Business Administration

Lecture No. 12: Delivery Improvement and Inventory System

1. Reduction of Production Period
2. Variety and Function of Inventory
3. Fixed-Quantity Order and Fixed-Period Order
4. Kanban System

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1. Reduction of Production Period

Competitive effect of reducing production period (Throughput Time)

Direct effect

(1) order production → delivery reduction
(2) stock production → demand projection accuracy
→ prevent out-of-stock
inventory cost

Indirect effect

elicitation of waste, production problem
→ increase in productivity, quality

What is Production Period (Throughput Time)?

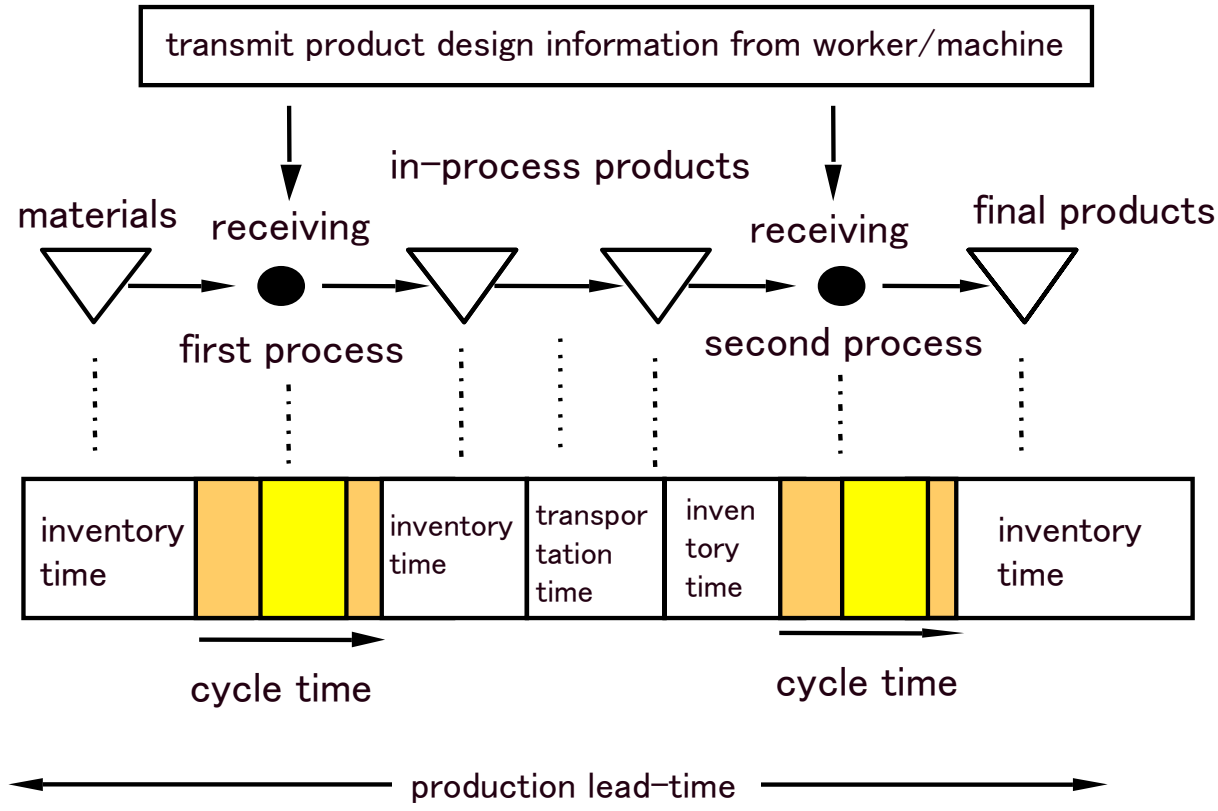
Time required for material to absorb (receive) product design information stocked within process, and be transformed to a product

Production Period = **time for receiving product design information**
+ **time for not receiving product design information**

Actually, in general, "time for not receiving information" is overwhelmingly large.
(typically, time to accumulate as an inventory)

→ Key to reduce a throughput time is in improving the inventory system.

Production Lead-Time as Time to Receive (absorb) Information (conceptual diagram)



legends: net working hours (time for receiving information)

time for not receiving information

(inventory, transportation, etc.)

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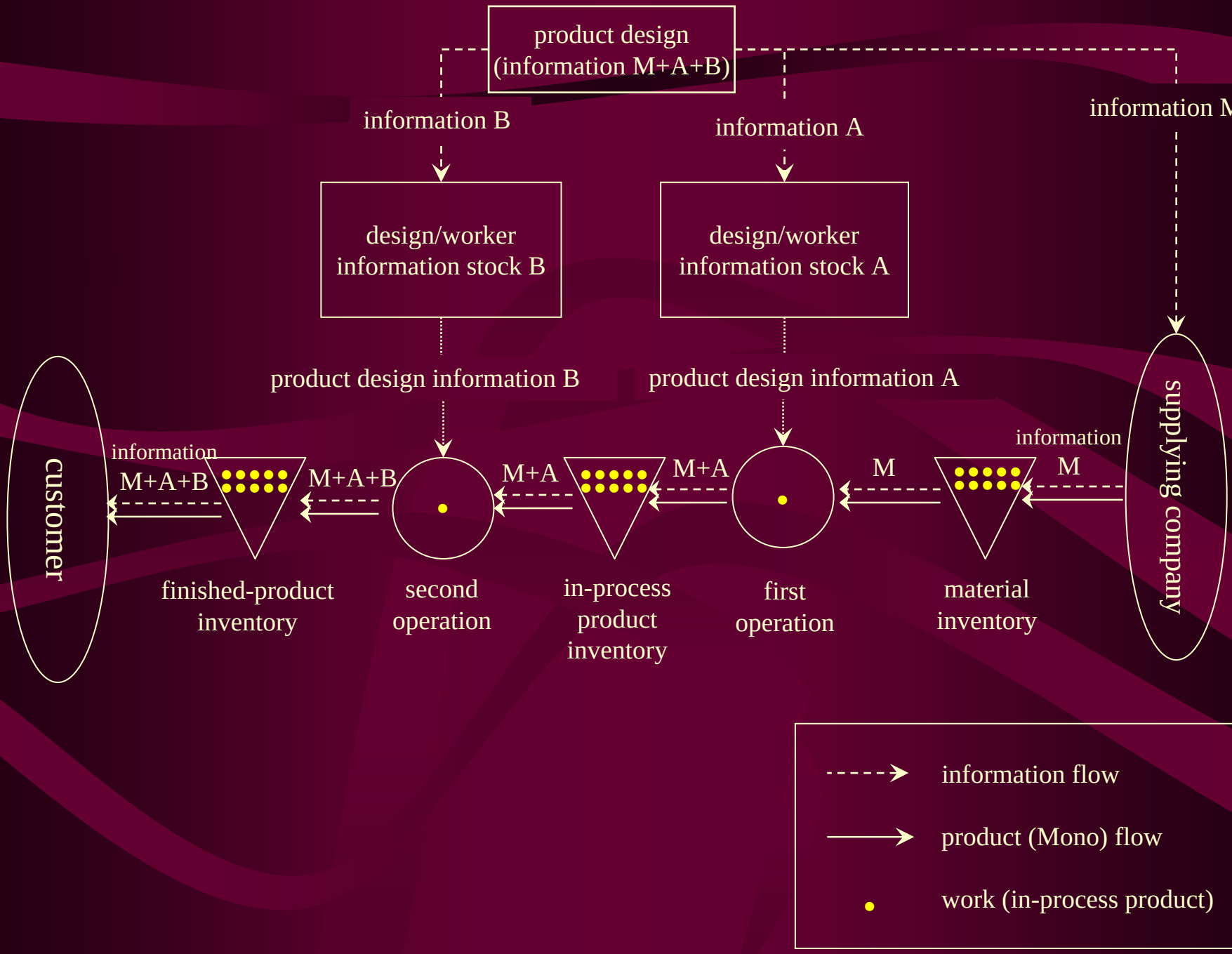
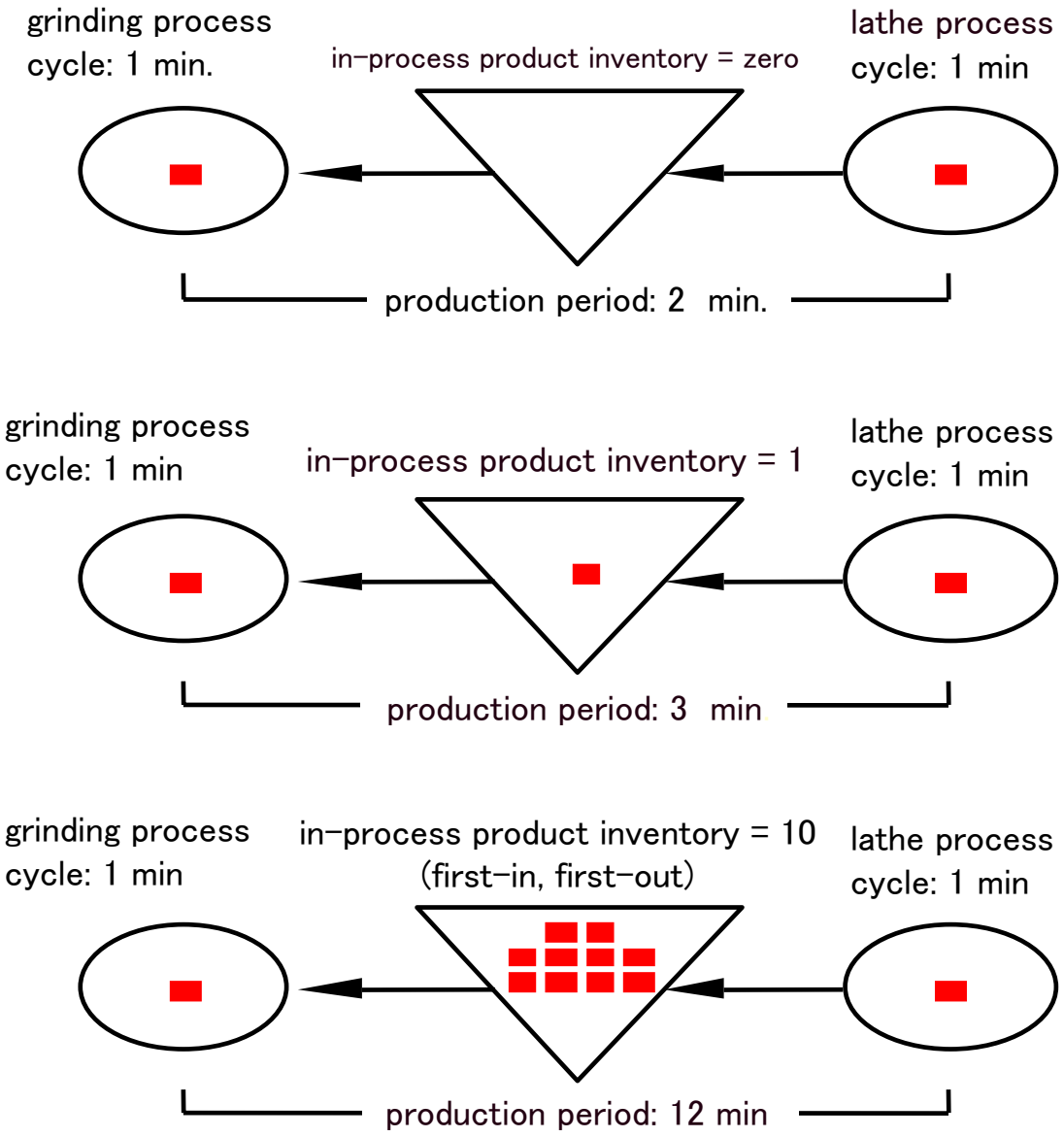

product design
(information M+A+B)
information B
information A
information M
design/worker
information stock B
design/worker
information stock A
product design information B
product design information A
customer
information
M+A+B
M+A+B
M+A
M+A
M
information
M
supplying company
finished-product
inventory
second
operation
in-process
product
inventory
first
operation
material
inventory
information flow
product (Mono) flow
work (in-process product)

Diagram 6 14 In-Process Product Inventory and Throughput Time



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2. Variety and Function of Inventory

(1) Pipeline inventory (warehouse, inventory in transportation)

