M2794.006900 DESIGN FOR MANUFACTURING

Week 6, October 12

Early Stages of Product Development

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Product Development Cycle

- **Product Planning**
- **Identifying Customer Needs**
- Product Specification
- Conceptual Design
  - Concept Generation
  - TRIZ
  - Concept Selection
- Detail Design
- Analysis (FEM/CFD)
- Prototype
- Manufacturing
- Marketing

Materials to be covered today

(Product Design and Development *by K T Ulrich & S D Eppinger*)

Consumer Products Process Thread

Industrial Design

Marketing

Product Configurator

Base Styling

Common Components

Options

Network Electronics

Apply Configuration Rules

Digital

ES2501
426181
456025
326140
326160

Analogue

ES2500
261811
156025
326190

Duel

ES2502
326181
560256
326200
326219

Styling

WAVE Concurrency Engineering

Approved Concept

Detailed Design

Rapid Prototyping

Surface Evaluation

Photorealistic Rendering

Plastics Analysis

Feature and Assembly Design

Manufacturing

Virtual Assembly

Quality & Inspection

Drafting & Documentation

Mold Design & Manufacture

High Speed Machining

NC Programme Generation

Characteristics of Successful Product

- Product Quality ↑
- Product Cost ↓
- Development time ↓
- Development Cost ↓
- Development Capability ↑
- Environmental impact ↓


2022 Twin App Trade Center

What is your vision?

-Volvo: Drive for life

-Nokia: Connecting people

-TA's ?

-Yours ?

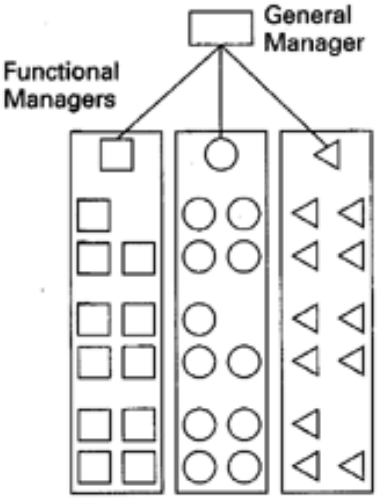
The Challenges of Product Development

- Trade-offs
- Dynamics
- Details
- Time Pressure
- Economics

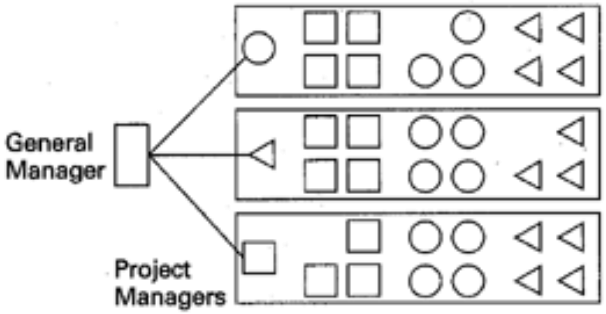
- Creation
- Satisfaction of Social and Individual Needs
- Team Diversity
- Team Spirit
- Environmental regulation

Development Processes and Organizations

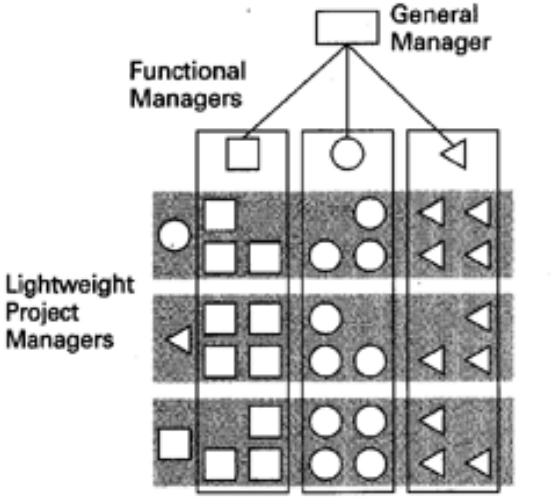
PDD chapter 2



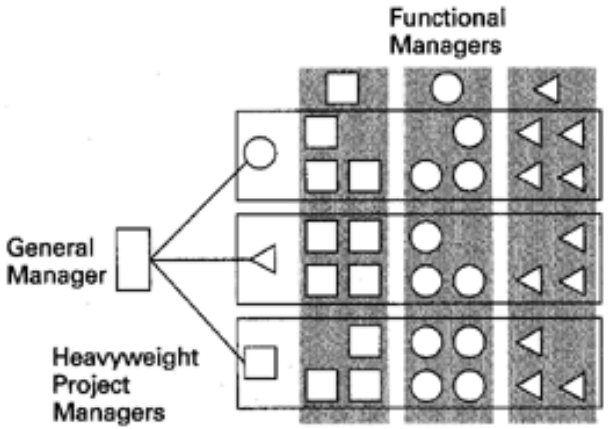
Functional Organization



Project Organization



Lightweight Project Matrix Organization



Heavyweight Project Matrix Organization

(Adapted from Hayes, et al., 1988.)

Product planning

Biomedical Equipment

- (PDD Ch 3)
- What product development project will be undertaken?
- What mix of fundamentally new products, platforms, and derivative products should be pursued?
- How do the various projects relate to each other as a portfolio?
- What will be the budget and time frame for the project?

Product Planning Process

- **Four types of product development projects**
  - **New product platforms**
  - **Derivatives of existing product platforms**
  - **Incremental improvements to existing products**
  - **Fundamentally new products**

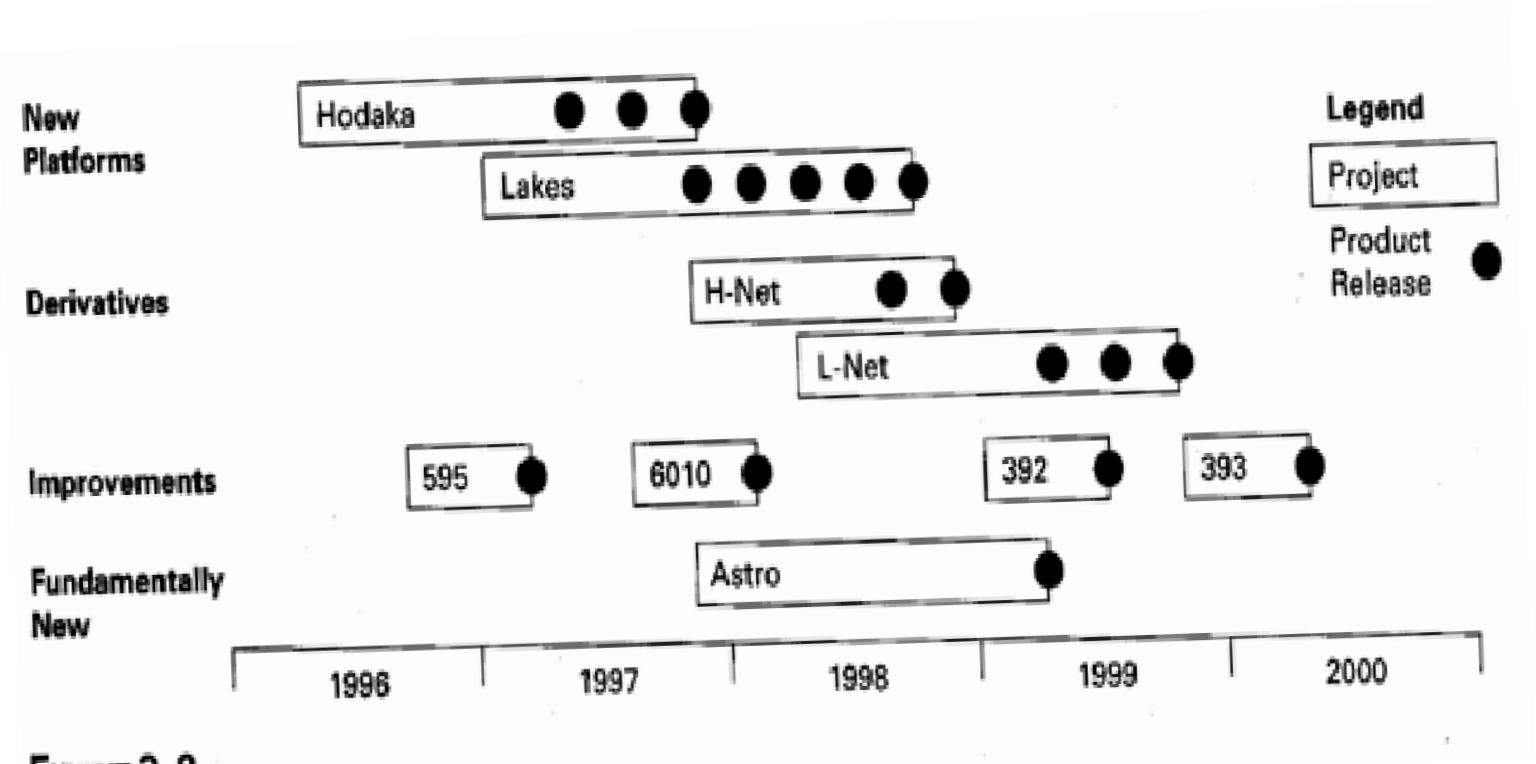


EXHIBIT 3–2

Product Planning Process (cont.)

1. Identify opportunities
2. Evaluate and prioritize projects
3. Allocate resources and plan timing
4. Complete pre-project planning
5. Reflect on the results and the process

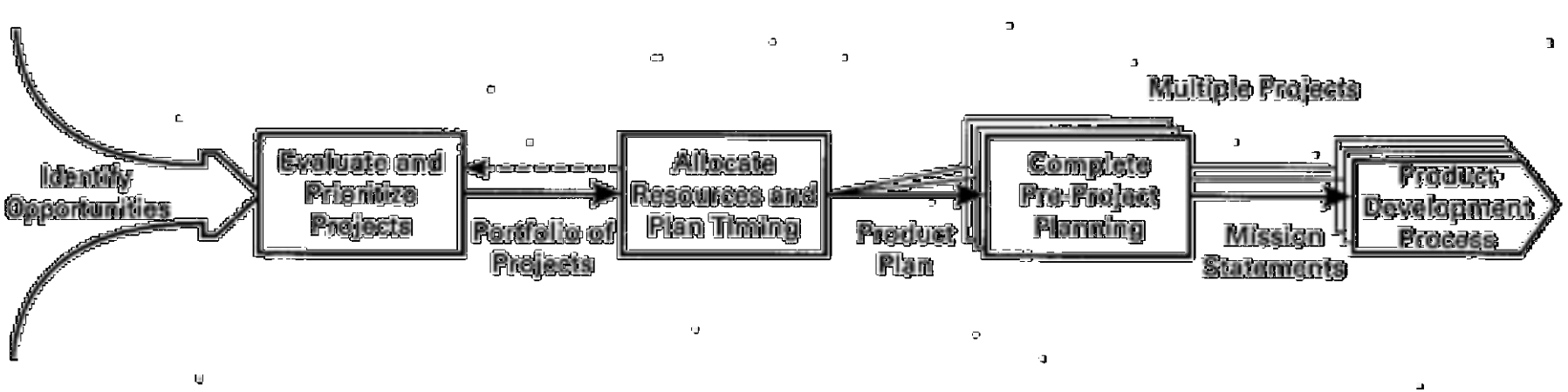
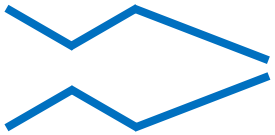


EXHIBIT 3–3

The product planning process. These activities address a portfolio of product development projects, resulting in a product plan and, for each selected project, a mission statement.

Step 1. Identify opportunities

- Opportunity Funnel ()
  - Bring together inputs from across the enterprise
- Identifying customer needs
  - Interview with lead users
  - Implication of trends in lifestyle, demographics, and technology
- Benchmarking competitor's products

Example of identifying customer needs – Vaccine delivery system

Step 2. Evaluate and prioritize projects (1)

- Select the most promising project to pursue
  - From hundreds or thousands opportunities,
  - Four basic perspectives in evaluation
    1. Competitive Strategy
    2. Market Segmentation
    3. Technological Trajectories
    4. Product Platform Planning

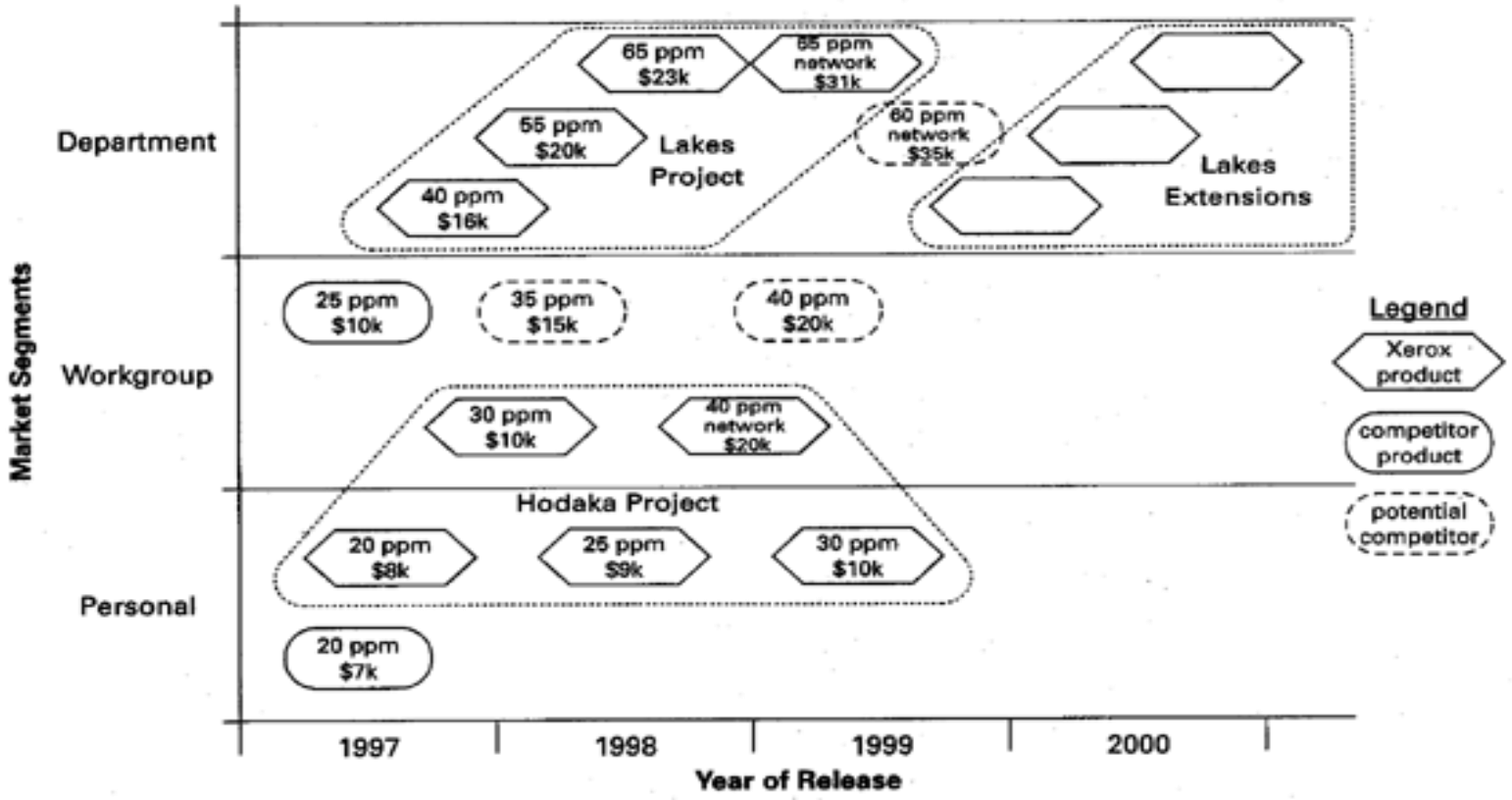
Step 2. Evaluate and prioritize projects (2)

1. Competitive Strategy
   - Technology leadership
   - Cost leadership
   - Customer focus
   - Imitative

Step 2. Evaluate and prioritize projects (3)

2. Market Segmentation

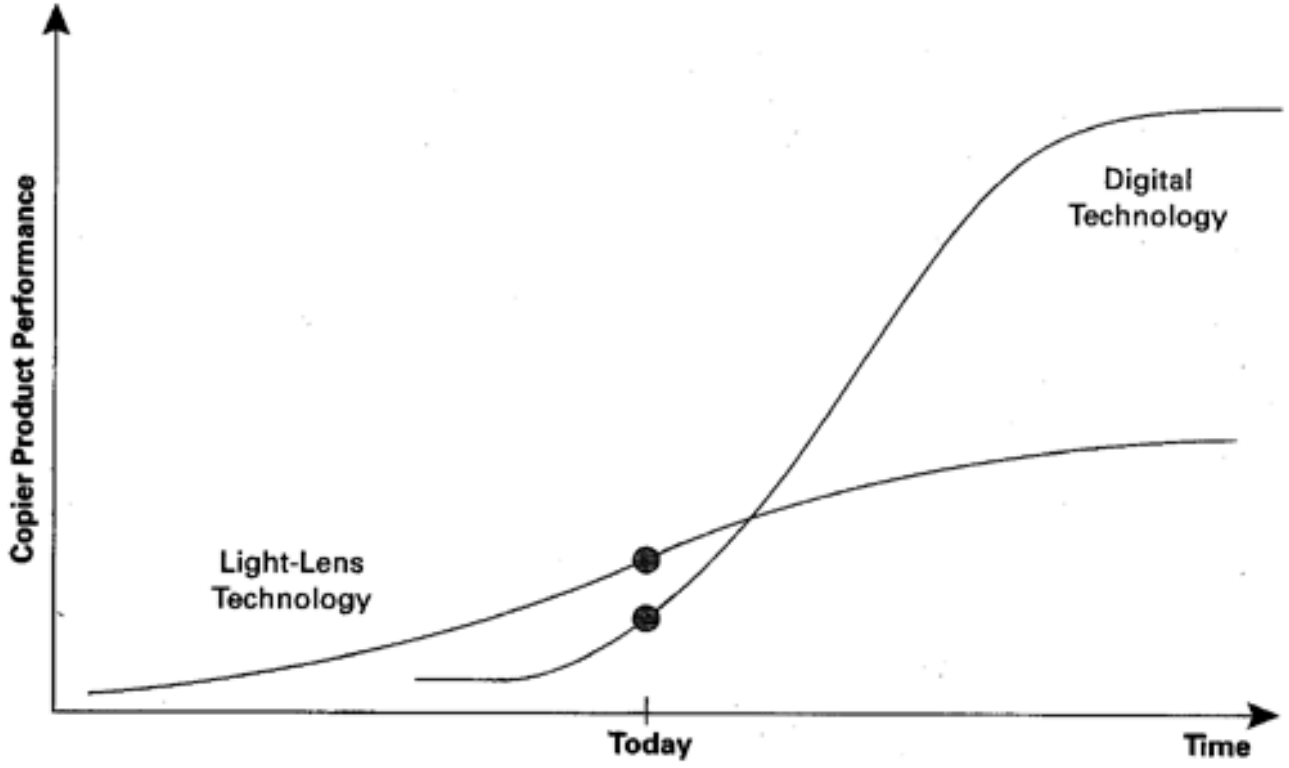
- Product segment map: comparison with competitors



