PRODUCTIVITY MEASUREMENT AND IMPROVEMENT STRATEGY PROGRAM

By

WILLIAM SHEEHAN BARBOSA VIANA

Bachelor of Science in Industrial Engineering and Management

Oklahoma State University

Stillwater, Oklahoma

1976

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 1982

PRODUCTIVITY MEASUREMENT AND IMPROVEMENT

STRATEGY PROGRAM

Thesis Approved:

D. Scott Sink
Thesis Adviser

Carl B. Estes

Joe H. Mize

Michael A Hitt

Norman N Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The author wishes to express his appreciation to his major adviser, Dr. Scott Sink, for his guidance and assistance throughout this study. Appreciation is also extended to the other committee members, Dr. Joe Mize, Dr. Carl B. Estes, and Dr. Michael A. Hitt, for their assistance and constant accessibility.

I would also like to acknowledge the participation of CBV Industria Mecanica S.A. which allowed the researcher to conduct the activities of inquiry.

Finally, my deepest gratitude is expressed to my parents, my wife, Glaucia, and our daughters, Patricia and Luciana, for their understanding, encouragement, and many sacrifices.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Traditionally, productivity improvement has come from better technology and conventional industrial engineering programs such as time and motion studies, individual work place layout, and production-line balancing. Even though there are still valid ways for improvement, much has been done in recent years to effectively measure, control, and improve productivity. Systems have been developed beyond traditional programs to identify areas needing improvement, to set goals, to motivate people to make improvements, and to measure progress. Productivity has become one of the most overriding concerns in organizations. The principal reason for measuring productivity is to establish a sound measurement system that will motivate people to make improvements. Usually people are not productive because they do not know what is expected from them. Therefore, productivity measurement can be one of the most effective tools of today's managers.

The research work involves a private firm, engaged in the struggle of survival and growth in a competitive environment. CBV Industria Mecanica is an oil field product manufacturer located in Rio de Janeiro, Brazil, with 1981

sales over $70,000,000. The researcher acted as an expert and formulated a system which was then presented to the management team for its acceptance and implementation. As an integral part of the methodology, the researcher used participative methods involving structured group processes to develop a productivity measurement and improvement strategy for CBV.

It is hoped that this research will form a solid base for the presentation of a methodology which will drive the organization into the development of a productivity measurement system, an improvement strategy, and an implementation program. By the end of this study, the organization's management team and the researcher will have worked together for over a year developing the system as well as testing. The objective is to create a sound system of performance evaluation which can be used as an additional decision-making device.

CHAPTER II

REVIEW OF THE LITERATURE

Reasons for Measuring Productivity

The basic reason for measuring productivity is that it will generate more profit for your organization. However, this is only true for a good measurement system. According to Arnold (1978), a good system measures people performance, and he adds:

> A good measurement standard evaluates a worker's performance only with respect to those factors over which the worker has control. Also a good measurement system provides the information necessary to pinpoint specific problems affecting performance. Finally, a good system provides immediate feedback to operation personnel to keep them informed on performance levels . . . (p. 23).

Arnold, further in his article, addresses the issue of using an industrial engineer as a person qualified in the area of performance standards engineering:

> . . . most industrial engineers are not enthusiastic about doing measurement work. Among industrial engineers, "measurement" has low status, undoubtedly tracing back to the days of the efficiency expert and the drudgery of stopwatch studies . . . .
>
> A side result of this is that many present day industrial engineers do <u>not</u> have good measurement skills (p. 30).

To effectively operate and control any system, it must be possible to measure various facets of its operation

against desired standards, or as Geisel (1978) puts it:

> To effectively control and improve productivity, it is necessary to have a system of productivity measurements to identify areas needing improvement, to set goals, to motivate people to make improvements, and to measure progress (p. 33).

Productivity measurements have become one of the most effective tools available to management to increase productivity. It seems quite obvious that unless productivity is quantitatively measured improvement most likely will not take place. As Mundel (1976, p. 24) has concluded, "We measure productivity as a prelude to enhancing it."

What Is Productivity?

Productivity has been defined in several ways, but essentially it means the effective use of resources relating outputs (goods, services) to inputs (labor, materials, energy, etc.). In the literature, one will find additional approaches to the challenge of defining productivity, such as:

1. . . . reaching the highest level of performance with the least expenditure of resources (Mali, 1978, p. 7).
2. . . . a combination of effectiveness (what we get accomplished) and efficiency (resource utilization) (Kuper, 1975, p. 2).
3. . . . is the efficiency with which outputs are produced--the ratio of output to input (Craig and Harris, 1973, p. 13).
4. For the purpose of measurement, whether at the company or any other level, it is sufficient to define productivity as a family of ratios of output to input (Siegel, 1976, p. 20).

5. . . . is always a ratio of output to input, and a productivity index is always the ratio of one period (or place) relative to the corresponding ratio for another period (or place) (Porter, 1973, p. 4).

Productivity Measurement

The need to manage productivity with measurement is found in nearly every work process of most organizations. However, many companies do not use productivity measurements as a day-to-day tool. There are reasons for this as mentioned by Mali (1978):

1. Work processes are complex and unwieldy. Any measure used tends to oversimplify the real complexity of the workflow, equipment, people and etc. One way to overcome this difficulty is to instead of using a single measure to use several measures. The greater the number of ratios used for measurement, the greater the validity of productivity measurement (p. 78).

2. Measurements have been activity-oriented rather than output-oriented. A failure to focus on the ouput of workflow tends to cause a loss of direction and forces a drift toward the hustle and bustle of activities. As a result, the 'activity trap' - conducting activities for the sake of activities. This measurement flow can be overcome by defining the work processes in terms of what the organization is trying to achieve rather than the activities it can conduct. Measurements defined and incorporated at the output phases of a work process tend to give more precise and meaningful evaluations of productivity of the process (p. 79).

Productivity measurements are gross indicators of where work needs to be done. A high degree of accuracy is usually not necessary or worth the cost. There are many ways to measure productivity, but for evaluative purpose,

productivity can and should be quantified. Productivity measurement is described as:

> The selection of physical, temporal, and/or perceptual measures for both input variables and output variables and the development of a ratio of output measure(s) to input measure(s). We can do this statically, using measure(s) reflecting a point in time. Or, we can do this dynamically, using a ratio of output measure(s) for two points in time to a ratio of input measure(s) for two points in time. Furthermore, we can attempt to, for either the static or the dynamic case, include all output measures and all input measures in the ratio which results in total factor productivity measurement. Or, we can only select and include certain output and input measures in the ratio which results in partial factor productivity measurement (Sink, 1981, p. 2).

Participative Approach

Involvement by key organizational members is fundamental in the development of a Productivity Measurement and Improvement Program (Stewart, 1978). Participation is most likely to create a receptive environment for actual implementation and acceptance of any solution to productivity improvement. In addition, effective participation in the development of a measurement system is likely to increase its validity among involved personnel.

The effectiveness of participative methods is extensively discussed in the behavioral science literature. The applicability of involvement strategies in the development of productivity measurement is suggested by Morris (1975):

> It has been clear since the Hawthorne studies that if productivity is measured, the process of measurement is almost certain to be accompanied by a productivity increase. It seems clear as well, that the more people involved in the productivity

> measurement process, the greater the associated productivity change and the greater the acceptance of the resulting measures as being 'fair' or representative. Participation in the process of designing a productivity measurement system captures viewpoints, permits expression of concerns, and creates an involvement which enhances the process of implementing changes resulting from management action or system redesign based on productivity measures (p. 36).

An important point to consider in group interactions is that the process must provide an efficient way of merging various viewpoints and ideas to produce useful results. Therefore, this research selected a structured group technique known as the Delphi Technique. This method has been defined by Delbecq, Van de Ven, and Gustafson (1975):

> The Delphi Technique is a method for systematic solicitation and collation of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses (p. 10).

This methodology is designed to increase creativity of group action, facilitate group decision, help stimulate the generation of critical ideas, give guidance in the aggregation of individual judgments and, in all these endeavors, save human effort and energy and leave the participants with a sense of satisfaction.

In all, participation is highly important in developing productivity measurement and improvement systems. Acceptance and understanding are necessary factors for implementation to be effective. Nevertheless, many participative processes are inefficient and ineffective. The Productivity Research Group at Ohio State University has experimented

with structured group processes such as the Delphi Technique and the Nominal Group Technique (NGT) for three years in 25 organizations of varying types and sizes. They found these techniques to be robust, effective, and efficient for specific applications (OSU-PRG, 1977).

Why Is Productivity Important To Brazil?

The issue of productivity is currently a salient topic among today's businessmen all over the world. Even for a protected market, such as the Brazilian market, which is free from foreign competition due to government regulations, a more productive industry is a general concern. With a foreign debt of over 56 billion dollars the need to export meeting international price levels have demanded greater effort to dispute a share of the world market (Kinkead, 1981).

Consider, for example, what happened to Volkswagen in Brazil. Early, aggressively, successfully VW executives saw the possibilities in Brazil, one of the few places in the Third World where real economics of scale are possible. Brazil's motor vehicle output has expanded from 30,700 in 1956 to nearly 1.2 million in 1980, making Brazil the world's ninth-largest automotive producer. Volkswagen's share of the Brazilian auto market remains at 44 percent, with 514,000 vehicles last year alone (Gall, 1981). However, even with export subsidies and low-cost Brazilian labor, which is one-tenth the hourly wage paid in the U.S.

and Germany, VW is losing out in the Third world. The Brazilian-made Beetle is threatened with annihilation in unprotected markets by newer, cheaper, and better Japanese cars.

Today, VW-Brazil is suffering the consequences of investing too little in its own business. There is not a single robot on Brazilian assembly lines, only hardworking humans fighting to keep their jobs. Volkswagen faces the future with an obsolete plant, stagnant productivity, and a continuing loss of export markets. And, incidentally, the export subsidies granted by the Brazilian government are due to expire next year (Gall, 1981).

CHAPTER III

STATEMENT OF THE PROBLEM

Background Material

Since 1978, CBV has included in the management performance evaluation two kinds of productivity ratios. These ratios have been used on a monthly basis and compared to its correspondent of the previous year. Such ratios are:

$$\frac{\text{Revenue}}{\text{No. Employees}} \quad \text{and} \quad \frac{\text{Revenue}}{\text{Man-Machine Hours}}$$

This productivity measurement system has been questioned for several reasons. For instance, the only output considered is revenue, which may be affected by price recovery, causing actual improvements in productivity to be disguised. In addition, both ratios are directly affected by inflation which, in Brazil, is running at 110 percent a year.

CBV has a very diversified product line, which includes gate valves, rockbits, wellheads, butterfly valves, ball valves, and many others. Usually, just one of these product lines would bring enough business for a company in the U.S. market but not in the small volume Brazilian market. The need to stay alive led CBV to diversification which meant greater complexity in the production activity. Nonetheless,

CBV has managed to stay in business for over 25 years. Its products are sold to end users, which include some of the major oil companies operating in Brazil such as, British Petroleum, Exxon, and Shell. In addition of the local market, CBV sells on a regular basis to Iraq and some countries in South America and Africa. American companies holding license agreement for technological support have also been buying from CBV.

To produce such great variety of products, CBV divided its production facility among six major product lines. From this idea CBV created six smaller plants under the same roof but independently managed.

- Industrial Valves
- Rock Bit
- Wellhead Equipment
- Gate Valve
- Bronze Bearing
- Fabricated Products

Each "plant" operates as a profit center having a balance sheet every quarter. The main idea is to have each "plant" with its management team ready to go to an independent facility whenever the market volume permit.

With minor exceptions the transformation process for all plants are basically the same, and can be summarized as follows (Figure 1):

1. Fabrication
    a. Raw material requistions

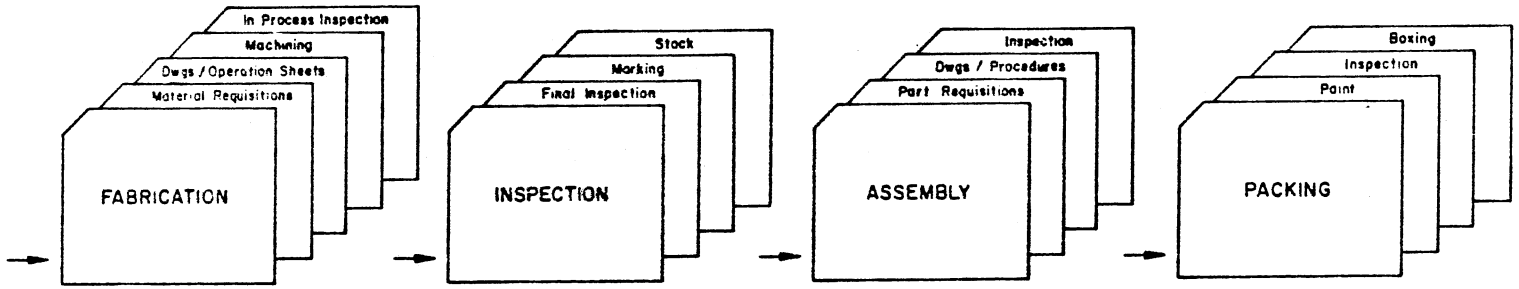


Figure 1. Transformation Process

b. Drawings, operation sheets (machinery procedures, fixtures, tools, etc.)

c. Machining

d. In process inspection

2. Inspection

a. Final inspection of parts

b. Marking

c. Stock-finished parts inventory

3. Assembly

a. Finished parts requisitions

b. Drawings, assembly procedures

c. Assembly inspection procedures (hidiostatic test and/or functional)

4. Packing

a. Paint

b. Inspection (customer order x product being shipped, aspect, etc.)

c. Boxing

Scope of Study

This study has been directed to develop a useful productivity measurement system and a sound improvement strategy for CBV. Measuring and attempting to improve the productivity of various departments or divisions in an organization can become very complex. Therefore, CBV's top management defined as the unit of analysis for this research the Production Division, which involves fabrication, inspection, assembly, and packing.

Objectives

Many companies try to use accounting data for performance appraisal and measurement (Arnold, 1978). However, it is just not designed to produce the type of evaluation results needed. Accounting systems normally tell only what has actually happened, not what should have happened. In addition, since most accounting systems deal only with money, they give little help in indicating what happened to make performance go up and down. Therefore, this study will be directed toward meaningful ways of performance appraisal for future improvements. Some of the principal objectives will be as follows:

1. Provide a measure of labor, capital, material, energy, and equipment utilization by establishing partial factor productivity ratios to measure performance in each of these areas.

2. Develop multiple productivity ratios to measure critical quality characteristics.

3. Develop a "Total Productivity Index" which will attempt to reflect an overall aggregated measure of productivity.

4. Develop an improvement strategy to improve productivity.

Research Questions

Usually what initiates the research interest at the most general level is a management problem or opportunity.

The desired research information leads to the second level, the research objectives, which reflect the general purposes of the study. Once the research objectives have been clearly defined, the research moves to the third level, the research questions. These are specific questions which the researcher must answer in order to meet the objectives. In addition, they guide the details of the study, including the development of concepts, and operational definitions (Emory, 1980).

Within this context several research questions are posed forming the foundation of the research inquiry.

1. Can an internal facilitator move the organization toward implementation of a program to measure and improve productivity?

2. Can an improvement program, using participative methods by mail (Delphi), generate enough insight to be well received?

3. Is productivity measurement a prelude for improvement?

4. Can productivity measurement be used in decision making and control of operations at CBV?

CHAPTER IV

RESEARCH METHODOLOGY

Applied Management Research Method

Some unique approaches have been developed that are especially suited to applied research in a business environment. To explore the details of this approach, which is applicable to this study, we should begin by addressing the issue as stated in Emory's (1980) text:

> In business the research need originates in the decision process. A manager needs specific information to assist in setting objectives, defining tasks, finding the best strategy by which to carry out the tasks, or judging how well the strategy is being implemented (p. 77).

Applied research has value to the extent that it assists management to make better decisions, or as Emory says:

> The value of research to management can, in theory, be measured in terms of the difference between the results of decisions made with the information and the results that would be made without it (p. 60).

In this study, the objective is to create for CBV an experience which can result in some positive benefit to the company. In pursuit of this objective, specific action steps are taken for the purpose of moving the organization toward a realization of its potential in the area of productivity measurement and improvement. The applied management research method was selected as being appropriate for this type

inquiry to a business problem.

Research Design

Emory (1980) suggests that the researcher usually faces a number of crucial design choices, but actually there is no satisfactory single design type. And he adds:

> This confusing array exists because 'research design' is a complex concept which cannot be described in a simple manner. In fact, there appear to be at least seven different perspectives from which any given study can be viewed (p. 84).

Productivity is directly related to effective use of resources in a business environment. The improvement of productivity, as the act of enhancing the effectiveness of the organization, can be classified as formalized and descriptive research studies. According to Emory, descriptive studies are those with substantial structure and specific research questions to be investigated.

