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INVENTORY CONTROL SYSTEM IN A PROCESS INDUSTRY

by

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Organised in co-operation with the German Foundation for Developing Countries and the German Association of Machinery Manufacturers (VDMA)

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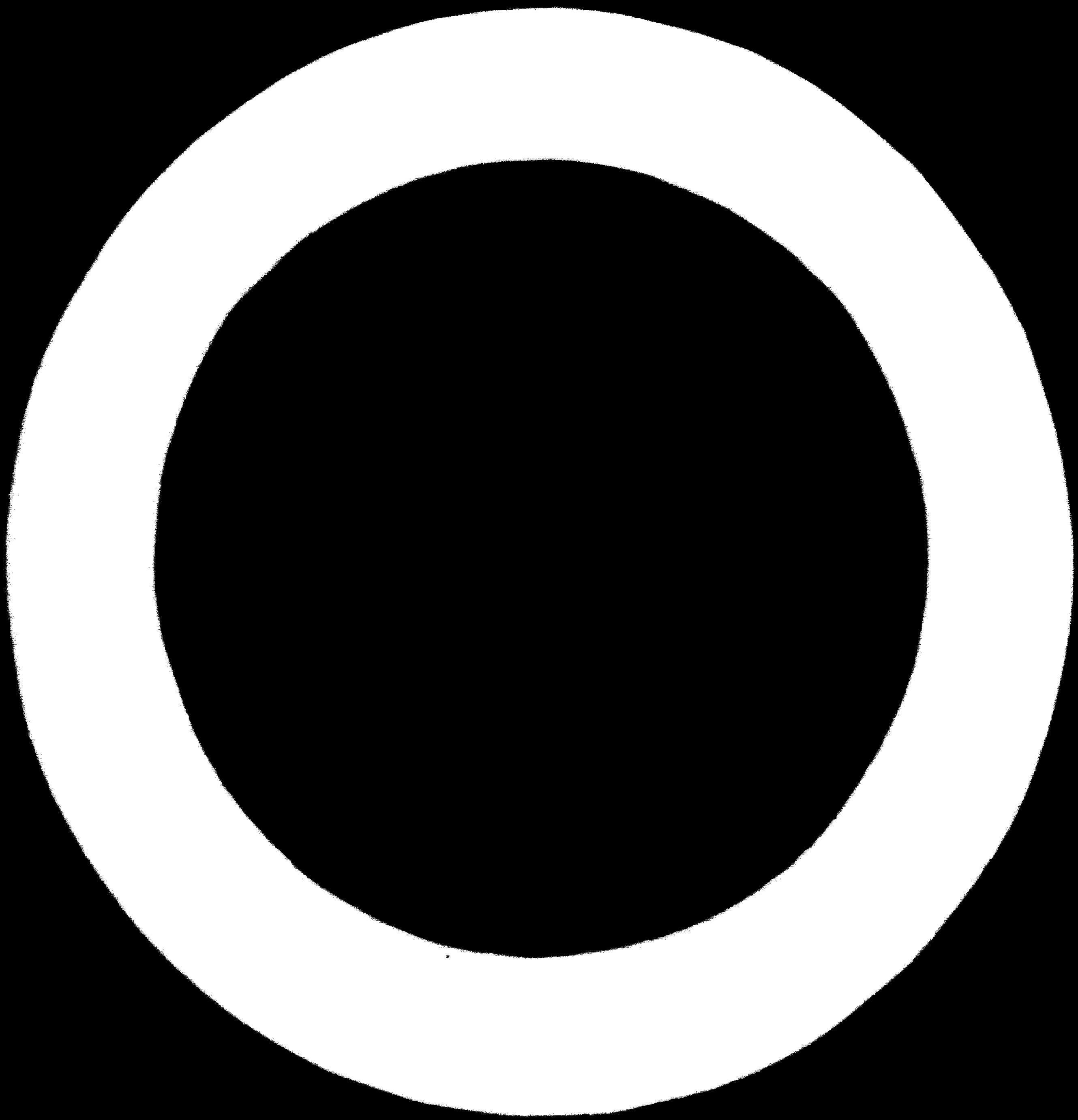


CONTENTS.