Step 2. Evaluate and prioritize projects (4)

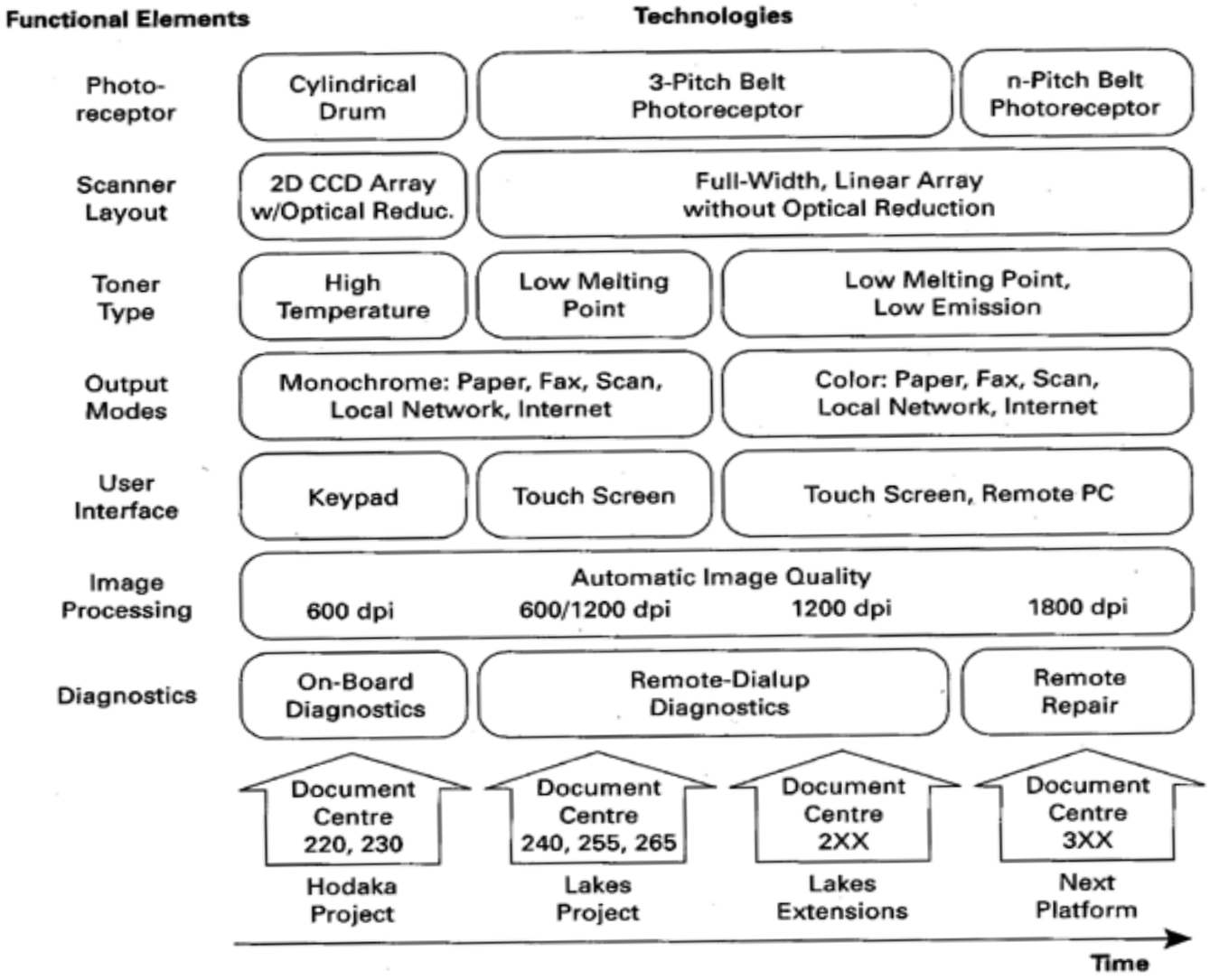
3. Technological Trajectories

- Technology S-curve: when to develop new product



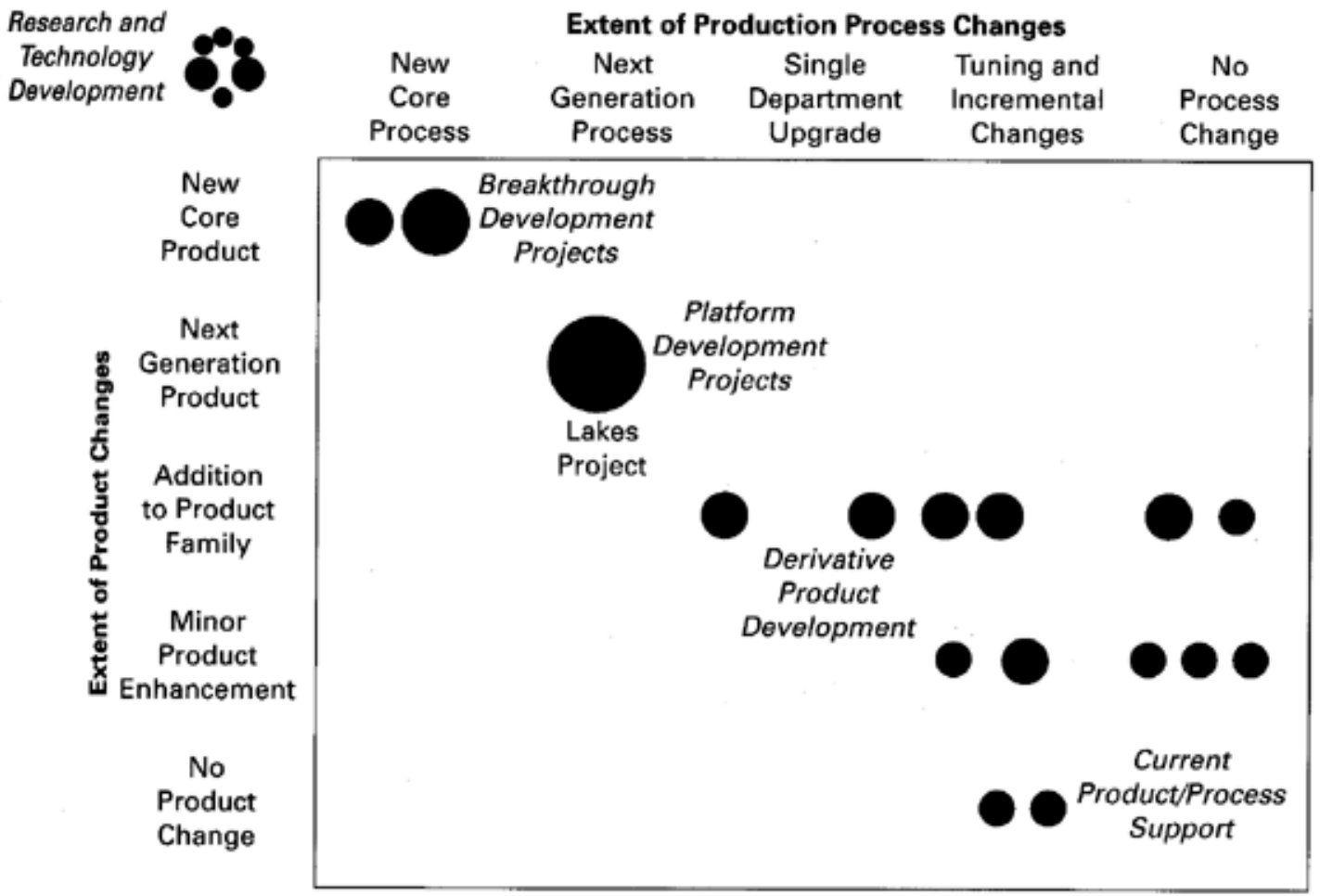
Step 2. Evaluate and prioritize projects (5)

■ Technology Roadmap



Step 2. Evaluate and prioritize projects (6)

- **Balancing the portfolio - 'Product-Process change matrix'**



(Adapted from Wheelright and Clark, 1992.)

Step 3. Allocate Resources and Plan Timing

- Resource allocation

  Aggregate planning: pursue only those projects can reasonably be completed within the budgeted resources

- Project timing

  Pipeline management

  - Timing of introduction
  - Technology readiness
  - Market readiness
  - Competition

Step 4. Complete Pre-Project Planning

- Product vision statement
  - Example: “develop a networked, mid-range, digital platform for imaging, marking, and finishing” (Xerox’s Lake)
- Mission Statement
  - Brief description of the product
  - Key business goal
  - Target market for the product
  - Assumptions and constraints
  - Stakeholder

Example of a mission statement

EXHIBIT 3–10

Mission statement for the Lakes project. This document summarizes the direction to be followed by the product development team. Many more details are appended to this mission statement, including the environmental goals, service objectives, and specific technologies identified for use in the Lakes platform.

Mission Statement: Multifunctional Office Document Machine	
Product Description	• Networkable, digital machine with copy, print, fax, and scan functions
Key Business Goals	• Support Xerox strategy of leadership in digital office equipment • Serve as platform for all future B&W digital products and solutions • Capture 50% of digital product sales in primary market • Environmentally friendly • First product introduction 4th Q 1997
Primary Market	• Office departments, mid-volume (40–65 ppm, above 42,000 avg. copies/mo.)
Secondary Markets	• Quick-print market • Small "satellite" operations
Assumptions and Constraints	• New product platform • Digital imaging technology • Compatible with CentreWare software • Input devices manufactured in Canada • Output devices manufactured in Brazil • Image processing engine manufactured in both the United States and Europe
Stakeholders	• Purchasers and users • Manufacturing operations • Service operations • Distributors and resellers

Brainstorming

- Throughout the early stages of your project, your team should answer several "what", "why", and "how" questions
- One of the methodologies is brainstorming

Brainstorming Rules

1. Collect as many ideas as possible from all participants with no criticisms or judgments made while ideas are being generated.

2. All ideas are welcome no matter how silly or far out they seem. Be creative. The more ideas the better because at this point you don't know what might work.

3. Absolutely no discussion takes place during the brainstorming activity. Talking about the ideas will take place after brainstorming is complete.

4. Do not criticize or judge. Don't even groan, frown, or laugh. *All ideas are equally valid at this point.*

5. Do build on others' ideas.

6. Do write all ideas on a flipchart or board so the whole group can easily see them.

7. Set a time limit (i.e., 30 minutes) for the brainstorming.

Brainstorming Sequence

1. One team member should review the topic of the brainstorm using "why", "how", or "what" questions.

   Example) The topic for the brainstorm is developing a training course on syringes. What should we focus on as the content?

2. Everyone should think about the question silently for a few moments. Each person might want to write down his/her ideas on a sheet of paper.

   Example:

   (1) Types of syringes; (2) Parts of syringes; (3) Syringe manufacturers; (4) Categories of syringes; (5) How syringes work.

3. Everyone suggests ideas by calling them out. Another way is to go around the room and have each person read an idea from his/her list until all ideas have been written on the board or flipchart. (Note: The team member in charge of the brainstorming session should be enforcing the rules.)

4. One team member writes down all ideas on board or flipchart.

Making the final selection

1. When all the ideas have been recorded, combine ideas as much as possible, but only when the original contributors agree.

   Example:

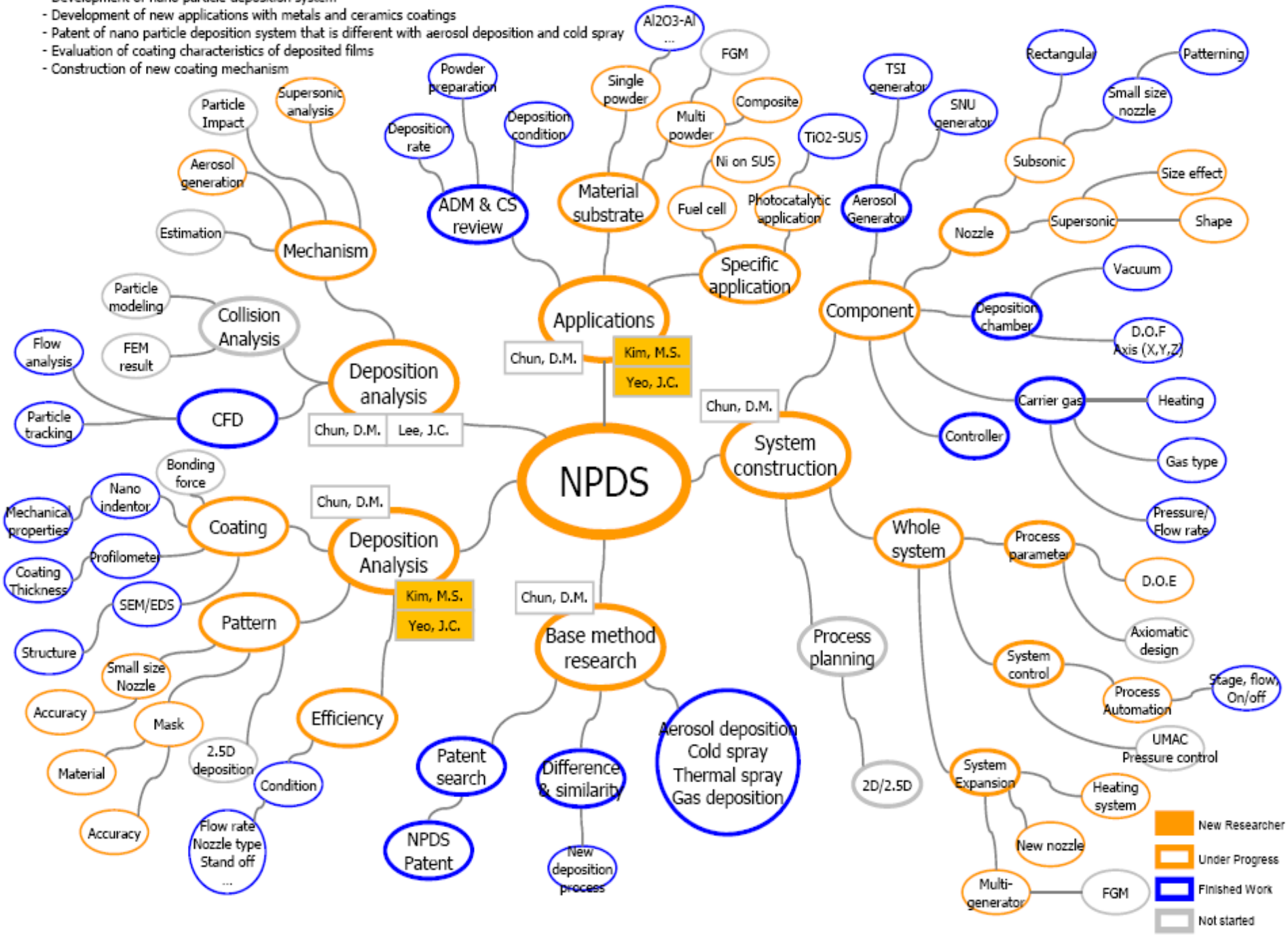
   (1) Types of cars and (4) Categories of cars (from example under #2 above) are really the same, so number 4 is eliminated.

