# Value Engineering Seminar/Handout & Reference Material

I. Introduction to Value Engineering

A. Techniques

1. V.E. Job Plan (1)

2. VE - What Is It? (12)

3. VE Definitions & Job Plan Outline (2)

4. VE Techniques Relationship Chart

5. General Techniques

B. History

C. General Orientation

II. Information Phase

A. Key Techniques

1. Get All the Facts

2. Determine Costs

3. Define Functions

4. Put a $ on Specs. and Reqs.

III. Creation Phase

A. Key Techniques

1. Blast & Create

CREATIVE THINKING GUIDE
OPERATIONAL TECHNIQUES TO STIMULATE C.T.
CREATIVE THINKING TECHNIQUES - OTHER REFS.
" APPROACH TO DES. PROBLEMS
HOW WE CAN DEVELOP IDEAS
DES. REVIEWERS

IV. Evaluation Phase

A. Key Techniques

1. Evaluate By Comparison

2. Evaluate Basic Function

3. Put $ on Each Idea

4. Refine Ideas

V. Investigation Phase

A. Key Techniques

1. Consult Vendors

2. Use Co. & Industrial Specialists

3. " " " Standards

4. Use Specialty Products, Processes & Materials

5. Determine Costs of Alternates

VI. Recommendation Phase

A. Key Technique

1. Motivate Positive Action

VII. Value Engineering in Industry

A. V.E. in Design

B. V.E. in Manufacturing

1. Make or Buy

2. Creep

C. V.E. in Purchasing

VIII. Value Engineering in Government

A. V.E. Contractual Info.

1. Incentive

2. Funded

B. V.E. Activities in Government

IX. Management Aspects of V.E.

A. Managing Value Programs

B. Organizational Relationships

C. The Value Engineering Function

D. The Value Engineering Specialists

E. Product Cost & Value Control

X. Other training material

A. Worksheets

B. Case histories

C. Checklists

D. Bibliograhy

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# VALUE ENGINEERING JOB PLAN

By Frederick S. Sherwin

A basic Value Engineering Technique is an Organized Approach -- A Job Plan. If outstanding results in getting better value are to be achieved, if 20, 50 and even 75% of the costs are to be taken out of a product, we must have a systematic plan of attack, an organized approach. Today we find these organized approaches being utilized in all areas of endeavor. It is recognized that we need a planned program that has been tested and proven to work. Just as the best houses are built to a carefully thought out plan, so the best value is found by a systematic plan of attack.

The Value Engineering Job Plan consists of five steps. They are:

1. Information Phase
2. Creation Phase
3. Evaluation Phase
4. Investigation Phase
5. Recommendation Phase

All of the techniques previously mentioned are integrated and used in carrying out this plan. Let's see how it works.

1. Information Phase

   Every program in which a decision must be reached puts in first place a fact finding stage. Many times 3/4 of any job is securing all the information, all the facts you need to study the project.

   Here in this phase we must

   1. Clearly define the problem.
   2. Establish the function to be performed - what the part or assembly has to do.
   3. Get all the facts.

   This involves

   1. Contacting the engineer to obtain the specifications, to find out the basic engineering, what has been tried, what has been considered.
   2. Contacting the manufacturing and/or planning man to determine how the part is made.
   3. Going to the cost section for detailed costs.
   4. To the purchasing section to learn what vendors are involved, or were considered.
   5. To the marketing section to determine customer requirements.

Every effort must be made to find the real fundamentals of the problem and reduce it to its simplest terms.

Here we use techniques of

1. Getting all the facts and determining costs.
2. Define the functions.
3. Put $ on specifications and requirements.
4. Getting information from the right sources.
5. Working on specifics.
6. Use good human relations.
7. And, of course, we are going to encounter many roadblocks in the fact finding stage, so we must learn how to overcome them and still accumulate the sound basic facts we need. You shouldn't let roadblocks influence your thinking in this or any succeeding phase of the Job Plan. It's very easy to get panicky, discouraged and even give up the project at this point in the game, especially if you only have part of the facts; but as you progress and use Value Engineering Techniques and get all the facts, you will find a solution. There has seldom been a case where the cost could not be reduced, and with no sacrifice in the necessary quality.

After the fact finding phase comes

2. The Creation Phase

Here's where we put to use our creative ability, the creative approach. Once the problem is defined and we have all the facts, we are ready to find a way to do it. We try to answer the question "What else will do the job?"

Make use of the brainstorm. No negative thought session.

Draw on ideas from other people.

Come up with as many ways of doing the job as you can. The more ideas, the better the chance that one or more will be the answer to the problem.

Write down all these ideas.

Use the technique

1. Blast & Create
   Knowledge of the creative approach using specialty product processes, materials, vendors and standards is helpful in thi technique.

3. Next is the Evaluation Phase

After all the ideas are written down it is time to evaluate them.

One of the first steps in this analysis is to estimate the dollar value of the ideas. This will show you which ideas are the most worthwhile developing.

It's important to remember here that we're not trying to eliminate ideas, but we are trying to analyze to see how they can be made to work. A positive approach must be used.

Recently in a department where a creative session was held only six ideas were developed. This is a small number and a lot of judicial thinking must have been used. Then they looked at the six ideas. A review eliminated all but one of them. When this was done, they said "Now we'll call in the engineer to tell us what's wrong with this remaining idea." Obviously, this is a poor approach.

Ideas which will perform the function must be developed regardless of specifications, interchangeability, etc. Many times good ideas come from trying to develop others, which obviously wouldn't work. Usually if the potential savings is great enough, the specifications may be changed to permit adoption of the method.

Here we can use the techniques of

1. Refine ideas
2. Put a $ on each idea
3. Evaluate the basic function
4. Evaluate by comparison

After you have analyzed and developed the best ideas, you will want to work on those that show the most promise. Here we come to the

4. Investigation Phase

This is where you take the best ideas and plan a program to attain the information you need to develop these ideas into sound usable suggestions. You may feel here that you don't have enough knowledge to work on the ideas yourself. This is a natural feeling, since we never can know everything we need to know.

What must be done then is to recognize the problem and search for the

person who can help you. There are many experts in your company, and the services of every specialist in industry is available at your call. In drawing in help from outside the company in the form of vendors or specialists, don't just hand them a drawing and specification and say "what can you do with this?" Instead, plan a program to inform him of the function you want, draw out his ideas on the problem, give him some latitude to work in, and you can really benefit from his new knowledge.

Here we put to work such techniques as

1. Consult vendors
2. Use Company and Industrial Specialists
3. Use Company and Industrial Standards
4. Use Specialty Processes, Products and Materials
5. Determine Costs

and of course we will encounter roadblocks to be overcome, and we must employ good Human Relations.

The program should be planned in the Manufacturing and Engineering areas so that the most effective use is made of the time they devote to you.

Now we see that certain ideas are really beginning to develop and have a future. They should be reviewed with the thought "Is it really the best idea?" "With this new information could a better job be done?" Now is the time to "Use good business judgment."

A planned program should be followed up in this phase. Actual work with vendors, specialists, engineers, and manufacturing people should be carried out. All the facts, ideas, information and conclusion are gathered to lead to the last phase.

6. Recommendation Phase

Here's the last and one of the most important steps in the Job Plan. It consists of buttoning up the project, doing something with the facts you have, taking action on the results of your study.

To the analysis team this may take the form of a suggestion for adoption by the responsible people. To line people it will mean the implementation or adoption of the new design, method, vendor, or approach to accomplish the necessary function for the lowest possible total cost consistent with the required quality.

# VALUE ENGINEERING DEFINITIONS

# AND

# JOB PLAN OUTLINE

# DEFINITIONS

VALUE --

Lowest price to reliably accomplish the function.

FUNCTION --

That which makes a product work or sell.

BASIC FUNCTION --

The prime or specific purpose which the part accomplishes.

SECOND DEGREE FUNCTION --

That which does not directly contribute to the basic function.

VALUE ENGINEERING JOB PLAN --

Information Phase
Creation Phase
Evaluation Phase
Investigation Phase
Recommendation Phase

VALUE ENGINEERING PHILOSOPHY FOR BETTER BUSINESS PERFORMANCE --

We Need:

1. Positive Approach
2. Team Work
3. Better Job

# VALUE ENGINEERING JOB PLAN
and
Contributing Techniques

## INFORMATION PHASE

Get all the facts.
Determine costs.
Define the functions.
Put a dollar sign on the specifications and requirements.

## CREATION PHASE

Blast - Create

## EVALUATION PHASE

Refine ideas.
Put a dollar sign on each idea.
Evaluate the basic function.
Evaluate by comparison.

## INVESTIGATION PHASE

Consult vendors.
Use Company and Industrial Specialists.
Use Company and Industrial Standards.
Use specialty processes, products and materials.
Determine costs.

## RECOMMENDATION PHASE

Motivate positive action.

### General Techniques

Use good human relations.
Inspire teamwork.
Work on specifics.
Overcome roadblocks.
Use good business judgment.

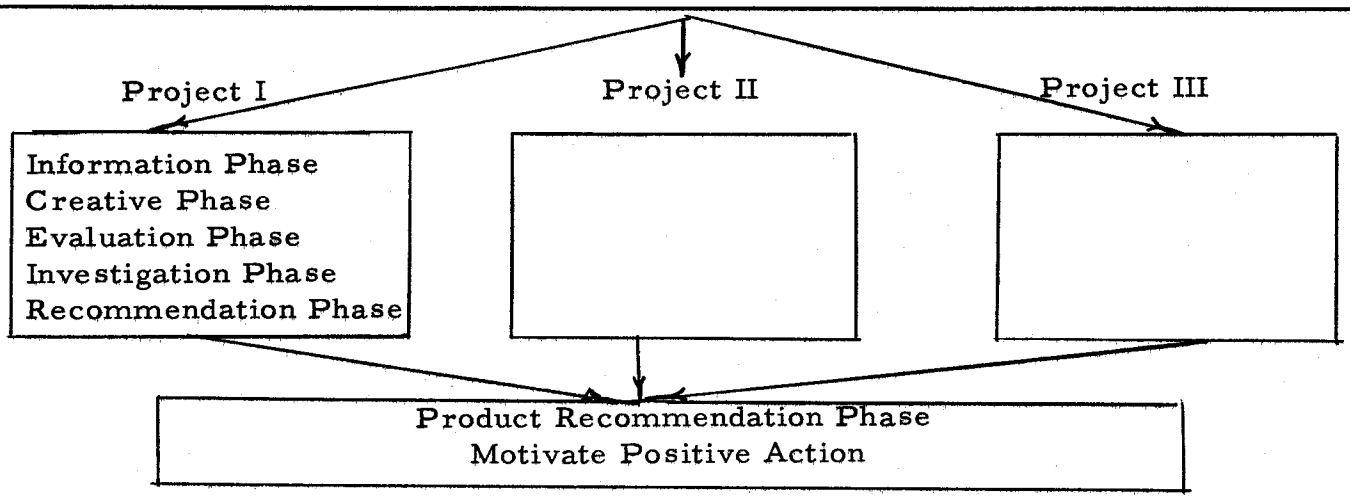
Product "A"

Information Phase

Get the facts
Determine the function
Determine Major Costs

Marketing, Engineering
Finance, Purchasing, Manufacturing

This phase identifies high cost areas which require further study.

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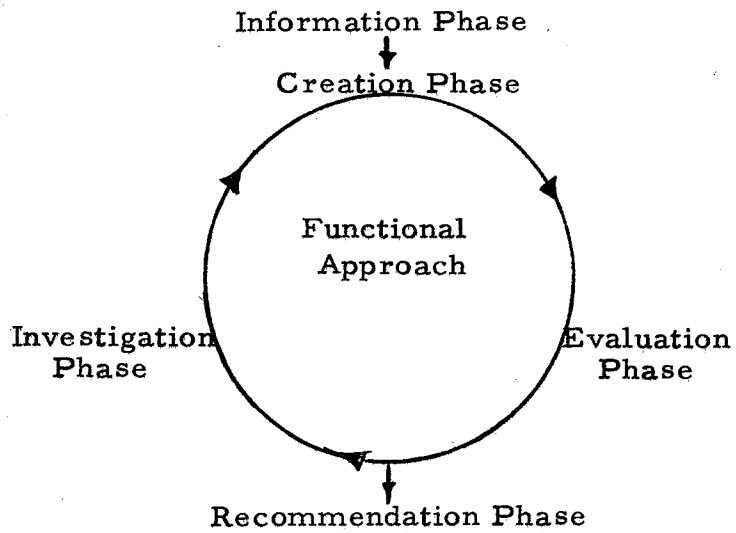
Project Study



# VALUE ENGINEERING

or

# VALUE ANALYSIS

What Is It?

