
      WCAPN=0
C Total capital investment is a Summation of the fixed and working
C capital Investment
C The working capital Investment will be taken as 15% of the Total
C Capital Investment,hence  the Fixed Capital Investment will be 85%
C of the Total Capital Investment
      TCAPN=TCAPN+FCAPN/0.85
      WCAPN=WCAPN+TCAPN*0.15
      WRITE(*,10)'Working Capital Investment is :','N',WCAPN
      WRITE(2,10)'Working Capital Investment is :','N',WCAPN
   10 FORMAT(//,10X,A,T56,A,F15.2)
      WRITE(*,20)
      WRITE(2,20)
   20 FORMAT(T56,16('-'))
      WRITE(*,30)'Total Capital Investment is :','N',TCAPN
      WRITE(2,30)'Total Capital Investment is :','N',TCAPN
```

One Guard Filter II	N	174731.50
Two Guard Filters II	N	349463.00
One Crystalliser	N	225621.50
Twelve Crystallisers	N	2707458.00
RBD Storage Tank	N	163785.30
Cold Water Tank	N	150413.80
Warm Water Tank	N	150413.80
Welders Filter Press	N	1504145.00
Stearin Tank	N	163785.30
One Olein Tank	N	163785.30
Two Olein Tanks	N	327570.70