The significant elements of a research design, as cited by Emory, are the plan, structure, and strategy of investigation conceived so as to obtain answers to research questions. The formal research plan may vary, but one set of action steps widely used includes the following:

1. The identification of problems or opportunities which are relevant to take some action.

2. Statement of research questions to be investigated by the research.

3. The research objectives should be clearly stated. Usually, the objectives will be a more general statement than

that of a research question alone.

4. The careful recording of actions taken and the accumulation of facts to determine the degree to which the objectives have been achieved.

5. The relationship displayed by the findings and the research questions should be verified through experimentation and judgmental evidence.

6. A clear statement of what will be done.

Procedure and Experimental Process

This section serves to describe and present all major activities of the research procedure. The action steps suggested are based on the premise that participation by company members in the development of a Productivity Measurement and Improvement Strategy Program is an effective approach. The researcher also assumes that the members of the organization are probably best suited for this improvement process.

The program is divided in two phases. Phase I is concerned with the development of an effective measurement system for the organization. The Delphi Technique is useful for the generation of productivity measures in that it can bring concensus among a heterogeneous group from within the company. Each measure can then be prioritized having its relative weight through group judgment, and used as a starting point for actual implementation. As Stewart (1980) has concluded:

> For a measurement system to be deemed relevant and useful by a wide cross section of the management team, the vector (composed by several productivity indicators) should include those attributes which capture a wide span of attention (p. 9).

Phase II is viewed as a continuous process in which ideas for improvement are generated using the Delphi or Nominal Group Technique (Morris, 1977). Those ideas, perceived as relevant to implementation, are submitted to top management approval. When a set of ideas is implemented to a satisfactory degree then the program is recycled (see Figure 2 and Table I).

1. Activities:

A1 - Top-management commitment to provide full support to the program.

A2 - Selection of the productivity improvement team.

Phase I

A3 - Develop a productivity measurement system.

- Productivity ratios (Brainstorming Technique).
- Rank and weight the ratios (Delphi - Round 1).

A4 - Data gathering.

A5 - Compile findings and submit them for top-management approval.

A6 - Start testing the measurement system on a monthly basis.

Phase II

A7 - Identify ideas for productivity improvement.

- Ideas generation process (Delphi - Round 2).

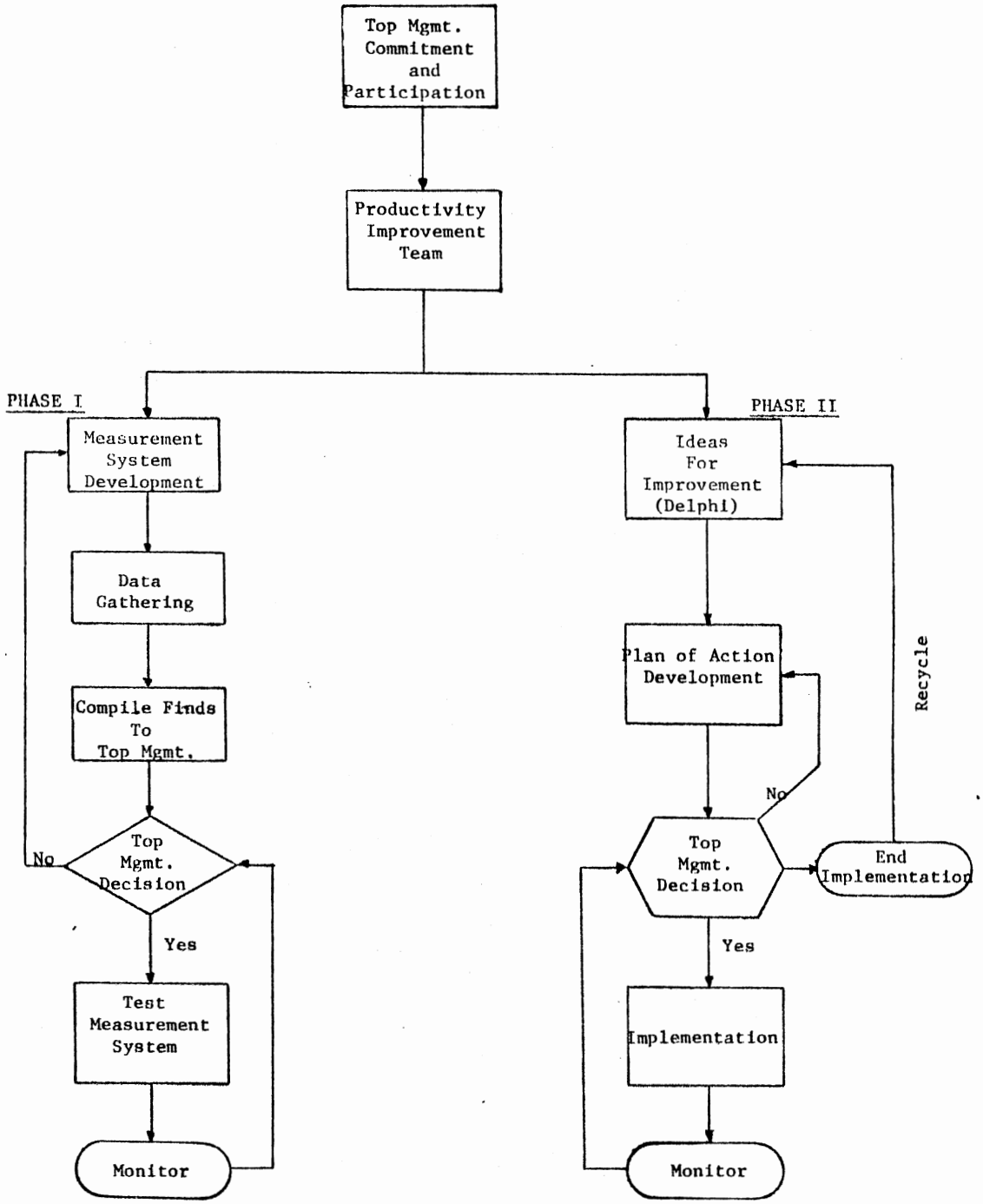


Figure 2. Flow Diagram

TABLE I

PLANNED TIME TABLE

		1981										1982					
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
A1.	Top Management Commitment	X																
A2.	Productivity Improvement Team		X															
A3.	Productivity Measurement System			X														
A4.	Data Gathering				X													
A5.	Compile Finding/ Top Mgmt. Approval					X												
A6.	Measurement System on Testing					IXXXXXXXXXX												
A7.	Ideas for Productivity Improvement			XXX														
A8.	Plan of Action				XXX													
A9.	Implementation																	
	•Plan #1					XXXXXXXX												
	•Plan #2					XXXXXXXX												
	•					•												
	•					•												
	•					•												
A10.	Monitor					IXXXXXXXX												
A11.	Recycle Phase II					PLANNED TO RECYCLE AUGUST - 1982												

- Vote and rank for the top five ideas (Delphi - Round 3).

A8 - Develop a plan of action for each idea (Delphi - Round 4) and submit to top-management.

A9 - Implement each plan of action.

A10 - Monitor and provide feedback to management.

A11 - Recycle Phase II.

CHAPTER V

PROGRAM SEQUENCE

This chapter serves to describe the program as it occurred in CBV. Such program was entitled "How to Boost Productivity in Our Plant," and will be presented in detail in the following pages.

Top Management Commitment and Participation

The measurement system must have top management support and participation, otherwise, it will not perform its main function of making someone do something to improve the operation. Furthermore, they must be involved in the program from the beginning, so that they are sensitive to which actions steps are required for improvement to occur (Morris, 1979). In this case the President of CBV, himself, has devoted full support and has been a very active participant since the beginnning. His message to the productivity improvement team is presented in Appendix A.

Productivity Improvement Team

Productivity means different things to different people and thus the more viewpoints involved, the more meaningful

the productivity measurement and improvement strategy will be (Sink, 1979). Who identifies the important measures and ways to improvement will make a difference when action takes place during the implementation phase. Therefore, the productivity improvement team was composed as follows (see organizational chart, Figure 3):

- six (6) top managers (including the President)
- eight (8) middle managers
- five (5) lower managers

From the 19 participants, it was selected the group of assistants to coordinate, analyze the responses, and develop the plan of action to be discussed and approved by CBV top management team (the Directory). Thus, the group of assistants was composed as follows:

- three (3) top managers
- one (1) middle manager

Measurement System

Measurements have been activity oriented rather than output oriented in many organizations. A failure to focus on the output of work flow tends to cause a loss of direction and forces a drift toward the hustle and bustle of activities (Mali, 1978). Thus, there is a need for a clear definition of the work process in terms of what the organization is trying to achieve rather than the activities it can conduct. Measures at the output phase tend to be more meaningful evaluations of productivity. In fact, the

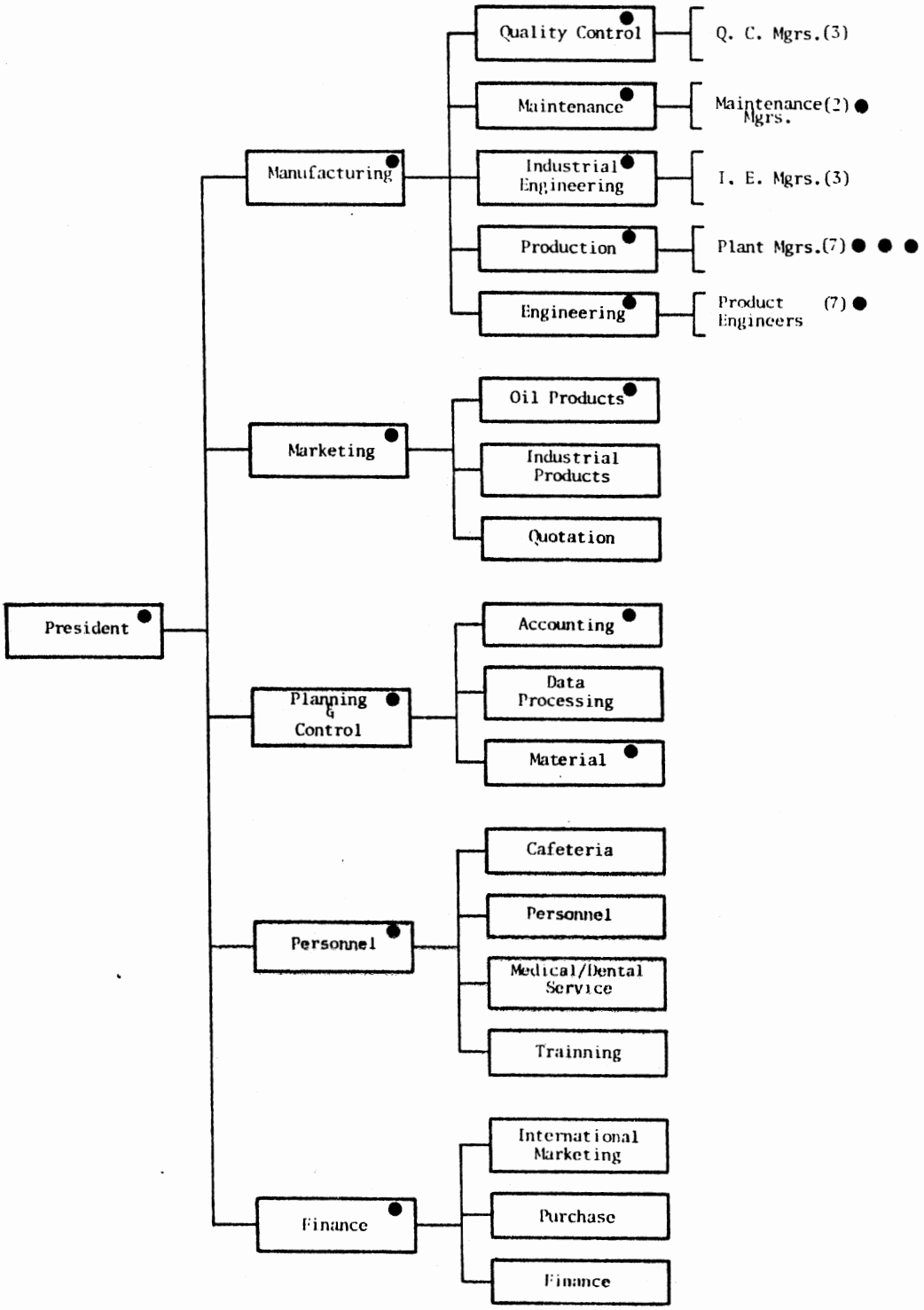


Figure 3. Organization Chart - Productivity Improvement Team

measuring system should be simple enough to be understood and administered but still measure the critical variables that indicate how effectively the system is accomplishing its function.

Productivity Ratios

The first set of ratios were developed in CBV by the six top managers utilizing the Brainstorming Technique. Later in the program a revision in the measurement system took place, and a second set of ratios were developed by all the members of the productivity improvement team utilizing the Nominal Group Technique.

Ranking and Weighting

Using a simple questionnaire the first and the second set of ten productivity ratios selected were ranked in a scale from one to ten. The process of rank-ordering yields to the measure of degree of importance for each ratio, which will provide the means of weighting (see Appendix B).

Data Gathering

Productivity measurements are gross indicators of where work needs to be done. A high degree of accuracy is usually not necessary or worth the cost (Mali, 1978). In fact, the purpose is to show comparisons between similar operations as well as year-to-year figures for establishing trends. If properly handled, the comparison can and will motivate people to improve.

The historical data received from CBV was extracted from the years of 1977, 1978, 1979 and 1980. The year of 1977 has been elected the year base, i.e., every productivity ratio of the subsequent years is compared to its respective productivity ratio of the year 1977. In addition, a comparison is made between the current year and its predecessor. For instance, the year of 1981 has been compared with 1980 and 1977.

The findings of the historical data considering 1977 to 1981 can be examined in Appendix C, which presents the performance table, and the performance trend chart for each productivity ratio. An example of how the performance table is computed can be examined in Table II.

Ideas Generation Process

The Delphi Technique is a structured group process which has been widely employed to serve a broad variety of interests. This method is designed to increase the creative productivity of group action; facilitate group decision; help stimulate the generation of critical ideas; give guidance in the aggregation of individual judgments; and, in all their endeavors, save human effort and energy and leave the participants with a sense of satisfaction (Delbecq, Van de Ven, Gustafson, 1975). The process was conducted in CBV in a series of three questionnaires to reach consensus among participants of how the company should go about improving plant productivity. The author will not present all the

TABLE II

PERFORMANCE TABLE

Weight Factor (W)	Ratios at yr. Base 1977 (B)	Productivity Ratios (R)		J	F	M	N	D
			VI =	1.18	1.22	1.92		
1.00	7.69	$\frac{\text{Revenue}}{\text{Payroll}}$		8.99	9.31	14.67		
			VI^* =	1.07	1.35	1.21		
0.41	0.029	$\frac{\text{Absentee Hrs.}}{\text{Man-Hr. Availability}}$		0.027	0.019	0.023		

1. Productivity Ratio (R) = $\frac{\text{Output}}{\text{Input}} = \frac{\text{Revenue}}{\text{Payroll}}$ $\qquad R_{Jan.} = \frac{217.156}{24.135} = 8.99$

2. Variation Index $(VI)_i = \frac{R_i}{B} = \frac{8.99}{7.69} = 1.18$

   Where:

   $i = 1, 2, \ldots, 12$ (Period)

3. Productivity Ratios (Inverse Effect)

$$(VI^*)_i = \left(\frac{B - R_i}{B}\right) + 1$$

or

$$(VI^*)_i = 2 - (VI)_i = 2 - \frac{Ri}{B}$$

4. Total Productivity Index (TPI)

$$TPI = \frac{\sum_{j=1}^{n} (VI)_i \, (W_j)}{n}$$

Where:

$j = 1, 2, 3, \ldots, n$

n = number of ratios

VI = Variation Index

W = Weight Factor

i = Period

B = Base Period

responses to the questionnaires, but significant outcomes are presented in Table III as well as the various steps involved in the Delphi process. Briefly, the responses for each questionnaire were as follows:

Questionnaire No. 1

- 100 percent response
- 138 ideas were generated
- Average of over seven ideas per participant
- After combining similar ideas, even though expressed in different ways, the number of ideas dropped to 65.

Questionnaire No. 2

- 100 percent response
- It was concerned with prioritizing the top five ideas considered to be the most important.
- The result is summarized in Table III.

Questionnaire No. 3

- 100% response
- It was concerned with generating ideas by which to implement the top five most important suggestions originated in Questionnaire No. 2.