How Does It Work?

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## PREFACE

It is the job of Value Engineering to help members of all functions--manufacturing, methods, engineering, purchasing, and others--to "grow" better habits, attitudes, and value-abilities sufficient to eliminate unnecessary costs from products without in the slightest diminishing quality.

To accomplish this, we need....

....."Better Attitudes and Habits"
....."Better Information"
....."Better Techniques"
....."Improved Value Skills"

## WHAT IS VALUE ENGINEERING?

Value Engineering is by no means a search for new materials and processes--the Laboratories, and Engineering and Manufacturing organizations are constantly doing that.

Nor is it a substitute for the effective cost reduction committees but can supplement and increase their effectiveness.

Value Engineering is a well-informed creative study of every item of cost in every part or material--in view of other possible materials, newer processes, abilities of specialty suppliers and possibilities for engineering re-evaluation focusing Engineering, Manufacturing and Purchasing in one objective--equivalent performance at lower cost.

Value Engineering must bring new information into the project from new areas within the company and from specialist suppliers outside of the company--new possibilities and new Value opportunities each with its definite cost for proper evaluation--and refer this new information into its proper normal channel--the manufacturing man, the engineer or the buyer--for decision.

Value Engineering relates cost to the function or service or operation purchased by that cost. Specialists in the company, and to a large degree outside, are assigned specific functional areas. Their engineering is put to work on our job instead of our competitor's. Their suggestions are provided with a dollar sign for evaluation.

## WHAT IS THE FUNCTION OF VALUE ENGINEERING?

To make certain that, viewing every usable idea, process, material and supplier, each part individually and each group of parts when considered as a unit, represents Value.

## TESTS FOR VALUE

1. Does its use contribute Value?
2. Is its cost proportionate to its usefulness?
3. Does it need all of its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower cost method?
6. Can a standard product be found which will be usable?
7. Is it made on proper tooling - considering quantities used?
8. Do material, reasonable labor, overhead and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

## HOW IS VALUE ANALYZED?

A team of the engineer, the manufacturing man, and the buyer makes an intensive study endeavoring to lower material and parts cost by substituting, eliminating, combining, simplifying or otherwise altering parts or materials through the application of a knowledge of materials and prices, the use of vendor's specialized skills, new ideas and purchasing negotiation.

The function, the construction, the manufacturing methods, the sources of supply and the purchasing arrangements for each part and each material are reviewed.

Each item of cost is severely questioned. While studying the part or service the answers to these questions are developed...

...What is it?
...What does it cost per year?
...What does it do?
...What else would do the job and what would that cost?

Then each item of cost is seriously questioned unless it clearly buys definite function.

Function is simple defined as...

...something that makes the product work better...
...or sell better.

## WHAT ARE THE QUALIFICATIONS FOR VALUE ENGINEERING WORK?

We have learned the qualifications for men to successfully accomplish this type of work. They are:

1. Engineering or methods and planning experience supported by a general understanding of the properties of materials and their uses.

2. A good creative imagination.

3. Enough initiative, self-organization, and self-drive to start and complete their projects with little if any supervision.

4. A feeling of the importance of value.

5. A mature personality, stable, not easily discouraged.

6. The desire to work and deal with others and the general knowledge of how to do it.

## WHAT IS NEEDED FOR AN EFFECTIVE PRODUCT STUDY?

1. Annual production and ordering quantities.

2. Six copies of all drawings including:

    a. Each part showing the material
    b. Assembly drawings
    c. Wiring diagrams, if any
    d. Test and Adjusting specifications
    e. Other supplementary specifications and data if necessary to completely define the product.

3. Breakdown showing detailed shop cost build-up including:

    a. Material
    b. Labor
    c. I.M.E.
    d. If other than basic raw material is used--the name of the vendor and the price.
    e. A memorandum concerning special labor accounting--whether adjusted or unadjusted, variances, etc.

4. A breakdown of assembly and sub-assembly shop costs.

5. Copy of planning cards or general description of the type of process.

6. Actual samples of the individual parts and the assembly using the parts, where practicable.

1. Information Phase

a. Secure all pertinent facts--actual samples of parts and assembly where practicable. Costs, quantities, vendors, drawings, specifications, planning cards and manufacturing methods information.
b. Learn the basic engineering, with the engineer, ask questions, listen, develop with him a thorough understanding of the product.
c. Learn the basic manufacturing--observe manufacturing, ask questions, listen, study.
d. Decide the amount of effort that should reasonably be expended on each item of cost.

2. Creation Phase

a. Generate every possible solution to the problem.
b. Consult others who may help you.
c. Systematically explore various materials, machine processes, re-arrangement of parts, etc.
d. Encourage free use of the imagination.
e. Record every suggestion that seems remotely possible.
f. Establish two man teams for creation of additional ideas.

3. Evaluation Phase

a. Estimate the dollar value of each idea.
b. Develop all ideas with emphasis placed in proportion to their value and probability of accomplishment.
c. Investigate those ideas with an "obvious" reason why "it won't work." List the good points and the bad points. Eliminate or overcome the objections.
d. Set up a program to vigorously pursue ideas with most promise.

4. Investigation Phase

a. Break the job down into a progression of functional areas; i.e., a fastening job, an electrical contact job, a support job, a dust protection job, etc.
b. Select the top specialist in the Company to consult on each.
c. Select from one to three of the best suppliers in the country for each functional area of the product.

d. Pointing out the top function desired--discuss the problems and solicit specific suggestions with both in-company and out-of-company specialists.
e. Constantly pursue thoroughly and intensely until suggestions of all specialists are in. Work with vendor companies until they can provide alternate practical suggestions and quotations.
f. Periodically support the work of the specialists by speculative or idea study and evaluation pertaining to the individual functional areas.
g. Stick to each promising suggestion. Thrash it out and reach definite tangible usable conclusion.

5. Recommendation Phase

a. Issue a concise suggestion sheet covering each part which shows possibilities.
b. The sheet shows pertinent information, such as...

... before and after sketch of the part.
...quantities used per year.
...material, labor, and shop cost.
...suggested cost, and tool cost, if any.
...statement describing function of part.
...suggestions in condensed form.

c. Send copies to the man designated by the manager to receive and follow up, also to others who should receive them.
d. Send all quotations to the Purchasing group concerned. Attach all specific engineering data, engineering studies, etc. to one copy and all studies pertinent to manufacturing methods, techniques, etc. to another of the copies given to the designated follow-up man.
e. Finish the job promptly and go on to the next.

A. Eliminate the part.

1. Change another part to perform its function.
2. Check accessory items and features--possibly the need for them no longer exists.

B. Simplify it.

1. Put all the tapped holes into one part--eliminate them from others.
2. Use available fastening devices and eliminate tapping entirely.
3. Challenge secondary punch press operations or secondary screw machine operations or other secondary operations.
4. Make the parts straight instead of curved--straight fittings cost less than elbows.
5. Don't plate copper parts which are later painted.
6. When blind holes are needed, show minimum depth with notation. "Don't Drill Through," rather than specifying depth limits.
7. Use square ends--ground ends double the cost of the spring.
8. Instead of two tapped holes for set screws at 90° put set screws one on top of the other in the same hole.
9. Avoid undercuts on molded plastics to eliminate mold cycles and slower machine cycle.
10. Question chrome plating or polishing on screw heads.
11. Question unusual machined surfaces. It may require secondary operations to obtain them.
12. Consider pal-nuts to eliminate nuts and lockwashers on light parts.
13. Stamp the nut impressions into the part--eliminate fastening devices.
14. Don't bend it.
15. Use a miniature casting in lieu of several small assembled stampings.
16. Use square instead of rounded corners on stampings.
17. Use roll pins to eliminate reaming.

C. Alter it so that a high speed method can be used.

1. With a slight change, perhaps it can go on a header or upsetter.
2. Make it of round or flattened wire on a wire forming machine rather than a complicated terminal.
3. Strike the slot in the screw instead of sawing it.
4. Design parts for die cast threads. A small flat in the parting line eliminates flash difficulty.
5. Drill and tap small parts in the strip before cutting apart.
6. When cross drilled screws or bolts are needed, design so that random drilling is permissible.
7. Make irregularly shaped parts of assembled laminations thin enough for stamping to avoid costly machining jobs.
8. Eliminate insulating sheets, strips, punchings and welding operations by making a composite molded parts for electrical applications.

9. Instead of long screw-machine parts for filter housings, etc., use flared copper tubing and a small internal flare nut.
10. Mold gears from powdered iron to save cost of machining the teeth. If extra strength is needed, impregnate the iron with copper.
11. Use permanent mold iron castings for lower cost and better quality.
12. Use projections and resistance weld in one operation rather than spot-weld one spot at a time.
13. Consider magnesium--it machines twice as fast as aluminum and five times as fast as steel.
14. On thin gears-alter for punching instead of broaching.

D. Alter--so that standard parts or materials may be used.

1. Design around standard nails, rivets, eyelets, washers, spacers, etc.
2. Specialty vendors provide standard materials in many classes. For example, use standard terminal boards, standard switch contact blades, standard contact blade spacers, etc.
3. Design for standard bushings--don't make it necessary to cut them off.
4. Instead of fabricating terminals, buy them from a specialist in parts made from tubing.
5. Try "Johnson" weld nuts for resistance welding to sheet metal. They cost less than half the price of most others.
6. Use stamped "weld" nuts for even lower cost.
7. Use standard sizes for raw material to avoid "extras" in cost.

E. Determine where the design might reasonably be altered for automatic assembly.

1. Don't use a complicated terminal when simple flattened wire applied by an automatic stapler would do as well.
2. Don't have springs pressing against all of the assembly parts.
3. Don't assemble concealed parts between plates. Make up some sub-assemblies which are made openly and snapped together.

F. Use a lower cost material

1. Use spring steel instead of music wire excepting when excessive loading demands additional properties and justifies additional cost of music wire.
2. There are many tempers of copper and many types of bronze. Remember that generally half the weight of copper will carry the same current as equivalent bronze.
3. Remember also that 1/2 to 1/4 the weight of spring brass carries equivalent current to phosphor bronze. Forty cent brass may replace 65 cent phosphor bronze. Suitable brass can be aged to provide comparable spring qualities.
4. Use Terratex or Quinterra instead of mica for high-temperature, low voltage applications.
5. Buy an aluminum or other disc instead of sheet or strip stock.
6. Use more magnesium extrusions. Dies cost only a few hundred dollars for small extrusions.
7. Check tubing costs. In smaller sizes, copper is lower cost than steel-aluminum and magnesium still lower-magnesium is the lowest.
8. Don't use drill rod if steel rod will do the job.
9. Use Zn-Cu-Be instead of brass. Save 20 per cent.
10. Use graphite-impregnated phenolic compound for a low-friction, low-cost bearing, thrust disc or seal nose.
11. For large die cast parts, check aluminum. It may cost less than zinc.

G. Use Lower Cost Processes.

1. Do the operation in a tumbling barrel. If the parts are too heavy and too precise--mount them on fixtures in the barrel and let the abrasive mixture flow through them.
2. Use automatic dial tapping machines.
3. Dip in paint rather than spray.
4. Design parts for barrel plating rather than hooking in still tank.
5. Use Multi-slide machines to eliminate secondary operation.
6. Stamp parts in punch press rather than hand stamp.
7. Use tubular rivets rather than solid rivets which have to be peened over slowly in a high speed hammer.
8. Lithograph or print rather than etch.
9. Permanent mold rather than sand cast.
10. When desired actually reduce the size of the shank on a screw by a special thread roller arrangement.

H. Use a higher cost material, which, by its nature and properties will afford a simplified design and facilitate lower cost assembly.

1. Consider fixture heat-treated beryllium copper, when phosphor bronze won't quite do the job. Eliminate adjusting labor.

2. Use Silicones--for innumerable benefits and savings.
3. Make the whole tip and support from silver rather than silver tip and brass support. Eliminating welding may offset the cost of additional silver.

4. Use Micaloi in flux paths. High permeability may save many laminations.
5. On very small parts with intricate forming use stainless to eliminate plating cost.
6. For high temperatures and high dielectric strength use Teflon to produce various savings.
7. Use brass instead of steel on very small screw machine parts. The saving in labor more than offsets the increased material cost.

