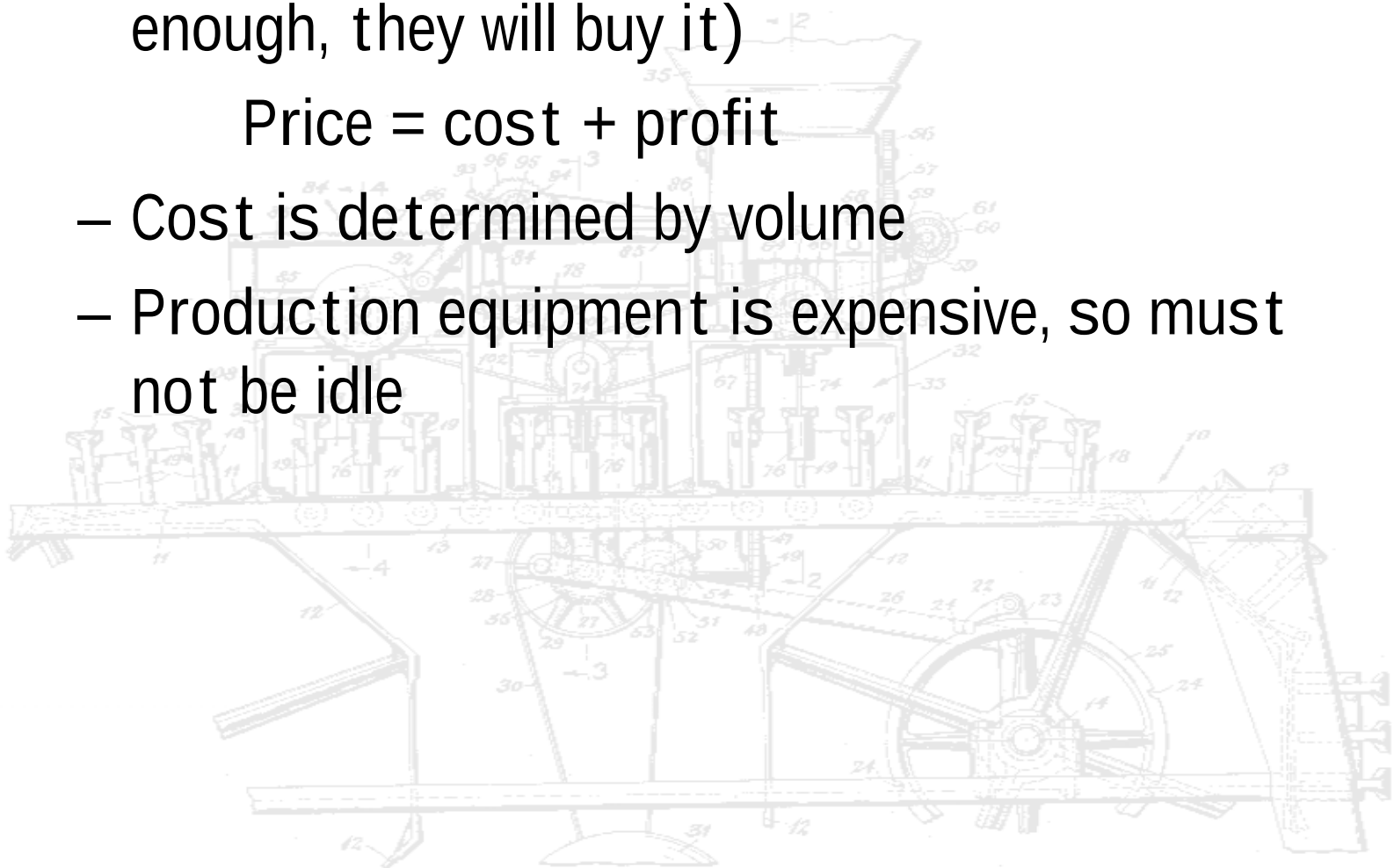
Manufacturing Philosophy

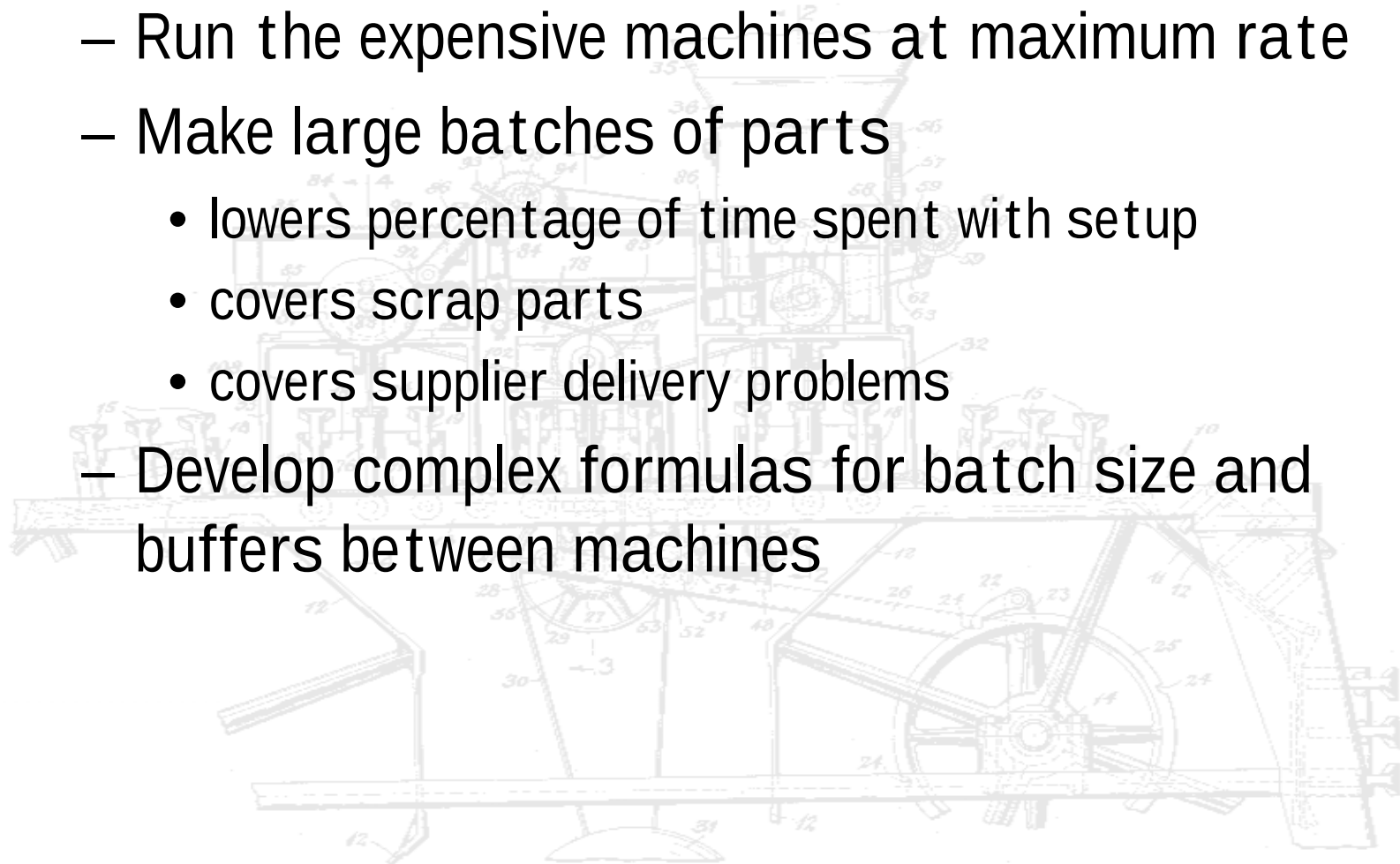
- Henry Ford:
  - Demand is driven by price (if you make it cheap enough, they will buy it)

    Price = cost + profit
  - Cost is determined by volume
  - Production equipment is expensive, so must not be idle



Henry Ford's Method

- Minimizing production cost
  - Design specialized, efficient machines
  - Run the expensive machines at maximum rate
  - Make large batches of parts
    - lowers percentage of time spent with setup
    - covers scrap parts
    - covers supplier delivery problems
  - Develop complex formulas for batch size and buffers between machines



Batches and Buffers

- Assembly operations can take a variable amount of time
  - Slowest operation sets cycle time for entire production line if there are no buffers
  - human fatigue
  - unpredictable operations (such as calibration)
  - variations between product models or options
  - malfunctions or other stoppages
- A buffer is an empty space where parts wait for the next machine

Batches and Buffers

- Stations downstream of stopped/slow machine keep working until upstream buffer is empty.
- Stations upstream of stopped machine keep working until downstream buffer is full.
- One station is the slowest - "bottleneck"
  - buffer upstream of bottleneck must never be empty
  - buffer downstream of bottleneck must never be full

Batches and Buffers

- With no buffers, if any station stops, bottleneck stops
- With one buffer, probability of a stop somewhere causing bottleneck to stop drops to 0.5. More buffers drop probability more.
