INCLUDES 240 ILLUSTRATED EXAMPLES

POKA-YOKE

IMPROVING PRODUCT QUALITY BY PREVENTING DEFECTS

EDITED BY NIKKAN KOGYO SHIMBUN MAGAZINE

OVERVIEW BY HIROYUKI HIRANO

Poka-yoke

Improving Product Quality by Preventing Defects

Overview of Poka-yoke

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A Successful Modern Factory

"Inadvertent mistakes increase work."

To survive in the competitive atmosphere of modern manufacturing, a company must adhere strictly to standards. While customers must be satisfied with all aspects of products and service, the company must still make a profit and protect its workers. In a successful modern factory:

Sales price = market price
Sell at a price consumers are willing to pay.

Diversity = many kinds of products in small numbers
Make only what consumers need.

Quality = highest possible quality
Make products that will satisfy consumers.

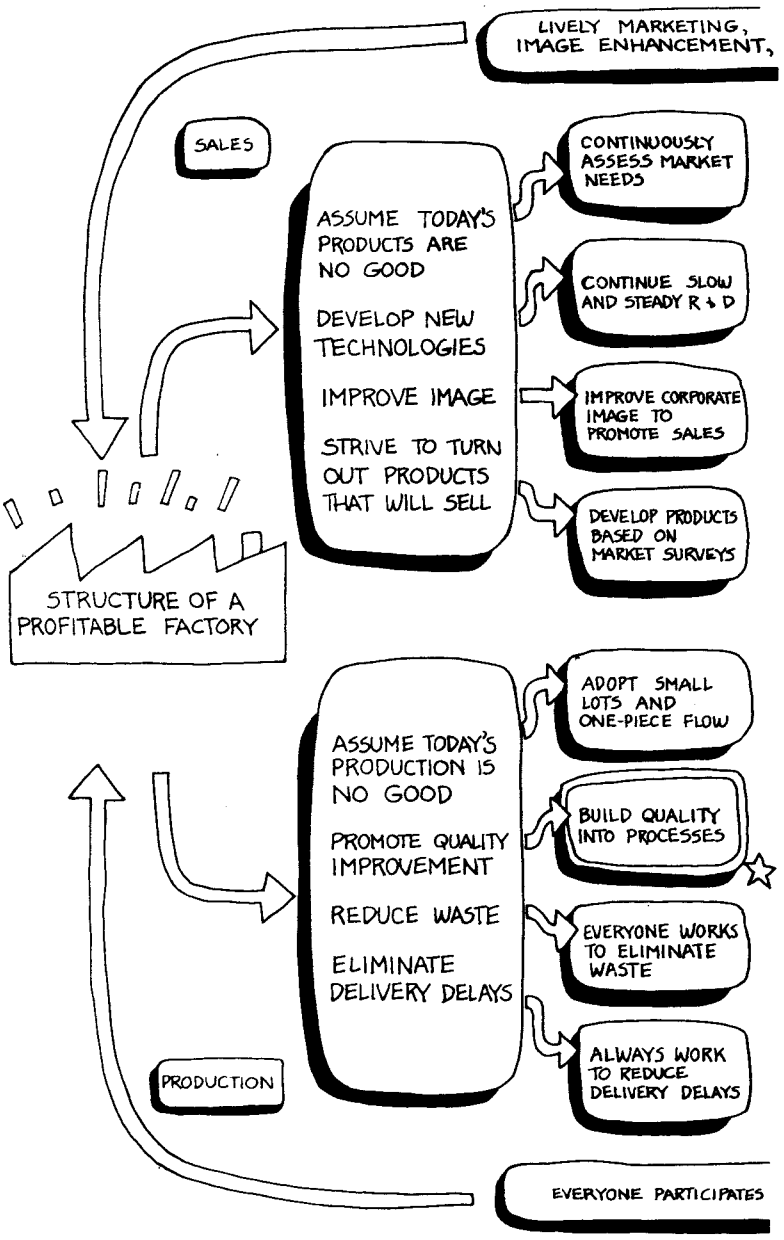
Delivery = always on time
Always meet delivery schedules. Deliver products just when consumers need them.

Cost = lowest unit cost
Produce at the lowest possible cost while satisfying consumer requirements.

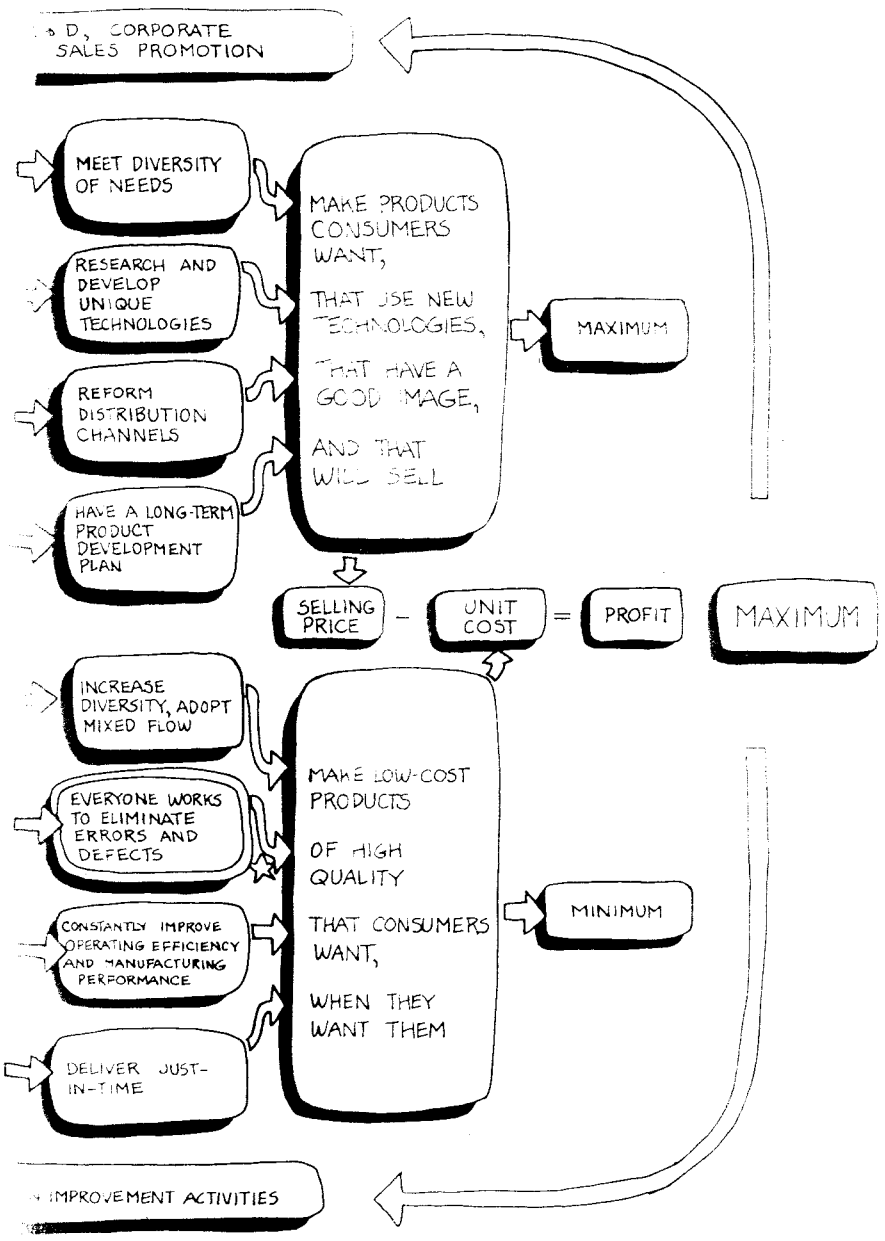
Safety = always first
Turn out safe products safely.

Do You Have a Consumer-driven Company?

A manufacturer that makes products to satisfy consumers is "consumer driven" or "outside-in." On the other hand, a factory that makes products that are forced on consumers is "producer driven" or "inside-out." In today's competitive economy, a company must be consumer driven to be successful. How are things in *your* factory?



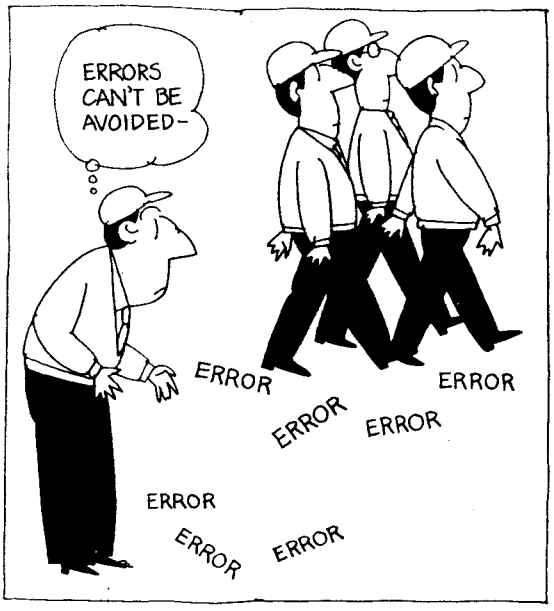

FACTORY


D, CORPORATE SALES PROMOTION
MEET DIVERSITY OF NEEDS
RESEARCH AND DEVELOP UNIQUE TECHNOLOGIES
REFORM DISTRIBUTION CHANNELS
HAVE A LONG-TERM PRODUCT DEVELOPMENT PLAN
MAKE PRODUCTS CONSUMERS WANT,
THAT USE NEW TECHNOLOGIES,
THAT HAVE A GOOD IMAGE,
AND THAT WILL SELL
MAXIMUM
SELLING PRICE
UNIT COST
PROFIT
MAXIMUM
INCREASE DIVERSITY, ADOPT MIXED FLOW
EVERYONE WORKS TO ELIMINATE ERRORS AND DEFECTS
CONSTANTLY IMPROVE OPERATING EFFICIENCY AND MANUFACTURING PERFORMANCE
DELIVER JUST-IN-TIME
MAKE LOW-COST PRODUCTS
OF HIGH QUALITY
THAT CONSUMERS WANT,
WHEN THEY WANT THEM
MINIMUM
IMPROVEMENT ACTIVITIES

All About Defects

Are Errors Unavoidable?