1 INTRODUCTION.

The ENCI (Eerste Nederlandse Cement Industrie, First Netherlands Cement Industry) in Maastricht, Netherlands, is a cement producing industry. The main raw material (calciumcarbonate), dug off the St. Pietersberg. The process turns the marl into portland- or melting-furnace cement.
The company employs about 1.000 men, of which 350 men are working in the maintenance department.
Production capacity:

Portland cement	:	1.500.000 tons/year
Melting-furnace cement	:	700.000 tons/year.

2 CONSIDERATIONS.

In 1967 we decided to undertake - with the assistance from Organisation Bureau Maynard - a complete reappraisal of the inventory control system and of the financial implications of the stocks on hand. The inventory consists mainly out of items that are needed for the maintenance of the means of production.

We felt that the existing system of inventory control, based on "play for safety in all cases", was in many respects inadequate to meet economic requirements. Buying and stock holding on an assortment of items means an investment. Not only the interest of the invested capital is lost, stocks also leads to storage- and administration costs. Therefore it is wrong to charge only 6 per cent loss of interest for investments in stocks.
The investment has no returns. The money that will become available by buying less items would undoubtedly not be put in a bank at 6 per cent interest, but should for example be used for the procurement of production machines, resulting in a 10 - 30 per cent profit (netto).

All stock-items were treated the same way concerning registration, reordering and such-like. We were convinced that this leads to spending too much time on less important items, or too little time on important items, thus unnecessarily increasing costs.

3 **PRELIMINARIES.**

Our new inventory control system contained the following aspects, characteristic for an inventory control system:
1. Inventory costs.
2. Stockout costs.
3. Material classification.
4. Ordering decision rules.
5. Order level and order quantity.
These aspects will be treated in the following paragraphs.

4.1 **INVENTORY COSTS.**

The inventory costs are the costs as a result of keeping an item in stock. More specifically we will deal with three cost ekements:
1. Loss of interest. The loss of interest should be equal to the rate of return on invested capital which could be 15 to 20 per cent. We chose 15 per cent for our calculations.
2. Fixed inventory costs. These costs are independent of the size of the stocks of the individual items. They include:

Administration, guarding and issuing orders:	± 1½ p.c.	of the size of the total stocks
Personnel and tools in warehouses:	± 1½ p.c.	"
Total :	3 p.c.	"

By "issuing an order" we mean all activities required for one single replenishment; these activities include e.g.: making out, typing, copying, sending out and filing an order form, inspection after receipt and invoicing. These costs can be computed by dividing the total costs by the total number of orders. They could be ƒ 15 to ƒ 20 per order (ƒ stand for Dutch florin; 1 $ = 3,6 ƒ). These costs are dependent on the no. of orders but not - within limits - on the order sizes (stocks).

3. Variable inventory costs. These costs are dependent of the size of the stocks. They include:

Insurance stocks	:	0,08 p.c.
Insurance warehouses	:	0,05 p.c.
Depreciation warehouses	:	1 p.c.
Maintenance warehouses	:	0,4 p.c.
Heating and lighting	:	0,3 p.c.
Depreciation stocks	:	5 p.c.
Total		6,8 p.c.

Depreciation comes into the picture for slow moving repair parts with a high value, when the machines to which they belong become obsolete.

4.2 STOCKOUT COSTS.

Stockout costs are the costs which originate from an item not being in stock at the moment at which it is needed. They include the costs of production loss, costs of expediting and additional costs for emergency measures.

The stockout costs must be treated off against the loss of interest (15 p.c.) and the storage costs (9,8 p.c.).

In principle we should only store these items if their stockout costs are greater than the inventory costs (loss of interest + storage costs).

4.3 MATERIAL CLASSIFICATION.

As mentioned before it is unpractical to control all items in the same manner. We must incorporate in the system the differences of importance of the items. In practice it is impossible to develop an individual system for each item. We should split up the items into groups according to their importance. What then is importance?

For the common consumption items (bulbs, gaskets, etc.) a good yardstick is found in consumption per year in terms of money. The greater the consumption the more sophisticated the control should be.

