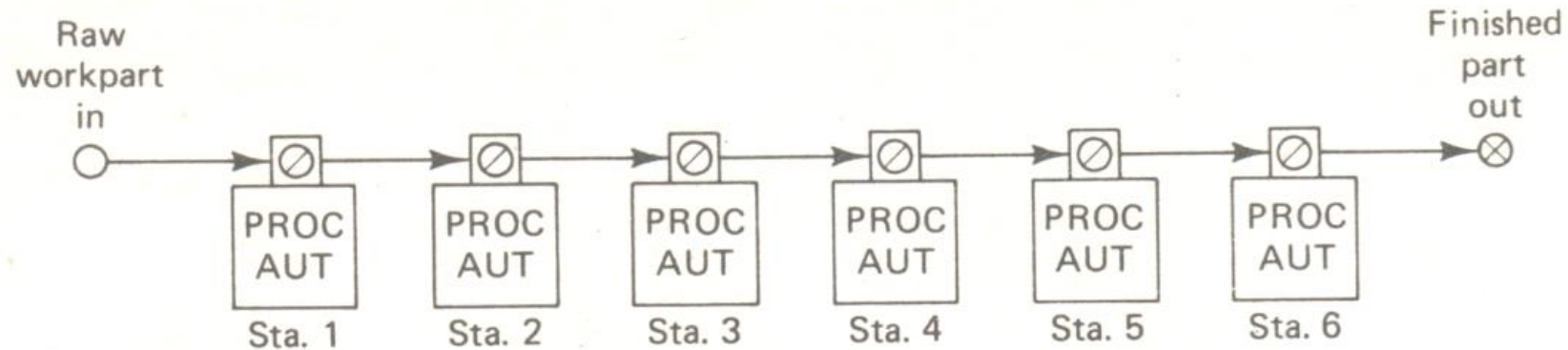




Detroit Type Automation: Automated Flow Lines



ASBY – Assembly Stations

INSP – Inspection Stations

SORT – Sortation Stations

The objectives of the use of flow line automation:

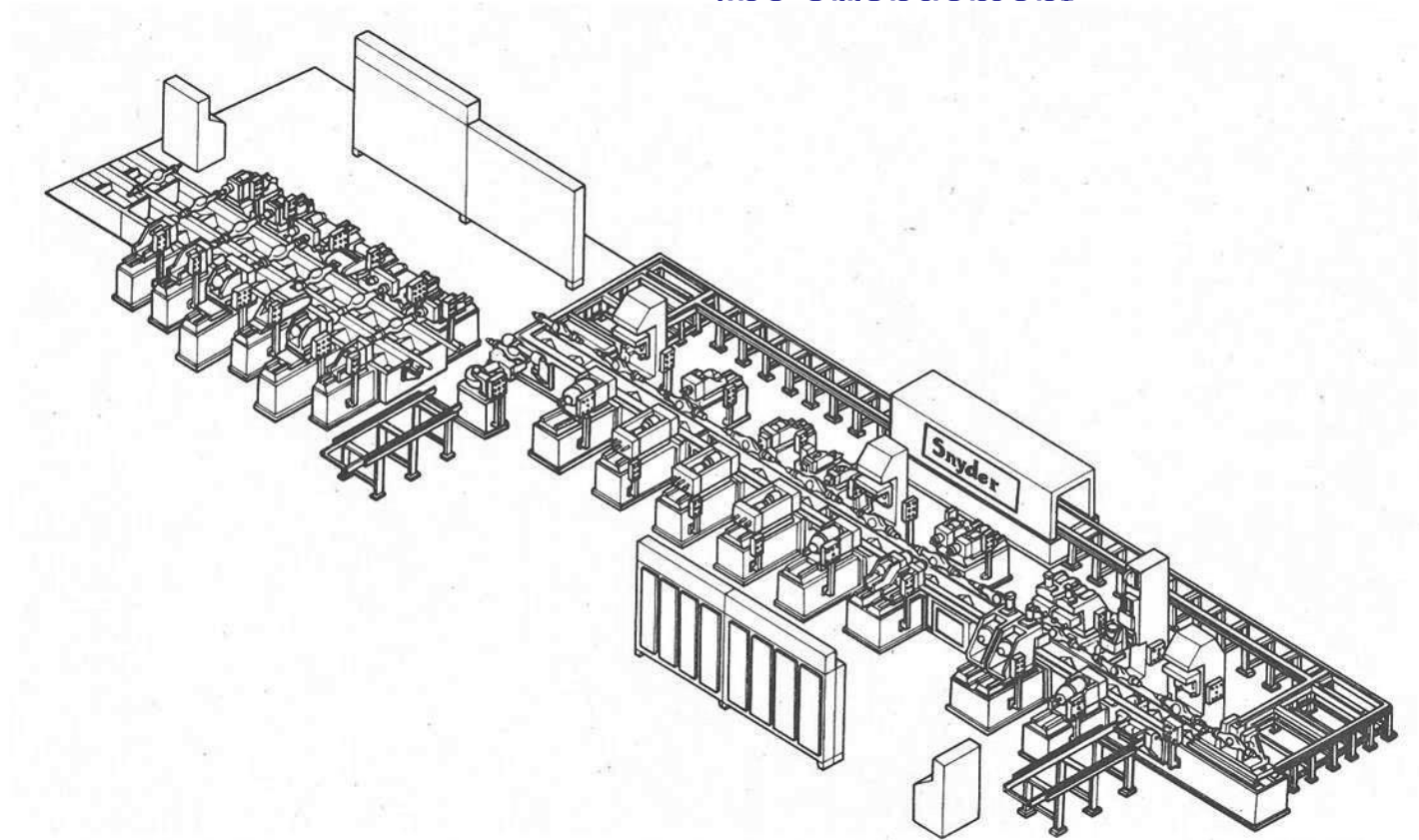
- To reduce labour cost
- To increase production rates
- To reduce work-in-process
- To minimize distances moved between operations
- To achieve integration of operations