- So, buffers anywhere in the line are there to keep the bottleneck machine running!
- If machines are similar in speed, buffers take a long time to refill after a stoppage.

Problems with Henry Ford's Method

- Work-in-process inventory (batches of parts) ties up money
- Changes in demand lead to unneeded parts
- Faulty processes lead to large amounts of scrap
- Changes in customer preferences lead to expensive machine obsolescence
- Long delay from order to finished product

Taiichi Ohno's Method (Toyota)

- Toyota was short on capital money
  - Couldn't afford large work-in-process inventory
  - Couldn't afford specialized machines
- Decided to build only what customer demanded
- Let the customer set the price

  profit = price - cost
- Machines depreciate, labor cost is constant
  - keep the people busy, even if machines are sometimes idle

Toyota Production System

- Inventory is the enemy
  - no buffers between machines
  - single piece part flow
  - no scrap or breakdowns permitted
    - bad parts must be recognized immediately
    - any malfunctions must be immediately analyzed and the causes fixed
  - setup times must be very short
  - transport of parts must be very efficient
  - product model mix handled by *production smoothing*

Toyota Production System

- Production smoothing
  - Example: orders for 50% sedans, 30% vans, 20% pickups
  - Don't make a batch of sedans, then a batch of vans, then a batch of pickups
  - Instead, interleave them:
    - SPSVSPSVSV SPSVSPSVSV...
  - What if it takes longer to make a van than a sedan or a pickup?
    - interleaving gets more complicated
    - add an extra V to the cycle occasionally