There are two approaches to dealing with errors:



- **Errors are inevitable!**

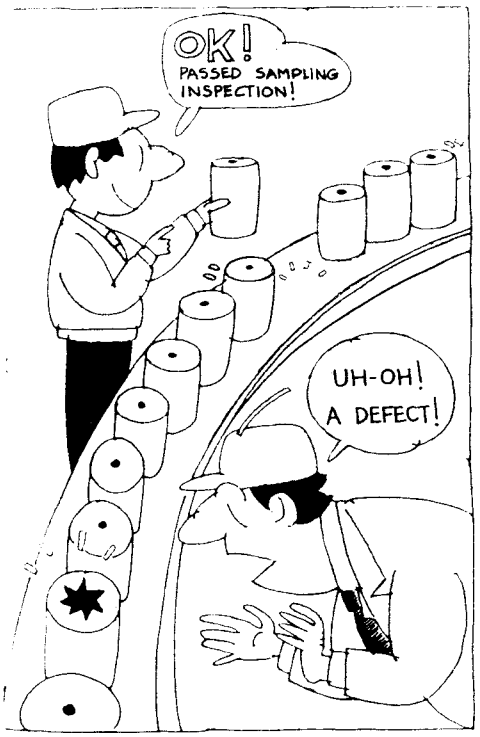
People always make mistakes. While we tend to accept the mistakes as natural, we blame the people who make them. With this kind of attitude, we're likely to overlook defects as they occur in production. They may be detected only in final inspection or, worse yet, by the customer.

- **Errors can be eliminated!**

Any kind of mistake people make can be reduced or even eliminated. People make fewer mistakes if they are supported by proper training and by a production system based on the principle that errors can always be prevented.

Is Sampling Inspection Really the Best Method?

One method of preventing errors is inspection. There are two major types of inspection.



- **Sampling inspection**

Some plant managers say, "It would take us all day to inspect all our products. There may be a few defects, but sampling is still the most practical way to check. We maintain our quality at an average quality level (AQL) of 0.1 percent."

But this means that one consumer in a thousand will get a defective product! For that consumer, the product is 100 percent defective, not 0.1 percent defective. Sampling inspection makes sense only from the manufacturer's view, not from the consumer's.

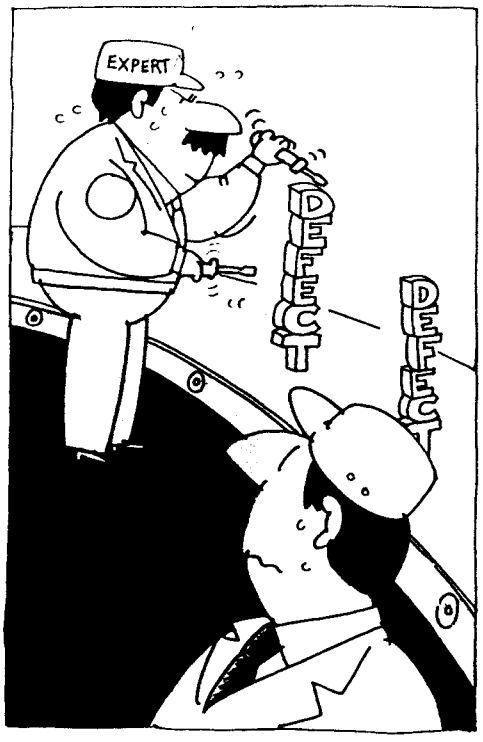
- **100 percent inspection makes the most sense!**

In the best factories, the attitude is, "We won't tolerate a single defect! We'll organize production so that 100 percent of the products can be inspected easily. That makes the most sense!"

Today, even one defective product is enough to destroy a consumer's confidence in the company. To stay competitive, a company must supply good products in the tens and hundreds of thousands. The best way to achieve this is to organize production to inspect 100 percent of the products.

The User Is the Best Inspector

No one intends to make mistakes. But while we are working, defects can show up without our noticing. We usually think we're doing the job right, even as we mistakenly mount the wrong part or drill a hole in the wrong position. How can we catch these errors before they turn into defective products?



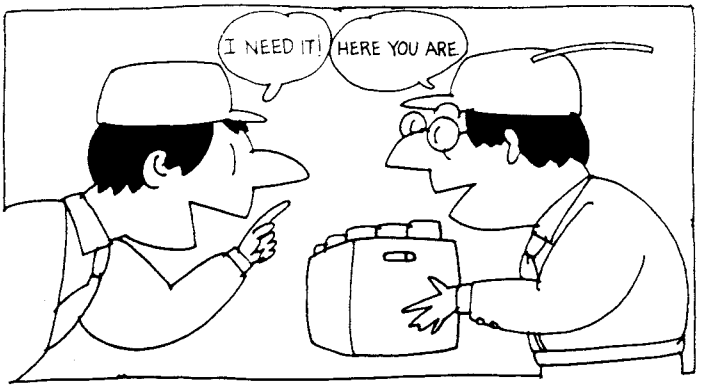
- **Finding defects in the subsequent process**

We don't expect to find defects, but if a product we use doesn't do what it is supposed to do, we know it's defective. Users are the best at discovering defects.

Since subsequent processes are also "users" of the product being manufactured, they are also expert at finding defects. If products are produced in a continuous flow, each product or part is sent to the next process as soon as it is finished, and defects are therefore found immediately.

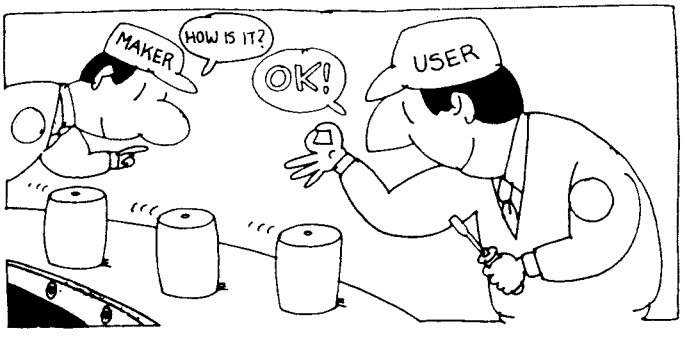
Three Strategies for Zero Defects

1. Don't make it!



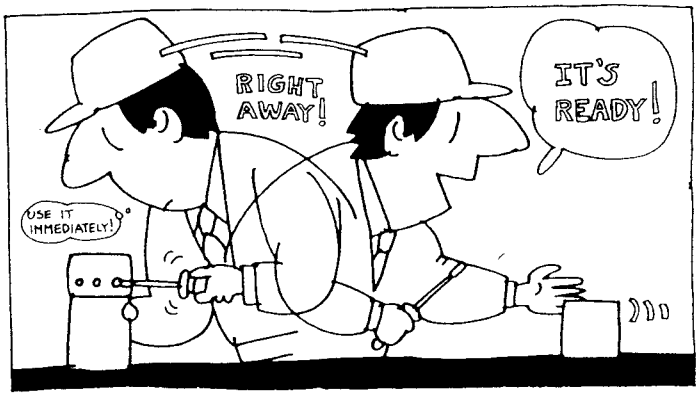
Don't make products you don't need. The more products you make, the greater the opportunity for defects as they sit in inventory. Therefore, follow the *just-in-time* principle and make only what is needed, when it is needed, and in the amount needed. Scratches and nicks will decrease dramatically.

2. Make it to withstand any use!



The user is an expert at finding defects. Therefore it is important to build safeguards into the production process to ensure that the product can withstand any use. Quality can be built into products by thoroughly implementing *poka-yoke*, *automation*, and *work standardization*.

3. Once you've made it, use it right away!



If a product cannot be made to withstand any use, then make sure it is used as soon as possible by using *continuous flow production*.

There Are Different Kinds of Errors

Almost all defects are caused by human errors. However, there are at least ten kinds of human errors.

1. *Forgetfulness:* Sometimes we forget things when we are not concentrating. For example, the stationmaster forgets to lower the crossing gate. *Safeguards:* Alerting operator in advance or checking at regular intervals.

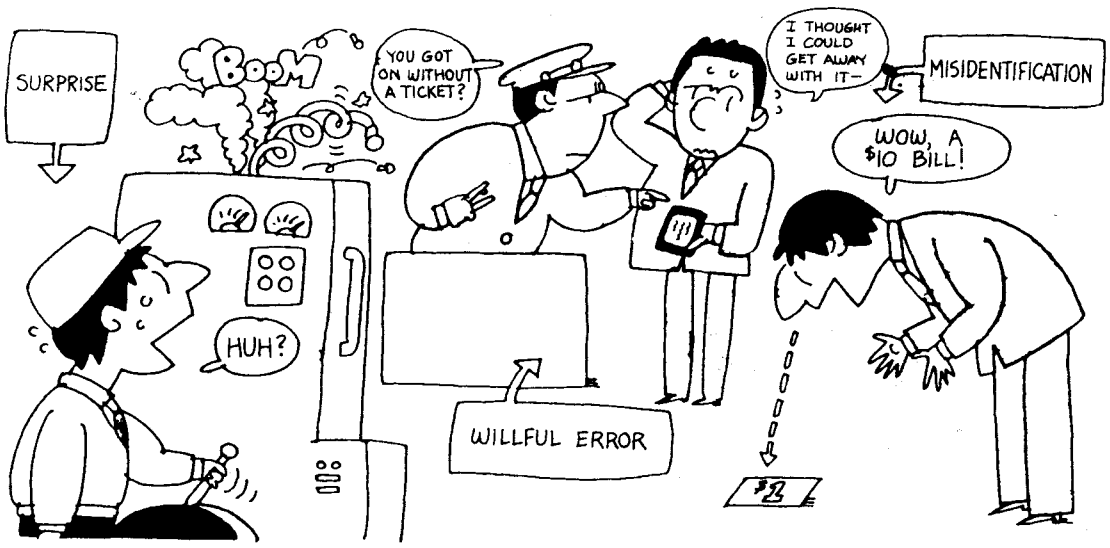
2. *Errors due to misunderstanding:* Sometimes we make mistakes when we jump to the wrong conclusion before we're familiar with the situation. For example, a person not used to a car with automatic transmission steps on the brake, thinking it is the clutch. *Safeguards:* Training, checking in advance, standardizing work procedures.