Automated Flow Lines In-Line Type:

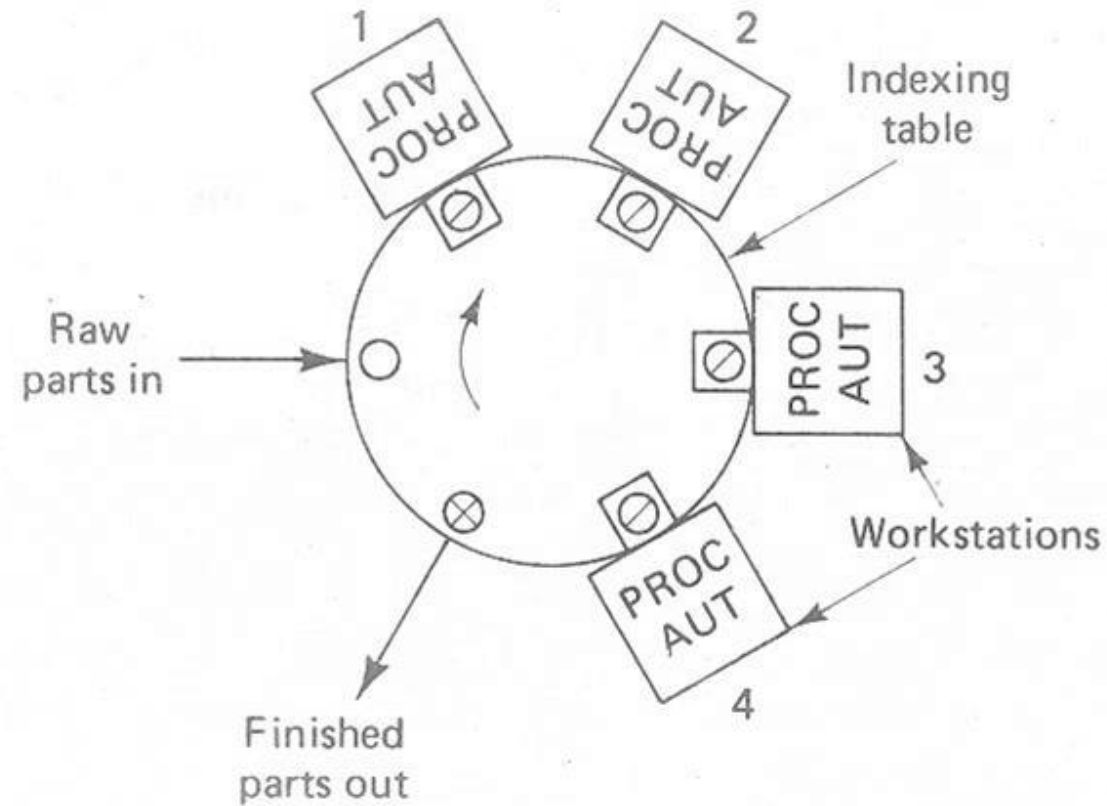
Two general forms that the workflow can take:

Sequence of workstations in more or less straight



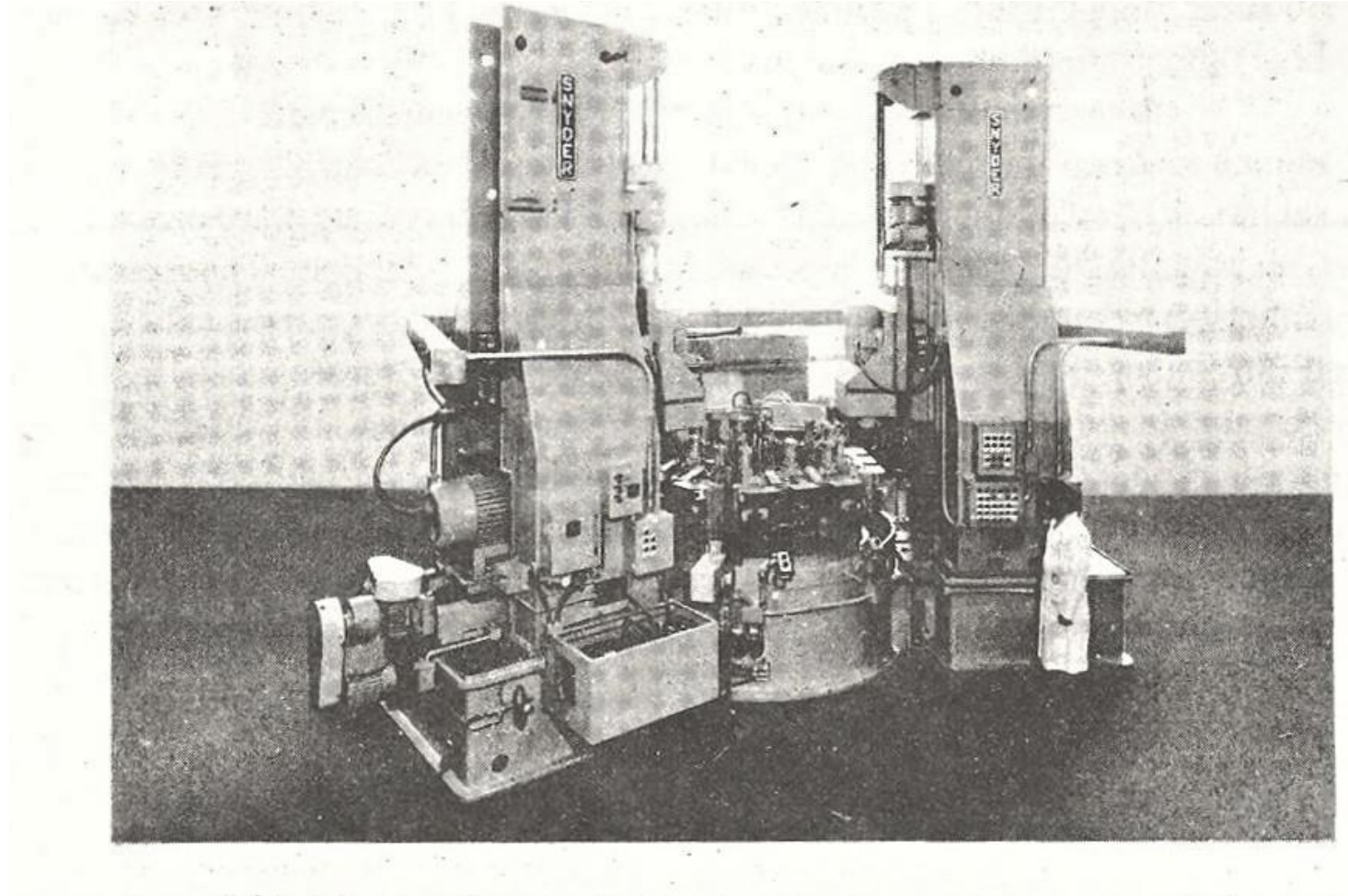
Rotary Type:

The workparts are indexed around a circular table or dial.