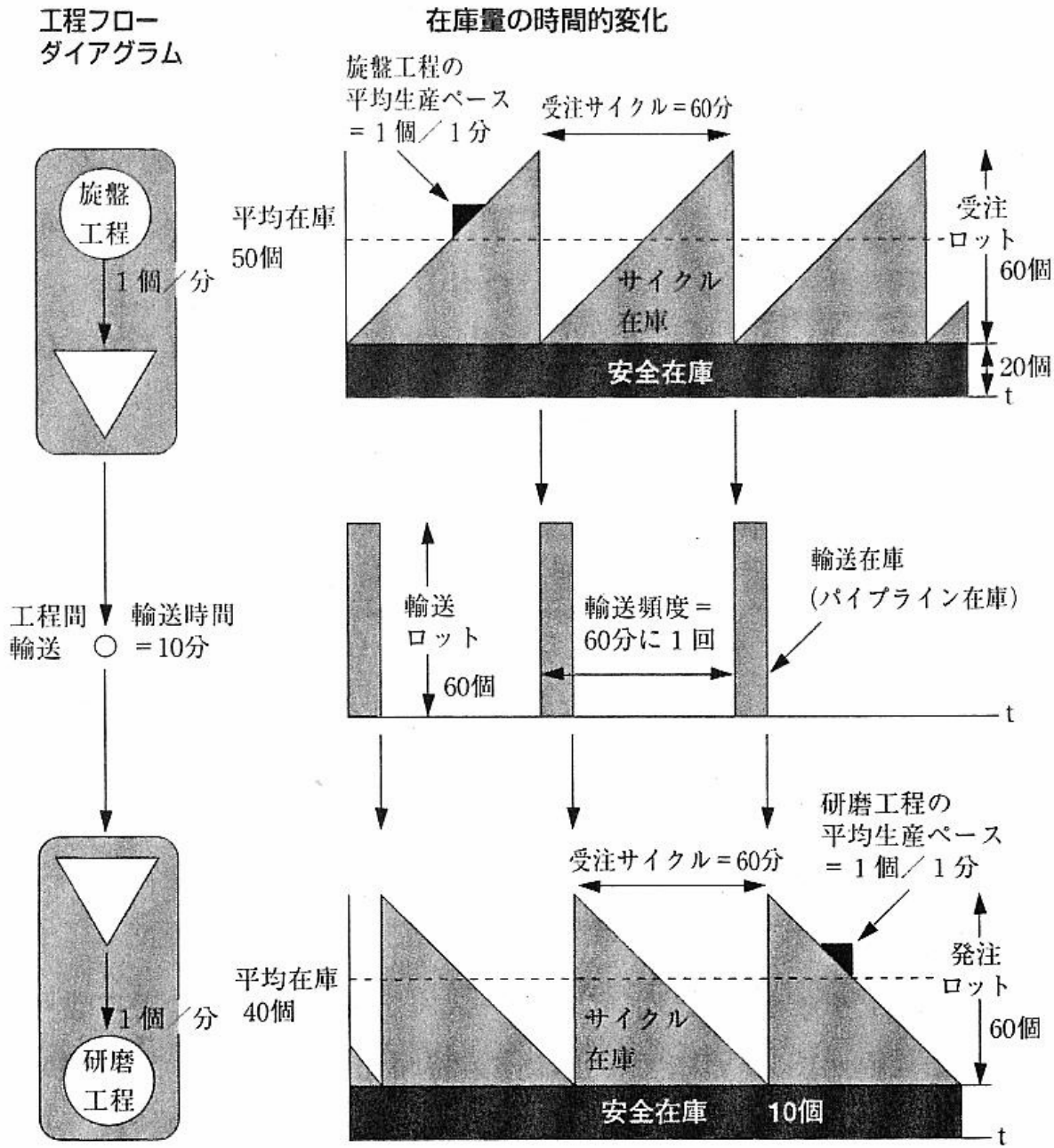
(2) Cycle inventory (to accrue depending on lot size)

(3) Buffer inventory
(to correspond to fluctuation of order volume)

(4) Inventory corresponding to seasonal variation
(gap between seasonal variation and leveled production)

(5) Decoupling in-process inventory
(to relieve interdependence among processes)

サイクル在庫・安全在庫・パイプライン在庫



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Types of Inventory System

(1) System corresponding to independent demand

fixed-quantity order system

fixed-time order system

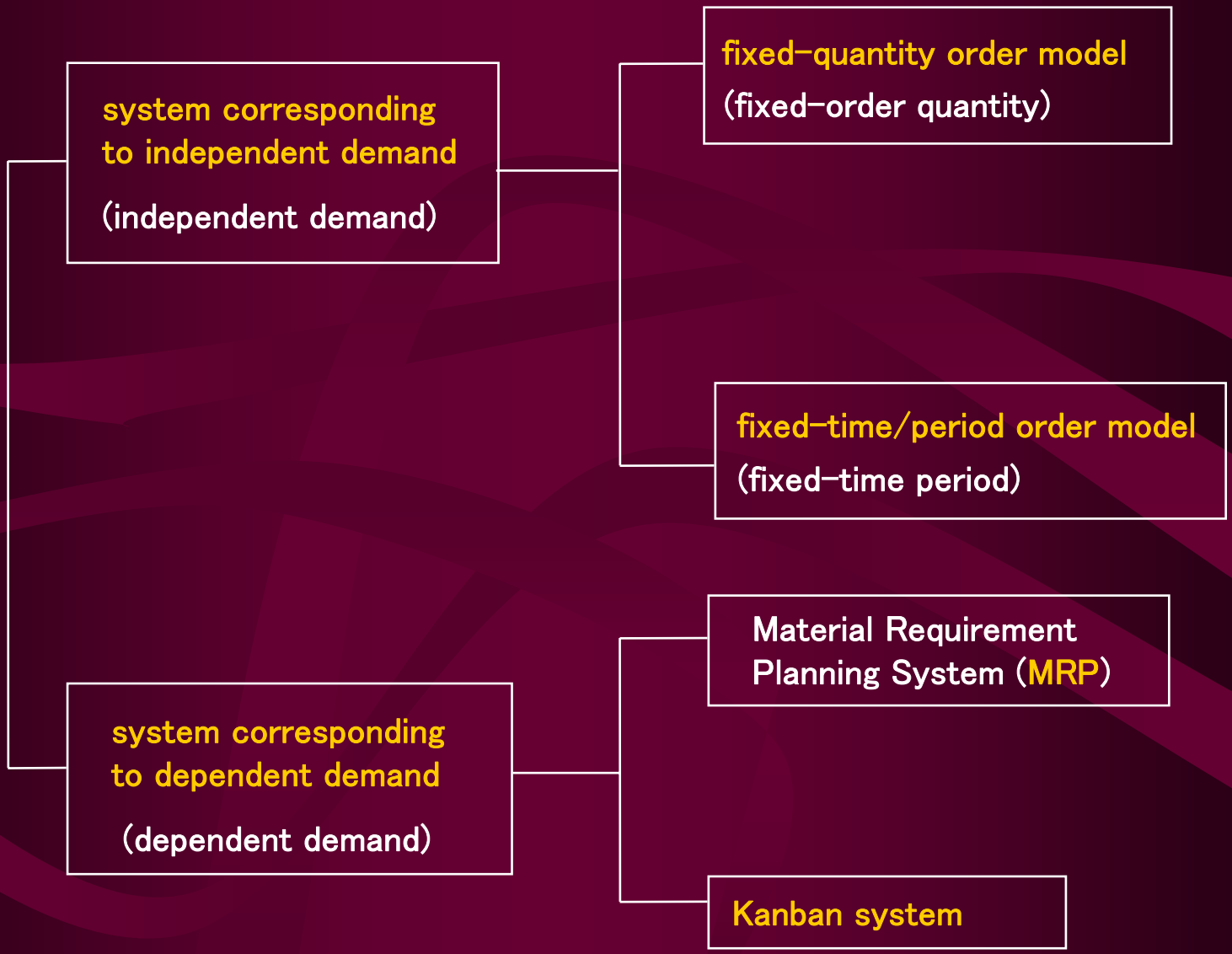
IPS (Inventory Planning System: MRP's independent-demand version)
(skip)

(2) System corresponding to dependent demand

MRP, MRP Ⅱ

Kanban system

Types of Main Inventory System



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3. Fixed-Quantity Order and Fixed-Period Order

(1) Fixed-Quantity Order

Order lot is constant.

Check inventory all the time.

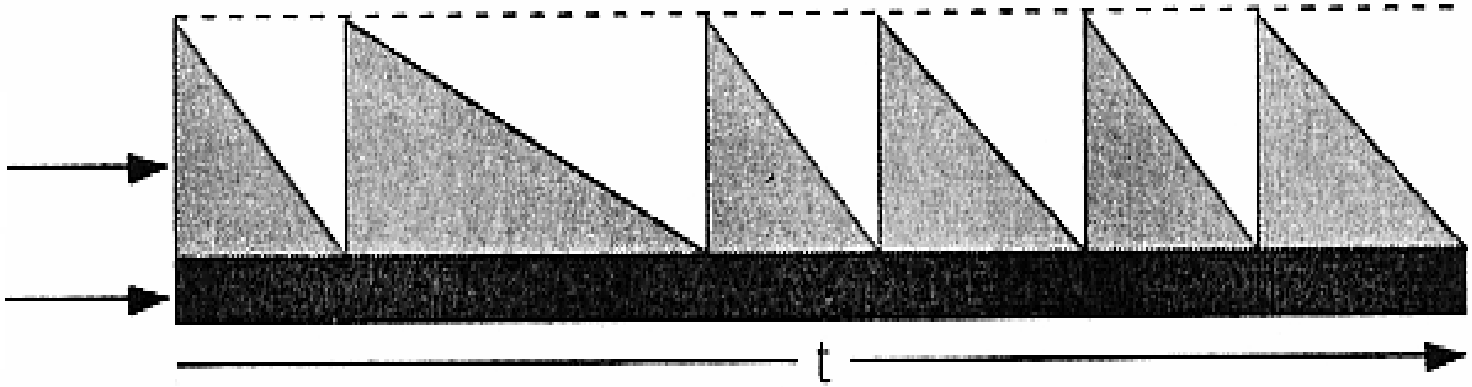
Automatically place order when inventory reaches reorder point.

Order interval is elastic.

"2 bin system" is a typical case in point.

Fixed-Quantity Order System

Order volume is constant each time. Order cycle is elastic.



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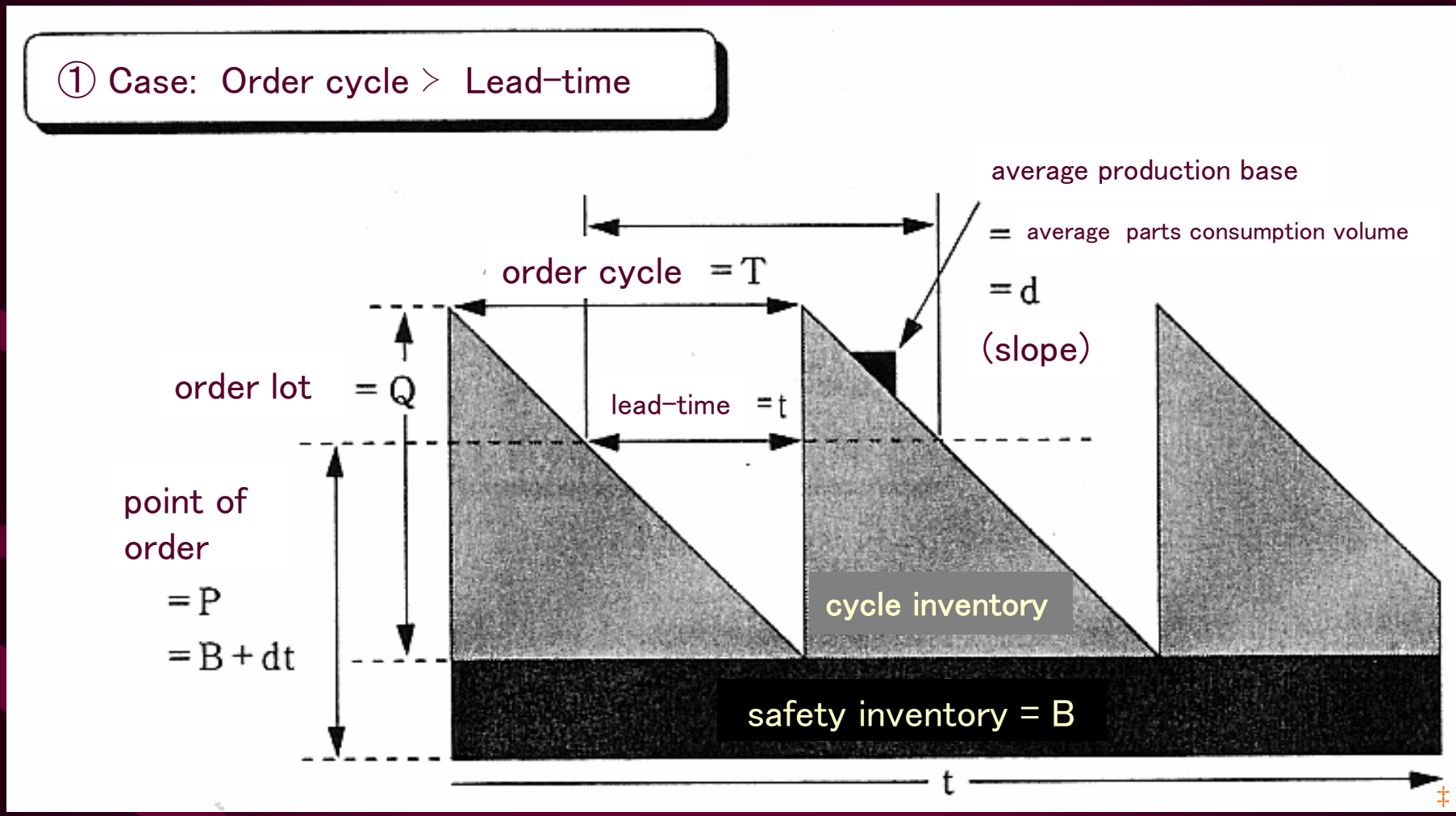