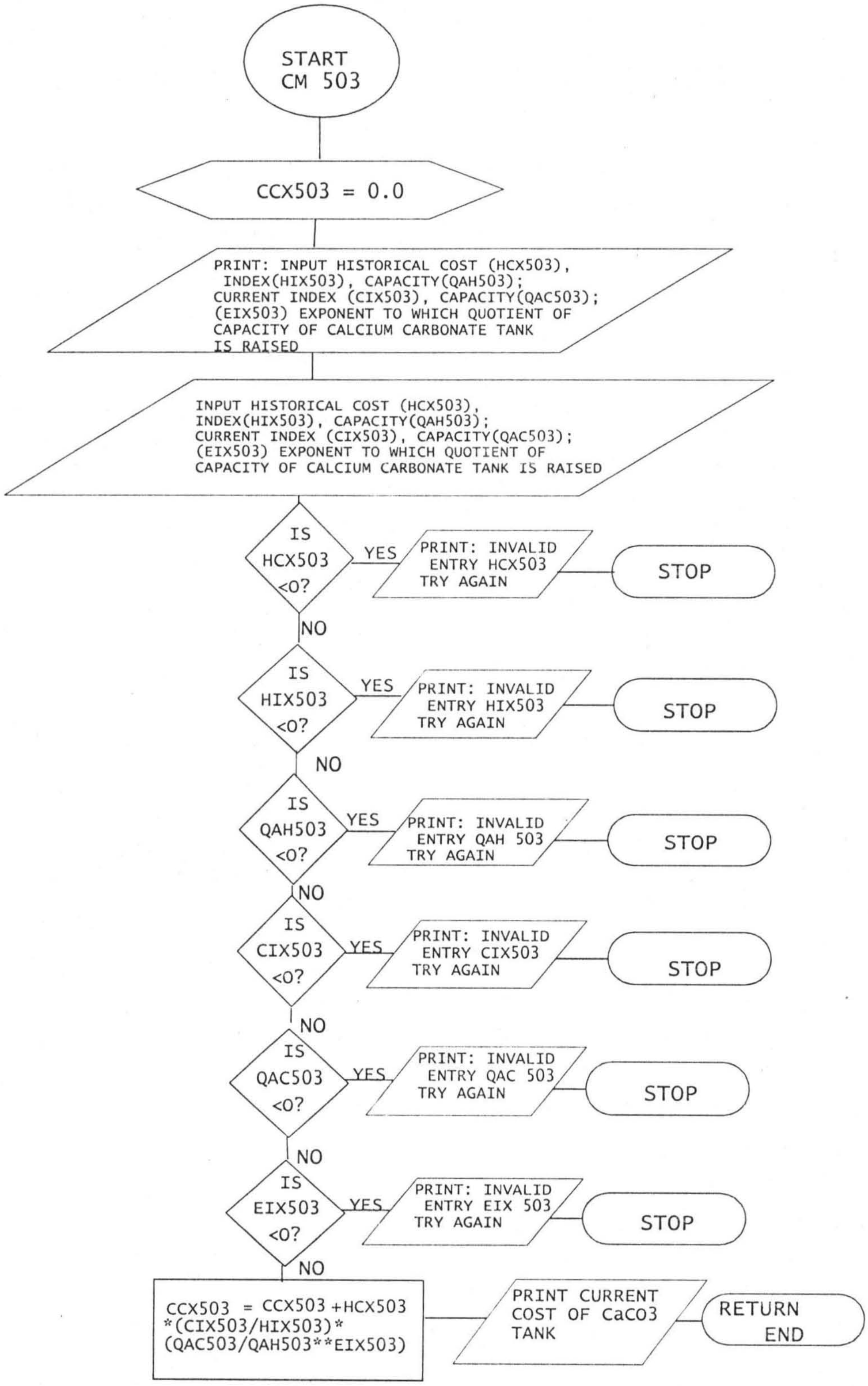
Delivered Purchased Equipment cost is :	N	32673060.00
Fixed Capital Investment is :	N	300598700.00
Working Capital Investment is :	N	53046830.00
Total Capital Investment is :	N	353645500.00

APPENDIX C1
Subroutine Flowchart for Program CISCAL

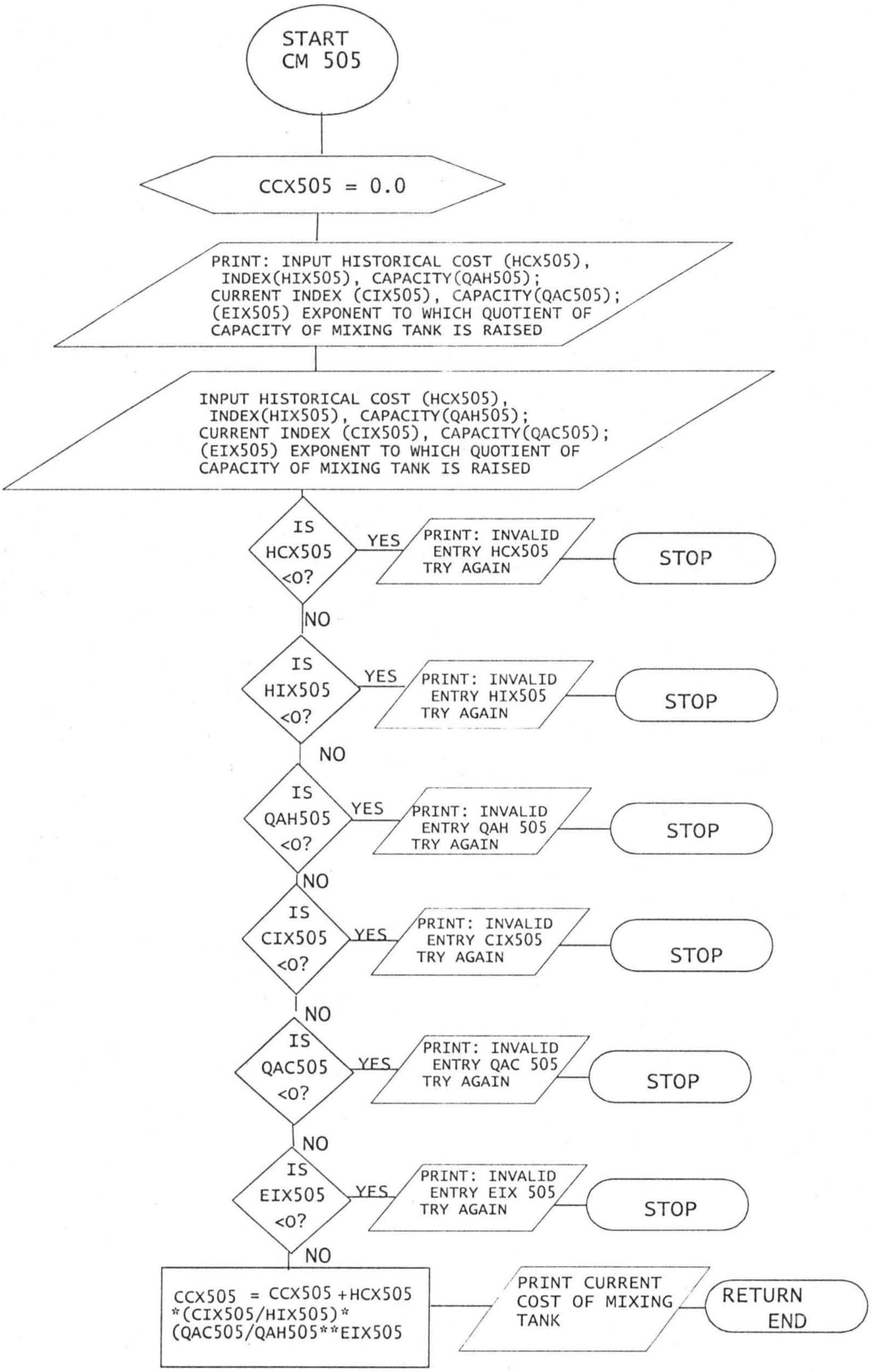
INTRODUCTORY MODULE FOR VALIDATION OF
REFERENCE YEAR FOR COST INDICES .



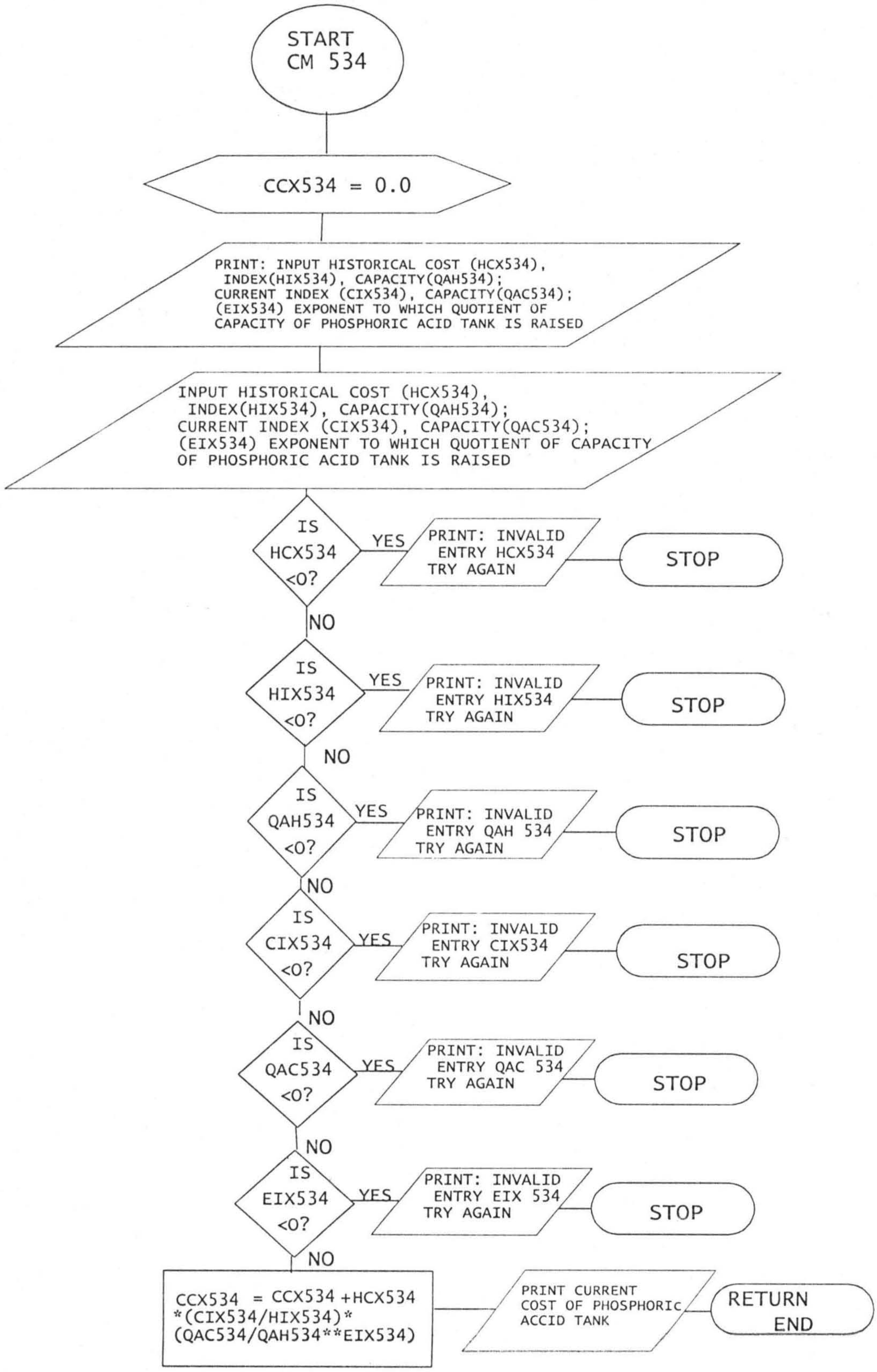
COMPUTATION OF THE CURRENT COST OF CALCIUM CARBONATE TANK



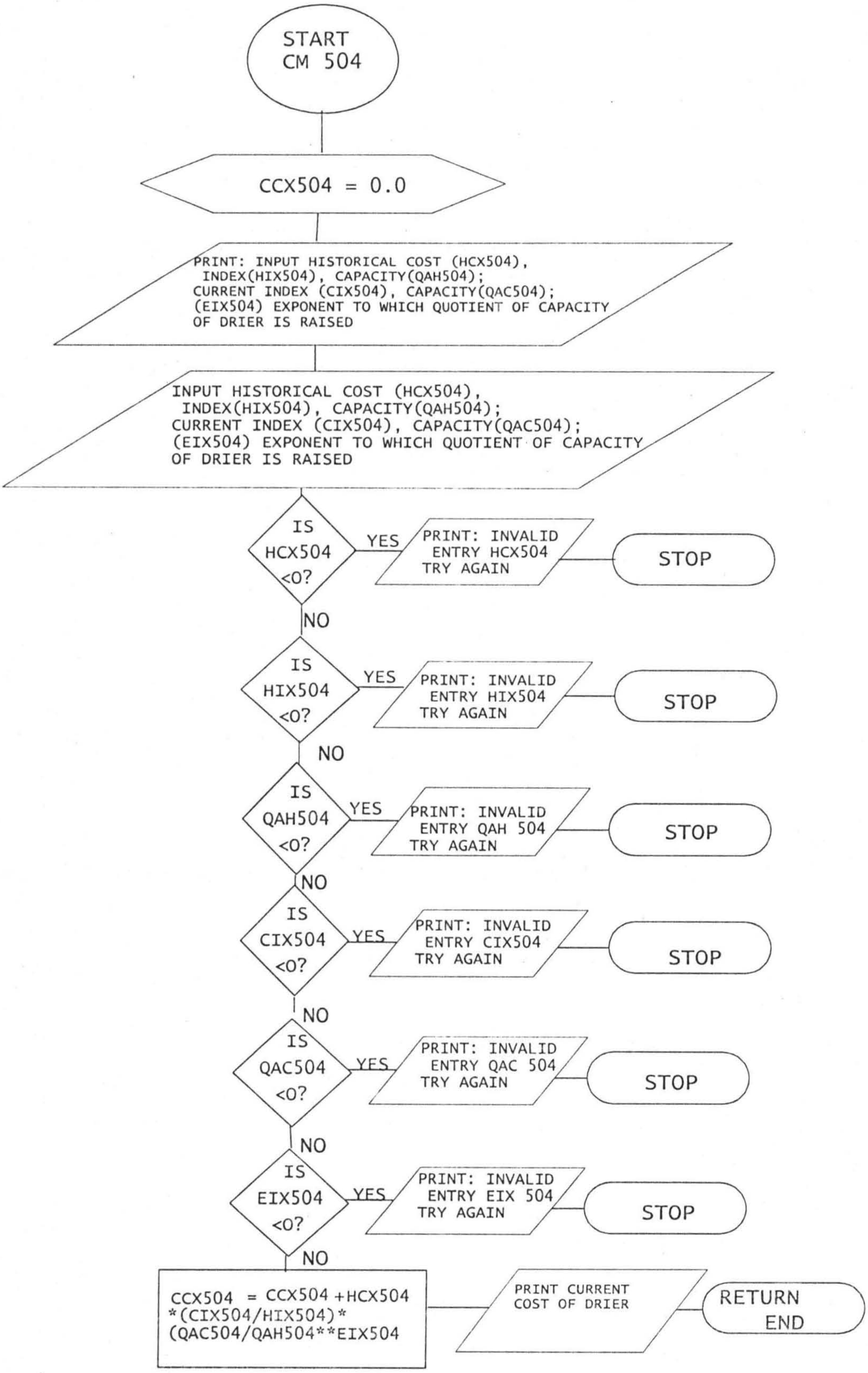
COMPUTATION OF CURRENT COST OF MIXING TANK



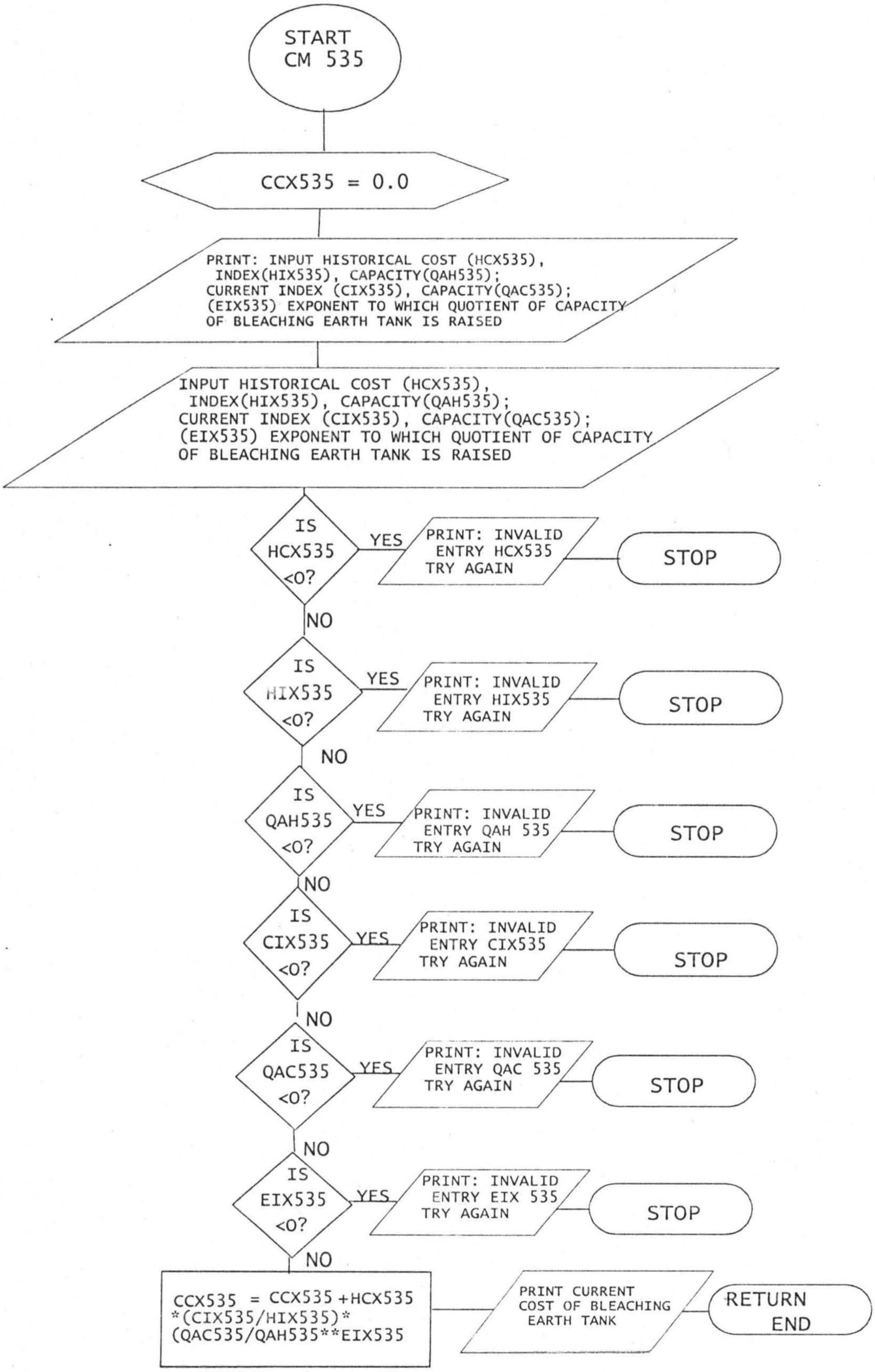
COMPUTATION OF CURRENT COST OF PHOSPHORIC ACID TANK



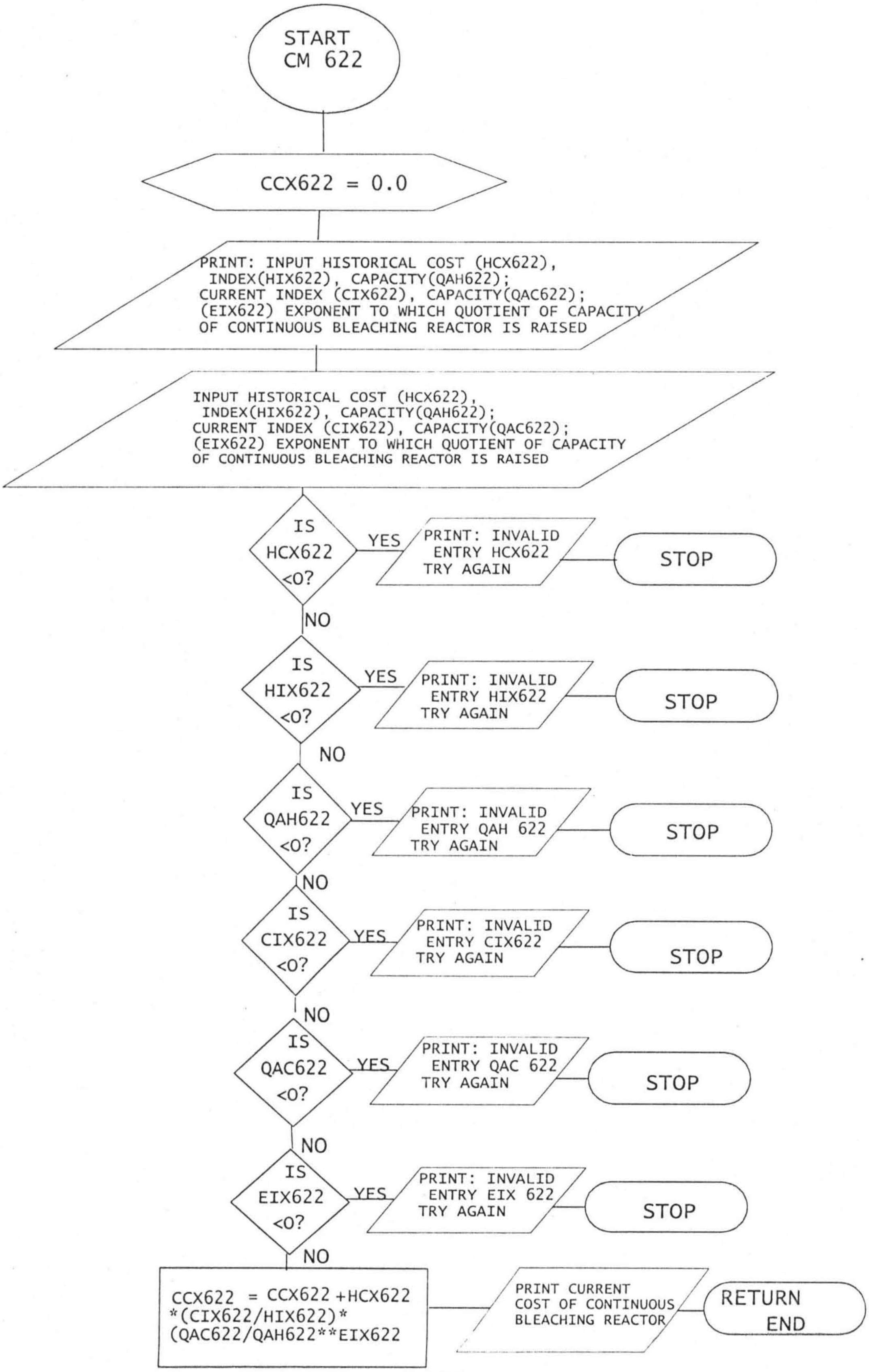
COMPUTATION OF CURRENT COST OF DRIER



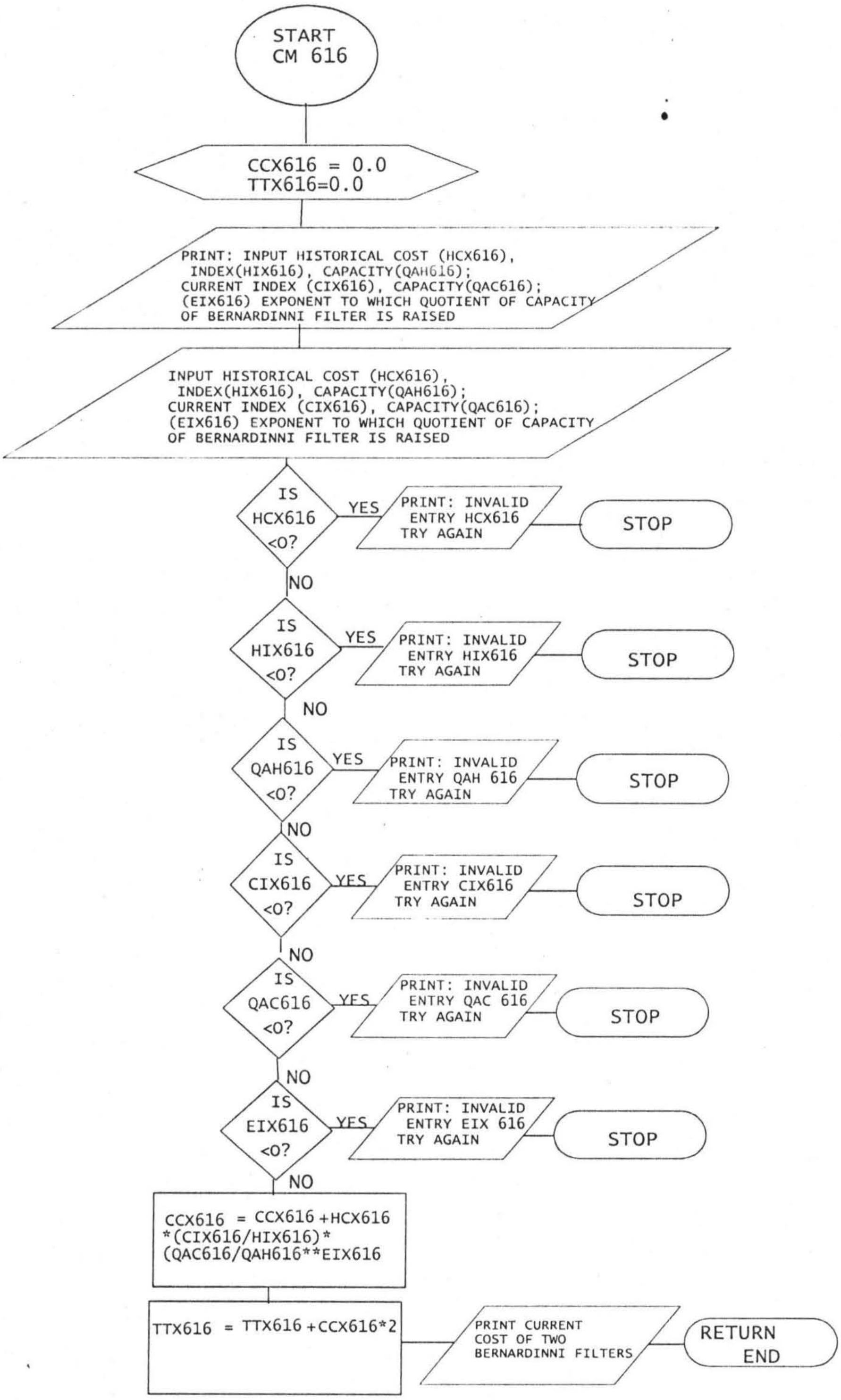
COMPUTATION OF CURRENT COST OF BLEACHING EARTH TANK



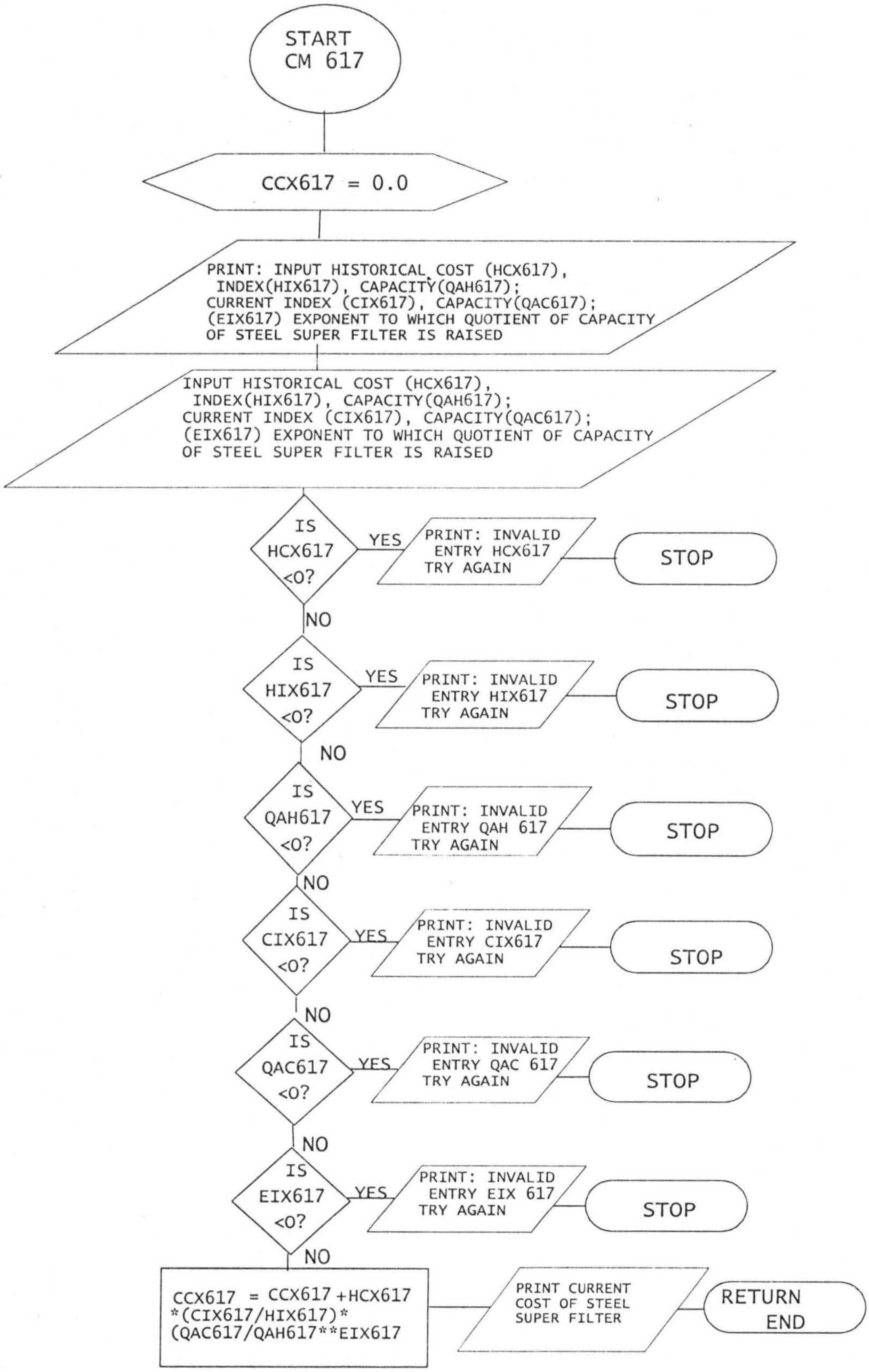
COMPUTATION OF CURRENT COST OF CONTINUOUS BLEACHING REACTOR



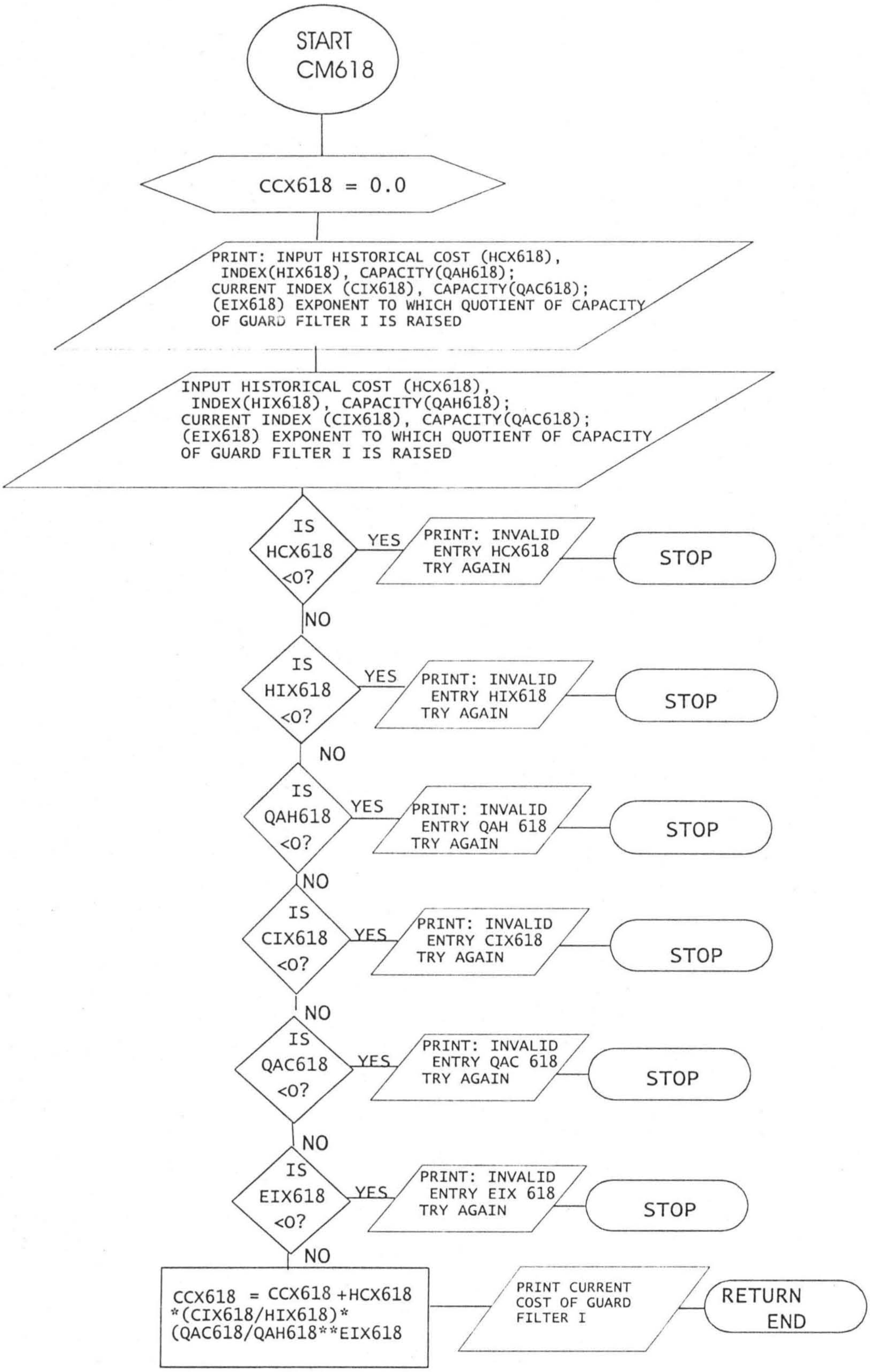