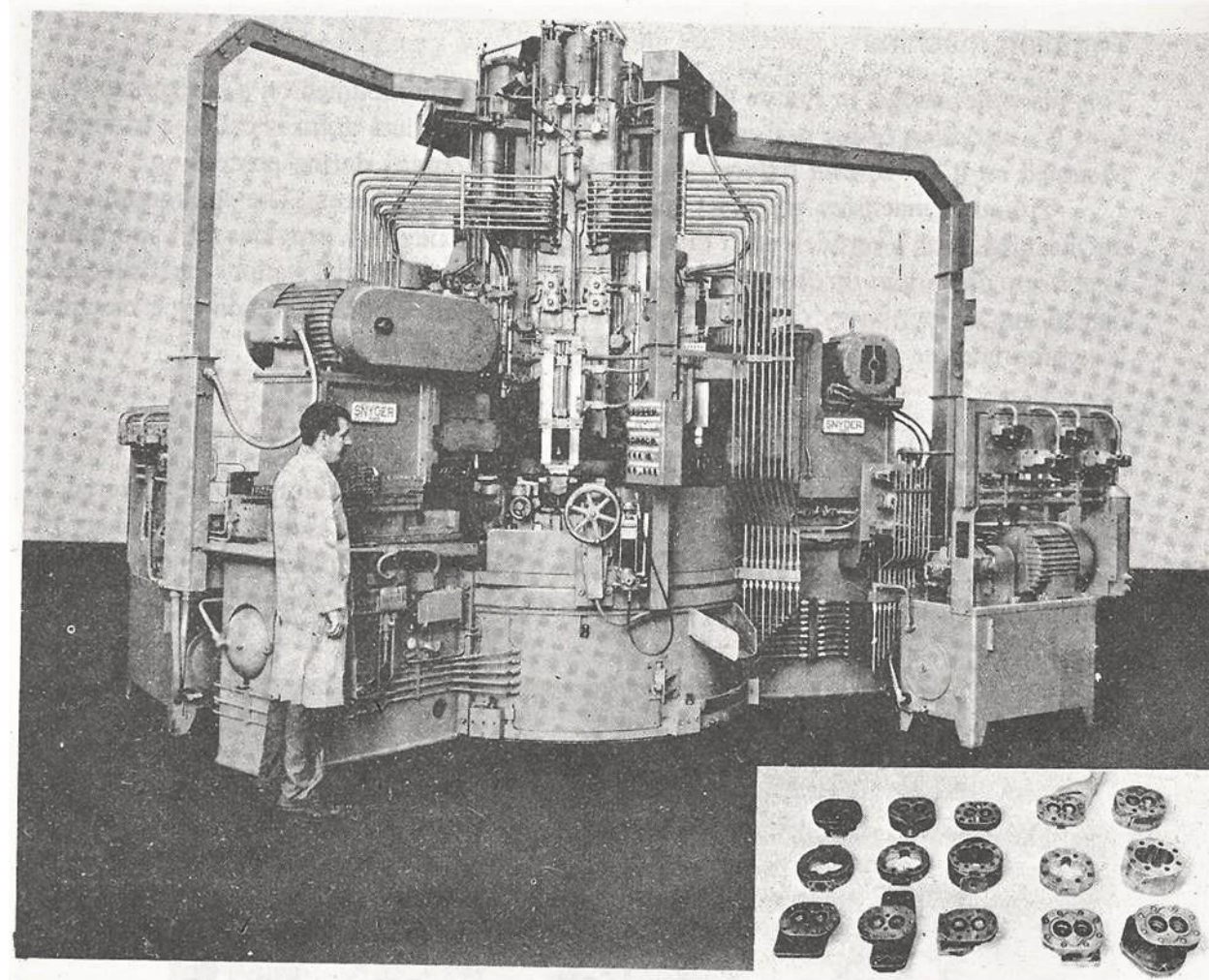


Rotary Indexing Machine





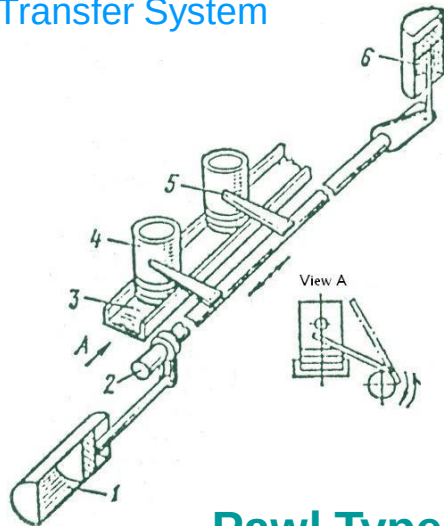
Rotary Indexing Machine



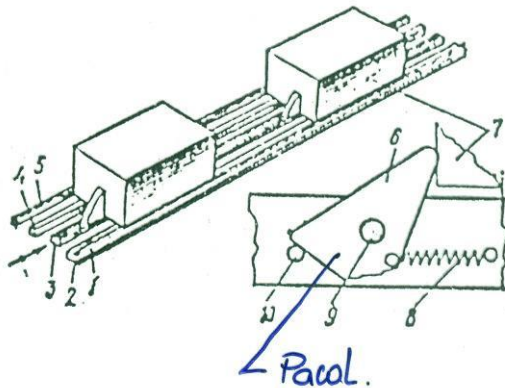
Part Transfer in Automated

Flow Lines

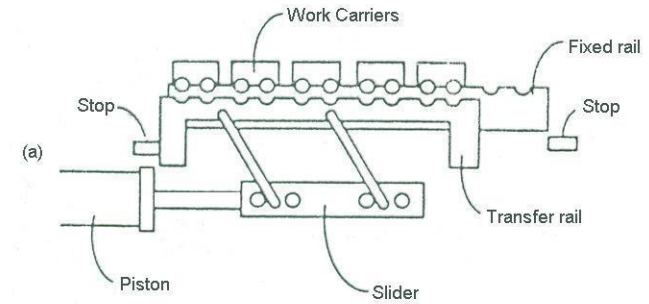
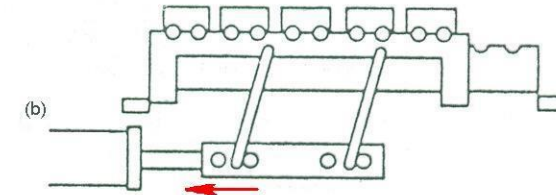
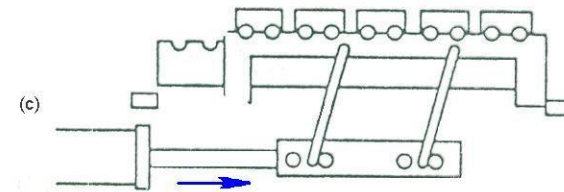
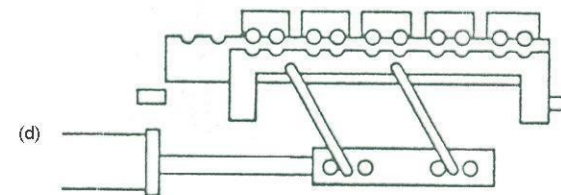
Walking Beam Transfer System