I. Miscellaneous Lower Costs

1. Use a good sampling method instead of 100 per cent inspection.
2. Make an entire subassembly smaller reducing material accordingly.
3. When buying adjacent parts from a vendor, have them pre-assembled if practicable.
4. Don't spend money for sizing if supplementary operations are necessary anyhow.
5. Make as many parts as practicable on a particular job of identical raw material.
6. Design part and tools to hold scrap in machining to a minimum.
7. Use Carboloy.
8. Hopper feed parts in assembly.
9. Provide proper tooling to eliminate need of expensive labor.
10. Conveyorize to facilitate material handling.
11. Avoid complicated equipment that requires continuous scrutiny and maintenance.

J. Check it against other methods of fabrication.

1. Fabricate it.
2. Die Cast it.
3. Extrude it.
4. Permanent mold cast it.
5. Roll and weld it.
6. Roll form it.

K. Check it against unique, less well-known methods of fabrication.

1. Lost wax casting.
2. Miniature casting.
3. Miniature casting on wire, cord, tape or rod.
4. Miniature casting automatically with inserts.
5. Electro-forming.
6. Low cost, low quality stampings.
7. Fabrication from copper or brass tubing.
8. Powder metallurgy.

L. Check unusual but available forms of raw materials for use on the job.

For example Steel

1. Preplated Steel
2. Prepainted steel
3. Steelclad with aluminum. Stainless, monel, etc.
4. Fibreclad steel
5. Rubberclad steel
6. Embossed metal
7. Expanded metal

Or Miscellaneous

1. Silicons
2. Nylons
3. Micalex, etc.

M. Survey the purchasing with the buyer.

1. Are the available highly specialized low cost suppliers being used?
2. Have the suppliers' engineers been given sufficient facts and pressed for suggestions which would produce equivalent performance at lower cost?
3. Has the buyer taken advantage of the know how of other purchasing units using larger quantities of similar materials?
4. Should some minor changes suggested by the supplier which afford lower cost material, be considered further?
5. Has the buyer found the basic source, the manufacturer who may be in a position to extend minimum prices?
6. Are parts obtained in best economical lot sizes?

## WHAT SAFEGUARDS ARE TAKEN TO PREVENT PROJECT STOPPING PREMATURELY BEFORE RESULTS ARE ACCOMPLISHED?

The necessary safeguard is the basic philosophy that "There is a lower cost way to get equivalent quality--only as yet it has not been thought of."

It is important not to waste time going around in mental circles. If progress towards lower costs seems stalled, some of the following or similar actions must be taken.

1. Select a well-qualified vendor--put the problem up to him and press him to produce. Get new information and a new idea from him.

2. Break the problem down into two or three specific but smaller problems and assign each to a qualified specialized vendor for solution.

3. Talk it over with the project engineer again. Jointly agree that a hypothetical 20 per cent of the cost must be removed and study with him how to start.

4. Determine how similar jobs are being done in other branches of the Company.

5. Determine how competitirs are doing it.

6. Counsel another buyer who may have a similar problem.

7. Find in the Company a proponent of the idea and foster it through him.

8. Talk about it to a man in one of the laboratories--tell him the problem--get some ideas from him.

9. Discuss it with the Standards Department. Frequently they have assisting information.

10. Talk it over with a man in the Manufacturing Services Division.

11. Mentally review all of the new processes and products reviewed in trade magazines for their applicability.

12. Make a quick list of a dozen or a hundred suggestions no matter how impractical some of them seem--then study the list.

13. As the part is studied--imagine that you are forbidden to use it. How then would the job be done?

14. If it is big enough, talk it over with the boss. He will probably have some good ideas.

15. Don't accept first effort--challenge further endeavor. Value Analysis pays off after the first answer is "no."

# VALUE ENGINEERING
## What It is And Its Contribution to Business

I. Value Engineering - What It Is

Value Engineering and Value Analysis are terms used to designate a search-oriented technology which includes a systematic, creative, organized approach to reduce unnecessary product costs to a minimum. This approach consists of a job plan and specific techniques which are used in the decision-making process. It may be applied at any stage in the product life cycle to prevent or remove costs which do not contribute to the reliable achievement of the essential, customer required, function. The techniques may also be used in management decisions which affect other costs associated with the conduct of the business. A Value Engineer is someone proficient in the use of these techniques.

Contrasted to past approaches to cost reduction, Value Engineering is product function directed and offers a method of assigning monetary values to basic functions which occur in all products. Value is achieved when any function is accomplished for the least total cost.

II. Value Engineering - What It Can Contribute

Value Engineering can contribute to any product producing business in several ways.

1. Staff Specialists who have no line responsibilities but are extremely proficient in Value Engineering techniques can assist line or decision-making personnel by providing information and recommendations which will lead to reduction in product or operating costs.

2. Value Engineering techniques can be taught to decision-making personnel so that they can vastly improve their ability to reduce costs.

3. Value Engineering task groups can be assigned to product design, development or improvement programs to remove large amounts of unnecessary costs.

4. These efforts will bring product costs down to a minimum, improve the competitive position and increase company profits.

NOTE: Value Engineering is not a substitute or replacement for any other effective approach to cost reduction such as work simplification, motion-time methods, manufacturing feasibility studies, etc. Rather, it is a supplement and supporting force which fills a gap and will greatly strengthen cost prevention and reduction activities.

III. Value Engineering - How to Start It

To begin a Value Engineering program, management must obtain the services of a person who has knowledge and experience in the field.

Such a person who is capable of directing a Value Engineering program will have a broad background in industry with about twenty years' experience and certain personality characteristics which would qualify him as a senior consultant in Value Engineering.

This Value Specialist could be hired or could be selected from ranks of present employees and given Value Engineering training.

The Company Office of Value Engineering Services can supply this training in various ways, also outside consultants are available.

IV. Value Engineering - Its Function and Organizational Placement

Value Engineering is a staff function which crosses other functional lines and reaches into Engineering, Purchasing, Manufacturing, Marketing, Financial, etc. Leadership for the activity can come from a general management staff position or from within one of the above mentioned areas. In the latter cases, however, the supervising manager must have a good grasp of the responsibility of the Value Engineering function so that it will carry out the full scope of the activity. Strong top management support is an essential ingredient for a successful Value program.

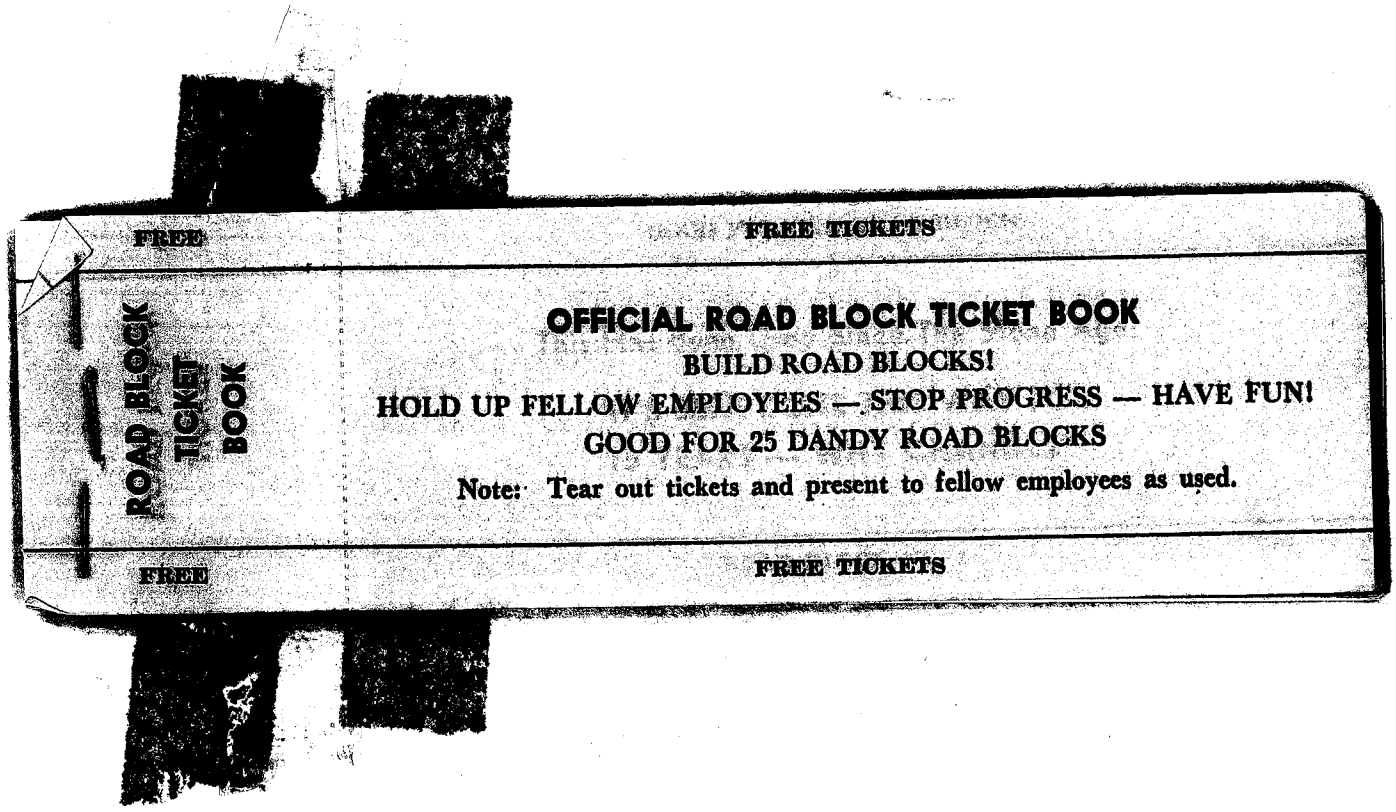
The Value Engineering function is largely educational and motivational in content. The educational part should consist of both formal and informal training of all key, line personnel in the techniques of Value Engineering through workshop type seminars of about 50 hours duration and discussions carried out during daily contact of the Value Specialist and line personnel.

The motivational part takes several forms. The Value Engineer is a catalyst whose function it is to bring about the improved performance of people responsible for product design and production. One such motivational form is the value recommendation which results from a product evaluation study made by the Value Specialist and submitted to the person responsible for implementing the change. Another form is consultation in which the Value Engineer gathers, develops and presents information needed for value decisions.

Since product value (cost) is the part responsibility of a number of groups, Value Engineering integrates these people into more effective teams, helping to bring together skills from each area as needed to get the best value product. No competitive business should overlook the potential contribution of Value Engineering.

F. S. Sherwin, Director
Value Engrg. Services

May 31, 1962


FREE
FREE TICKETS
ROAD BLOCK TICKET BOOK
OFFICIAL ROAD BLOCK TICKET BOOK
BUILD ROAD BLOCKS!
HOLD UP FELLOW EMPLOYEES — STOP PROGRESS — HAVE FUN!
GOOD FOR 25 DANDY ROAD BLOCKS
Note: Tear out tickets and present to fellow employees as used.
FREE
FREE TICKETS

RAYTHEON VALUE ENGINEERING SEMINAR

# ROADBLOCKS TO PROGRESS

Learn to Recognize Phrases which Chloroform Ideas, Put Minds to Sleep, and Stop Progress.

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55. Let's look into it further before we act
56. You're two years ahead of your time
57. Let's give it more thought
58. It works OK, let's not change it now
59. Let someone else try it firs

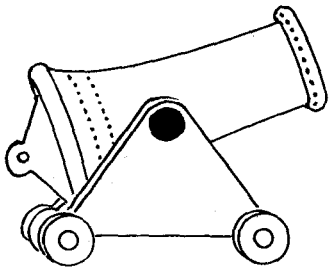
ROADBLOCKS

## KILLER PHRASES WHICH CHLOROFORM IDEAS AND PUT MEN'S MINDS TO SLEEP

1. We tried that before.
2. Our place is different.
3. It cost too much.
4. That's beyond our responsibility.
5. That's not my job.
6. We're all too busy to do that.
7. It's too radical a change.
8. We don't have the time.
9. Not enough help.
10. That will make other equipment obsolete.
11. Let's make a market research test of it first.
12. We're too small for it.
13. Not practical for operating people.
14. The men will never buy it.
15. The Union will scream.
16. We've never done it before.
17. It's against company policy.
18. Runs up our overhead.
19. We don't have the authority.
20. That's too ivory tower.
21. Let's get back to reality.
22. That's not our problem.
23. Why change it, it's still working o.k.
24. The Executive Committee will never go for it.
25. What do they do in our competitor's plant?
26. I don't like the idea.
27. We're not ready for that.
28. It isn't in the budget.
29. Can't teach an old dog new tricks.
30. Good thought, but impractical.
31. Let's hold it in abeyance.
32. Let's give it more thought.
33. Top management would never go for it.
34. Let's put it in writing.
35. We'll be the laughing stock.
36. Not that again.
37. We'd lost money in the long run.
38. Where'd you dig that one up?
39. We did all right without it.
40. That's what we can expect from staff.
41. It's never been tried before.
42. Let's shelve it for the time being.
43. Let's form a committee.
44. Has anyone else ever tried it?
45. What's use?
46. Customers won't like it.
47. Too hard to sell.
48. I don't see the connection.
49. It won't work in our industry.
50. What you are really saying is ...
51. Maybe that will work in your department, but not in mine.
52. Don't you think we should look into it further before we act?
53. Let's all sleep on it.
54. You're right--but.....
55. You're two years ahead of your time.
56. We don't have the money, equipment, room, personnel.