However for repair parts - usually with limited applications - this does not apply universally. Generally the consumption is low, delivery time is long and stockout costs are high. Therefore it is better to classify repair parts on the basis of stockout costs.
We distinguished the following groups:
1. Common stocks:
1.1. Group A, items with high consumption per year.
1.2. Group B, items with moderate consumption per year.
1.3. Group C, items with low consumption per year.
2. Repair parts:
2.1. Group D, items with high stockout costs.
2.2. Group E, items with moderate stockout costs.
2.3. Group F, items with low stockout costs.
Repair parts with low stockout costs (group F) will be treated as common stocks.
3. Items, whose consumption can be forecasted reliably. For example predictable by inspections or because of replacement on predetermined time basis.

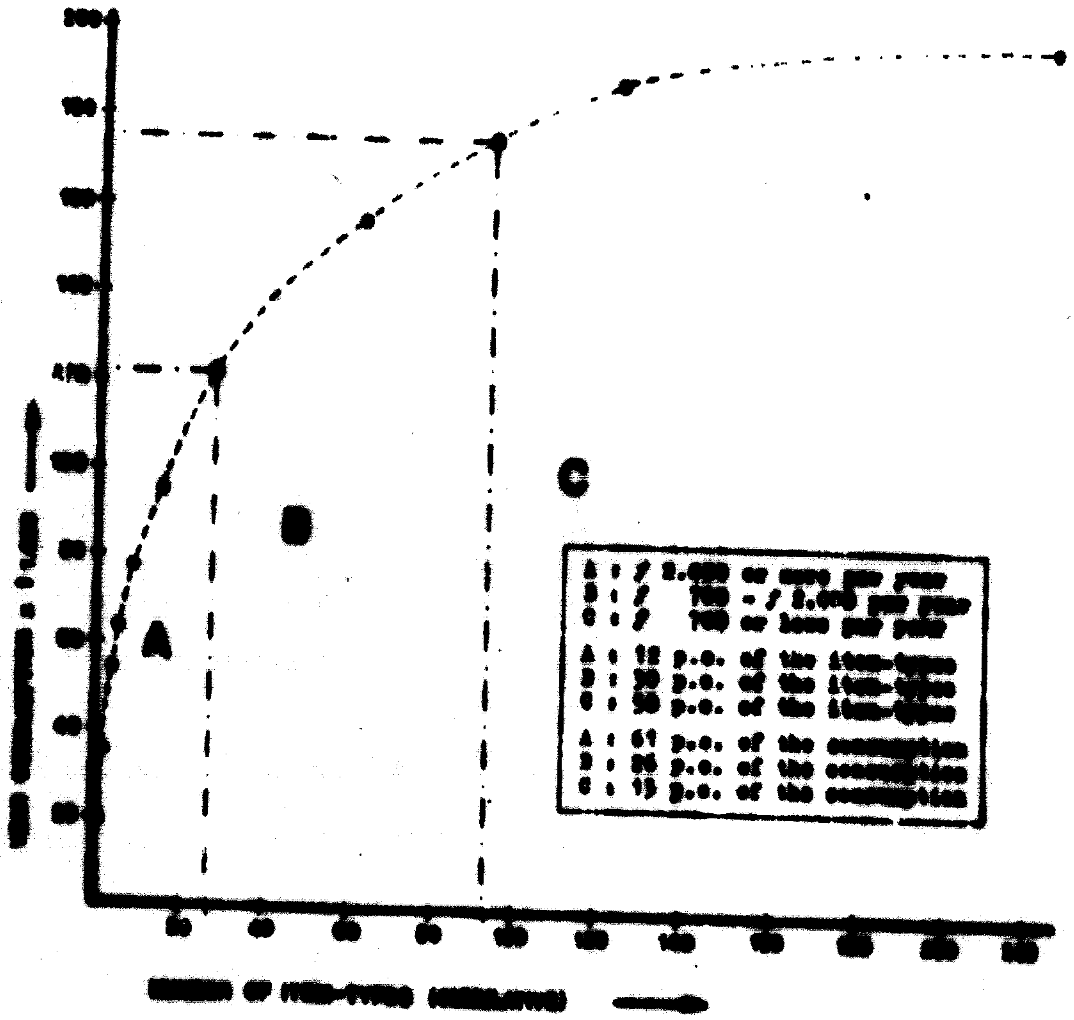
In order to determine the limits of the groups A, B and C we will apply graphic techniques.

In a graph we plot the consumption per year against the number of item-types (cumulative). We will explain this my means of an example.
Let us assume that table 1 represents all item-types tabulated in the sequence of consumption (in terms of money).