3. *Errors in identification:* Sometimes we misjudge a situation because we view it too quickly or are too far away to see it clearly. For example, a $1 bill is mistaken for a $10 bill. *Safeguards:* Training, attentiveness, vigilance.

4. *Errors made by amateurs:* Sometimes we make mistakes through lack of experience. For example, a new worker does not know the operation or is just barely familiar with it. *Safeguards:* Skill building, work standardization.

5. *Willful errors:* Sometimes errors occur when we decide that we can ignore rules under certain circumstances. For example, crossing a street against a red light because there are no cars in sight at the moment. *Safeguards:* Basic education and experience.

6. *Inadvertent errors:* Sometimes we are absentminded and make mistakes without knowing how they happened. For example, someone lost in thought tries to cross the street without even noticing that the light is red. *Safeguards:* Attentiveness, discipline, work standardization.



7. *Errors due to slowness:* Sometimes we make mistakes when our actions are slowed down by delays in judgment. For example, a person learning to drive is slow to step on the brake. *Safeguards:* Skill building, work standardization.

8. *Errors due to lack of standards:* Some errors occur when there are no suitable instructions or work standards. For example, a measurement may be left to an individual worker's discretion. *Safeguards:* Work standardization, work instructions.

9. *Surprise errors:* Errors sometimes occur when equipment runs differently than expected. For example, a machine might malfunction without warning. *Safeguards:* Total productive maintenance, work standardization.

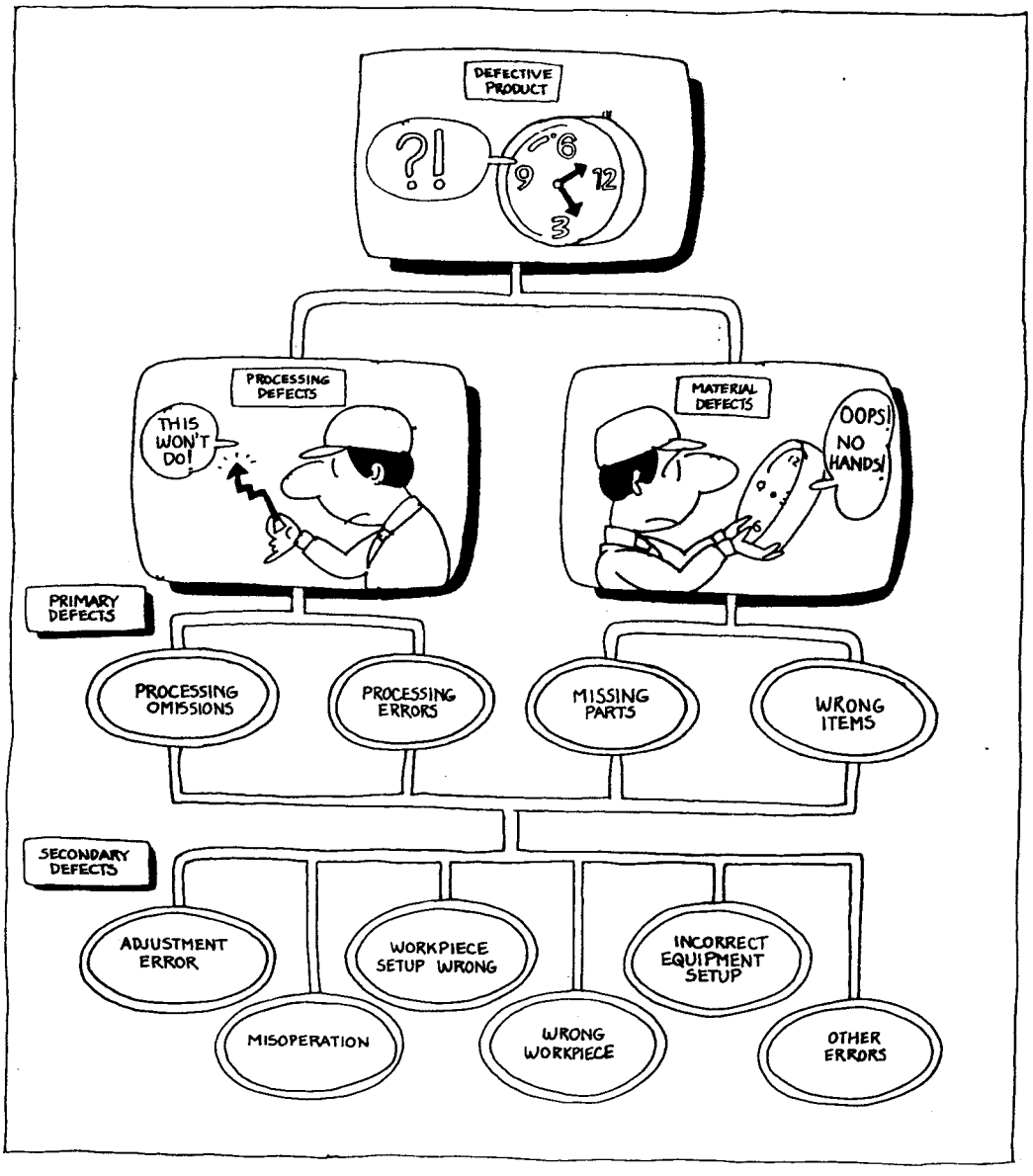
10. *Intentional errors:* Some people make mistakes deliberately. Crimes and sabotage are examples. *Safeguards:* Fundamental education, discipline.

Mistakes happen for many reasons, but almost all can be prevented if we take the time to identify when and why they happen and then take steps to prevent them by using poka-yoke methods and the safeguards listed above.

There Are Different Kinds of Defects, Too

What kinds of defects are caused by human errors?

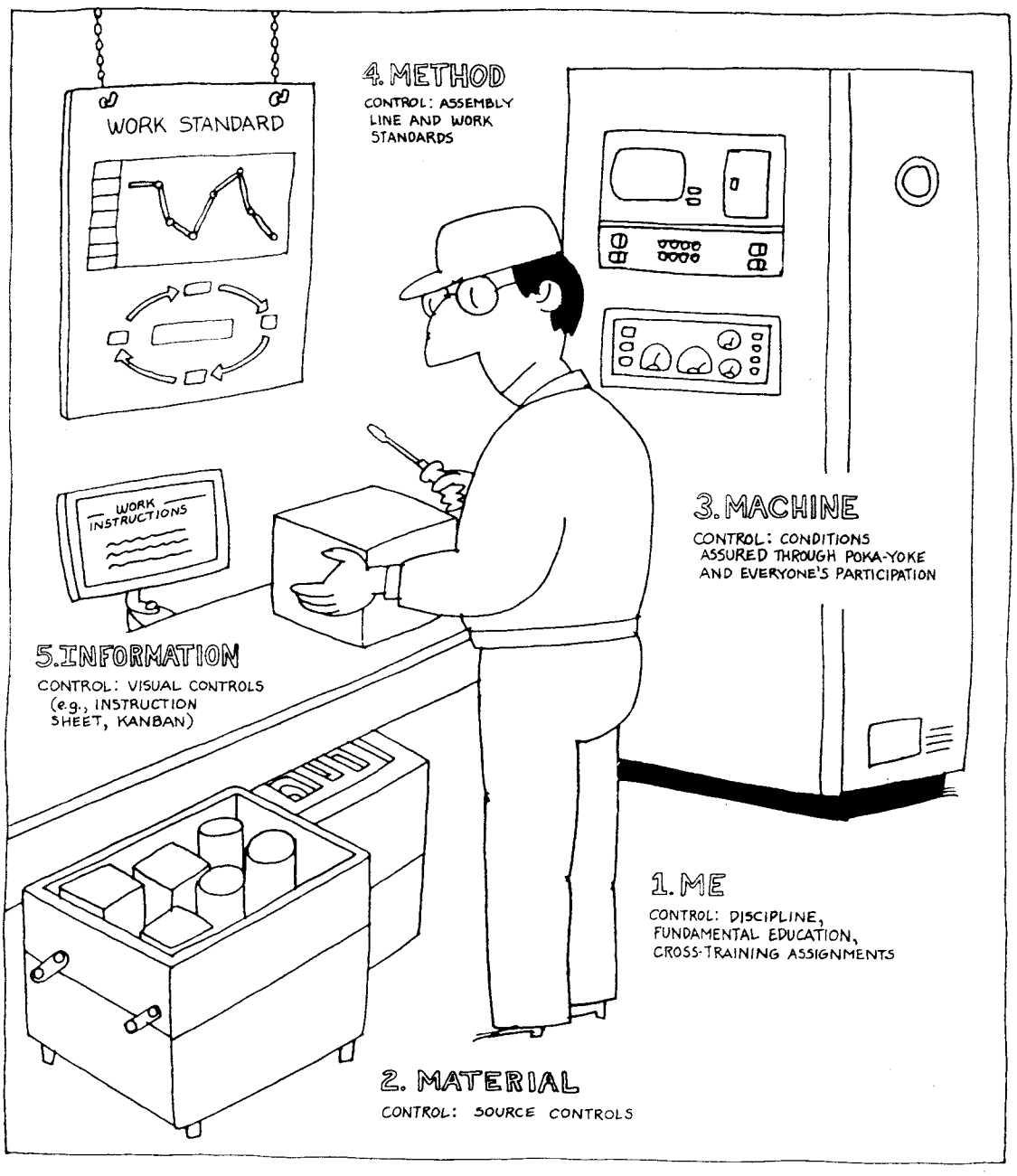
- *Example:* Cut surfaces are covered with burrs.
  Cause: Someone did not replace the cutting tools on time.
- *Example:* Machinery malfunctions, resulting in defects.
  Cause: Regular inspection of the machinery has been neglected.
- *Example:* Processing mistakes resulted in defects.
  Cause: Someone mistook a workpiece of one type for one of another type.