COMPUTATION OF CURRENT COST OF BERNARDINNI FILTER



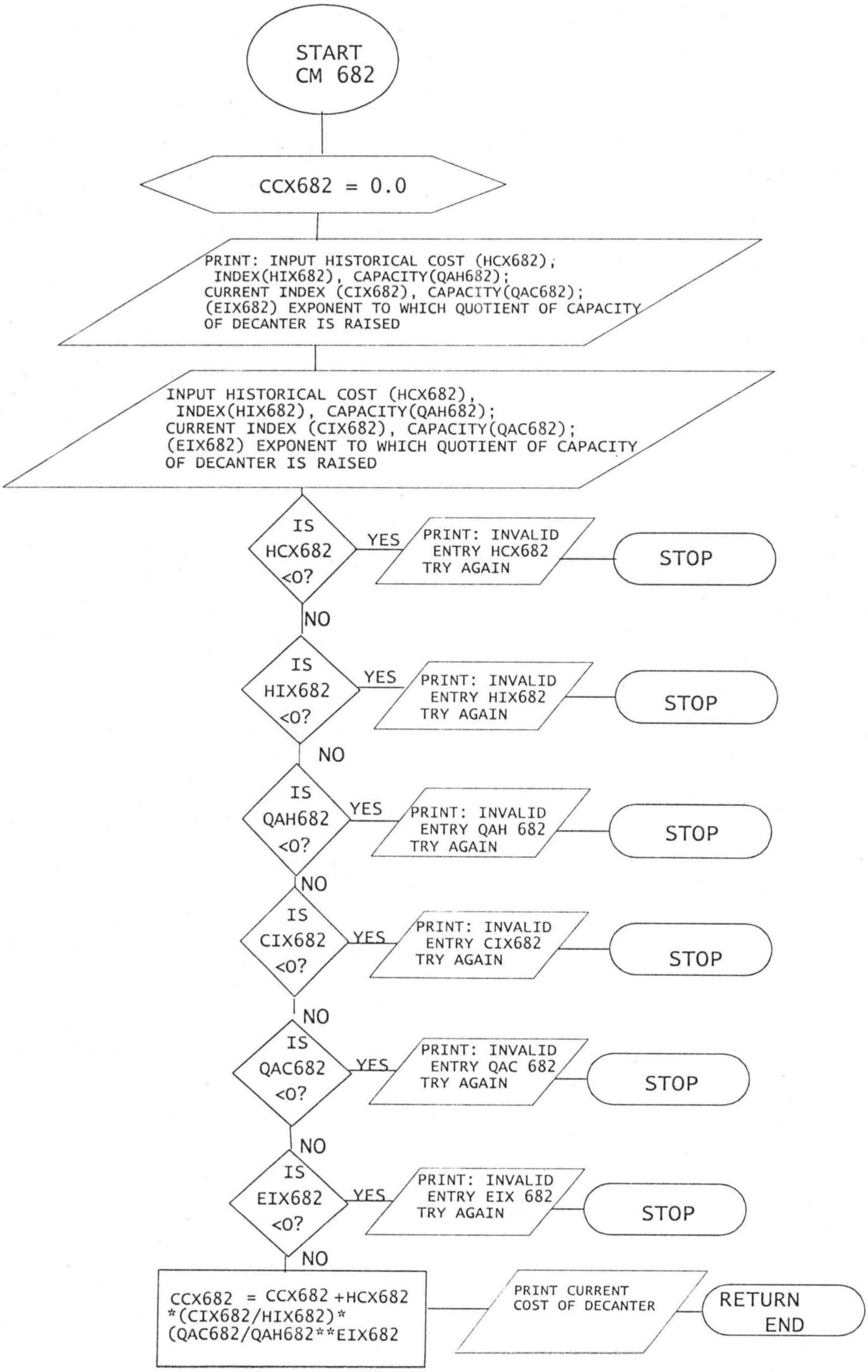
COMPUTATION OF CURRENT COST OF STEEL SUPER FILTER



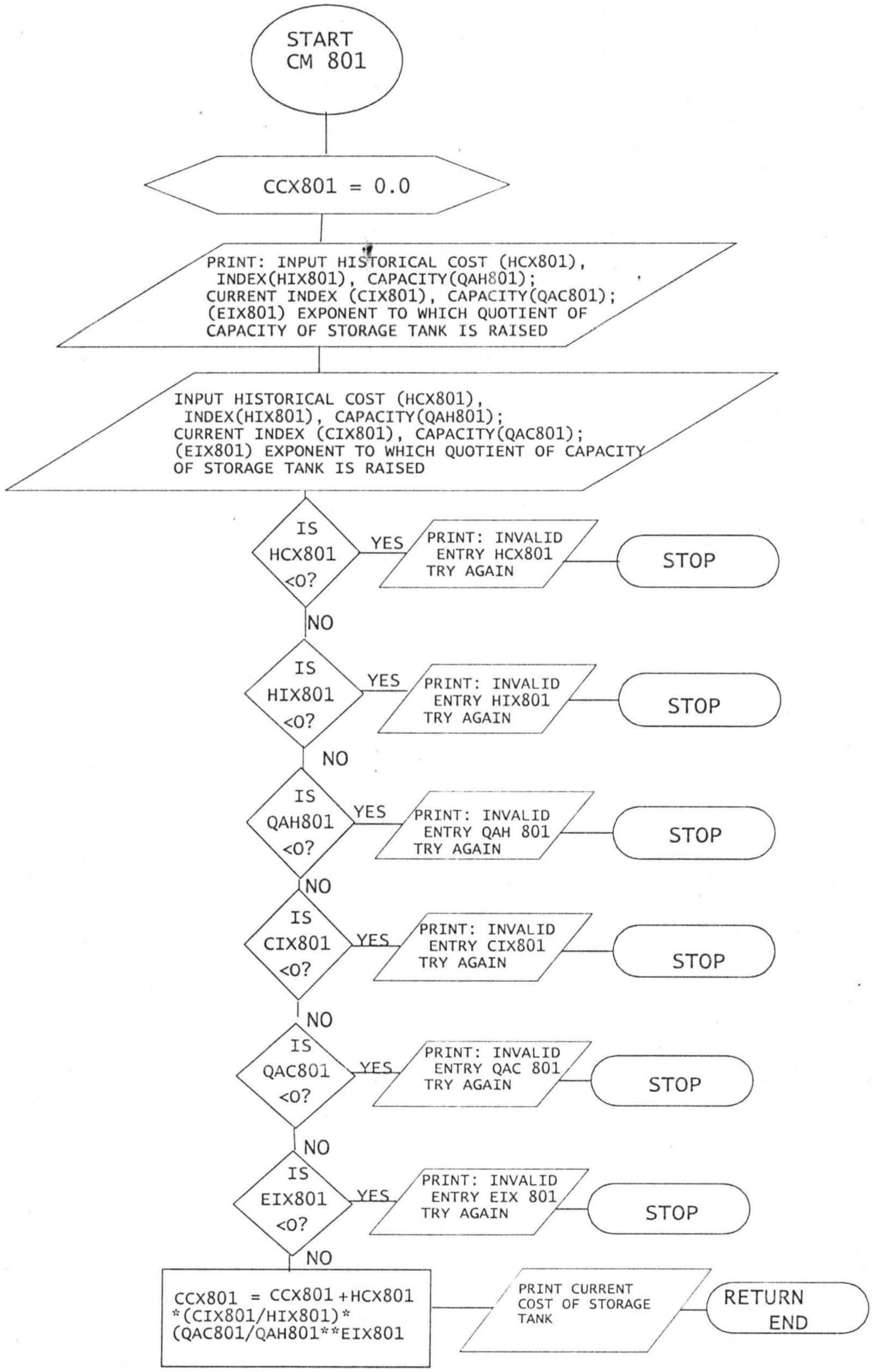
COMPUTATION OF CURRENT COST OF GUARD FILTER I



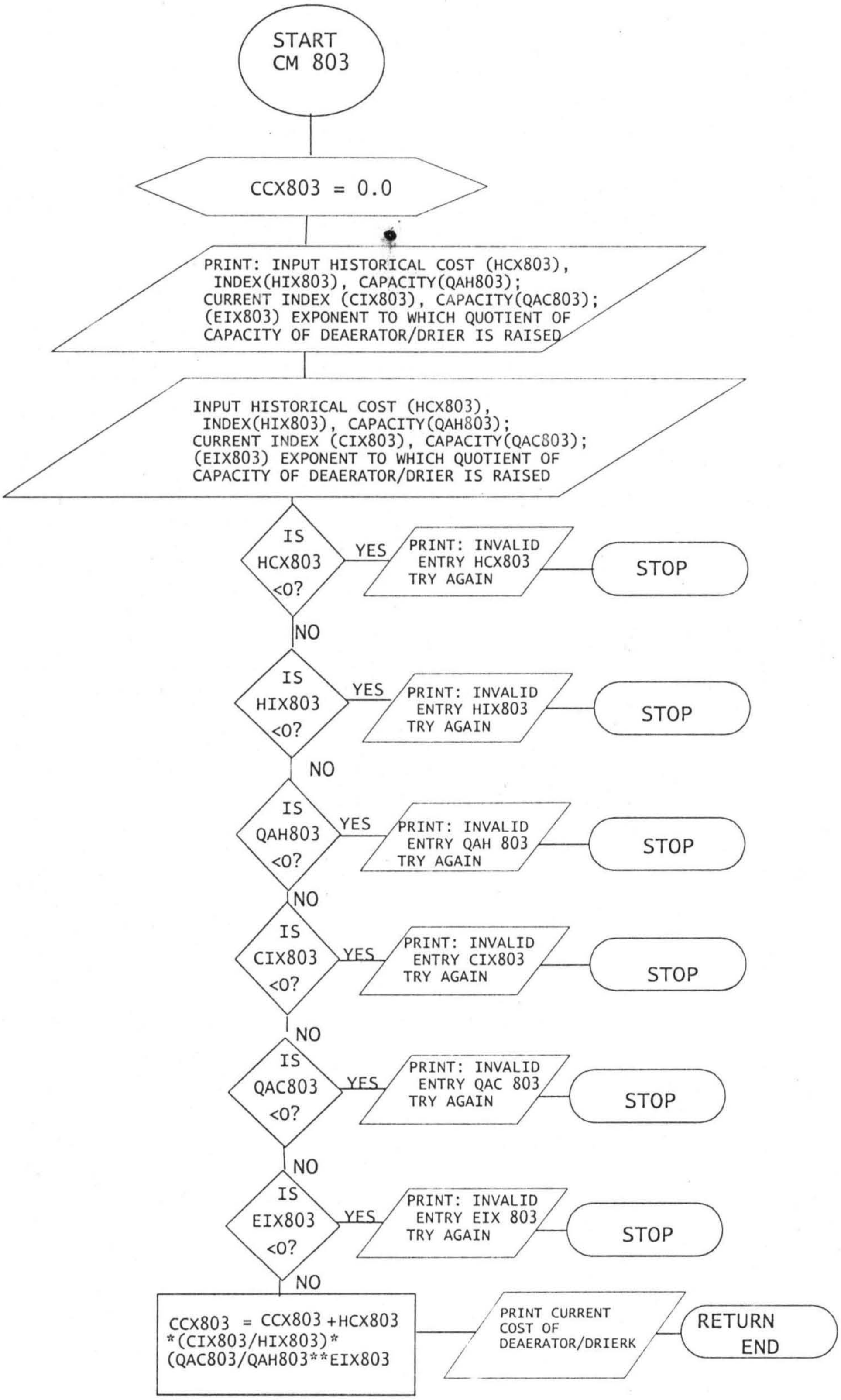
COMPUTATION OF CURRENT COST OF DECANTER



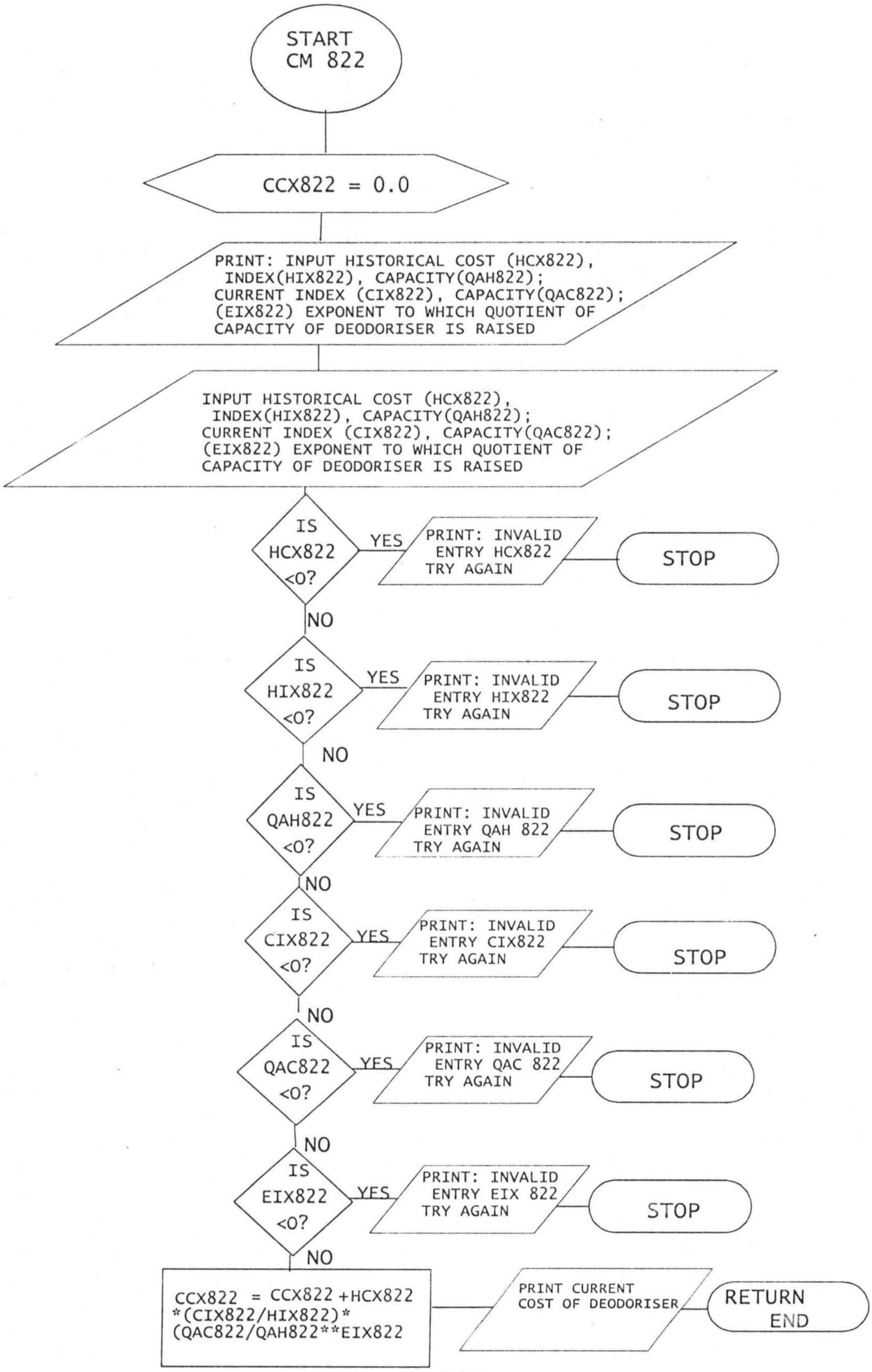
COMPUTATION OF CURRENT COST OF STORAGE TANK



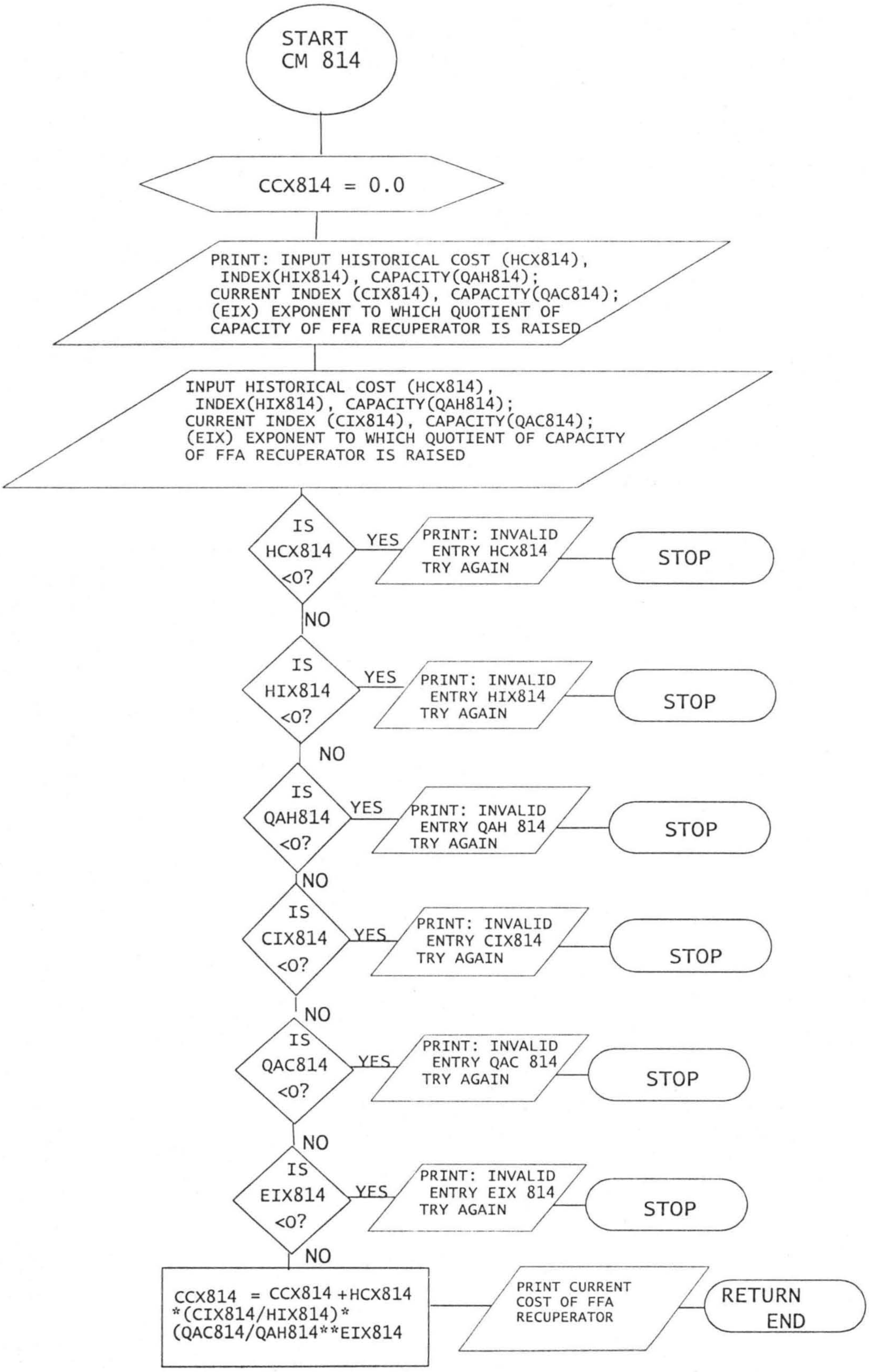
COMPUTATION OF CURRENT COST OF DEAERATOR/DRIER



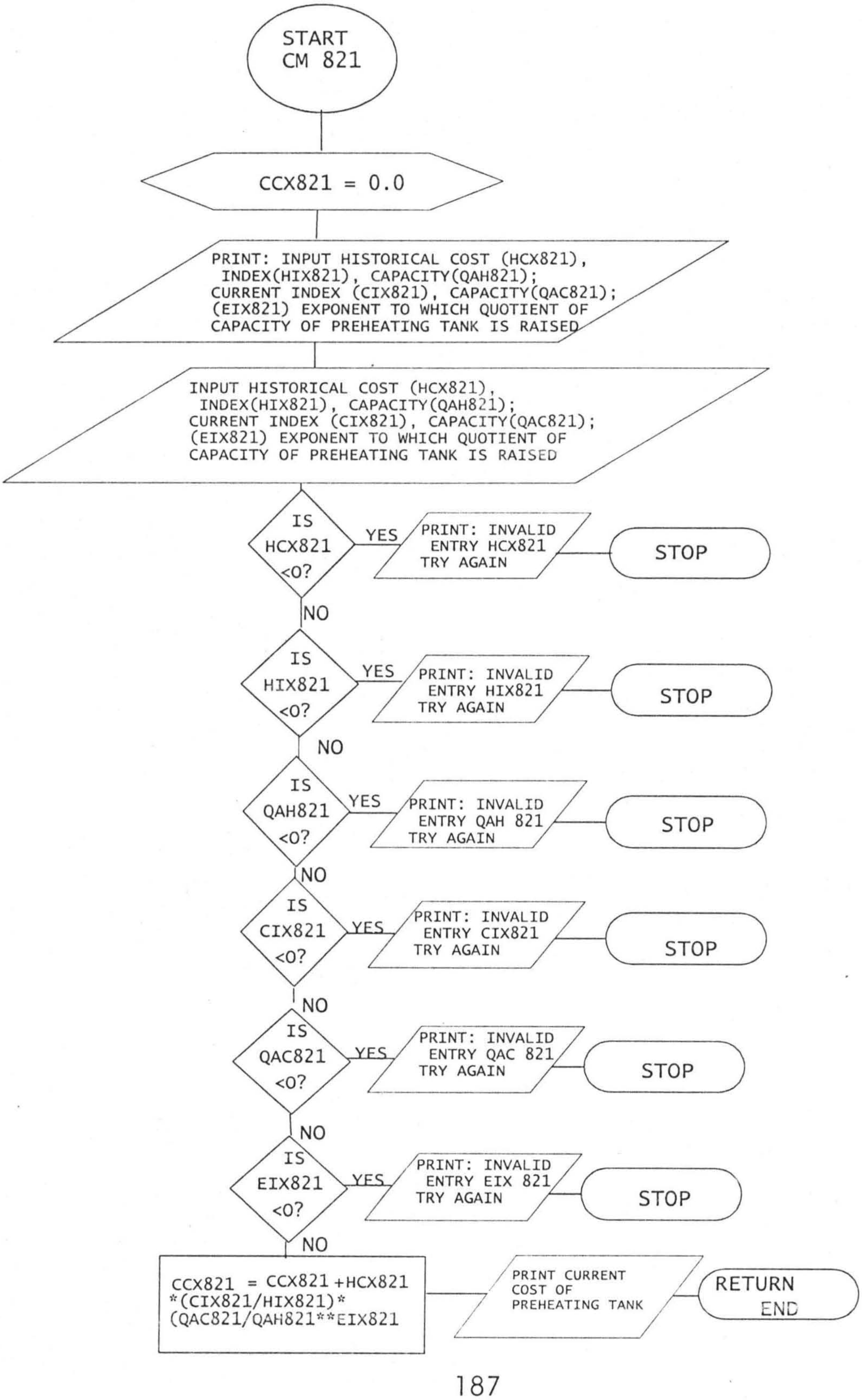
COMPUTATION OF CURRENT COST OF DEODORISER



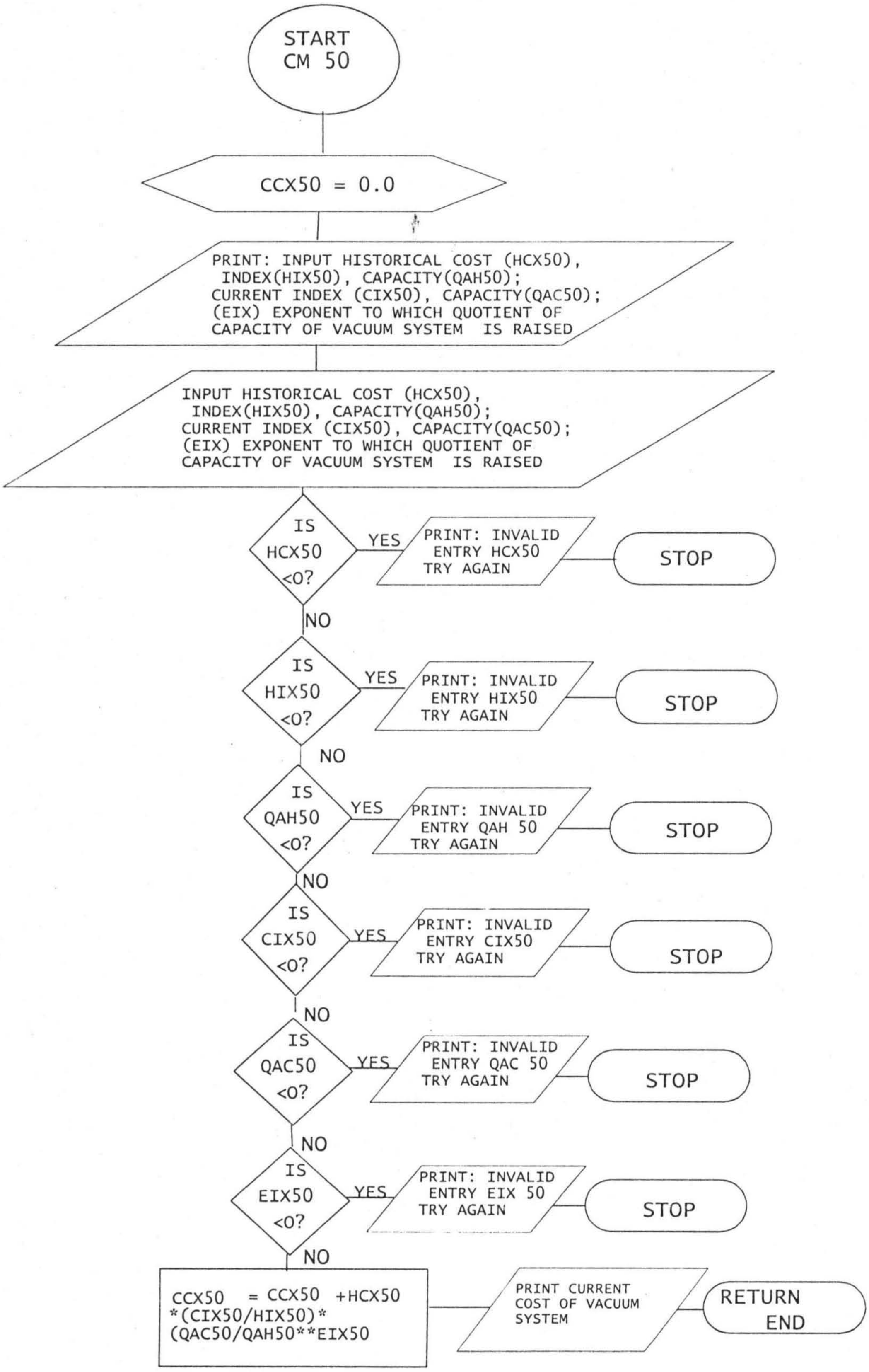
COMPUTATION OF CURRENT COST OF FFA RECUPERATOR



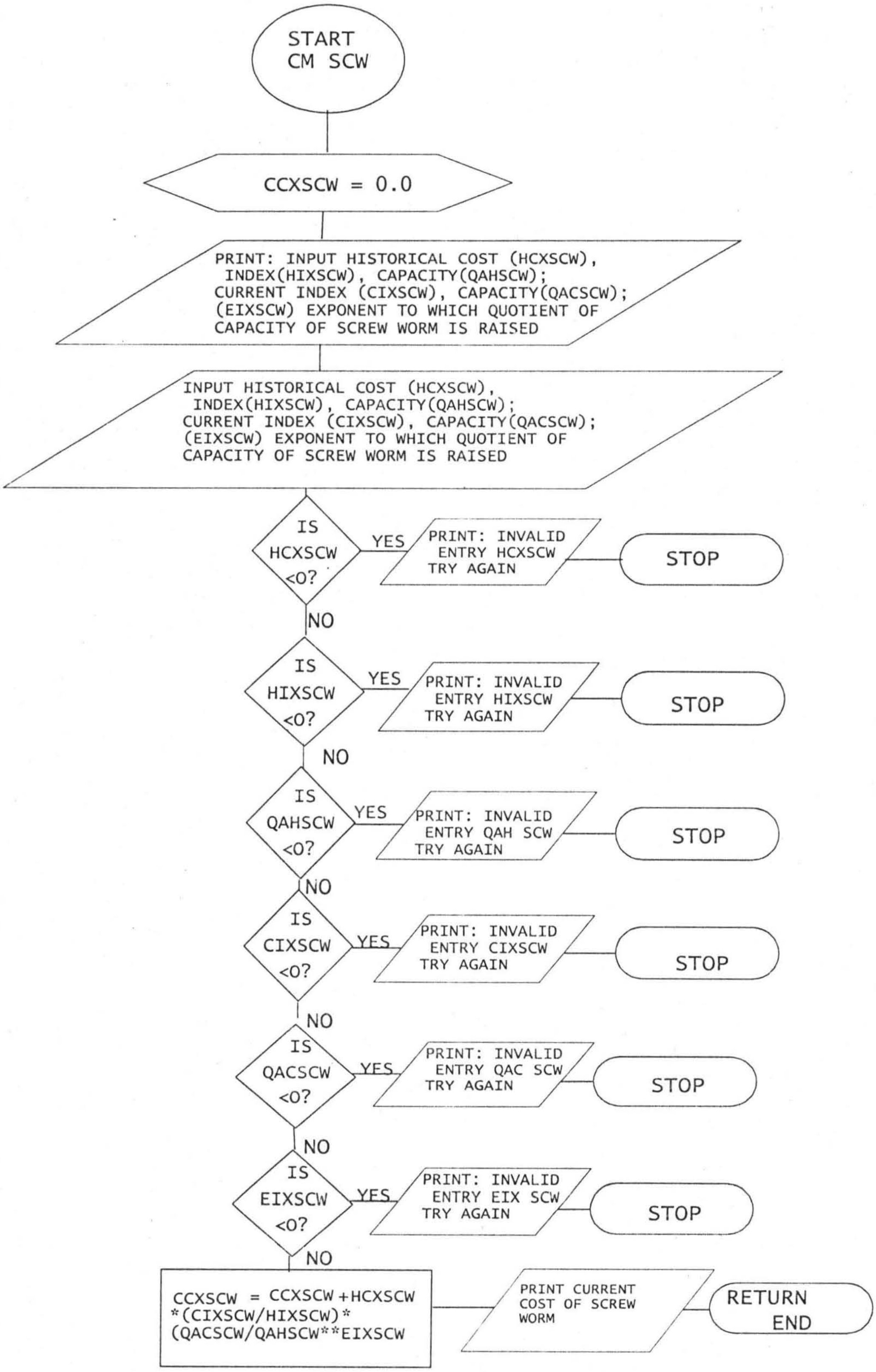
COMPUTATION OF CURRENT COST OF PREHEATING TANK



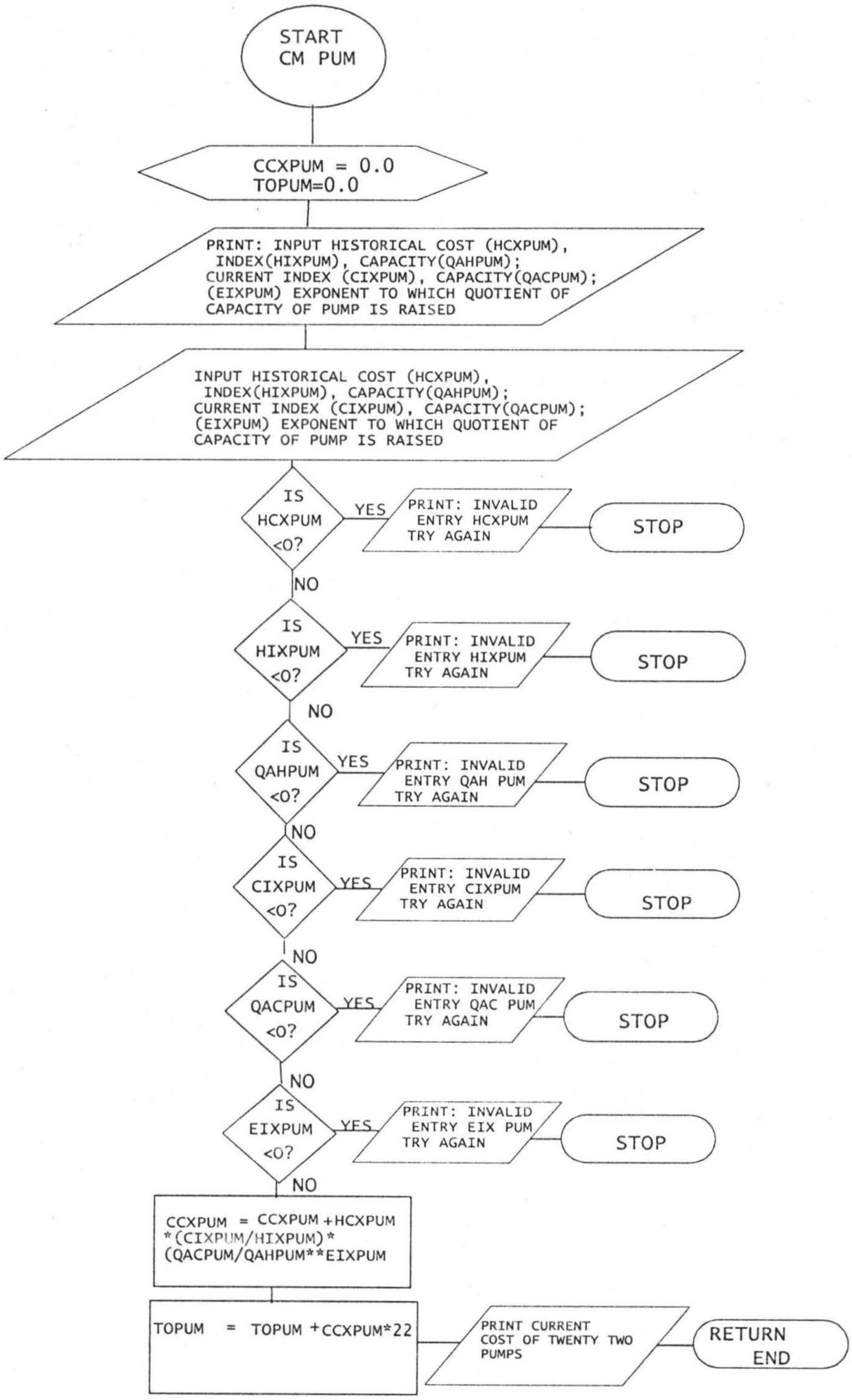
COMPUTATION OF CURRENT COST OF VACUUM SYSTEM



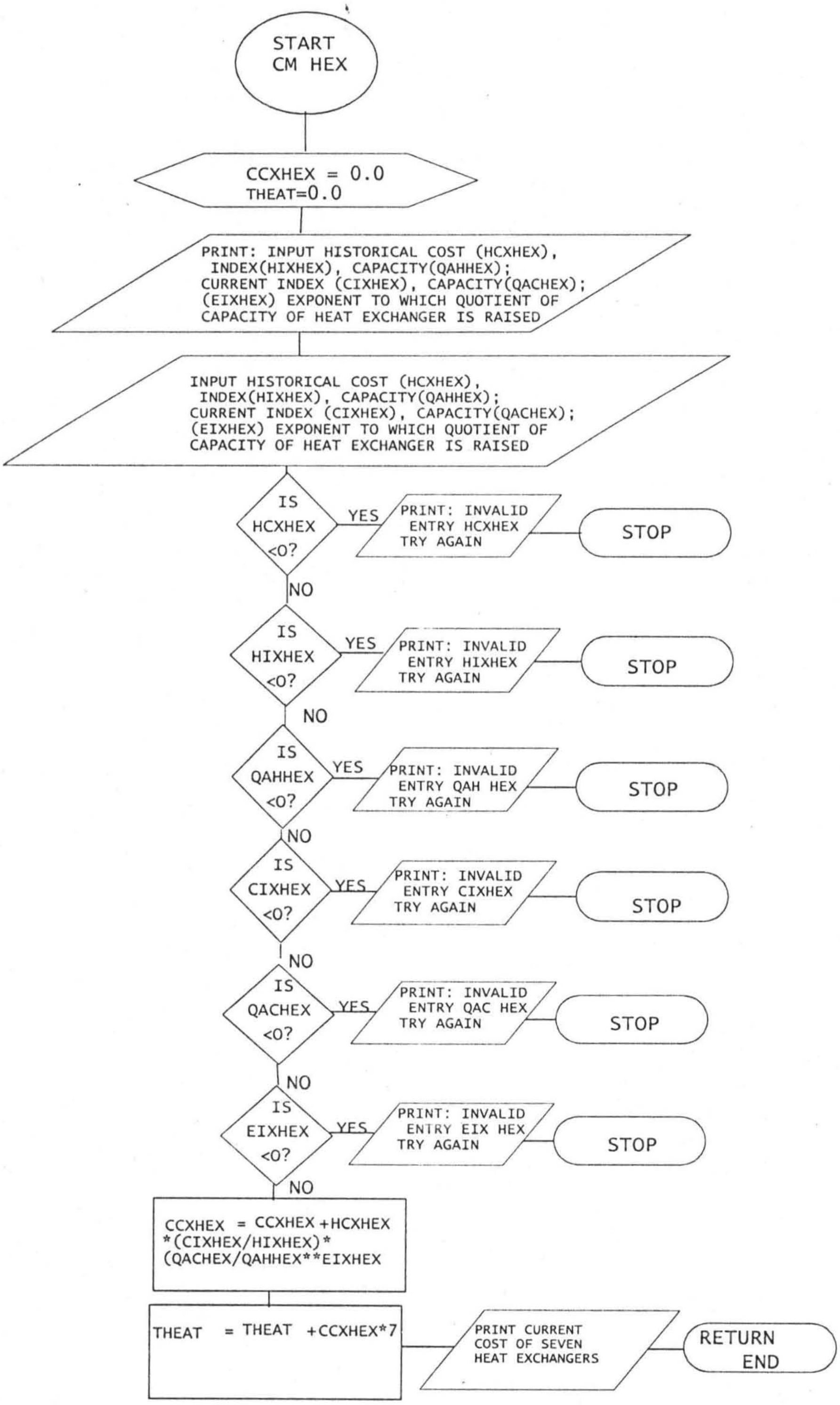
COMPUTATION OF CURRENT COST OF SCREW WORM



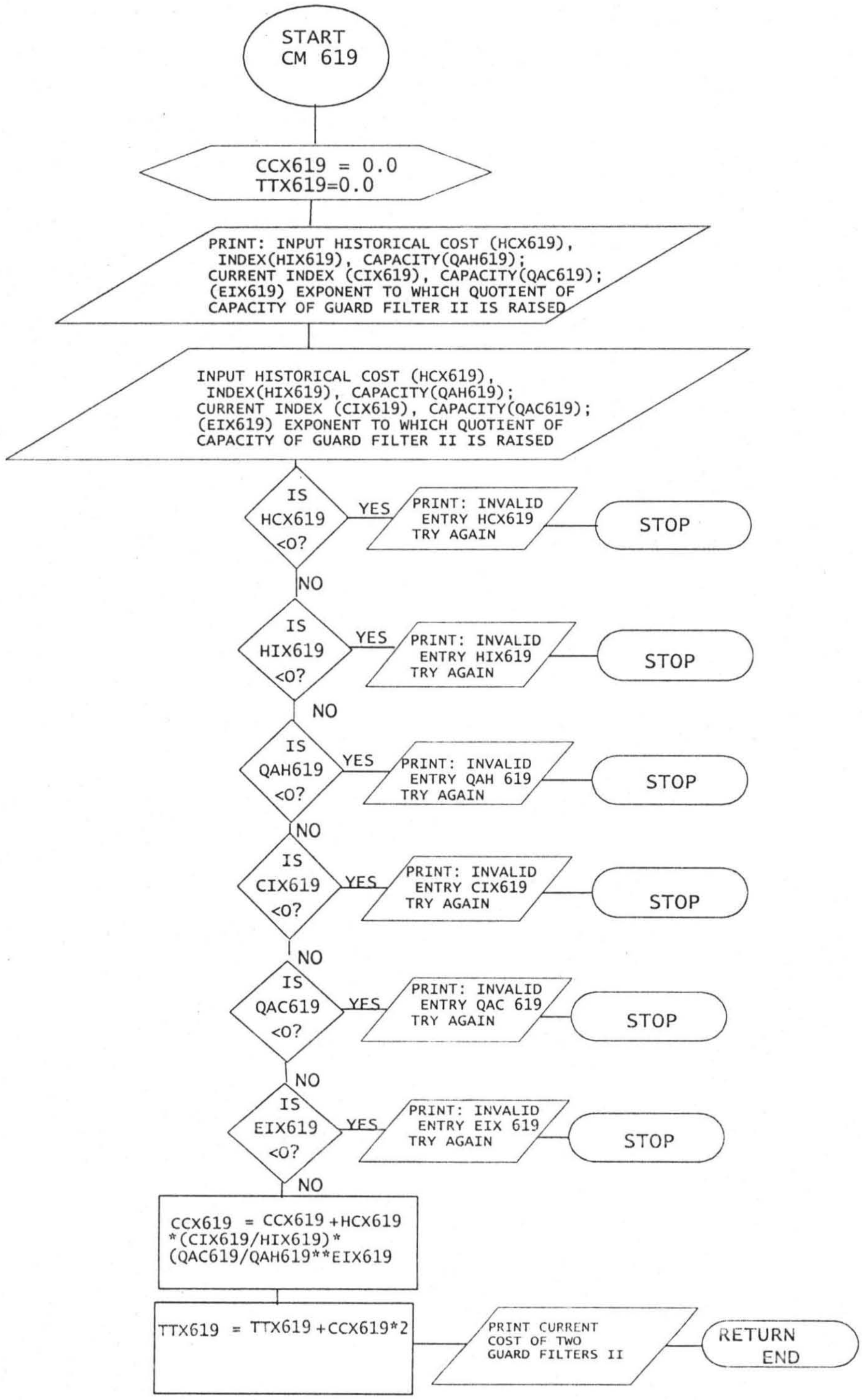
COMPUTATION OF CURRENT COST OF TWENTY TWO PUMPS