Number of item-types	Consumpt. per item-type	Consumpt. whole group	Consumption of the whole group cumulative	Number of item-types cumulative
1	ƒ 20.000	ƒ 20.000	ƒ 20.000	1
1	ƒ 15.000	ƒ 15.000	ƒ 35.000	2
2	ƒ 10.000	ƒ 20.000	ƒ 55.000	4
1	ƒ 8.000	ƒ 8.000	ƒ 63.000	5
3	ƒ 5.000	ƒ 15.000	ƒ 78.000	8
6	ƒ 3.000	ƒ 18.000	ƒ 96.000	14
13	ƒ 2.000	ƒ 26.000	ƒ 122.000	27
35	ƒ 1.000	ƒ 35.000	ƒ 157.000	62
62	ƒ 500	ƒ 31.000	ƒ 188.000	124
100	≤ ƒ 250	ƒ 25.000	ƒ 198.000	224

table 1

We plot the last two columns of table 1 against each other (see fig. 1). Fig. 1 shows clearly that a relative expensive group of items accounts for the greatest share of the consumption; a much bigger group of cheap items represents only a small share of the consumption. The first group contains the group A items and the second group contains the group C items. The group B items are in between. In the case the curve should make an extrem sharp bend a group B items does not exist.
To obtain a reliable graph a sample of 10 p.c. (minimum 50 item-types) taken at random proved sufficient.



From the graph the limits can only roughly be derived. The definite limits are determined in such manner that they will correspond to a rounded off consumption per year. In our example the limit between the groups B and C is ƒ 700 and ƒ 2.000 between the groups A and B. For these three groups different ordering systems should be applied.

As a matter of fact the behavior of the item may change in the long run. Therefore a periodic check is necessary in order to verify if the items still belong to their original groups.

4.4 ORDERING DECISION RULES.

In principle we distinguished two possibilities:
1. Ordering system based on fixed order quantities (and variable order times).
2. Ordering system based on fixed order times (and variable order quantities).

4.4.1 ORDERING SYSTEM BASED ON FIXED ORDER QUANTITIES.

If the stock reaches a certain level (order level) a fixed quantity is ordered. This order quantity is determined beforehand. The order level should be so high that the ordered quantity is received before the stock is expected to be exhausted.