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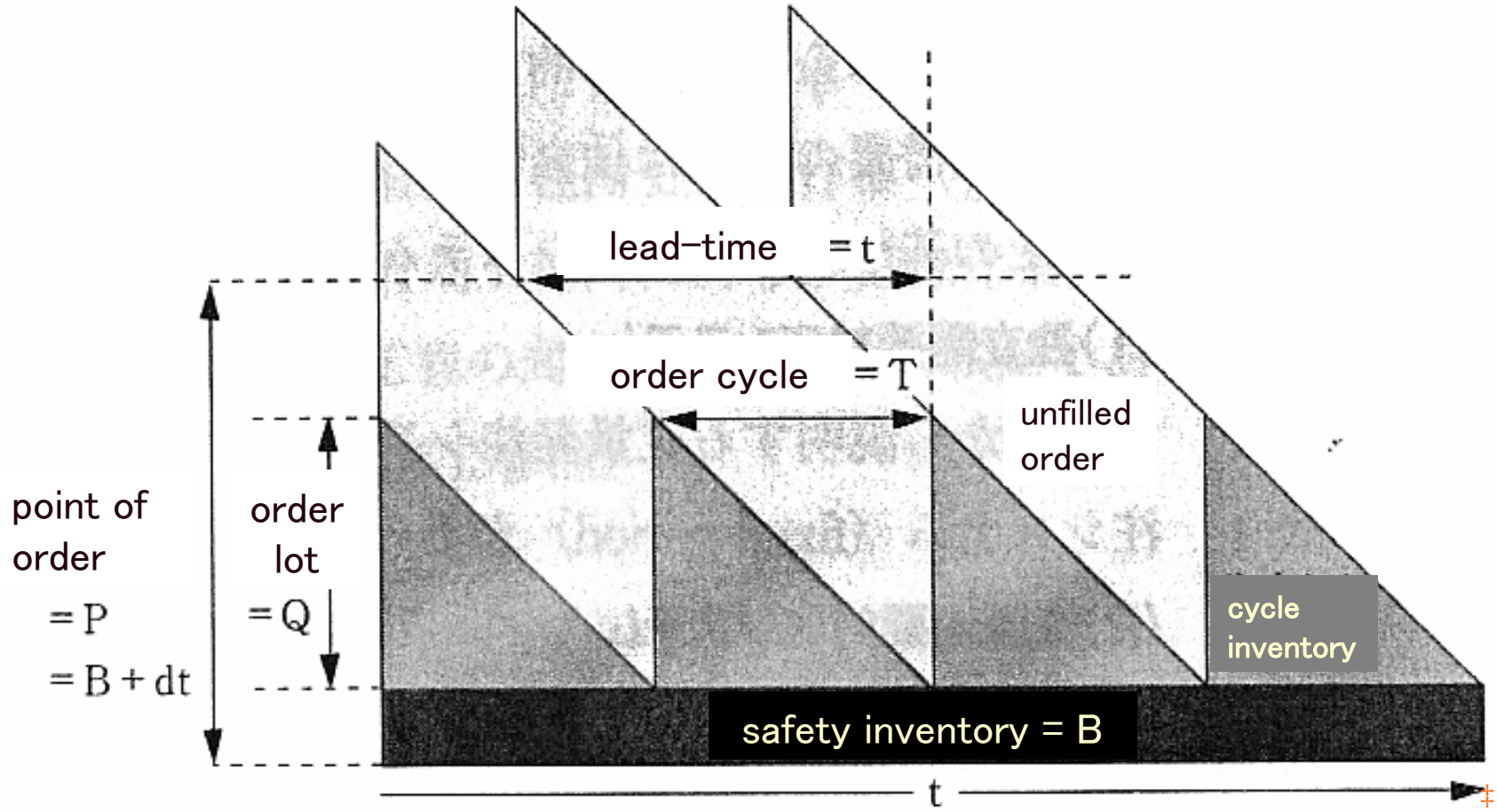
② Case: Lead-time > Order cycle



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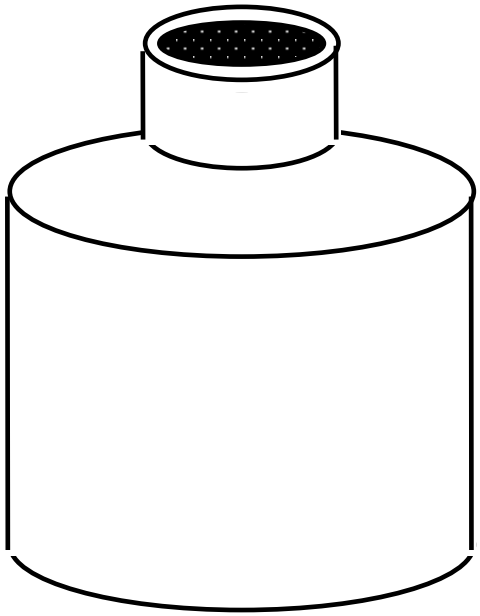
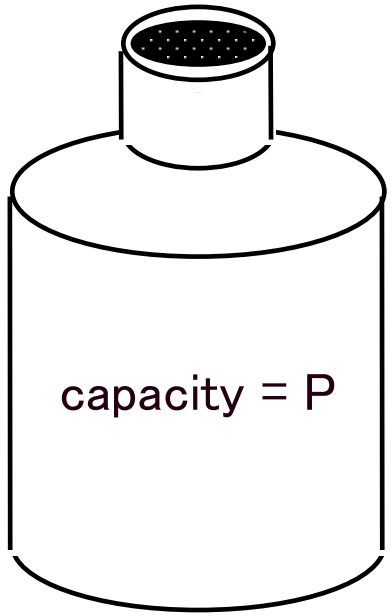
2-Bin System

container 1



container 2



Consume material from Container 1.
When Container 1 becomes empty, place a refill order.

Container 2 is firstly filled with the arrived material.

‡

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Fixed-Quantity Order :
Level of Buffer Inventory (Safety Inventory)

Balance between inventory-holding cost and out-of-stock cost (opportunity cost)

Assume a probability distribution of demand volume to accrue in a given period.

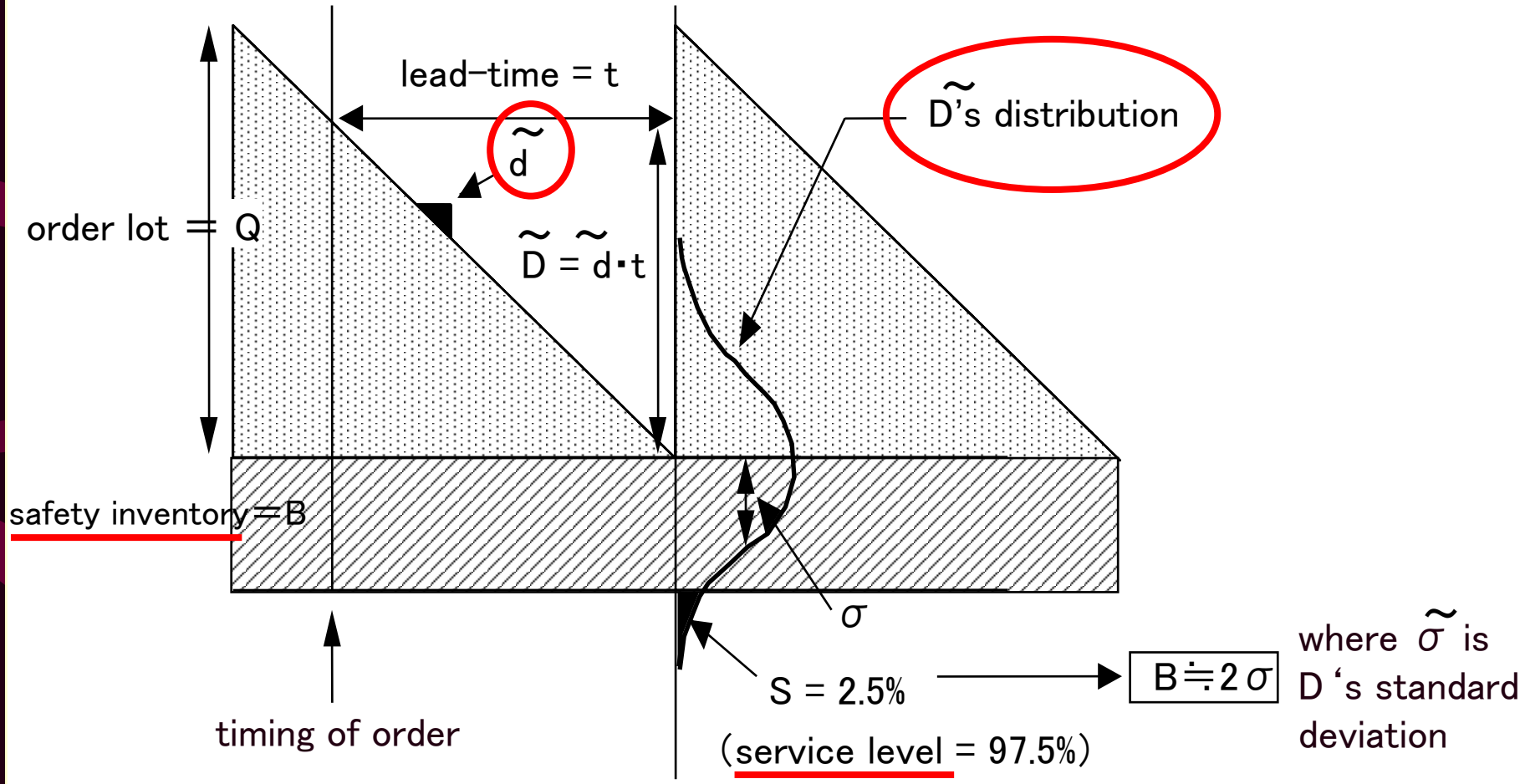
Set "probability of desirable out-of-stock" (service level: 1 - s).

Set safety inventory at a level where out-of-stock probability becomes "S" at the bottom of inventory.

for example, in Critical Fractile method,

s = L / (G + L)　L = variable profit,　G = inventory cost, etc.

Level of Safety Stock



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Fixed-Quantity Order: Setting Order Lot Size (EOQ)

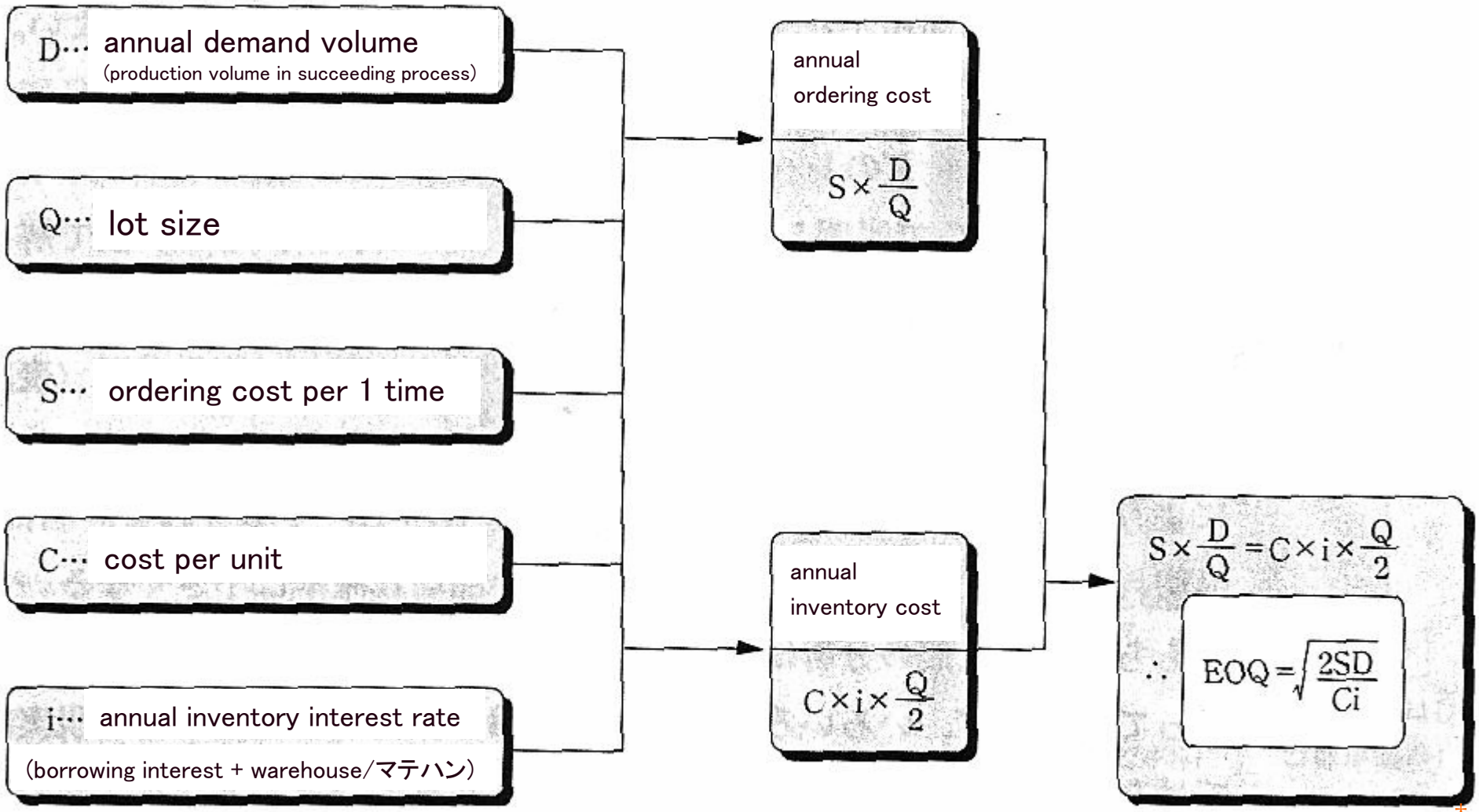
When an order lot size = Q,
then, an average cycle inventory level = Q / 2.