The Five Elements of Production

Everyday work in the manufacturing plant is aimed at turning out products consumers will like. Break down daily activities in a factory and you will find that: In response to work instructions (*Information*), parts and materials (*Material*) are obtained and set up on machinery and equipment (*Machinery*), where workers (*Me*) make things in accordance with the established standard operating procedure (*Method*).

These five elements (4M and 1I) determine whether a product is correctly manufactured or a defect is made. Defect-free products are assured by controls in each of these areas.

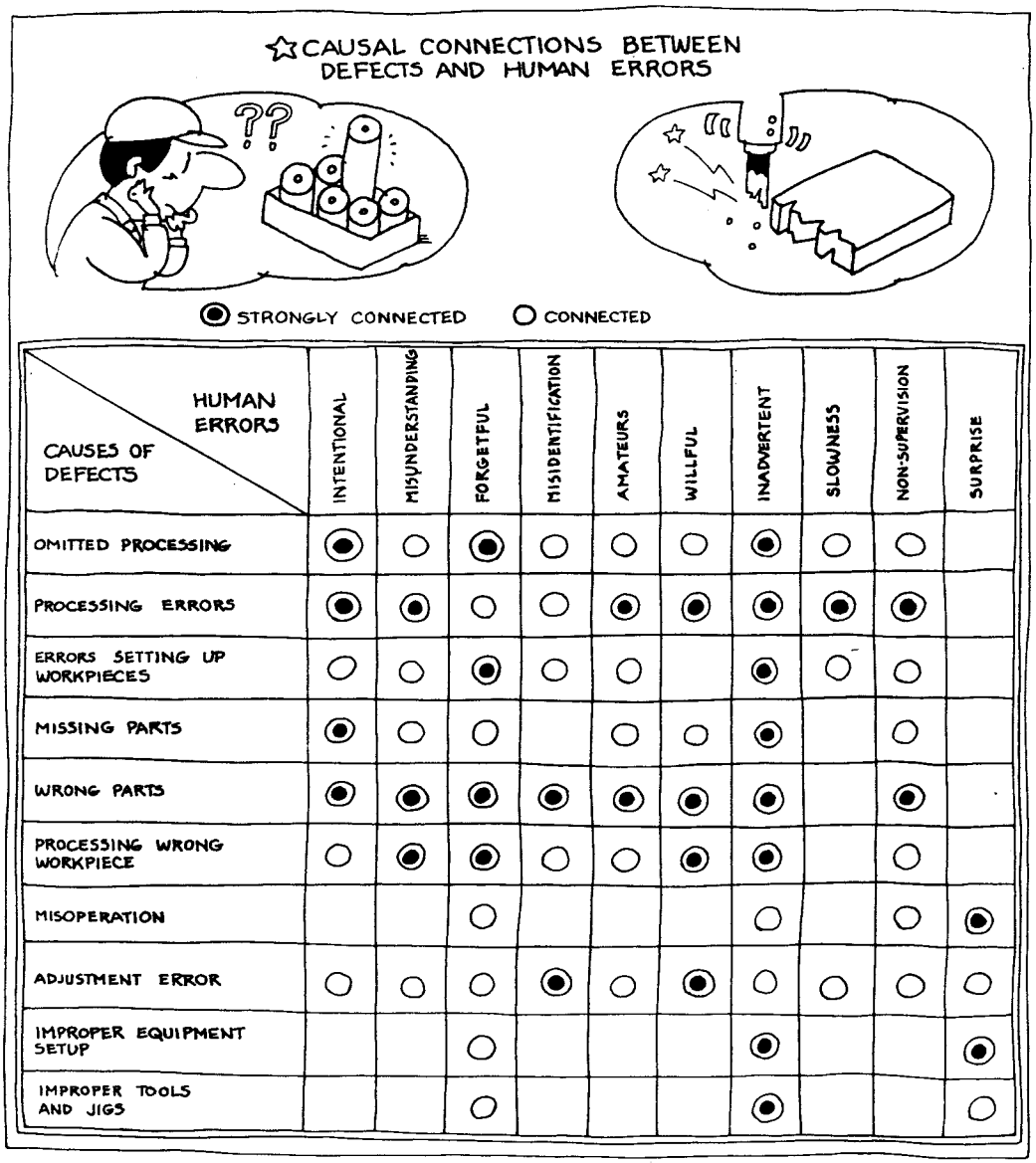


What Are the Sources of Defects?

There are various types of defects. In order of importance these are:

1. Omitted processing
2. Processing errors
3. Errors setting up workpieces
4. Missing parts
5. Wrong parts
6. Processing wrong workpiece
7. Misoperation
8. Adjustment error
9. Equipment not set up properly
10. Tools and jigs improperly prepared

What are the connections between these defects and the mistakes people make?



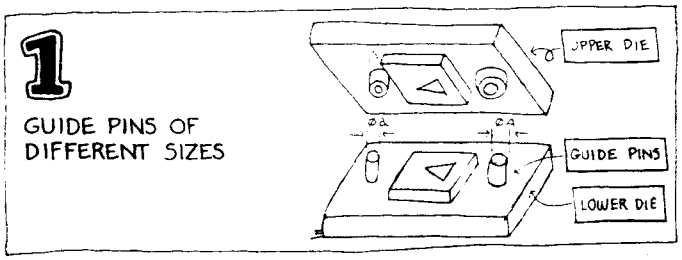
CAUSES OF DEFECTS \ HUMAN ERRORS	INTENTIONAL	MISUNDERSTANDING	FORGETFUL	MISIDENTIFICATION	AMATEURS	WILLFUL	INADVERTENT	SLOWNESS	NON-SUPERVISION	SURPRISE
OMITTED PROCESSING	◉	○	◉	○	○	○	◉	○	○	
PROCESSING ERRORS	◉	◉	○	○	◉	◉	◉	◉	◉	
ERRORS SETTING UP WORKPIECES	○	○	◉	○	○		◉	○	○	
MISSING PARTS	◉	○	○		○	○	◉		○	
WRONG PARTS	◉	◉	◉	◉	◉	◉	◉		◉	
PROCESSING WRONG WORKPIECE	○	◉	◉	○	○	◉	◉		○	
MISOPERATION			○				○		○	◉
ADJUSTMENT ERROR	○	○	○	◉	○	◉	○	○	○	○
IMPROPER EQUIPMENT SETUP			○				◉			◉
IMPROPER TOOLS AND JIGS			○				◉			○

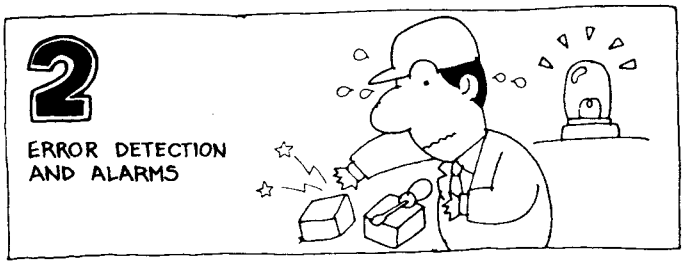
All About Poka-yoke

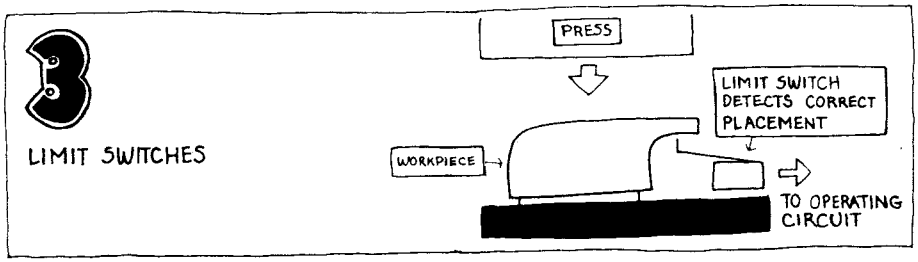
What Are the Five Best Poka-yoke?

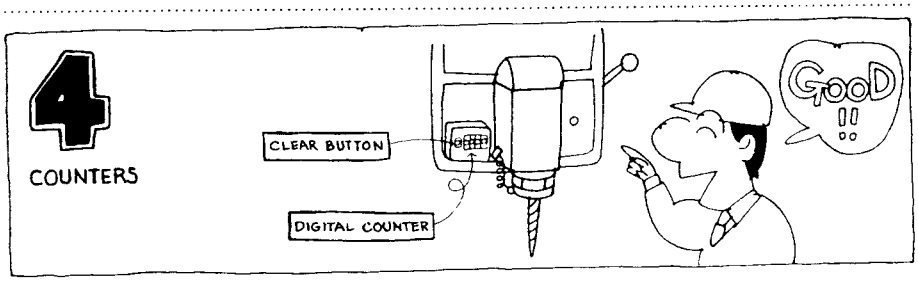
Human errors are usually inadvertent. Poka-yoke devices help us avoid defects, even when inadvertent errors are made. Poka-yoke help build quality into processes.

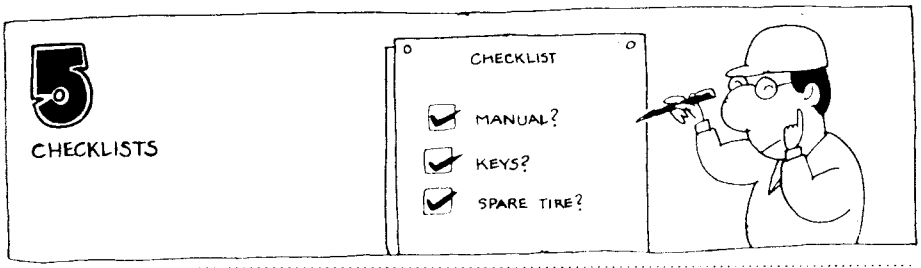
Here are five examples of poka-yoke for detecting or avoiding defects caused by human errors.