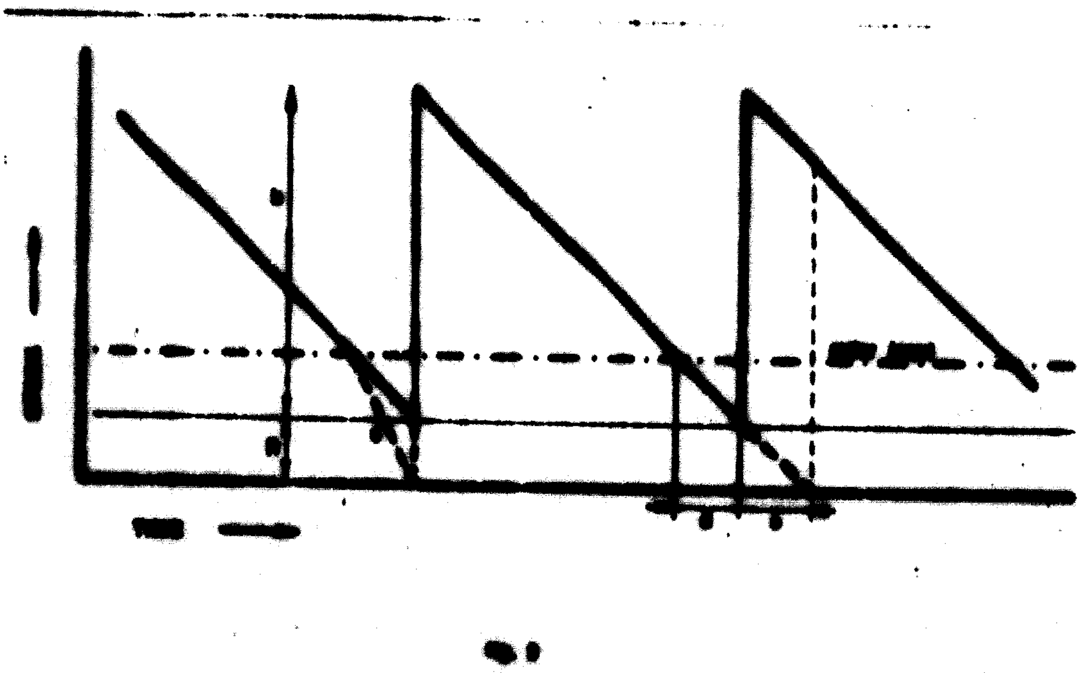
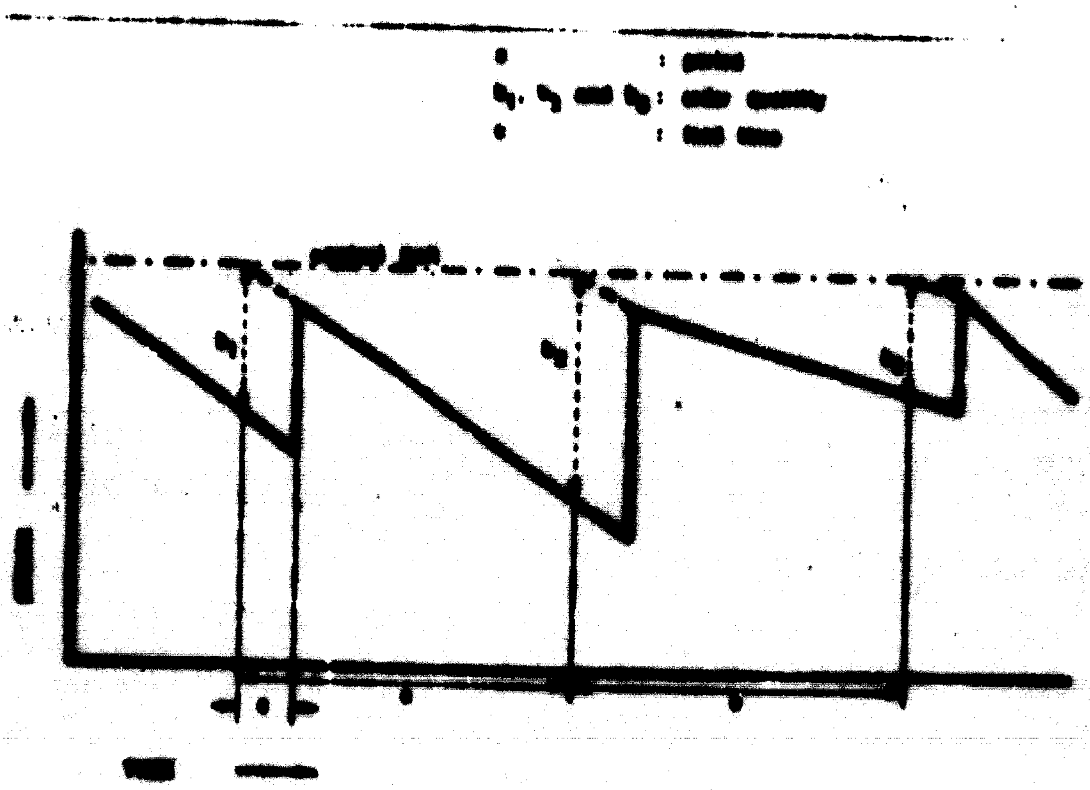


Figure 2 shows the stock pattern. Each time the order level is reached quantity b (order quantity) is ordered. When the lead time (= time for warehouse administration + time for issuing an order + delivery time) is elapsed, the ordered material is received.

At that moment quantity R (safety stock) is the stock size. A safety stock is necessary to compensate a delay in delivery time (a) or an incidental increase of consumption (c).

4.4.2 ORDERING SYSTEM BASED ON FIXED ORDER TIMES.

The stock is replenished to a certain level (control limit). The order period and the control limit are previously determined. At the beginning of each period the stock is replenished to the control limit; the quantity ordered is the difference between control limit and the stock on hand. Fig. 3 shows the stock pattern.



This system is pre-eminently useful for cheap items, which can be procured in batches from one contractor. After checking the whole group a combined, and therefore cheap, order can be placed. The system is often used for group C items showing continuously a high and regular consumption and having a low value.