EOQ (Economic Order Quantity)

an optimum lot size in short term,
on assumptions of fixed-quantity order,
without buffer inventory, with no uncertainty

static balance concept (⇔ Kanban system)

concept of EOQ



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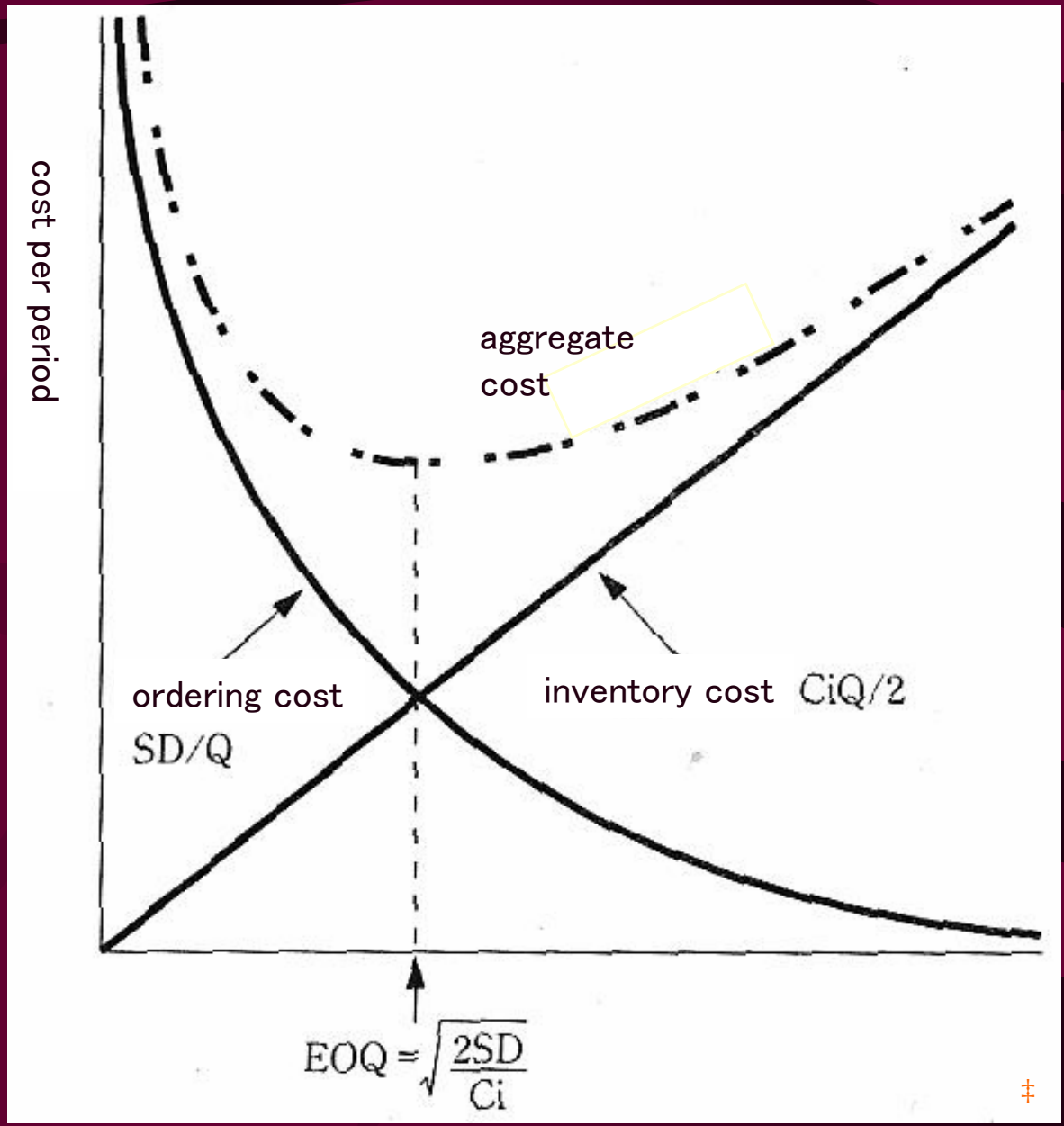
Aggregate cost = Inventory cost + Ordering cost ---Minimization thereof



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(2) Fixed-Period Order System

Order periodically (Order interval is constant.).

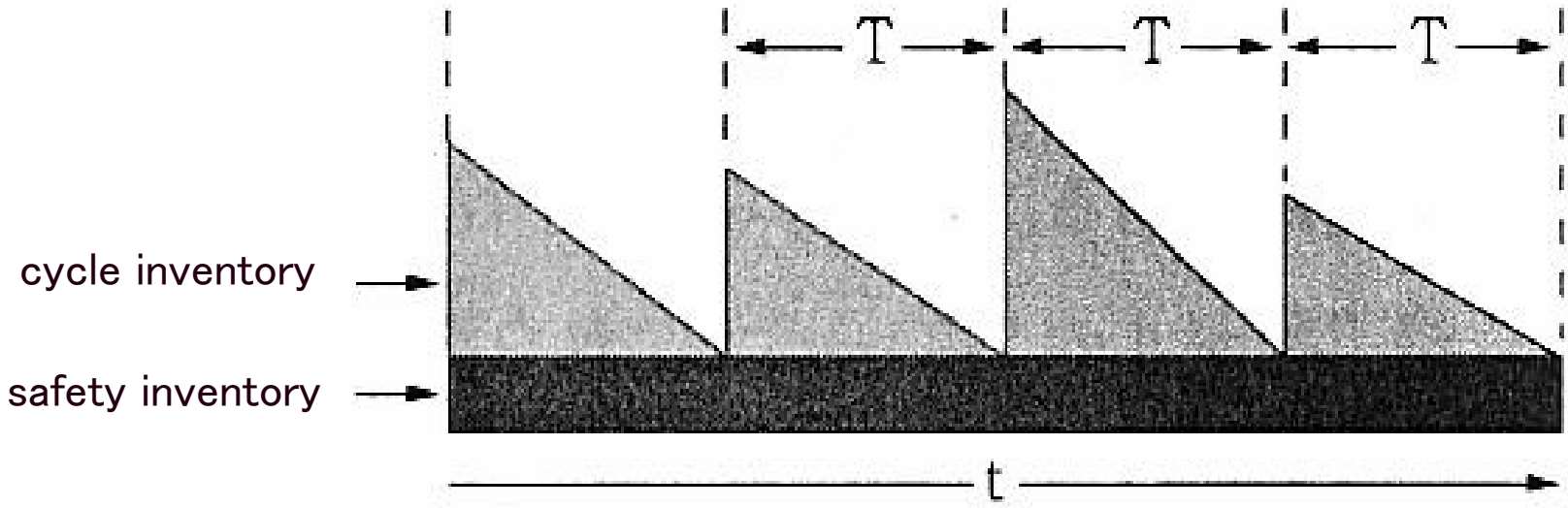
Order quantity per one occasion is elastic (Qt).

Set an upper limit value (M) for unfilled order + inventory,
based on safety inventory, order interval, and delivery lead-time →
When unfilled order = Ot, inventory = It ,at ordering time-point = t,
an order volume at t time t is Qt = M − Ot − It.

Basic thought on setting a safety inventory level is the same with one on the fixed-volume order.

Fixed-Period Order System

Order cycle is constant. Order volume is elastic each time.



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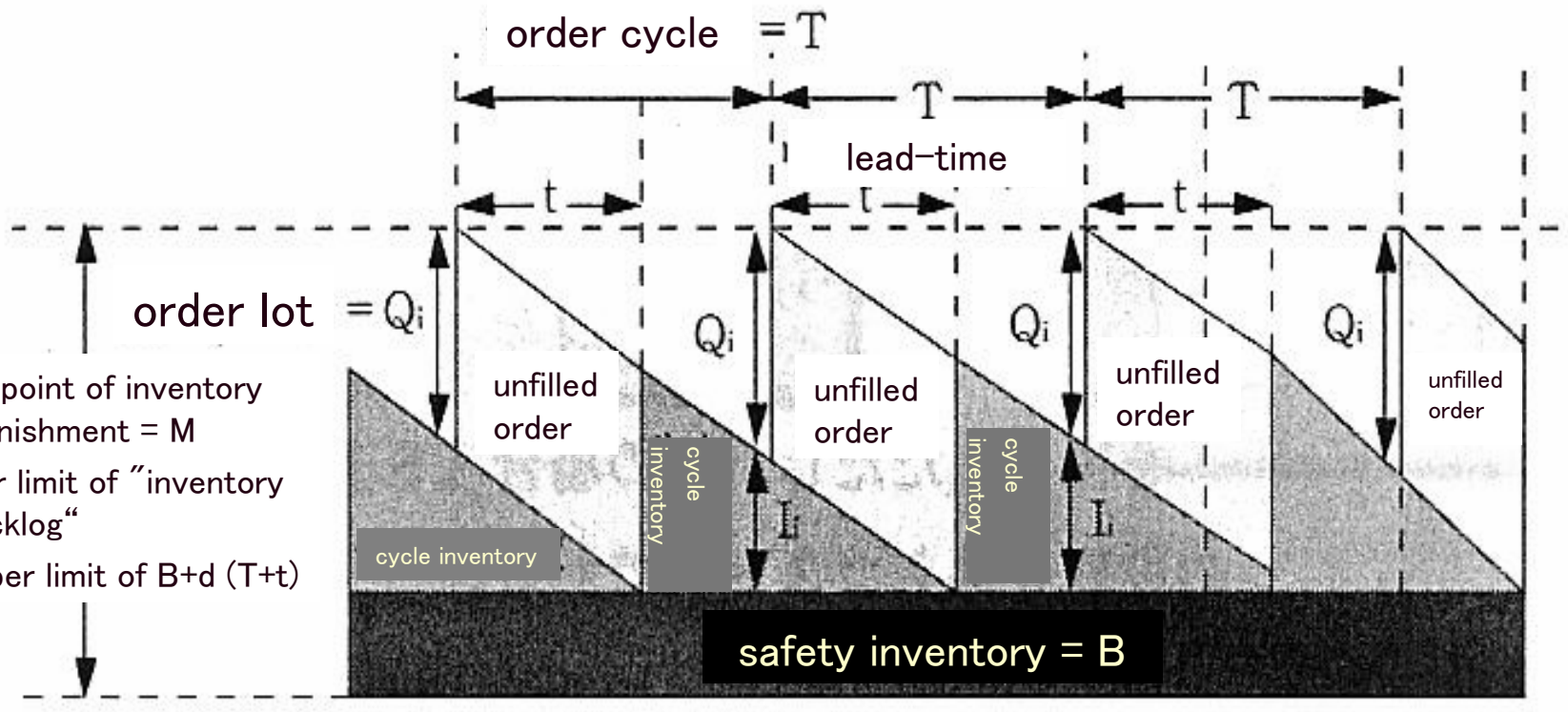
Case: Delivery Lead-time (t) < Order Cycle (T)

$Q_i = M - I_i - B$



while,

M = inventory level point = upper limit of "safety inventory + cycle inventory + unfilled order"

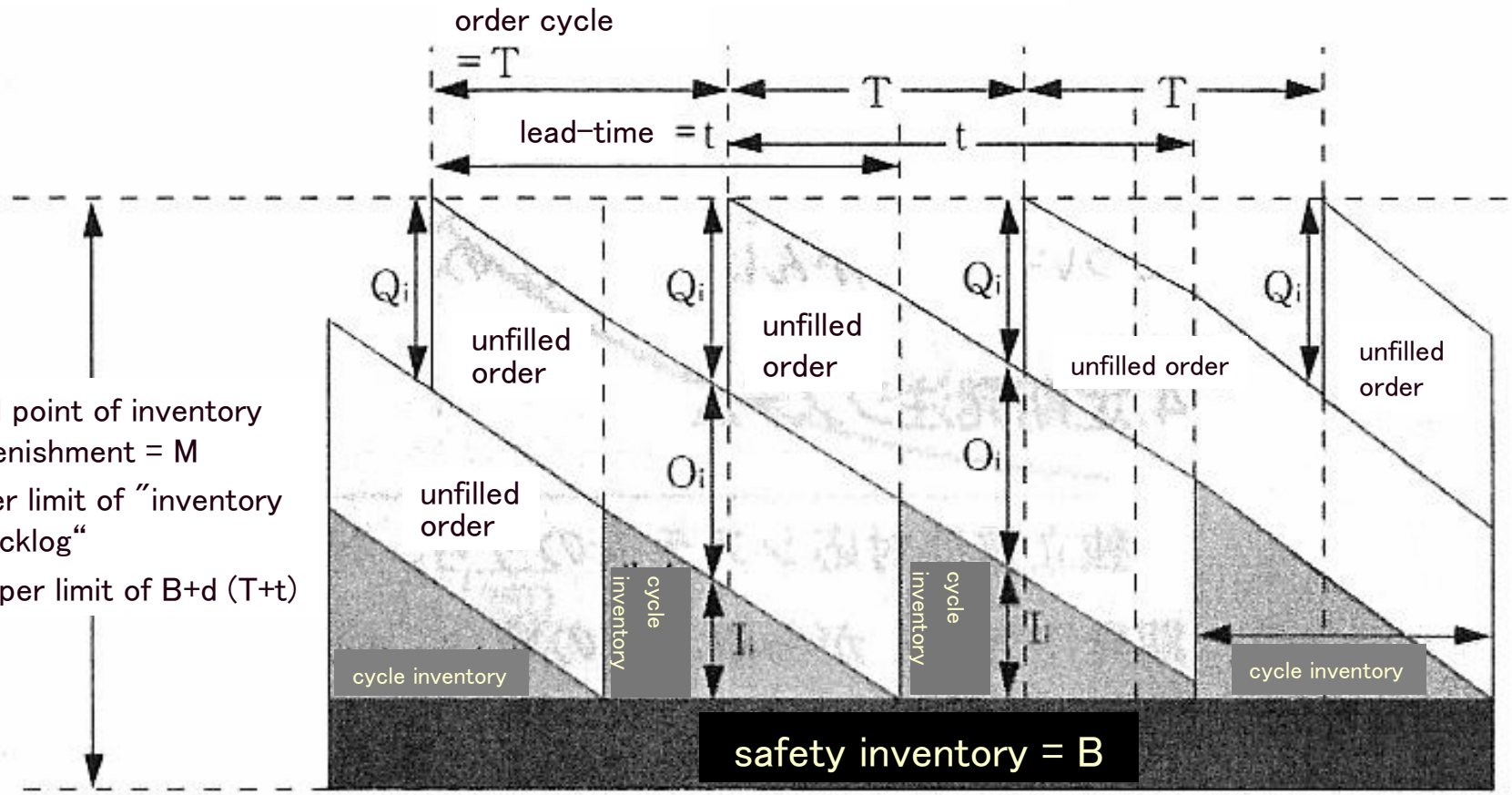
Ii = inventory at ordering time-point of sequential order i

Oi = unfilled order = 0 at ordering time-point of sequential order i

Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (I p222 figure.6.21)

Case: Delivery Lead-time (t) > Order Cycle (T)

$$Q_i = M - I_i - O_i - B$$



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‡

Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (I p222 figure.6.21)

4. Kanban System

One of representative "dependent demand corresponding systems", along with MRP.