The entire process of utilization of the Delphi Technique is made available in Appendix D, which includes the following:

a. Thank you note

b. Presentation note

c. Agenda

d. Questionnaire No. 1 - worksheet

e. Questionnaire No. 2 - worksheet

f. Questionnaire No. 3 - worksheet

TABLE III

THE TOP FIVE IDEAS

Idea No.	Description	No. of Participants Voting for the Idea	Total Grade
27	Improve the production control of each division.	10	36
1	Increase training programs for workers.	7	23
24	Increase determination of standard time to all products.	6	17
14	Improve training for supervisors and managers.	4	15
2	Automate existent devices for machining. (Fixtures automation)	4	13

Implementation and Follow-up

In this case, for each idea to be implemented, the group of assistants developed a plan of action in which responsibility for implementation was assigned as well as someone from the directory to monitor each plan (Appendix E). Furthermore, a computer program was developed to evaluate all productivity ratios on a monthly basis to guide progress as well as to provide feedback for the program. Since the third quarter of 1981, the ratios became targets to be achieved by the division managers and by the production superintendent on a trial basis. This led to the revision of the measurement system and development of a second set of productivity ratios, which has been in effect since January of 1982.

New targets have been set for the management team for 1982 according to previous outcomes. The careful recording of actions and the accumulation of facts have been in effect throughout the current year until April. At this time, the research work was discontinued and final results presented. Table IV shows all activities with the respective duration in an orderly fashion to illustrate in a pictorial format what exactly took place throughout the whole research study.

TABLE IV

ACTUAL TIME TABLE

	1981											1982					
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
A1. Top Management Commitment	X																
A2. Productivity Improvement Team	X																
A3. Productivity Measurement System		X															
A4. Data Gathering		X															
A5. Compile Finding Top Mgmt. Approval			X														
A6. Measurement System on Testing			IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX . . .				(Revision)										
A7. Ideas for Productivity Improvement		XXX															
A8. Plan of Action			XXX														
A9. Implementation																	
•Plan #1										IXXXXX(Approx. 12 mo.)XX . . .							
•Plan #2				XXXXXXXXXXXXXXXXXXXX													
•Plan #3										IXXXXX(Approx. 12 mo.)XX . . .							
•Plan #4										IXXXXX(Approx. 8 mo.)XX . . .							
•Plan #5										IXXXXX(Approx. 8 mo.)XX . . .							
A10. Monitor			IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX . . .														
A11. Recycle Phase II					PLANNED TO RECYCLE AUGUST - 1982												

CHAPTER VI

RESULTS

Presentation and Analysis

This research study has been conducted towards the development of a productivity measurement mechanism and an improvement strategy utilizing the participative approach among a wide cross section of the management team. In fact, key ingredients of this program strategy are perceived to be the structured group process that is used in the idea generation process, along with the plan of action to guide implementation. In order to faciliate the exposition of the results, the two areas of major concern in this study will be presented as distinct separate areas, even though they complement each other.

Measurement

The study has been in effect since February, 1981, until April, 1982, when the research work has been discontinued. The results of the measurement system are summarized in Table V, and additional information can be found in Appendix F, where the productivity ratios are computed on a monthly basis.

TABLE V

SUMMARY OF PRODUCTIVITY RATIOS RESULT

Productivity Ratios	81/80	81/77	82/81*	82/77*
Revenue/Payroll	+29%	+24%	+17%	+46%
Prod Shipped (KG)/Man-Machine Hr	+37%	+104%	9%	+105%
Revenue/Capital	+76%	66%	-73%	-56%
Prod Shipped (KG)/Energy (KWH)	+7%	+21%	+9%	+32%
Revenue/Production Cost	+23%	+42%	0%	+41%
Noncomformity Cost**/Production Cost	-32%	-166%	-97%	-427%
Mach. Idletime/Mach. Availab. (INV)	+6%	+4%	-8%	-4%
Reject. Parts/Inspect. Parts (INV)	-15%	+59%	+28%	+71%
Absentee Hrs./Man Hr. Avail. (INV)	+5%	+36%	-7%	+31%
No. Accidents/No. Employees (INV)	-55%	-69%	+69%	+47%
Total Productivity Index	+6%	+21%	-23%	0%

Note. Plus (+) = became better
Minus (-) = became worse

*Only from January-April, 1982

**Nonconformity Cost = Scrap cost + Rework cost + Warranty cost

Improvement

There are two aspects that should be explained in this improvement process. One has to do with the ideas for improvement which are expected, if implemented, to have some effect on productivity. Another aspect is the measurement system itself which may very well indeed have a positive effect, boosting productivity up. Nonetheless, it seems logical and more effective to have the measuring systems combined with some improvement action. Therefore, a brief comment on each plan of action to implement the top five ideas will provide a general view of what has been accomplished up to this point in time.

Plan 1. "Increase training programs for workers."

a. Lathe operator course - A preparatory course was introduced to prepare the workers in basic mathematics.

b. Welding course - Five workers were submitted to this new course with satisfactory results, and a second group is scheduled in July, 1982.

c. Safety course - 460 employees were submitted to this new course of Basic Notions of Safety which started with supervisors. Note: No. accidents/no. employees became worse 69 percent in 1981 when compared to 1977. This ratio became better 47 percent in 1982 when compared

to 1977. Coincidence?

Plan 2. "Improve training for supervisors and managers."

a. Seminar about the company - CBV

b. Quality Awareness Seminar

c. Preventive Maintenance Course

d. Outside course in management techniques and production planning and control were also granted to some supervisors and managers.

Plan 3. "Increase determination of standard time to all Products."

a. Training in motion and time study

b. It still remains the figure of 40 percent of the parts which go through the plant without standard time. No improvement has been observed.

Plan 4. "Improve the production control of each plant."

a. Order raw material according to a forecast.

b. Implement an MRP system in CBV. A bill of materials for butterfly valves and gate valves are in progress.

Plan 5. "Automate existing devices for machining (fixtures automation)."

a. Thirty-nine suggestions were collected among the employees.

b. Ten of those were implemented.

c. Seven of those suggestions are on the drawing board, and it is expected to make use of almost 50 percent of the suggestions.

Answering Research Questions

In Chapter III of this document, several research questions and objectives were posed forming the foundation of the research inquiry. The questions as well as objectives will now be addressed in an attempt to meet their proposed requirement based on the research work.

Question 1: "Can an internal facilitator move the organization toward implementation of a program to measure and improve productivity?"

The research clearly indicates the promise for this approach in causing CBV to take actual steps to measure as well as improve organizational productivity. The kind of participation and involvement from all members of the improvement team in both phases of the program appear to be of high quality. It is my firm belief that an inside facilitator is essential to perpetuate such a major program. Otherwise, in case of an outside facilitator, there appears to be a greater probability for the program to die when he leaves the organization.

Question 2: "Can an improvement program, using participative methods by mail (Delphi), generate enough insight to be well received?"

The research has indicated the benefits of using a

large task force to find and identify ways to measure and improve productivity. Such a large scale involvement among a wide cross section of the management team lays a solid foundation of acceptance which can be useful during the subsequent implementation of the ideas for productivity improvement. The Delphi Technique has the capability of combining efforts without disturbing the participants with meetings and attendance of everybody in a particular place and time. Today, productivity is being measured not just at corporate level but also at division level using basically the same measurement system.

Question 3: "Is productivity measurement a prelude for improvement?"

Unfortunately, there is no definite answer to this question. However, the researcher believes that several indications lead one to anticipate a close relationship between measurement and improvement. If nothing else, the monthly report on productivity would remind every CBV's manager of the importance of productivity improvement in his own area of responsibility. If this reminder will increase management sensitivity for improvement, then the presence of a measurement mechanism may indeed have a positive impact. In addition, productivity measurement may be used, as in CBV case, to set goals and objectives to division managers and corporate managers. After 14 months of continuous measurement, I believe that the potential for a measurement mechanism to impact productivity growth is highly significant and essential for the endurance of the whole program.

Question 4: "Can productivity measurement be used in decision making and control of operations at CBV?"

The simple fact that this program has been in effect for 14 months assures us that to some extent the measurement system has been perceived being worthwhile. However, the true test is whether the system has been used by CBV managers in decision-making activities. Several indications that this process is slowly but actually taking place can be verified by the following:

a. Reduce the number of accidents.
   - Train supervisors to how to prevent accidents.
   - Publicize the need for safety in the quarterly meeting of the security council formed by workers supervisors.
   - Hold supervisors responsible for work safety rules.

b. Open a separate cost account for every division to keep track more precisely of nonconformity costs (rework, scrap, warranty).

c. Set productivity goals for 1982.
   - At the corporate level an increase of 15 percent in the "total productivity index" has been set relative to 1981.
   - At the division level emphasis was placed on the partial factor productivity ratios and expected improvement varying from 5 to 30 percent.

Meeting Research Objectives

An attempt was made to evaluate how well or to what extent the research objectives were achieved through the eyes of the CBV management group, who are presumably qualified to issue an opinion. Therefore, a questionnaire was prepared in such a way that each manager would rate the objectives on a scale from one to seven. In addition, the respondents were divided in two groups such that: one group called "Participants" was formed by all the members of the Productivity Improvement Team (19 managers); another group called "Non-Participants" was formed by other managers that did not take part in the development of this program to measure and improve productivity.

This questionnaire was used to ascertain the reaction of these two distinct groups, and the following scale was utilized to quantify these responses (see Appendix G for a questionnaire sample):

Definitively No

1:-Unacceptable
2:----------Poor
3:----------Unsatisfactory
4:----------Indifferent
5:----------Satisfactory
6:----------Good
7:-Excellent

Definitively Yes

Objective 1: "Provide a measure of labor, capital, material, energy, and equipment utilization by establishing partial factor productivity ratios to measure perfomance in each of these areas."

Question 1: To what extent does the Productivity Measurement System provide a measure of labor, capital, material, energy, and equipment utilization?

	1	2	3	4	5	6	7
Participants	0	0	1	1	7	7	1
Non-Participants	0	0	1	1	7	8	0
Overall	0	0	2	2	14	15	1

Participants: Mean = 5.35 Standard Deviation = 0.90

Non-Participants: Mean = 5.29 Standard Deviation = 0.82

Overall: Mean = 5.32 Standard Deviation = 0.86

Objective 2: "Develop multiple productivity ratios to measure critical quality characteristics."

Question 2: To what extent does the Productivity Measurement System provide a measure of Quality?

	1	2	3	4	5	6	7
Participants	0	2	2	1	5	7	0
Non-Participants	0	2	6	0	8	1	0
Overall	0	4	8	1	13	8	0

Participants: Mean = 4.76 Standard Deviation = 1.39

Non-Participants: Mean = 4.00 Standard Deviation = 1.23

Overall: Mean = 4.38 Standard Deviation = 1.37

Objective 3: "Develop a 'Total Productivity Index' which will attempt to reflect an overall aggregated measure of productivity."

Question 3: To what extent does the "Total Productivity Index" coincide with your intuition as to how CBV is doing with respect to productivity?

	1	2	3	4	5	6	7
Participants	0	0	1	2	5	7	2

Participants: Mean = 5.41 Standard Deviation = 1.03

Non-Participants : 0/1 : 0/2 : 2/3 : 1/4 : 8/5 : 6/6 : 0/7 :

Mean = 5.06 Standard Deviation = 0.94

Overall : 0/1 : 0/2 : 3/3 : 3/4 : 13/5 : 13/6 : 2/7 :

Mean = 5.23 Standard Deviation = 1.00

Question 5: To what extent is the "Total Productivity Index" a valid indication or measure of CBV productivity?

Participants : 0/1 : 0/2 : 1/3 : 0/4 : 9/5 : 4/6 : 3/7 :

Mean = 5.47 Standard Deviation = 0.97

Non-Participants : 0/1 : 0/2 : 1/3 : 0/4 : 5/5 : 11/6 : 0/7 :

Mean = 5.53 Standard Deviation = 0.77

Overall : 0/1 : 0/2 : 2/3 : 0/4 : 14/5 : 15/6 : 3/7 :

Mean = 5.50 Standard Deviation = 0.88

Objective 4: "Develop an improvement strategy to improve productivity.

Question 4: To what extent was your participation in the Productivity Improvement Team a worthwhile experience?

Participants : 0/1 : 0/2 : 0/3 : 1/4 : 4/5 : 5/6 : 7/7 :

Mean = 6.06 Standard Deviation = 0.93

Non-Participants : (This question was not submitted)

A few additional questions were included to illustrate some relevant facts that may be in close relationship with the survival of this Productivity Program.

Question 6: To what extent is Productivity Measure important to CBV?

Participants : 0/1 : 0/2 : 0/3 : 0/4 : 0/5 : 3/6 : 14/7 :

Mean = 6.82 Standard Deviation = 0.38

Non-Participants : 0/1 : 0/2 : 0/3 : 0/4 : 0/5 : 1/6 : 16/7 :

Mean = 6.94 Standard Deviation = 0.23

Overall : 0/1 : 0/2 : 0/3 : 0/4 : 0/5 : 4/6 : 30/7 :

Mean = 6.88 Standard Deviation = 0.32

Question 7: To what extent do you think CBV top management supported this Productivity Measurement and Improvement Program?

Participants : 0/1 : 0/2 : 1/3 : 3/4 : 3/5 : 7/6 : 3/7 :

Mean = 5.47 Standard Deviation = 1.14

Non-Participants : 0/1 : 0/2 : 0/3 : 0/4 : 5/5 : 7/6 : 5/7 :

Mean = 6.00 Standard Deviation = 0.76

Overall : 0/1 : 0/2 : 1/3 : 3/4 : 8/5 : 14/6 : 8/7 :

Mean = 5.73 Standard Deviation = 1.00

Question 8: To what extent do you think the monthly report on Productivity will help to identify areas for improvement?

Participants : 0/1 : 0/2 : 0/3 : 0/4 : 3/5 : 7/6 : 7/7 :

Mean = 6.23 Standard Deviation = 0.73

Non-Participants : 0/1 : 0/2 : 0/3 : 0/4 : 0/5 : 3/6 : 14/7 :

Mean = 6.82 Standard Deviation = 0.38

Overall : 0/1 : 0/2 : 0/3 : 0/4 : 3/5 : 10/6 : 21/7 :

Mean = 6.53 Standard Deviation = 0.65

Question 9: To what extent do you think productivity should be measured in other activities in CBV, such as, sales personnel and purchasing?

Participants	:	0	0	0	1	0	3	13
		1	2	3	4	5	6	7

Mean 6.65 Standard Deviation = 0.76

Non-Participants	:	0	0	0	2	0	7	8
		1	2	3	4	5	6	7

Mean = 6.23 Standard Deviation = 0.94

Overall	:	0	0	0	3	0	10	21
		1	2	3	4	5	6	7

Mean = 6.44 Standard Deviation = 0.88

Discussion

Hopefully the attitudes expressed by the participants and non-participants of the program can be further linked to the outcomes concerning implementation. As 34 managers responded to the questionnaire respresenting almost two-thirds of CBV management team, it seems clear that the whole program has a high probability of being effective in causing the company to keep on pursuing productivity improvement.

A video tape presentation has been prepared to provide further details concerning the responses to the questionnaire. Color-coded graphics illustrated top, middle, and lower management response to each question. A pie chart representing all the responses indicated that 88 percent fell in those categories of excellent, good, and satisfactory, which represented a very promising result. An additional set of colored graphics was presented to show the evolution of each productivity ratio from 1977 to 1981.

Even though the opportunities for productivity improvement require a span of time before results can be

ascertained, there is significant evidence of actual improvement in 4 of the 10 partial factor productivity ratios.

Revenue/Payroll:

1981 X 1980 - resulted in 29% improvement
1981 X 1977 - resulted in 24% improvement
1982 (Jan.-Apr.) X 1981 - resulted in 17% improvement
1982 (Jan.-Apr.) X 1977 - resulted in 46% improvement

Products Shipped (kg)/Man-Machine Hour:

1981 X 1981 - resulted in 37% improvement
1981 X 1977 - resulted in 104% improvement
1982 (Jan.-Apr.) X 1981 - resulted in 0% improvement
1982 (Jan.-Apr.) X 1977 - resulted in 105% improvement

Products Shipped (kg)/Utilized Energy (KWH)

1981 X 1980 - resulted in 7% improvement
1981 X 1977 - resulted in 21% improvement
1982 (Jan.-Apr.) X 1981 - resulted in 9% improvement
1982 (Jan.-Apr.) X 1977 - resulted in 32% improvement

Revenue/Production Cost

1981 X 1980 - resulted in 23% improvement
1981 X 1977 - resulted in 42% improvement
1982 (Jan.-Apr.) X 1981 - resulted in 0% improvement
1982 (Jan.-Apr.) X 1977 - resulted in 41% improvement

Some of the other ratios show signs of improvement; however, it is premature to cite evidence of actual improvement. On the other hand, the ratio Nonconformity Cost/Production Cost presents alarmant figures at first sight, but it can be explained. Nonconformity Cost is the summation of scrap cost, rework cost, and warranty cost. Those

costs are not easily computed in regular cost accounting systems, and usually many things are left out, and CBV is no exception. A new set of rules and procedures have been established in the attempt to have a reliable system for this purpose. CBV expects to have a satisfactory degree of accuracy before the end of 1982.