4.5 COMPUTATION OF ORDER LEVEL AND ORDER QUANTITY.

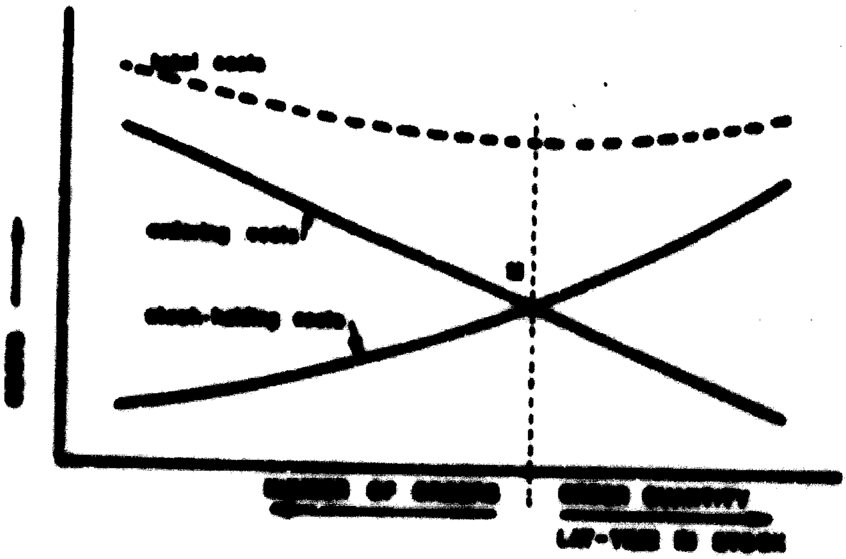
We will compute order levels and order quantities.

4.5.1 ORDER LEVEL.

At the moment of ordering the stock on hand should be sufficient to be secured against the consumption during the lead time, taking into account delay in deliveries and flustuations of the consumption.

4.5.2 ORDER QUANTITY.

The order quantity is the quantity by which the sum of ordering costs and stock-holding costs are at minimum (graphically represented in fig. 4).
The sum of ordering costs and stock-holding costs is at minimum in point M, when ordering costs are equal to stock-holding costs.



We now can compute the order quantity:

Ordering costs (OC) = Stock-holding costs

or : $OC = O \times P \times R \times L$

or: $OC = O \times P \times \frac{O}{365} \times I \times \frac{O}{365}$

or: $OC = \frac{O^2 \times P \times C \times I}{365^2}$

or: $OC = \frac{O^2 \times I \times Y}{365^2}$

or: $O = 365\sqrt{\frac{OC}{I \times Y}}$

O = order quantity in days consumption
P = price per item
R = loss of interest in p.c. per item per year
L = lay-time in days per year
C = year consumption apiece
I = loss of interest in p.c.
Y = year consumption in terms of money.

For example, if OC = ƒ 20,
I = 20 p.c. and
Y = ƒ 900.

the economic order quantity = $365\sqrt{\frac{20}{0{,}2 \times 900}}$ =
122 days consumption = 1/3 year consumption. So we have to order three times a year.

4.5.3 SAFETY STOCK.

The safety stock is necessary to take into account delay in deliveries and abnormal consumption. Covering this for 100 p.c. isn't necessary; a certain risk has to be accepted. If there is no safety stock a chance of 1 : 1 exists that the new supply will arrive in time. This means that the chances for arriving-in-time are characterized by a Gauss-curve (see fig. 5).