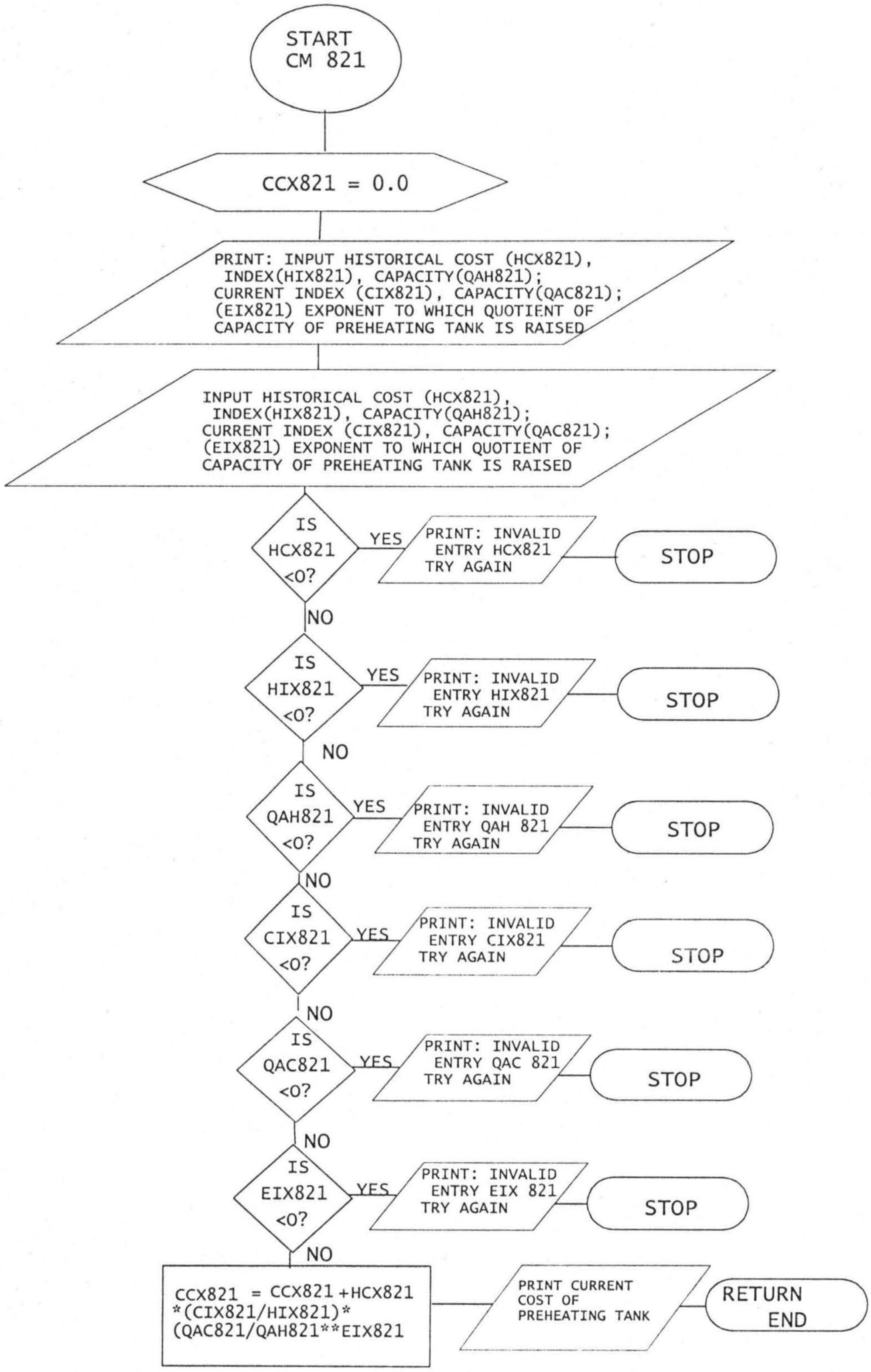
COMPUTATION OF CURRENT COST OF SEVEN HEAT EXCHANGERS



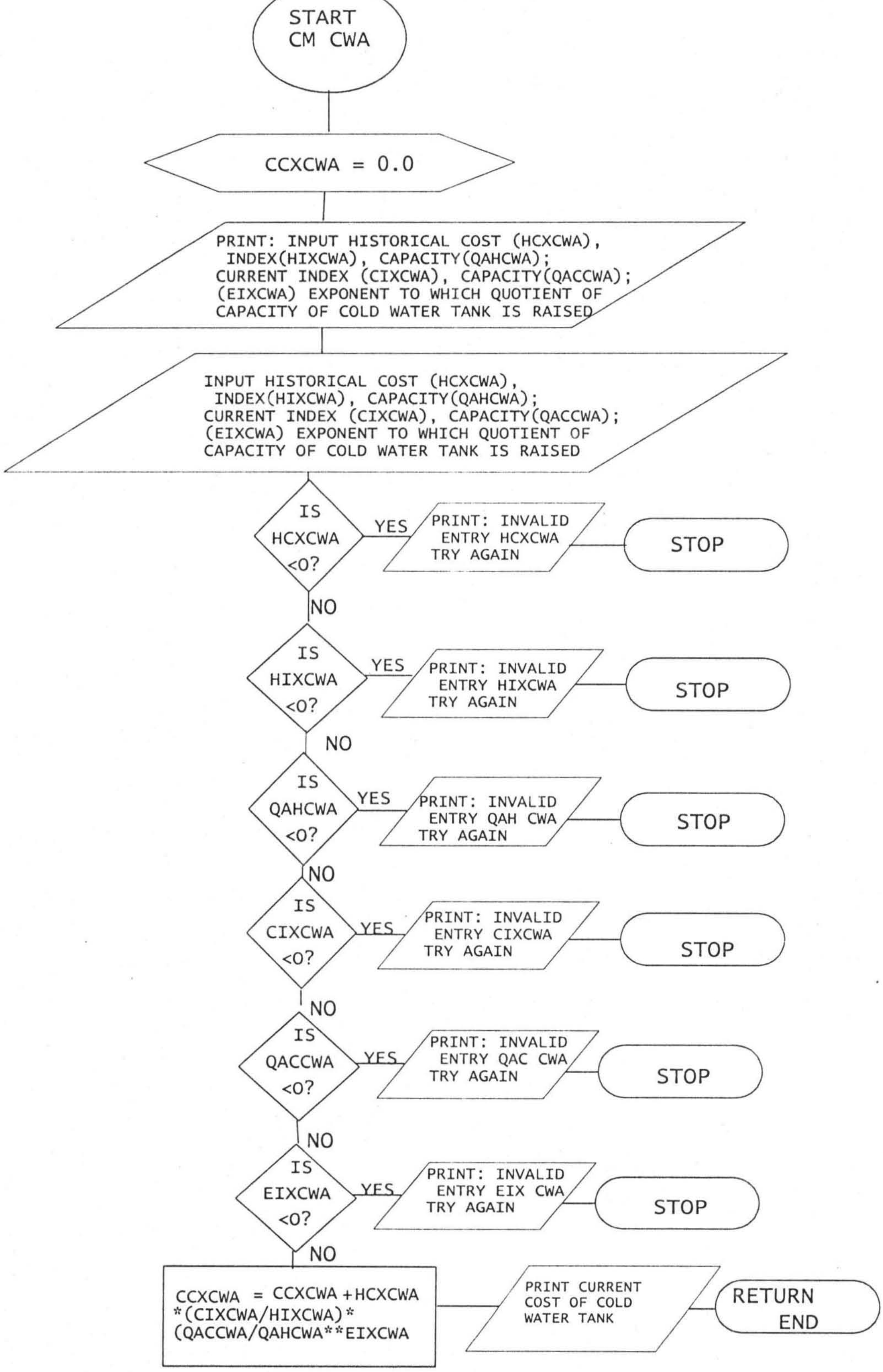
COMPUTATION OF CURRENT COST OF GUARD FILTER II



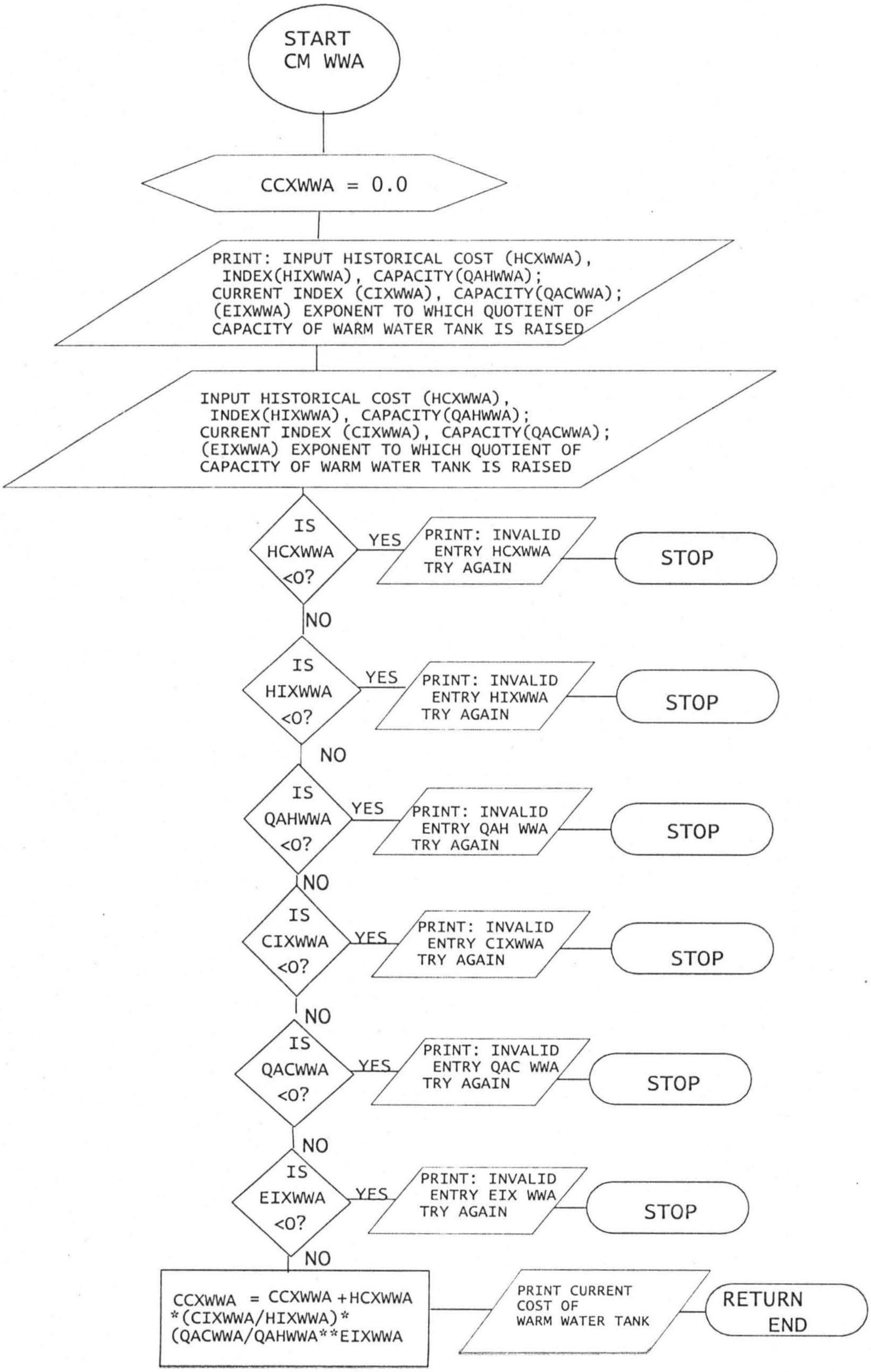
COMPUTATION OF CURRENT COST OF PREHEATING TANK



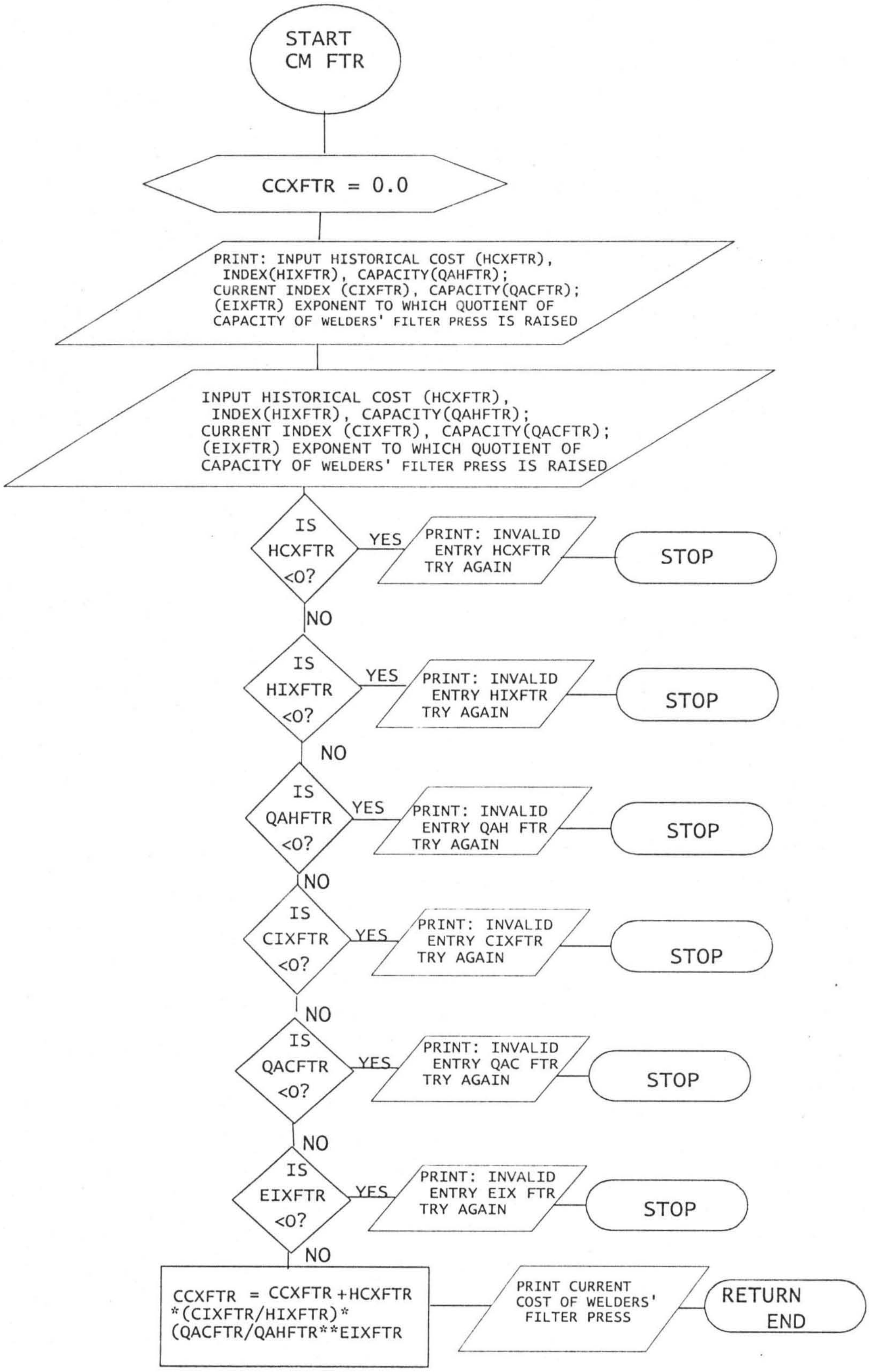
COMPUTATION OF CURRENT COST OF COLD WATER TANK



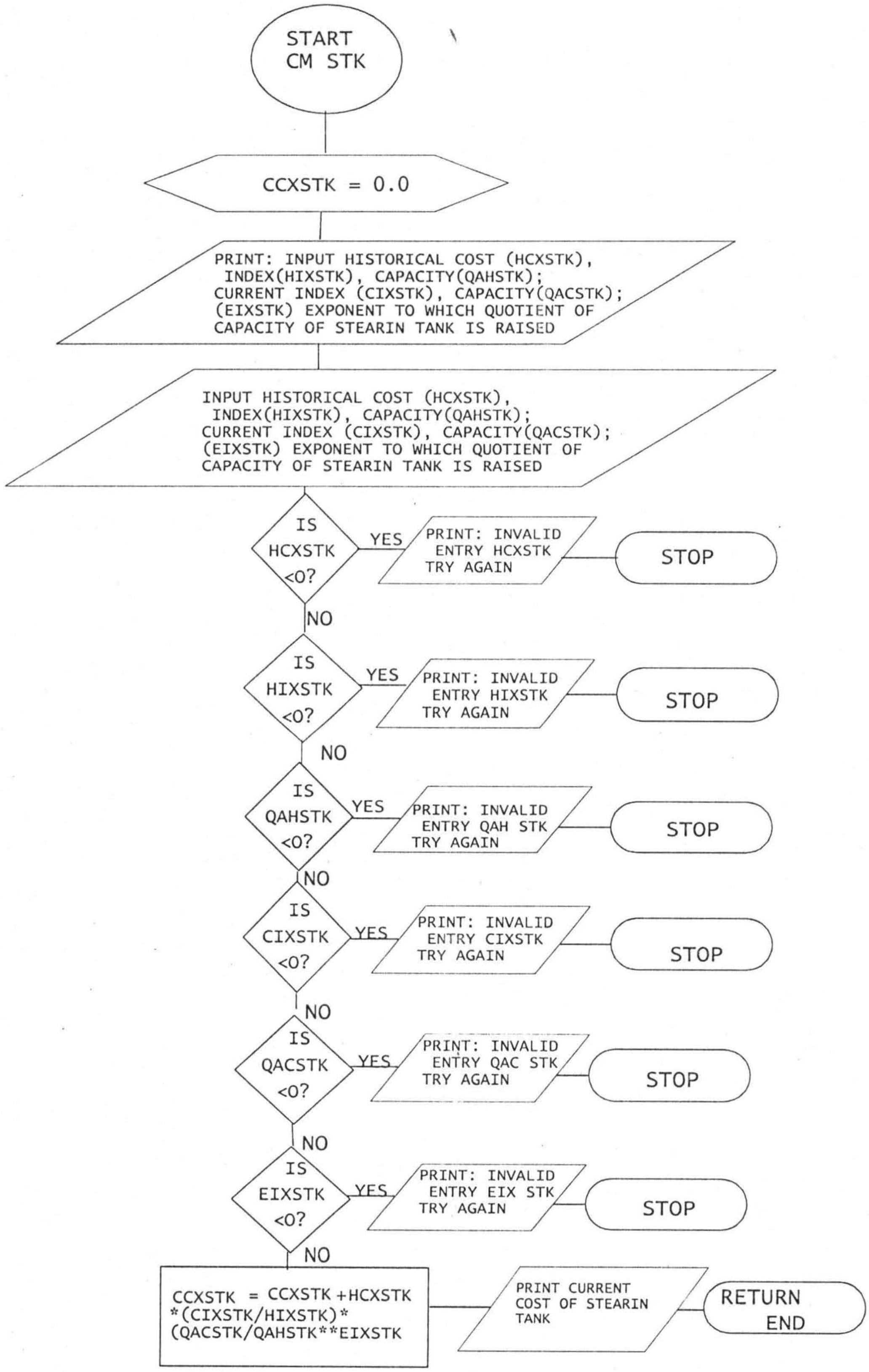
COMPUTATION OF CURRENT COST OF WARM WATER TANK



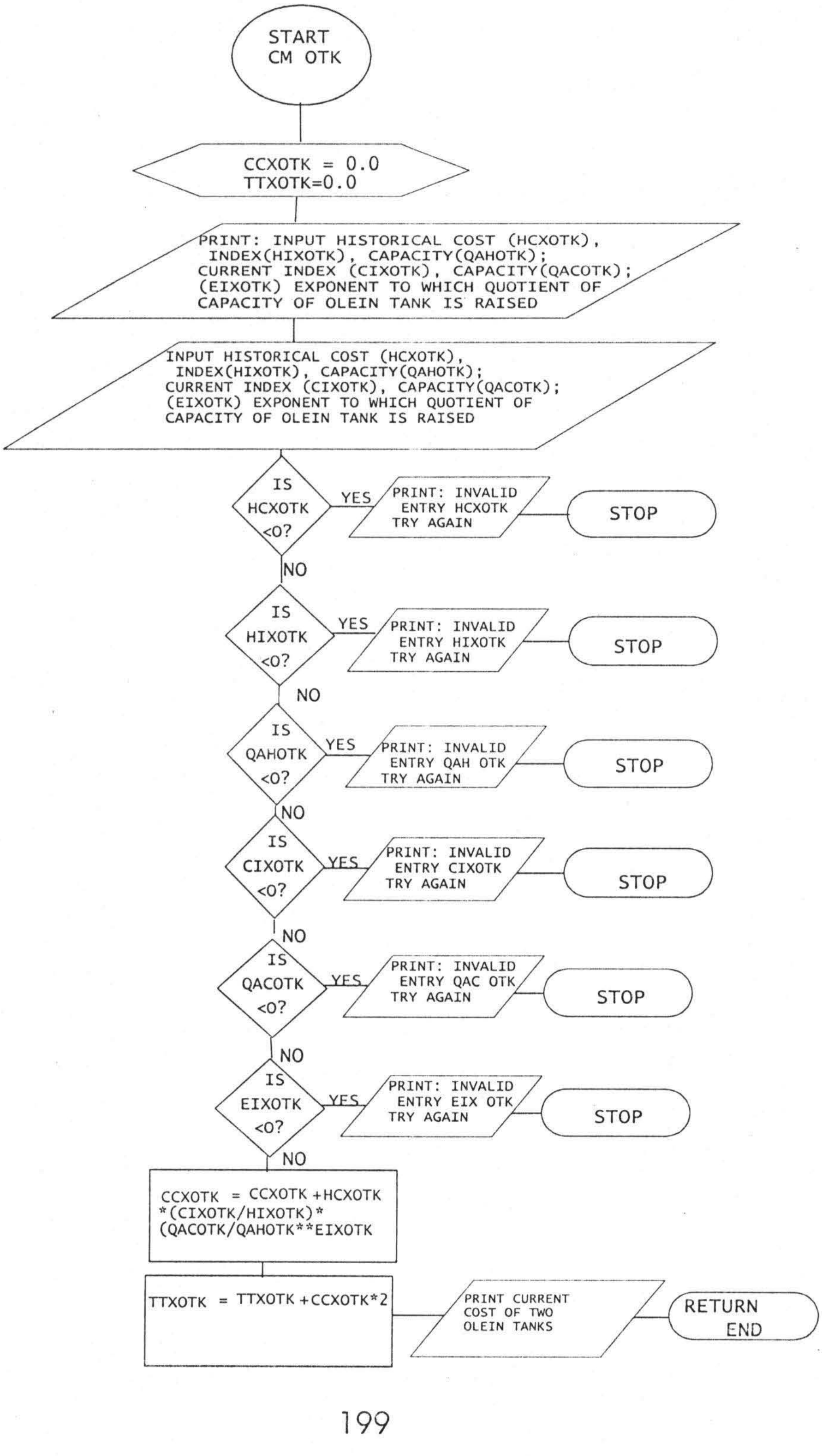
COMPUTATION OF CURRENT COST OF WELDERS' FILTER PRESS



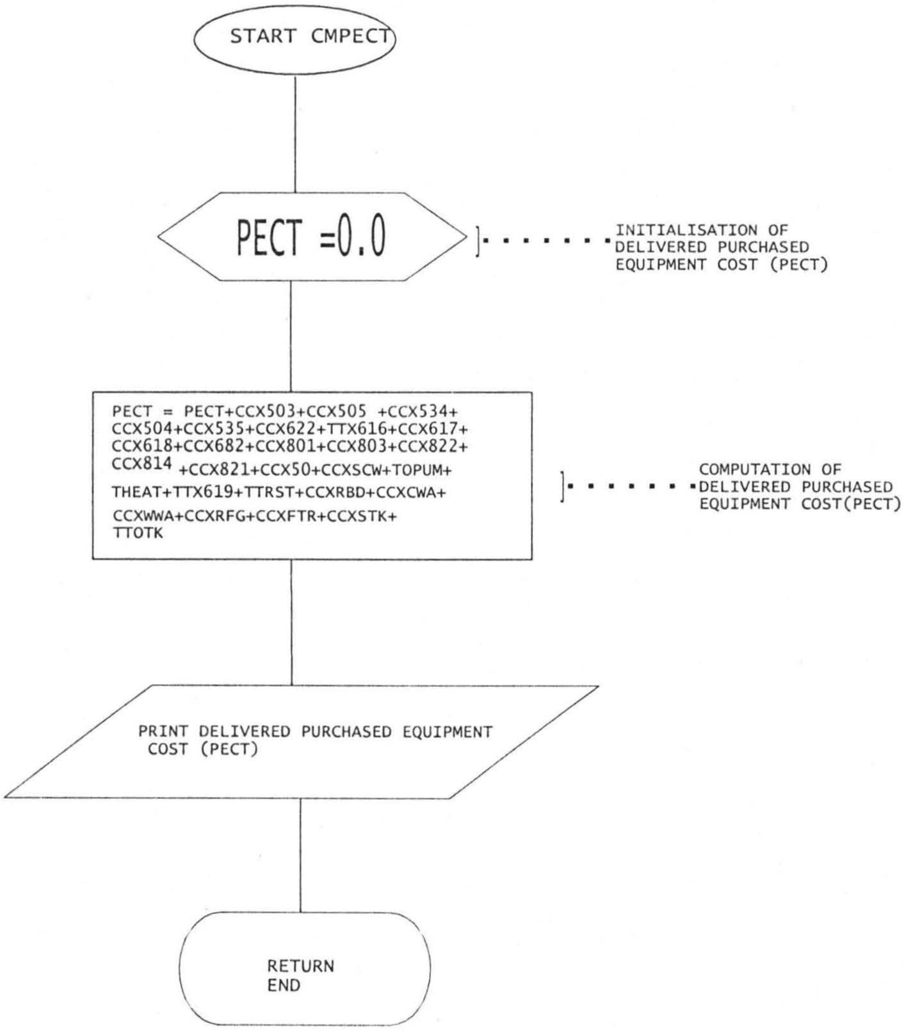
COMPUTATION OF CURRENT COST OF STEARIN TANK



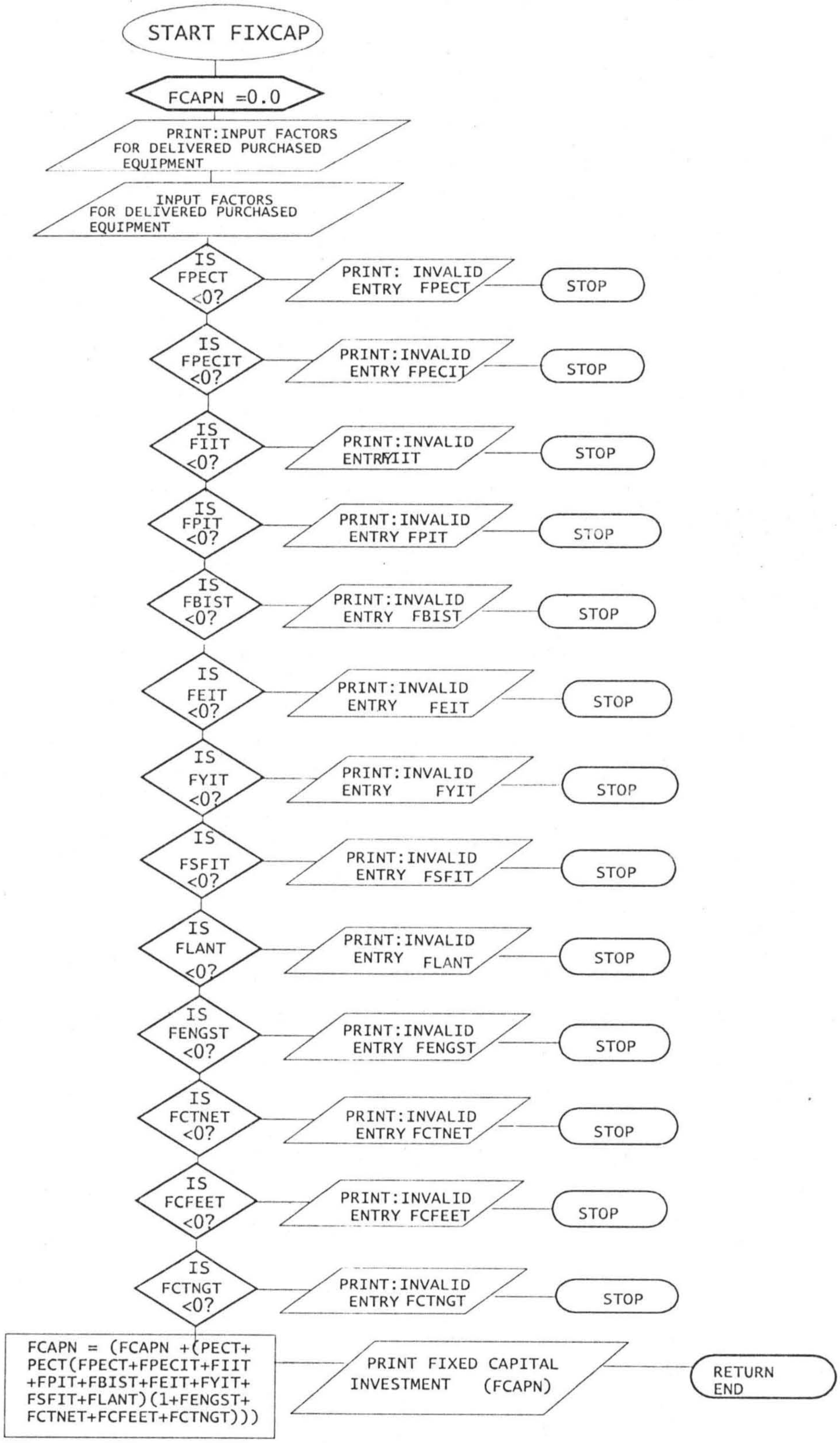
COMPUTATION OF CURRENT COST OF TWO OLEIN TANKS



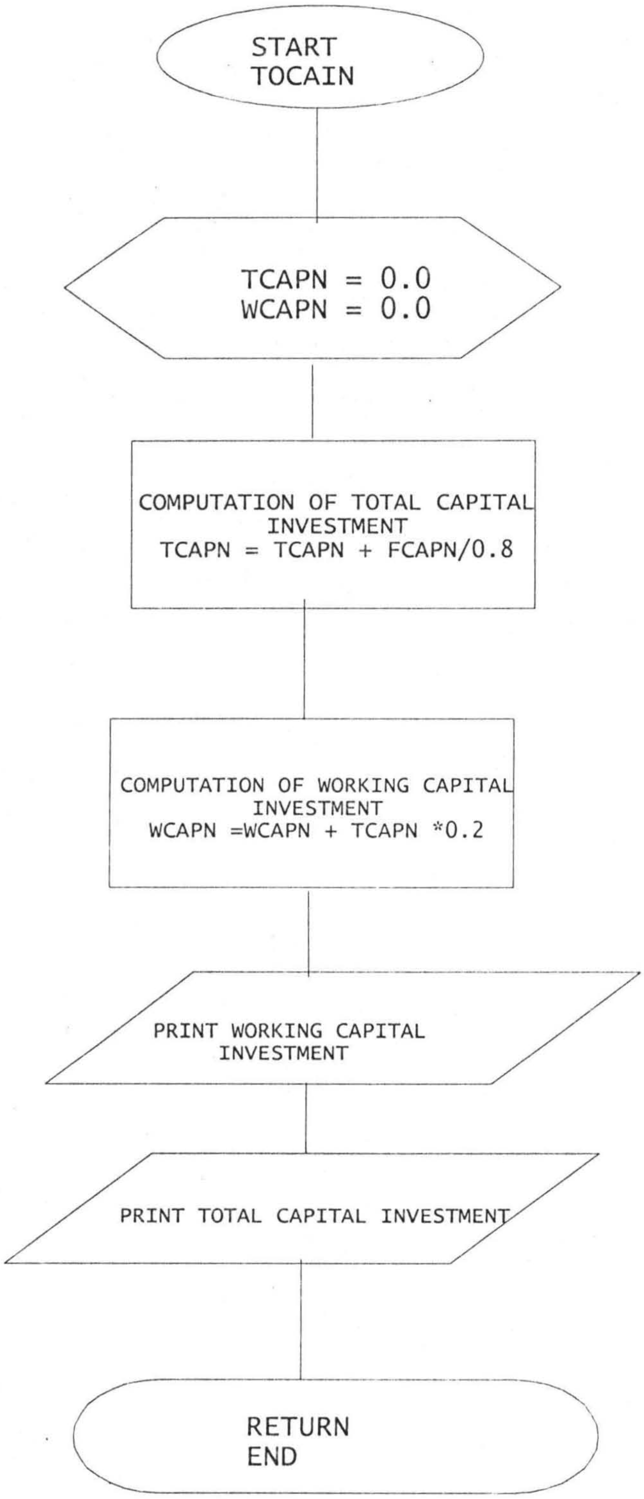
COMPUTATION OF THE DELIVERED
PURCHASED EQUIPMENTT COST



COMPUTATION OF THE FIXED CAPITAL INVESTMENT



COMPUTATION OF THE WORKING AND TOTAL CAPITAL INVESTMENTS



APPENDIX C2: Program CISCAL Representing the Cost Index and Scaling Method.