The "Total Productivity Index", which appears a likely source of disagreement, turned out at a satisfactory level of acceptance. In both questions addressed to check the management reaction, well over three-fourths of the respondents indicated either satisfactory or good the aggregated measure. Only 3 managers out of 34 indicated the "Total Productivty Index" as unsatisfactory.

CHAPTER VII

CONCLUSION AND RECOMMENDATIONS

The vast growth in size, complexity, and diversity of operations of the modern organization has made the managerial task exceedingly difficult, but more essential to the success of the enterprise. Pressures from most segments of our society are growing so that breakthroughs in productivity are necessary if the competitiveness strength of CBV is to continue to improve.

This program, "How to Boost Productivity in Our Plant", has no guarantee that it will, in fact, increase productivity in the long run. Managers at all levels will have to use productivity as a focus to quick performance toward the enhancement of CBV's objectives. It will be the effects of this focus that will make this program a successful one. The way the program has been established it does create a high probability that final implementation for improvement will indeed occur. Key ingredients of this program strategy are percieved to be the structured group process that is used in the idea generation process, along with the plan of action to guide implementation.

In sum, this thesis study achieved its primary purpose of developing the productivity measurement system and

improvement strategies for a pilot plan in assessing productivity of CBV's main plant in Rio de Janeiro, Brazil. The increased knowledge resulting from this experience greatly enhanced the understanding of productivity for future application in other sectors and subsidiaries of CBV.

As with all similar research, several questions arise concerning this study which deserve further attention. First is the question of long-term post-process outcomes, which was not within the scope of this study, but it is one area that definitely needs to be examined to fully evaluate the effects of productivity measure and these participative methodologies.

Another research need is one that follows any innovative development since only three participative methodologies (Brainstorming, NGT, Delphi) have been applied to this problem to date. Many other participative techniques, as well as non-participative techniques exist, which have the potential to be used for the same purpose as those of this study. Furthermore, as more methodologies are developed, the question of which techniques work best in specific types of organizations must also be examined. In other words, characteristics of organizations, such as climate, employee's attitudes, non-union and pro-union organizations, should be looked at to determine the right technique for each potential application.

A third research need comes from the fact that the computation of the "Total Productivity Index" is highly

sensitive to the variability of each ratio. In other words, a ratio with greater variability or variance will have more impact in the "Total Productivity Index" regardless of its relative weight than a ratio with smaller variability or variance. A suggestion to overcome this problem came from Dr. Scott Sink who proposed to investigate all the ratios and establish a range for each one of them. This defined range could be transferred to a scale from zero to one, which would equalize the variability of all the ratios.

Today, throughout the world, many managers have no productivity measuring system. Are they overlooking the subject as being of secondary importance, or are they ignoring them because of the difficulties in measuring productivity? This approach to productivity shows great promise in creating and monitoring productivity improvement within an organization. Utilizing effective group process techniques, one can establish a productivity measurement and improvement program which can be perceived as relevant and valid by the members of the management team. Individuals with upgraded measurement skills and well prepared with methods and techniques are those most likely to sell to top management a productivity measurement system. In any case, productivity will remain the most prominent and pressing problem in today's aggressive market place.

BIBLIOGRAPHY

Arnold, Thomas L.

1978 "Using Engineered Performance Standards to Cut Costs." TAPPI, 61, 8 (August), pp. 29-31.

Craig, Charles E., and Harris, Clark R.

1973 "Total Productivity at the Firm Level." Sloan Management Review (Spring), pp. 13-29.

Delbecq, Andre L., Van de Ven, Andrew H., and Gustafson, David H.

1975 Group Techniques for Programming Planning. Glenville, Illinois: Scott, Foresman & Company.

Emory, C. William

1980 Business Research Methods. Homewood, Illinois: Richard D. Irwin, Inc.

Gall, Norman

1981 "There are No More Rabbits in Volkswagen's Hat." Forbes (August 17), pp. 71-75.

Geisel, Charles E.

1978 "Productivity Measurement: A Prelude to Improvement," TAPPI, 61 (August), pp. 33-36.

Kinkead, Gwen

1981 "Trouble in D. K. Ludwig's Jungle." Fortune (April 20), pp. 102-117.

Kuper, George

1975 "Productivity: A National Concern," Police Foundation (established by the Ford Foundation), New York, pp. 1-3.

Mali, Paul

1978 Improving Total Productivity. New York: John Wiley & Sons, Inc.

Morris, Keith Emmett

1977 The Application of the Delphi Technique to the Development of Productivity Measures. Columbus, Ohio: The Ohio State University Productivity Research Group, NSF No. APR 75-20561.

Morris, William T.

1975 "Toward New Strategies for Productivity Growth." AIIE Symposium, Las Vegas, Nevada, pp. 35-41.

Morris, William T.

1979 Implementation Strategies for Industrial Engineers. Columbus, Ohio: Grid Publishing Inc.

Mundel, Marvin E.

1976 "Measures of Productivity." Industrial Engineer (May), pp. 24-26.

The Ohio State University Productivity Research Group

1977 Measuring and Improving the Productivity of Administrative Computing and Information Services: A Manual of Structural Participation Methods. Columbus, Ohio: NSF No. APR 75-20561.

The Ohio State University Productivity Research Group

1977 Productivity Measurement Systems for Administrative Computing and Information Services: An Executive Summary. Columbus, Ohio, NSF No. APR 75-20561.

Porter, Allan A.

1973 Productivity, Costs and Prices: An Examination of Trends in Selected Manufacturing Industries. Ottawa: Labour Canada, Economics and Research.

Siegel, Irving H.

1976 "Measurement of Company Productivity." Improving Productivity Through Industry and Company Measurement, Series 2 (October), pp. 15-26.

Sink, D. Scott

1980 "Designing Successful Productivity Measurement Systems." ASQC, 35th Conference, Tulsa, pp. 1-6.

Sink, D. Scott

1978 "Development and Implementation of Productivity Measurement Systems With Emphasis on Interorganizational Relationships." Unpub. Ph.D. dissertation, Ohio State University, Columbus, Ohio.

Sink, D. Scott

1981 "Productivity Management: The Basics." Productivity Management, Oklahoma Productivity Center Newsletter No. 1. Stillwater, Oklahoma: Oklahoma State University, Winter.

Sink, D. Scott

1979 "Productivity Measurement and Improvement. A Participative Approach." Ohio Cities and Villages (December), pp. 11-13.

Stewart, William T.

1978 "The Facilitation of Productivity Measurement and Improvement in Manufacturing Organizations." Unpub. dissertation, Ohio State University, Columbus, Ohio.

Stewart, William T.

1980 "Productivity Measurement at Firm Level." Manufacturing Productivity Frontiers (1980), pp. 6-11.

APPENDICES

APPENDIX A

MESSAGE OF CBV'S PRESIDENT

CBV

PAPELETA DE ENCAMINHAMENTO

FICHA .....
ORDEM .....

DOCUMENTO .....

ASSUNTO "HOW TO BOOST PRODUCTIVITY IN OUR PLANT"

DE	PARA	DESPACHO
Paulo Viana	Cte.Sydow	PRESIDENT'S MESSAGE
	A.Carlos	
	Sílvio	As we all know productivity has become a major concern throughout
	Amaral	business as a matter of significant and growing importance. Its
	Jayr	relevance to the future of this company directly impacts each of
	Pedrinho	us. As President of this company I have the previlege to invite
	Waldir	you to participate in a program to boost productivity in our
	Arlindo	plant. This program will be coordinated by Mr. William Viana,
	Wellington	who will have proper guidance from his instructors at Oklahoma
	R.Martins	State University. I personally will give full support as a high-
	L.Humberto	priority problem for the company. Therefore I urge you to be
	P.Coelho	honest with your responses and do not hesitate in bringing up
	O.Dieguez	any idea or suggestion that you think might be useful.
	R.Silva	
	Nelson	
	R.Neves	
	Ricardo	Paulo Didier Viana
	M.Monção	President

PM-1

ARQUIVE-SE em, ... / ... / 19 ...

APPENDIX B

PRODUCTIVITY RATIOS

RANKING PROCESS

Instructions:

- Perform the judgement in an alternative basis between the most important productivity ratio and the least important.
- Assign grades, as described below, using a scale from 1 to 10.

1. To the most important assign 10; to the least important assign 1.
2. To the second most important assign 9; to the second least important assign 2.
3. To the third most important assign 8; to the least third important assign 3.
4. To the fourth most important assign 7; to the fourth least important assign 4.
5. To the fifth most important assign 6; to the fifth least important assign 5.

ASSIGN THE DEGREE OF IMPORTANCE OF THE FOLLOWING PRODUCTIVITY RATIOS*

$\frac{\text{PRODUCTS SHIPPED (KG)}}{\text{MAN-MACHINE HOUR}}$	_____
$\frac{\text{PRODUCTS SHIPPED (KG)}}{\text{ENERGY (KWH)}}$	_____
$\frac{\text{ABSENTEE HOURS}}{\text{MAN-HOUR AVAILABILITY}}$	_____
$\frac{\text{MACHINE IDLE TIME}}{\text{MACHINE AVAILABILITY}}$	_____
$\frac{\text{NO. ACCIDENTS}}{\text{NO. EMPLOYEES}}$	_____
$\frac{\text{REVENUE}}{\text{PAYROLL}}$	_____
$\frac{\text{REVENUE}}{\text{INVENTORY}}$	_____
$\frac{\text{REVENUE}}{\text{CAPITAL}}$	_____
$\frac{\text{PROFIT}}{\text{PAYROLL}}$	_____
$\frac{\text{PROFIT}}{\text{CAPITAL}}$	_____

*Productivity ratios developed utilizing the Brainstorming technique by six (6) CBV top managers.

OUTCOME FOR PRODUCTIVITY RATIOS IN THE RANKING PROCESS
(First Set of Ratios)

Productivity Ratio	No. of Respondents Voting for Each Item	Individual Votes	Total Grade	Weight* Factor
$\frac{\text{REVENUE}}{\text{PAYROLL}}$	6	10-10-8-10-10-6	54	1
$\frac{\text{PRODUCTS SHIPPED (KG)}}{\text{MAN-MACHINE HOURS}}$	6	9-7-9-5-9-2	41	0.76
$\frac{\text{REVENUE}}{\text{CAPITAL}}$	6	8-8-4-8-8-3	35	0.72
$\frac{\text{PRODUCTS SHIPPED (KG)}}{\text{ENERGY (KWH)}}$	6	7-6-10-2-7-1	33	0.61
$\frac{\text{REVENUE}}{\text{INVENTORY}}$	6	5-2-7-7-4-8	33	0.61
$\frac{\text{PROFIT}}{\text{CAPITAL}}$	6	6-4-5-5-5-4	33	0.61
$\frac{\text{MACHINE IDLE TIME}}{\text{MACHINE AVAILABILITY}}$	6	2-9-3-4-3-10	31	0.57
$\frac{\text{PROFIT}}{\text{PAYROLL}}$	6	1-3-6-6-6-7	29	0.54
$\frac{\text{ABSENTEE HOURS}}{\text{TIME AVAILABLE}}$	6	4-5-1-1-2-9	22	0.41
$\frac{\text{NO. ACCIDENTS}}{\text{NO. EMPLOYEES}}$	6	3-1-2-3-1-5	15	0.27

*Weight Factor (W) = $\frac{\text{Total Grade}}{54}$

Where: 54 is the highest total grade attributed to a ratio.
Total Grade = Sum of the individual votes.

ASSIGN THE DEGREE OF IMPORTANCE OF THE FOLLOWING PRODUCTIVITY RATIOS*

$\frac{\text{PRODUCTS SHIPPED (KG)}}{\text{MAN-MACHINE HOUR}}$	_____
$\frac{\text{PRODUCTS SHIPPED (KG)}}{\text{ENERGY (KWH)}}$	_____
$\frac{\text{ABSENTEE HOURS}}{\text{MAN-HOUR AVAILABILITY}}$	_____
$\frac{\text{MACHINE IDLE TIME}}{\text{MACHINE AVAILABILITY}}$	_____
$\frac{\text{NO. ACCIDENTS}}{\text{NO. EMPLOYEES}}$	_____
$\frac{\text{REVENUE}}{\text{PAYROLL}}$	_____
$\frac{\text{REVENUE}}{\text{PRODUCTION COST}}$	_____
$\frac{\text{NONCONFORMITY COST}}{\text{PRODUCTION COST}}$	_____
$\frac{\text{REJECTED PARTS}}{\text{INSPECTED PARTS}}$	_____
$\frac{\text{REVENUE}}{\text{CAPITAL}}$	_____

*Productivity ratios developed utilizing the Nominal Group Technique by the nineteen (19) CBV top managers.

OUTCOME FOR PRODUCTIVITY RATIOS IN THE RANKING PROCESS
(Second Set of Ratios)

Productivity Ratio	No. of Respondents Voting for Each Item	Individual Votes	Total Grade	Weight* Factor
PRODUCTS SHIPPED (KG) / ENERGY (KWH)	18	9-7-10-7-5-9-7-7-8 6-8-8-9-9-9-8-9-8	143	1
PRODUCTS SHIPPED (KG) / MAN-MACHINE HOURS	18	10-8-6-10-4-10-1-8-5 5-9-9-10-10-10-10-8-9	142	0.99
REVENUE / PRODUCTION COST	18	7-10-8-9-2-7-3-9-10 1-7-10-7-5-7-9-5-10	126	0.88
REVENUE / PAYROLL	18	8-9-9-3-1-8-4-10-7-2 10-5-8-7-8-7-10-6	122	0.85
MACHINE IDLE TIME / MACHINE AVAILABILITY	18	2-6-4-5-6-6-2-6-6-3 5-6-6-8-6-6-6-4	93	0.65
REVENUE / CAPITAL	18	6-3-7-6-3-3-8-5-9-8 4-2-5-4-4-3-1-3	84	0.59
ABSENTEE HOURS / MAN-HOUR AVAILABILITY	18	4-5-3-2-9-2-9-3-2-9 6-7-1-3-2-5-7-2	81	0.57
NONCONFORMITY COST / PRODUCTION COST	18	3-1-5-8-8-5-10-2-3-7 2-3-4-2-5-2-3-7	80	0.56
REJECTED PARTS / INSPECTED PARTS	18	5-4-1-4-7-4-5-1-4-4 1-1-2-6-3-1-4-5	62	0.43
NO. ACCIDENTS / NO. EMPLOYEES	18	1-2-2-1-10-1-6-4-1 10-3-4-2-1-1-4-2-1	56	0.39