# HOW TO KILL PROGRESS

# HOW TO KILL PROGRESS



ADAPTED FROM THE REMARKS OF
DAVID L. YUNICH, PRESIDENT
L. BAMBERGER AND COMPANY
NEWARK, NEW JERSEY

*Do you resist progress?*

You don't think so? Well, don't be too sure. Human beings who don't resist progress are rare exceptions. The plain fact is that most of us do.

Progress is a wonderful thing — as long as it involves somebody else. But when a new idea crops up in YOUR company, affecting YOUR job, how do you react? Do you step forward eagerly to appraise its merits with an open mind? Or are you more apt to draw back — perhaps unconsciously — and reach for something to kill it?

Resistance to change is almost instinctive. Doing things differently would upset our comfortable habits of thought and action. It would create the need for thinking, planning and making new decisions. And what if those decisions happened to be wrong?

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Change always involves risk — the risk of failure, the risk that things won't turn out as much to our liking as they are now. We're familiar with our present problems. But who knows what our problems would be if we started making changes?

Are you still confident you don't resist progress? Well, just for fun check the following list of twenty-five expressions. See if any of them sound familiar. Each of them is an expression I've heard people in our company use to kill progress, to avoid considering or trying new ideas. I suspect you've heard them, too.

## "IT ISN'T IN THE BUDGET."

Maybe it isn't in the budget. But the budget represents yesterday's planning. If reasons are compelling enough, the budget can be — and should be — changed. The budget is not a straight jacket intended to freeze all thought and action.

## "IT WON'T WORK IN OUR DEPARTMENT."

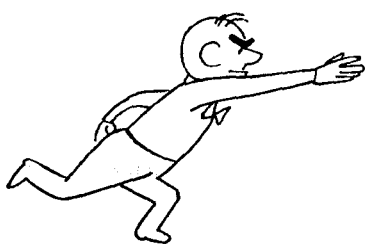
Yes, if you want to search hard enough, you can find reasons — real or imagined — why your department is different. But are they reasons or merely excuses for lack of action?

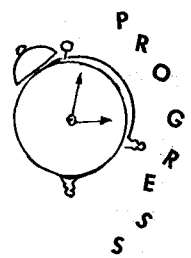
## "WE TRIED THAT BEFORE."

Did you? Precisely this idea or merely something like it? And how was it executed? Don't be too sure that ideas that were tried and didn't work are bad ideas. Many a terrific idea has failed simply because it was poorly executed.

## "IT'S TOO RADICAL A CHANGE."

Sometimes a change is too radical to put into effect all at once. But other times a radical change is exactly what's needed. Anyone who calls a change too radical ought to have specific reasons to back up his opinion. Otherwise he's merely ducking.






## "WE DON'T HAVE THE TIME."

This is the favorite comment of people who've planned something and don't want their plans changed. If they really want to change things, it's amazing what can be accomplished in a very brief period.

## "THAT PRICE IS TOO HIGH FOR US."

No price is too high until you've considered value, need, and possible alternatives. Otherwise it's just a convenient way of killing the idea.

## "NOT PRACTICAL FOR OPERATING PEOPLE."

What's different about operating people? The man who makes this comment without specific, sensible reasons is merely throwing mud at the proposition.

## "DON'T BE RIDICULOUS!"

A comment designed to end discussion before it begins. It not only kills the idea in question, but also cautions the man against suggesting any others.

## "WE'RE TOO SMALL FOR IT."

Another way of saying no and sounding profound. Without valid, supporting reasons it's a meaningless comment.

## "THAT WILL MAKE OUR SYSTEM OBSOLETE."

Perhaps the system is obsolete already. The company which refused to consider changes that would outmode existing systems or equipment would be headed for the junk pile.

## "IT DOESN'T FIT OUR PROGRAM"

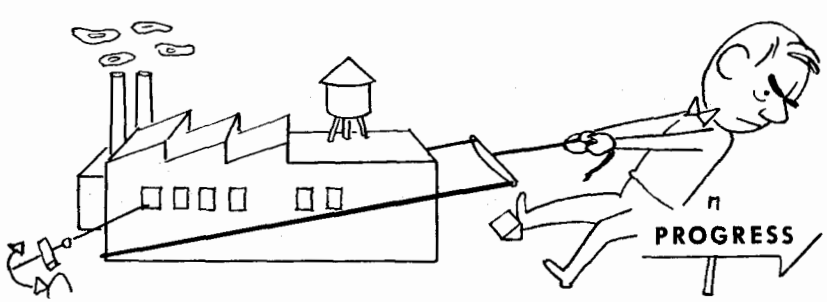
The death sentence of many an excellent idea. Plans and programs are drawn up to facilitate progress, not stifle it. New ideas deserve consideration regardless of previous planning. Maybe the program ought to be junked because it doesn't fit the idea.

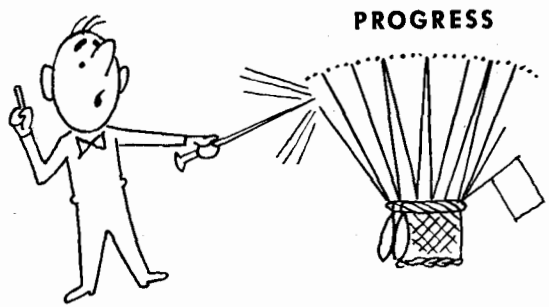
## "WE'VE NEVER DONE IT BEFORE."

All the more reason why it may be well worth considering.

## "YOU'RE TWO YEARS AHEAD OF YOUR TIME."

Spoken from the vantage point of superior experience, but seldom backed by good, sound reasons. This is one of the favorite ways of turning something down without making the man who suggested it feel too badly. After all, who isn't flattered by the thought that he's ahead of his time? The organization, by failing to consider his idea, may find itself behind the times.




## "LET'S GET BACK TO REALITY."

This remark implies — without saying specifically why — that the whole idea is theoretical and impractical. The fellow who makes it conveys the impression — also for no good reason — that he himself is a solid character with his feet on the ground. Actually, he's just another stumbling block in the path of progress.

## "THAT'S NOT OUR PROBLEM."

No? Well maybe it should be. Things which affect our suppliers and customers also affect us. We might be a lot better off by opening our eyes to more of these problems instead of looking the other way.

## "WHY CHANGE IT? IT'S STILL WORKING O.K."

The company which never changes anything as long as it works will never be known for progressiveness. Changes that are delayed until they *have* to be made are often costly.

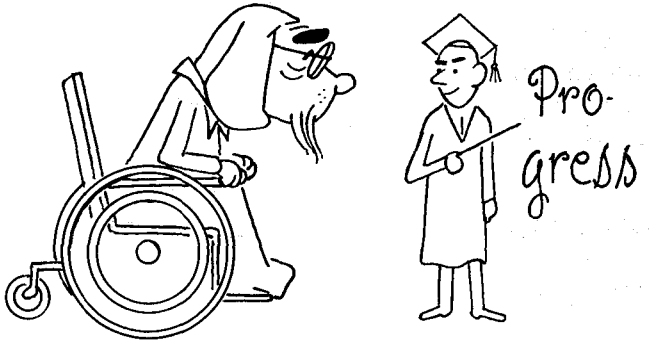
If you wait until something fails to work before you look for a better substitute, one of these days you're going to find yourself way up the creek without a paddle. Thousands of businesses have closed their doors for that very reason.

## "WE'RE NOT READY FOR THAT."

Sound like words of wisdom, don't they? Perhaps they are. But the man who uses them had better be ready with good, logical reasons. Otherwise they're nothing but a stall.

## "CAN'T TEACH AN OLD DOG NEW TRICKS."

People can learn new things at any age — if they want to learn and if you're willing to teach them. This is a demonstrated fact, not wishful thinking. If something is really worth doing, it ought to be done no matter who has to learn new tricks.




## "THE EXECUTIVE COMMITTEE WOULD NEVER GO FOR IT."

What the Board of Directors, the Executive Committee, or any other committee will approve has no bearing on what ought to be submitted. One of the greatest wastes of time and talent in business and industry is that spent on guessing what people in authority will approve. If the same energies were used to study our problems, and to develop courageous programs based on sound reasoning, everyone concerned would be a lot better off.

The remark, unfortunately, is a handy one for killing off new ideas. It completely evades the merits of the question. It also conjures up fears of the supposedly mysterious reactions of those in higher authority.

## "WE'LL BE THE LAUGHING STOCK."

Anyone in this world who ever accomplished anything worthwhile has been laughed at. The more people who are inclined to laugh at an idea, the greater the chance it might be something really unusual. It certainly shouldn't deter you from taking a good look.

## "WE DID ALL RIGHT WITHOUT IT."

The fellow who opposes a new idea for this reason is really grasping at straws. But you've heard it; so have I.

## "LET'S SHELVE IT FOR THE TIME BEING."

A convenient way to kill something without being charged with the murder. People who make the remark aren't openly opposed to the idea; they just want to give it time to ripen. What they really want is time for it to die.

## "LET'S FORM A COMMITTEE."

If you're opposed to action, this is a convenient way to stall it.

## "HAS ANYONE ELSE TRIED IT?"

This is a good question — if it's asked for the purpose of obtaining information. The trouble is that it's so often asked by someone groping desperately for a reason to say no.

## "IT'S AGAINST OUR POLICY."

Policies are a valuable guide to action. But there are also times when a policy is a poor substitute for good judgment. Policies have to be changed occasionally to meet changing conditions. When a policy blocks progress, it ought to be brought to the attention of people who have the authority to change it.

* * * * * *

Under the proper circumstances, some of the expressions quoted above make excellent sense. That's precisely what makes them so damaging. Wrongly used, they sometimes stop a valuable idea dead in its tracks.

When you catch yourself using one of these expressions — or a reasonable facsimile thereof — stop and ask yourself a few questions: Do I really mean this? Do I have good reasons for what I am saying? Or am I merely looking for excuses to kill the idea and avoid action?

You can't stop progress. All you can do is kill it in your own department or your own company. If an idea is a good one, someone somewhere is going to think of it and put it to use. Why shouldn't it be you? The fellow who kills progress is killing his own future.

* * *

1A

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59. Let someone else try it first
60. A good idea! Let's sleep on it!

↑

THE CLINCHER

# HOW TO COMMUNICATE IDEAS

THIS booklet contains Richard Borden's famous four-point formula for transplanting an idea from your head into someone else's. It's a simple, time-tested method of presenting ideas clearly and effectively. Professional writers and speakers use it constantly. Why don't you?

We used to call this booklet "How to Make a Speech That Listeners Like". The trouble was that people thought it was a booklet for public speakers.

It *is* a booklet for public speakers. It was written specifically for them. But the principles it presents apply to every form of communication including letter writing, reports, magazine articles and informal talks. Direct mail specialist Orville Reed calls it "one of the best booklets on writing direct mail copy I've ever seen".

Borden's four-point formula, (1) Ho hum! (2) Why bring that up? (3) For instance! (4) So what?, is used by professionals in every field of writing and speaking. Many use it unconsciously–it's a trick of the trade they've come by through years of experience.

There's nothing new in this booklet. It is condensed from a book Borden wrote more than 20 years ago. We continue to offer it because it is still–today–the simplest and clearest presentation of these ideas that we have ever seen.

If you write letters, just substitute the word "letter" in place of the word "speech". If you're an advertising man, substitute the word "copy". If you're a salesman, think in terms of "sales talk". If your work–or your community activities–involve getting an idea out of your head and into someone else's, you are about to discover pure gold. Read away!