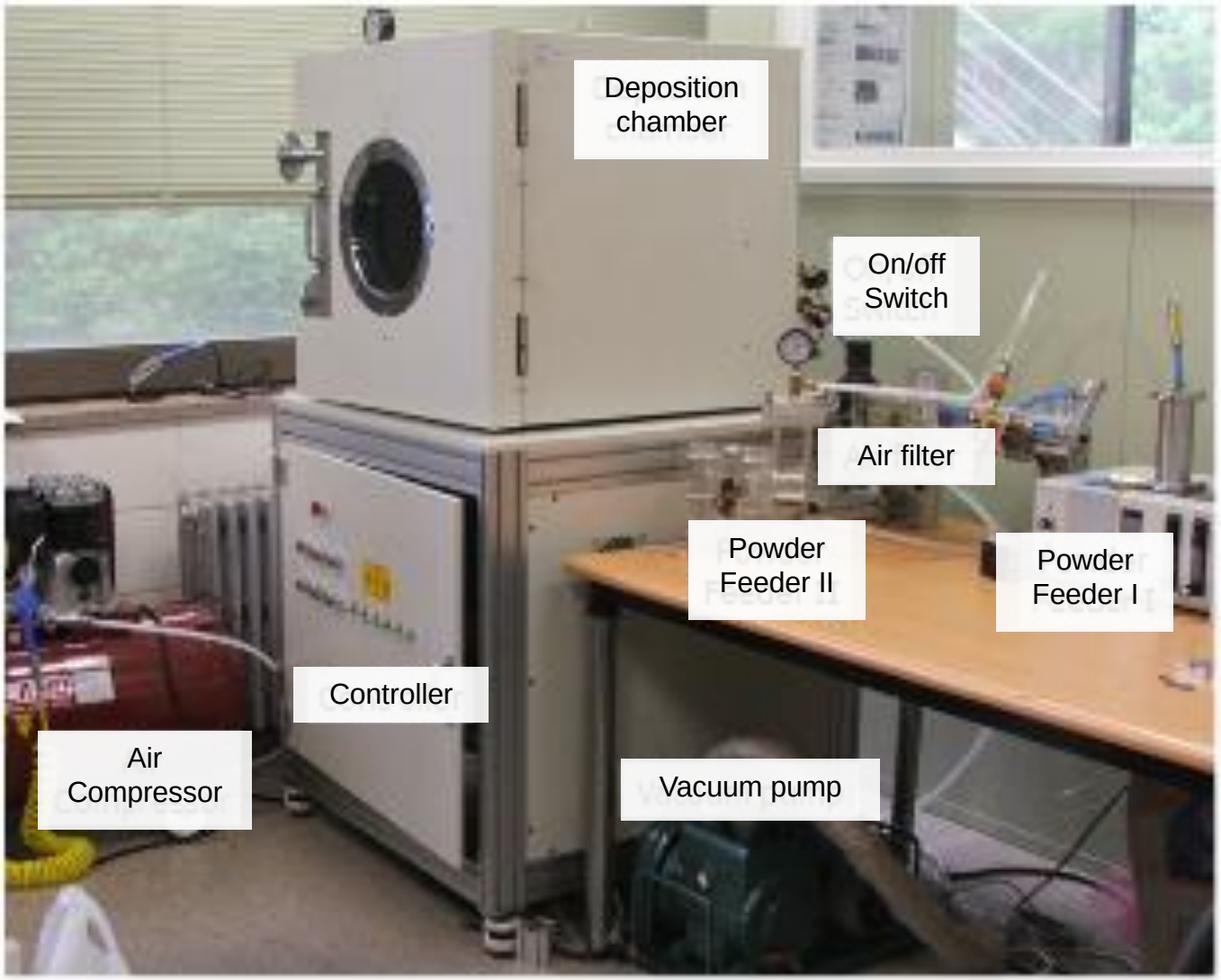
2. Number all of the ideas.

3. Each member votes on the ideas by making a list of the numbers of the ideas he/she thinks are important or should be discussed further. This list should contain no more than one third of the total number of ideas.

4. After counting the votes, cross out ideas with only one or two votes. Then vote again until only a few ideas remain (i.e., 3 or 4). If there is no clear-cut winner, then vote again or discuss the remaining ideas and determine which idea best answers the original question.

Goal
- Development of nano particle deposition system
- Development of new applications with metals and ceramics coatings
- Patent of nano particle deposition system that is different with aerosol deposition and cold spray
- Evaluation of coating characteristics of deposited films
- Construction of new coating mechanism




Deposition chamber
On/off Switch
Air filter
Powder Feeder II
Powder Feeder I
Controller
Air Compressor
Vacuum pump

Product Development Cycle

- Product Planning
- Identifying Customer Needs
- **Product Specification**
- Conceptual Design
  - Concept Generation
  - TRIZ
  - Concept Selection
- Detail Design
- Analysis (FEM/CFD)
- Prototype
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(Product Design and Development *by K T Ulrich & S D Eppinger*)

What are specs?

- PDD ch. 5
- Example of suspension forks for the mountain bike market
- “language of the customer” is sometimes too subjective
- Specification spell out what the product has to do in precise, measurable detail
- Consist of a metric and a value

Customer needs into spec.

EXHIBIT 5–2

Customer needs for the suspension fork and their relative importance (shown in a convenient spreadsheet format).

No.		Need	Imp.
1	The suspension	reduces vibration to the hands.	3
2	The suspension	allows easy traversal of slow, difficult terrain.	2
3	The suspension	enables high-speed descents on bumpy trails.	5
4	The suspension	allows sensitivity adjustment.	3
5	The suspension	preserves the steering characteristics of the bike.	4
6	The suspension	remains rigid during hard cornering.	4
7	The suspension	is lightweight.	4
8	The suspension	provides stiff mounting points for the brakes.	2
9	The suspension	fits a wide variety of bikes, wheels, and tires.	5
10	The suspension	is easy to install.	1
11	The suspension	works with fenders.	1
12	The suspension	instills pride.	5
13	The suspension	is affordable for an amateur enthusiast.	5
14	The suspension	is not contaminated by water.	5
15	The suspension	is not contaminated by grunge.	5
16	The suspension	can be easily accessed for maintenance.	3
17	The suspension	allows easy replacement of worn parts.	1
18	The suspension	can be maintained with readily available tools.	3
19	The suspension	lasts a long time.	5
20	The suspension	is safe in a crash.	5

"The average time to assemble the fork to the frame is less than 75 Seconds"

Establishing target specs.

- Step 1:

  List of metric

Metric No.	Need Nos.	Metric	Imp.	Units
1	1, 3	Attenuation from dropout to handlebar at 10 Hz	3	dB
2	2, 6	Spring preload	3	N
3	1, 3	Maximum value from the Monster	5	g
4	1, 3	Minimum descent time on test track	5	s
5	4	Damping coefficient adjustment range	3	N-s/m
6	5	Maximum travel (26-in. wheel)	3	mm
7	5	Rake offset	3	mm
8	6	Lateral stiffness at the tip	3	kN/m
9	7	Total mass	4	kg
10	8	Lateral stiffness at brake pivots	2	kN/m
11	9	Headset sizes	5	in.
12	9	Steertube length	5	mm
13	9	Wheel sizes	5	List
14	9	Maximum tire width	5	in.
15	10	Time to assemble to frame	1	s
16	11	Fender compatibility	1	List
17	12	Instills pride	5	Subj.
18	13	Unit manufacturing cost	5	US$
19	14	Time in spray chamber without water entry	5	s
20	15	Cycles in mud chamber without contamination	5	k-cycles
21	16, 17	Time to disassemble/assemble for maintenance	3	s
22	17, 18	Special tools required for maintenance	3	List
23	19	UV test duration to degrade rubber parts	5	Hours
24	19	Monster cycles to failure	5	Cycles
25	20	Japan Industrial Standards test	5	Binary
26	20	Bending strength (frontal loading)	5	kN

EXHIBIT 5–4

List of metrics for the suspension. The relative importance of each metric and the units for the metric are also shown. "Subj." is an abbreviation indicating that a metric is subjective.

Needs-metric matrix

- Quality Function Deployment (QFD)

	Need	Metric	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
			Attenuation from dropout to handlebar at 10 Hz	Spring preload	Maximum value from the Monster	Minimum descent time on test track	Damping coefficient adjustment range	Maximum travel (26-in. wheel)	Rake offset	Lateral stiffness at the tip	Total mass	Lateral stiffness at brake pivots	Headset sizes	Steertube length	Wheel sizes	Maximum tire width	Time to assemble to frame	Fender compatibility	Instills pride	Unit manufacturing cost	Time in spray chamber without water entry	Cycles in mud chamber without contamination	Time to disassemble/assemble for maintenance	Special tools required for maintenance	UV test duration to degrade rubber parts	Monster cycles to failure	Japan Industrial Standards test	Bending strength (frontal loading)
1	Reduces vibration to the hands		●		●	●																						
2	Allows easy traversal of slow, difficult terrain			●																								
3	Enables high-speed descents on bumpy trails		●		●	●																						
4	Allows sensitivity adjustment						●																					
5	Preserves the steering characteristics of the bike							●	●																			
6	Remains rigid during hard cornering			●						●																		
7	Is lightweight										●																	
8	Provides stiff mounting points for the brakes											●																
9	Fits a wide variety of bikes, wheels, and tires												●	●	●	●												
10	Is easy to install																●											
11	Works with fenders																	●										
12	Instills pride																		●									
13	Is affordable for an amateur enthusiast																			●								
14	Is not contaminated by water																				●							
15	Is not contaminated by grunge																					●						
16	Can be easily accessed for maintenance																						●					
17	Allows easy replacement of worn parts																						●	●				
18	Can be maintained with readily available tools																							●				
19	Lasts a long time																								●	●		
20	Is safe in a crash																										●	●

EXHIBIT 5–5

The needs-metrics matrix.

Step 2: competitive benchmarking

Metric No.	Need Nos.	Metric	Imp.	Units	ST Tritrack	Maniray 2	Rox Tahx Quadra	Rox Tahx Ti 21	Tonka Pro	Gunhill Head Shox
1	1, 3	Attenuation from dropout to handlebar at 10Hz	3	dB	8	15	10	15	9	13
2	2, 6	Spring preload	3	N	550	760	500	710	480	680
3	1, 3	Maximum value from the Monster	5	g	3.6	3.2	3.7	3.3	3.7	3.4
4	1, 3	Minimum descent time on test track	5	s	13	11.3	12.6	11.2	13.2	11
5	4	Damping coefficient adjustment range	3	N-s/m	0	0	0	200	0	0
6	5	Maximum travel (26 in. wheel)	3	mm	28	48	43	46	33	38
7	5	Rake offset	3	mm	41.5	39	38	38	43.2	39
8	6	Lateral stiffness at the tip	3	kN/m	59	110	85	85	65	130
9	7	Total mass	4	kg	1.409	1.385	1.409	1.364	1.222	1.100
10	8	Lateral stiffness at brake pivots	2	kN/m	295	550	425	425	325	650
11	9	Headset sizes	5	in.	1.000 1.125	1.000 1.125 1.250	1.000 1.125	1.000 1.125 1.250	1.000 1.125	NA
12	9	Steertube length	5	mm	150 180 210 230 255	140 165 190 215	150 170 190 210	150 170 190 210 230	150 190 210 220	NA
13	9	Wheel sizes	5	List	26 in	26 in	26 in	26 in 700C	26 in	26 in

Continued

EXHIBIT 5–6

Competitive benchmarking chart based on metrics.

Alternative competitive benchmarking

No.	Need	Imp.	ST Tritrack	Maniray 2	Rox Tahx Quadra	Rox Tahx Ti 21	Tonka Pro	Gunhill Head Shox
1	Reduces vibration to the hands	3	•	••••	••	•••••	••	•••
2	Allows easy traversal of slow, difficult terrain	2	••	••••	•••	•••••	•••	•••••
3	Enables high-speed descents on bumpy trails	5	•	•••••	••	•••••	••	•••
4	Allows sensitivity adjustment	3	•	••••	••	•••••	••	•••
5	Preserves the steering characteristics of the bike	4	••••	••	•	••	•••••••	
6	Remains rigid during hard cornering	4	•	•••	•	•••••	•	•••••
7	Is lightweight	4	•	•••	•	•••	••••	•••••
8	Provides stiff mounting points for the brakes	2	•	••••	•••	•••	•••••••	
9	Fits a wide variety of bikes, wheels, and tires	5	••••	•••••	•••	•••••	•••	•
10	Is easy to install	1	••••	•••••	••••	••••	•••••	•
11	Works with fenders	1	•••	•	•	•	•	•••••
12	Instills pride	5	•	••••	•••	•••••	•••	•••••
13	Is affordable for an amateur enthusiast	5	•••••	•	•••	•	•••	••
14	Is not contaminated by water	5	•	•••	••••	••••	••	•••••
15	Is not contaminated by grunge	5	•	•••	•	••••	••	•••••
16	Can be easily accessed for maintenance	3	••••	•••••	••••	••••	•••••	•
17	Allows easy replacement of worn parts	1	••••	•••••	••••	••••	•••••	•
18	Can be maintained with readily available tools	3	•••••	•••••	•••••	•••••	••	•
19	Lasts a long time	5	•••••	•••••	•••••	•••	•••••	•
20	Is safe in a crash	5	•••••	•••••	•••••	•••••	•••••	•••••

EXHIBIT 5–7

Competitive benchmarking chart based on perceived satisfaction of needs. (Scoring more "dots" corresponds to greater perceived satisfaction of the need.)

Step 3: set ideal and marginally acceptable target values for each metric

- Next step to set final specs

Metric No.	Need Nos.	Metric	Imp.	Units	Marginal Value	Ideal Value
1	1, 3	Attenuation from dropout to handlebar at 10 Hz	3	dB	>10	>15
2	2, 6	Spring preload	3	N	480–800	650–700
3	1, 3	Maximum value from the Monster	5	g	<3.5	<3.2
4	1, 3	Minimum descent time on test track	5	s	<13.0	<11.0
5	4	Damping coefficient adjustment range	3	N-s/m	0	>200
6	5	Maximum travel (26-in. wheel)	3	mm	33–50	45
7	5	Rake offset	3	mm	37–45	38
8	6	Lateral stiffness at the tip	3	kN/m	>65	>130
9	7	Total mass	4	kg	<1.4	<1.1
10	8	Lateral stiffness at brake pivots	2	kN/m	>325	>650
11	9	Headset sizes	5	in.	1.000 1.125	1.000 1.125 1.250
12	9	Steertube length	5	mm	150 170 190 210	150 170 190 210 230
13	9	Wheel sizes	5	List	26 in.	26 in. 700C
14	9	Maximum tire width	5	in.	>1.5	>1.75
15	10	Time to assemble to frame	1	s	<60	<35
16	11	Fender compatibility	1	List	None	All
17	12	Instills pride	5	Subj.	>3	>5
18	13	Unit manufacturing cost	5	US$	<85	<65
19	14	Time in spray chamber without water entry	5	s	>2300	>3600
20	15	Cycles in mud chamber without contamination	5	k-cycles	>15	>35
21	16, 17	Time to disassemble/assemble for maintenance	3	s	<300	<160
22	17, 18	Special tools required for maintenance	3	List	Hex	Hex
23	19	UV test duration to degrade rubber parts	5	Hours	>250	>450
24	19	Monster cycles to failure	5	Cycles	>300k	>500k
25	20	Japan Industrial Standards test	5	Binary	Pass	Pass
26	20	Bending strength (frontal loading)	5	kN	>7.0	>10.0

EXHIBIT 5–8

The target specifications. Like the other information systems, this one is easily encoded with a spreadsheet as a simple extension to the list of specifications.

Product Development Cycle

- Product Planning
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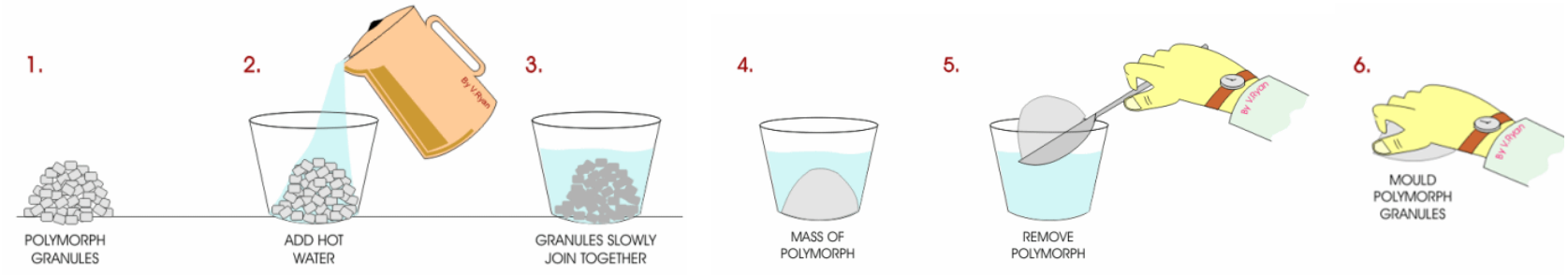
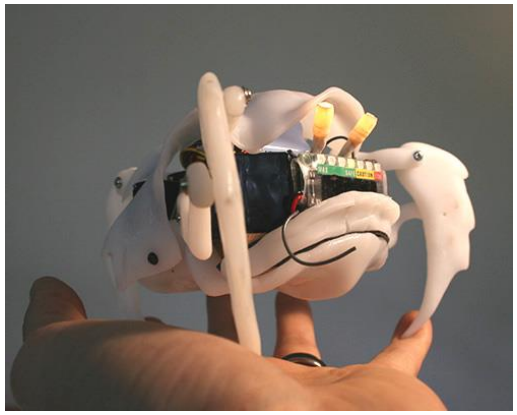
(Product Design and Development *by K T Ulrich & S D Eppinger*)

Design Thinking - Polymorph

- Polymorph
  - Thermoplastic material that can be shaped and reshaped any number of times.



Sequential step to use polymorph



Application of polymorph

Preface

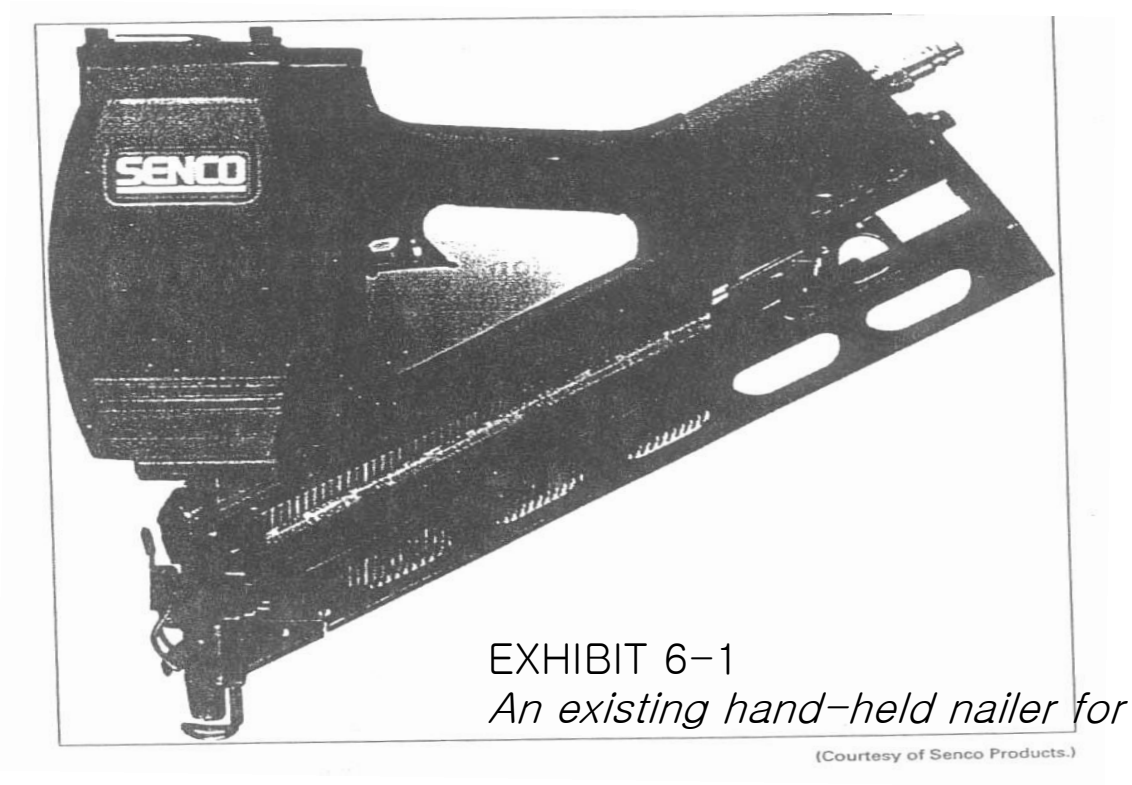


EXHIBIT 6-1
An existing hand-held nailer for the professional market.
(Courtesy of Senco Products.)