*Weight Factor (W) = $\frac{\text{Total Grade}}{143}$

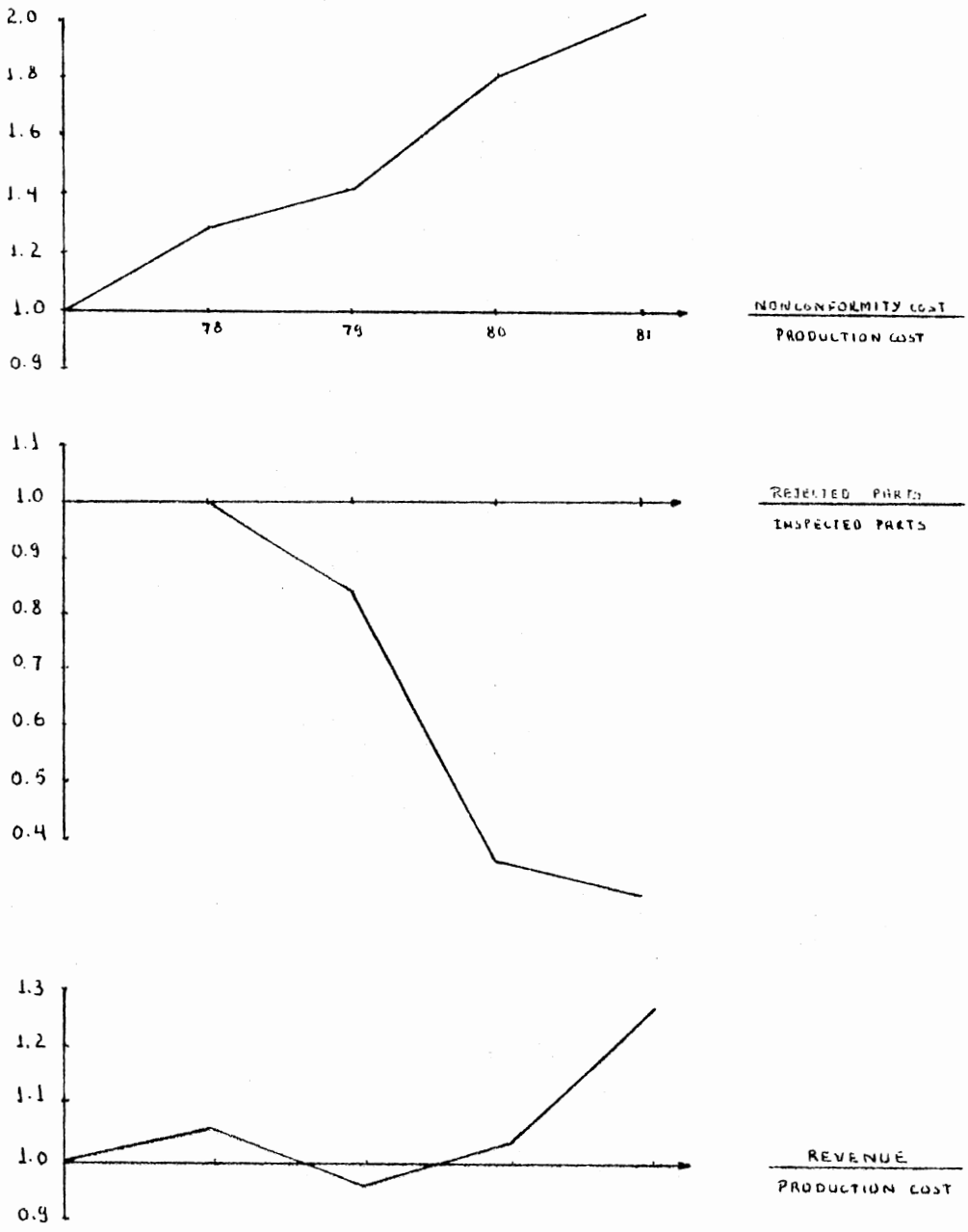
APPENDIX C

FINDINGS AND PERFORMANCE TREND CHARTS

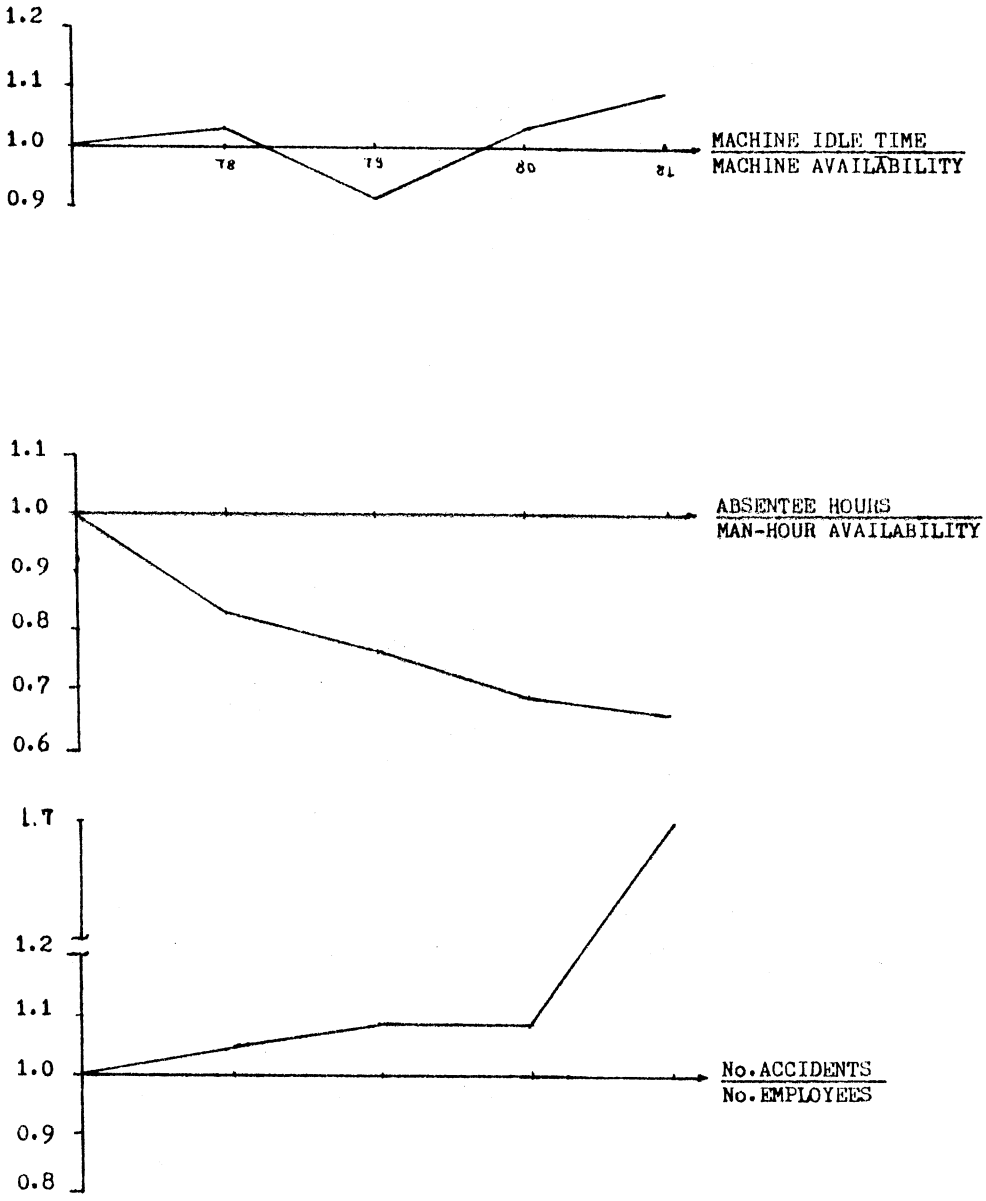
PERFORMANCE TABLE

Weight Factor	Productivity Ratios		Base 77	Base 78	Base 79	Base 80	Base 81
0.85	Revenue/Payroll	VI	1	0.89	0.90	0.96	1.34
			7.62	6.77	6.83	7.34	9.47
0.99	Prod. Shipped (KG)/Man-Mach.	VI	1	1.60	1.28	0.90	2.17
			2.54	4.08	3.27	2.30	5.52
0.58	Revenue/Capital	VI	1	0.90	0.80	0.95	1.67
			7.23	6.53	5.78	6.85	12.08
1.00	Prod. Shipped (KG)/Energy (KWH)	VI	1	1.12	0.97	0.62	1.19
			0.32	0.36	0.31	0.20	0.38
0.88	Revenue/Production Cost	VI	1	1.06	0.96	1.03	1.27
			1.81	1.93	1.74	1.87	2.30
0.56	Nonconformity Cost/Prod. Cost	VI*	1	0.73	0.59	0.18	-0.27
			0.022	0.028	0.031	0.040	0.05
0.65	Mach. Idle Time/Mach. Avail.	VI*	1	0.97	1.09	0.97	0.91
			0.33	0.34	0.30	0.34	0.36
0.43	Rejec. Parts/Insp. Parts	VI*	1	1.0	1.16	1.66	1.70
			0.006	0.006	0.005	0.002	0.002
0.56	Absentee Hrs./Man-Hr. Avail.	VI*	1	1.17	1.24	1.31	1.34
			0.029	0.024	0.022	0.020	0.019
0.39	No. Accidents/No. Employees	VI*	1	0.95	0.91	0.91	0.31
			0.22	0.23	0.24	0.24	0.37
	TOTAL PRODUCTIVITY INDEX		1	1.07	1	0.90	1.21
			0.69	0.74	0.69	0.62	0.84

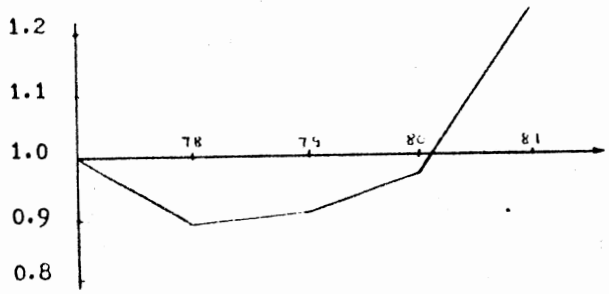
PERFORMANCE TREND CHARTS



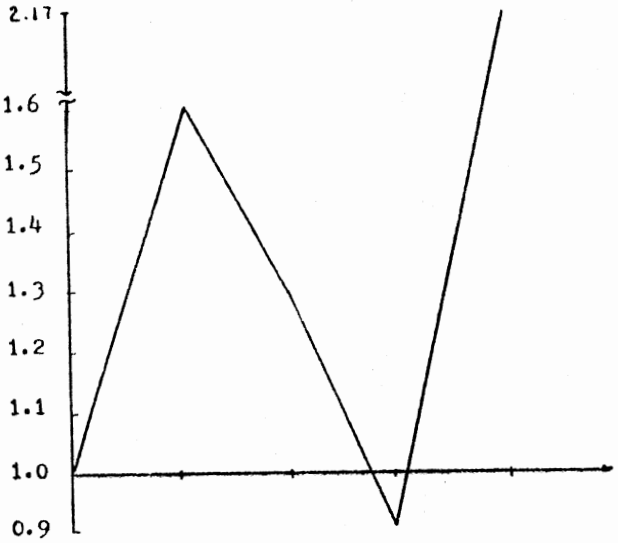
PERFORMANCE TREND CHARTS



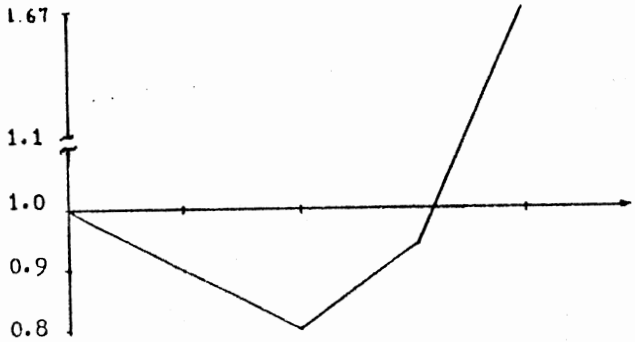
PERFORMANCE TREND CHARTS



REVENUE
PAYROLL

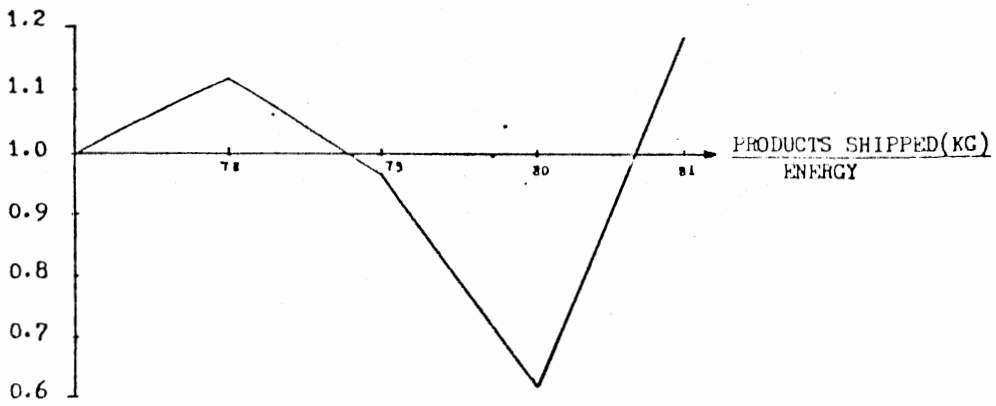


PRODUCTS SHIPPED(KG)
MAN-MACHINE HOURS

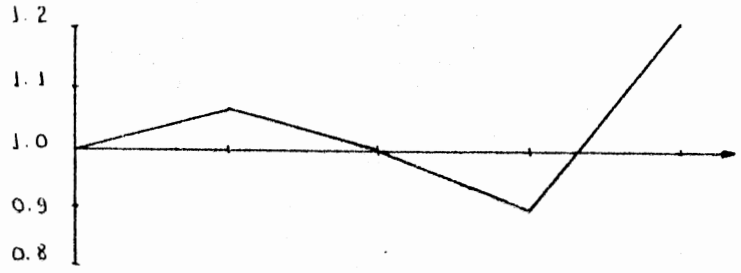


REVENUE
CAPITAL

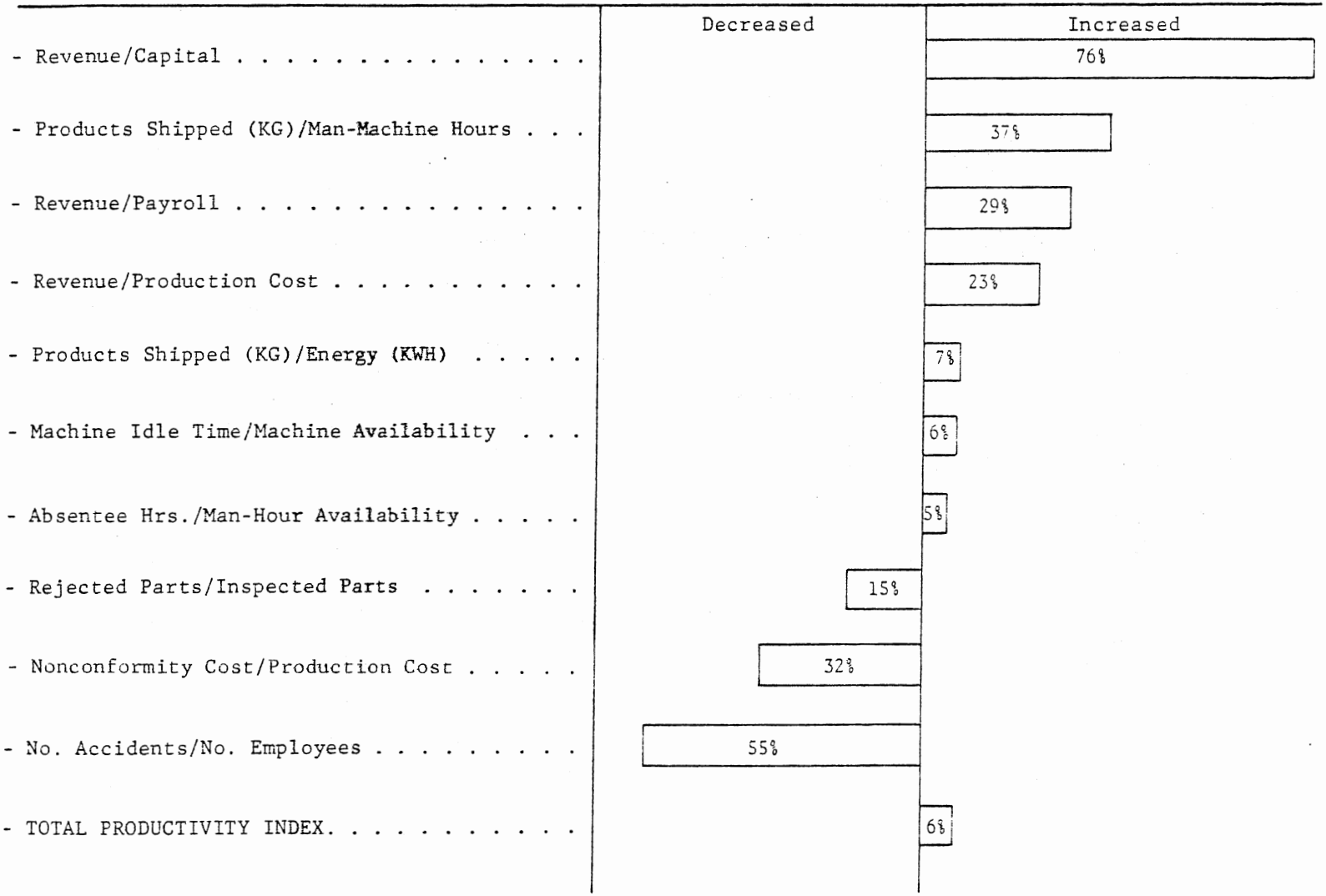
PERFORMANCE TREND CHARTS



TOTAL PRODUCTIVITY INDEX



Productivity 1981/1980



APPENDIX D

IDEAS GENERATION PROCESS (DELPHI)

PRESENTATION

"HOW TO BOOST PRODUCTIVITY IN OUR PLANT"

It will be used a technique called Delphi in which the participants are carefully selected as potential idea generators. The method has been widely used to identify problems, establish objectives and priorities, generate and evaluate solutions, and many other applications. Delphi is essentially a series of questionnaires. Each subsequent questionnaire is built upon responses to the preceding questionnaire. The process stops when consensus has been reached among participants about the solution of the problem in question. The process does not require face-to-face contact, however, it is particularly useful for involving administrators who can not come together physically. Delphi has demonstrated to be very effective when compared to individual solutions. The ideas are generated anonymously, therefore, belonging to the group not to individuals. Any idea or suggestion is always welcome, and criticisms are not allowed. The quality of the result will depend heavily upon the effort and interest that each participant dedicated during the several phases of the process.