Pawl Type



- To provide linear travel for in-line machines





Methods of Workpart Transport

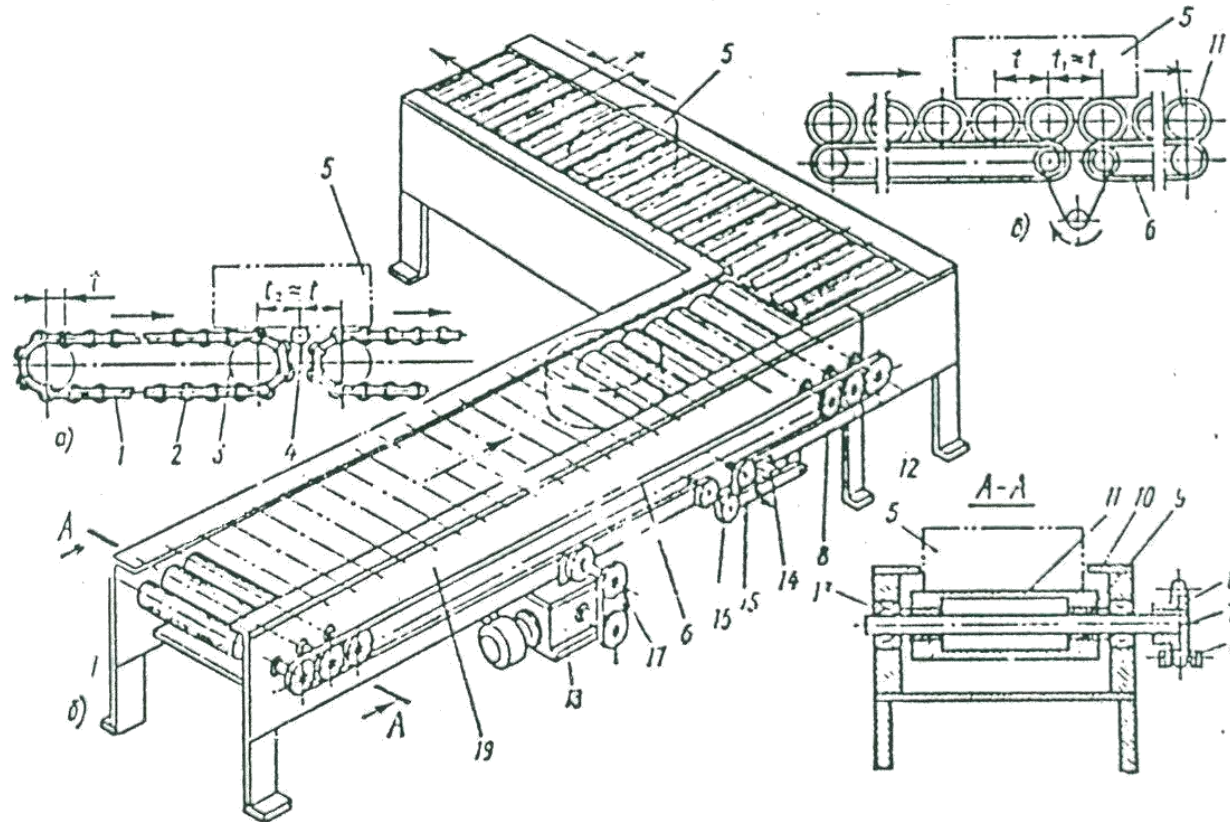
General Methods of transporting workpieces:

- **Continuous Transfer**
- **Intermittent or Synchronous Transfer**
- **Asynchronous or Power-and-Free Transfer**

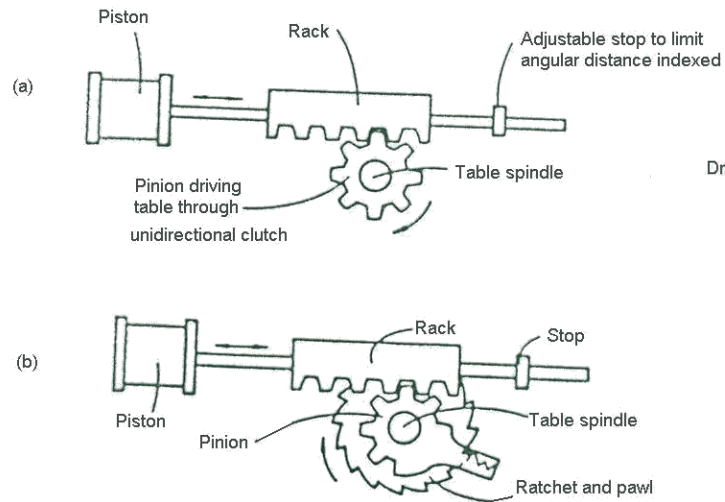
Choice depends on:

- **The types of operations**
- **The number of stations on the line**
- **The weight and size of the workpiece**
- **Whether manual stations are included on the line**
- **Production rate requirement**
- **Balancing various process times on the line**