Which was established primarily by 耐一　Ono in Toyota Automobiles.

Kanban is---

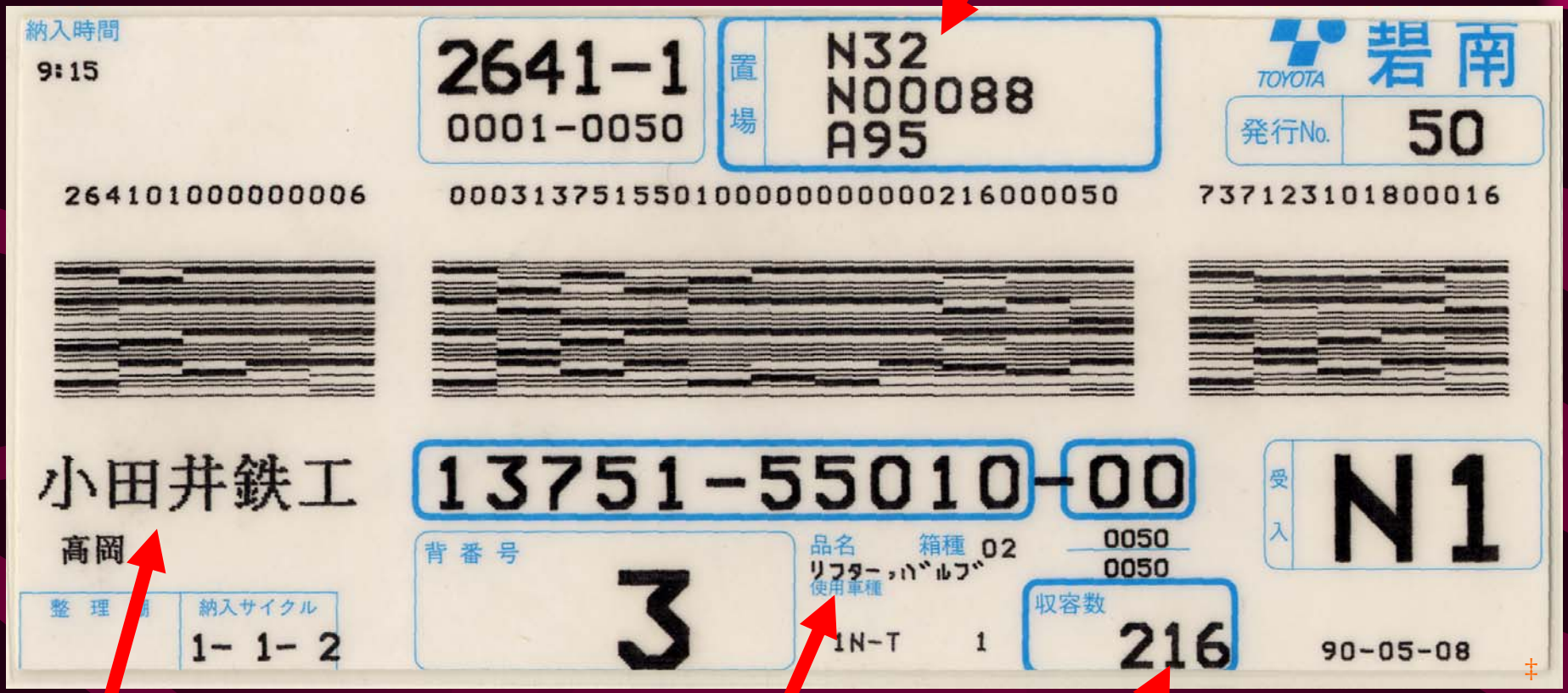
used for both delivery instruction (order) and production instruction (order release)

the card (circulating invoice) which can be used repeatedly.

(1) take-back Kanban

(2) order release (in-process) Kanban

Take-back Kanban



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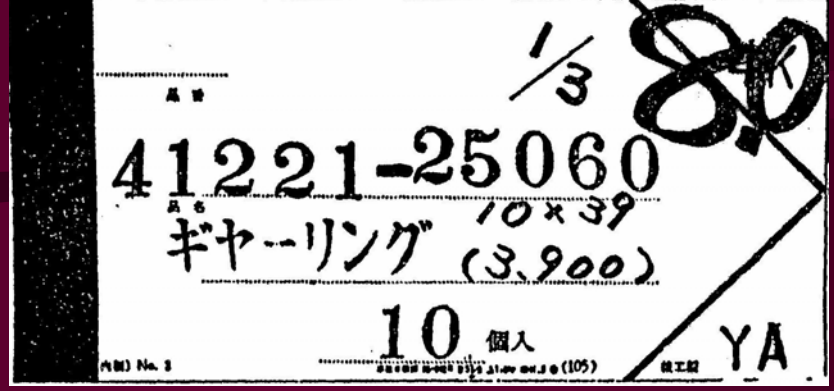
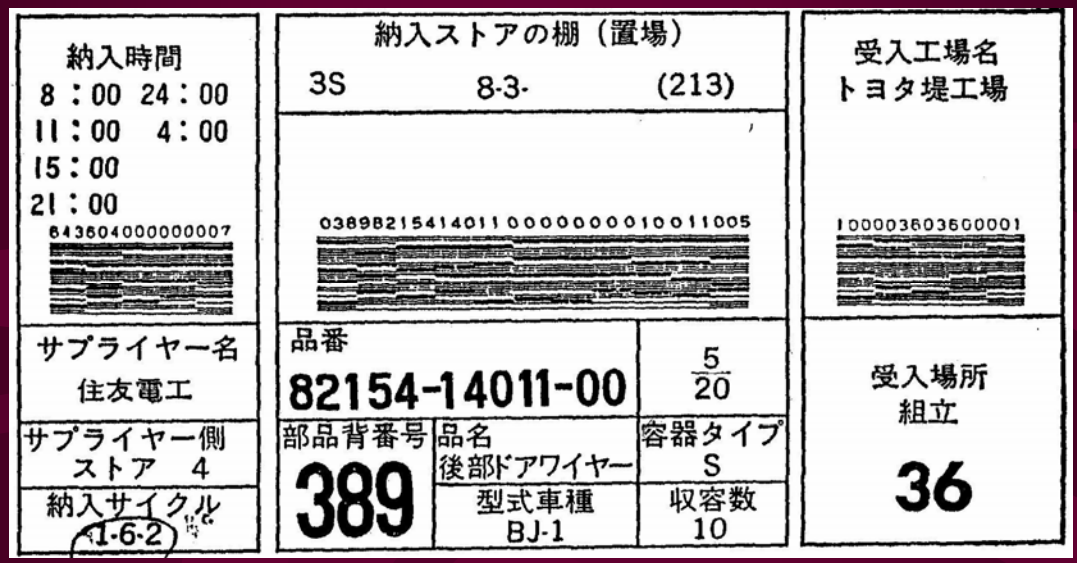
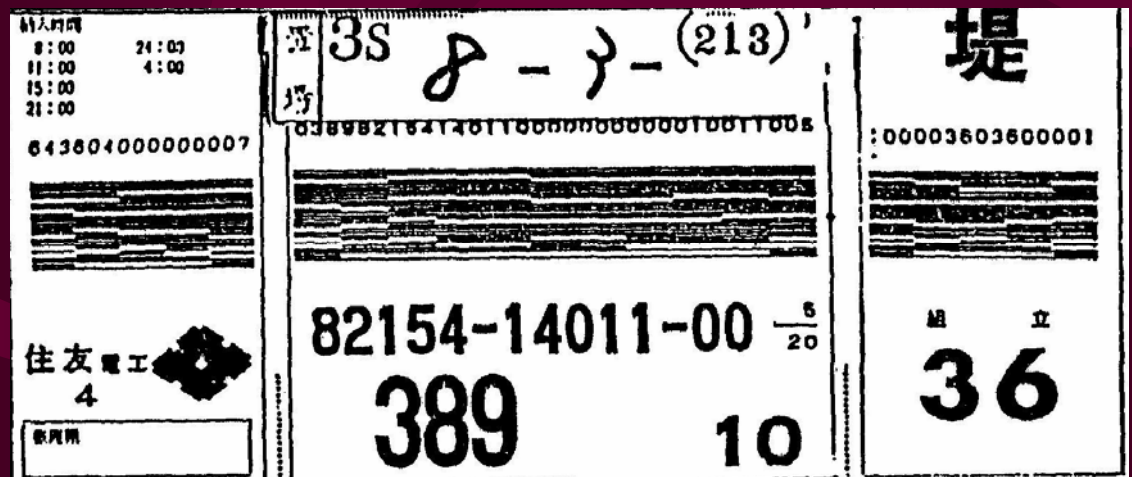
Variety of Kanban







Basics of Kanban System

"Take back by succeeding process"

--- Process in a downstream goes to its upper stream to take its required parts in a required quantity. I.e., a "pull method".

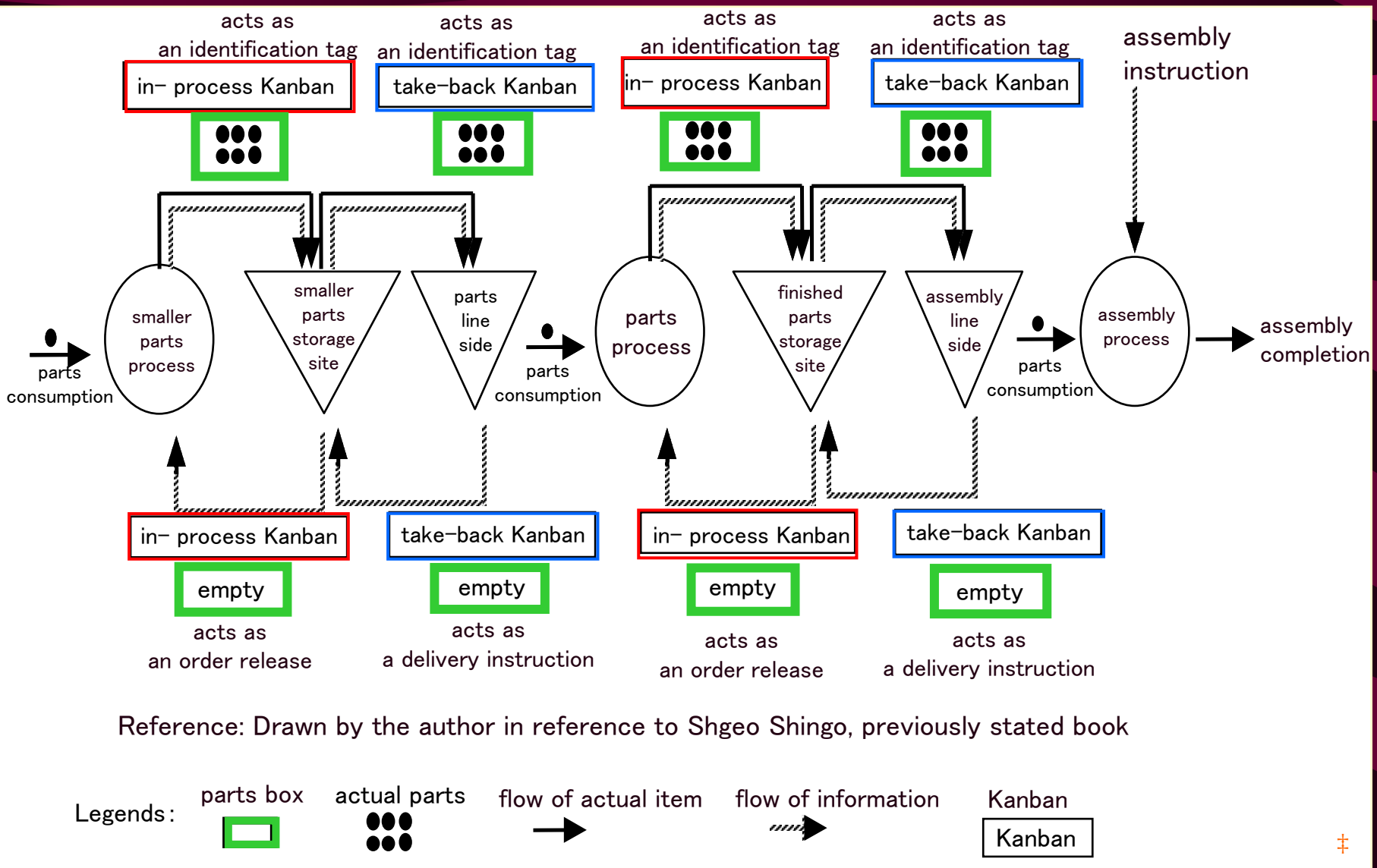
Kanban moves together with a standardized container which includes n units of in-process parts. (shadow of container)

number of containers (N) = number of Kanban pieces

speed of container's movement = speed of Kanban

(synchronization of Mono and information)

Flow of Kanban, Container, and Actual Items



Reference: Drawn by the author in reference to Shgeo Shingo, previously stated book

Legends: parts box, actual parts, flow of actual item, flow of information, Kanban (Kanban)

Author making (reference: Shigeo Shingo 'IE consideration of the Toyota Production System')
Reference: Takahiro Fujimoto 'Introduction to Production Mmanagement' Nihon Keizai Shimbun, Inc. 2001 (I p226)

Function of Kanban changes depending on the container' conditions.