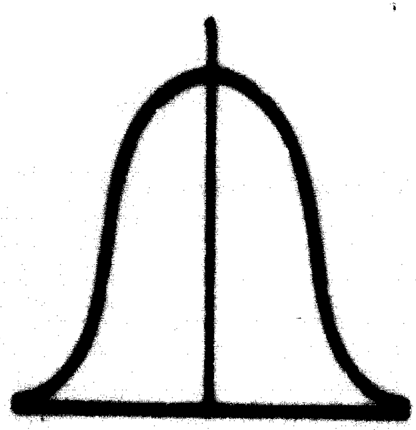


fig. 5

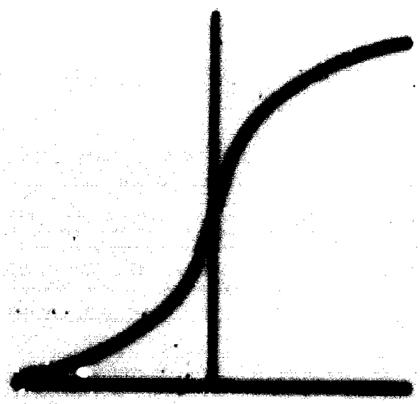
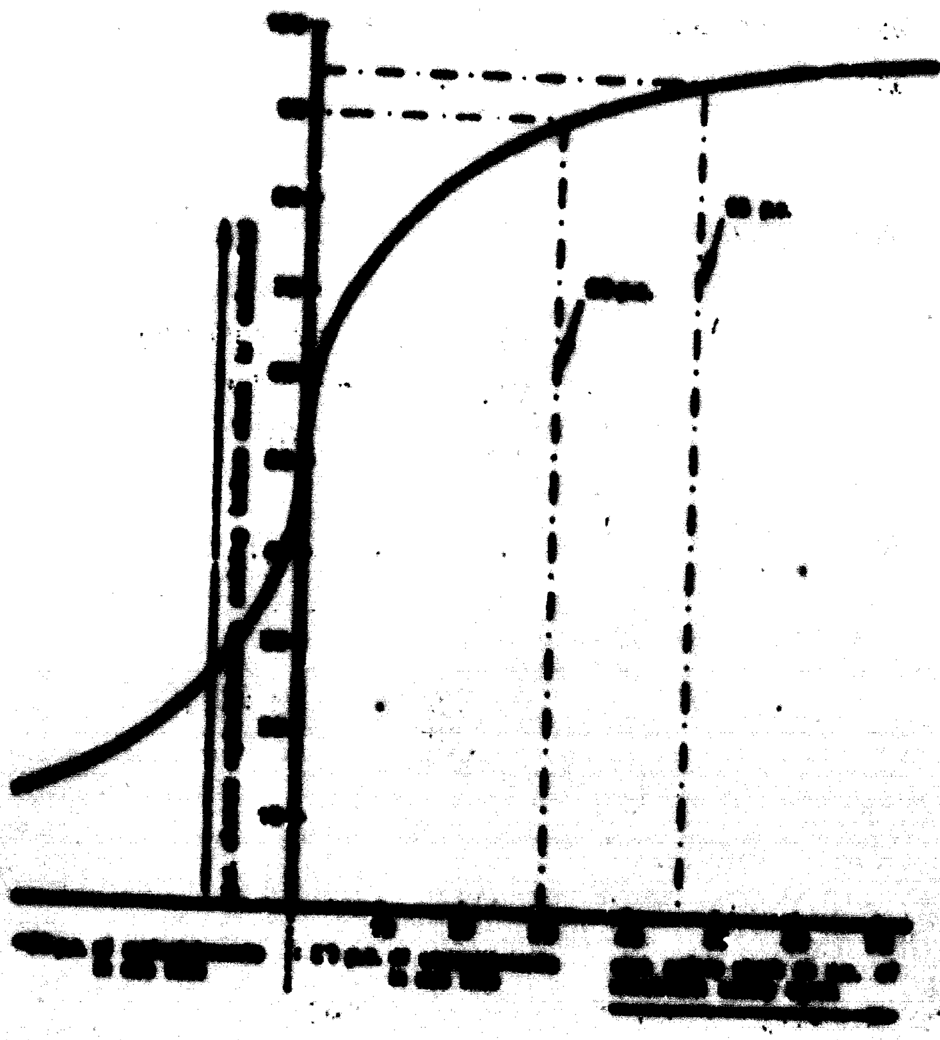


fig. 6

Usually we operate with a cumulative Gauss-curve, or S-curve (see fig. 6).

In practice we only need the portion at the right of fig. 6 (delivery overdue). If we accept a 5 p.c. risk (5 out of 100 orders arrive after the stock is exhausted) the safety stock is 44 p.c. of the maximum stock (see fig. 7).



For example:

Year consumption of an item : 1.000 piece.

Maximum delay in delivery : 3 months.

Maximum safety stock : $\frac{3}{12} \times 1.000 = 250$ piece.

If we accept a 10 p.c. risk, the safety stock has to be : 30 p.c. of 250 = 75 piece (see fig. 7).

5 COMPUTATIONS.

We will make some computations on common stocks and repair parts.