**The Editors**

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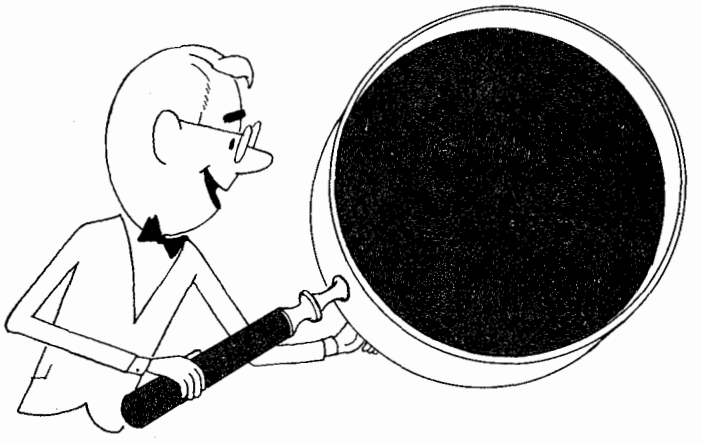


## LISTENERS' LAWS FOR SPEECH ORGANIZATION

THE fundamental law of speech organization can be stated in eight words:

Give every speech you make purpose—and form!

Listeners like vertebrate speeches —speeches with a *spine*.

They dislike speech jellyfish.

They dislike flabby, shapeless speeches that begin nowhere, ramble on in all directions—and end up in the air.

### THE FORMAL PLATFORM SPEECH

THE organization formula of the formal platform speech is not complex. It is simple.

It is so simple that you can write it on your thumb nail:

1. Ho hum!
2. Why bring that up?
3. For instance!
4. So what?

The apparently cryptic phrases in this formula describe the four stages of audience reaction which you, as a platform speaker, must meet.

They are the clues to the four-step organization of your speech.

### First Step: Ho hum!

IN THE FIRST SECTION OF YOUR FORMAL PLATFORM SPEECH—START A FIRE!

Your speech is not well organized unless you kindle a quick flame of spontaneous interest *in your first sentence.*

Smokers do not like matches that fail to light with the first scratch. Listeners do not like speakers who fail to "light" with the first sentence.

When you rise to make a speech, do not picture your audience as waiting with eager eyes and bated breath to catch your message.

Picture it, instead, as definitely

bored—and distinctly suspicious that you are going to make this situation worse.

Picture your listeners as looking uneasily at their watches, stifling yawns and giving vent to a unanimous "HO HUM!"

The first sentence of your speech, like the three redskins who bite the dust in the opening sentence of the Western thriller, must crash through your audience's initial apathy.

Don't open your speech on Safety First by saying: "The subject which has been assigned to me is the reduction of traffic accidents." Say, instead: "Four hundred and fifty shiny new coffins were delivered to this city last Thursday."

Emulate the technique of Henry Ward Beecher, as related by Milton MacKaye:[1]

> Henry Ward Beecher had a genius for bringing the most somnolent audience to life. One July morning he rode into a West Virginia town which was widely known in lecture circles as "Death Valley"—for the reason that any speaker unfortunate enough to have an engagement to lecture there wilted and curled up when he faced the town's stupid and indifferent audience.
>
> Beecher was duly warned. That afternoon, when he was being introduced, half the audience was already dozing. Beecher rose from his chair and, wiping his brow with a large handkerchief, strode to the front of of the platform.
>
> "It's a God-damned hot day," the clergyman began.
>
> A thousand pairs of eyes goggled and an electrical shock straightened the crowd erect. Beecher paused and then, raising a finger of solemn reproof, went on, "That's what I heard a man say here this afternoon!"
>
> He proceeded into a stirring condemnation of blasphemy—and took his audience with him.

[1] Published in *The New Yorker*.

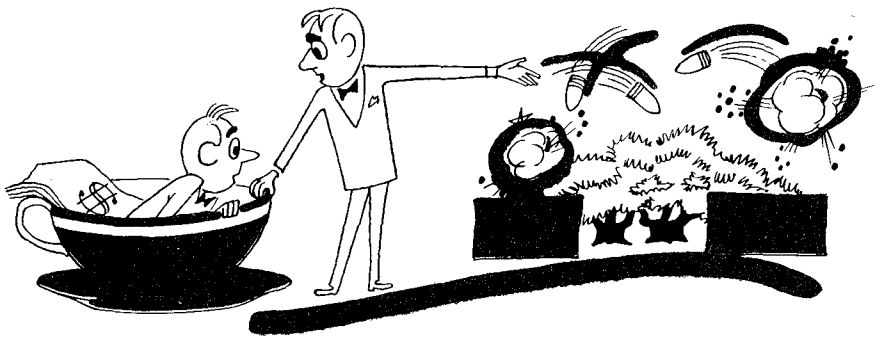
### Second Step: Why bring that up?

IN THE SECOND SECTION OF YOUR FORMAL PLATFORM SPEECH—BUILD A BRIDGE!

Your listener lives on an island—an island of *his* interests.

Why should he worry, for instance, about this jungle war between Bolivia and Paraguay, which you have introduced as the subject of your speech?





"Yes," your listener admits, "you caught my attention by an intriguing opening sentence. But in the cold light of second thought —*why bring up this subject anyway?*"

The second section of your speech must answer this question squarely.

"I bring up this subject of an apparently remote war because the war in reality is not remote. It affects *your* morning cup of coffee. Through its influence on Latin-American trade it affects the number of dollars in *your* pocketbook. The repercussions of this war are rattling the furniture in *your* home."

Thus, in a few sentences, you build a bridge from the heart of a far-off jungle—to the little island of your listener's interests.

Listen to a psychologist motivate his talk on insanity before an audience of parents. He has introduced the subject of insanity with a ho-hum squelching opening sentence, but his listeners are now asking, "Why bring that up?"

I invite you parents to consider this subject of insanity, because *you* have most at stake.

*Your* child, today, has almost one chance in twenty of being confined to an asylum before he dies.

And suppose your child escapes? *You* are still affected.

If your neighbor's boy is the victim, records show that institutional life will claim him for approximately seven years. The twenty-five thousand dollars expended by the state during those seven years, *you* will pay.

Whether as a parent, or as a taxpayer, *you* are vitally interested in this subject of insanity.

It makes no difference whether the subject of your speech is jungle warfare or insanity. In either case you must build a bridge to your listeners.

Until this bridge is built, you are not ready to begin the body of your speech.

### Third Step: For instance!

IN THE THIRD SECTION OF YOUR FORMAL PLATFORM SPEECH—GET DOWN TO CASES!

Let's assume that you have introduced your speech subject interestingly, arresting all ho-hums with your first sentence—that you have motivated it deftly, convincing your listeners in your second sentence that the subject hits their interests.

*Now get down to cases.*

The body of your speech must be keyed to one relentless audience demand—FOR INSTANCE!

To be true, the body of your speech properly begins with some purposive general assertion about your subject. But once you have made this key assertion, resist the temptation to "put the idea in other words."

Your audience is not interested in "other words." It is tapping its collective foot impatiently and demanding—"FOR INSTANCE!"

If you start your speech body by asserting that wars are caused by economic rivalry, let your next sentence deal with the War of 1812, the Franco-Prussian War of 1870, the World War. *For instance!*

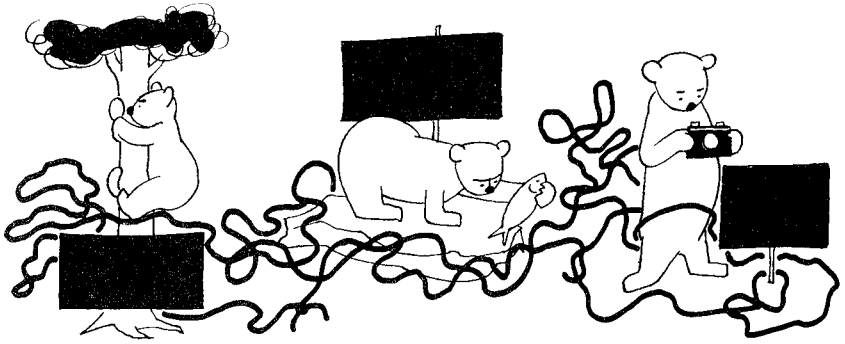
If you claim that the oil-burner you represent will change cellars into living-rooms, let your next sentence describe the glorified cellar of Mr. Davis, the cellar of Mrs. Wilkins, the cellar of the family next door. *For instance!*

Listen to Marcus Duffield who has just introduced and motivated the subject of overlapping functions in bureaus of the federal government. Note how he plunges immediately into his for-instances, after opening the body of his speech with a *purposive assertion* about his subject.[2]

> Overlapping functions in government bureaus are not necessary—but just plain foolish!
>
> Take highways. An ordinary public highway is built by the Bureau of Public Roads of the Department of Agriculture.
>
> If it runs through a national park, the National Park Service of the Department of the Interior builds it.
>
> If it is in Alaska, the Engineer Corps of the War Department builds it.
>
> Take colonial government. Hawaii is governed by the Department of the Interior; the Philippines by the War Department; Guam by the Navy Department.

[2]Published in article form in *Vanity Fair.*





Take foxes. If a man shoots a fox in Alaska, he must settle accounts with the Department of Agriculture. But if he traps the fox, he must settle with the Department of Commerce.

If you think two-department care of Alaskan foxes is just an accident—then take bears !

The Secretary of the Interior protects grizzly bears.

The Secretary of Commerce protects polar bears.

And the Secretary of Agriculture protects brown bears.

If a brown Kodiak bear has twins, one brown and one black, they are under the auspices of two different federal departments.

As you analyze the preceding speech excerpt, note that the speaker does not present his "for-instances" in a jig-saw jumble. He presents them as organized platoons—in marching order.

Note also that when one platoon marches by, that's the end of it. The speaker does not say, in the middle of his wild-life discussion: "Oh, by the way—while I was on the subject of highways, I should have mentioned . . ."

Remember this when you come to the body of *your* speech. *Listeners like speakers who serve their "for-instances" as course dinners, not goulash!*

### Fourth Step: So what?

IN THE CONCLUDING SECTION OF YOUR FORMAL PLATFORM SPEECH—ASK FOR ACTION!

The end of your speech, like the end of your pencil, should have a *point.*

The conclusion of your speech must be more than a graceful leave-taking. It must be more than a review of the for-instances covered in the body of your speech. It must be more than a reminder of your subject's general importance.

It must answer the audience's question: "SO WHAT?"

"So far, so good," say your listeners. "You have introduced your subject in a manner to arrest our attention. You have motivated it in a manner to command our seri-

ous interest. You have illustrated it with enough concrete cases to carry conviction. But now what? Where do we go from here? What do you want us to do about all this?"

In the conclusion of your speech, ask your audience for some specific action—some action response *which it is within their power to give.*

Join! Contribute! Vote! Write! Telegraph! Buy! Boycott! Enlist! Investigate! Acquit! Convict!

When you feel tempted to end your speech without such a request for action, remember the Chinese proverb of the Middle Ages:

"To talk much and arrive nowhere is the same as climbing a tree to catch a fish."

### Illustration of a Formal Platform Speech That Listeners Like

In the following two-minute speech, the Listener Formula for organizing a formal platform address is accurately applied.

As you read this illustration, note, in passing, that much can be said in two minutes.

The world would be merrier, and listeners happier, if more speeches were only two minutes long.

*Illustration*

(Bruce Barton is urging an audience of young men to use their spare hours constructively.[3])

[3]Published in article form in *The American Magazine.*

**Ho hum!** Last month a man in Chicago refused a million dollars for an invention he had evolved *in his spare time.*

**Why bring that up?** You are interested in this because it confronts you with the possibilities of *your* spare time. Did you ever stop to think that most of the world's great men have achieved their true life work, not in the course of their needful occupations, but—*in their spare time?*

**For instance!** A tired-out rail-splitter crouched over his tattered books by candle-light or by fire-glow, at the day's end; preparing for his future, instead of snoring or skylarking like his co-laborers. Lincoln cut out his path to later immortality—*in his spare time.*

An underpaid and overworked telegraph clerk stole hours from sleep or from play, at night, trying to crystallize into realities certain fantastic dreams in which he had faith. Today the whole world is benefiting by what Edison did—*in his spare time.*

A down-at-heel instructor in an obscure college varied the drudgery he hated by spending his evenings and holidays in tinkering with a queer device of his, at which his fellow teachers laughed. But he invented the telephone—*in his spare time.*

**So what?** Gentlemen, you, too, have spare time. The man who says: "I would do such and such a great thing, if only I had time!" would do nothing if he had all the time on the calendar. There is always time—*spare time*—at the disposal of every human who has the energy to use it. USE IT!

### THE AFTER-DINNER SPEECH

THERE is little fundamental difference between the after-dinner speech and the formal platform speech.

Both should be based on the organization formula which recognizes the four audience reactions:

1. Ho hum!
2. Why bring that up?
3. For instance!
4. So what?

The only important distinguishing earmark of the after-dinner speech is its emphasized use of the humorous illustrative story.