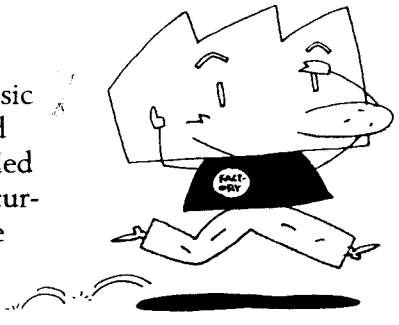




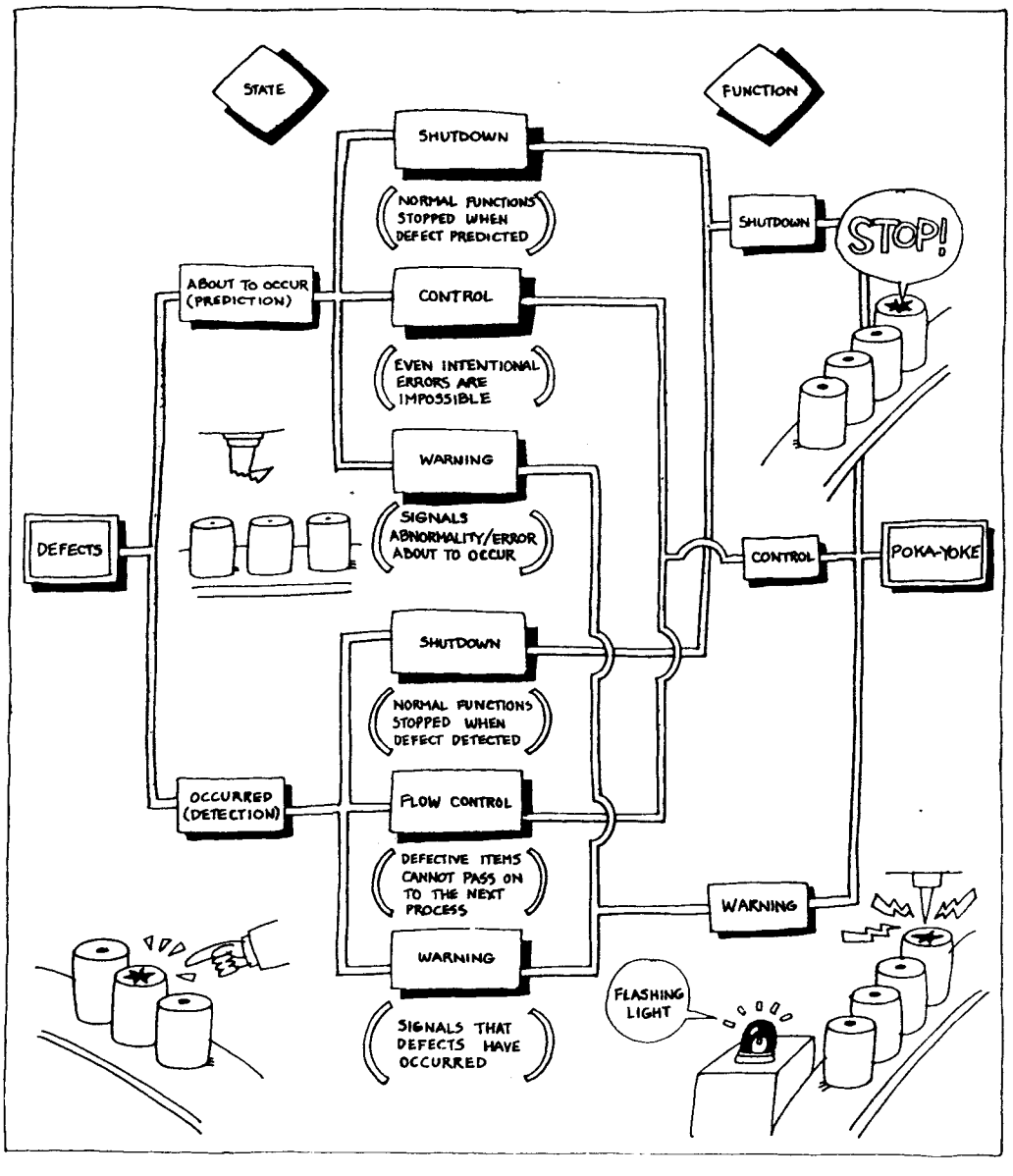




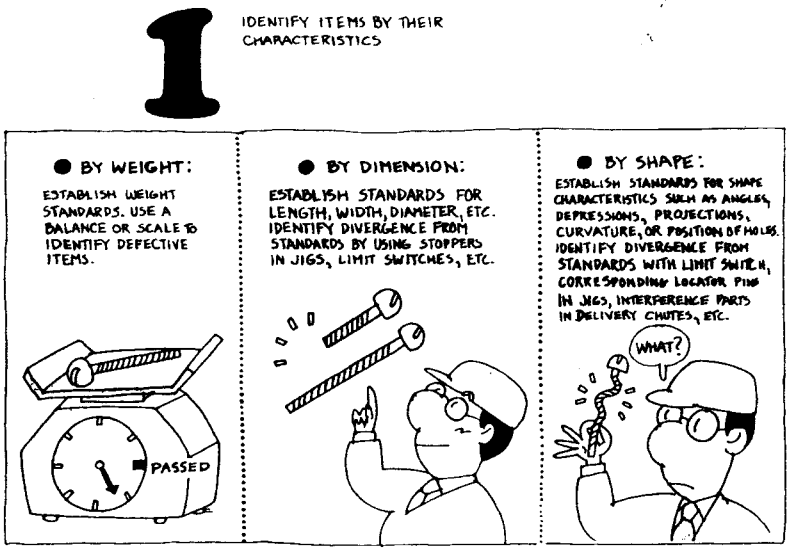
The Basic Functions of Poka-yoke

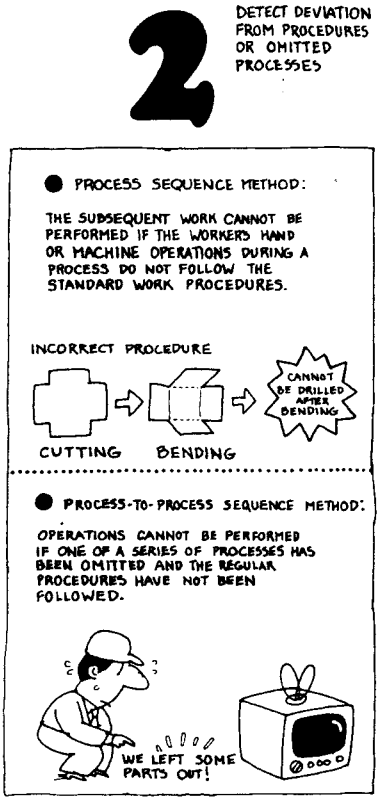


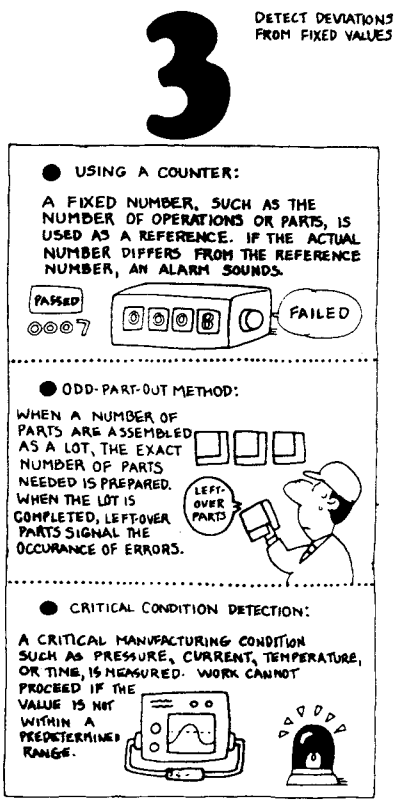
A defect exists in one of two states: It is either about to occur, or it has already occurred. Poka-yoke have three basic functions to use against defects – shutdown, control, and warning. Recognizing that a defect is about to occur is called "prediction," and recognizing that a defect has already occurred is called "detection." The following diagram shows the relationship of the two possible states of defects with the three functions of poka-yoke.



Poka-yoke Hints







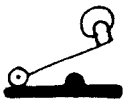
Detection Devices to Use for Poka-yoke

A wide variety of devices can be used to detect errors and defects. The detectors used for poka-yoke can be divided into those which contact the part being tested, and those which do not contact the part.

