**AN INTRODUCTION TO
PRODUCTION AND
INVENTORY CONTROL**

By the same authors

PRODUCTION AND INVENTORY CONTROL: THEORY AND PRACTICE

Philips Technical Library

AN INTRODUCTION TO
PRODUCTION AND
INVENTORY CONTROL

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and

W. MONHEMIUS

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Preface

Not without reason has this century been termed ‘the century of technology’ because of the enormous advance made in the domain of pure techniques. It is, however, surprising to find that considerable gaps in our knowledge have arisen in this technical sphere. Many scientific workers have applied themselves to the development of technical ability but far less attention has been devoted to planning and organizational problems of technical and administrative processes; of these, there is still relatively little appreciation.

This work discusses the background processes of production planning in connexion with which we deal mainly with the situation encountered when products are manufactured in considerable quantities. It deals, in principle, with existing methods for managing stocks of these articles, methods of placing replenishment orders for stock, and methods for the eventual planning of the production of these articles.

In the main, attention is given to the short-term planning of products not produced to order. Problems which arise in the planning of an engineering job shop are not discussed. Although the examples are frequently borrowed from the technical field—since it is there that the authors acquired their experience—the train of thought and the methods described are certainly applicable and useful in the commercial sphere where one frequently speaks of order-quantities and has less to do with production-batch quantities.

In our terminology, ‘order’ is reserved for the acquisition of goods which we, ourselves, do *not* produce and it is in this connexion that ‘order-quantity’ is discussed.

If, however, we meet our requirements by our own production, we speak of ‘production-batch’ quantities. The problems are the same in both cases.

As already stated, we notice considerable gaps in the field of production planning. Particularly in recent years, however, much work has been done in this respect, thanks to the advent of electronic calculating machines (computers). Computers enable us to assimilate large quantities of information rapidly and accurately; consequently, it is no longer an exception for complicated arithmetical rules to be used in planning. Conversely, the development of planning techniques has increasingly advanced the use of computers, and

instead of merely book-keeping, they also assist in managing the business affairs of a company; but this does not mean that the availability of computers is a prerequisite for putting modern views into practice in the field of planning.

We have written this book because it became apparent to us that the need exists for an introduction to the principal lines of thinking regarding production planning and management of stocks. This book therefore includes scarcely any formulae, and 'recipes' do not appear, but an attempt is made to elucidate the arguments by means of numerous figures. It is meant to be a rounded-off introduction for those who wish to orientate themselves in the field concerned without either being, or aspiring to be, specialists.

The companion volume (*Production and Inventory Control: Theory and Practice*) is arranged altogether differently and is specifically meant for those who wish to specialize in handling production planning and stock management techniques. Consequently, in that book we discuss how calculations are carried out, how cost-components are compiled, and the manner in which a good procedural structure can be attained. In our view the present volume is also to be recommended as an introductory study to *Production and Inventory Control: Theory and Practice*.

The material dealt with in this book is divided into three sections. In Section I, 'Backgrounds', the essence of planning is considered; therein are analysed the laws according to which irregularity in the consumption of a product actually behaves. Lastly, we discuss the characteristic features which cause the various processes of consumption and production to differ from each other.

Based partly upon Section I, Section II investigates the behaviour of stocks and waiting times, their function and cause respectively and how they must be planned and managed. The various existing systems of stock management are then submitted to further analysis. The method of calculating the average amount of stock is demonstrated by reference to two stock-components, viz. the size of the replenishment quantity and the safety stock.

Finally, a few pages are devoted to the difficult problems arising when 'chains' of stock occur. In a large concern, for example, successive stocks can be found of raw materials, parts, semi-manufactured goods and of the finished products, while stocks of the finished product can again be found in a central warehouse, at the principal branch depots, and at the ultimate places of sale.

In Section III, part of the material discussed is further substantiated in the shape of a practical example.

We would like to express our thanks here to the many who, consciously or unconsciously, have contributed towards the creation of this work. Of our colleagues and former colleagues, we would in the first place single out A. R. W.

Muyen; further, we would like to mention Drs Buitenhuis, van Houten, Hovius, Ir. Meertens, Ir. v. d. Meerendonk, Meyer, Moonen and Dr Schrakamp.

The conversations we have been able to have with Dr R. F. Meyer of Arthur D. Little (Massachusetts) as well as with Dr Whitby and Dr S. Allen of Stanford Research Institute (California) have also been particularly fruitful for us.

For stimulus in developing fundamental thinking in the field of planning, we would offer many thanks to Ir. A. H. Schaafsma who also frequently participated in this development himself.

Furthermore we would like to mention our pleasant and instructive association with numerous colleagues in Messrs Philips Ltd, both in the management and in the various staff divisions (Technical Efficiency and Organization, Technical and Commercial Planning and Production offices, Commercial Preliminary Calculation and Planning, Administrative Organization and General Industrial office). Finally, we much appreciated the many meetings outside N. V. Philips, especially with the Vereniging voor Statistiek (Statistical Society). We are, moreover, much indebted to Mesdames E. Sengers and J. Bauwens, for typing the draft and for attending to the MS., respectively and to Mr E. Mitzer for drawing the original figures.

June 1962

R. N. van Hees
W. Monhemius

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Notation

a	= Safety factor
b	= Safety stock
B	= Re-order level
B_z	= Re-order level with a risk z of running out of stock
c	= Cost parameter
c_i	= Cost of holding a unit of product in stock for a year
c_p	= Cost of changing the production level by an amount p
c_r	= Cost per product in stock and p.a. resulting from lost profitability of the capital invested
c_w	= Space costs per product in stock and p.a.
C	= Costs of being out of stock per product p.a.
d	= Consumption in quantity per period
D	= Consumption in quantity p.a.
e	= Economic stock ($= i + o$)
F	= Fixed costs per batch
i	= Stock level
I	= Aggregate stock of a number of products
k	= Smoothing constant
m	= Order interval in a fixed interval order system
n	= Number of products within a certain homogeneous group of articles
o	= Amount of a product actually on order but not yet received (orders outstanding to replenish stock)
p	= Parameter
P	= Production per period
R	= Cost of running out of stock
Q	= Order quantity or production batch size for replenishment of stock
Q^*	= Optimum batch quantity
r	= Profitability factor
σ	= Standard deviation
s	= Lower stock level in a (s, S)-system
S	= Upper stock level in a (s, S)-system
t	= Delivery time (time from the moment of placing the order to the date of receipt of goods) unless otherwise stated

T	=	Time
v	=	Risk of being out of stock
z	=	Risk of stock being negative when a replenishment order arrives

USE OF SPECIAL SYMBOLS

d	=	Consumption in quantity per period
$\underline{d}$	=	<i>Idem</i> , seen as a stochastic variable
$\bar{d}$	=	<i>Idem</i> , average value
$\hat{d}$	=	<i>Idem</i> , value to be expected in the future
d_t	=	Consumption during a period equal to delivery time t
$P[i < 0]$	=	The risk that at a certain moment i will be less than 0