The after-dinner situation is more convivial than the platform situation, more intimate, more informal.

After-dinner listeners want not merely to learn, but to laugh in

the learning. They want a worth-while message—but they want that worth-while message brightened with highlights of whimsicality.

The humorous illustrative story is dangerous speech material. When it's good, it's very, very good, but when it's bad, it's awful. If you would avoid laughter misfires and backfires in the organization of your after-dinner speech, observe three simple principles.

**First Principle:**

*Make sure that the humorous illustrative story which you use in your after-dinner speech actually IS illustrative.*

After-dinner listeners are not vaudeville listeners.

They dislike the speaker who turns out to be merely an amateur comedian. They dislike the purposeless "that-reminds-me" rambler.

When you face an after-dinner audience, first establish a serious theme, exactly as you would do in a formal platform speech.

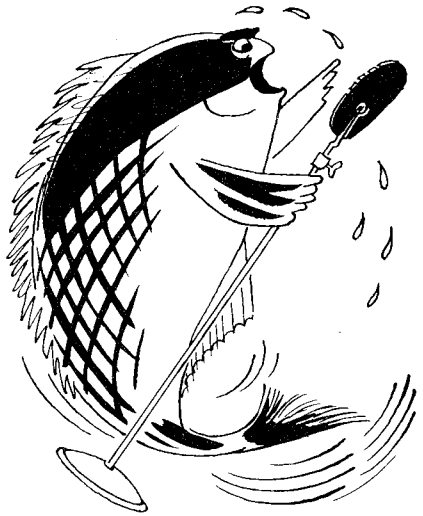
Then illustrate your serious theme by a whimsical story which is so apt, so thoroughly illustrative, that it doesn't make much difference whether your audience laughs or not. If your listeners laugh, fine! But if they don't, no harm done! The story still stands on its own legs as a legitimate for-instance.

Contrast with this laugh independence the complete laugh dependence of the after-dinner speaker who drags in a story by the hind leg. The audience instantly realizes that the speaker is not illustrating a point, but telling a joke. Well, suppose the joke isn't as good as the speaker thinks—and the audience doesn't laugh. What then?

The speaker's plight is pitiful. The muscles in his face work visibly to conceal his embarrassment.

His Adam's apple jumps up and down.

Finally he says: "Well, I guess that wasn't so good. Let's see, where was I?" And he flounders on.



If your humorous story is really illustrative, however, a laugh misfire is not fatal. You have not failed to get a laugh. You have succeeded in illustrating your point interestingly.

A laugh in an after-dinner speech is a by-product. It is not a strained-for end in itself.

**Second Principle:**

*Make the transition from your speech context into your humorous illustrative story—casually.*

"That reminds me of the story of the two Irishmen . . ."

"It seems there were once four Scotchmen . . ."

"In this connection I heard a good story last week . . ."

All such story-opening phrases are taboo! They *announce* that you are now about to tell a funny story. And the natural listener reaction is: "All right! Try and make me laugh. This had better be good!"

The good humorous story sneaks up on the listener and bites him in the leg when he isn't looking. It preserves the invaluable quality of surprise.

Get out of your speech context and into your story so casually that there is no dividing line. Throw the clutch without a noisy clashing of gears.

**Third Principle:**

*Make the transition from your humorous illustrative story back into your speech context—purposively.*

"But to become serious again . . ."

"Let's see now, where was I? . . ."

"But to get back to the point . . ."

Such transition phrases are not transitions at all. They are thought jolts which make your listeners suspect, quite properly, that the story you have just completed was just so much digressive nonsense.

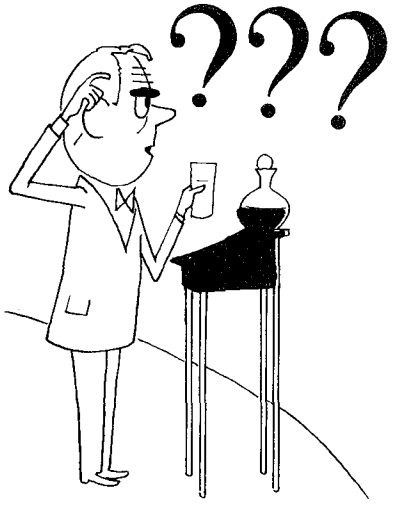
The last sentence of your story and the first sentence of your resumed speech context should mesh with an easy naturalness—with an "and-so-we-see" *purposiveness.*

## LISTENERS' LAWS FOR SPEECH SUBSTANCE

You have learned a two-word formula for investing the body of a speech with audience interest. For instance!

So magic are the two words in this formula, that if you repeat them about every ten sentences, the body of every speech you make *must* be interesting.

Of course, if you apply this formula without adequate preparation, you will get into trouble. About the third time you say "For instance," you may clap your hand to your head and ask, "For instance—*what?*"



If the answer is "For instance —*nothing!*" the body of your speech has come to an end. Do not try to draw it out by abstract speculation, by unsupported assertion, or by mere repetitious wordiness. *The body of your speech has come to an end.*

No amount of speech organization can make up for lack of speech substance. No amount of manner can make up for matter.

The relationship between speech organization and speech substance is the relationship between cooking and food. When one of the early Puritan fathers wrote a recipe for wild turkey, he quite properly began his instructions with the simple phrase, "First catch your turkey."

This is the basic listener's law governing speech substance. *First catch your "for-instances!"*

There are six forms of speech substance best adapted for the body of your speech—the six "for-instances" that listeners like best.

### 1. Listeners like "for-instances" in story form.

Listeners not merely *like* "for-instances" in story form. They *demand* them.

Until you learn how to animate the illustrations in the body of your speech with the narrative touch, you will remain "just another speaker."

Analyze yourself for a moment, not as a speaker, but as a listener. *What was the first listener demand that you ever put into words?* You were only a child when you voiced it—"Tell me a story!"



### 2. Listeners like "for-instances" which involve famous people.

If your story-form "for-instance" involves a famous person, its interest is measurably increased.

This is something you should note carefully!

Good stories involving famous people, with an illustrative angle that makes them useful to speakers, are not picked up overnight. *You must accumulate them*—slowly, systematically.

### 3. Listeners like "for-instances" which animate the pages of history.

If your story-form "for-instance" dramatizes an incident of recorded history, it carries a persuasive weight which undocumented anecdotes often lack.

Stories about Tommy and Bill are usually regarded as "just stories," useful in the interests of exposition, but having no value as evidence.

Even stories about famous people are often accepted as George Washington-and-the-cherry-tree yarns.

But historical "for-instances" can *convince.*

In the following illustration, Arthur D. Little urges an audience to be tolerant of all new ideas—to examine them, unprejudiced by past traditions or present opinions.[1]

> If you permit your opinions to harden, you retard your own advance, and you do something far worse. You retard the advance of the world.
>
> There hangs in my office a picture entitled "The Arrest of Lavoisier." The great chemist, one of the greatest men ever produced by France, had been the first to explain combustion in the terms we now accept. During the French Revolution Marat denounced him as the "Master of Charlatans." In my picture Lavoisier listens in silent dignity to the reading of the warrant by an arrogant fellow in a red cap, behind whom crowds the exulting rabble. His arrest was followed by sentence of death from a judge who declared, "The Republic has no need of chemists."

[1]This illustration published in article form in *The Technology Review.*

Marco Polo, the greatest, and probably the most accurate of mediaeval travelers, returned to Venice from his amazing journey across the deserts of Persia to the dazzling court of the Great Khan—only to be greeted with incredulity and to acquire the insulting sobriquet of *Marco millioni,* Marco of the Millions. His story, which since has been verified in most of its details, was incredible. Who could believe in such things as paper money, printed books, black stones which burned, and nuts as large as a man's head? For many years after his return every carnival of Venice was enlivened by the preposterous antics of a clown who impersonated *Marco millioni.*

We are now living in what we call the machine age, and our civilization is largely based on coal and oil. Such foundation was not established nor was the machine developed without passionate resistance from people with hardened opinions. In the days of King Edward I, it was a capital offense to burn coal in London. In 1619 the growing scarcity of wood in England led Dudley to attempt the substitution of coal for charcoal in his blast furnace. The ironmasters drove him out of Worcester County. He set up another furnace. A riot was organized and the furnace wrecked. Only 150 years ago today it was illegal to sell coal in the city of Philadelphia.

Our gigantic petroleum industry came into being because a man had faith in an idea at at which his neighbors scoffed. Edwin L. Drake, of Titusville, Pennsylvania, believed that large quantities of petroleum existed in subterranean cavities. In 1859 he started drilling, and his effort became the laughingstock of all western Pennsylvania. But when his well filled with oil, Drake's folly became, overnight, the envy of the countryside.

In 1802 William Murdoch made gas from coal, and with it lighted his house in Cornwall. Furious opposition was aroused when Murdoch and his associates attempted to extend the use of gas. Scott, Byron, and Napoleon were among those who ridiculed the crazy notion. Scott wrote: "There is a madman proposing to light the streets with—what do you suppose—*smoke!*"

Don't let the arteries of *your* opinion harden. The world moves irresistibly on. Move with it!

In the preceding speech excerpt, Mr. Little does more than interest his audience. He does more than make his point clear. He wins *conviction* as well, through the use of story-form "for-instances" that animate the pages of recorded history.

### 4. Listeners like "for-instances" based on colorful analogies.

You should be glad to know that listeners like "for-instances" based on analogies, because analogies, as a rule, are *your most effective weapons of exposition.*

Graft the new idea, which your listeners don't understand, into an old idea, which they do understand.

Suppose you are making a speech against monetary inflation. How will you explain to your listeners the nature of inflation? By abstract definition? By citing the technical expositions of economists?

Not if you are wise.

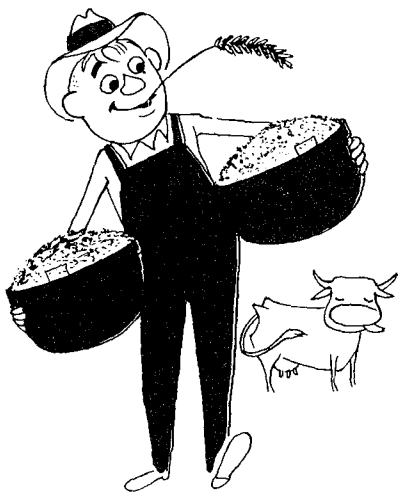
If you are wise, you will use the grafting technique and proceed with your explanation as follows:

There was once a farmer whose harvest yielded him 1,000 bushel baskets full of wheat.

But he decided that this amount wasn't enough.

So he placed an order for some smaller baskets.

A week later the farmer smiled happily as he surveyed his inflated harvest. He now had 2,000 baskets full of wheat—2,000 *half*-bushel baskets.



Ladies and Gentlemen, you cannot add to the wealth of a nation by changing the size of the tickets called money any more than you can create more wheat by reducing the size of bushel baskets.

### 5. Listeners like "for-instances" which dramatize important statistics.

It is often impossible for you to avoid the introduction of statistics into the substance of your speech.

And why *should* you avoid statistics?

Some place or other you've picked up the notion that figures bore listeners.

But that's where you're wrong.

Listeners *like* figure "for-instances"—

(1) if they are really important
(2) if they are easy to understand
(3) *if they are properly dramatized*

Note that in the following anti-war speech by Nicholas Murray Butler, statistics become more than a necessary evil in a process of proof. They are made a tool of *interest* as well as of persuasion.

> The money spent by all nations for the destructive purposes of the World War amounted to four hundred billion dollars.
>
> Do you know what we could have done with that money if we had used it constructively?
>
> We could have built a $2,500 house, furnished it with $1,000 worth of furniture, placed it in the middle of five acres of land worth $100 an acre, and given this estate outright to each and every family in the United States, Canada, Australia, Wales, Ireland, Scotland, France, Belgium, Germany, and Russia.
>
> We could have given to each city of 20,000 inhabitants or over, in each country named, a five-million-dollar library and a ten-million-dollar university.
>
> Out of what was left we could have set aside a sum at five per cent that would provide a $1,000 yearly salary for an army of 125,000 nurses, and another army of 125,000 teachers.
>
> Who says statistics are inherently uninteresting?
>
> If you dramatize them as Nicholas Murray Butler did in the preceding speech, they can be made to sparkle with interest.

### 6. Listeners like "for-instances" interwoven with visual aids.

The eyes of your listener are more learned than his ears.

Appeal to them as often as possible!

Use "for-instances" which can be made more vivid by the interweaving of simple visual aids.