- **Contact devices**

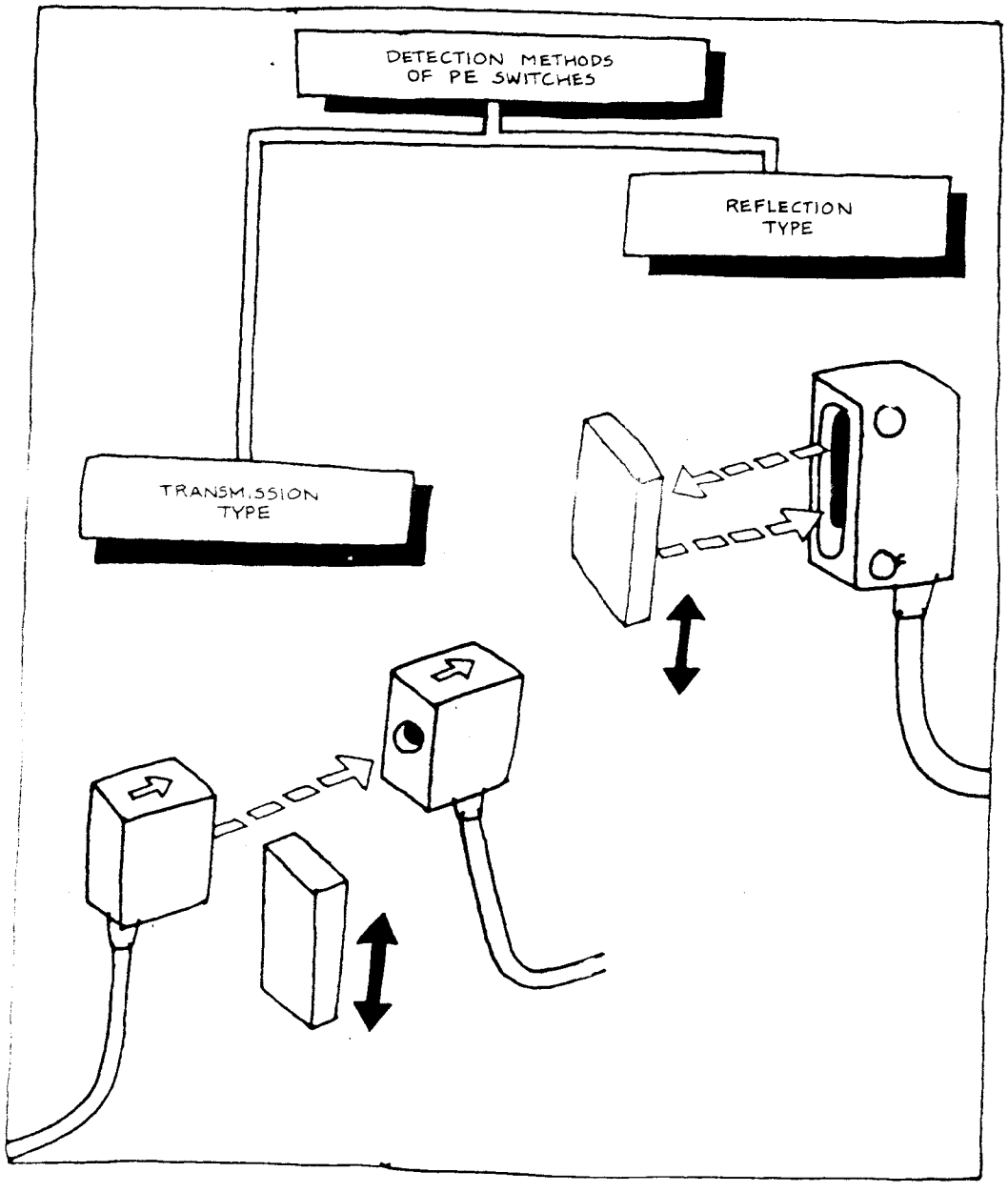
Microswitches and *limit switches* are the most frequently used detection devices in poka-yoke. They can detect the presence of items such as workpieces, dies, or cutting tools and are very flexible. Limit switches can be used to ensure that a process does not begin until the workpiece is in the correct position, for example, or they can be used to stop a process if the workpiece has the wrong shape.

There are many other contact detection devices used in poka-yoke including proximity switches, positioning sensors, displacement sensors, metal-passage sensors, and a variety of mechanical devices.

SHAPE	TYPE	MOTION BEFORE OPERATION	MOTION AFTER OPERATION	FORCE REQUIRED	VIBRATIONS, IMPACTS	CHARACTERISTICS
	PIN PUSH-BUTTON	SMALL	SMALL	LARGE	EXCELLENT	SUITABLE FOR LINEAR AND SHORT-STROKE OPERATIONS. DETECTS POSITIONS WITH THE HIGHEST PRECISION BECAUSE SNAP-ACTION MECHANISM IS ACTUATED DIRECTLY BY PIN PUSH-BUTTON. HOWEVER, IT HAS THE LEAST MOTION AFTER OPERATION, AND REQUIRES A RELIABLE STOPPER.
	PANEL-MOUNTED ROLLER PUSH-BUTTON	SMALL	LARGE	LARGE	ACCEPTABLE	SUITABLE FOR FAST-MOVING CAMS OR DOGS.
	HINGED LEVER	LARGE	MEDIUM	SMALL	ACCEPTABLE	OPERATES WITH A SMALL FORCE. SUITABLE FOR USE WITH LOW-SPEED CAMS OR DOGS. HAS A LARGE STROKE. LEVERS OF VARIOUS SHAPES CAN BE USED TO MATCH THE SHAPES OF THE PARTS BEING DETECTED.
	HINGED LEVER-ROLLER	LARGE	MEDIUM	SMALL	ACCEPTABLE	CAN BE USED WITH HIGH-SPEED CAMS OR DOGS, FORCE NEEDED TO OPERATE THE PIN PUSH-BUTTON DEPENDS ON LEVER RATIO. HAS A LARGE STROKE.
	HINGED LEVER-ROLLER OPERATING IN ONE DIRECTION	MEDIUM	MEDIUM	MEDIUM	ACCEPTABLE	CAN BE OPERATED BY A BODY MOVING IN ONLY ONE DIRECTION. IF FORCE IS APPLIED IN THE OPPOSITE DIRECTION, THE ROLLER PART FOLDS AND BECOMES INOPERATIVE.
	ROLLER-LEAF SPRING	MEDIUM	MEDIUM	MEDIUM	GOOD	ALSO CAN BE USED WITH HIGH-SPEED CAMS.

- **Noncontact devices**

Photoelectric switches can handle opaque, translucent, and transparent objects, depending upon the need. There are two types of detection possible. In the *transmission* type, two units are used, one to transmit a light beam, the other to receive the light beam. This type can be normally on, meaning light is unobstructed, or normally off, meaning light is not transmitted. The *reflecting* type of PE sensor responds to light reflected from an object to detect its presence.



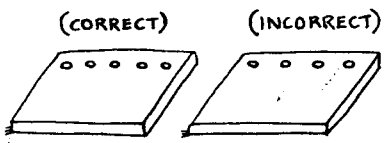
Typical Examples of Poka-yoke

- Processing omissions

SUBJECT: PREVENTING ERRORS IN NUMBER OF HOLES DRILLED	CAUSE OF DEFECT: OMITTED PROCESSING STEP
PROBLEM: DEFECTS DUE TO TOO FEW HOLES DRILLED	

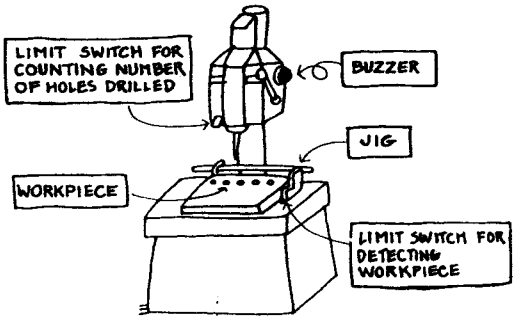
BEFORE IMPROVEMENT:

THE OPERATOR WAS RESPONSIBLE FOR COUNTING THE NUMBER OF HOLES DRILLED. SOMETIMES THE OPERATOR LOST COUNT AND DRILLED TOO FEW HOLES.



AFTER IMPROVEMENT:

A LIMIT SWITCH IS MOUNTED ON THE DRILL PRESS TO COUNT THE NUMBER OF HOLES DRILLED. ANOTHER LIMIT SWITCH IS MOUNTED ON THE JIG TO DETECT WHEN A WORKPIECE IS PRESENT. A BUZZER SOUNDS IF THE WORKPIECE IS REMOVED BEFORE THE CORRECT NUMBER OF HOLES HAVE BEEN DRILLED.



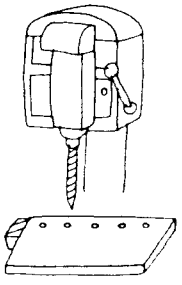
- Processing errors

SUBJECT: PREVENTING HOLE-DRILLING DEFECTS	CAUSE OF DEFECT: PROCESSING ERRORS

PROBLEM: IN DRILLING PROCESSES USING A DRILL PRESS, THE DRILL WAS OFTEN WITHDRAWN BEFORE IT HAD GONE ALL THE WAY IN. THE RESULTING DRILLING DEFECTS CAUSED TROUBLE DURING ASSEMBLY.

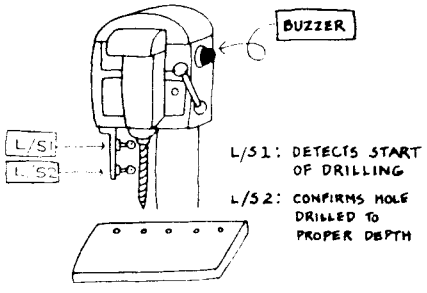
BEFORE IMPROVEMENT:

THE PROCEDURE WAS TO LOWER THE DRILL UNTIL IT WENT ALL THE WAY THROUGH THE PART. SOMETIMES THE DRILL WAS RAISED BEFORE ACHIEVING THE REQUIRED DEPTH, RESULTING IN DEFECTIVE HOLES. IT WAS UP TO THE OPERATOR'S SKILL AND INTUITION TO TELL WHETHER THE HOLE WAS DRILLED PROPERLY. DEFECTIVE HOLES WERE NOT DISCOVERED UNTIL THE ASSEMBLY STAGE.



AFTER IMPROVEMENT:

TWO LIMIT SWITCHES WERE MOUNTED. DRILLING IS ASSUMED TO BE DEFECTIVE IF SWITCH 1 IS RELEASED BEFORE SWITCH 2 IS TRIPPED. IN THIS CASE A BUZZER SOUNDS TO NOTIFY THE OPERATOR.



- **Missing parts**

SUBJECT:
PREVENTING OMISSION OF BUSHINGS

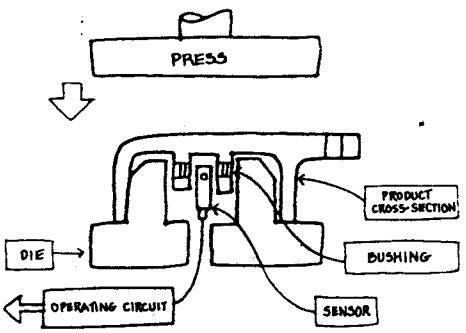
NATURE OF DEFECT: MISSING PARTS

PROBLEM:

BUSHINGS WERE TO BE INSERTED DURING DIE CASTING, BUT THEY WERE OFTEN OMITTED. FOR THIS REASON A SPECIAL INSPECTION PROCESS WAS PROVIDED, AND ALL OF THE ITEMS WERE INSPECTED VISUALLY. IN SPITE OF THIS, CUSTOMERS CONTINUED TO COMPLAIN OF MISSING BUSHINGS.