5.1 COMMON STOCKS.

The group B and C items should be ordered at fixed times. It is justified for these items to compute the order quantity and the safety stock of the whole group in the same manner.
If the limit between group B and group C is ƒ700, the average order quantity for the whole group C items is:

$$\frac{3650}{\sqrt{\frac{700}{2}}} = \pm 196 \text{ days.}$$

For practical purposes we could take one half year (182 days).
The safety stock for these cheap items can be taken upwards to 95 p.c. of the at most possible reserve in this group.

5.2 **REPAIR PARTS WITH LOW CONSUMPTION.**

1. The stockout costs of cheap and current repair parts are not essential (group F items). These items are treated as common stocks.

2. Repair parts, whose consumption can be forecasted reliably, should not be in the inventory.

3. For the other repair parts we should consider stockout costs. If consumption is low (less than one per year) we need to know if we have to take these items in stock. We compute the total inventory costs with the formula:

$$K = A\left\{(1 + R_1)^Y + (Y + R_2)\right\}$$

K = total inventory costs
A = new price
R_1= loss of interest (15 p.c.)
R_2= fixed and variable inventory costs (12 p.c.)
Y = years in stock

For example, if A = ƒ 10.000, and
Y = 5 years:
$K = 10.000\left\{(1 + 0{,}15)^5 + 5 \times 0{,}12\right\} =$ ƒ 26.200.
If total stockout costs > ƒ 26.200 we should take (or hold) this item in stock.

4. By checking stocks it is quite well possible to find items which should not have been taken in stock.
4.1. If there is no application any more we have to get rid off these items.
4.2. If we find for example an item - bought for ƒ 10.000, having stockout costs of ƒ 25.000 - that has been laying in a warehouse for say ten years and we expect that this item may be needed after approximately five years, we compute the total costs by means of the formula:

$$K = B\,(1 + R_1)^Y + A\,(Y + R_2)$$

K = total costs.
A = new price.
B = scrap price.
R_1 = loss of interest.
R_2 = variable and fixed inventory costs
(2 p.c. instead of 12 p.c. because there is no depreciation any more).
Y = years in stock.

$$K = 270(1 + 0{,}15)^5 + 10.000(5 + 0{,}02) = ƒ\ 1.943.$$

The total costs are less than the stockout costs, so we decide to keep the item in stock.

6 INTRODUCTION AND RESULTS OF THE SYSTEM.

1. Before the system we had 27.000 items in stock; invested in the following categories:

Common stocks (new):	2.100.000.
Repair parts (new) :	5.200.000.
Used items :	2.700.000.
Total	10.000.000

2. After introduction of the system we have:

2.1. Common stocks:

To be discarded : 1.700 items.
To be consumed without reordering : 2.800 items.

2.1.1. Group A:
8 p.c. of the total number of common items.
80 p.c. of the consumption of common items.
600 items.

2.1.2. Group B:
8 p.c. of the total number of common items.
10 p.c. of the consumption of common items.
600 items.

2.1.3. Group C:

84 p.c. of the total number of common items.
10 p.c. of the consumption of common items.
6.300 items.

2.1.4. The processing is executed by automatic data processing:

2.1.4.1. Input. Control limits, order levels and order quantities.

2.1.4.2. Output:

Every week: A list of items to reorder (group A and B). Order quantities are printed.

Every two weeks: A list of items to reorder (group C). Order quantities are printed.

Every month : Stock situation.

2.1.5. Implementation. Ten months with two men.

2.1.6. Stock. Stock decreased to 7.500 items.

2.2. Repair parts.

To be discarded	:	700 items.
To be consumed and after that replacement by equivalents	:	600 items.
To be replaced by equivalents	:	2.500 items.
Classified to stockout costs	:	3.600 items.

Stock decreased to 11.000 items with a value of ƒ 4.000.000.

2.3. Warehouses. 25 p.c. less warehouse-space is needed.

7 CONCLUSIONS.

1. Efficient inventory control requires a systematic approach of the total problem area.
2. An assortment has to be split up in groups each having their one control methods.

3. Once the systematic steps to be taken have been determined, the necessary quantitative analysis is relatively simple.

4. A systematic approach as mentioned delivers as a by-product many easily found opportunities for costs savings.

5. The benefits of such an approach are relatively large.

6. Though very helpful, automatic data processing is not necessary in such situations of the size treated.

LITERATURE.

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