CBV

PAPELETA DE ENCAMINHAMENTO

FICHA .....
ORDEM .....

DOCUMENTO .....

ASSUNTO THANK YOU NOTE

DE	PARA	DESPACHO
W. Viana		Dear
		I would like to thank you for your participation and collabolation in this program "How to Boost Productivity in Our Plant." Your ideas will be most helpful to promote appropriate ways to reach this objective.
		Basically, we need your help to identify possible solutions that can contribute significantly to improve productivity.
		I am attaching the first in a series of questionnaires specially prepared to seek your assistance. Please complete the questionnaire and return it to us in time for analysis on / / until noon time. Again, thank you for your help.
		Regards,
		William Viana

PE.1

ARQUIVE-SE em, ... / ... / 19 .....

AGENDA

PHASE I - The participants generate the ideas using QUESTIONNAIRE No. 1 (10-20 minutes).

PHASE II - The coordinator and his assistants prepare a list of all ideas that were generated.

PHASE III - The participants, using QUESTIONNAIRE No. 2, will vote and assign the degree of importance for the top five most important ideas.

PHASE IV - The coordinator and his assistants summarize the results and inform the participants.

PHASE V - The participants, using QUESTIONNAIRE No. 3, generate ideas and suggestions (10-20 minutes) to put into action the top five most important ideas.

QUESTIONNAIRE NO. 1

CD: _____

Date: ___/___/___ Due Date: ___/___/___

PLEASE LIST BELOW SOME IDEAS YOU THINK COULD AND/OR SHOULD BE USED TO IMPROVE PRODUCTIVITY IN OUR PLANT.

Instructions:

(1) Apply 10 - 20 minutes of your time generating the ideas.

(2) Any idea is welcome.

(3) Write each idea with no more than 6 words.

QUESTIONNAIRE NO. 2

CD: _____

Date: ___/___/___ Due Date: ___/___/___

PLEASE READ CAREFULLY THE LIST OF IDEAS DEVELOPED IN QUESTIONNAIRE NO. 1 AND SELECT THE FIVE THAT YOU THINK ARE THE MOST IMPORTANT IDEAS TO IMPROVE PRODUCTIVITY. WRITE THEM BELOW. THEN, ASSIGN THE DEGREE OF IMPORTANCE FOR EACH ONE AS DESCRIBED BELOW.

Instructions:

- Perform the judgement in an alternative basis between the most important idea and the least important.
- Assign grades, as described below, using a scale from 1 to 5.

(1) To the most important assign 5; to the least important assign 1.

(2) To the second most important assign 4; to the second least important assign 2.

(3) To the third most important assign 3.

Idea No.	Description	Grades	Comments

INSTRUCTIONS TO ANSWER QUESTIONNAIRE NO. 3

The ideas generated in Questionnaire No. 1 were ranked with the degree of importance in Questionnaire No. 2, which indicated the top five most important ideas by general consensus. Questionnaire No. 3 will be extremely important for these ideas actually become essential factors to improve productivity.

THE TOP FIVE IDEAS

Idea No.	Description	No. of Participants Voting for the Idea	Total Grade
27	Improve the production control of each division.	10	36
1	Increase training programs for workers.	7	23
24	Increase determination of standard time to all products.	6	17
14	Improve training for supervisors and managers.	4	15
2	Automate existent devices for machining. (Fixtures automation)	4	13

QUESTIONNAIRE NO. 3

CD: _____

Date: ___/___/___ Due Date: ___/___/___

PLEASE LIST BELOW SOME IDEAS YOU THINK COULD BE USED TO IMPLEMENT THE TOP FIVE MOST IMPORTANT IDEAS TO IMPROVE PRODUCTIVITY IN OUR PLANT.

Instructions:

- Apply 10-20 minutes of your time to generate the ideas.
- Any idea is welcome.
- Write each idea with no more than 15 words.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

APPENDIX E

PLANS OF ACTION

IDEAS FOR PRODUCTIVITY

IMPROVEMENT

PLAN 1 - JAYR

"Increase training programs for workers."

PLAN 2 - JAYR & AMARAL

"Improve training for supervisors and managers."

PLAN 3 - AMARAL & LUIZ HUMBERTO

"Increase determination of standard time to all products."

PLAN 4 - AMARAL & ORLANDO

"Improve the production control of each plant."

PLAN 5 AMARAL & LUIZ HUMBERTO

"Automate existing devices for machining (Fixtures automation)."

PLAN OF ACTION

No: 1

IDEA: INCREASE TRAINING PROGRAMS FOR WORKERS.

IMPLEMENTATION CHARACTERISTICS -

A: Personnel requirement:	1 person	
	2 - 4 pers	
	More than 5	X
B: Duration of program:	3 months or less	
	1 year or less	X
	More than 1 year	
C: Capital investment:	None	
	Less than $25000	
	More than $25000	X
D: Required involvement:	Single focus	
	Several depts	
	Widespread	X

ASSIGN IMPLEMENTATION RESPONSIBILITY -

Nomination(s): Jair F. Nascimento - Director

ACTION PLANS FOR THE SUCCESSFUL IMPLEMENTATION OF THIS IDEA -

The first step toward implementation is: Promote meetings to emphasize the importance of productivity.

Subsequent action steps would include: Recycle training to former workers. Promote seminaries such as: (1) How to sharp tools, (2) How to select tools; (3) welding techniques; (4) Inspection techniques.

POSSIBLE OBSTACLES -

- Lack of qualified people to direct the training.
- Lack of interest

MEASURES TO INDICATE PROGRAM SUCCESS OR FAILURE -

Revenue/Payroll	X	Profit/Capital	
Products Shipped/Man-Mach.Hrs.	X	Mach.Idle Time/Mach.Availability	
Revenue/Capital		Profit/Payroll	
Products Shipped/Energy	X	Absentee Hrs./Time Available	
Revenue/Inventory		No.Accidents/No.Employees	X

Additional Indicators: Follow up in every phase of the plan.

PLAN OF ACTION

No: 2

IDEA: IMPROVE TRAINING PROGRAMS FOR SUPERVISORS AND MANAGERS

IMPLEMENTATION CHARACTERISTICS -

A: Personnel requirement:	1 person	
	2 - 4 persons	
	More than 5	X
B: Duration of program:	3 months or less	
	1 year or less	X
	More than 1 year	
C: Capital investment:	None	
	Less than $25000	X
	More than $25000	
D: Required involvement:	Single focus	
	Several depts	
	Widespread	X

ASSIGN IMPLEMENTATION RESPONSIBILITY -

Nomination(s): A. C. Amaral - Director

Jair F. Nascimento - Director

ACTION PLANS FOR THE SUCCESSFUL IMPLEMENTATION OF THIS IDEA -

The first step toward implementation is: Prepare an specific program emphasizing key points.

Subsequent action steps would include: Prepare a company manual to guide supervisors and managers. Prepare seminaries to improve managerial techniques. Give to supervisors a broad view of CBV's products. Put emphasis on quality. Provide more opportunities for supervisors to participate in decision making. Give publicity to outstanding performance achieved by supervisors or managers.

POSSIBLE OBSTACLES -

- Lack of qualified people to give lectures in this subject.
- Lack of interest.

MEASURES TO INDICATE PROGRAM SUCCESS OR FAILURE -

Revenue/Payroll	X	Profit/Capital	
Products Shipped/Man-Mach.Hrs.	X	Mach.Idle Time/Mach.Availability	X
Revenue/Capital	X	Profit/Payroll	
Products Shipped/Energy	X	Absentee Hrs./Time Available	
Revenue/Inventory		No.Accidents/No.Employees	

Additional Indicators:

PLAN OF ACTION

No: 3

IDEA: INCREASE DETERMINATION OF STANDARD TIME TO ALL PRODUCTS.

IMPLEMENTATION CHARACTERISTICS -

A: Personnel requirement:	1 person	
	2 - 4 persons	
	More than 5	X
B: Duration of program:	3 months or less	
	1 year or less	X
	More than 1 year	
C: Capital investment:	None	
	Less than $25000	X
	More than $25000	
D: Required involvement:	Single focus	
	Several depts	X
	Widespread	

ASSIGN IMPLEMENTATION RESPONSIBILITY -

Nomination(s): A. C. Amaral - Director
Luiz Humberto S. Carvalho - IE Manager

ACTION PLANS FOR THE SUCCESSFUL IMPLEMENTATION OF THIS IDEA -

The first step toward implementation is: Promote meetings to emphasize the importance of standard time.

Subsequent action steps would include: Prepare a team to handle this problem in each division. Some how, correlate the introduction of a work-piece in operation without standard time with a penalty in the bonus given to supervisors and division managers. Hold the time and motion study sector responsible.

POSSIBLE OBSTACLES -

- Worker resistance to stopwatches; - Lack of interest by supervisors.
- Lack of experience by the people in the time and motion study sector.

MEASURES TO INDICATE PROGRAM SUCCESS OR FAILURE -

Revenue/Payroll	X	Profit/Capital	
Products Shipped/Man-Mach.Hrs.	X	Mach.Idle Time/Mach.Availability	X
Revenue/Capital	X	Profit/Payroll	
Products Shipped/Energy	X	Absentee Hrs./Time Available	
Revenue/Inventory		No.Accidents/No.Employees	

Additional Indicators: Check the degree of cooperation provided by supervisors from now on.
Workers attitudes.

PLAN OF ACTION

No: 4

IDEA: IMPROVE THE PRODUCTION CONTROL OF EACH DIVISION.

IMPLEMENTATION CHARACTERISTICS -

A: Personnel requirement:	1 person	
	2 - 4 persons	
	More than 5	X
B: Duration of program:	3 months or less	
	1 year or less	
	More than 1 year	X
C: Capital investment:	None	
	Less than $25000	
	More than $25000	X
D: Required involvement:	Single focus	
	Several depts	
	Widespread	X

ASSIGN IMPLEMENTATION RESPONSIBILITY

Nomination(s): A. C. Amaral - Director; Cnl Sauer - Data Processing Center Manager; Orlando Dieguez - Planning and Control Manager.

ACTION PLANS FOR THE SUCCESSFUL IMPLEMENTATION OF THIS IDEA -

The first step toward implementation is: Emphasize the use of programmed work load for machines.

Subsequent action steps would include: Have absolute control over the material in process. Emphasize the utilization of Gantt charts. Improve material flow. Give high priority to have the production control handled by computer.

POSSIBLE OBSTACLES -

- Lack of standard time; - Drawings, raw materials, operation sheets, and tools in hand to start production at programmed date.

MEASURES TO INDICATE PROGRAM SUCCESS OR FAILURE -

Revenue/Payroll	X	Profit/Capital	
Products Shipped/Man-Mach.Hrs.	X	Mach.Idle Time/Mach.Availability	X
Revenue/Capital	X	Profit/Payroll	
Products Shipped/Energy	X	Absentee Hrs./Time Available	
Revenue/Inventory	X	No.Accidents/No.Employees	

Additional Indicators: Reduction in the amount paid as penalty fine due to delays in delivery.

PLAN OF ACTION

No: 5

IDEA: AUTOMATE EXISTENT DEVICES FOR MACHINING. (FIXTURES AUTOMATION)

IMPLEMENTATION CHARACTERISTICS -

A: Personnel requirement:	1 person	
	2 - 4 persons	
	More than 5	X
B: Duration of program:	3 months or less	
	1 year or less	
	More than 1 year	X
C: Capital investment:	None	
	Less than $25000	
	More than $25000	X
D: Required involvement:	Single focus	
	Several depts	X
	Widespread	

ASSIGN IMPLEMENTATION RESPONSIBILITY -

Nomination(s): A.C. Amaral - Director

L. Humberto S. Carvalho - IE Manager

ACTION PLANS FOR THE SUCCESSFUL IMPLEMENTATION OF THIS IDEA -

The first step toward implementation is: Prepare a team to identify the points in the work process that are holding up production.

Subsequent action steps would include: Identify ways to automate fixtures. Increase the utilization of GO-NOGO gauges by machine operators.

POSSIBLE OBSTACLES -

- Budget limitations
- Define the priorities.

MEASURES TO INDICATE PROGRAM SUCCESS OR FAILURE -

Revenue/Payroll	X	Profit/Capital	
Products Shipped/Man-Mach.Hrs.	X	Mach.Idle Time/Mach.Availability	
Revenue/Capital		Profit/Payroll	
Products Shipped/Energy	X	Absentee Hrs./Time Available	
Revenue/Inventory		No.Accidents/No.Employees	

Additional Indicators:

APPENDIX F

MONTHLY PRODUCTIVITY REPORT

SUMMARY	81/80	81/77
R E V E N U E / P A Y R O L L	29%	24%
PROD SHIPPED (KG) / MAN - MACHINE HR	37%	104%
R E V E N U E / C A P I T A L	76%	66%
PROD SHIPPED (KG) / ENERGY (KWH)	7%	21%
REVENUE / PRODUCTION COST	23%	42%
QUALITY CONTR COST / PROD COST (INV)	-32%	-166%
MACH IDLETIME / MACH AVAILAB (INV)	6%	4%
REJECT. PARTS / INSPECT. PARTS (INV)	-15%	59%
ABSENTEE HRS / MAN-HR AVAIL (INV)	5%	36%
NO. ACCIDENTS / NO. EMPLOYEES (INV)	-55%	-69%
TOTAL PRODUCTIVITY INDEX	6%	21%

REVENUE / PAYROLL	WEIGHT FACTOR = 0.85	RATIOS BASE 1977 = 7.62
	ACC. PROD. 81/80 = 1.29	ACC. PROD. 81/77 = 1.24

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.18	1.25	1.93	1.94	1.32	1.71	1.30	1.36	1.03	1.23	0.86	0.98
PROD RAT	8.993	9.559	14.740	14.783	10.043	13.001	9.941	10.375	7.866	9.389	6.572	7.441

PROD SHIPPED (KG) / MAN - MACHINE HR	WEIGHT FACTOR = 0.99	RATIOS BASE 1977 = 2.71
	ACC. PROD. 81/80 = 1.37	ACC. PROD. 81/77 = 2.04

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.53	1.83	2.30	1.85	2.16	2.48	1.91	1.82	1.72	2.65	2.28	1.93
PROD RAT	4.144	4.962	6.239	5.008	5.865	6.713	5.185	4.934	4.656	7.193	6.170	5.234

REVENUE / CAPITAL	WEIGHT FACTOR = 0.58	RATIOS BASE 1977 = 7.30
	ACC. PROD. 81/80 = 1.76	ACC. PROD. 81/77 = 1.66

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.08	1.20	1.92	1.55	1.48	1.94	1.60	1.79	1.39	2.14	1.51	1.98
PROD RAT	7.869	8.740	14.016	11.350	10.794	14.175	11.674	13.102	10.119	15.647	11.037	14.457

PROD SHIPPED (KG) / ENERGY (KWH)	WEIGHT FACTOR = 1.00	RATIOS BASE 1977 = 0.32
	ACC. PROD. 81/80 = 1.07	ACC. PROD. 81/77 = 1.21

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	0.81	1.29	1.26	1.13	1.31	1.53	1.23	1.05	1.09	1.44	1.43	1.07
PROD RAT	0.258	0.412	0.405	0.361	0.418	0.488	0.385	0.335	0.321	0.460	0.447	0.341

REVENUE / PRODUCTION COST	WEIGHT FACTOR = 0.88	RATIOS BASE 1977 = 1.62
	ACC. PROD. 81/80 = 1.23	ACC. PROD. 81/77 = 1.42

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.45	2.02	1.74	1.32	1.45	1.41	1.15	1.66	1.76	1.37	1.12	1.37
PROD RAT	2.341	3.267	2.821	2.143	2.343	2.282	1.864	2.691	2.852	2.220	1.815	2.222

QUALITY CONTR COST / PROD COST (INV)	WEIGHT FACTOR = 0.56	RATIOS BASE 1977 = 0.02
	ACC. PROD. 81/80 = 0.67	ACC. PROD. 81/77 = -0.67

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	-0.76	-1.54	0.07	-0.46	-0.30	-0.11	0.29	-1.22	-3.10	-0.12	-1.22	-0.78
PROD RAT	0.055	0.071	0.039	0.049	0.046	0.042	0.034	0.064	0.102	0.042	0.064	0.056

MACH IDLETIME / MACH AVAILAB (INV)	WEIGHT FACTOR = 0.65	RATIOS BASE 1977 = 0.37
	ACC. PROD. 81/80 = 1.06	ACC. PROD. 81/77 = 1.04