```
      PROGRAM CISCAL
      INTEGER CUYEAR
      COMMON PECT
C This program calculates the current cost of Palm Oil Refinery and
C Fractionation Plant making use of Cost Indices and Scaling to account
C for fluctuation in the cost of equipment due to inflation, Government
C regulation, type and size of equipment, location of the plant,
c operating time and rate of production, and a host of other factors.
C
C  AUTHOR:           NGUBI FREDERICKS WIRSIY
C  MAT. NO.:         M. ENG.\SEET\573\2000\2001
C  COURSE TITLE:     M.ENG PROJECT WORK
C  COURSE CODE:      CEE 623
C  PROJECT TITLE:    EFFECT OF COST FLUCTUATION ON THE DESIGN OF A PALM
C                    OIL REFINERY AND FRACTIONATION INDUSTRY
C  SUPERVISOR:       DR. K.R.ONIFADE
C  LANGUAGE:         FORTRAN 77
C  DATE:             5 MAY,2002
C
C  FILES:            CISCAL.LST,CISCAL.RES
C  ARRAYS            NONE
C
C   SECTION FOR DEFINITION OF SUBROUTINES
C
C  START                       INTRODUCTORY MODULE
C  CM503                       COST MODULE FOR CaCO3 TANK
C  CM505                       COST MODULE FOR MIXING TANK
C  CM534                       COST MODULE FOR PHOSPHORIC ACID TANK
C  CM504                       COST MODULE FOR DRIER
C  CM535                       COST MODULE FOR BLEACHING EARTH TANK
C  CM622                       COST MODULE FOR CONTINUOUS BLEACHING REACTOR
C  CM616                       COST MODULE FOR BERNARDINNI FILTER
C  CM617                       COST MODULE FOR STEEL SUPER FILTER
C  CM618                       COST MODULE FOR GUARD FILTER I
C  CM682                       COST MODULE FOR DECANTER
C  CM801                       COST MODULE FOR STORAGE TANK
C  CM803                       COST MODULE FOR DEAERATOR/DRIER
C  CM822                       COST MODULE FOR DEODORISER
C  CM814                       COST MODULE FOR FFA RECUPERATOR
C  CM821                       COST MODULE FOR PREHEATING TANK
C  CM50                        COST MODULE FOR VACUUM SYSTEM
C  CMSCW                       COST MODULE FOR SCREW WORM
C  CMPUM                       COST MODULE FOR PUMPS
C  CMHEX                       COST MODULE FOR HEAT EXCHANGERS
C  CM619                       COST MODULE FOR GUARD FILTER II
C  CMRST                       COST MODULE FOR CRYSTALLISERS
C  CMRBD                       COST MODULE FOR RBD TANK
C  CMCWA                       COST MODULE FOR COLD WATER TANK
C  CMWWA                       COST MODULE FOR WARM WATER TANK
C  CMWFR                       COST MODULE FOR WELDERS' FILTER PRESS
C  CMSTK                       COST MODULE FOR STEARIN TANK
C  CMOTK                       COST MODULE FOR OLEIN TANK
C  FIXCAP                      COST MODULE FOR FIXED CAPITAL INVESTMENT
C  TOCAIN                      COST MODULE FOR WORKING & TOTAL CAPITAL
C                              INVESTMENTS
C
```