PDD ch. 6

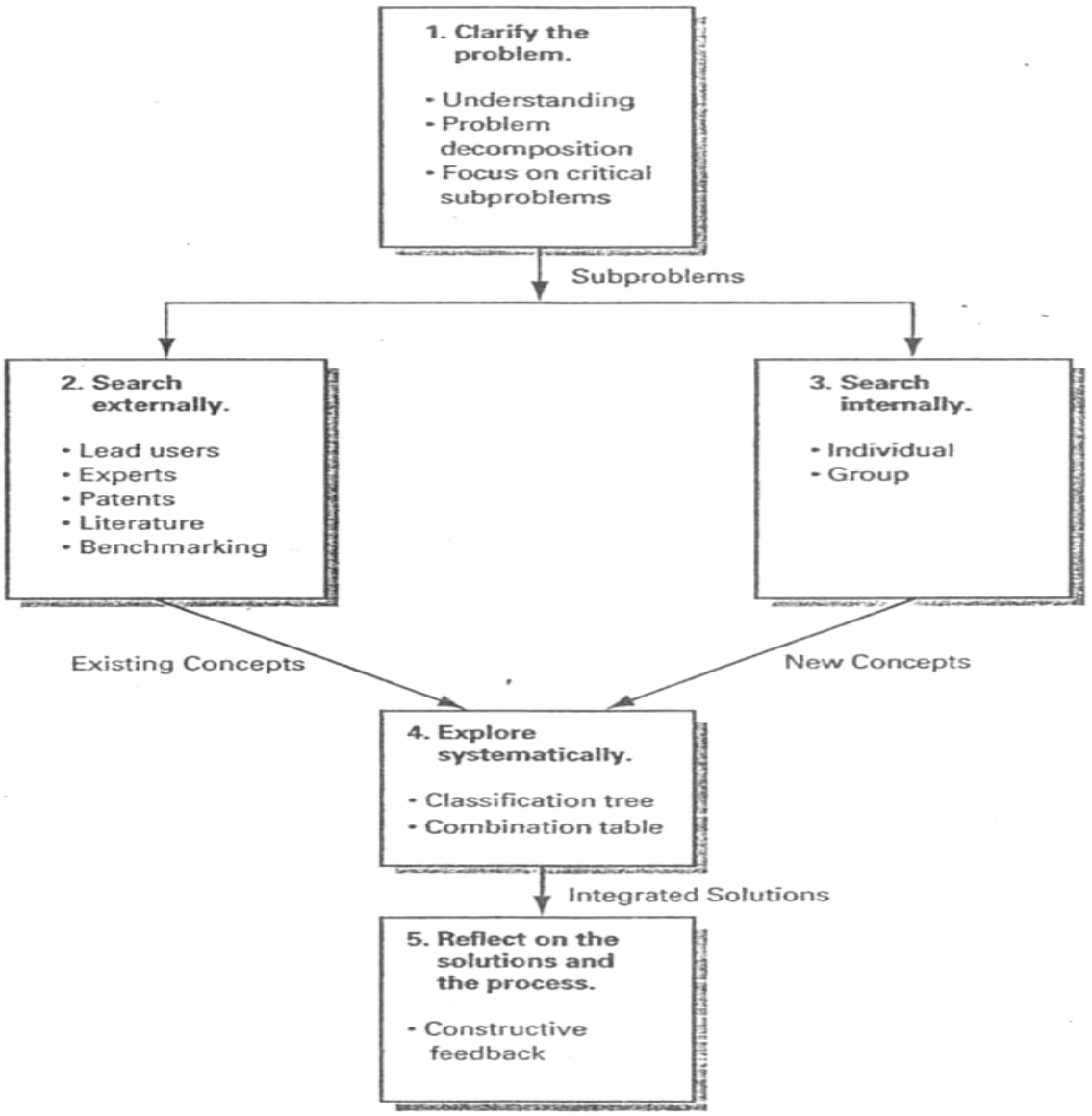
- Questions after establishing target specs:
  - What existing concepts could be adapted for this application?
  - What new concepts might satisfy the established needs and specs?
  - What methods can be used to facilitate the concept generation process?

The Activity of Concept Generation - (1)

- Product concept
  - An approximate description of the technology, working principles, and form of the product
- Importance of concept
  - A good concept is sometimes poorly implemented in subsequent development phases, but a poor concept can rarely be manipulated to achieve
  - Consumes 5% of budget and 15% of development time
  - No excuse for a lack of diligence and care for sound concept generation
- Generate hundreds of concepts

The Activity of Concept Generation - (2)

- Five-step method

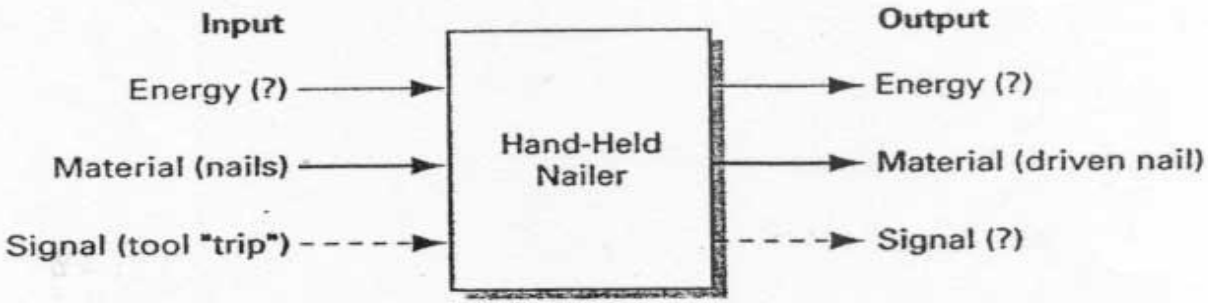


STEP 1: Clarify the Problem

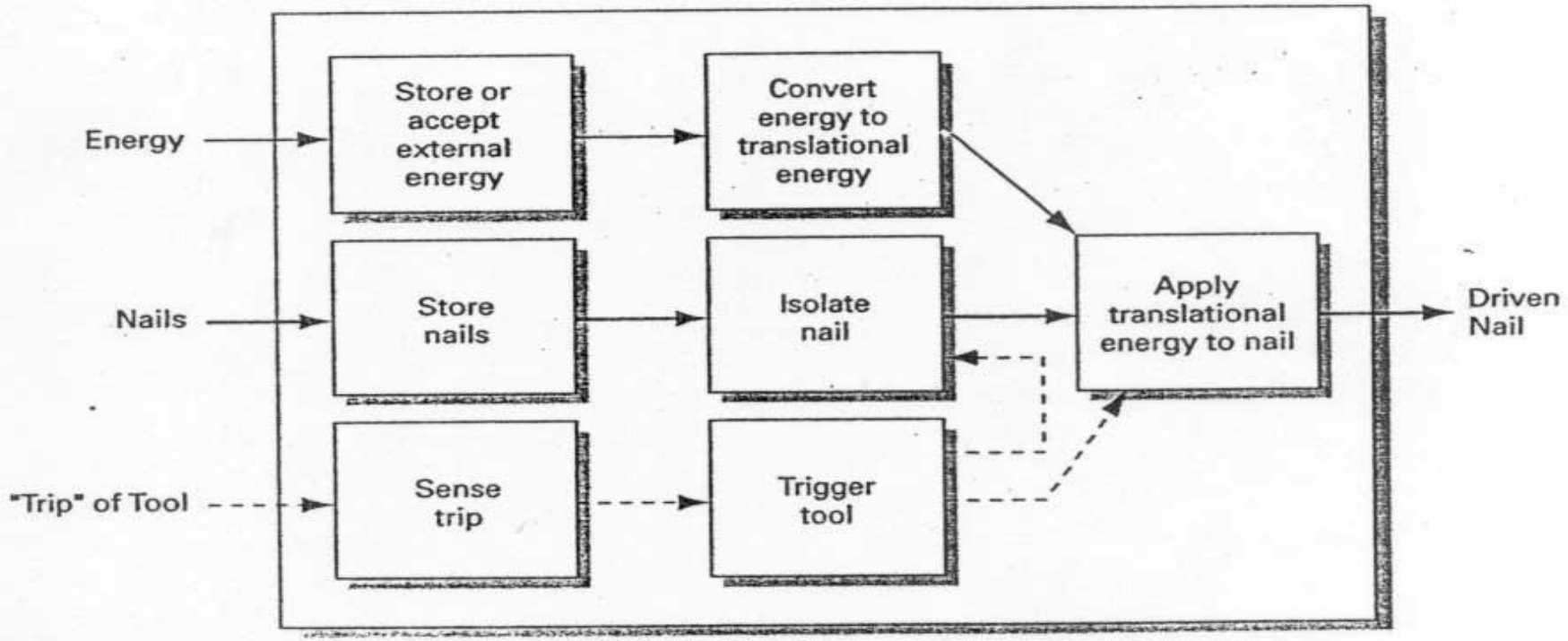
- General understanding
  - Mission statement, customer needs, and target specs.

- Problem Decomposition
  1. Functional decomposition (Exhibit 6- 4)
  2. Decomposition by sequence of user actions
  3. Decomposition by key customer needs

- Focus initial efforts on the critical subproblems
  - Divide a complex problem into simpler problems such that these simpler problems can be tackled in a focused way



(a)



(b)

EXHIBIT 6–4

Function diagram of a hand-held nailer arising from a functional decomposition: (a) overall "black box"; (b) refinement showing subfunctions.

STEP 2: Search Externally

- Finding existing solutions throughout the development process
- Expand and Focus strategy
- Five good ways to gather information from external sources
  - Interview Lead Users
  - Consult experts
  - Search patents (goldfire, patent search site)
  - Search published literature
  - Benchmark related products (Thomas register)

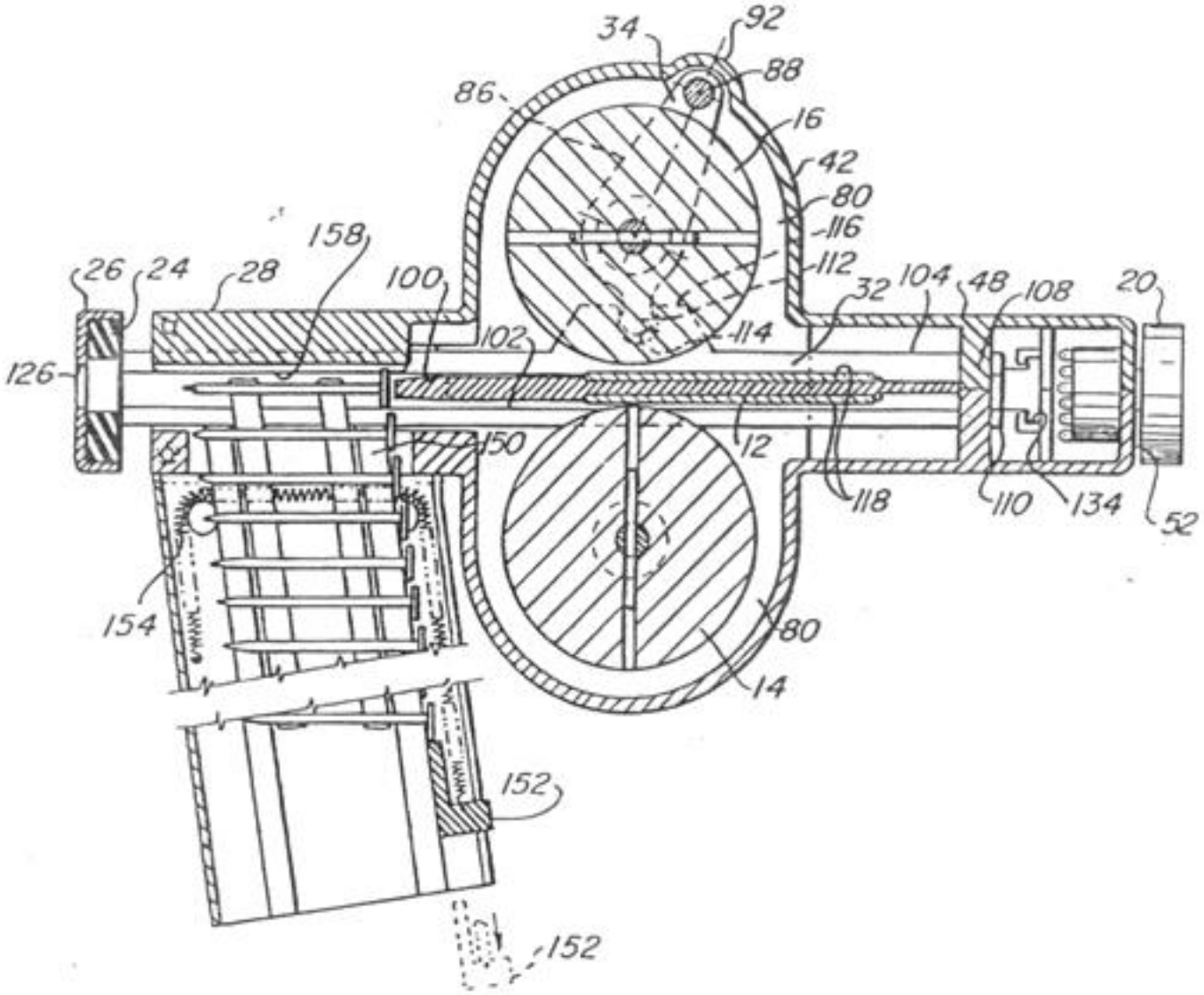


Exhibit 6–5

Concept from motor-driven double-flywheel nailer patent (U.S. Patent 4,042,036). The accompanying text describing the patent is nine pages long.

STEP 3: Search Internally - (1)

- Use of personal and team knowledge and creativity

- Four guidelines
  - Suspend judgment !!
  - Generate a lot of ideas
    - More ideas the better concept
  - Welcome ideas that may seem infeasible
  - Use graphical and physical media
    - foam, clay, cardboard, and other 3D media

STEP 3: Search Internally - (2)

- Techniques to stimulate new ideas
  - Make analogies
    - natural or biological analogy
  - Wish and wonder
    - “I wish we could…”, “I wonder what would happen if…”
  - Use related stimuli
    - Passing each one’s idea to group members
  - Use unrelated stimuli
    - Random photo of objects
  - Set quantitative goals
    - Assign 10~20 concepts
  - Use the gallery method
  - TRIZ

STEP 3:
Search Internally - (3)

Solutions to Subproblem of Storing or Accepting Energy

- Self-regulating chemical reaction emitting high-pressure gas
- Carbide (as for lanterns)
- Combusting sawdust from job site
- Gun powder
- Sodium azide (air bag explosive)
- Fuel-air combustion (butane, propane, acetylene, etc.)
- Compressed air (in tank or from compressor)
- Carbon dioxide in tank
- Electric wall outlet and cord
- High-pressure oil line (hydraulics)
- Flywheel with charging (spin-up)
- Battery pack or tool, belt, or floor
- Fuel cell
- Human power: arms or legs
- Methane from decomposing organic materials
- "Burning" like that of chemical hand warmers
- Nuclear reactions
- Cold fusion
- Solar electric cells
- Solar-steam conversion
- Steam supply line
- Wind
- Geothermal

Solutions to Subproblem of Applying Translational Energy to Nail

Single Impact

Multiple Impacts (tens or hundreds)

Multiple Impacts (hundreds or thousands)

Push

Twist-Push

STEP 4: Explore Systematically – (1)

- Fragments for each subproblems and combinations of the fragments

- Two tools for managing
  - Concept Classification Tree
  - Concept Combination Tree

STEP 4: Explore Systematically – (2)

- Concept Classification Tree
  - Divide possible solutions into independent categories
    - Pruning of less promising branches
    - Identification of independent approaches to the problem
    - Exposure of inappropriate emphasis on certain branches
    - Refinement of the problem decomposition for a particular branches (Exhibit 6-8)

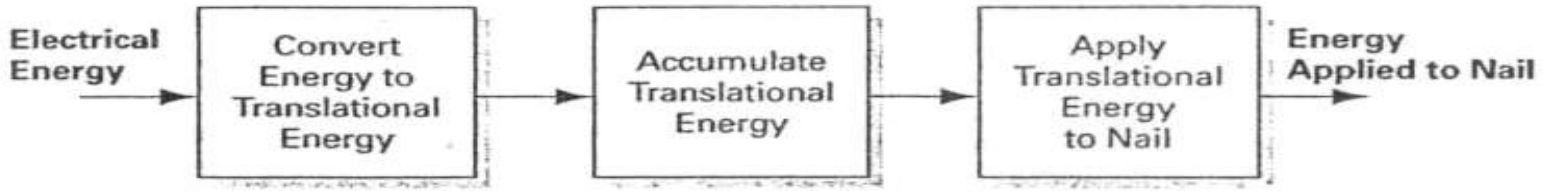


EXHIBIT 6–8

A new problem decomposition assuming an electrical energy source and the accumulation of energy in the mechanical domain.