AFTER IMPROVEMENT:

A SENSOR WAS MOUNTED IN THE DEBURRING PROCESS FOLLOWING DIE CASTING AND INTERLOCKED WITH THE PRESS POWER CIRCUIT. THE PRESS WILL NOT OPERATE IF THE BUSHING HAS BEEN OMITTED. AT THE SAME TIME, AN ALARM SOUNDS AND A LAMP LIGHTS TO INFORM THE OPERATOR THAT THE BUSHING HAS BEEN OMITTED.



- **Errors in setting up workpieces**

SUBJECT:
PREVENTING HOLE-DRILLING DEFECTS

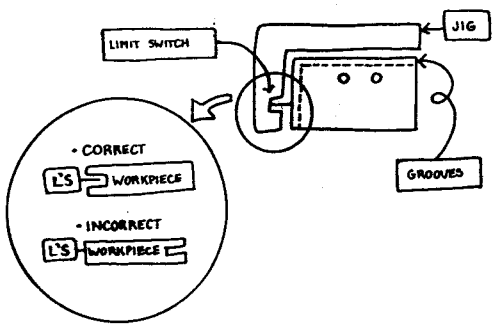
CAUSE OF DEFECT: ERROR IN SETTING WORKPIECE IN PLACE

PROBLEM:

IN DRILLING PROCESSES USING A DRILL PRESS, THE WORKPIECE WAS OFTEN SET IN PLACE BACKWARDS, WHICH PRODUCED INCORRECT HOLE POSITIONS. THE DEFECTS WERE NOT DISCOVERED UNTIL ASSEMBLY.

AFTER IMPROVEMENT:

A LIMIT SWITCH WAS MOUNTED ON THE JIG TO DETECT GROOVES CUT ON TWO SIDES OF THE WORKPIECE. WHEN THE WORKPIECE IS BACKWARDS, THE LIMIT SWITCH IS ACTIVATED AND THE MACHINE CANNOT OPERATE. DEFECTS DUE TO DRILLING MISTAKES IN THIS PROCESS WERE COMPLETELY ELIMINATED, ACHIEVING ZERO DEFECTS.



- Improper, damaged, or poorly designed jigs

SUBJECT: PREVENTING MOUNTING ERRORS WHEN MOUNTING DRAWER RAILS ON LEFT AND RIGHT CABINET SIDES

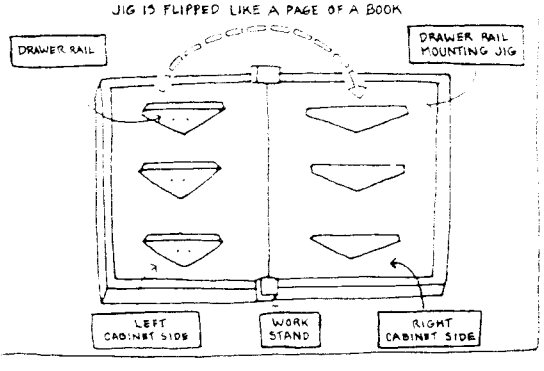
CAUSE OF DEFECT: INADEQUATE JIGS

PROBLEM:

IN THE PROCESS OF MOUNTING DRAWER RAILS ON CABINET SIDES, ERRORS OCCURRED WHEN THE MOUNTING JIGS SLIPPED, OR WHEN THE OPERATOR FORGOT TO REVERSE THE MOUNTING JIGS WHEN CHANGING FROM THE RIGHT TO THE LEFT SIDES.

AFTER IMPROVEMENT:

THE DRAWER RAIL MOUNTING JIGS WERE FASTENED IN PLACE SO THEY CANNOT SLIP. AT THE SAME TIME, THE JIG WAS MODIFIED SO IT IS IMPOSSIBLE TO MOUNT THE DRAWER RAILS WITHOUT REVERSING THE JIG FOR THE LEFT AND RIGHT SIDES.



- Using the wrong parts

SUBJECT: PREVENTING MOUNTING OF WRONG PARTS DURING ASSEMBLY

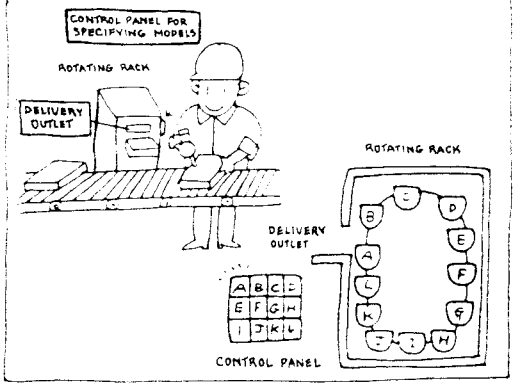
NATURE OF DEFECT: WRONG PARTS ASSEMBLED

PROBLEM:

IN THE ASSEMBLY PROCESS, MODELS WERE CHANGED SEVERAL TIMES A DAY, AND THE OPERATORS SOMETIMES MOUNTED THE WRONG ITEMS.

AFTER IMPROVEMENT:

A ROTATING PARTS RACK WAS MADE. IT HAS ONLY ONE DELIVERY OUTLET. WHEN THE MODEL BUTTON IS PRESSED, ONLY THOSE PARTS NEEDED FOR A PARTICULAR MODEL ARE AVAILABLE FROM THE DELIVERY OUTLET. THIS MAKES IT IMPOSSIBLE TO INSTALL PARTS FOR THE WRONG MODEL, EVEN ACCIDENTALLY.



Achieving Mistake-proof, Zero-defect Manufacturing through Poka-yoke

The Eight Principles of Basic Improvement for Poka-yoke and Zero Defects

1. Build quality into processes

Make it impossible to turn out defective items even if an error is committed. The approach in this case is 100 percent inspection, using poka-yoke safeguards built into jigs and processes.

2. All inadvertent errors and defects can be eliminated

We must assume that mistakes are not inevitable. Where there is a powerful will, a way can be found to eliminate all errors and defects.

3. Stop doing it wrong and start doing it right — now!

Let's eliminate entirely the "buts" in statements like "we know that it is not right, but..."

4. Don't think up excuses, think about how to do it right

Rather than thinking up excuses, let's think about how things can be done right.

5. A 60% chance of success is good enough — implement your idea now!

In improvements, there is no need to aim for perfection before taking action. Analyze the cause and think of a solution. If your solution has better than a 50-50 chance of succeeding, implement it right away. You can change or further refine your solution based on the facts that result from implementing it right off.

6. Mistakes and defects can be reduced to zero when everyone works together to eliminate them

Zero mistakes and zero defects cannot be achieved by one person alone. It is important for everyone in the entire company to work together to eliminate mistakes and defects.