```
C  SECTION FOR COMPUTING THE CURRENT COST OF EACH  EQUIPMENT
C

      PECT=0.0
      CALL START(NRYEAR,CUYEAR)
      CALL CM503(HC503,HI503,CH503,CI503,CF503,EI503,CC503)
      CALL CM505(HC505,HI505,CH505,CI505,CF505,EI505,CC505)
      CALL CM534(HC534,HI534,CH534,CI534,CF534,EI534,CC534)
      CALL CM504(HC504,HI504,CH504,CI504,CF504,EI504,CC504)
      CALL CM535(HC535,HI535,CH535,CI535,CF535,EI535,CC535)
      CALL CM622(HC622,HI622,CH622,CI622,CF622,EI622,CC622)
      CALL CM616(HC616,HI616,CH616,CI616,CF616,EI616,CC616,TTF616)
      CALL CM617(HC617,HI617,CH617,CI617,CF617,EI617,CC617)
      CALL CM618(HC618,HI618,CH618,CI618,CF618,EI618,CC618)
      CALL CM682(HC682,HI682,CH682,CI682,CF682,EI682,CC682)
      CALL CM801(HC801,HI801,CH801,CI801,CF801,EI801,CC801)
      CALL CM803(HC803,HI803,CH803,CI803,CF803,EI803,CC803)
      CALL CM822(HC822,HI822,CH822,CI822,CF822,EI822,CC822)
      CALL CM814(HC814,HI814,CH814,CI814,CF814,EI814,CC814)
      CALL CM821(HC821,HI821,CH821,CI821,CF821,EI821,CC821)
      CALL CM50(HC50,HI50,CH50,CI50,CF50,EI50,CC50)
      CALL CMSCW(HCSCW,HISCW,CHSCW,CISCW,CFSCW,EISCW,CCSCW)
      CALL CMPUM(TOPUMS,HCHUM,HIPUM,CHPUM,CIPUM,CFPUM,EIPUM,CCPUM)
      CALL CMHEX(THEATS,HCHEX,HIHEX,CHHEX,CIHEX,CFHEX,EIHEX,CCHEX)
      CALL CM619(TTF619,HC619,HI619,CH619,CI619,CF619,EI619,CC619)
      CALL CMRST(TTRST,HCRST,HIRST,CHRST,CIRST,CFRST,EIRST,CCRST)
      CALL CMRBD(HCRBD,HIRBD,CHRBD,CIRBD,CFRBD,EIRBD,CCRBD)
      CALL CMCWA(HCCWA,HICWA,CHCWA,CICWA,CCCWA,EICWA,CCCWA)
      CALL CMWWA(HCWWA,HIWWA,CHWWA,CIWWA,CFWWA,EIWWA,CCWWA)
      CALL CMFTR(HCFTR,HIFTR,CHWFR,CIFTR,CFFTR,EIFTR,CCFTR)
      CALL CMSTK(HCSTK,HISTK,CHSTK,CISTK,CFSTK,EISTK,CCSTK)
      CALL CMOTK(TTOTK,HCOTK,HIOTK,CHOTK,CIOTK,CFOTK,EIOTK,CCOTK)

C SECTION FOR COMPUTING DELIVERED PURCHASED EQUIPMENT COST(PECT).
C
C The Delivered purchased equipment cost is obtained by summing the
C calculated currunt costs of all equipment.
      CALL CMPECT(PECT,CC503,CC505,CC534,CC504,CC535,CC622,TTF616,CC617,
     $CC618,CC682,CC801,CC803,CC822,CC814,CC821,CC50,CCSCW,TOPUMS,
     $THEATS,TTF619,TTRST,CCRBD,CCCWA,CCWWA,CCFTR,CCSTK,TTOTK)

C
C  SECTION FOR COMPUTING FIXED CAPITAL INVESTMENT(FCAPN)
C
      CALL FIXCAP(FCAPIN,PECT,FPEC,FPECI,FII,FPI,FBIS,FEI,
     $FYI,FSFI,FLAN,FENGS,FCTNE,FCFEE,FCTNG)

C SECTION FOR COMPUTING TOTAL CAPITAL INVESTMENT(WCAPIN,TCAPIN)

      CALL TOCAIN(FCAPIN,TCAPIN,WCAPIN)
      END

C SECTION FOR SUBROUTINES

      SUBROUTINE START(MRYEAR,CUYEAR)
      INTEGER CUYEAR
      OPEN(2,FILE='CISCAL.RES')
      PRINT*,'Input Reference for Cost Indices (MRYEAR)'
      PRINT*,'Input Current for Cost Indices (CUYEAR)'
      READ(*,*)MRYEAR,CUYEAR
      IF(MRYEAR.LT.1996)THEN
```

```
      PRINT10,'INVALID ENTRY:',MRYEAR,'TRY AGAIN!'
10    FORMAT(/,10X,A,1X,I5,2X,A)
      STOP
     ELSE
      WRITE(*,13)'APPENDIX C2:Results for Program CISCAL,'
      WRITE(*,15)'Representing The Cost Index & Scaling Method'
      WRITE(2,13)'APPENDIX C2:Results for Program CISCAL,'
      WRITE(2,15)'Representing The Cost Index & Scaling Method'
      WRITE(*,20)'The Reference Year used is:',MRYEAR
      WRITE(2,20)'The Reference Year used is:',MRYEAR
      WRITE(*,22)
      WRITE(2,22)
      WRITE(*,25)'The Current Year is:',CUYEAR
      WRITE(2,25)'The Current Year is:',CUYEAR
      WRITE(*,27)
      WRITE(2,27)
13    FORMAT(/,12X,A)
15    FORMAT(12X,A)
20    FORMAT(/,22X,A,4X,I5)
22    FORMAT(22X,27('-'),5X,4('-'))
25    FORMAT(/,22X,A,11X,I5)
27    FORMAT(22X,20('-'),12X,4('-'))
     ENDIF
     CONTINUE
     WRITE(*,40)'Name of Equipment','Cost of Equipment in 2002 (Naira)'
     WRITE(2,40)'Name of Equipment','Cost of Equipment in 2002 (Naira)'
40   FORMAT(/,11X,A,17X,A)
     WRITE(*,50)
     WRITE(2,50)
50   FORMAT(11X,17('-'),17X,33('-'))
     RETURN
     END
C                 VARIABLES IN THE SUBROUTINES
C  CM                            Cost Module
C  For instance CM503 stands for Cost Module for equipment 503 which is
C the CaCO3 tank, etc...

C  CCT                            Current Cost of  equipment
C  HCT                            Historical cost of equipment
C  CIT                            Current cost Index of equipment
C  HIT                            Historical cost Index of equipment
C  QAH                            Historical Capacity of equipment
C  QAC                            Current Capacity of equipmebnt
C  EIX                            Exponent to which the quotient of the
current
C                                 to historical capacities of the
equipment is
C                                 raised
C  For instance,CCT503,HCT503,CIT503, HIT503,QAH,QAC and EIX stand for
Current
C  Cost, Historical Cost,Current  cost Index , Historical cost Index,
C  Historical Capacity,Current Capacity and Exponent of CaCo3 tank
designated
C  503.
      SUBROUTINE CM503 (HCT503,HIT503,QAH503,CIT503,QAC503,EIX503,
     $CCT503)
C  Subroutine CM503 calculates the Current cost of CaCO3 Tank
      CCT503=0.0
      PRINT1,'Input Historical Cost (HCT503),',
     $'Historical index (HIT503),',
```

```
     $'Historical capacity (QAH503),',
     $'Current index (CIT503),',
     $'Current capacity (QAC503),',
     $'Exponent (EIX503) of CaCO3 Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT503,HIT503,QAH503,CIT503,QAC503,EIX503
      IF(HCT503.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT503) :',HCT503,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT503.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT503) :',HIT503,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT503.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT503) :',CIT503,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC503.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC503) :',QAC503,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH503.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH503) :',QAH503,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX503.LE.0.OR.EIX503.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX503) :',EIX503,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C The following formula calculates the Current cost of CaCO3 Tank
        CCT503=CCT503+(HCT503*(CIT503/HIT503)*(QAC503/QAH503)**EIX503)
        WRITE(*,70)'CaCO3 Tank', 'N',CCT503
        WRITE(2,70)'CaCO3 Tank', 'N',CCT503
   70   FORMAT(/,10X,A,33X,A,F15.2)
      ENDIF
      RETURN
      END


      SUBROUTINE CM505(HCT505,HIT505,QAH505,CIT505,QAC505,EIX505,CCT505)
C Subroutine CM505 calculates the current cost of Mixing Tank
      CCT505=0.0
      PRINT1,'Input Historical Cost (HCT505),',
     $'Historical index (HIT505),',
     $'Historical capacity (QAH505),',
     $'current index (CIT505),',
     $'current capacity (QAC505),',
     $'Exponent (EIX505) of Mixing tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT505,HIT505,QAH505,CIT505,QAC505,EIX505
      IF(HCT505.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT505) :',HCT505,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT505.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT505) :',HIT505,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT505.LE.0)THEN
```

```
         PRINT30,'INVALID ENTRY (CIT505) :',CIT505,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC505.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC505) :',QAC505,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH505.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH505) :',QAH505,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX505.LE.0.OR.EIX505.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX505) :',EIX505,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C The following formula calculates the current cost of Mixing Tank
        CCT505=CCT505+(HCT505*(CIT505/HIT505)*(QAC505/QAH505)**EIX505)
        WRITE(*,70)'Mixing Tank', 'N',CCT505
        WRITE(2,70)'Mixing Tank', 'N',CCT505
   70   FORMAT(/,10X,A,32X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM534(HCT534,HIT534,QAH534,CIT534,QAC534,EIX534,CCT534)
C Subroutine CM534 calculates the current cost of Phosphoric Acid Tank
      CCT534=0.0
      PRINT1,'Input Historical Cost (HCT534),',
     $'Historical index (HIT534),',
     $'Historical capacity (QAH534),',
     $'current index (CIT534),',
     $'current capacity (QAC534),',
     $'Exponent (EIX534) of Phosphoric Acid tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT534,HIT534,QAH534,CIT534,QAC534,EIX534
      IF(HCT534.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT534) :',HCT534,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT534.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT534) :',HIT534,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT534.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT534) :',CIT534,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC534.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC534) :',QAC534,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH534.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH534) :',QAH534,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX534.LE.0.OR.EIX534.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX534) :',EIX534,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
```

```
C  The following formula calculates the current cost of Phosphoric Acid
Tank
        CCT534=CCT534+(HCT534*(CIT534/HIT534)*(QAC534/QAH534)**EIX534)
        WRITE(*,70)'Phosphoric Acid Tank','N',CCT534
        WRITE(2,70)'Phosphoric Acid Tank','N',CCT534
   70   FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM504(HCT504,HIT504,QAH504,CIT504,QAC504,EIX504,CCT504)
C Subroutine CM504 calculates the current cost of Drier
      CCT504=0.0
      PRINT1,'Input Historical Cost (HCT504),',
     $'Historical index (HIT504),',
     $'capacity (QAH504),',
     $'current index (CIT504),',
     $'current capacity (QAC054),',
     $'Exponent (EIX504) of Drier'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT504,HIT504,QAH504,CIT504,QAC504,EIX504
      IF(HCT504.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT504) :',HCT504,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT504.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT504) :',HIT504,'TRY AGAIN!'
   20    FORMAT(/,10X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT504.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT504) :',CIT504,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC504.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC504) :',QAC504,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH504.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH504) :',QAH504,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX504.LE.0.OR.EIX504.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX504) :',EIX504,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula is computes the current cost of Drier
        CCT504=CCT504+(HCT504*(CIT504/HIT504)*(QAC504/QAH504)**EIX504)
        WRITE(*,70)'Drier', 'N',CCT504
        WRITE(2,70)'Drier', 'N',CCT504
   70   FORMAT(/,10X,A,38X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM535(HCT535,HIT535,QAH535,CIT535,QAC535,EIX535,CCT535)
C Subroutine CM535 calculates the current cost of Bleaching Earth Tank
      CCT535=0.0
      PRINT1,'Input Historical Cost (HCT535),',
     $'Historical index (HIT535), ',
     $'Historical capacity (QAH535),',
```

```
     $'current index (CIT535),',
     $'current capacity (QAC535),',
     $'Exponent (EIX535) of Bleaching Earth Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT535,HIT535,QAH535,CIT535,QAC535,EIX535
      IF(HCT535.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT535) :',HCT535,'TRY AGAIN!'
   10    FORMAT(1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT535.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT535) :',HIT535,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT535.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT535) :',CIT535,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC535.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC535) :',QAC535,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH535.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH535) :',QAH535,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX535.LE.0.OR.EIX535.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX535) :',EIX535,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula computes the current cost of Bleaching Earth
Tank
        CCT535=CCT535+(HCT535*(CIT535/HIT535)*(QAC535/QAH535)**EIX535)
        WRITE(*,70)'Bleaching Earth Tank','N',CCT535
        WRITE(2,70)'Bleaching Earth Tank','N',CCT535
   70   FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM622(HCT622,HIT622,QAH622,CIT622,QAC622,EIX622,CCT622)
C Subroutine CM622 calculates the current cost of continuous Bleaching
Reactor
      CCT622=0.0
      PRINT1,'Input Historical Cost (HCT622),',
     $'Historical index (HIT622),',
     $'Historical capacity (QAH622),',
     $'current index (CIT622),',
     $'current capacity (QAC622),',
     $'Exponent(EIX622) of continuous Bleaching Reactor'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT622,HIT622,QAH622,CIT622,QAC622,EIX622
      IF(HCT622.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT622) :',HCT622,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT622.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT622) :',HIT622,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT622.LE.0)THEN
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```
         PRINT30,'INVALID ENTRY (CIT622) :',CIT622,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC622.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC622) :',QAC622,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH622.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH622) :',QAH622,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX622.LE.0.OR.EIX622.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX622) :',EIX622,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula computes the current cost of continuous
C  Bleaching Reactor
        CCT622=CCT622+(HCT622*(CIT622/HIT622)*(QAC622/QAH622)**EIX622)
        WRITE(*,70)'Continuous Bleaching Reactor','N',CCT622
        WRITE(2,70)'Continuous Bleaching Reactor','N',CCT622
   70   FORMAT(/,10X,A,15X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM616(HCT616,HIT616,QAH616,CIT616,QAC616,EIX616,
     $CCT616,TTX616)
C Subroutine CM616 calculates the current cost of Bernardinni Filter
      CCT616=0.0
      TTX616=0.0
      PRINT1,'Input Historical Cost (HCT616),',
     $'Historical index (HIT616),',
     $'Historical capacity (QAH616),',
     $'current index (CIT616),',
     $'current capacity (QAC616),',
     $'Exponent(EIX616) of Bernardinni Filter'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT616,HIT616,QAH616,CIT616,QAC616,EIX616
      IF(HCT616.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT616) :',HCT616,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT616.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT616) :',HIT616,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT616.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT616) :',CIT616,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC616.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC616) :',QAC616,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH616.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH616) :',QAH616,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX616.LE.0.OR.EIX616.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX616) :',EIX616,'TRY AGAIN!'
```