(1)When it is with a container full of parts (outward):

---- Kanban is an "identification tag".

(2)When it is with an empty box (homeward):

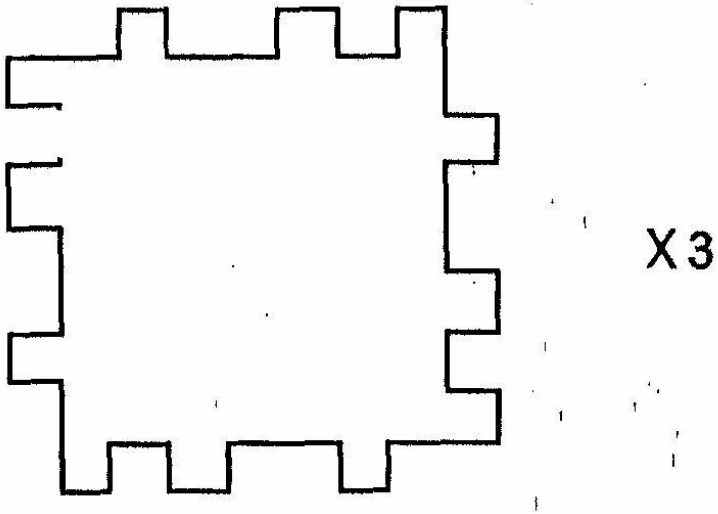
--- Kanban is a "delivery instruction tag" and an "order release".

Analogy of a ski lift

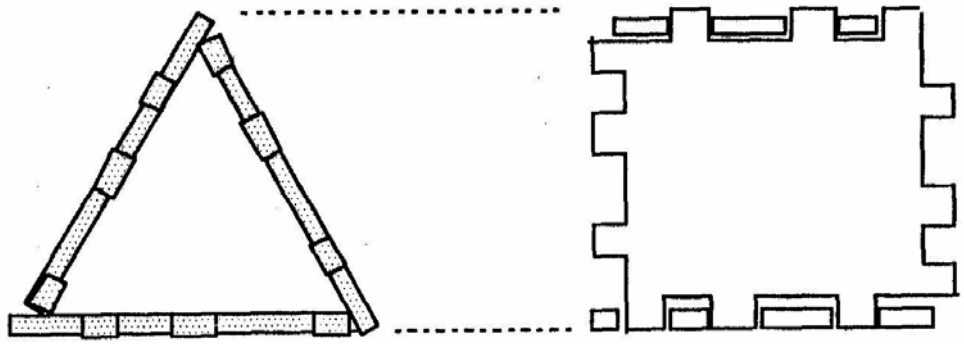
Consider the ski lift's chairs as containers, and persons as parts;
An equalized movement;
Number of people disembarked at the mountain peak accrues number of empty seats (accrual of empty boxes);
Number of seats (content quantity) is set (1 seat, 2 seats, 3 seats ---);
People get on the lift at the hillside when empty seats come around;
Departure time is not fixed. (fixed-quantity and irregular trip).

Kanban Test --- Design-Draw Product

<parts>



<product assembly drawing>



front view

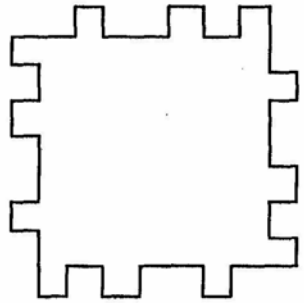
side view

hollow triangle pole

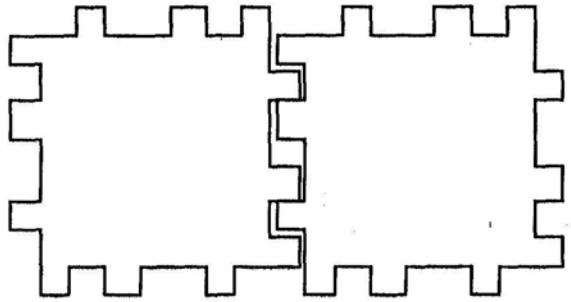
Kanban Test --- Work Standardization of Upstream Process

＜Work Standard of the First Process＞

（1）Prepare
2 plates.



（2）Bring 2 sheets together as the following .

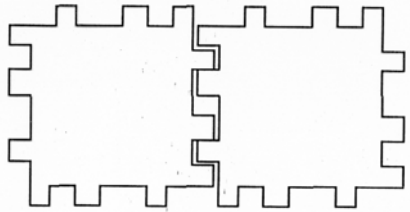


（3）Put the completed parts (sub assembly) into a container.

Kanban Test --- Work Standardization of Downstream Process

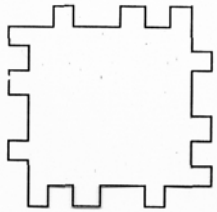
第２工程の作業標準

（１）第１工程から来た部品

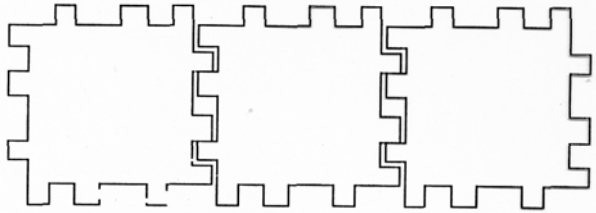


の品質をチェックする。

（２）これに手持ちの部品

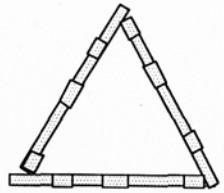


を接合して



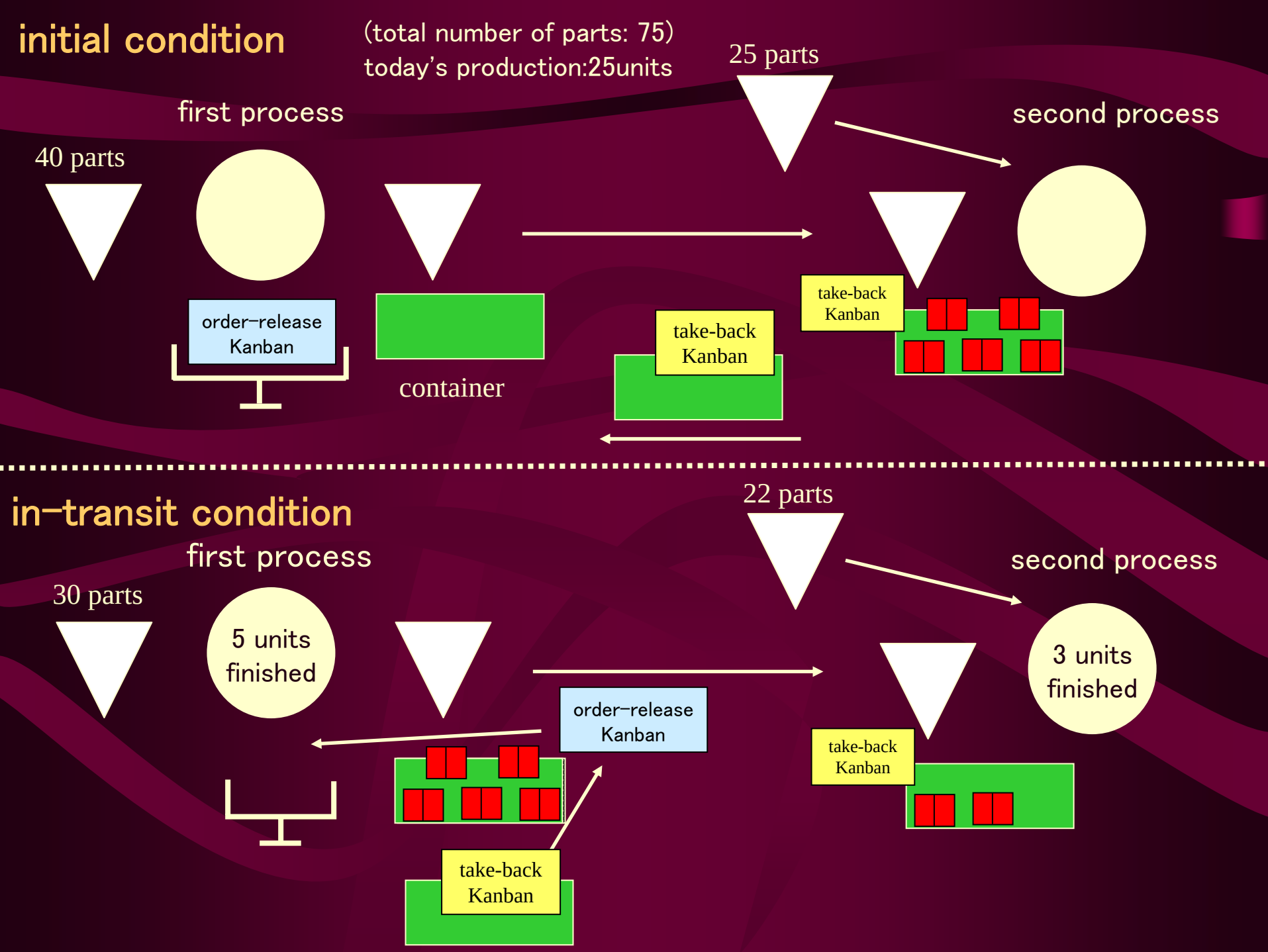
を作る。

（３）さらに両端を接合して、中空の三角柱



を作る。

（４）出来上がった製品の品質をチェックし、良品を コンテナに入れる。


initial condition
(total number of parts: 75)
today's production:25units
25 parts
first process
second process
40 parts
order-release Kanban
container
take-back Kanban
take-back Kanban
in-transit condition
22 parts
first process
second process
30 parts
5 units finished
3 units finished
order-release Kanban
take-back Kanban
take-back Kanban

Take-back Kanban

name of parts: subassembly (pair of 2 sheets)

preceding process = first process
succeeding process = 2nd process
container content quantity = 5

Take-back Kanban

name of parts: subassembly (pair of 2 sheets)

preceding process = first process
succeeding process = 2nd process
container content quantity = 5

Order-release Kanban

name of parts: subassembly (pair of 2 sheets)

preceding process = first process
production quantity = 5

Decision on Pieces of Kanban (= Quantity of Containers)

$$N = (Q + B) / n$$

Demand speed of a succeeding process (constant, assured) = d

When a delivery equals a re-order (zero lead-time),

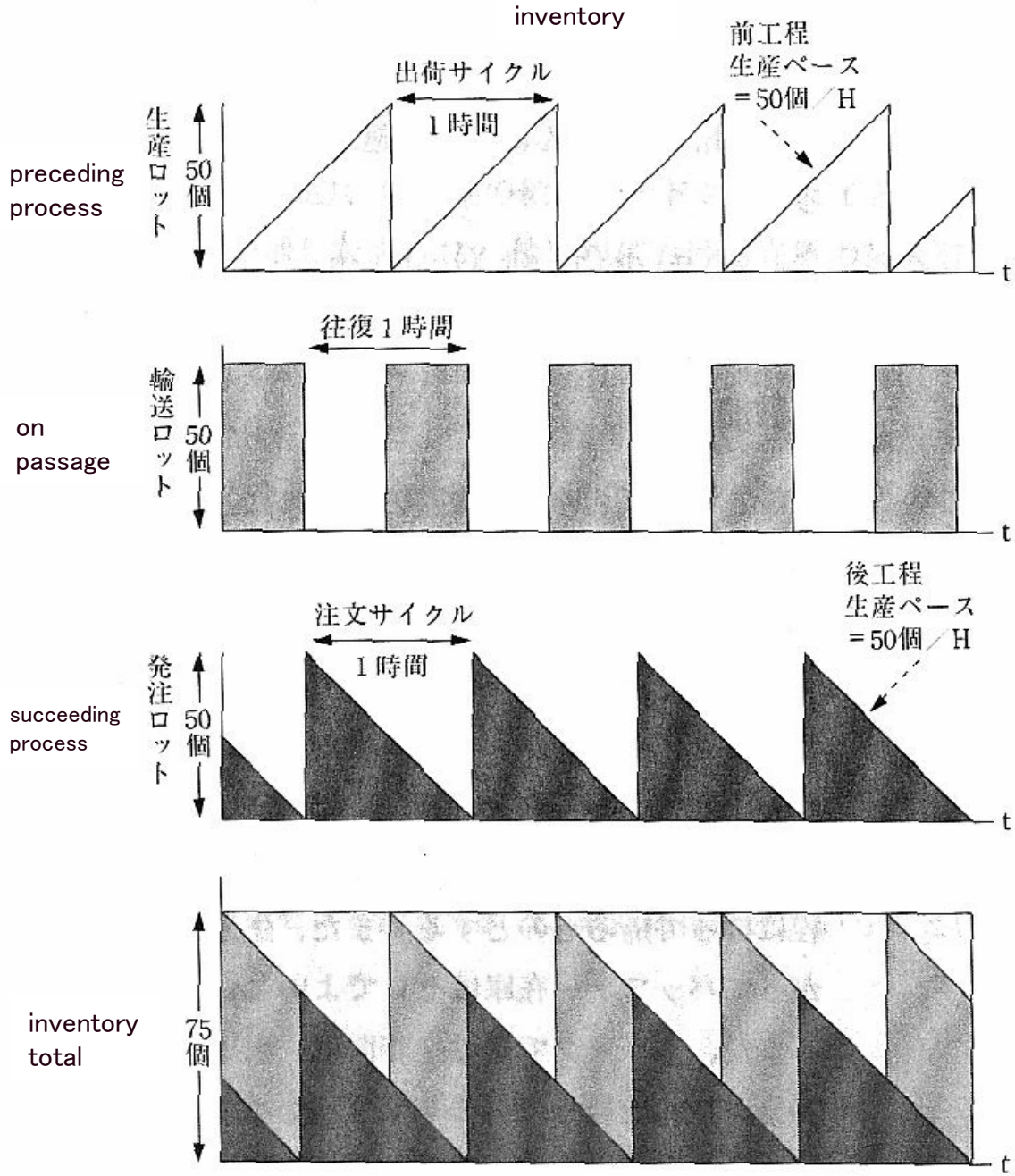
$$N = (d \cdot t + B) / n$$

While t = delivery lead-time of preceding process,

= time for container to make one cycle of trip
between preceding and succeeding processes