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	0.98	1.03	1.06	1.15	1.10	1.12	1.06	1.10	1.01	0.95	0.98	0.90
PROD RAT	0.377	0.359	0.348	0.313	0.333	0.326	0.349	0.332	0.366	0.387	0.377	0.407

REJECT. PARTS / INSPECT. PARTS (INV)	WEIGHT FACTOR = 0.43	RATIOS BASE 1977 = 0.01
	ACC. PROD. 81/80 = 0.84	ACC. PROD. 81/77 = 1.59

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.68	1.43	1.55	1.84	1.94	2.00	1.71	2.00	1.71	0.65	0.65	1.17
PROD RAT	0.002	0.003	0.003	0.001	0.000	0.000	0.002	0.000	0.002	0.008	0.008	0.005

ABSENTEE HRS / MAN-HR AVAIL (INV)	WEIGHT FACTOR = 0.56	RATIOS BASE 1977 = 0.03
	ACC. PROD. 81/80 = 1.05	ACC. PROD. 81/77 = 1.36

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.10	1.35	1.23	1.45	1.47	1.42	1.45	1.29	1.26	1.43	1.48	1.41
PROD RAT	0.027	0.020	0.023	0.016	0.016	0.017	0.016	0.021	0.022	0.017	0.016	0.018

NO. ACCIDENTS / NO. EMPLOYEES (INV)	WEIGHT FACTOR = 0.39	RATIOS BASE 1977 = 0.22
	ACC. PROD. 81/80 = 0.44	ACC. PROD. 81/77 = 0.30

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.89	1.88	1.89	1.89	1.86	1.78	1.84	1.87	1.87	1.92	1.78	1.83
PROD RAT	0.025	0.026	0.024	0.024	0.031	0.048	0.036	0.030	0.030	0.018	0.048	0.037

TOTAL PRODUCTIVITY INDEX	WEIGHT FACTOR = 0.90	RATIOS BASE 1977 = 0.69
	ACC. PROD. 81/80 = 1.16	ACC. PROD. 81/77 = 1.21

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.09	1.24	1.54	1.38	1.40	1.57	1.34	1.28	1.02	1.44	1.16	1.21
PROD RAT	0.751	0.855	1.065	0.951	0.963	1.081	0.926	0.886	0.703	0.994	0.800	0.832

SUMMARY	82/81	82/77
R E V E N U E / P A Y R O L L	17%	46%
PROD SHIPPED (KG) / MAN - MACHINE HR	0%	105%
R E V E N U E / C A P I T A L	-73%	-56%
PROD SHIPPED (KG) / ENERGY (KWH)	9%	32%
REVENUE / PRODUCTION COST	0%	41%
QUALITY CONTR COST / PROD COST (INV)	-97%	-427%
MACH IDLETIME / MACH AVAILAB (INV)	-8%	-4%
REJECT. PARTS / INSPECT. PARTS (INV)	28%	71%
ABSENTEE HRS / MAN-HR AVAIL (INV)	-7%	31%
NO. ACCIDENTS / NO. EMPLOYEES (INV)	69%	47%
TOTAL PRODUCTIVITY INDEX	-23%	0%

REVENUE / PAYROLL	WEIGHT FACTOR = 0.85	RATIO BASE 1977 = 7.62
	ACC. PROD. 82/81 = 1.17	ACC. PROD. 82/77 = 1.46

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.06	1.80	1.37	1.60								
PROD RAT	8.059	13.743	10.442	12.156								

PROD SHIPPED (KG) / MAN - MACHINE HR	WEIGHT FACTOR = 0.99	RATIO BASE 1977 = 2.71
	ACC. PROD. 82/81 = 1.00	ACC. PROD. 82/77 = 2.05

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.59	1.89	2.85	1.71								
PROD RAT	4.316	5.125	7.716	4.633								

REVENUE / CAPITAL	WEIGHT FACTOR = 0.58	RATIO BASE 1977 = 7.30
	ACC. PROD. 82/81 = 0.26	ACC. PROD. 82/77 = 0.43

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	0.94	1.39	1.13	1.70								
PROD RAT	6.833	10.151	8.265	12.387								

PROD SHIPPED (KG) / ENERGY (KWH)	WEIGHT FACTOR = 1.00	RATIO* BASE 1977 = 0.32
	ACC. PROD. 82/81 = 1.09	ACC. PROD. 82/77 = 1.32

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	0.85	1.42	1.87	1.09								
PROD RAT	0.272	0.455	0.599	0.350								

REVENUE / PRODUCTION COST	WEIGHT FACTOR = 0.88	RATIO* BASE 1977 = 1.62
	ACC. PROD. 82/81 = 0.99	ACC. PROD. 82/77 = 1.41

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.12	1.74	1.48	1.35								
PROD RAT	1.620	2.823	2.390	2.190								

QUALITY CONTR COST / PROD COST (INV)	WEIGHT FACTOR = 0.56	RATIO* BASE 1977 = 0.82
	ACC. PROD. 82/81 = 0.02	ACC. PROD. 82/77 = -3.28

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	-1.85	-4.18	-6.14	-1.93								
PROD RAT	0.077	0.124	0.163	0.079								

MACH IDLETIME / MACH AVAILAB (INV)	WEIGHT FACTOR = 0.65	RATIO BASE 1977 = 0.37
	ACC. PROD. 82/81 = 0.91	ACC. PROD. 82/77 = 0.95

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	0.94	0.90	0.94	1.02								
PROD RAT	0.391	0.408	0.392	0.363								

REJECT. PARTS / INSPECT. PARTS (INV)	WEIGHT FACTOR = 0.43	RATIO BASE 1977 = 0.01
	ACC. PROD. 82/81 = 1.28	ACC. PROD. 82/77 = 1.71

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.75	1.79	1.88	1.32								
PROC RAT	0.001	0.001	0.001	0.004								

ABSENTEE HRS / MAN-HR AVAIL (INV)	WEIGHT FACTOR = 0.56	RATIO BASE 1977 = 0.03
	ACC. PROD. 82/81 = 0.92	ACC. PROD. 82/77 = 1.31

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	1.54	1.38	1.36	1.17								
PROC RAT	0.020	0.019	0.019	0.025								

NO. ACCIDENTS / NO. EMPLOYEES (INV)	WEIGHT FACTOR = 0.39	RATIO* BASE 1977 = 0.22
	ACC. PROD. 82/81 = 1.69	ACC. PROD. 82/77 = 1.47

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OPT	NOV	DEZ
VARI IND	1.84	1.93	1.80	1.89								
PROD RAT	0.036	0.014	0.043	0.023								

TOTAL PRODUCTIVITY INDEX	WEIGHT FACTOR = 0.00	RATIOS BASE 1977 = 0.69
	ACC. PROD. 82/81 = 0.76	ACC. PROD. 82/77 = 1.00

MONTH	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
VARI IND	0.96	1.12	1.05	1.14								
PROD RAT	0.666	0.771	0.725	0.786								

APPENDIX G

QUESTIONNAIRE SAMPLE FOR FEEDBACK

QUESTIONNAIRE

CD:_____

Date:___/___/___ Due Date:___/___/___

INSTRUCTIONS:

1. The questions should be answered according to a scale from one to seven representing different levels of acceptance.

Definitively NO

1:-Unacceptable
2:----------Poor
3:----------Unsatisfactory
4:----------Indifferent
5:----------Satisfactory
6:----------Good
7:-Excellent

Definitively YES

2. Mark with an "X" the level which is closest to your opinion.

- -

Question 1:

To what extend does the Productivity Measurement System provide a measure of labor, capital, material, energy, and equipment utilization?

Definitively NO							Definitively YES
__:1	__:2	__:3	__:4	__:5	__:6	__:7	

Question 2:

To what extent does the Productivity Measurement System provide a measure of Quality?

Definitively NO							Definitively YES
__:1	__:2	__:3	__:4	__:5	__:6	__:7	

Question 3:

To what extent does the "Total Productivity Index" coincide with your intuition as to how CBV is doing with respect to productivity?

Definitively NO							Definitively YES
__:1	__:2	__:3	__:4	__:5	__:6	__:7	

Question 4:

To what extent was your participation in the Productivity Improvement team a worthwhile experience?

Definitively NO ___1: ___2: ___3: ___4: ___5: ___6: ___7 Definitively YES

Question 5:

To what extent is the "Total Productivity Index" a valid indication or measure of CBV productivity?

Definitively NO ___1: ___2: ___3: ___4: ___5: ___6: ___7 Definitively YES

Question 6:

To what extent is the Productivity measure important to CBV?

Definitively NO ___1: ___2: ___3: ___4: ___5: ___6: ___7 Definitively YES

Question 7:

To what extent do you think CBV top management supported this Productivity Measurement and Improvement Program?

Definitively NO ___1: ___2: ___3: ___4: ___5: ___6: ___7 Definitively YES

Question 8:

To what extent do you think the monthly report on Productivity will help to identify areas for improvement?

Definitively NO ___1: ___2: ___3: ___4: ___5: ___6: ___7 Definitively YES

Question 9:

To what extent do you think productivity should be measured in other activities in CBV, such as, sales, personnel, and purchasing?