If you are urging an audience to stay away from auction sales, pull out your watch and hold it up. Then ask: "Can you tell me the exact value of the watch which I hold in my hand? Look at it closely. Is it worth one hundred and twenty dollars—or a dollar and twenty cents? Do you KNOW? If you don't know, and know for certain, *you've no business at an auction sale!*"



## LISTENERS' LAWS FOR SPEECH PHRASEOLOGY

To BE "pleasing" in your speech phraseology means more than you think.

It means that your language must be unvaryingly sincere. It means that your choice of words must reflect listeners' preference for the specific, the colorful, the picturesque. It means that your sentences must not only stand on their own grammatical legs, but must mesh coherently with their neighbors. It means, above all, that your phraseology must be unremittingly clear, expressing at all times your acceptance of the fundamental axiom that the purpose of language is to reveal thought, not to conceal it.

### 1. Listeners like speech phraseology free from wax.

In ancient days Roman sculptors sometimes sought to conceal surface cracks in a statue with the aid of melted beeswax.

A buyer, deceived into believing that he was purchasing a flawless piece of marble, would place such a statue proudly in his atrium.

A few weeks later the beeswax would dry out, crumble away, and leave the original cracks exposed.

To such alarming proportions did this practice of wax trickery grow, it finally became the custom of reputable sculptors to guarantee their works as *sine cera*—literally translated, "without wax."

Our present word "sincere" we owe to a rebellion against wax.

You are not in the business of carving statues out of marble. But you do something basically similar. You carve speeches out of words.

*Beware the use of wax!*

Beeswax tricked the ancient Romans. But word wax never tricked anybody. It is instantly recognized and thoroughly despised by all listeners.

Word wax may be defined as any phrase, any group of words, which is not an *integral part* of the thought you seek to express.

For instance—

(a) *Superlatives are usually wax.*

"This is absolutely and positively essential!"

Eliminate the word wax and what remains is not less, but more forceful. "This is essential!"

"This is true beyond any possible shadow of a doubt!"

If you wish to strengthen the simple assertion, "This is true!" do so by presenting confirming "for-instances"—not by pouring word wax into the cracks.

(b) *Trite expressions are wax.*

When the introducer says, "We have in our midst . . . a man who needs no introduction . . . it is indeed an honor and a privilege . . .", listeners mutter to themselves: "Word wax!"

When the graduation day speaker says, "As I look into your smiling faces . . ."

When the political orator shouts, "I believe I can say without fear of contradiction . . ."

When any of these stale phrases assail the ears of listeners, a thumbs-down diagnosis is instantly made. *Word wax.*

(c) *Groping expressions are wax.*

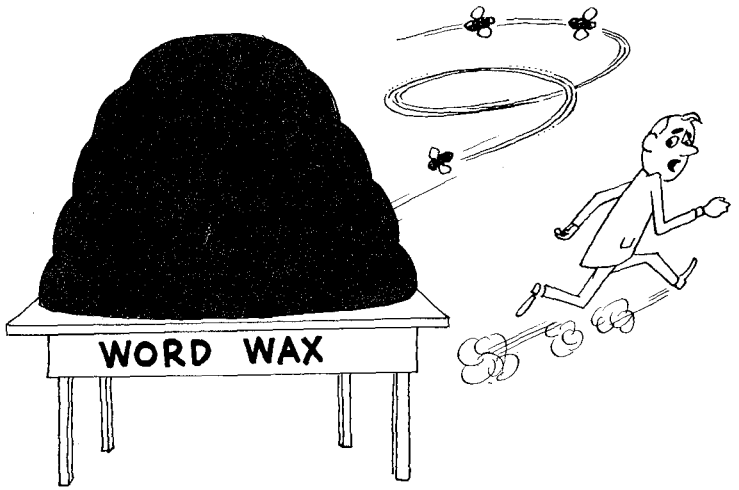
"What I'm trying to get at is . . ."

"What I want to say is . . ."

If you want to get at something, then get at it!

If you want to say something, say it!

Your failure to express your idea clearly the first time is not helped by word wax. Try a "for-instance" instead.






(d) *Repititious expressions are wax.*

"As I said before . . ."

"And so may I again repeat . . ."

If you wish to gain the emphasis which comes from restatement—as you do in the opening and close of a conference comment—go ahead and restate.

But omit the waxy "as I said before."

(e) *"And so forth" expressions are wax.*

"America has produced such inventors as Fulton, Edison, the Wright brothers—and so forth and so on."

When you list items in series, stop cleanly with your last item.

"And so forth" expressions are uncharitably interpreted as wax calculated to make others believe you know more than you do.

Such expressions have the same value as the obnoxious phrase, "I could go on this way for hours."

(f) *Weasel words are wax.*

"Of course it's only my opinion, but . . ."

"It seems to me . . ."

Of course it's your opinion! That's why you're expressing it.

Naturally "it seems to you," or you wouldn't be saying it.

"More or less . . . to a greater or less degree . . . or something like that . . ."

Punch-pulling phrases, which fuzz the crispness of a thought, are just as obnoxious as the superlatives at the opposite extreme.

Avoid them!

**2. Listeners like speech phraseology that is grammatically sure-footed.**

It often happens that you are called upon to deliver a speech extemporaneously.

This means that you have a chance to plan your speech organization and to select, mentally, a few good "for-instances." But there is no opportunity to plan a definite sequence of words.

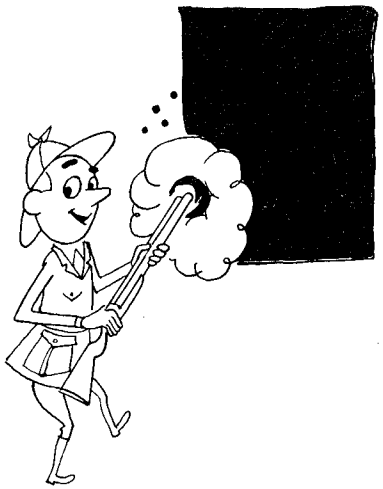
This means that the extemporaneous-speaking situation submits to the acid test your ability to phrase your thoughts under fire—*grammatically.*

How easy it is to bog down in the middle of a sentence!

How easy it is to match plural subjects with singular verbs, to disrupt the form of a sentence with a shapeless parenthetical remark, to leave clauses hanging forlornly in the air!

But there is one simple way to keep out of trouble.

*Use plenty of periods.*



When a sentence begins to crumple under its own weight—period!

When a dependent clause starts to miss on one grammatical cylinder—period.

Short sentences are the royal highroad to grammatical surefootedness in extemporaneous speaking.

*Illustration*

(Lincoln Steffens is urging parents to animate their children with the pioneer spirit. Note that by a technique of short sentences he achieves not merely grammatical surefootedness, but *force.*[1])

Nothing is done.

Everything in the world remains to be done—or done over.

The greatest picture is not yet painted. The greatest play isn't written. The greatest poem is unsung.

There isn't in all the world a perfect railroad. Nor a good government. Nor a sound law.

Physics and mathematics are being fundamentally revised. Chemistry is just becoming a science. Phychology, sociology, and economics await a Darwin.

Tell that to your children.

A faucet leaks. I cannot close it tight. Good. I call my seven-year-old son. He seizes the faucet, tries to turn it off. Can't. He grins.

"What's the matter, Pete?" I ask.

He looks up happily and gives the answer. "Grown-ups, Daddy."

Propaganda, of course. I have taught him that we, his elders, cannot make a fit faucet. And *he* may. There's a job for him and his generation in the plumbing business. And in every other business.

Teach *your* children—

That nothing is done, finally and right.

That nothing is known, positively and completely.

That the world is theirs . . . all of it!

[1]Published in article form in *The Cosmopolitan Magazine.*



### 3. Listeners like speech phraseology that is conversational.

Beware sounding like a book when you speak.

Your function as a speaker is to be communicative, not oracular.

You are not an essayist in an ivory tower, but a *man talking.* A man who talks his listener's language!

This does not mean that the phraseology of your speech should be mediocre or casual.

It *does* mean that your phraseology should achieve the sincere directness of conversation. Brilliant conversation! Organized conversation! Purposive conversation! But still—*conversation.*

To achieve the conversational touch, employ grammatical contractions such as "Wouldn't you . . .", "Doesn't it seem to you . . .", "Haven't you ever. . . ."

Above all—feature the second personal pronoun.

Freckle your phraseology with "you's!"

### 4. Listeners like speech phraseology that is specific.

Which is more interesting—

He passed between two trees.

Or—

He passed between a shagbark hickory and a stunted blue spruce.

The specific is *always* more interesting.

If you would develop the kind of phraseology that listeners like, talk of cucumbers rather than vegetables . . . of Frenchmen rather than foreigners . . . of eighty-mile-an-hour tanks rather than modern military equipment.

As the "for-instance" principle should guide you in planning ideas within the framework of your speech organization, so this same master principle should guide you in planning words within the framework of your speech phraseology.

Choose words which are *specific!*

Choose words so specific that they throw sharp shadows of individuality . . . words so specific that they have color . . . words so specific that your listeners *see* at the moment they hear.

### 5. Listeners like speech phraseology that is picturesque.

The surest way to develop a colorful, picturesque manner of expression is to experiment with metaphors and similes.

For instance! How picturesque is the metaphor-bristling phraseology of Ralph Waldo Emerson as he discusses with his listeners "The Language of the Street":

> The language of the street is always *strong.*
>
> I confess to some pleasure from the *stinging* rhetoric of a *rattling* oath in the mouths of truckmen and teamsters. How *laconic* and *brisk* it is by the side of a page of the North American Review.
>
> *Cut these words of the street and they bleed; they are vascular and alive; they walk and they run.*
>
> Moreover, they who use them do not *trip* in their speech. Their phraseology is a *shower of bullets,* whilst Cambridge men and Yale men correct themselves and begin again at every half sentence.

You can make the phraseology of your next speech as picturesque as Emerson's by using the same technique. Metaphors. Similes. Nouns that bleed. Verbs that sting and rattle.

### 6. Listeners like speech phraseology that is clear.

Clarity in your language takes precedence over every other listener demand.

Why, then, is it listed last in this chapter?

Because clarity is not a means —but an end.

It is the joint product of all the other elements in good speech phraseology.

It results from the sincerity of language free from word wax . . . from the simplicity of short sentences . . . from the directness of the conversational style . . . from the exactness of specific words . . . from the picturesque vividness of metaphors and analogies.

If your speech phraseology is clear, you gain more than clarity. *To be clear is also to be convincing.*

The editors of the Encyclopaedia Britannica appreciate this truth when they write:

> Nine readers out of ten take a lucid statement for a true one.

Napoleon knew his listeners' laws when he gave three instructions to the secretaries who relayed his messages:

> Be clear!
> Be clear!
> Be clear!



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THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
74 Trinity Place, New York 6, N. Y.

no. 11

*Advance copy of paper to be presented at Annual Meeting, New York, N. Y., November 13–14, 1958.*
*Written discussion should be delivered to the Secretary on or before November 1, 1958.*

# SYMPOSIUM ON VALUE ENGINEERING

## 1—Putting Value Engineering to Work

By Capt. J. M. Reigart, USN,[1] *Visitor*, and M. D. Roderick,[2] *Associate Member*

IN the foreword to the Agenda for the Bureau of Ships Value Engineering Seminar, Rear Admiral Mumma, Chief, Bureau of Ships, stated "I heartily welcome you to the Bureau of Ships Fall Value Engineering Seminar. This Seminar is of particular interest to me because it is the first one being conducted primarily for the private contractors that design and build our ships and equipment. I have always considered our private contractors to be important members of our defense team and as such, I am confident that you will co-operate fully with this Bureau in its continuing effort to produce functional, reliable and maintainable equipment at the lowest possible cost to the taxpayer . . . ." These words are particularly significant for two reasons. They indicated that the Bureau of Ships Value Engineering Program, inaugurated in 1954, with a motto of "More Ships for Less Dollars" had proven successful in practice within the Bureau of Ships and its field activities. They further indicated a desire on the part of the Bureau of Ships to enlist the aid of industry in applying these successful techniques to ships and equipment.

The shipbuilding industry can be justifiably proud of the technological advancements made over the past 30 years. In the functional area, improved research, design and construction have produced such ships as the *Nautilus*, the *Forrestal*, and the guided-missile ships. Management effectiveness has been improved, and, within itself, the industry is competitive. However, as compared to foreign markets, the shipbuilding industry has not been truly competitive since 1829. Today, for example, on the world tanker building program, costs are ranging from $100 to $150 per DWT in Japan, about $200 per DWT ton in Europe, to about $300 per DWT in the United States. Recognizing our higher labor and material costs, it would be too much to expect that we will become economically competitive in the shipbuilding field with foreign countries. However, we do face the problem of keeping our costs as low as feasible.