= cycle time of take-back K + cycle time of order- release K

Case of Kanban System



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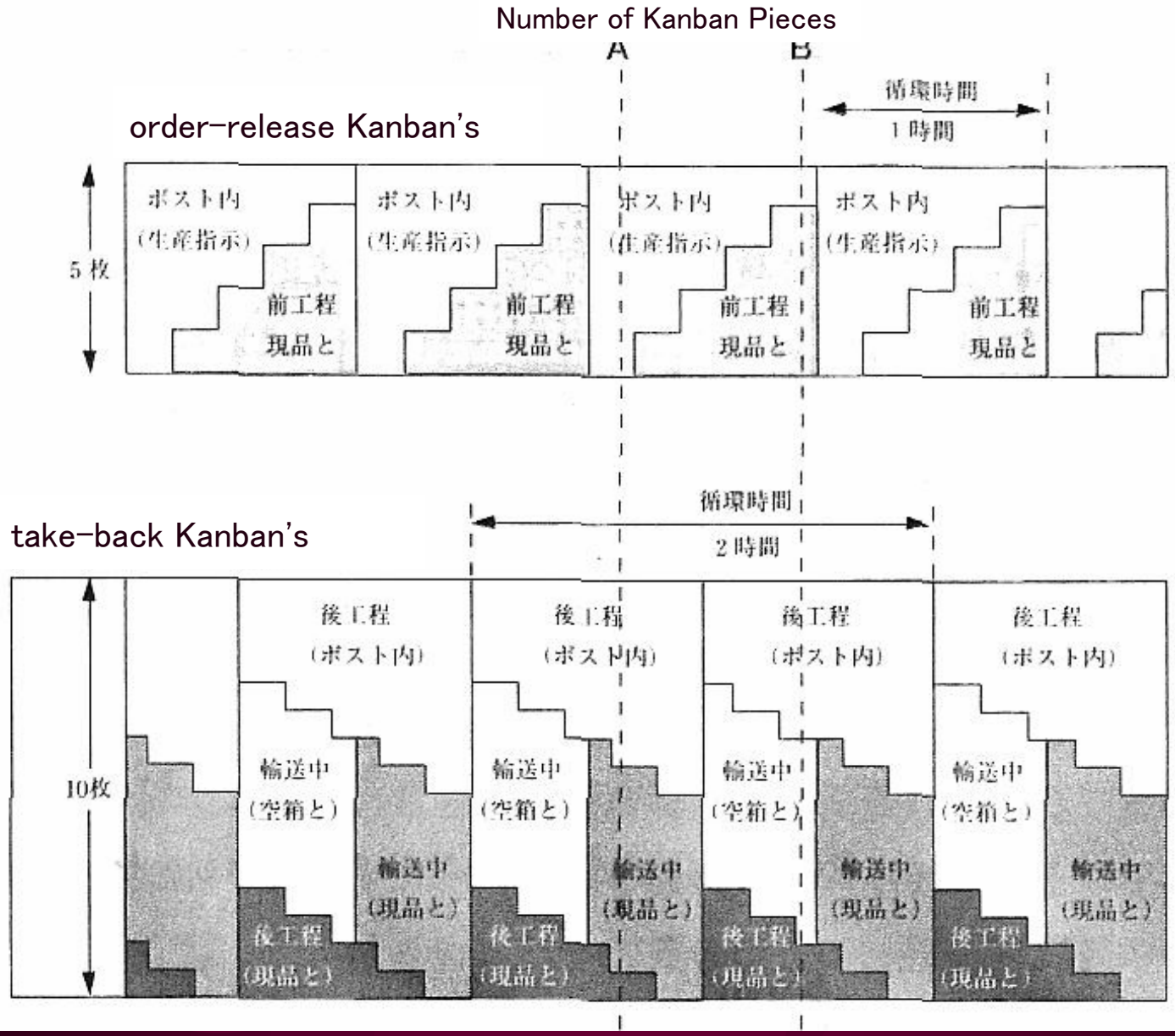
'Introduction to Production Management'
Nihon Keizai Shimbun, Inc. 2001
(Ⅰp230 figure.6.24)

(continued from previous slide)



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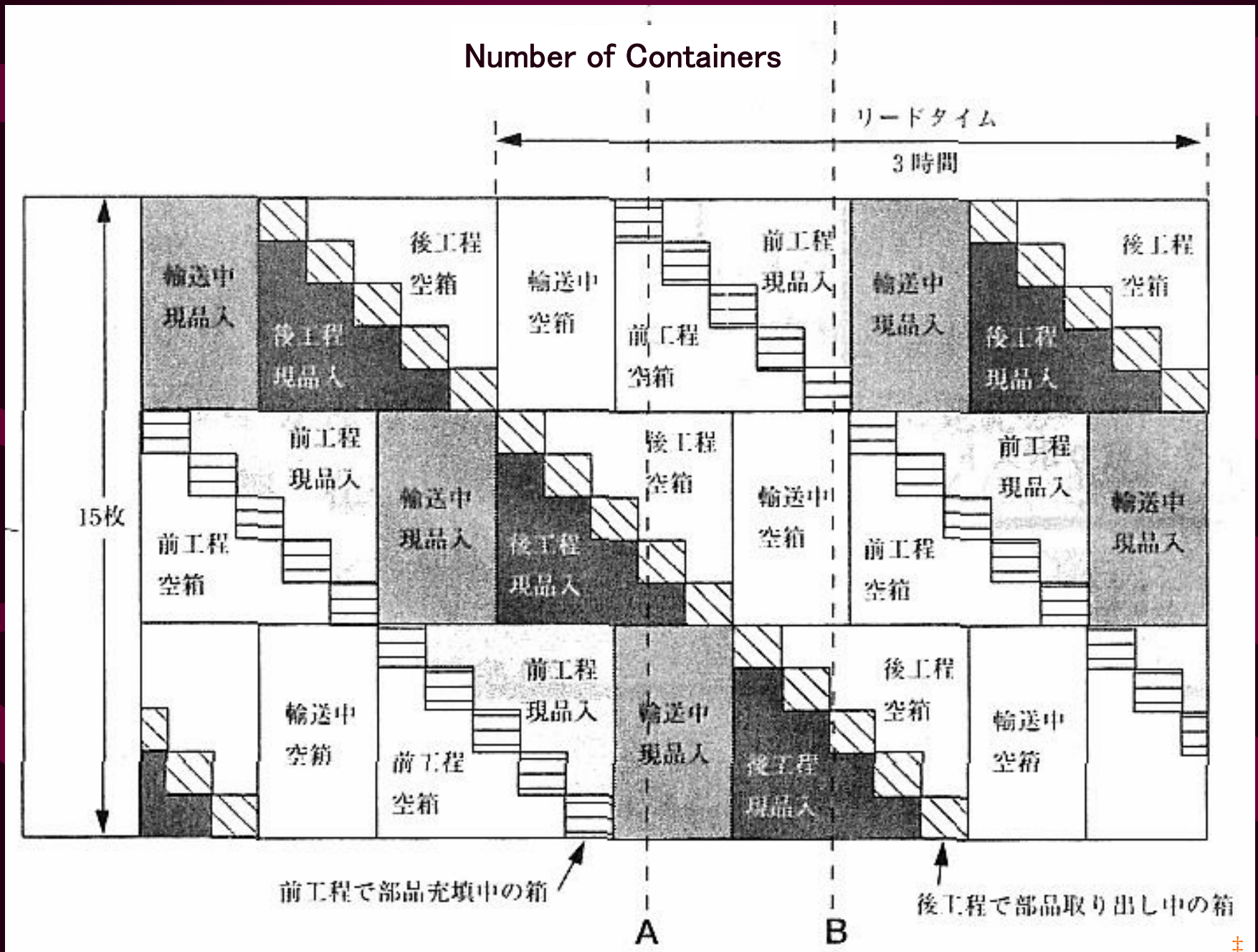
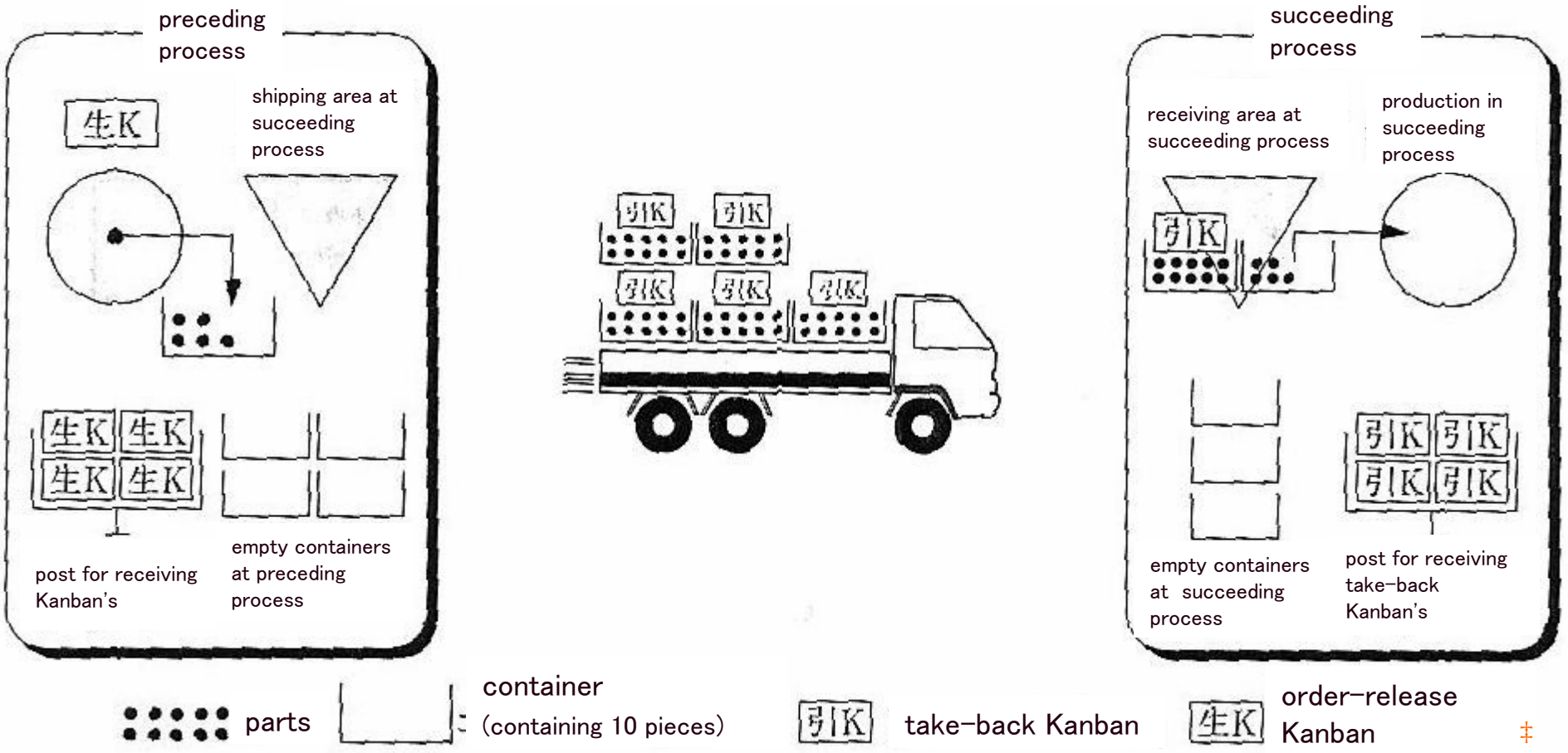


Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (I p231 figure.6.24)

(a) Snapshot of Kanban System (time point AA)