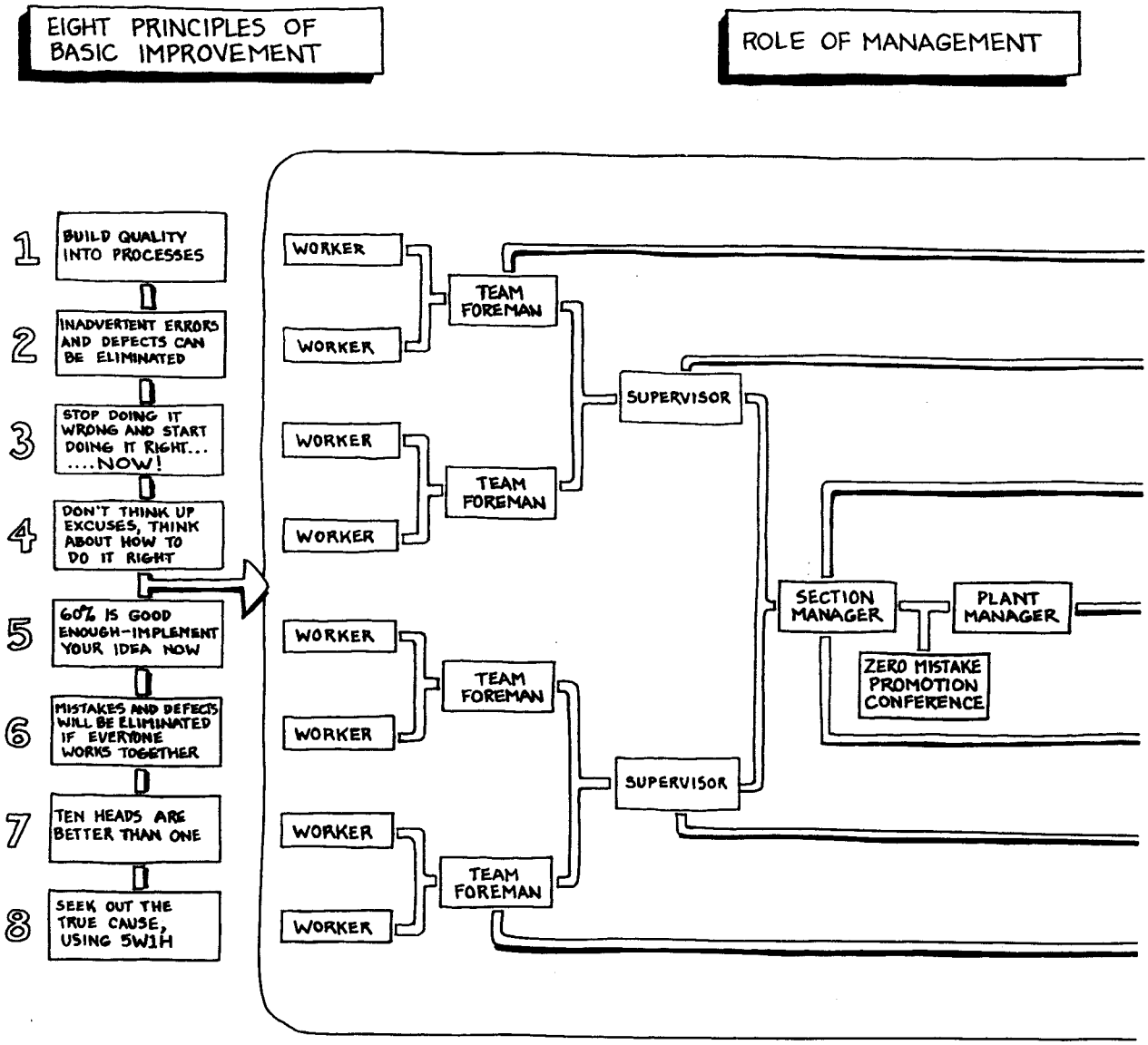
7. Ten heads are better than one

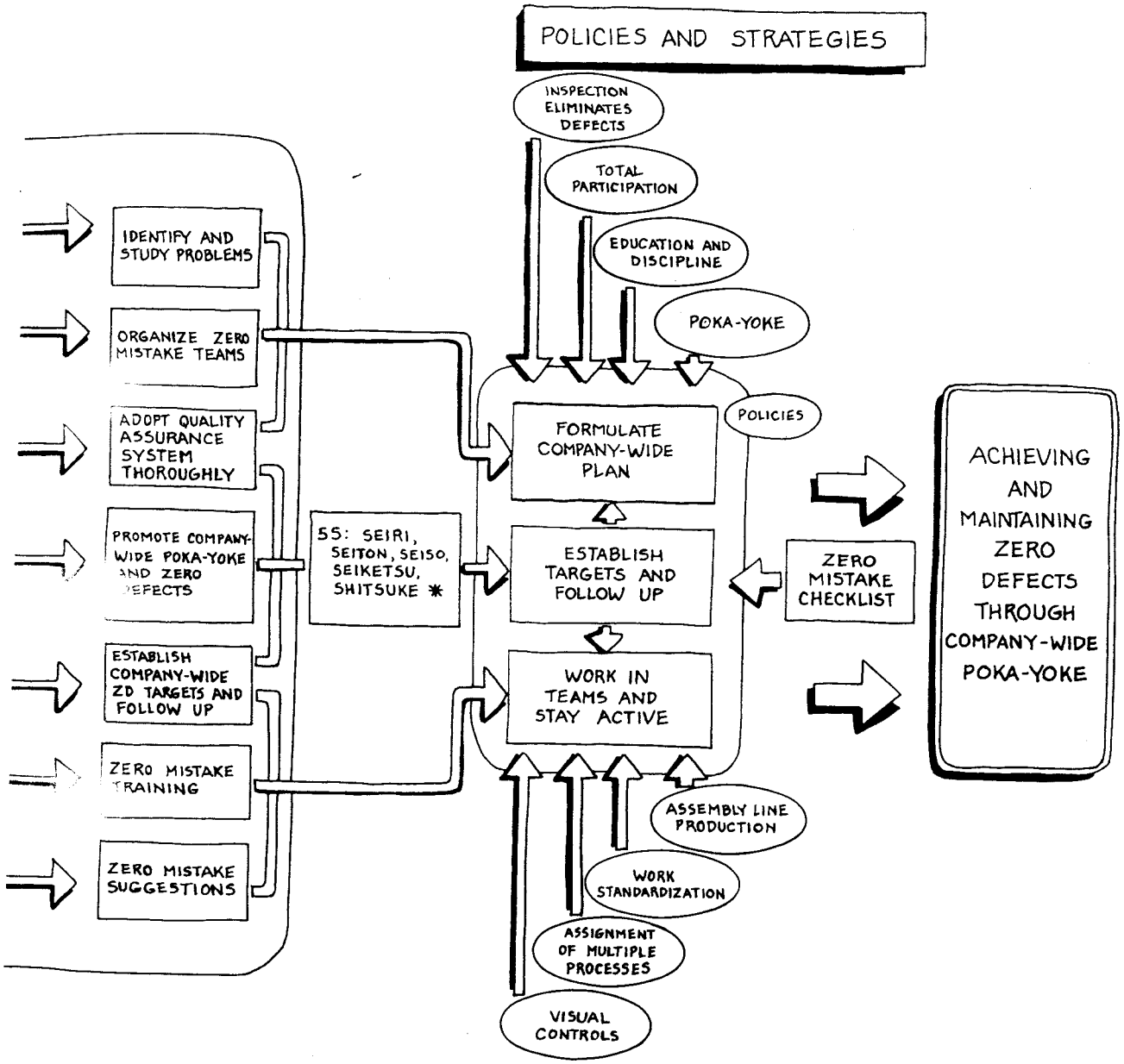
The brainstorm of any one individual is important, but the wisdom and creativity that comes through the efforts of ten people is more valuable. Teamwork is the key to effective improvement ideas.

8. Seek out the true cause, using 5 W's and one H

Should a defect occur, *do not* demand more inspectors. Instead, get to the root of the problem to ensure that the countermeasure applied is a real solution, and not just a bandage. Ask "Why did the defect occur?" and to the answer you get, ask "Why?" again. Don't be satisfied with causes that come to mind easily. Ask "Why?" at least five times to discover the roots of the problem. Only then ask "How do we fix it?" and put the solution into practice.

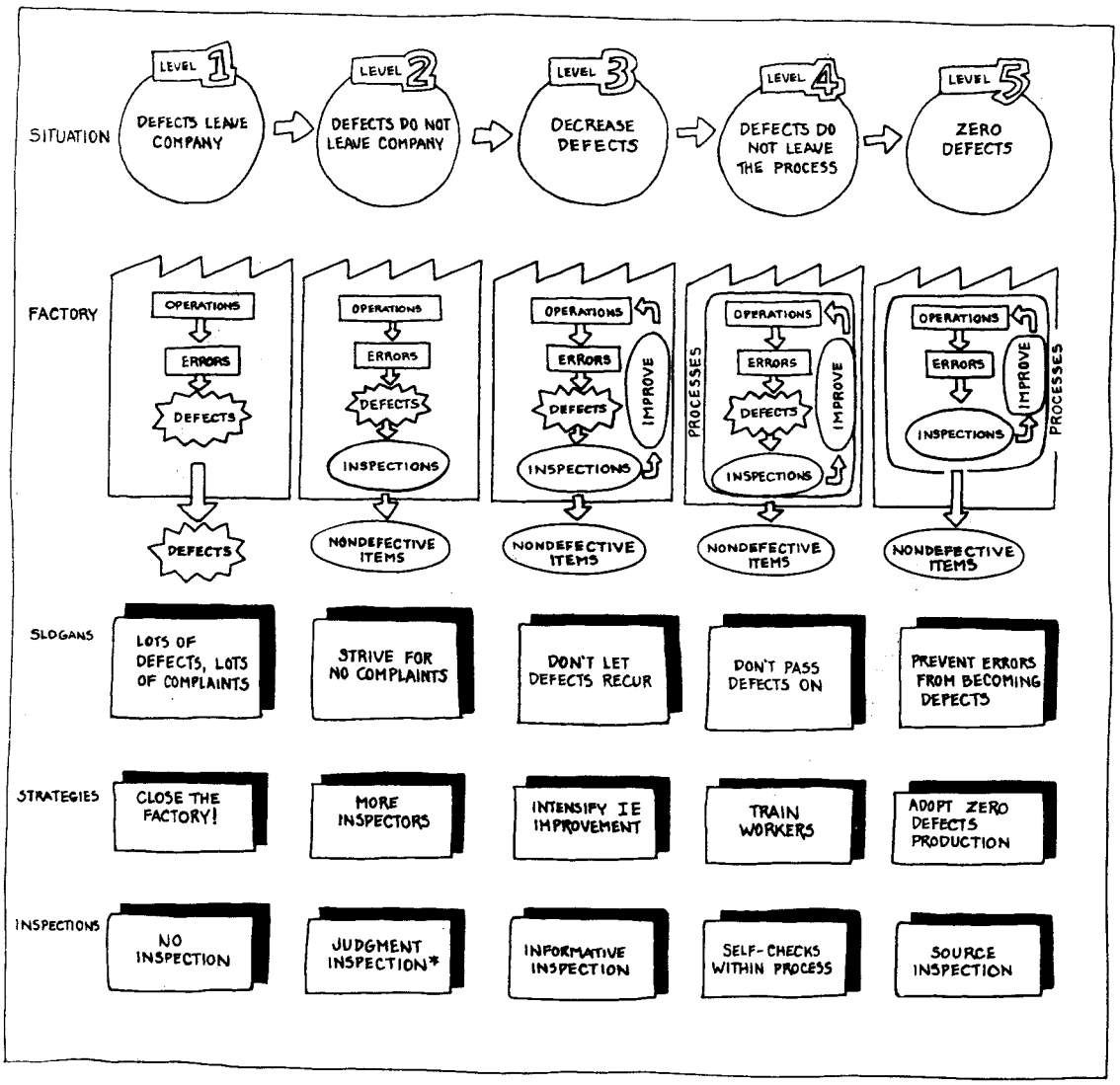
A Company-wide Mistake-proofing, Zero Defect Effort





* The "five S's" are key concepts of industrial housekeeping that begin with "S" in Japanese. They are: *seiri* (organization), *seiton* (orderliness), *seiso* (the act of cleaning), *seiketsu* (the state of cleanliness), and *shitsuke* (the practice of discipline).

Zero Defect Strategies for Factories



* Judgment inspection is comparison with a standard; this identifies defects, but does not reduce them. By giving feedback to the work process, an informative inspection can lower the defect rate. An advanced form of informative inspection is the self-check system. Often using poka-yoke devices, a self-check cuts the feedback time by discovering defects before the product leaves the process. Source inspection skips the feedback stage and catches errors at their source to prevent them from becoming defects in the first place. For more on these concepts, see Shigeo Shingo, *Zero Quality Control: Source Inspection and the Poka-yoke System*, Cambridge, MA: Productivity Press, 1986.