Powered Roller Conveyor System or Chain Drive Conveyor System

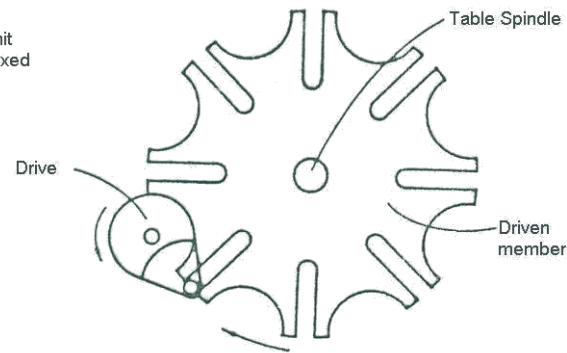


Indexing Mechanisms

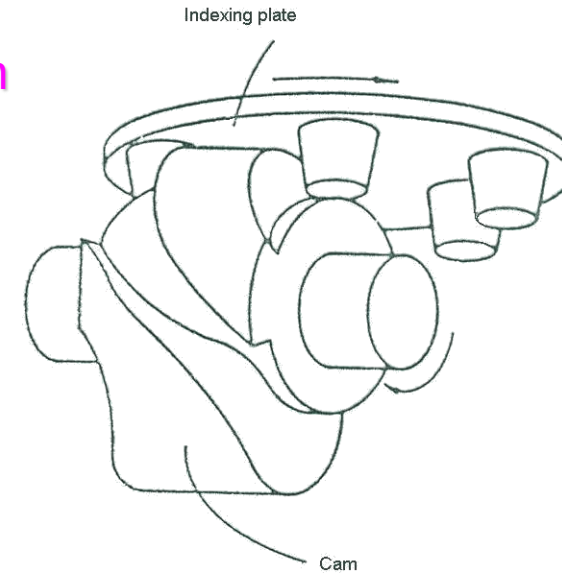


Converts intermittent translation motion into angular motion

Continuously Driven



Geneva Mechanism



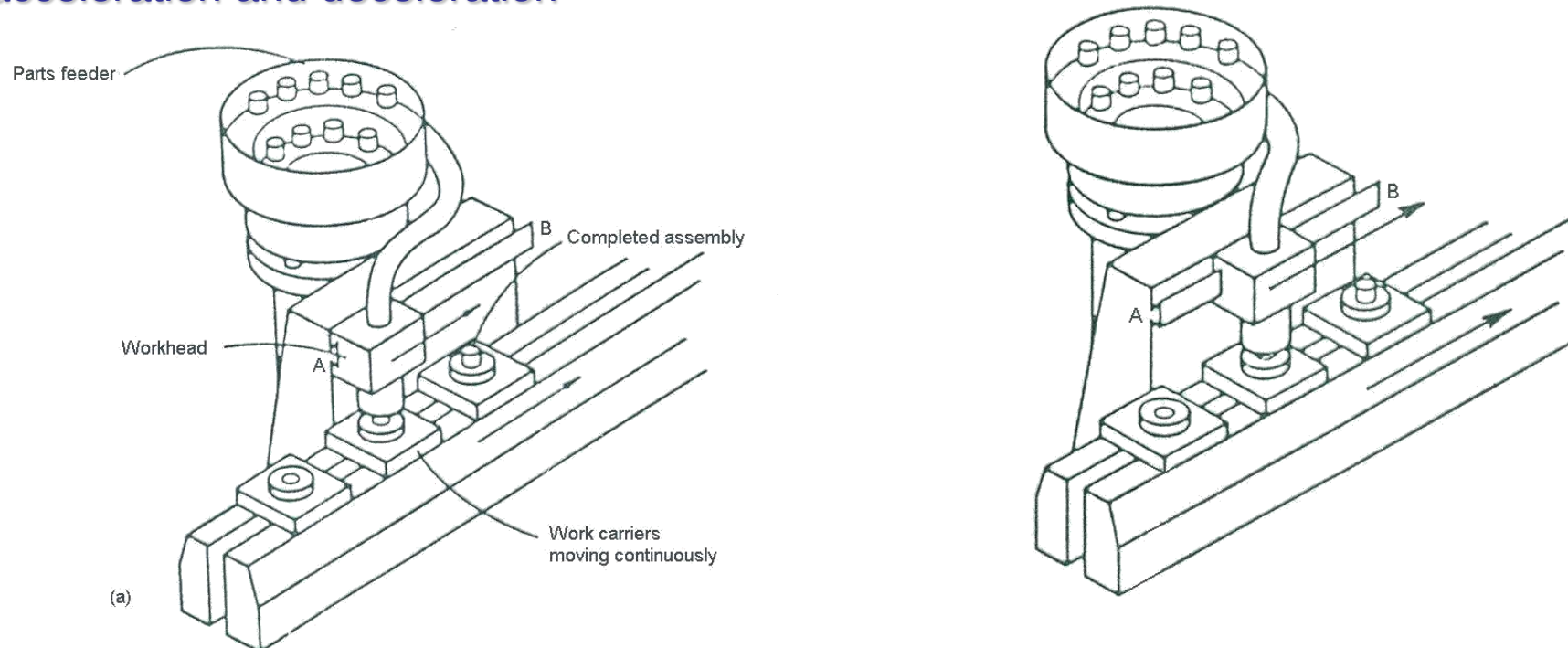
Crossover Cam Indexing Unit



Transfer System in Automated Assembly