```
   60     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSE
C  The following formula calculates the Current cost of Bernardinni
Filter
          CCT616=CCT616+(HCT616*(CIT616/HIT616)*(QAC616/QAH616)**EIX616)
          TTX616=TTX616+CCT616*2
          WRITE(*,70)'One Bernardinni Filter','N',CCT616
          WRITE(2,70)'One Bernardinni Filter','N',CCT616
   70     FORMAT(/,10X,A,21X,A,F15.2)
          WRITE(*,80)'Two Bernardinni Filters','N',TTX616
          WRITE(2,80)'Two Bernardinni Filters','N',TTX616
   80     FORMAT(/,10X,A,20X,A,F15.2)
       ENDIF
       RETURN
       END

       SUBROUTINE CM617(HCT617,HIT617,QAH617,CIT617,QAC617,EIX617,CCT617)
C Subroutine CM617 calculates the current cost of Steel Super Filter
       CCT617=0.0
       PRINT1,'Input Historical Cost (HCT617),',
      $'Historical index (HIT617),',
      $'Historical capacity (QAH617)',
      $'current index (CIT617),current capacity (QAC617),',
      $'Exponent(EIX617) of Steel Super Filter'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
       READ(*,*)HCT617,HIT617,QAH617,CIT617,QAC617,EIX617
       IF(HCT617.LE.0)THEN
          PRINT10,'INVALID ENTRY (HCT617) :',HCT617,'TRY AGAIN!'
   10     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(HIT617.LE.0)THEN
          PRINT20,'INVALID ENTRY (HIT617) :',HIT617,'TRY AGAIN!'
   20     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(CIT617.LE.0)THEN
          PRINT30,'INVALID ENTRY (CIT617) :',CIT617,'TRY AGAIN!'
   30     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(QAC617.LE.0)THEN
          PRINT40,'INVALID ENTRY (QAC617) :',QAC617,'TRY AGAIN!'
   40     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(QAH617.LE.0)THEN
          PRINT50,'INVALID ENTRY (QAH617) :',QAH617,'TRY AGAIN!'
   50     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(EIX617.LE.0.OR.EIX617.GE.1)THEN
          PRINT60,'INVALID ENTRY (EIX617) :',EIX617,'TRY AGAIN!'
   60     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSE
C  The following formula calculates the current cost of Steel Super
Filter
          CCT617=CCT617+(HCT617*(CIT617/HIT617)*(QAC617/QAH617)**EIX617)
          WRITE(*,70)'Steel Super Filter', 'N',CCT617
          WRITE(2,70)'Steel Super Filter', 'N',CCT617
70        FORMAT(/,10X,A,25X,A,F15.2)
       ENDIF
       RETURN
       END
```

```
      SUBROUTINE CM618(HCT618,HIT618,QAH618,CIT618,QAC618,EIX618,CCT618)
C Subroutine CM618 calculates the current cost of  Guard Filter I
      CCT618=0.0
      PRINT1,'Input Historical Cost (HCT618),',
     $'Historical index (HIT618),',
     $'Historical capacity (QAH618),',
     $'current index (CIT618),',
     $'current capacity (QAC618),',
     $'Exponent(EIX618) of Guard Filter I'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT618,HIT618,QAH618,CIT618,QAC618,EIX618
      IF(HCT618.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT618) :',HCT618,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT618.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT618) :',HIT618,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT618.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT618) :',CIT618,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC618.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC618) :',QAC618,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH618.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH618) :',QAH618,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX618.LE.0.OR.EIX618.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX618) :',EIX618,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula calculates of the current cost of Guard Filter
        CCT618=CCT618+(HCT618*(CIT618/HIT618)*(QAC618/QAH618)**EIX618)
        WRITE(*,70)'Guard Filter I','N',CCT618
        WRITE(2,70)'Guard Filter I','N',CCT618
   70   FORMAT(/,10X,A,29X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM682(HCT682,HIT682,QAH682,CIT682,QAC682,EIX682,CCT682)
C Subroutine CM682 calculates the current cost of Decanter
      CCT682=0.0
      PRINT1,'Input Historical Cost (HCT682),',
     $'Historical index (HIT682),',
     $'Historical capacity (QAH682),',
     $'current index (CIT682),',
     $'current capacity (QAC682),',
     $'Exponent(EIX682) of Decanter'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT682,HIT682,QAH682,CIT682,QAC682,EIX682
      IF(HCT682.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT682) :',HCT682,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
```

