production and inventory control

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PRODUCTION AND INVENTORY CONTROL

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Reston Publishing Company, Inc.
A Prentice-Hall Company
Reston, Virginia

Library of Congress Cataloging in Publication Data
Reinfeld, Nyles V.
Production and inventory control.

Includes index.
1. Production control. 2. Inventory control.
I. Title.
TS157.R44 658.5'1 81-12052
ISBN 0-8359-5629-6 AACR2

A Prentice-Hall Company
Reston, Virginia

10 9 8 7 6 5 4 3 2 1

Printed in the United States of America

PRODUCTION AND INVENTORY CONTROL

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Mathematical Programming
(co-authored with W. R. Vogel)

Production Control

Survival Management for Industry

To my mother and father, Doris and Ernst

PREFACE

When Matthew Fox, President of Reston Publishing Co., suggested I write another book on production and inventory control, my first thought was that the old one could be updated. But as I began to write, I realized that, in the two decades that had passed, many changes had taken place in the field, such as the development of Material Requirements Planning and the evolution of computer technology. These changes, however, were revisions and expansions to a body of knowledge. More significant have been the changes in perspective.

The first book was built on a background of consulting, lecturing, and field experience. Since then, I have operated four firms as general manager, participated in the installation of several computer systems, and consulted with a number of different manufacturers. Much of this work began on the job and expanded to supervision, and sometimes to serving on the Board of Directors for clients. Lecturing has been somewhat curtailed by other commitments, although it still goes on whenever possible.

The result is that this new book looks at the problems and needs of production and inventory control both generally and specifically. The early book was more of a cook book, offering recipes for the beginning cook. It obviously reached an important market because it was well received and is still published in foreign languages, even if no longer in print in this country. This book takes a broader, more mature, view. It stresses not only the development and understanding of technical competence, but the *reasons why* things happen—concepts which are so important to improvement and creativity. The purpose is to get the practitioner in production and inventory control to question the many approaches which have evolved in the field over the years, and which are so widely accepted without challenge. Furthermore, the emphasis is on practicality and application—on results and accomplishment. Having seen the field from both sides, and from the top and bottom, some of this perspective is bound to have crept into the book itself. This cannot do harm if it will make the reader a little more aware of how he fits in and how he can improve his operation as a part of management. The student of management, on the college level, will find that theory and practice are not as widely separated as he might imagine, because both, to be useful, stress concepts and understanding, not ritual.

Because this book is an outgrowth of many years in the field and many wonderful friendships, I owe a debt of gratitude to a long chain of people. I will single out only two for comment. I want especially to thank my daughter Kathleen for typing the manuscript and Jeanne-Marie Peterson, production editor, for her help in producing this book. By comparison, my job was easy.

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Chapter 1

THE EVOLUTION OF PRODUCTION AND INVENTORY CONTROL

At the time that it was built, the Shasta Dam was the biggest construction project in the world. Its waters backed up on thousands of acres and provided fishing, boating, and shoreline for millions of visitors. Its stored energy produced electricity for much of California, and its water overages provided irrigation and water to many localities in the surrounding desert country. For me, it was my first important summer job after high school, serving as an interlude between the Great Depression and a stint in the U.S. Navy. The year was 1942, and although the Japanese had overrun the Phillipines and were marching southward through Borneo, threatening Australia and knocking at the door of Hawaii, construction and hiring continued as if the project were part of the war effort.

Situated in the desert, a few miles north and slightly west of Redding, California, planted astride the Sacramento River Valley, the Shasta Dam project became the permanent home for thousands and the temporary home for many more. Redding was a sleepy, sun-baked town of perhaps 5000 inhabitants and at the time boasted a single hamburger stand. Although it was but 15–20 miles to the dam site, and gas prices were as low as 13 cents, it was more convenient for many workers to locate near the project, so that tent and trailer cities sprang up around the countryside close by the base of the dam. Temporary structures of plywood, sheet metal, and clapboard followed, and one of the towns became known as "Project City," a name it still retains. Restaurants came along, with a movie and a bowling alley and the usual bars and places of entertainment. Air conditioning was almost unknown, and in the sweltering 110° days and cold nights the populace survived on swamp coolers and soft drinks. Army cots, open skies, and outhouses were commonplace in a climate with less than ten inches of rain a year. Water came from the streams, and baths from a bucket. There were some fights, but the people were as friendly as a picnic crowd, having drifted in from all over the country. There were goodly representations of Steinbeck's "Okies" and "Arkies" and others driven west by the "Dust Bowl" period of the thirties. Many of these people dragged their homes behind them, traveling in old beat-up cars; and when they arrived, they dropped their little trailers on a spot in the desert. And that became the permanent home for many. The first station wagons and travel trailers were invented by these people, who—abandoning their homes to the prairie—were forced to adopt their cars and trucks as living quarters. Many of them were drawing their first paycheck.