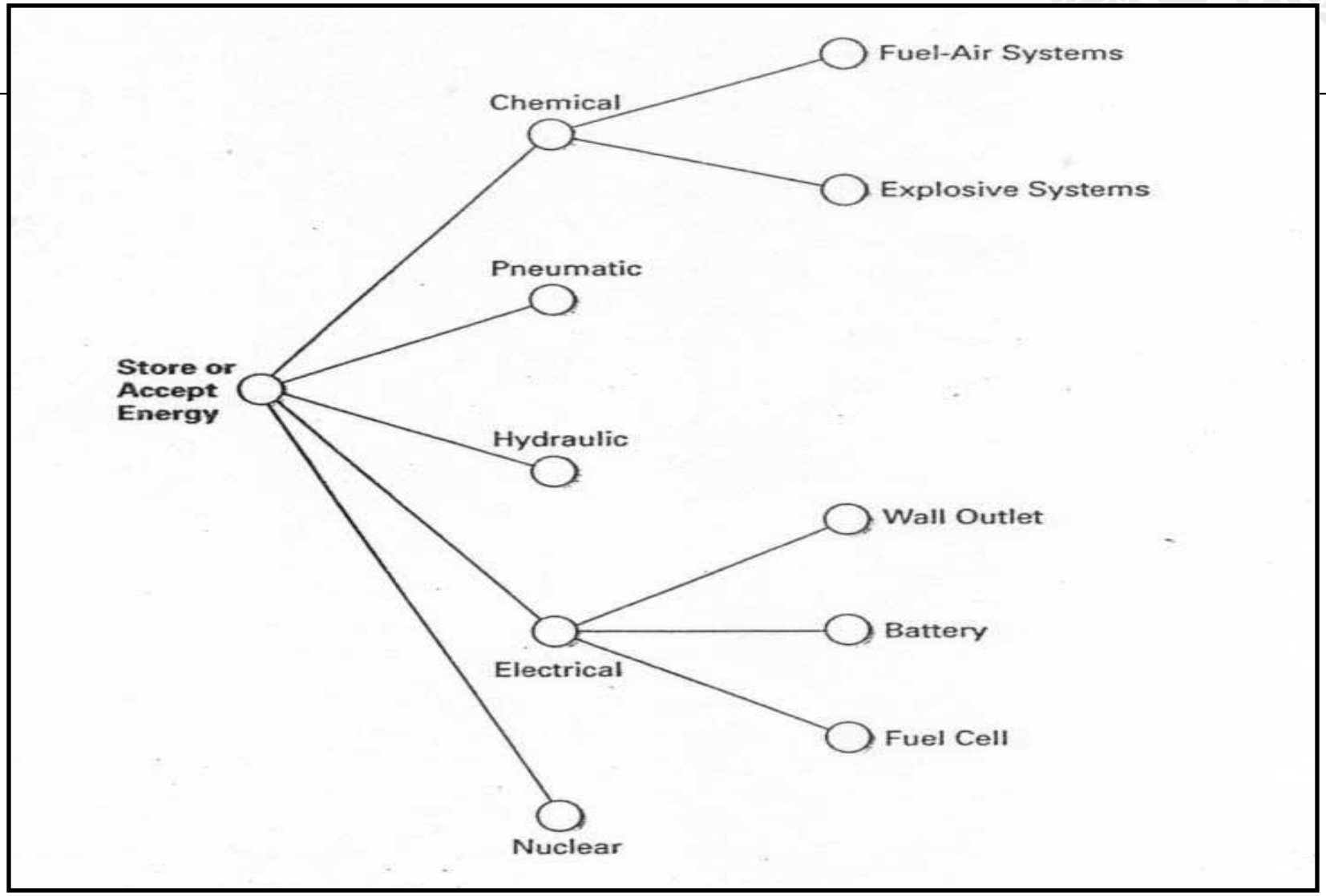


EXHIBIT 6-7

A classification tree for the nailer energy source concept fragments.

STEP 4: Explore Systematically – (3)

- Concept Combination Tree
  - Guides in selectively considering combinations of fragments

Convert Electrical Energy to Translational Energy	Accumulate Energy	Apply Translational Energy to Nail
Rotary motor with transmission	Spring	Single impact
Linear motor	Moving mass	Multiple impacts
Solenoid		Push nail
Rail gun		

EXHIBIT 6–9

Concept combination table for the hand-held nailer.

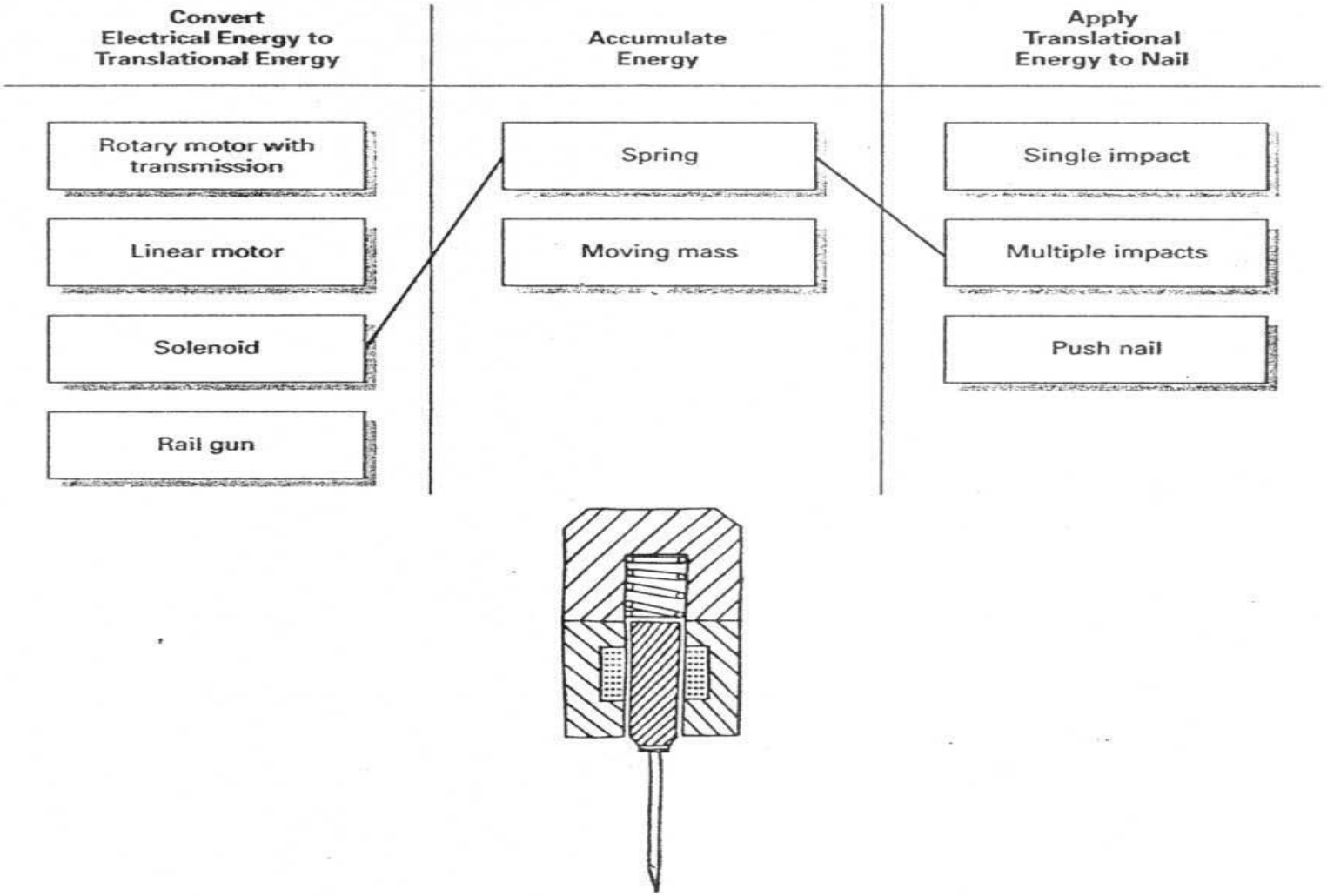
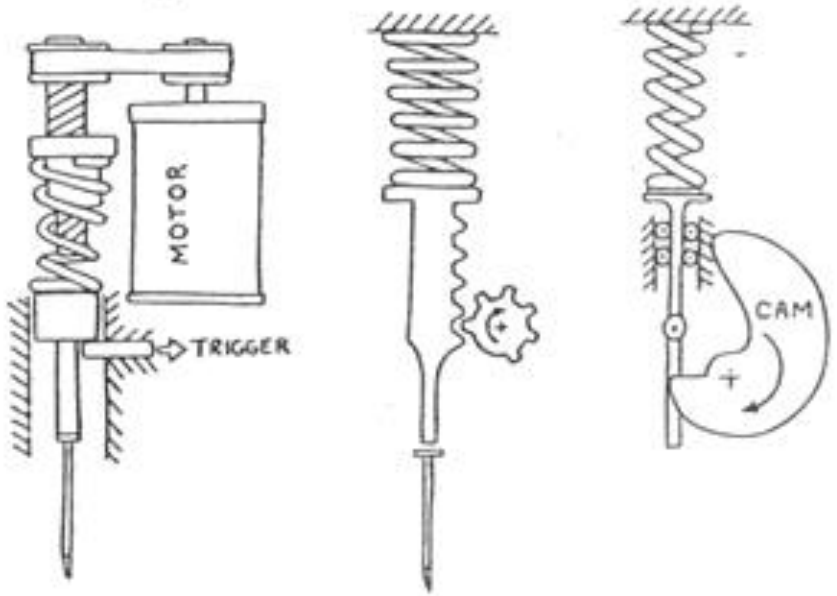


EXHIBIT 6–10

In this solution concept, a solenoid compresses a spring and then releases it repeatedly in order to drive the nail with multiple impacts.

Convert Electrical Energy to Translational Energy	Accumulate Energy	Apply Translational Energy to Nail
Rotary motor with transmission	Spring	Single impact
Linear motor	Moving mass	Multiple impacts
Solenoid		Push nail
Rail gun		



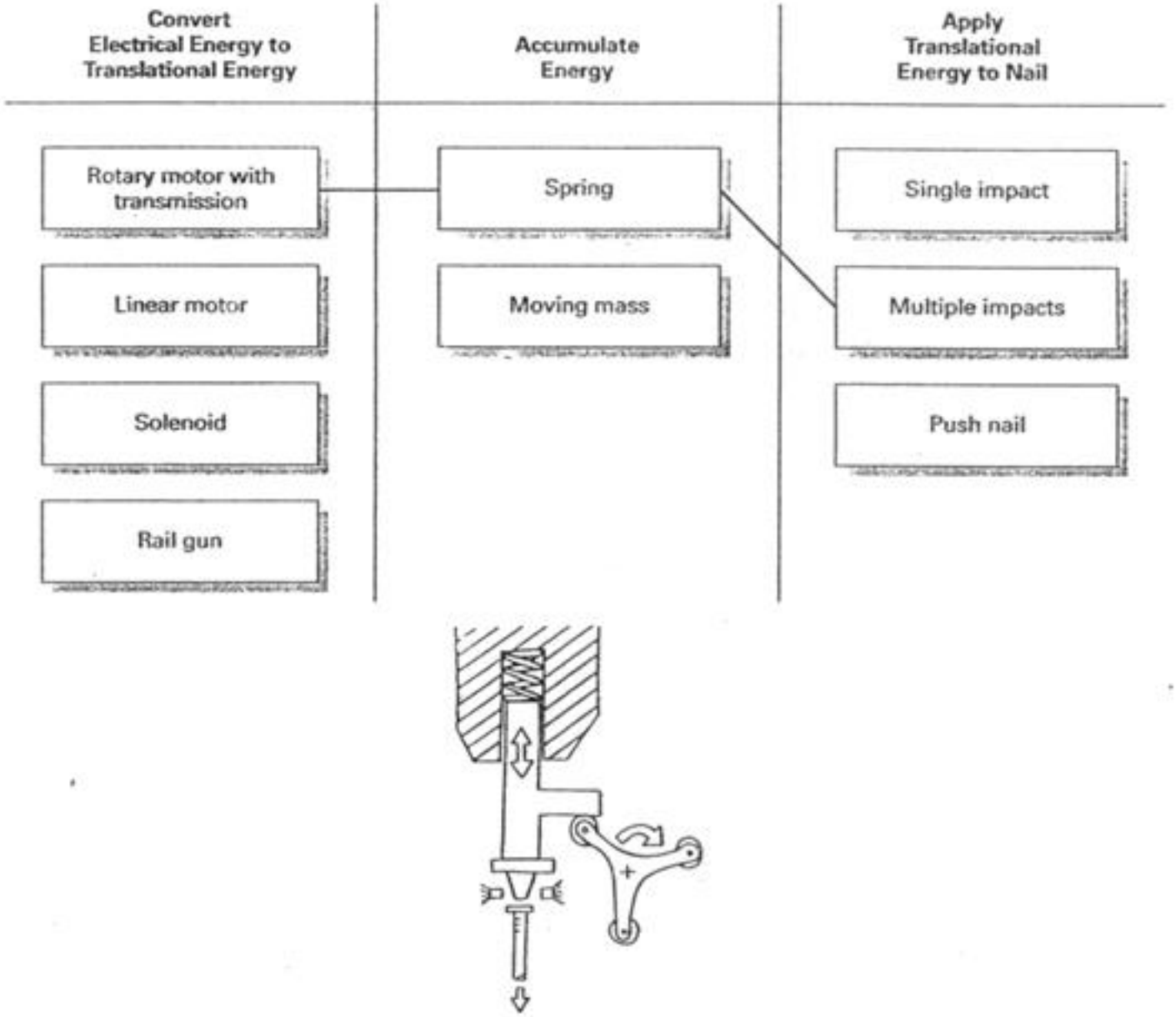


Exhibit 6–12

Solution from the combination of a motor with transmission, a spring, and multiple impacts. The motor repeatedly winds and releases the spring, storing and delivering energy over several blows.

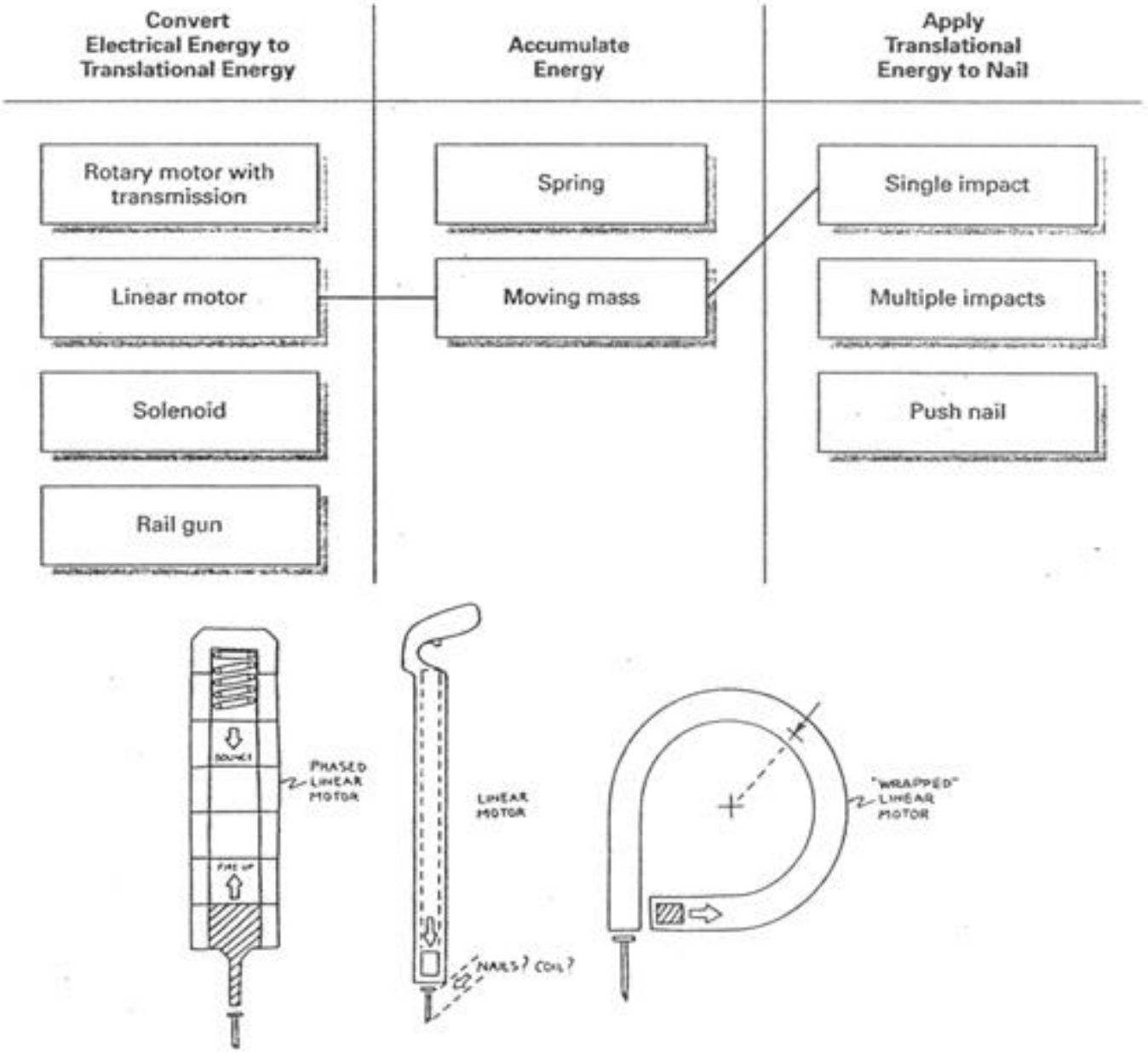
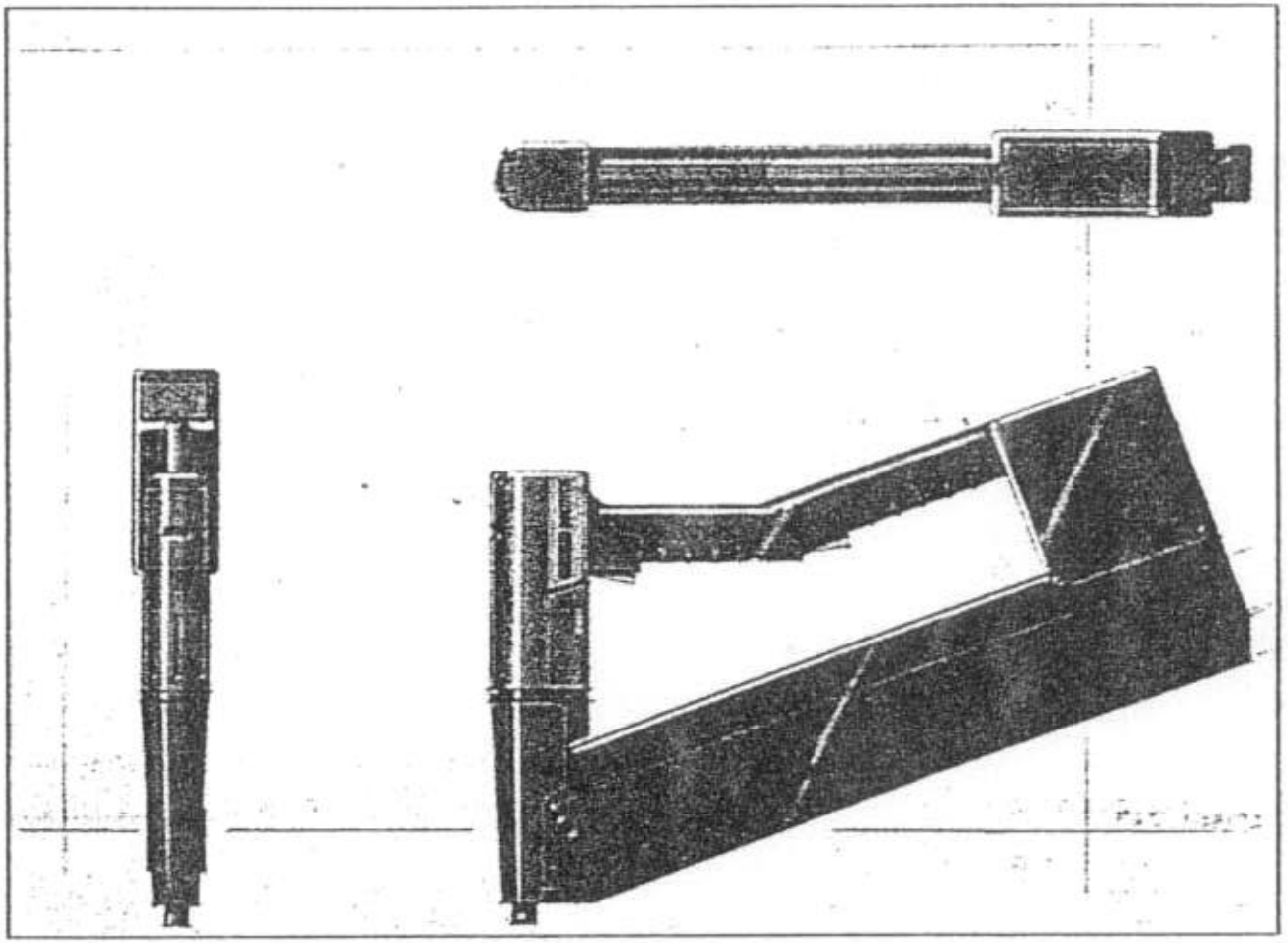