In-Line Continuous Transfer Machines

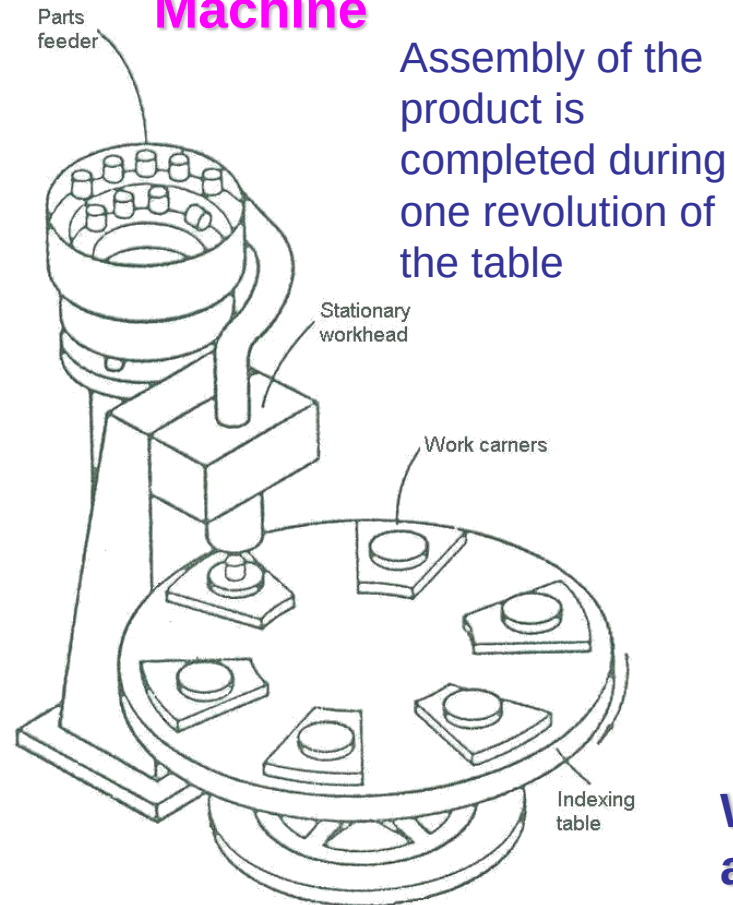
- Work carriers move at constant speed while the workheads index back and forth
- Can not be used for heavy workheads and associated equipment due to difficulty in acceleration and deceleration



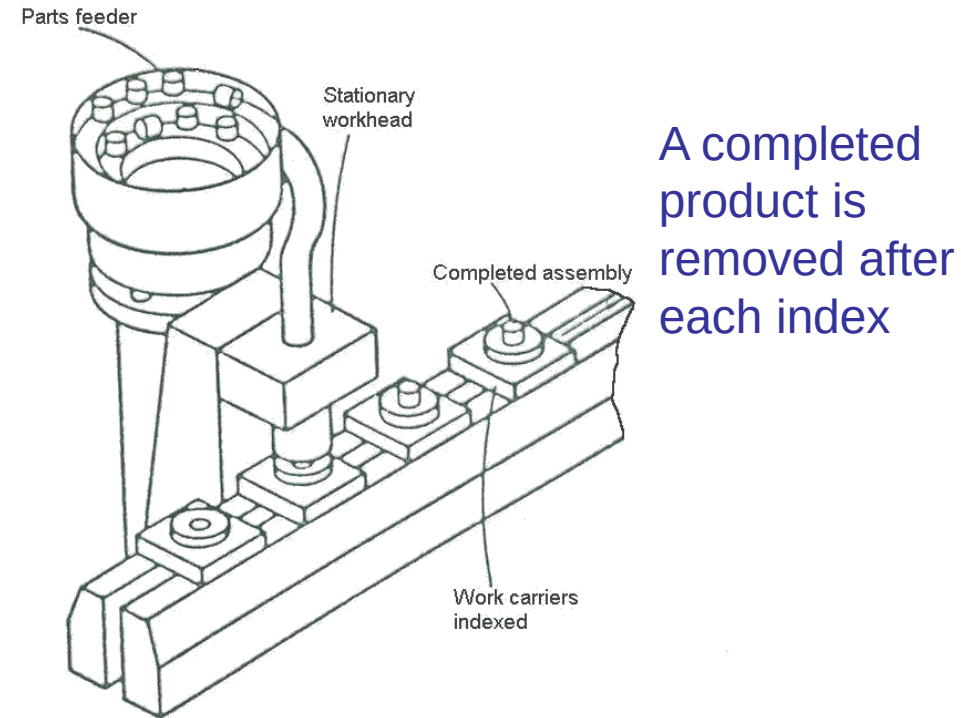


Intermittent Transfer (synchronous)