The skills required by the project and its ancillary activities ranged from dishwasher to engineer. A large number of common laborers were employed, as well as skilled workers, to pour cement, move dirt, and build special machinery. The project included architects, engineers, managers, planners, office and payroll personnel, supervisors, purchasing agents, and all the related activities that go with such a project. Being then of strong back and weak mind, a condition common to those just out of high school, my niche in the labor pool was as pitch scraper and brush cleaner. Working with two other men of equal talent, our assignment was to ride a scaffold down the side of the concrete dam, scraping pitch off the wall along the expansion joint where it had oozed out between two columns of cement. Starting at the top of the dam, and lowering the scaffold as we went, three of us did the work of one, until we reached the bottom. That job complete, we joined other crews working upstream, clearing debris and underbrush to make way for the rising water. Because the brush near the dam had already been cleared, our section was upstream about three hours' ride in the project station wagon. After two hours work with a half-hour for lunch, we spent the next three hours riding back on government time. The next project involved moving the sightseeing pavilion to high water. This pavilion, built for visiting dignitaries, was originally located inside and near the bottom of the dam, but it was moved to higher ground as the water began to climb.

It is obvious from the preceding comments that some of the events that take place when a project gets underway are planned, and some just happen. The conditions that occurred at Shasta Dam could not have been significantly different from those that accompanied the building of the pyramids. In fact, some surprisingly modern management techniques were used by both the Egyptians and the Sumerians as early as five thousand years ago.

Both as a percentage of the gross national product (GNP) and in terms of actual numbers of people employed, the Pyramid of Cheops in the IVth Dynasty, built at the dawn of civilization, completely dwarfs the projects of modern man. The huge blocks of limestone or granite used in the pyramid weighed up to 350 tons. They were quarried at Tura, on the east bank of the Nile, and then were floated downstream to Gizah above Cairo, from whence they were dragged up a ramp to the plateau 100 feet above the river. We are told by the Greek historian Herodotus that 100,000 men alone were employed continuously for ten years in the quarrying operation. These laborers and serfs were composed of quarrymen, masons, and porters, all of whom had to be provided with food, shelter, supplies, equipment, and medical and sanitary facilities. The architects and overseers who planned and supervised the project had to learn to control and coordinate this vast army of workers and to solve the mechanical problems of lifting the heavy blocks into position. The only tools available were wood, stone, and manpower, since the use of metal in Egypt trailed that of Sumeria by a thousand years and then was limited to dagger points and ornamentation.

The accuracy of the Egyptian calendar is well known, rivaling that of our modern system for recording the passage of the years; but the accuracy of the pyramids themselves is an even greater marvel of human accomplishment. The base of the Great Pyramid measures approximately 775.75 feet on a side, with a deviation, on each of the four sides, not greater than one inch. The monument was planned to scale in advance, and extant mathematical texts confirm the calculations and planning that preceded the construction of the pyramids. In some cases, whole groups of problems were devoted to calculating the angles involved.

At the same time that the Egyptians were developing some rudimentary tools of management, the Sumerians in the Fertile Crescent were establishing independent systems of their own. The early Sumerian texts are better preserved than those of the Egyptians because they were impressed on clay tablets (cuneiform), as compared to the less durable papyrus of the Egyptians.

In Sumeria, standardized weights and measures and a system of legal torts were evolved early to facilitate commerce. One of the oldest known legal texts, the Code of Hammurabi (ca. 1800 B.C.), is largely devoted to commercial regulations. Without a standard system of weights and measures, which could be applied throughout the Fertile Crescent, large-scale manufacturing and trade would have been impossible.

The earliest record that we have as to the evolution of writing is that found in the first Ziggurat of Erech, in Sumeria. Built about 3000 B.C., the temple at Erech was rebuilt on the same site at least four times, with each successive temple grander than its predecessor. The first temple towered 35 feet above the surrounding terrain, and its top measured over 1000 square yards. The evolution of writing is of interest to those in management and especially so to those involved in accounting and inventory control because the first records at Erech show that writing evolved out of management practices, and not vice versa. It was at the Ziggurat temple that excavators found a tablet bearing the impression of a seal and numbers. It is the world's oldest known account tablet. These and similar tablets were inscribed with symbols and numerals. The symbols were mostly pictures, but they include conventional signs that have clearly evolved from pictographs or images.

There are signs for units, 10s, and 60s (or 100s). (The Sumerians used the base 60 in counting.) The tablets contain simple arithmetical formulas such as the formula for the area of a field. Archeologists tell us that the earliest documents were records of transactions and revenue collections. As the temples grew richer, the task of administration increased. Because a means for recording complicated business transactions was needed, the Sumerians gradually evolved a system of writing, "which not only their colleagues and immediate successors, but also modern scholars could read."[1] By the time of the fourth Ziggurat, decipherable documents had emerged. Thus the first inventory records were established almost one thousand years before literary writing came into being.