Exhibit 6–13

Solutions from the combination of a linear motor, a moving mass, and single impact. A linear motor accelerates a massive hammer, accumulating kinetic energy which is delivered to the nail in a single blow.

STEP 5: Reflect on the Results and the Process



(Courtesy of Product Genesis Inc.)

EXHIBIT 6–14

One of several refined solution concepts.

Product Development Cycle

- Product Planning
- Identifying Customer Needs
- Product Specification
- **Conceptual Design**
  - Concept Generation
  - **TRIZ**
  - Concept Selection
- Detail Design
- Analysis (FEM/CFD)
- Prototype
- Manufacturing
- Marketing

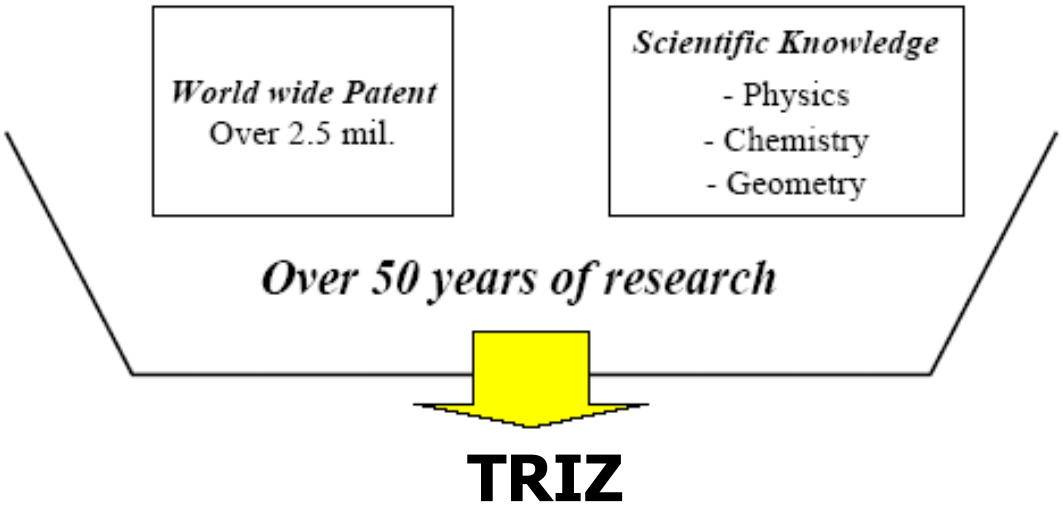
(Product Design and Development *by K T Ulrich & S D Eppinger*)

TRIZ

- **Problem Solving & Innovation Ability =**

Knowledge × Innovation Ability × Thinking Tool × Interest *

Time

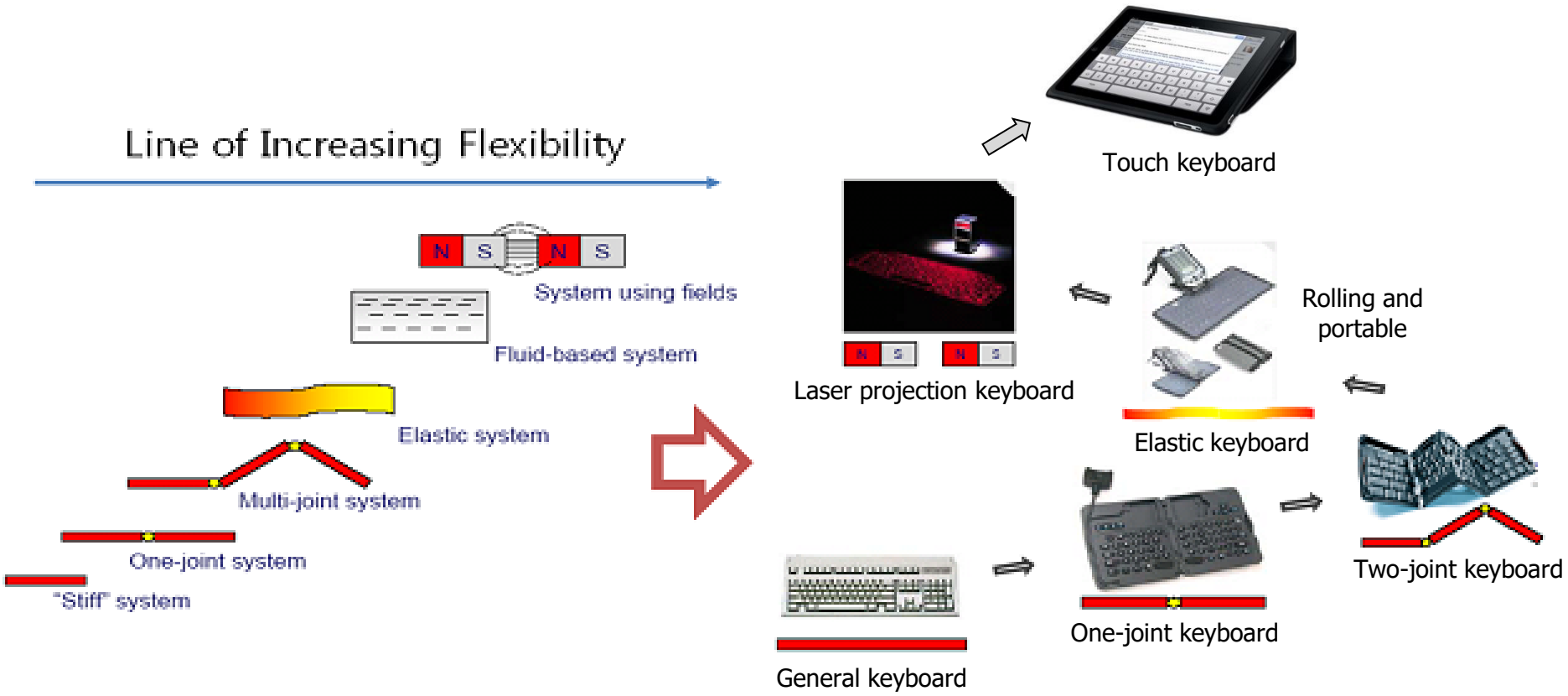


Genrich Altshuller

Teoriya Reshniya Izobretatelskikh Zadatch

(Theory of Inventive Problem Solving)

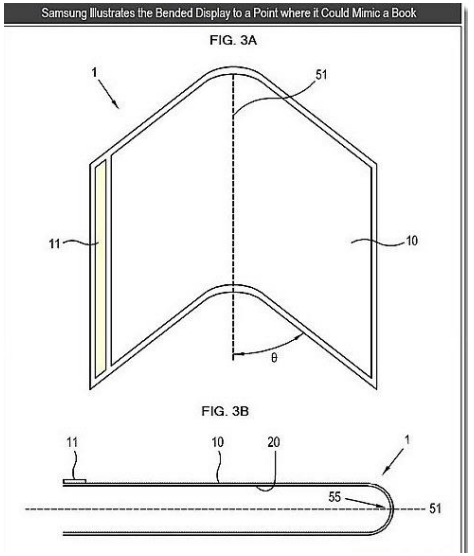
Example of TRIZ I



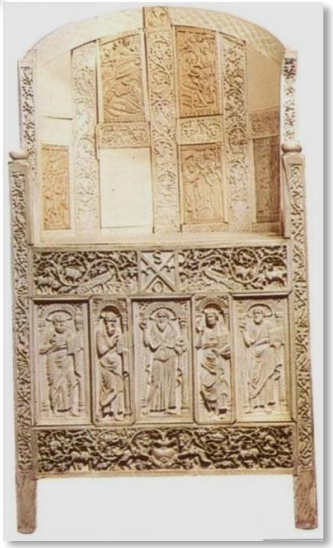
- TRIZ (Teoriya Reshniya Izobretatelskikh Zadatch)
- (Theory of Inventive Problem Solving)

Bended Display

Samsung Project 'Valley' for foldable mobile



Chairs



Archbishop Maximian's throne
c. 550

Thonet, 1904

Blow, De Pas, D'Urbino, Lomazzi and Scolari, 1967

?

Floating chiar?

Oki Sato, fadeout chair

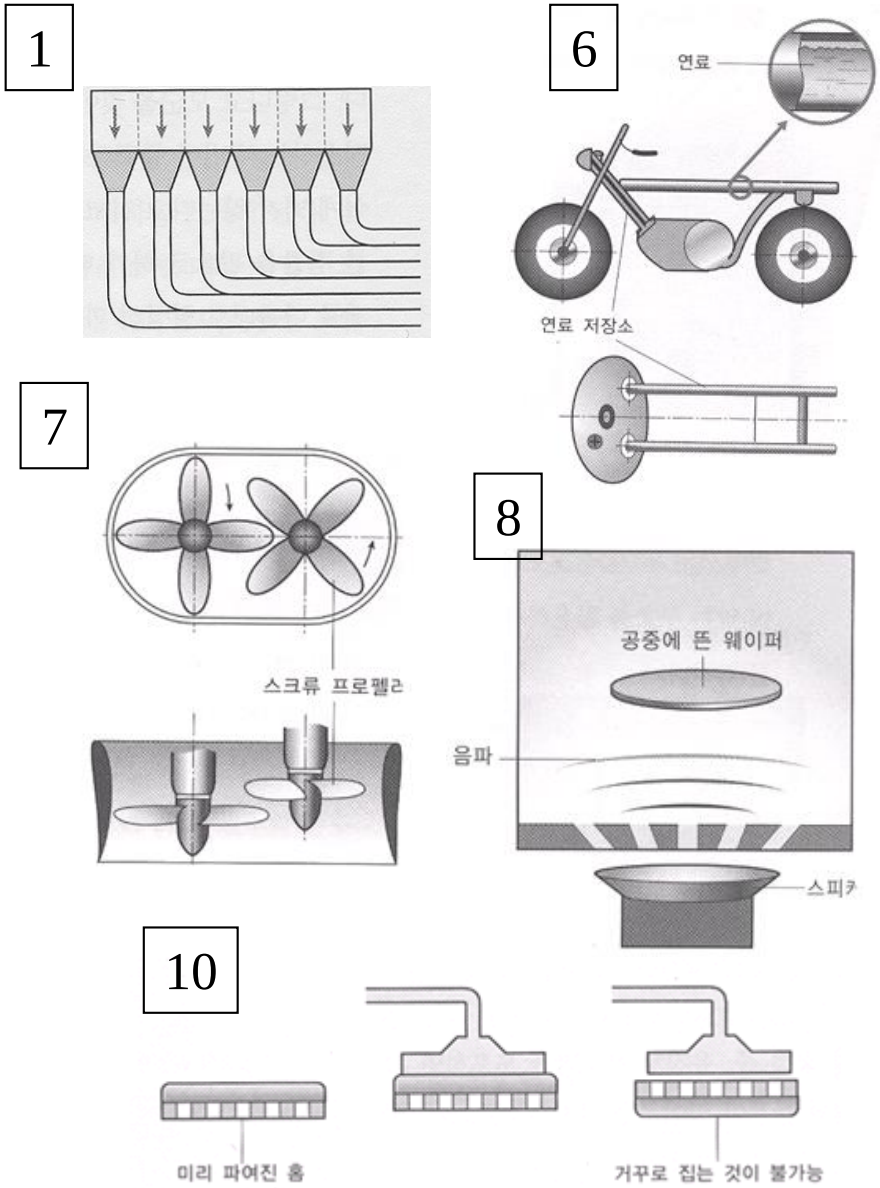
floating chair2008

40 principles of TRIZ

- From Genrich Altshuller's *40 principles: TRIZ Keys to Technical Innovation*
- One of easy way to apply TRIZ
- In order to utilize these principles, you need to almost memorize them
- Try to apply for your project

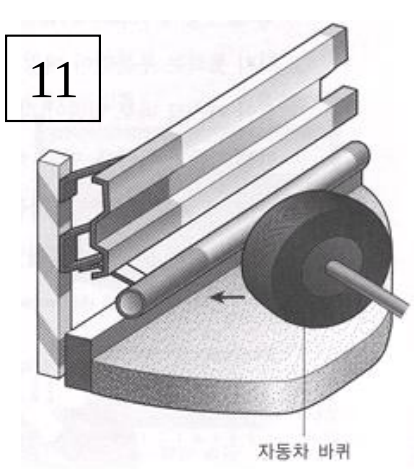
40 principles of TRIZ

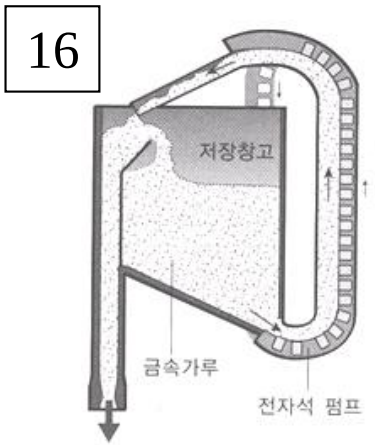
1. Segmentation (분할)
2. Extraction (추출)
3. Local quality (국부적 품질)
4. Asymmetric (비대칭)
5. Consolidation (통합)
6. Multifunction (다용도)
7. Nesting (포개기)
8. Counterweight (공중부양)
9. Preliminary counter action (사전반대조치)
10. Preliminary action (사전조치)

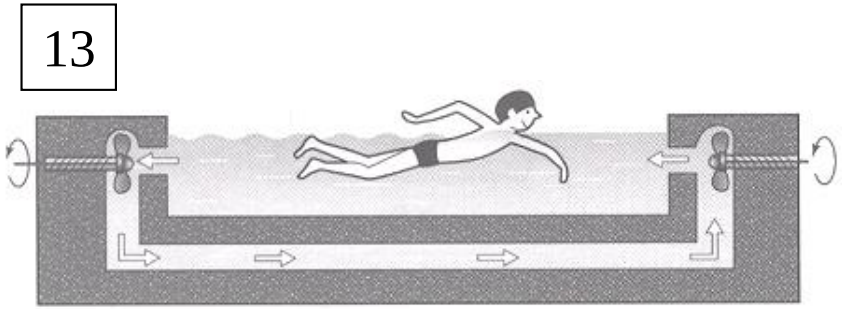


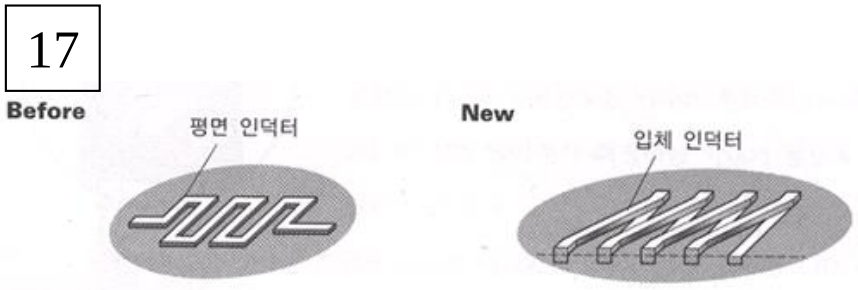
40 principles of TRIZ

11. Preliminary compensation (사전예방조치)
12. Equipotential (굴리기)
13. Do it reverse (역방향)
14. Curvature increase (곡선화)
15. Dynamicity (자유도증가)
16. Partial or excessive (초과나 부족)
17. Dimension change (차원변화)
18. Vibration (진동)
19. Periodic action (주기적 작용)
20. Continuity of useful action (유용한 작용의 지속)