```
      ELSEIF(HIT682.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT682) :',HIT682,'TRY AGAIN!'
 20      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT682.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT682) :',CIT682,'TRY AGAIN!'
 30      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC682.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC682) :',QAC682,'TRY AGAIN!'
 40      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH682.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH682) :',QAH682,'TRY AGAIN!'
 50      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX682.LE.0.OR.EIX682.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX682) :',EIX682,'TRY AGAIN!'
 60      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula calculates the Current cost of Decanter
        CCT682=CCT682+(HCT682*(CIT682/HIT682)*(QAC682/QAH682)**EIX682)
        WRITE(*,70)'Decanter', 'N',CCT682
        WRITE(2,70)'Decanter', 'N',CCT682
 70     FORMAT(/,10X,A,35X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM801(HCT801,HIT801,QAH801,CIT801,QAC801,EIX802,CCT801)
C Subroutine CM801 calculates the current cost of Storage Tank
      CCT801=0.0
      PRINT1,'Input Historical Cost (HCT801),'
     $,'Historical index (HIT801),',
     $'Historical capacity (QAH801),',
     $'current index (CIT801),',
     $'current capacity (QAC801),',
     $'Exponent (EIX801) of Storage Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT801,HIT801,QAH801,CIT801,QAC801,EIX801
      IF(HCT801.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT801) :',HCT801,'TRY AGAIN!'
 10      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT801.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT801) :',HIT801,'TRY AGAIN!'
 20      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT801.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT801) :',CIT801,'TRY AGAIN!'
 30      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC801.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC801) :',QAC801,'TRY AGAIN!'
 40      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH801.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH801) :',QAH801,'TRY AGAIN!'
 50      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
```

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      ELSEIF(EIX801.LE.0.OR.EIX801.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX801) :',EIX801,'TRY AGAIN!'
 60      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C The following formula calculates the current cost of Storage Tank
        CCT801=CCT801+(HCT801*(CIT801/HIT801)*(QAC801/QAH801)**EIX801)
        WRITE(*,70)'Storage Tank', 'N',CCT801
        WRITE(2,70)'Storage Tank', 'N',CCT801
 70     FORMAT(/,10X,A,31X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM803(HCT803,HIT803,QAH803,CIT803,QAC803,EIX803,CCT803)
C Subroutine CM803 calculates the current cost of Deaerator/Drier
      CCT803=0.0
      PRINT1,'Input Historical Cost (HCT803),',
     $'Historical index (HIT803),',
     $'Historical capacity (QAH803),',
     $'current index (CIT803),',
     $'current capacity (QAC803),',
     $'Exponent (EIX803) of Deaerator/Drier'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT803,HIT803,QAH803,CIT803,QAC803,EIX803
      IF(HCT803.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT803) :',HCT803,'TRY AGAIN!'
 10      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT803.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT803) :',HIT803,'TRY AGAIN!'
 20      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT803.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT801) :',CIT803,'TRY AGAIN!'
 30      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC803.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC803) :',QAC803,'TRY AGAIN!'
 40      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH803.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH803) :',QAH803,'TRY AGAIN!'
 50      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX803.LE.0.OR.EIX803.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX803) :',EIX803,'TRY AGAIN!'
 60      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C The following formula the calculates the current cost of
Deaerator/Drier
        CCT803=CCT803+(HCT803*(CIT803/HIT803)*(QAC803/QAH803)**EIX803)
        WRITE(*,70)'Deaerator/Drier', 'N',CCT803
        WRITE(2,70)'Deaerator/Drier', 'N',CCT803
 70     FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM822(HCT822,HIT822,QAH822,CIT822,QAC822,EI822,CCT822)
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```
C Subroutine CM822 calculates the current cost of Deodorizer
      CCT822=0.0
      PRINT1,'Input Historical Cost (HCT822),',
     $'Historical index (HIT822),',
     $'Historical capacity (QAH822),',
     $'current index (CIT822),',
     $'current capacity (QAC822),',
     $'Exponent (EIX822) of Deodorizer'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT822,HIT822,QAH822,CIT822,QAC822,EIX822
      IF(HCT822.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT822) :',HCT822,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT822.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT822) :',HIT822,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT822.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT822) :',CIT822,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC822.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC822) :',QAC822,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH822.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH822) :',QAH822,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX822.LE.0.OR.EIX822.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX822) :',EIX822,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula the calculates the current cost of Deodorizer
        CCT822=CCT822+(HCT822*(CIT822/HIT822)*(QAC822/QAH822)**EIX822)
        WRITE(*,70)'Deodorizer','N',CCT822
        WRITE(2,70)'Deodorizer','N',CCT822
   70   FORMAT(/,10X,A,33X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM814(HCT814,HIT814,QAH814,CIT814,QAC814,EIX814,CCT814)
C Subroutine CM814 calculates the current cost of FFA Recuperator
      CCT814=0.0
      PRINT1,'Input Historical Cost (HCT814),',
     $'Historical index (HIT814),',
     $'Historical capacity (QAH814),',
     $'current index (CIT814),',
     $'current capacity (QAC814),',
     $'Exponent (EIX814) of FFA Recuperator'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT814,HIT814,QAH814,CIT814,QAC814,EIX814
      IF(HCT814.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT814) :',HCT814,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT814.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT814) :',HIT814,'TRY AGAIN!'
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   20     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(CIT814.LE.0)THEN
          PRINT30,'INVALID ENTRY (CIT814) :',CIT814,'TRY AGAIN!'
   30     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(QAC814.LE.0)THEN
          PRINT40,'INVALID ENTRY (QAC814) :',QAC814,'TRY AGAIN!'
   40     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(QAH814.LE.0)THEN
          PRINT50,'INVALID ENTRY (QAH814) :',QAH814,'TRY AGAIN!'
   50     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(EIX814.LE.0.OR.EIX814.GE.1)THEN
          PRINT60,'INVALID ENTRY (EIX814) :',EIX814,'TRY AGAIN!'
   60     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSE
C  The following formula the calculates the current cost of FFA
Recuperator
         CCT814=CCT814+(HCT814*(CIT814/HIT814)*(QAC814/QAH814)**EIX814)
         WRITE(*,70)'FFA Recuperator', 'N',CCT814
         WRITE(2,70)'FFA Recuperator', 'N',CCT814
   70    FORMAT(/,10X,A,28X,A,F15.2)
       ENDIF
       RETURN
       END

       SUBROUTINE CM821(HCT821,HIT821,QAH821,CIT821,QAC821,EIX821,CCT821)
C Subroutine CM821 calculates the current cost of Preheating Tank
       CCT821=0.0
       PRINT1,'Input Historical Cost (HCT821),',
      $'Historical index (HIT821),',
      $'Historical capacity (QAH821),'
      $'current index (CIT821),',
      $'current capacity (QAC821),',
      $'Exponent(EIX821) of Preheating Tank'
     1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
       READ(*,*)HCT821,HIT821,QAH821,CIT821,QAC821,EIX821
       IF(HCT821.LE.0)THEN
          PRINT10,'INVALID ENTRY (HCT821) :',HCT821,'TRY AGAIN!'
   10     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(HIT821.LE.0)THEN
          PRINT20,'INVALID ENTRY (HIT821) :',HIT821,'TRY AGAIN!'
   20     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(CIT821.LE.0)THEN
          PRINT30,'INVALID ENTRY (CIT821) :',CIT821,'TRY AGAIN!'
   30     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(QAC821.LE.0)THEN
          PRINT40,'INVALID ENTRY (QAC821) :',QAC821,'TRY AGAIN!'
   40     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(QAH821.LE.0)THEN
          PRINT50,'INVALID ENTRY (QAH821) :',QAH821,'TRY AGAIN!'
   50     FORMAT(/,1X,A,1X,F15.2,1X,A)
          STOP
       ELSEIF(EIX821.LE.0.OR.EIX821.GE.1)THEN
```

```
         PRINT60,'INVALID ENTRY (EIX821) :',EIX821,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula the calculates the current cost of Preheating
Tank
        CCT821=CCT821+(HCT821*(CIT821/HIT821)*(QAC821/QAH821)**EIX821)
        WRITE(*,70)'Preheating Tank', 'N',CCT821
        WRITE(2,70)'Preheating Tank', 'N',CCT821
   70   FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM50(HCT50,HIT50,QAH50,CIT50,QAC50,EIX50,CCT50)
C Subroutine CM50 calculates the current cost of Vacuum System
      CCT50=0.0
      PRINT1,'Input Historical Cost (HCT50),',
     $'Historical index (HIT50),',
     $'Historical capacity (QAH50),',
     $'current index (CIT50),',
     $'current capacity (QAC50),',
     $'Exponent (EIX50) of Vacuum System'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT50,HIT50,QAH50,CIT50,QAC50,EIX50
      IF(HCT50.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT50) :',HCT50,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT50.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT50) :',HIT50,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT50.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT50) :',CIT50,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC50.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC50) :',QAC50,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH50.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH50) :',QAH50,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIX50.LE.0.OR.EIX50.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX50) :',EIX50,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula the calculates the current cost of Vacuum
System
        CCT50=CCT50+(HCT50*(CIT50/HIT50)*(QAC50/QAH50)**EIX50)
        WRITE(*,70)'Vacuum System', 'N',CCT50
        WRITE(2,70)'Vacuum System', 'N',CCT50
   70   FORMAT(/,10X,A,30X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMSCW(HCTSCW,HITSCW,QAHSCW,CITSCW,QACSCW,EIXSCW,CCTSCW)
```

```
C Subroutine CMSCW calculates the current cost of Screw Worm
      CCTSCW=0.0
      PRINT1,'Input Historical Cost (HCTSCW),',
     $'Historical index (HITSCW),',
     $'Historical capacity (QAHSCW),',
     $'current index (CITSCW),',
     $'current capacity (QACSCW),',
     $'Exponent (EIXSCW) of Screw Worm'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTSCW,HITSCW,QAHSCW,CITSCW,QACSCW,EIXSCW
      IF(HCTSCW.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTSCW) :',HCTSCW,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITSCW.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITSCW) :',HITSCW,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITSCW.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITSCW) :',CITSCW,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QACSCW.LE.0)THEN
         PRINT40,'INVALID ENTRY (QACSCW) :',QACSCW,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAHSCW.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAHSCW) :',QAHSCW,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIXSCW.LE.0.OR.EIXSCW.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIXSCW) :',EIXSCW,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula calculates the current cost of Screw Worm
        CCTSCW=CCTSCW+(HCTSCW*(CITSCW/HITSCW)*(QACSCW/QAHSCW)**EIXSCW)
        WRITE(*,70)'Screw Worm', 'N',CCTSCW
        WRITE(2,70)'Screw Worm', 'N',CCTSCW
   70   FORMAT(/,10X,A,33X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMPUM(TOPUM,HCTPUM,HITPUM,QAHPUM,CITPUM,QACPUM,EIXPUM,
     $CCTPUM)
C Subroutine CMPUM calculates the current cost of 22 Pumps
      CCTPUM=0.0
      TOPUM=0.0
      PRINT1,'Input Historical Cost (HCTPUM),',
     $'Historical index (HITPUM),',
     $'Historical capacity (QAHPUM),',
     $'current index (CITPUM),',
     $'current capacity (QACPUM),',
     $'Exponent (EIXPUM) of a Pump'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTPUM,HITPUM,QAHPUM,CITPUM,QACPUM,EIXPUM
      IF(HCTPUM.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTPUM) :',HCTPUM,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
```

```
      ELSEIF(HITPUM.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITPUM) :',HITPUM,'TRY AGAIN!'
 20      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITPUM.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITPUM) :',CITPUM,'TRY AGAIN!'
 30      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QACPUM.LE.0)THEN
         PRINT40,'INVALID ENTRY (QACPUM) :',QACPUM,'TRY AGAIN!'
 40      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAHPUM.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAHPUM) :',QAHPUM,'TRY AGAIN!'
 50      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIXPUM.LE.0.OR.EIXPUM.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIXPUM) :',EIXPUM,'TRY AGAIN!'
 60      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula is used for the calculation of the cost of 1
Pumps
        CCTPUM=CCTPUM+(HCTPUM*(CITPUM/HITPUM)*(QACPUM/QAHPUM)**EIXPUM)
        WRITE(*,70)'One Pump', 'N',CCTPUM
        WRITE(2,70)'One Pump', 'N',CCTPUM
 70     FORMAT(/,10X,A,35X,A,F15.2)
C  The following formula calculates the current cost of 22 Pumps
        TOPUM=TOPUM+CCTPUM*22
        WRITE(*,80)'Twenty Two Pumps', 'N',TOPUM
        WRITE(2,80)'Twenty Two Pumps', 'N',TOPUM
 80     FORMAT(/,10X,A,27X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMHEX(THEAT,HCTHEX,HITHEX,QAHHEX,CITHEX,QACHEX,EIXHEX,
     $CCTHEX)
C Subroutine CMHEX calculates the current cost of 7 Heat Exchangers
      CCTHEX=0.0
      THEAT=0.0
      PRINT1,'Input Historical Cost (HCTHEX),',
     $'Historical index (HITHEX),',
     $'Historical capacity (QAHHEX),',
     $'current index (CITHEX),',
     $'current capacity (QACHEX),',
     $'Exponent (EIXHEX) of a Heat Exchanger'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTHEX,HITHEX,QAHHEX,CITHEX,QACHEX,EIXHEX
      IF(HCTHEX.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTHEX) :',HCTHEX,'TRY AGAIN!'
 10      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITHEX.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITHEX) :',HITHEX,'TRY AGAIN!'
 20      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITHEX.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITHEX) :',CITHEX,'TRY AGAIN!'
 30      FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
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      ELSEIF(QACHEX.LE.0)THEN
         PRINT40,'INVALID ENTRY (QACHEX) :',QACHEX,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAHHEX.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAHHEX) :',QAHHEX,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIXHEX.LE.0.OR.EIXHEX.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIXHEX) :',EIXHEX,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula computes the cost of 1 Heat Exchanger
        CCTHEX=CCTHEX+(HCTHEX*(CITHEX/HITHEX)*(QACHEX/QAHHEX)**EIXHEX)
        WRITE(*,70)'One Heat Exchanger','N',CCTHEX
        WRITE(2,70)'One Heat Exchanger','N',CCTHEX
   70   FORMAT(/,10X,A,25X,A,F15.2)
C  The following formula  calculates the Current Cost of 7 Heat
C  Exchangers.
        THEAT=THEAT+CCTHEX*7
        WRITE(*,80)'Seven Heat Exchangers','N',THEAT
        WRITE(2,80)'Seven Heat Exchangers','N',THEAT
   80   FORMAT(/,10X,A,22X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CM619(TTX619,HCT619,HIT619,QAH619,CIT619,QAC619,EIX619,
     $CCT619)
C Subroutine CM619 calculates the current cost of 2 Guard Filters
      CCT619=0.0
      TTX619=0.0
      PRINT1,'Input Historical Cost (HCT619),',
     $'Historical index (HIT619),',
     $'Historical capacity (QAH619),',
     $'current index (CIT619),',
     $'current capacity (QAC619),',
     $'Exponent (EIX619) of 1 Guard Filters'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCT619,HIT619,QAH619,CIT619,QAC619,EIX619
      IF(HCT619.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCT619) :',HCT619,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HIT619.LE.0)THEN
         PRINT20,'INVALID ENTRY (HIT619) :',HIT619,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CIT619.LE.0)THEN
         PRINT30,'INVALID ENTRY (CIT619) :',CIT619,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAC619.LE.0)THEN
         PRINT40,'INVALID ENTRY (QAC619) :',QAC619,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAH619.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAH619) :',QAH619,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
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      ELSEIF(EIX619.LE.0.OR.EIX619.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIX619) :',EIX619,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula calculates Current the cost of 1 Guard Filters
        CCT619=CCT619+(HCT619*(CIT619/HIT619)*(QAC619/QAH619)**EIX619)
        WRITE(*,70)'One Guard Filter II', 'N',CCT619
        WRITE(2,70)'One Guard Filter II', 'N',CCT619
   70   FORMAT(/,10X,A,24X,A,F15.2)
        TTX619=TTX619+CCT619*2
        WRITE(*,80)'Two Guard Filters II','N',TTX619
        WRITE(2,80)'Two Guard Filters II','N',TTX619
   80   FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMRST(TTXRST,HCTRST,HITRST,QAHRST,CITRST,QACRST,EIXRST,
     $CCTRST)
C Subroutine CMRST calculates the current cost of 12    Crystallisers
      CCTRST=0.0
      TTXRST=0.0
      PRINT1,'Input Historical Cost (HCTRST),',
     $'Historical index (HITRST),',
     $'Historical capacity (QAHRST),',
     $'current index (CITRST),',
     $'current capacity (QACRST),',
     $'Exponent (EIXRST) of 1 Crystalliser'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTRST,HITRST,QAHRST,CITRST,QACRST,EIXRST
      IF(HCTRST.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTRST) :',HCTRST,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITRST.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITRST) :',HITRST,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITRST.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITRST) :',CITRST,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QACRST.LE.0)THEN
         PRINT40,'INVALID ENTRY (QACRST) :',QACRST,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAHRST.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAHRST) :',QAHRST,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIXRST.LE.0.OR.EIXRST.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIXRST) :',EIXRST,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula calculates the Current cost of 12 Crystallisers
        CCTRST=CCTRST+(HCTRST*(CITRST/HITRST)*(QACRST/QAHRST)**EIXRST)
        WRITE(*,70)'One Crystalliser', 'N',CCTRST
        WRITE(2,70)'One Crystalliser', 'N',CCTRST
   70   FORMAT(/,10X,A,27X,A,F15.2)
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        TTXRST=TTXRST+CCTRST*12
        WRITE(*,80)'Twelve Crystallisers', 'N',TTXRST
        WRITE(2,80)'Twelve Crystallisers', 'N',TTXRST
   80   FORMAT(/,10X,A,23X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMRBD(HCTRBD,HITRBD,QAHRBD,CITRBD,QACRBD,EIXRBD,CCTRBD)
C Subroutine CMRBD calculates the current cost of RBD Storage Tank
      CCTRBD=0.0
      PRINT1,'Input Historical Cost (HCTRBD),',
     $'Historical index (HITRBD),',
     $'Historical capacity (QAHRBD),',
     $'current index (CITRBD),',
     $'current capacity(QACRBD),',
     $'exponent (EIXRBD) of RBD Storage Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTRBD,HITRBD,QAHRBD,CITRBD,QACRBD,EIXRBD
      IF(HCTRBD.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTRBD) :',HCTRBD,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITRBD.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITRBD) :',HITRBD,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITRBD.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITRBD) :',CITRBD,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QACRBD.LE.0)THEN
         PRINT40,'INVALID ENTRY (QACRBD) :',QACRBD,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAHRBD.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAHRBD) :',QAHRBD,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIXRBD.LE.0.OR.EIXRBD.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIXRBD) :',EIXRBD,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula the calculates the Current cost of RBD Storage
Tank
        CCTRBD=CCTRBD+(HCTRBD*(CITRBD/HITRBD)*(QACRBD/QAHRBD)**EIXRBD)
        WRITE(*,70)'RBD Storage Tank', 'N',CCTRBD
        WRITE(2,70)'RBD Storage Tank', 'N',CCTRBD
   70   FORMAT(/,10X,A,27X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMCWA(HCTCWA,HITCWA,QAHCWA,CITCWA,QACCWA,EIXCWA,CCTCWA)
C Subroutine CMCWA calculates the current cost of Cold Water Tank
      CCTCWA=0.0
      PRINT1,'Input Historical Cost (HCTCWA),',
     $'Historical index (HITCWA),',
     $'Historical capacity (QAHCWA),',
     $'current index (CITCWA),',
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     $'current capacity (QACCWA),',
     $'Exponent (EIXCWA) of Cold Water Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTCWA,HITCWA,QAHCWA,CITCWA,QACCWA,EIXCWA
      IF(HCTCWA.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTCWA) :',HCTCWA,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITCWA.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITCWA) :',HITCWA,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITCWA.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITCWA) :',CITCWA,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QACCWA.LE.0)THEN
         PRINT40,'INVALID ENTRY (QACCWA) :',QACCWA,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAHCWA.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAHCWA) :',QAHCWA,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIXCWA.LE.0.OR.EIXCWA.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIXCWA) :',EIXCWA,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula the calculates the Current cost of Cold Water
Tank
        CCTCWA=CCTCWA+(HCTCWA*(CITCWA/HITCWA)*(QACCWA/QAHCWA)**EIXCWA)
        WRITE(*,70)'Cold Water Tank', 'N',CCTCWA
        WRITE(2,70)'Cold Water Tank', 'N',CCTCWA
   70   FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMWWA(HCTWWA,HITWWA,QAHWWA,CITWWA,QACWWA,EIXWWA,CCTWWA)
C Subroutine CMWWA calculates the current cost of Warm Water Tank
      CCTWWA=0.0
      PRINT1,'Input Historical Cost (HCTWWA),',
     $'Historical index (HITWWA),',
     $'Historical capacity (QAHWWA),',
     $'current index (CITWWA),',
     $'current capacity (QACWWA),',
     $'Exponent (EIXWWA) of Warm Water Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTWWA,HITWWA,QAHWWA,CITWWA,QACWWA,EIXWWA
      IF(HCTWWA.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTWWA) :',HCTWWA,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITWWA.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITWWA) :',HITWWA,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITWWA.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITWWA) :',CITWWA,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
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      STOP
   ELSEIF(QACWWA.LE.0)THEN
      PRINT40,'INVALID ENTRY (QACWWA) :',QACWWA,'TRY AGAIN!'
40    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSEIF(QAHWWA.LE.0)THEN
      PRINT50,'INVALID ENTRY (QAHWWA) :',QAHWWA,'TRY AGAIN!'
50    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSEIF(EIXWWA.LE.0.OR.EIXWWA.GE.1)THEN
      PRINT60,'INVALID ENTRY (EIXWWA) :',EIXWWA,'TRY AGAIN!'
60    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSE
C  The following formula calculates the Current  cost of Warm Water Tank
     CCTWWA=CCTWWA+(HCTWWA*(CITWWA/HITWWA)*(QACWWA/QAHWWA)**EIXWWA)
     WRITE(*,70)'Warm Water Tank', 'N',CCTWWA
     WRITE(2,70)'Warm Water Tank', 'N',CCTWWA
70   FORMAT(/,10X,A,28X,A,F15.2)
   ENDIF
   RETURN
   END

   SUBROUTINE CMFTR(HCTFTR,HITFTR,QAHFTR,CITFTR,QACFTR,EIXFTR,CCTFTR)
C Subroutine CMFTR calculates the current cost of Welders''Filter
   CCTFTR=0.0
   PRINT1,'Input Historical Cost (HCTFTR),',
  $'Historical index (HITFTR),',
  $'Historical capacity (QAHFTR),',
  $'current index (CITFTR),',
  $'current capacity (QACFTR),',
  $'Exponent (EIXFTR) of Welders''Filter Press'
 1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
   READ(*,*)HCTFTR,HITFTR,QAHFTR,CITFTR,QACFTR,EIXFTR
   IF(HCTFTR.LE.0)THEN
      PRINT10,'INVALID ENTRY (HXCFTR) :',HCTFTR,'TRY AGAIN!'
10    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSEIF(HITFTR.LE.0)THEN
      PRINT20,'INVALID ENTRY (HITFTR) :',HITFTR,'TRY AGAIN!'
20    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSEIF(CITFTR.LE.0)THEN
      PRINT30,'INVALID ENTRY (CITFTR) :',CITFTR,'TRY AGAIN!'
30    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSEIF(QACFTR.LE.0)THEN
      PRINT40,'INVALID ENTRY (QACFTR) :',QACFTR,'TRY AGAIN!'
40    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSEIF(QAHFTR.LE.0)THEN
      PRINT50,'INVALID ENTRY (QAHFTR) :',QAHFTR,'TRY AGAIN!'
50    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSEIF(EIXFTR.LE.0.OR.EIXFTR.GE.1)THEN
      PRINT60,'INVALID ENTRY (EIXFTR) :',EIXFTR,'TRY AGAIN!'
60    FORMAT(/,1X,A,1X,F15.2,1X,A)
      STOP
   ELSE
C  The following formula calculates the Current cost of Welders''Filter
     CCTFTR=CCTFTR+(HCTFTR*(CITFTR/HITFTR)*(QACFTR/QAHFTR)**EIXFTR)
```

```
      WRITE(*,70)'Welders Filter', 'N',CCTFTR
      WRITE(2,70)'Welders Filter', 'N',CCTFTR
   70 FORMAT(/,10X,A,29X,A,F15.2)
     ENDIF
     RETURN
     END

     SUBROUTINE CMSTK(HCTSTK,HITSTK,QAHSTK,CITSTK,QACSTK,EIXSTK,CCTSTK)
C Subroutine CMSTK calculates the current cost of STEARIN Tank
     CCTSTK=0.0
     PRINT1,'Input Historical Cost (HCTSTK),',
    $'Historical index (HITSTK),',
    $'Historical capacity (QAHSTK),',
    $'current index (CITSTK),',
    $'current capacity (QACSTK),',
    $'Exponent (EIXSTK) of STEARIN Tank'
   1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
     READ(*,*)HCTSTK,HITSTK,QAHSTK,CITSTK,QACSTK,EIXSTK
     IF(HCTSTK.LE.0)THEN
        PRINT10,'INVALID ENTRY (HCTSTK) :',HCTSTK,'TRY AGAIN!'
   10   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
     ELSEIF(HITSTK.LE.0)THEN
        PRINT20,'INVALID ENTRY (HICSTK) :',HITSTK,'TRY AGAIN!'
   20   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
     ELSEIF(CITSTK.LE.0)THEN
        PRINT30,'INVALID ENTRY (CITSTK) :',CITSTK,'TRY AGAIN!'
   30   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
     ELSEIF(QACSTK.LE.0)THEN
        PRINT40,'INVALID ENTRY (QACSTK) :',QACSTK,'TRY AGAIN!'
   40   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
     ELSEIF(QAHSTK.LE.0)THEN
        PRINT50,'INVALID ENTRY (QAHSTK) :',QAHSTK,'TRY AGAIN!'
   50   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
     ELSEIF(EIXSTK.LE.0.OR.EIXSTK.GE.1)THEN
        PRINT60,'INVALID ENTRY (EIXSTK) :',EIXSTK,'TRY AGAIN!'
   60   FORMAT(/,1X,A,1X,F15.2,1X,A)
        STOP
     ELSE
C  The following formula calculates the Current cost of STEARIN Tank
      CCTSTK=CCTSTK+(HCTSTK*(CITSTK/HITSTK)*(QACSTK/QAHSTK)**EIXSTK)
      WRITE(*,70)'Stearine Tank', 'N',CCTSTK
      WRITE(2,70)'Stearine Tank', 'N',CCTSTK
   70 FORMAT(/,10X,A,30X,A,F15.2)
     ENDIF
     RETURN
     END

     SUBROUTINE CMOTK(TTXOTK,HCTOTK,HITOTK,QAHOTK,CITOTK,QACOTK,
    $EIXOTK,CCTOTK)
C Subroutine CMOTK calculates the current cost of 2 Olein Tanks
     CCTOTK=0.0
     TTXOTK=0.0
     PRINT1,'Input Historical Cost (HCTOTK),',
    $'Historical index (HITOTK),',
    $'Historical capacity (QAHOTK),',
    $'current index (CITOTK),',
```

```
     $'current capacity (QACOTK),',
     $'Exponent (EIXOTK) of Olein Tank'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A)
      READ(*,*)HCTOTK,HITOTK,QAHOTK,CITOTK,QACOTK,EIXOTK
      IF(HCTOTK.LE.0)THEN
         PRINT10,'INVALID ENTRY (HCTOTK) :',HCTOTK,'TRY AGAIN!'
   10    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(HITOTK.LE.0)THEN
         PRINT20,'INVALID ENTRY (HITOTK) :',HITOTK,'TRY AGAIN!'
   20    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(CITOTK.LE.0)THEN
         PRINT30,'INVALID ENTRY (CITOTK) :',CITOTK,'TRY AGAIN!'
   30    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QACOTK.LE.0)THEN
         PRINT40,'INVALID ENTRY (QACOTK) :',QACOTK,'TRY AGAIN!'
   40    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(QAHOTK.LE.0)THEN
         PRINT50,'INVALID ENTRY (QAHOTK) :',QAHOTK,'TRY AGAIN!'
   50    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSEIF(EIXOTK.LE.0.OR.EIXOTK.GE.1)THEN
         PRINT60,'INVALID ENTRY (EIXOTK) :',EIXOTK,'TRY AGAIN!'
   60    FORMAT(/,1X,A,1X,F15.2,1X,A)
         STOP
      ELSE
C  The following formula calculates the Current cost of 2 Olein Tanks
        CCTOTK=CCTOTK+(HCTOTK*(CITOTK/HITOTK)*(QACOTK/QAHOTK)**EIXOTK)
        WRITE(*,70)'One Olein Tank', 'N',CCTOTK
        WRITE(2,70)'One Olein Tank', 'N',CCTOTK
   70   FORMAT(/,10X,A,29X,A,F15.2)
        TTXOTK=TTXOTK+CCTOTK*2
        WRITE(*,80)'Two Olein Tanks', 'N',TTXOTK
        WRITE(2,80)'Two Olein Tanks', 'N',TTXOTK
   80   FORMAT(/,10X,A,28X,A,F15.2)
      ENDIF
      RETURN
      END

      SUBROUTINE CMPECT(PECT,CCT503,CCT505,CCT534,CCT504,CCT535,CCT622,
     $TTX616,CCT617,CCT618,CCT682,CCT801,CCT803,CCT822,CCT814,CCT821,
     $CCT50,CCTSCW,TOPUM,THEAT,TTX619,TTXRST,CCTRBD,CCTCWA,CCTWWA,
     $CCTFTR,CCTSTK,TTXOTK)
C Subroutine CMPECT Computes the Delivered Purchased Equipment Cost
      PECT=0
      PECT=PECT+CCT503+CCT505+CCT534+CCT504+CCT535+CCT622+TTX616+CCT617
     $+CCT618+CCT682+CCT801+CCT803+CCT822+CCT814+CCT821+CCT50+CCTSCW
     $+TOPUM+THEAT+TTX619+TTXRST+CCTRBD+CCTCWA+CCTWWA+CCTFTR
     $+CCTSTK+TTXOTK
      WRITE(*,5)'Delivered Purchased Equipment cost is :','N',PECT
      WRITE(2,5)'Delivered Purchased Equipment cost is :','N',PECT
    5 FORMAT(//,10X,A,T56,A,F15.2)
      WRITE(*,10)
      WRITE(2,10)
   10 FORMAT(T56,16('-'))
      RETURN
      END
```

```
      SUBROUTINE FIXCAP(FCAPN,PECT,FPECT,FPECIT,FIIT,FPIT,FBIST,FEIT,
     $FYIT,FSFIT,FLANT,FENGST,FCTNET,FCFEET,FCTNGT)
C Subroutine FIXCAP calculates the current cost of Fixed Capital
Investment
      FCAPN=0.0
      PRINT1,'Input factors for Purchased Equipment (FPECT),',
     $'Purchased Equipment installation (FPECIT),',
     $'Instrumentation (installed) (FIIT),',
     $'Piping (Installed) (FPIT),',
     $'Buildings (includimg services) (FBIST),',
     $'Electrical (Intsalled) (FEIT),',
     $'Yard Improvements (FYIT),',
     $'Service facilities (installed) (FSFIT),',
     $'Land (FLANT),',
     $'Engineering and Supervision (FENGST),',
     $'Construction Expenses (FCTNET),',
     $'Contractors''fee (FCFEET),',
     $'Contingency (FCTNGT)'
    1 FORMAT(/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,/,1X,A,
     $/,1X,A,/,1X,A,/,1X,A/,1X,A,/,1X,A)
      READ(*,*)FPECT,FPECIT,FIIT,FPIT,FBIST,FEIT,FYIT,FSFIT,FLANT,
     $FENGST,FCTNET,FCFEET,FCTNGT
      IF(FPECT.LE.0.OR.FPECT.GT.1)THEN
         PRINT5,'INVALID ENTRY (FPECT) :',FPECT,'TRY AGAIN!'
    5    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FPECIT.LE.0.OR. FPECIT.GE.1)THEN
         PRINT15,'INVALID ENTRY (FPECIT) :',FPECIT,'TRY AGAIN!'
   15    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FIIT.LE.0.OR. FIIT.GE.1)THEN
         PRINT25,'INVALID ENTRY (FIIT) :',FIIT,'TRY AGAIN!'
   25    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FPIT.LE.0.OR. FPIT.GE.1)THEN
         PRINT35,'INVALID ENTRY (FPIT) :',FPIT,'TRY AGAIN!'
   35    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FBIST.LE.0.OR. FBIST.GE.1)THEN
         PRINT45,'INVALID ENTRY (FBIST) :',FBIST,'TRY AGAIN!'
   45    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FEIT.LE.0.OR. FEIT.GE.1)THEN
         PRINT55,'INVALID ENTRY (FEIT) :',FEIT,'TRY AGAIN!'
   55    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FYIT.LE.0.OR. FYIT.GE.1)THEN
         PRINT65,'INVALID ENTRY (FYIT) :',FYIT,'TRY AGAIN!'
   65    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FSFIT.LE.0.OR. FSFIT.GE.1)THEN
         PRINT75,'INVALID ENTRY (FSFIT) :',FSFIT,'TRY AGAIN!'
   75    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FLANT.LE.0.OR. FLANT.GE.1)THEN
         PRINT85,'INVALID ENTRY (FLANT) :',FLANT,'TRY AGAIN!'
   85    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FENGST.LE.0.OR. FENGST.GE.1)THEN
         PRINT95,'INVALID ENTRY (FENGST) :',FENGST,'TRY AGAIN!'
   95    FORMAT(/,1X,A,1X,F15.1,1X,A)
```

```
         STOP
      ELSEIF(FCTNET.LE.0.OR. FCTNET.GE.1)THEN
         PRINT105,'INVALID ENTRY (FCTNET) :',FCTNET,'TRY AGAIN!'
  105    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FCFEET.LE.0.OR. FCFEET.GE.1)THEN
         PRINT115,'INVALID ENTRY (FCFEET) :',FCFEET,'TRY AGAIN!'
  115    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSEIF(FCTNGT.LE.0.OR. FCTNGT.GE.1)THEN
         PRINT125,'INVALID ENTRY (FCTNGT) :',FCTNGT,'TRY AGAIN!'
  125    FORMAT(/,1X,A,1X,F15.1,1X,A)
         STOP
      ELSE
         FCAPN=(FCAPN+(PECT+ PECT*(FPECT+FPECIT+FIIT+FPIT+FBIST
     $   +FEIT+FYIT+FSFIT+FLANT)*(1+FENGST+FCTNET+FCFEET+FCTNGT)))
         WRITE(*,135)'Fixed Capital Investment is :','N',FCAPN
         WRITE(2,135)'Fixed Capital Investment is :','N',FCAPN
  135    FORMAT(//,10X,A,T56,A,F15.2)
         WRITE(*,145)
         WRITE(2,145)
  145    FORMAT(T56,16('-'))
      ENDIF
      RETURN
      END

      SUBROUTINE TOCAIN (FCAPN,TCAPN,WCAPN)
C Subroutine TOCAIN calculates the current Working Capital
Investment(WCAPN)
C and Total capital Investment(TCAPN).
      TCAPN=0
      WCAPN=0
C Total capital investment is a Summation of the fixed and working
C capital Investment
C The working capital Investment will be taken as 15% of the Total
C Capital Investment,hence  the Fixed Capital Investment will be 85%
C of the Total Capital Investment
      TCAPN=TCAPN+FCAPN/0.85
      WCAPN=WCAPN+TCAPN*0.15
      WRITE(*,10)'Working Capital Investment is :','N',WCAPN
      WRITE(2,10)'Working Capital Investment is :','N',WCAPN
   10 FORMAT(//,10X,A,T56,A,F15.2)
      WRITE(*,20)
      WRITE(2,20)
   20 FORMAT(T56,16('-'))
      WRITE(*,30)'Total Capital Investment is :','N',TCAPN
      WRITE(2,30)'Total Capital Investment is :','N',TCAPN
   30 FORMAT(//,10X,A,T56,A,F15.2)
      WRITE(*,40)
      WRITE(2,40)
   40 FORMAT(T56,16('-'))
      WRITE(*,50)
      WRITE(2,50)
   50 FORMAT(T56,16('-'))
      RETURN
      END
```

APPENDIX C3: Results for Program CISCAL, Representing the Cost Index & Scaling Method.

The Reference Year used is: 1996

The Current Year is: 2002

Name of Equipment		Cost of Equipment in 2002(₦)
CaCO3 Tank	N	114284.30
Mixing Tank	N	114284.30
Phosphoric Acid Tank	N	140507.70
Drier	N	148144.00
Bleaching Earth Tank	N	182993.50
Continuous Bleaching Reactor	N	929148.30
One Bernardinni Filter	N	1042075.00
Two Bernardinni Filters	N	2084149.00
Steel Super Filter	N	191646.40
Guard Filter I	N	182151.60
Decanter	N	108890.10
Storage Tank	N	152379.60
Deaerator/Drier	N	161981.00
Deodorizer	N	522673.10
FFA Recuperator	N	142469.10
Preheating Tank	N	151760.10
Vacuum System	N	651048.90
Screw Worm	N	676718.20
One Pump	N	259878.10
Twenty Two Pumps	N	5717319.00
One Heat Exchanger	N	1714369.00
Seven Heat Exchangers	N	12000590.00
One Guard Filter II	N	182151.60
Two Guard Filters II	N	364303.20

One Crystalliser	N	192372.80
Twelve Crystallisers	N	2308473.00
RBD Storage Tank	N	151761.50
Cold Water Tank	N	139373.70
Warm Water Tank	N	139371.70
Welders Filter	N	1568019.00
Stearine Tank	N	149672.20
One Olein Tank	N	149672.20
Two Olein Tanks	N	299344.40

Delivered Purchased Equipment cost is : N 29493460.00

Fixed Capital Investment is : N 271345700.00

Working Capital Investment is : N 47884540.00

Total Capital Investment is : N 319230300.00