The derivation of writing as a means of record keeping (the "economic origin of writing" as Professor V. Gordon Childe terms it[2]) is perhaps less surprising than the fact that both the Sumerians and Egyptians had associated time with productivity. Both groups had divided the day into 12 parts and the night into another 12. Both used the sundial and the water clock, and the process of dividing day into 12 hours carried over into the Bible, in which there are a number of references to a specific time of day—such as "10 o'clock in the morning."

Tablets on file at the Strasbourg and British Museums contain additional clues as to the level of planning employed by the Sumerians. The British tablet contains 32 problems that have been deciphered. These include problems dealing with masses of earth moved and the tasks to be assigned to workers, how to determine the number of bricks used to build a side or well, the division of water clocks, and the time used by weaving operations.

Here was no collected body of management knowledge, to be sure, as was the case with the Egyptians and their writings on medicine. Furthermore, the aspects of management that were included were treated as a part of the field of engineering; but, nevertheless, there can be no doubt that many of the essential needs of modern production techniques were being described by these tablets.

Combined with the techniques for handling large masses of labor and its concomittant logistics, the total Sumerian system presented a fairly respectable body of knowledge. In fact, it was to be another five thousand years before man advanced his control over production again.

This advance came first and was most noticeable in the allied field of accounting, which originally was not divorced from production control as is done today.

It is not usual today to group accounting procedures and production control together, but if you include cost controls and shop floor control in the discussion, then the two systems come very close together, merging at some points. Shop production reports—showing labor hours, work centers, and pieces produced—are collected together; and at the point where they enter the computer, the two systems are common. At the computer level, the data are split off one way to get costs, and another way to get production reports, which are used for relieving workloads and rescheduling.

Very little change had occurred over the centuries in the manner of accounting until about 1340, when the concept of double-entry bookkeeping was introduced, first into banking and later into the records of the arsenal of Venice. The arsenal, which covered 60 acres of territory, was the facility that produced the ships that made Venice the most powerful maritime city-state in the Mediterranean.

The bookkeeping system developed at the arsenal recognized the familiar types of expenses: namely, fixed, variable, and extraordinary. By the middle of the fifteenth century, separate bookkeepers were hired to maintain the records, and separate journals and ledgers were posted. An early form of cost accounting was used.

The arsenal also practiced the policy of numbering and warehousing finished parts; it operated assembly lines; had personnel procedures; and, practiced standardization of parts and inventory control. To accomplish a flow-type of production (in anticipation of Henry Ford), the various parts used in the ships' rigging and in artillery were stored in warehouses along both sides of a channel. All parts were numbered and stocked in designated bins. As the hulls of the galleys were towed past the open warehouse windows, the various parts were handed out, in proper sequence, to fill the needs of the assemblers. Through such methods, it was possible to complete "ten galleys, fully armed, between the hours of three and nine," according to one visitor from Spain. Detailed cost studies were common, and one report showed that it cost three times as much to *find* a log as the log was worth. The study resulted in setting up a separate lumberyard, in which the material could be stored in an orderly manner, to avoid searching through a random pile. The degree to which standardization was used and appreciated is shown by a directive that required that all sternposts be built to a single design, in such a manner that they could all use a common rudder, *which was to be built and stocked in advance*. Design changes had to be approved by the general manager. Depending on the job, the various tasks performed were paid for either as piecework or on a day rate.

Throughout history, there has been a recognized relationship between time-study and scheduling because scheduling and planning of work require some means of measurement. The Egyptians and the Sumerians recognized this in project planning and in running the early textile factories in Babylonia. The length of the day offered a crude method of measurement, but the day varied in length and provided less control than an hourly record. Once the clock had been invented, the means for evaluating effort had been vastly improved. Next, the invention of the watch further improved the ability to measure, so that activity could now be measured in fractions of a minute. It is no accident that the modern pioneers of scientific management were interested in both time-study and scheduling.

THE MODERN MANAGEMENT PIONEERS

Production and manufacturing advances came rapidly with the close of the Middle Ages. Large factories began to evolve. The gun factories of France and Sweden were the first large industries of Europe. In preparation for its defenses against the Ottomans, Austria in 1404 built the first giant cannon on record. It had a barrel nearly 12 feet long. Forty-nine years later, Mehmet II, in preparation for the siege of Constantinople, had a cannon built that measured 26 feet in length. Its trajectory was more than a mile, and the missile buried itself six feet in the ground upon impact. The Sultan was delighted and ordered another cannon twice as large.

This tendency toward progressive growth and expansion is a characteristic of all societies. It was called "megalomania" by Oswald Spengler, the German philosopher-historian and is exemplified by Stonehenge and the monoliths on the Easter Islands as well as by the pyramids of Central America and Egypt. From the late Middle Ages on, "megalomania" began to assert itself in the form of industrial growth.

Factories and public demand expanded rapidly in the next four centuries and brought about the need for better management and greater