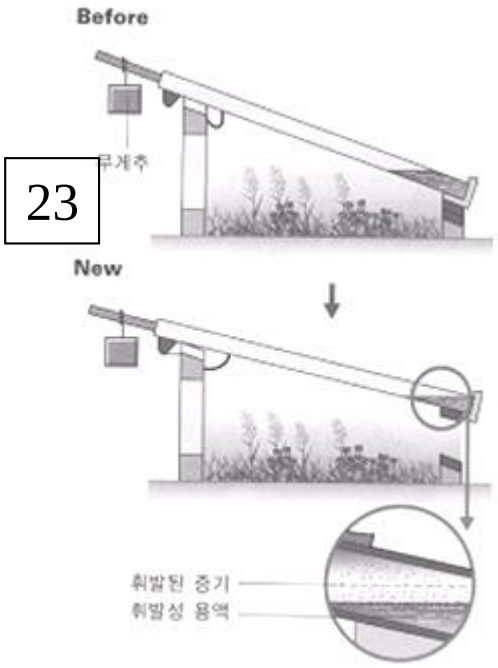




40 principles of TRIZ

21. Rushing through (급히 통과)
22. Convert harmful to useful (전화위복)
23. Feedback (피드백)
24. Intermediate (중간매개물)
25. Self-service (셀프서비스)
26. Copy (복사)
27. Cheap short life (값싸고 짧은 수명)
28. Replacing mechanical system (기계시스템의 대체)
29. Pneumatics and hydraulics system (공기 및 유압사용)
30. Flexible membrane and thin film (얇은 막)

23



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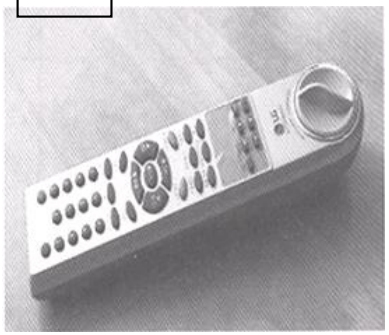
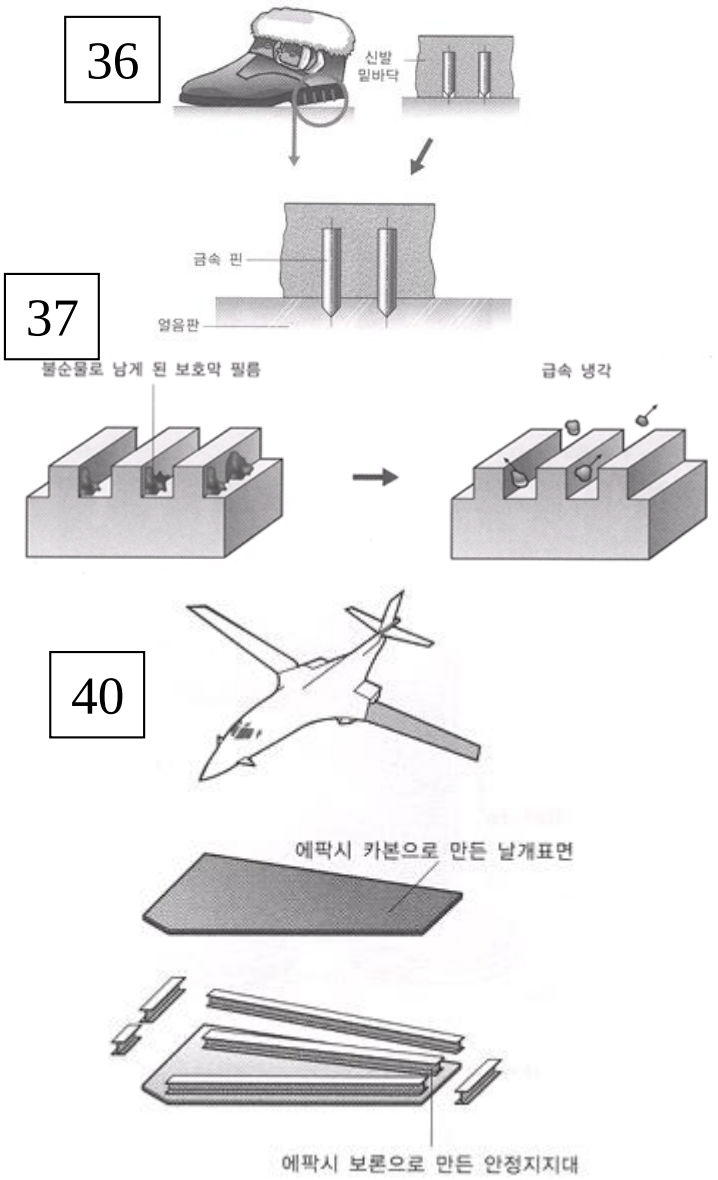


26

40 principles of TRIZ

31. Porous material (다공성 물질)
32. Changing color (색깔 변화)
33. Homogeneity (동질성)
34. Rejection and regeneration (폐기 및 재생)
35. Parameter change (속성변화)
36. Phase transformation (상전이)
37. Thermal expansion (열팽창)
38. Oxidant (산화제)
39. Inert environment (불활성 환경)
40. Composite material (복합재료)



Product Development Cycle

- Product Planning
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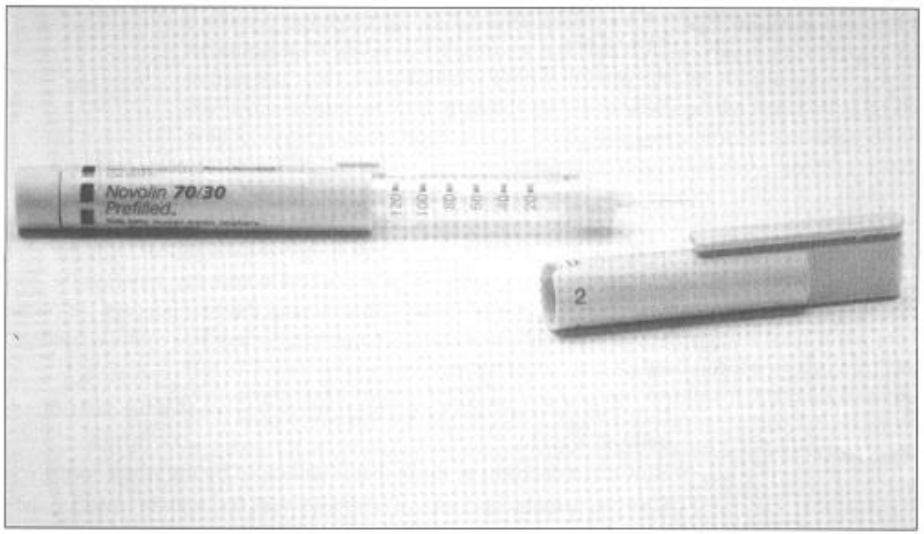
- Product Specification
- **Conceptual Design**
  - Concept Generation
  - TRIZ
  - **Concept Selection**
- Detail Design
- Analysis (FEM/CFD)
- Prototype
- Manufacturing
- Marketing

(Product Design and Development *by K T Ulrich & S D Eppinger*)

Reusable syringe with dosage control



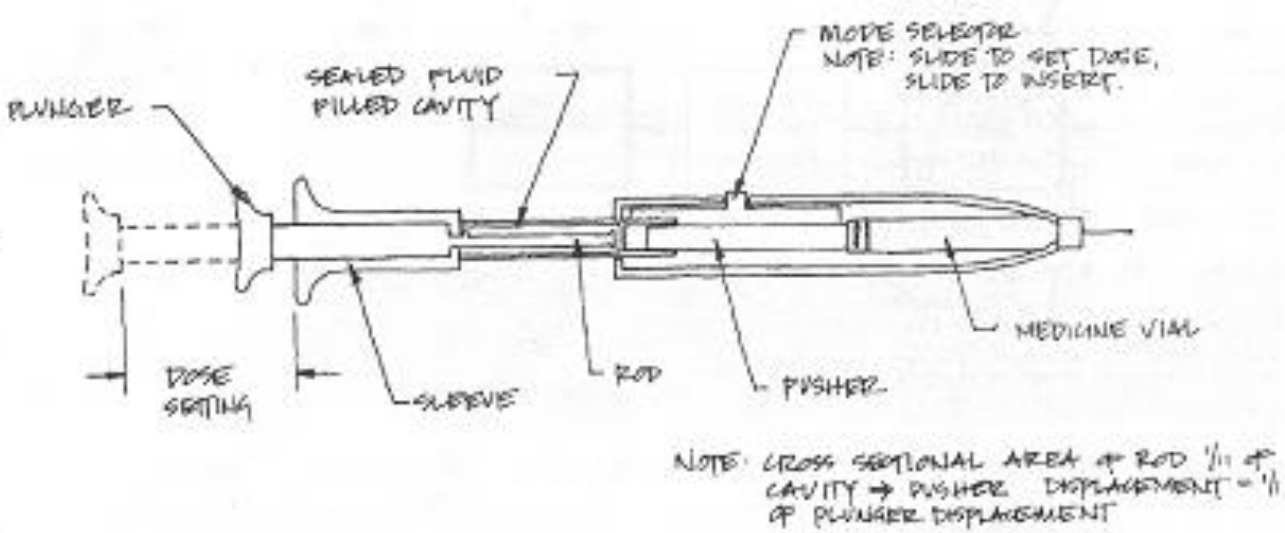
(Courtesy of Novo Nordisk Pharmaceuticals Inc.)

EXHIBIT 7–1
One of the existing outpatient syringes.

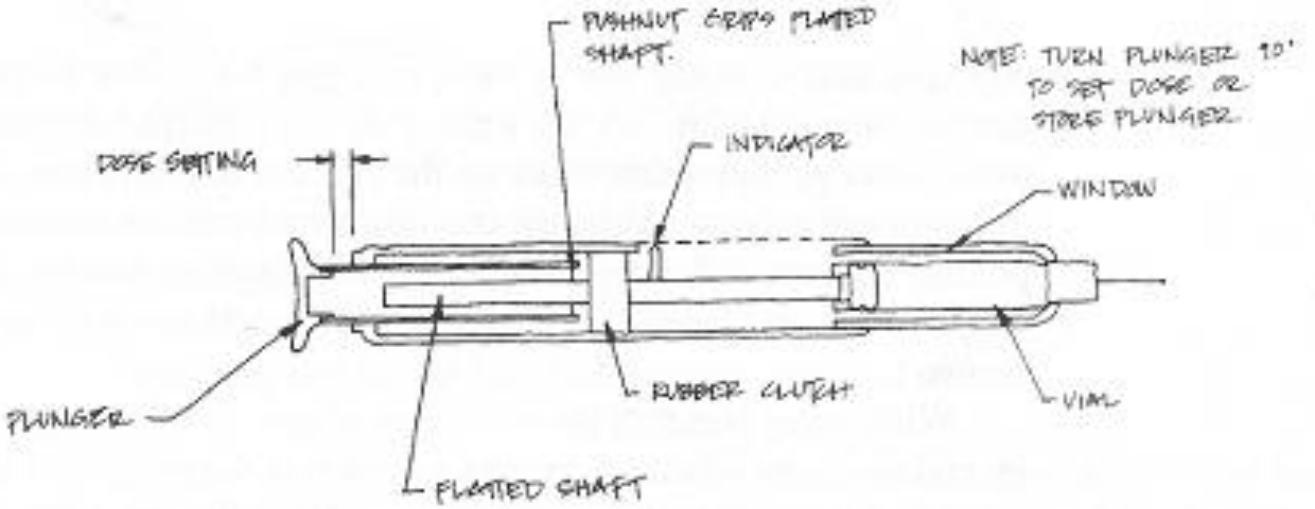
- PDD ch. 7
- Two major problems of existing product
  - Cost (stainless steel)
  - Accuracy of dose metering
- Concept selection is a convergent process

Seven concepts for the outpatient syringe

Concept A: Master Cylinder

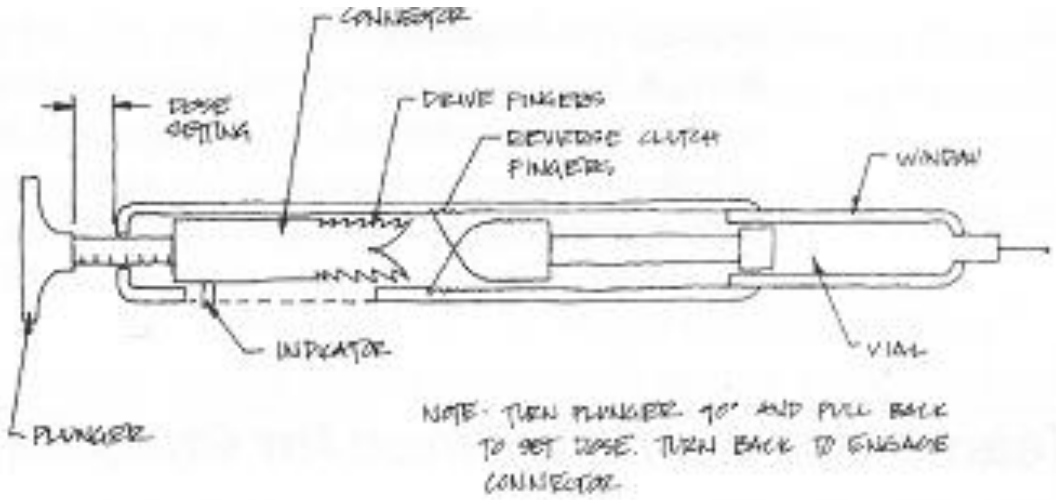


Concept B: Rubber Brake

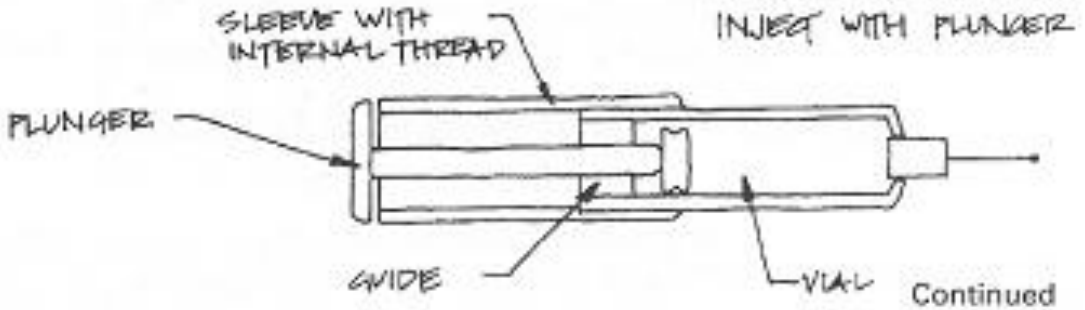


Seven concepts for the outpatient syringe (2)

Concept C:
Ratchet



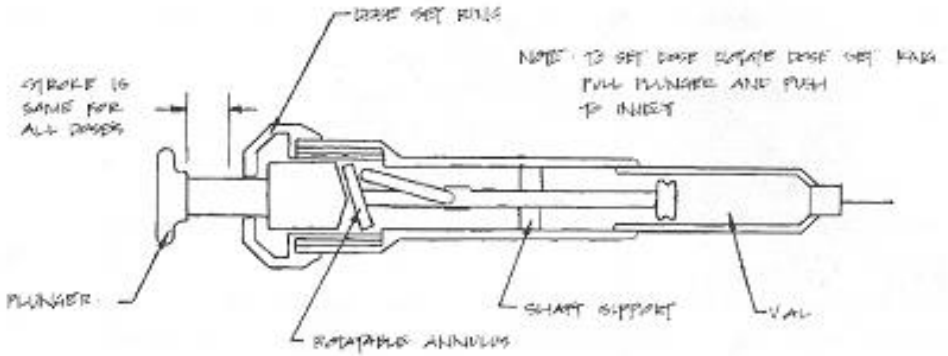
Concept D:
Plunge Stop



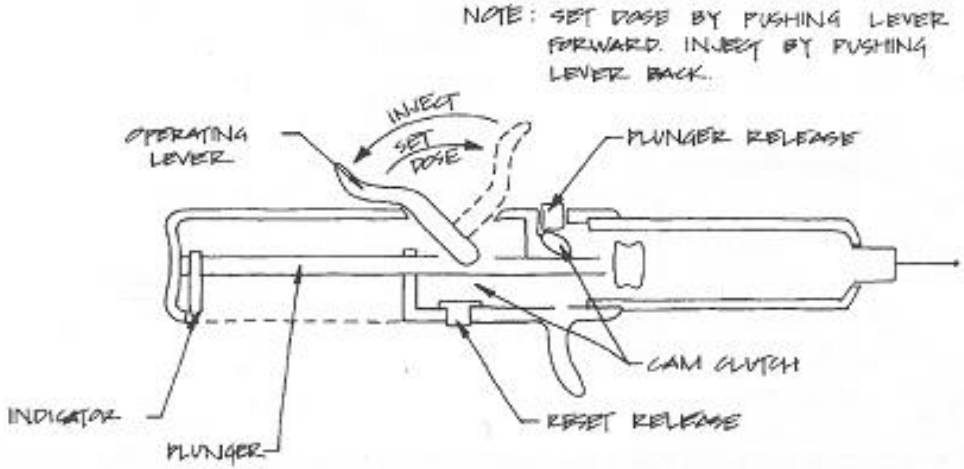
Continued

Seven concepts for the outpatient syringe (3)