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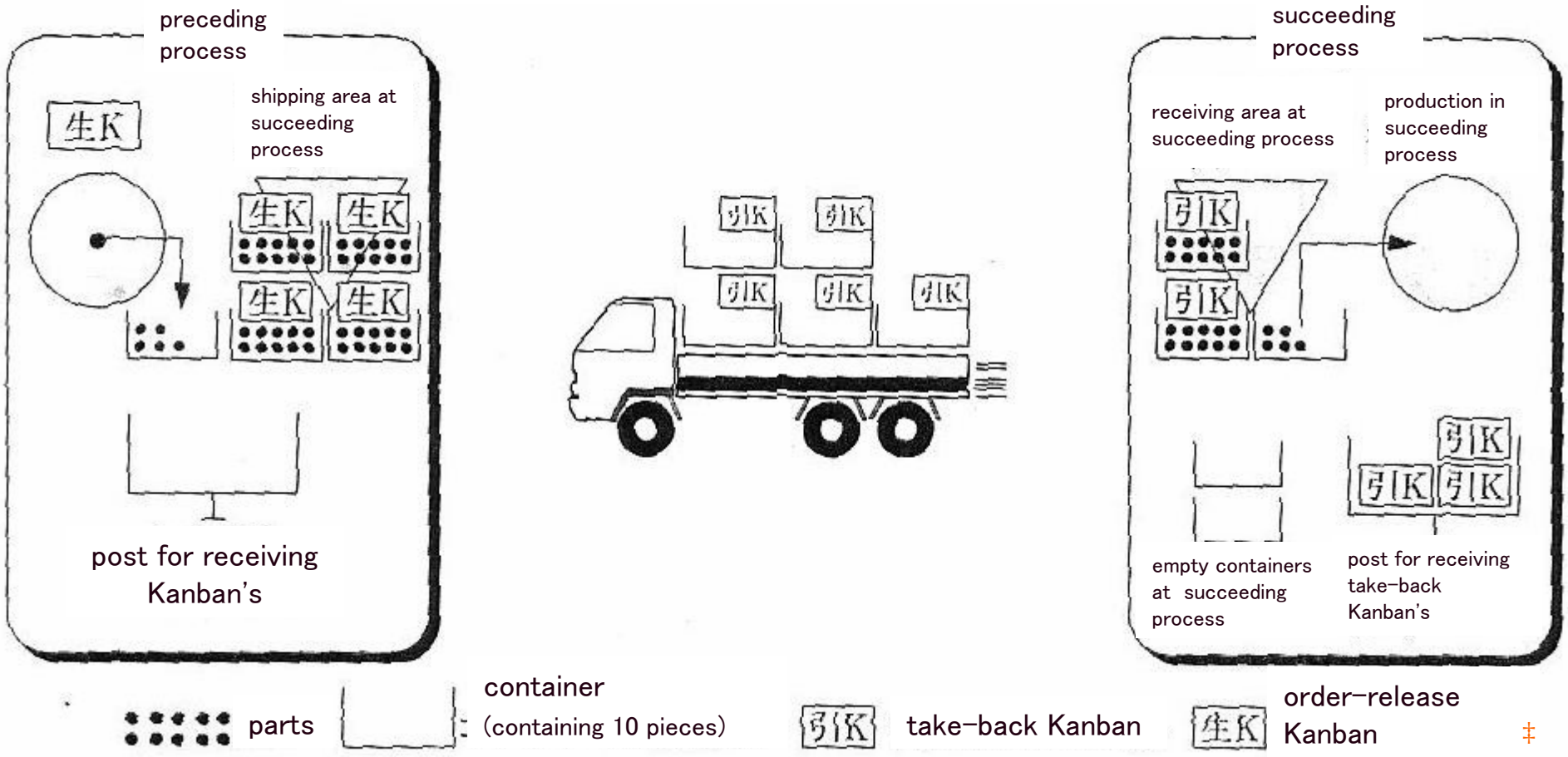
(b) Snapshot of Kanban System (time point BB)



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (I p232 figure.6.25)

Improvement of Production by Reducing Quantity of Kanban's

Calculate an optimum number of Kanban pieces by EOQ (Economic Order Quantity)?

$N = (EOQ + B) / n$ (right side → left side)

but, this is a static balance concept. No idea on improvement.

Rather, improve production through an effort to reduce number of Kanban pieces. (left side → right side)

(1) improvement on production and distribution
→ cutting down of lead-time (t)

(2) deduction of reserved-capability time

(3) equalization and stabilization of production
→ reduction of safety inventory (B)

Kanban System Contrasted to MRP

Both are based on Master Schedule
→ Calculate requirements by parts explosion.

Premises for Kanban are an equalization and a consistent cycle time.
Instead, no "lead-time compensation".

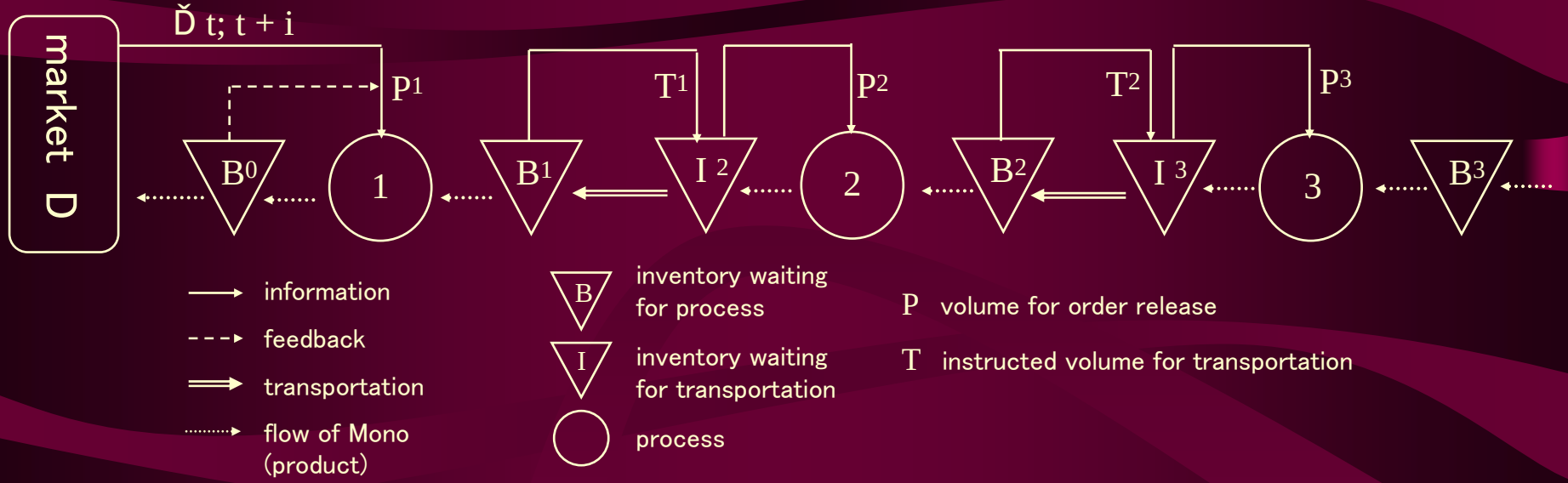
Kanban is a "pull method", while MRP is a "push method"

MRP does not have a means of an order release contained in Kanban.

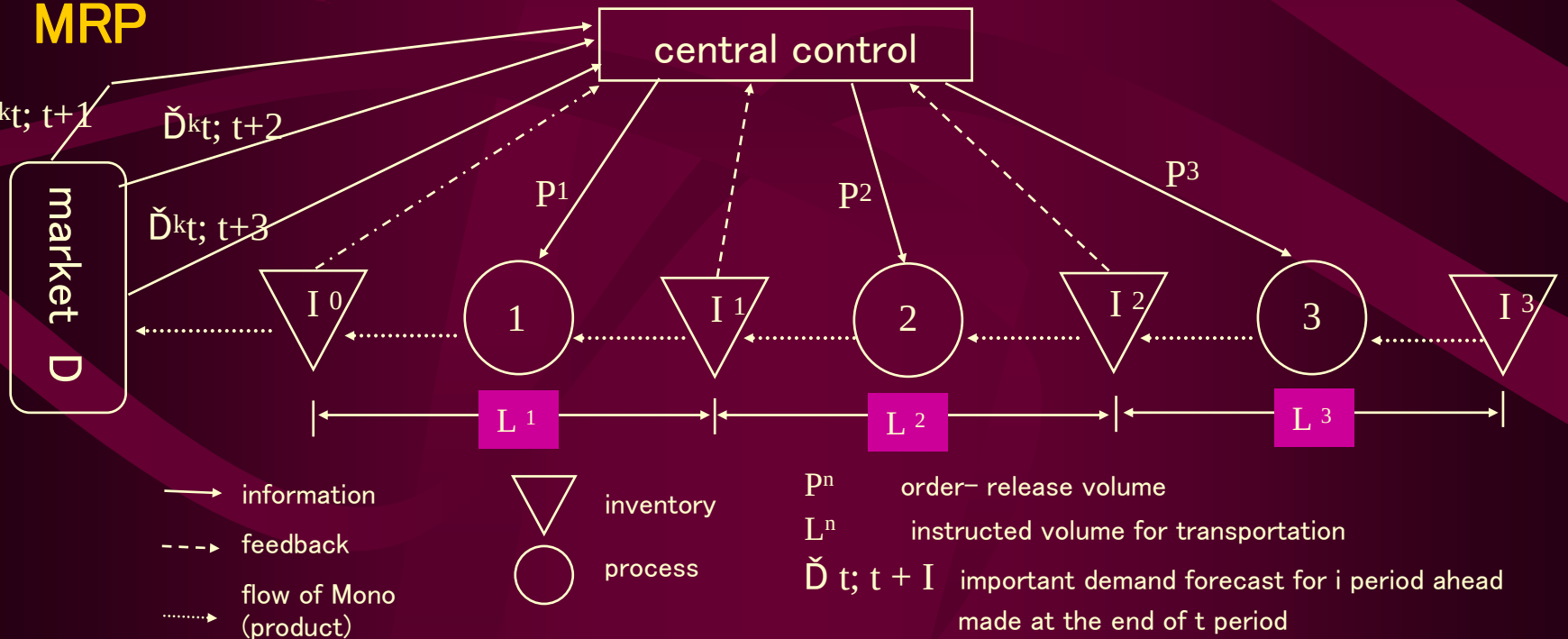
MRP does not contain a fine-tuning means and an improvement mechanism when deviations from plans incur.

MRP (planning) and Kanban (execution/fine-tuning) can be used together complementarily.

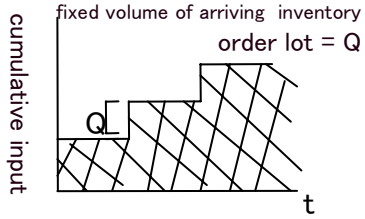
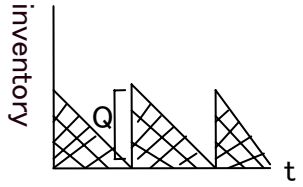
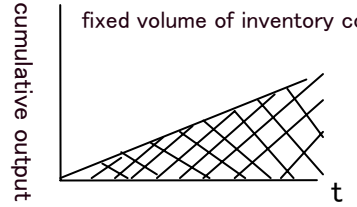
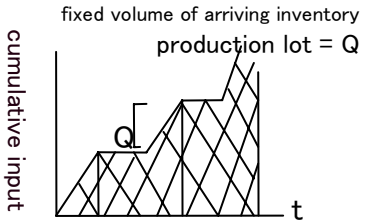
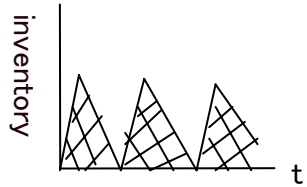
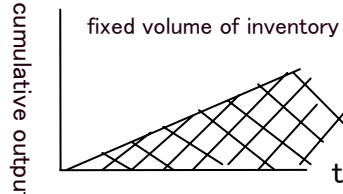
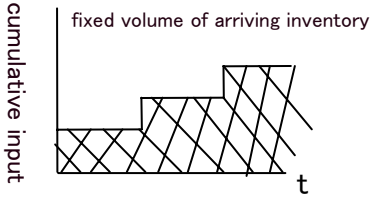
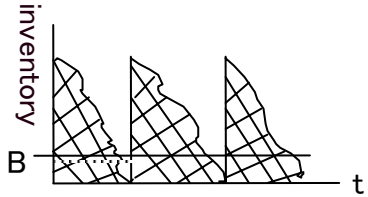
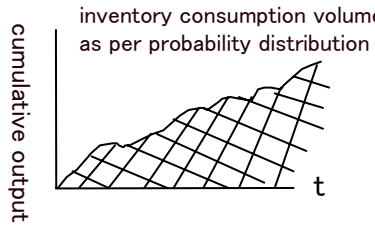
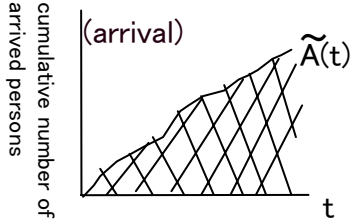
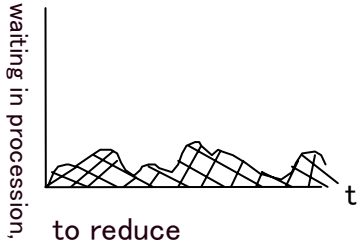
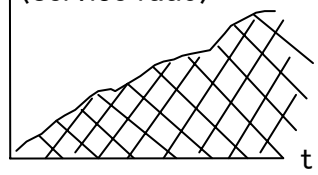
① Kanban System



② MRP



For Reference: Comparison Between Waiting-in-Procession Problem and Inventory Problem

	① input (arrival)	② waiting, stagnation, inventory	③ output (process)
① EOQ (decision on order lot)			
② EOQ (decision on product lot)			
③ Safety inventory decision problem	 (case of order lot problem)	 safety inventory level = B	
④ Waiting-in-procession problem	 pace of arrivals as per probability distribution	 to reduce	⟨service ratio⟩  pace of process as per probability distribution