Definitively NO ___1: ___2: ___3: ___4: ___5: ___6: ___7 Definitively YES

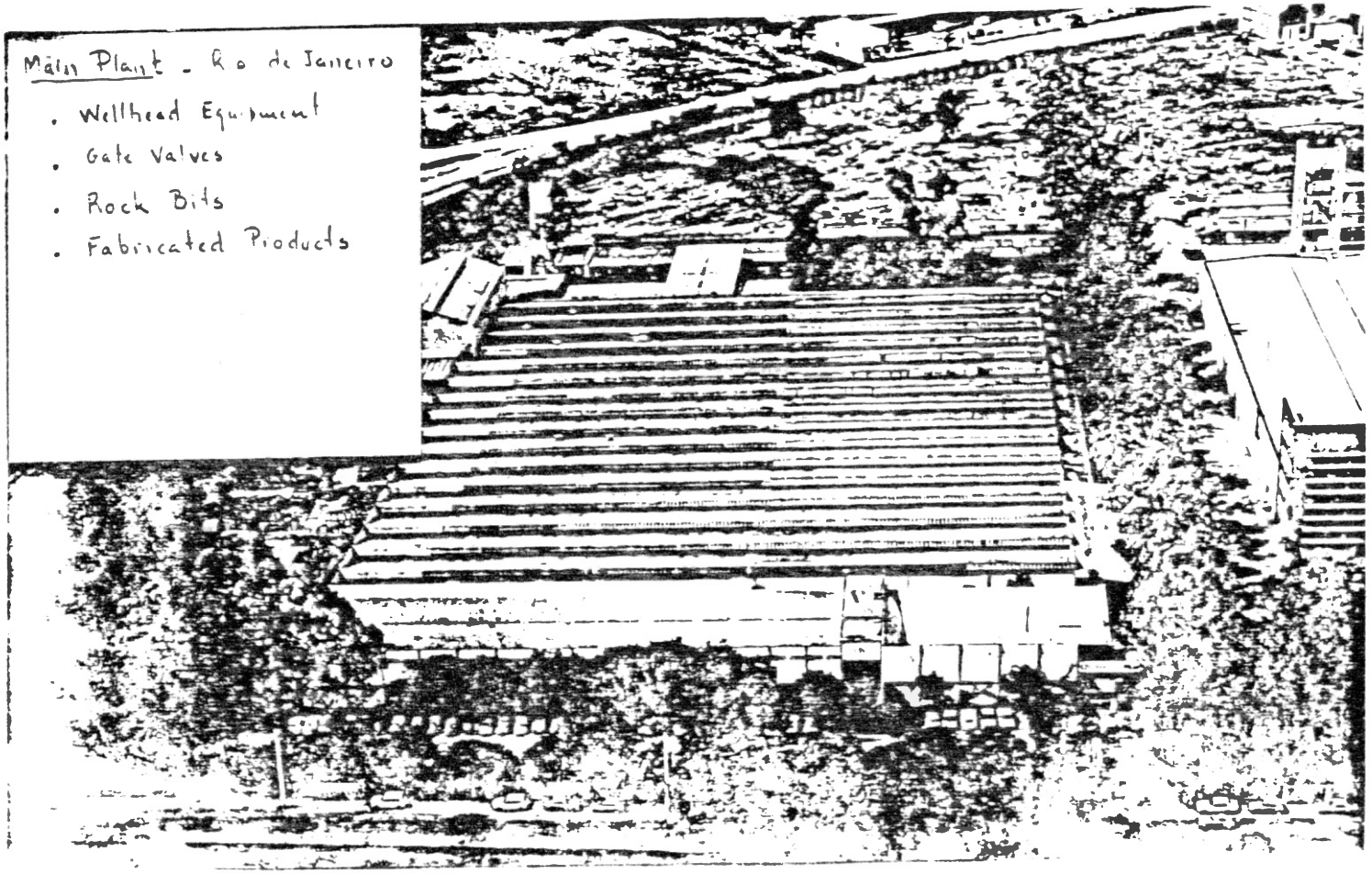
APPENDIX H

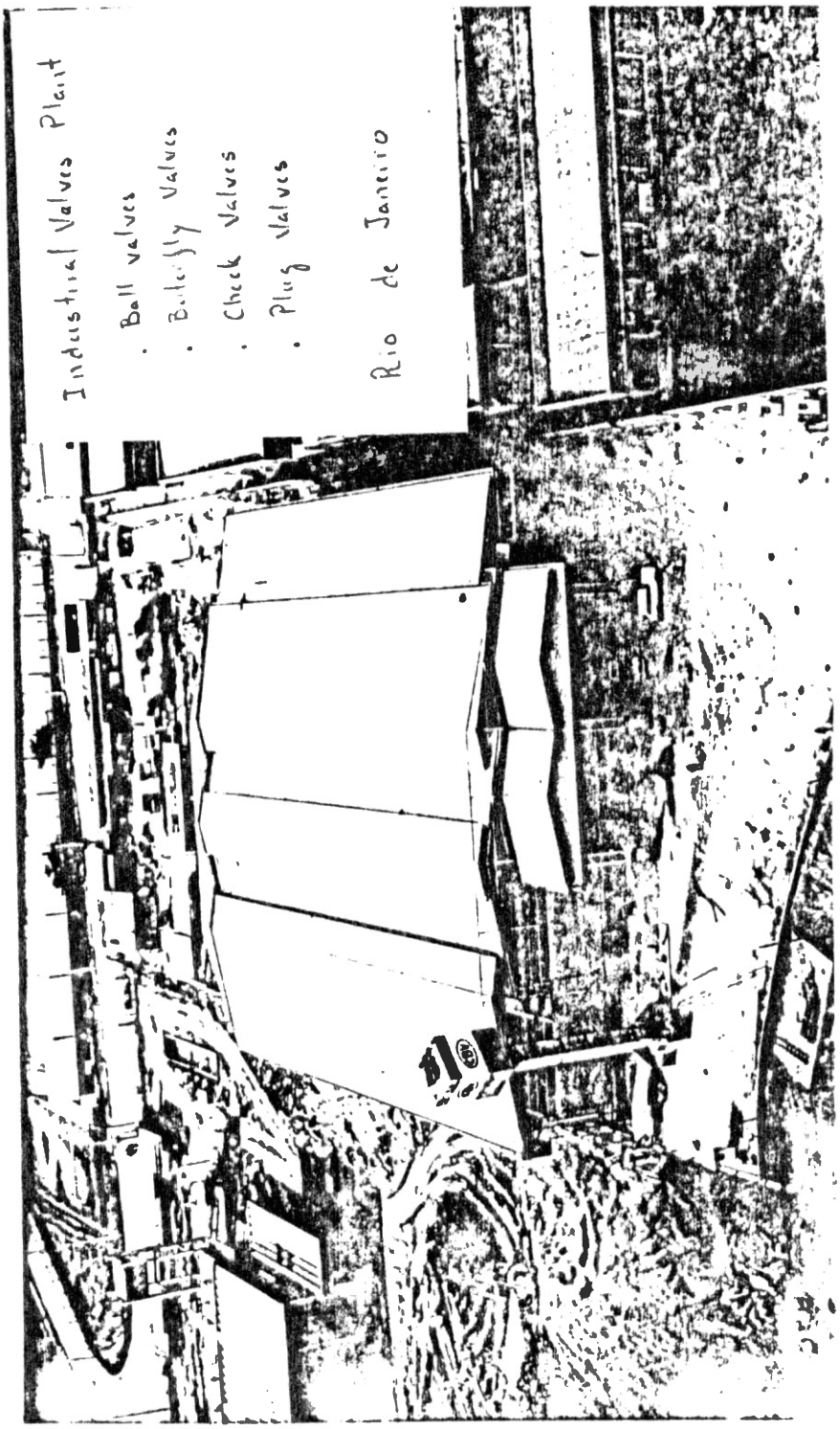
PLANT LOCATIONS AND PICTURES

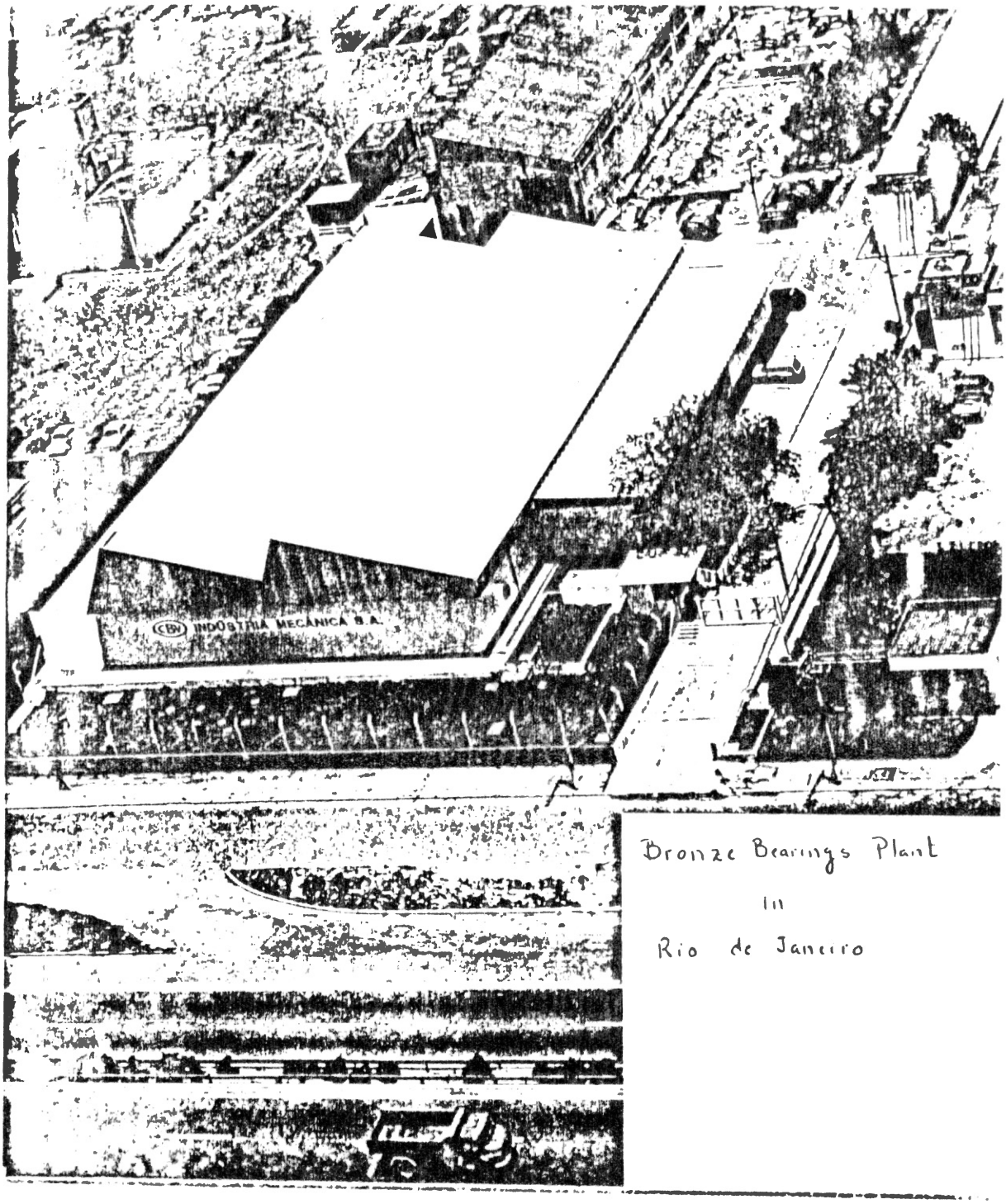
CBV - PLANT LOCATIONS:

Main Plant - Rio de Janeiro

- Wellhead Equipment
- Gate Valves
- Rock Bits
- Fabricated Products



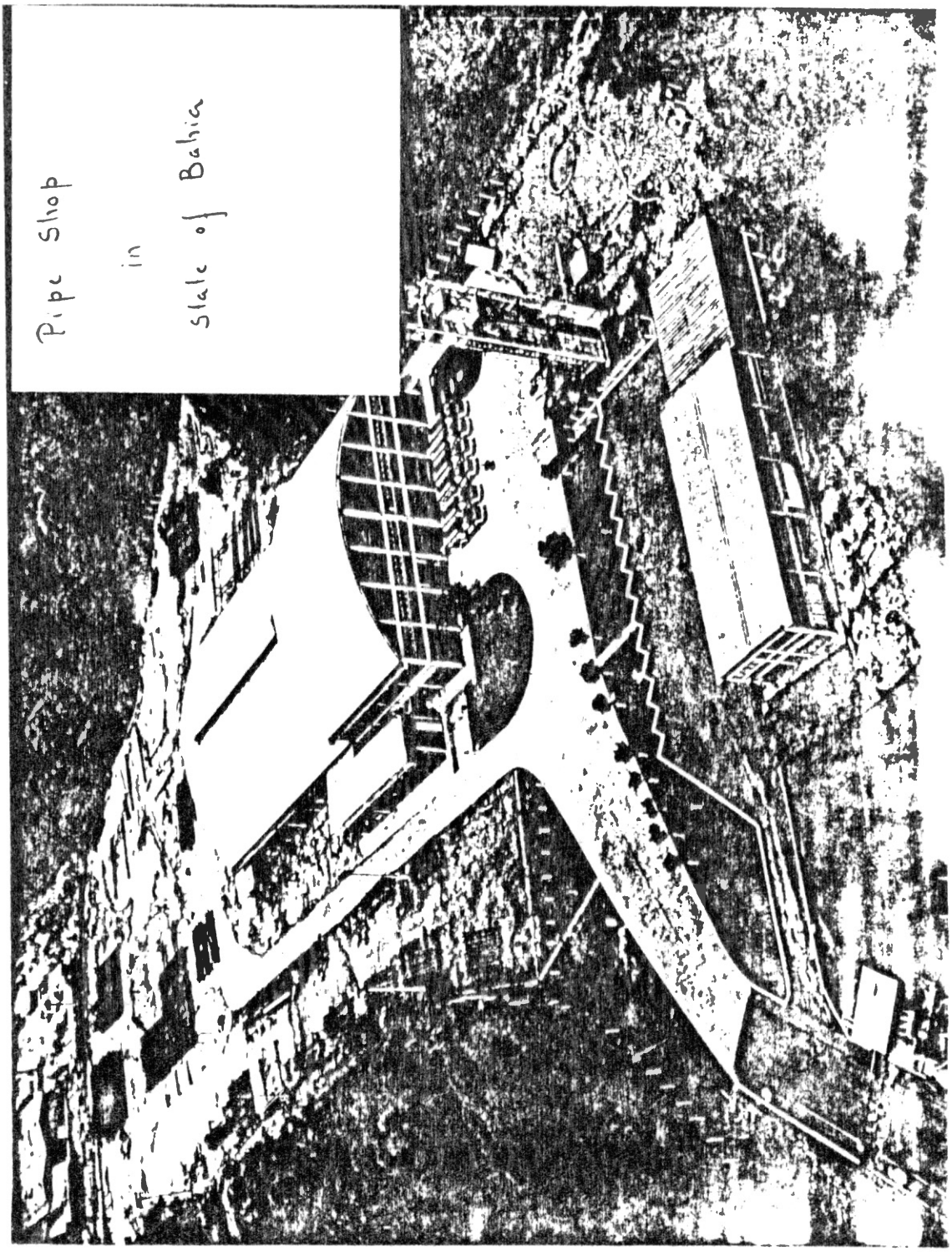

Industrial Valves Plant
. Ball valves
. Butterfly Valves
. Check Valves
. Plug Valves
Rio de Janeiro

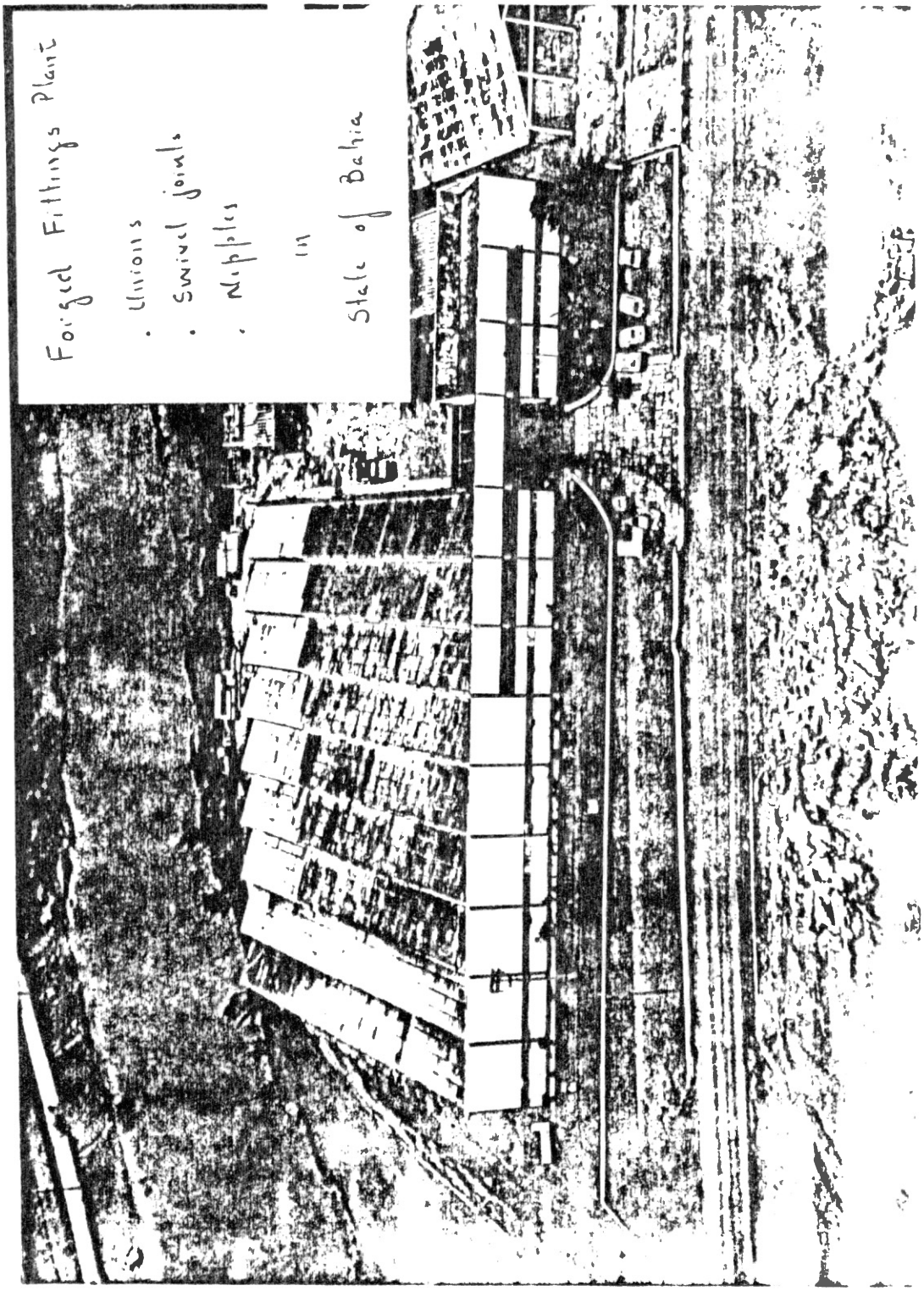


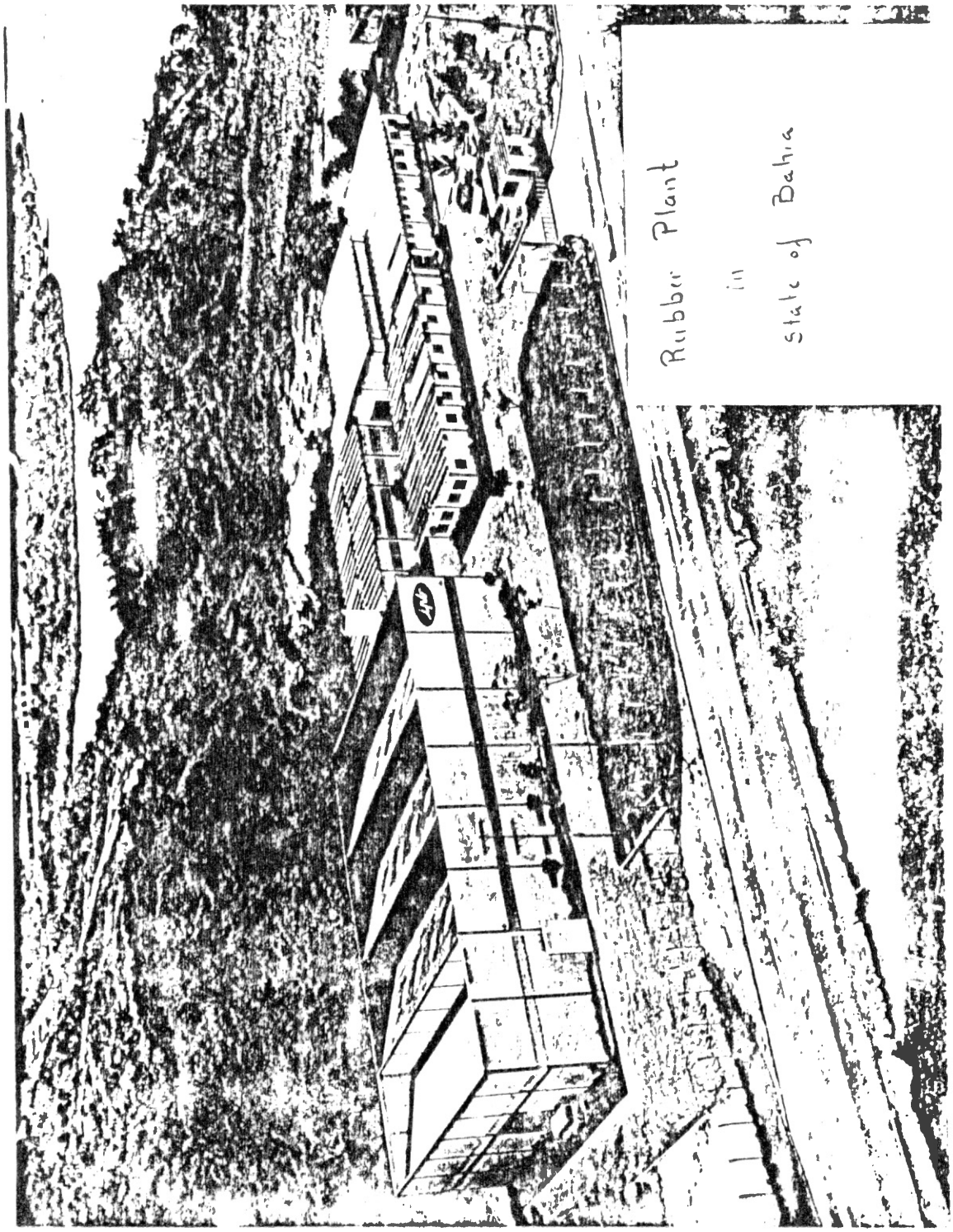
Bronze Bearings Plant

in

Rio de Janeiro


Pipe Shop
in
State of Bahia


Forged Fittings Plant
. Unions
. Swivel joints
. Nipples
in
State of Bahia


Rubber Plant
in
State of Bahia

VITA

William Sheehan Barbosa Viana

Candidate for the Degree of

Master of Science

Thesis: PRODUCTIVITY MEASUREMENT AND IMPROVEMENT STRATEGY PROGRAM

Major Field: Industrial Engineering and Management

Biographical:

Personal Data: Born in Baltimore, Maryland, April 10, 1950, the son of Mr. and Mrs. P. B. Viana.

Education: Graduated from Universidade Federal do Rio de Janeiro, Brazil, Operational Engineering - Mechanics, in December, 1973; received Bachelor of Science in Industrial Engineering and Management degree from Oklahoma State University in 1976; enrolled in master's program at Oklahoma State University in January, 1981; completed requirements for the Master of Science degree, Oklahoma State University in July, 1982.

Professional Experience: Trainee, CBV Industria Mecanica S.A., 1970-71; Chief of Inspection, CBV, 1971-72; Quality Control Manager, CBV, 1972-74; Production Manager, CBV, 1976-78; Director of Manufacturing, CBV, 1978-81; research assistant, Department of Industrial Engineering and Management, Oklahoma State University, 1981-82.