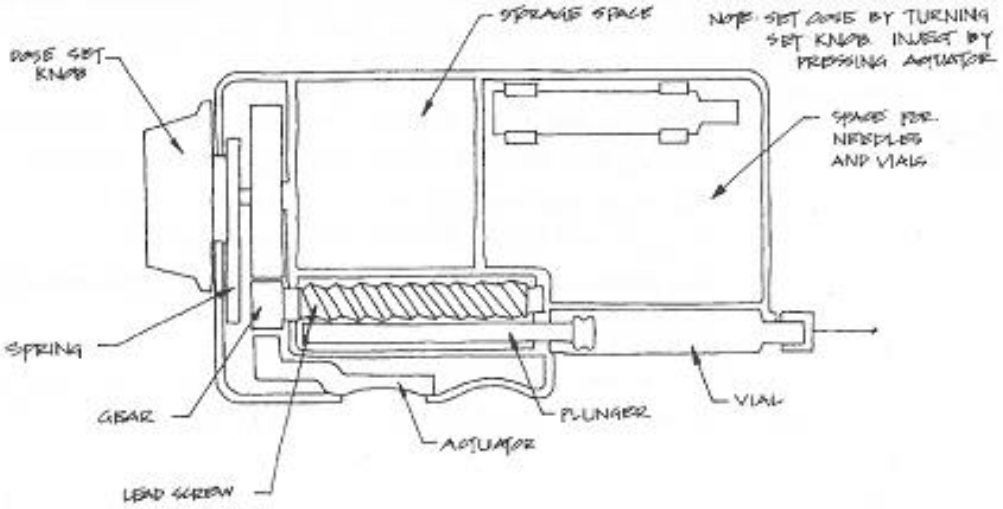
Concept E: Swash Ring



Concept F: Lever Set



Concept G: Dial Screw



Methods to choose a concept

- External decision
- Product champion
- Intuition
- Multivoting
- Pros and cons
- Prototyping and test
- Decision matrices

Iterative process

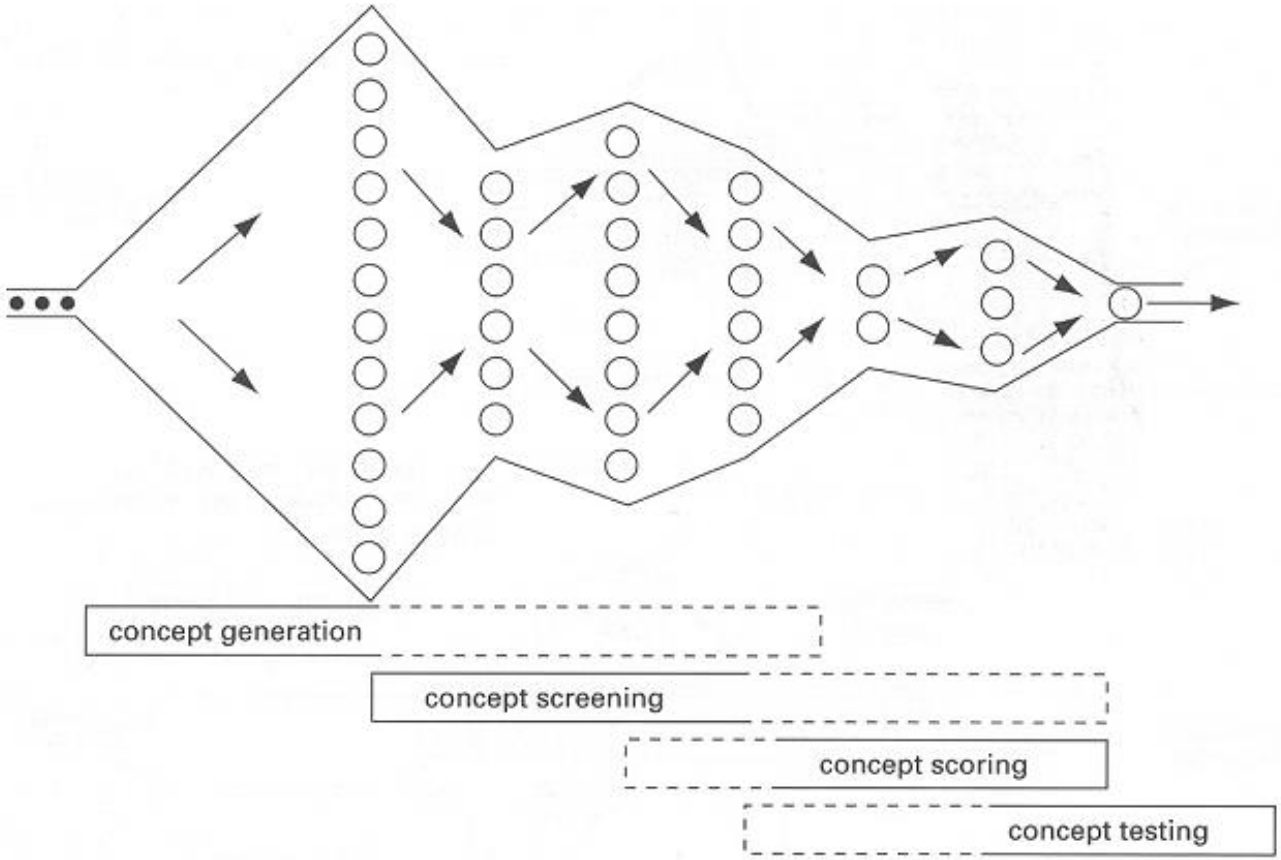


EXHIBIT 7–4

Concept selection is an iterative process closely related to concept generation and testing. The concept screening and scoring methods help the team refine and improve the concepts, leading to one or more promising concepts upon which further testing and development activities will be focused.

Two step methodology

1. Concept screening
   - Quick, approximate evaluation aimed at producing a few viable alternatives
   - Screening matrix
   - Pugh concept selection (Stuart Pugh, 1990)
2. Concept scoring
   - More careful analysis of these relatively few concepts in order to select the single concepts
   - Scoring matrix

Concept screening

- Step 1: prepare the selection matrix
- Step 2: rate the concepts
- Step 3: rank the concepts

Selection Criteria	Concepts						
	A Master Cylinder	B Rubber Brake	C Ratchet	D (Reference) Plunge Stop	E Swash Ring	F Lever Set	G Dial Screw
Ease of handling	0	0	–	0	0	–	–
Ease of use	0	–	–	0	0	+	0
Readability of settings	0	0	+	0	+	0	+
Dose metering accuracy	0	0	0	0	–	0	0
Durability	0	0	0	0	0	+	0
Ease of manufacture	+	–	–	0	0	–	0
Portability	+	+	0	0	+	0	0
Sum +'s	2	1	1	0	2	2	1
Sum 0's	5	4	3	7	4	3	5
Sum –'s	0	2	3	0	1	2	1
Net Score	2	–1	–2	0	1	0	0
Rank	1	6	7	3	2	3	3
Continue?	Yes	No	No	Combine	Yes	Combine	Revise

EXHIBIT 7–5

The concept screening matrix. For the syringe example, the team rated the concepts against the reference concept using a simple code (+ for "better than," 0 for "same as," – for "worse than") in order to identify some concepts for further consideration. Note that the three concepts ranked "3" all received the same net score.

Concept screening (2)

- Step 4: combine and improve the concepts
- Step 5: select one or more concepts
- Step 6: reflect on the results and the process

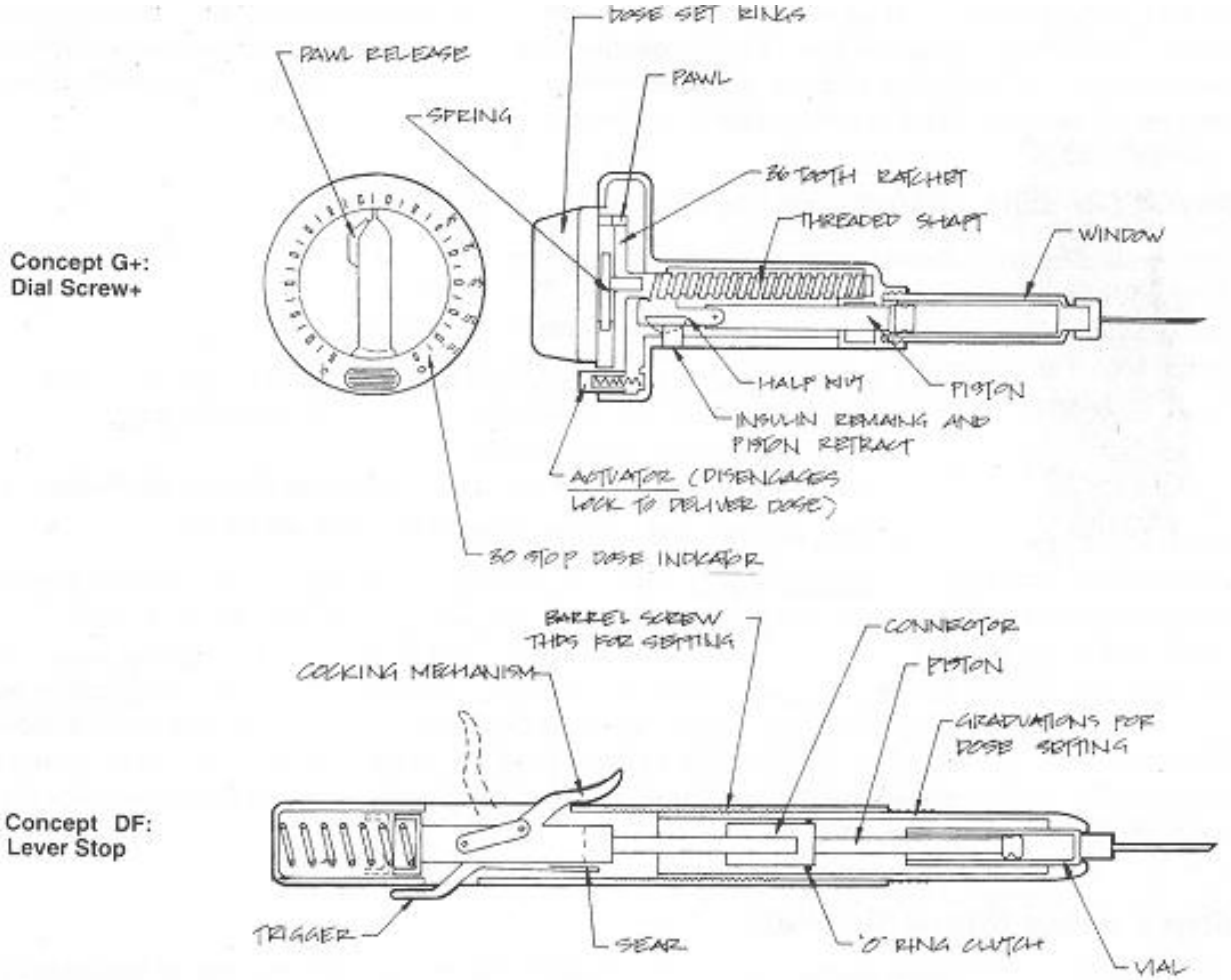


EXHIBIT 7–6

New and revised concepts for the syringe. During the selection process, the syringe team revised concept G and generated a new concept, DF, arising from the combination of concepts D and F.

Concept scoring

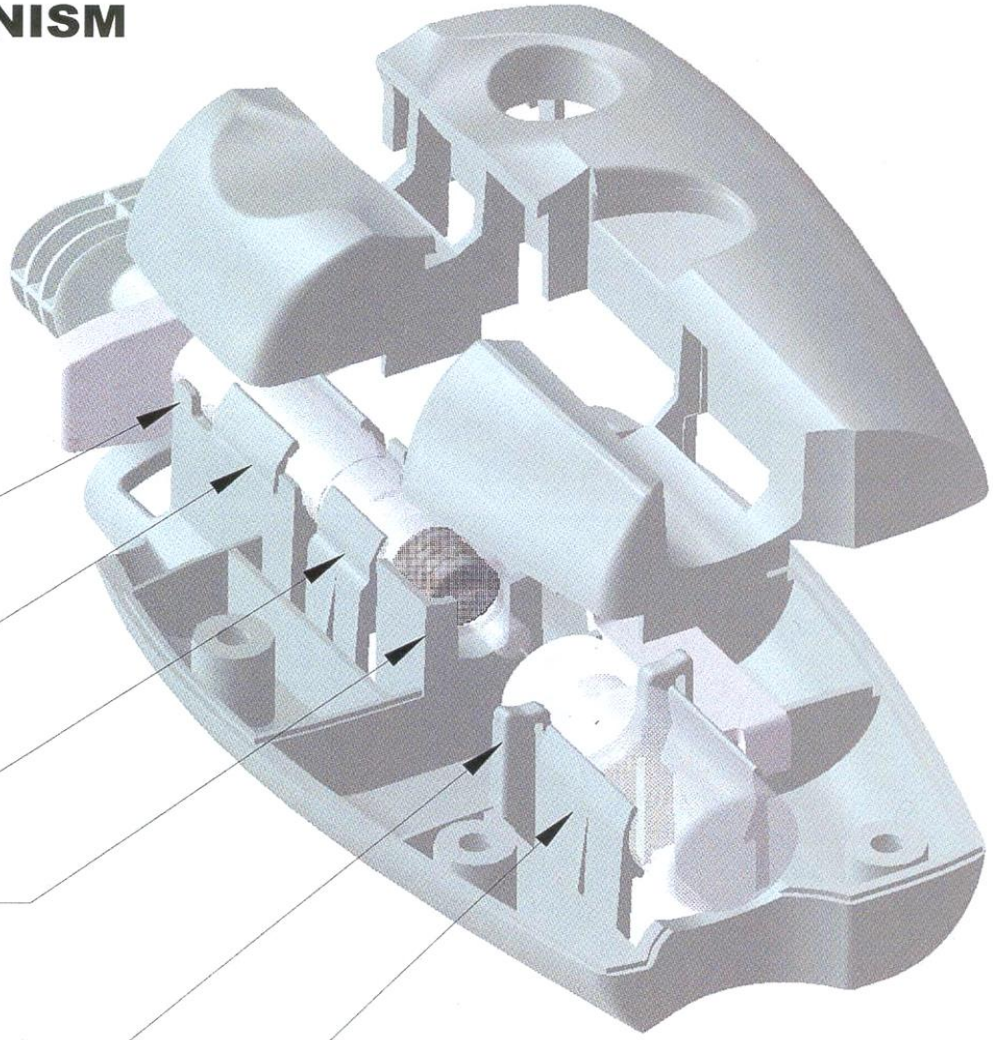
- Step 1: prepare the selection matrix
- Step 2: rate the concepts
- Step 3: rank the concepts
- Step 4: combine and improve the concepts
- Step 5: select one or more concepts
- Step 6: reflect on the results and the process

		Concepts							
		A (Reference) Master Cylinder		DF Lever Stop		E Swash Ring		G+ Dial Screw+	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Ease of handling	5%	**3**	0.15	3	0.15	4	0.2	4	0.2
Ease of use	15%	**3**	0.45	4	0.6	4	0.6	3	0.45
Readability of settings	10%	2	0.2	**3**	0.3	5	0.5	5	0.5
Dose metering accuracy	25%	**3**	0.75	3	0.75	2	0.5	3	0.75
Durability	15%	2	0.3	5	0.75	4	0.6	**3**	0.45
Ease of manufacture	20%	**3**	0.6	3	0.6	2	0.4	2	0.4
Portability	10%	**3**	0.3	3	0.3	3	0.3	3	0.3
	Total Score	2.75		3.45		3.10		3.05	
	Rank	4		1		2		3	
	Continue?	No		Develop		No		No	

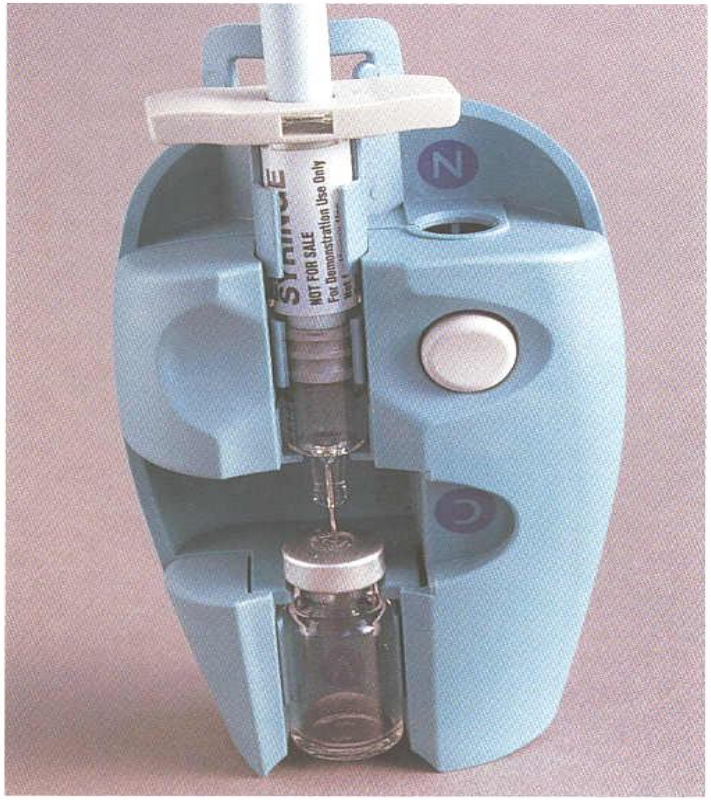
EXHIBIT 7–7

The concept scoring matrix. This method uses a weighted sum of the ratings to determine concept ranking. While concept A serves as the overall reference concept, the separate reference points for each criterion are signified by ***bold*** *rating values.*

ALIGNMENT MECHANISM



The built-in alignment mechanism guarantees perfect needle alignment in the vial every time.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