Rotary Indexing Machine



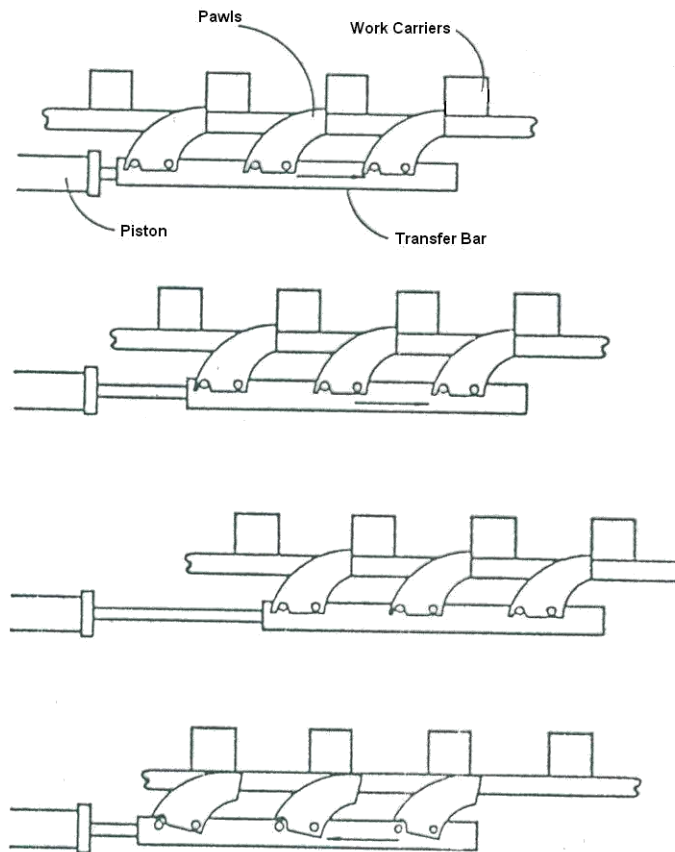
In-Line Indexing Machine



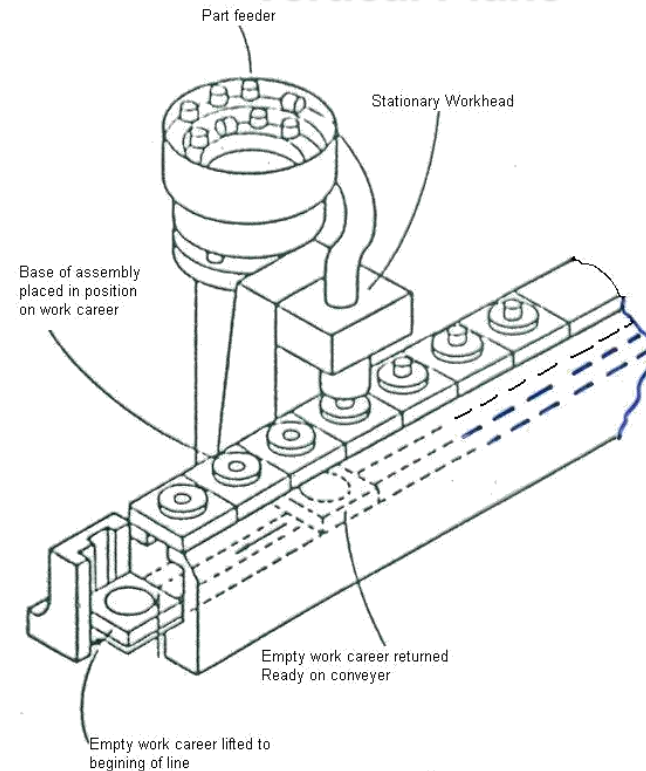
Work carriers are transferred intermittently and the workheads remain stationary

In-Line Intermittent Transfer Mechanisms

Pawl-Type Transfer System



In-Line Transfer Machine with Shunting Work Carriers Returned in Vertical Plane





Asynchronous Transfer Mechanisms

This system of transfer allows each workpart to move to the next station when processing at the current station has been completed.

These lines are often used where there are one or more manually operated stations.



Analysis of Automated Flow Lines

Flow line performance can be analysed based on the following measures:

1. Average production rate
2. Line efficiency (proportion of time the line is operating)
3. Cost per item produced on the line

Let us assume a synchronous transfer system with an ideal or theoretical cycle time, T_c

T_c is the time required for parts to transfer plus processing time at the longest workstation



The stations requiring less processing time than the longest station will have a certain amount of idle time

Because of the breakdowns of the line, the actual average production time (T_p) will be longer than T_c



T_d is the average downtime to diagnose the problem and make repairs when a breakdown occurs

F is the frequency with which the line stops per cycle

Then, the mean time per cycle the machine will be down = $T_d \times F$

The average production time, $T_p = T_c + T_d \times F$

Average Production Rate, $R_p = 1 / T_p$



Theoretical Production Rate, $R_c = 1/T_c$

The line efficiency, $E = \frac{T_c}{T_c + FT_d}$

Proportion of downtime, $D = \frac{FT_d}{T_p} = \frac{FT_d}{F_c + FT_d}$

In general, $E + D = 1$



Cost per item produced:

Let,

C_m is the cost of raw material per product

C_L is the cost per minute to operate the line including labour, overhead, maintenance, and the allocation of capital cost of the equipment over its expected service life.

C_t is the cost of any disposable tooling on a per workpiece basis.

Then, cost per workpiece, $C_{pc} = C_m + C_L T_p + C_t$



Partial Automation:

Reasons for introducing Partial automation:

1. Mechanisation of a manually operated flow line is often introduced gradually
2. Some manual operations are difficult to automate and it may be uneconomical to do so. For example:
Alignments, assembly, inspection etc.



$$\text{Total Line Cost, } C_L = n_0 C_0 + n_a C_{as} + C_{at}$$

Where,

C_0 is the operator cost per manual station

C_{as} is the cost per automatic workstation, Rs./minute

C_{at} is the cost per minute of the automatic transfer mechanism which will be used for both manual and automatic stations to transfer the workpart.

n_a is the number of automatic stations

n_0 is the number of manually operated stations

$$n_a + n_0 = n = \text{Total number of workstations on the line.}$$



Average production time = Ideal Cycle time + Average downtime per cycle

$$T_p = T_c + T_d \times F = T_c + n_a p T_d$$

Where, p is the probability of part jamming at a particular station.

It is to be noted that the breakdown occurs at automatic workstations only.