Actually we are collectively in competition with ourselves when we try to reconcile a relatively fixed budget for new construction and conversion, a desire for a strong Navy in the defense of our country, and continually rising costs of ship construction. The latter *must* give! In this Society's President's Annual Address in 1954, Mr. W. E. Blewett, Jr. stated, "In an industry which is already marked by high cost and which has priced itself out of foreign competition, we cannot afford for one minute to lose sight of costs. In fact ways must be found to lower the cost of shipbuilding." Value Engineering is one of these ways. It is not management *per se*. It is not the panacea to solve all cost problems. It is a systematic, organized, tool of management which turns the spotlight on high-cost areas in ship hardware, fabrication, and installation, and through the use of fresh thinking, new techniques, and new processes permits the desired function to be obtained with equal reliability but at lower cost.

### What Is Value Engineering?

Value in itself is somewhat difficult to define. From an economist's viewpoint, there are four elements which determine the worth of goods or services. These are:

Esteem value—the diamond ring you might wear on your finger or the extra chrome or styling used to sell automobiles.

Cost value—closely associated with esteem value is the mistaken belief that because something costs more it is worth more.

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For presentation at the Annual Meeting, New York, N. Y., November 13–14, 1958 of THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

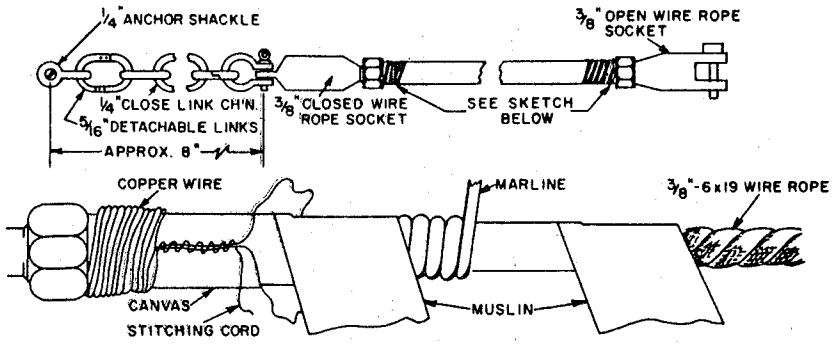


Fig. 1 Hatch guard

Resale value—the ability of an article to withstand depreciation.

Use value—the ability of an article to perform a useful function reliably.

All of these "values" play an important part in our national economy. Only one of them *should* be of primary importance in obtaining a truly functional Navy at the lowest possible cost—*use value!* We should be striving constantly to obtain function, and only needed function, without the frills or gadgets which add little to an item except cost, maintenance problems, and unreliability.

For example, in the carrier program, it was found that the guard rail for hatches required by the working plans was composed of wire rope 3/8-in. diam cut to length and special stainless-steel fittings put on each end. The wire rope is preserved with paint wrapped with muslin and served with marline cord. This in turn is again wrapped with muslin and the whole length covered with hand-stitched canvas. Each end of the canvas is served with copper wire and soldered. One end is fastened to the hatch cover by means of a short length of 1/4-in. close-link chain, the other to the deck or stanchion. This, as shown in Fig. 1, is an expensive item. There are approximately 344 hatches per carrier and the guard rail outlined cost $16,438 per carrier. Its function? To guard people! For this application, the substitution of 1/4-in. chain was recommended at a cost of $1,233 per carrier. The acceptance of this recommendation saved approximately $15,000 per ship!

Value Engineering involves a search for just such areas of high cost and is formally defined by the Bureau of Ships as "an objective appraisal of each element of design, manufacture, procurement and installation to achieve only necessary function and reliability at minimum cost." Less formally it is an intensive second look at a workable design to obtain the required function *and no other*, at minimum cost.

### Value Engineering Techniques

To perform the job of Value Engineering a series of techniques has been developed. These techniques are all directed toward the effective answering of five basic questions:

1 What is the item?
2 What does it do?
3 What does it cost?
4 What else will do the job?
5 What will that cost?

As an example, let us take a look at a familiar piece of shipboard "hardware." What is the item?—A 3-in. terminal fitted with a gate valve, Fig. 2. What does it do?—Vents air.

(Although this is the basic function, Section S48-9-d of General Specifications for Ships of the U. S. Navy requires:

*a*) All air escapes shall terminate in return bends.

*b*) Air escapes from floodable and nonfloodable voids shall terminate in gate valves.

*c*) Air escapes from fuel oil, HEAF, etc., shall be fitted with double screens.)

What does it cost?—$72.60 installed.

What else will do the job?—Any type of return-bend piping with screw cap, pipe plug, or other suitable device for closing off the line. Starting with this premise led the Puget Sound Naval Shipyard to the design shown in Fig. 3.

What will that cost?—$19.85 installed.

This idea is now approved by the Bureau of Ships and issued as a mechanical type drawing, Bureau of Ships Number 1385730 dated 3 March 1958. In addition to a per ship savings of $7,385 on a carrier conversion, there was a weight savings of 4200 lb per ship plus an obvious reduction in interference problems!

Among the series of techniques available as tools for Value Engineering, some of the most important are as follows:

### *(a) Get the Facts and Know the Costs*

In order that we may fully appreciate the problem and its possibilities and build our efforts on a firm foundation, we must get the facts and know the costs. Each specification and requirement responsible for the detail and over-all design must be exposed and evaluated. The cost of each component item manufactured or procured and its installation, operational and maintenance needs are considered. When this is done, the areas of unnecessary high cost will become apparent.

As an example, a naval shipyard installs about 150,000 electrical cable-marker tags per year on new construction, repair and conversion work. A Bureau of Ships Instruction was issued directing that care be taken to avoid painting these tags since repeated painting would impair legibility. This instruction taken at face value eliminates an act. For this reason, very little consideration was given to what actually occurred. Painting out of a space is a spray application, so that to avoid painting these tags, masking was necessary. This involves the demasking upon completion of the job. The tags also in many instances required cleaning and touching up. Labor is the expensive item we face in shipyard work. By permitting the cable tags to be painted and deleting the necessity to mask them, a savings of $55,600 per year is effected at one naval shipyard. What is the effect on legibility? Spray painting is a thin coat by contrast to hand-brushed application. Legibility of a tag is not affected until more than a dozen spray coats have been applied. Normally a shipyard in new construction work will apply a maximum of four coats in any given space. For these reasons, once the total picture of facts and costs was presented a Bureau of Ships Notice, 9620 of 15 April 1958, was issued permitting the painting of cable tags.

### *(b) Determine the Function*

A searching and fundamental test for value is obtained by determining and evaluating the function. Functions that any item furnishes can be divided into prime and secondary in importance. They should be listed and described as briefly as possible. Next a note should be made as to the cost and whether they are needed or not. Then comes the "blast and refine" treatment. We pick the one prime function that the item must furnish and try to meet this function with the simplest known product. A price is established for the product and here is a logical base point for determining the true value of the item. As a base point price it must have

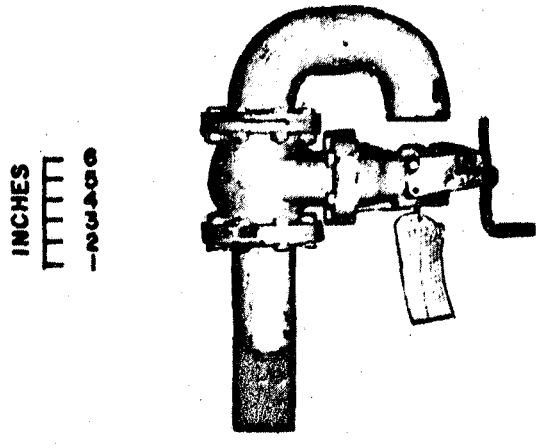


Fig. 2 Air-escape terminal valve (former)

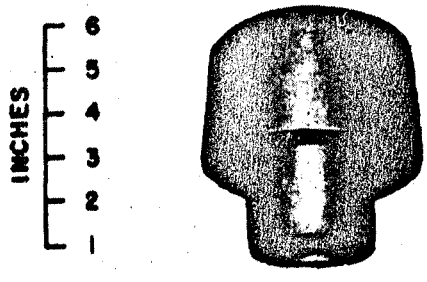


Fig. 3 Air-escape terminal valve (new)

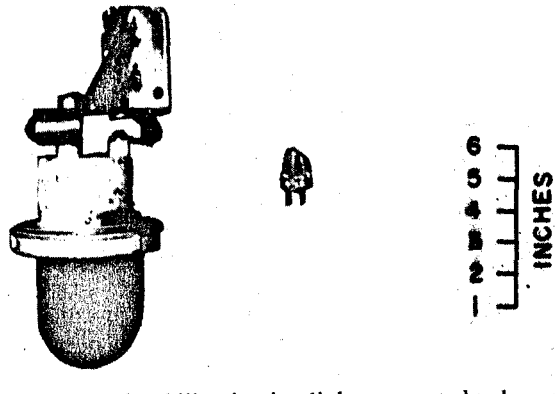


Fig. 4 Low-level illumination light contrasted to home-type night light

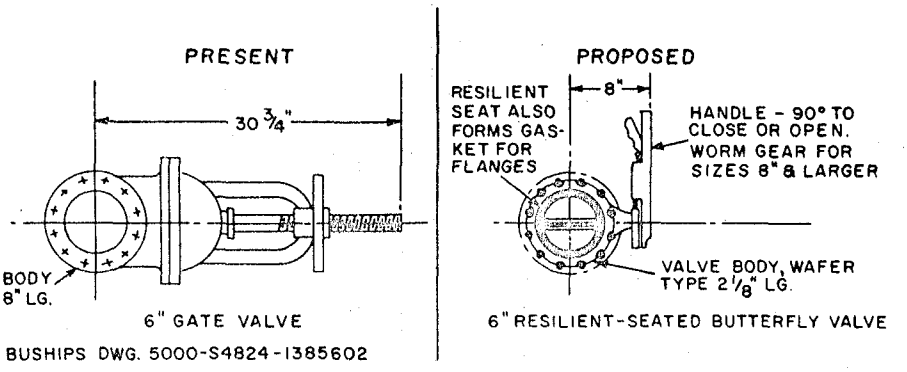


Fig. 5 Gate valve contrasted to resilient seated butterfly valves

added those secondary functions required for the truly functional product. Each will be added however in full knowledge of its cost and contribution.

Here is an item to consider: The unit now used to obtain low-level illumination in Navy practice is as noted on Bureau of Ships Drawing 9000-S6401-74218, Fig. 4, and is composed of a plastic globe, a mounting box, a shock support, electric wire, stuffing tubes and a switch. Prime function—provide low-level light. To do this, it has a 50-watt bulb plus a nearly opaque plastic shield which permits the passage of only a few watts of usable light. The entire assembly of the fixture plus switch costs $12.10. Secondary functions, such as shock, corrosion resistance and on-off switch, are supplied in this assembly. For our immediate purpose, however, let us consider the simplest item that could supply the prime function. What do you use in your home? A night light costing 35¢, which uses ¾ watt—has no switch—you plug it in and leave it on. Obviously, this item must pick up needed secondary functions to reach the stage of being a useful product to us. Now at this point which do you consider to be nearer the true value for the item—$12.10 or 35¢?

### (c) *Evaluate by Comparison*

This is the most familiar method we use daily in establishing value. Comparison is used when we buy cars, clothes, lawn mowers or what have you. We compare the item we are considering with other items on the market that can do the specific job required.

Gate valves are a high-cost item generally used as cut-out valves in fire-main systems aboard ship. General Specifications S48 and Piping Schedule, Bureau of Ships Drawing 5000-S4800-3000 cover the use of these valves. One of our field activities was dissatisfied with the excessive space requirements, the difficulty of operation with pressure on only one side of the disk, the tendency to foul with debris especially when mounted in horizontal lines, the slowness of closure and high cost to both procure and maintain these valves. The various valve designs used in the commercial field were reviewed and one type, the butterfly valve, stood out in its simplicity, use for similar applications (circulating water on various craft, water works applications, processing plants and other difficult operations), and low cost. These resilient seated valves give positive tight closures and give better service than gate valves. They are streamlined for low pressure drop. Installation and remote control are simplified. Space occupied is half or less. Repairs are needed with much less frequency (100 per cent of the gate valves required repair at each overhaul) and when needed are easily and quickly accomplished by replacement of seat disk or stem without any grinding in or precision fitting. Cost-wise the butterfly types Fig. 5, are about half as expensive as gate valves on first cost and much lower on maintenance. These valves have now been authorized for selected applications and a specification is being prepared to cover their general use.

By subjecting this item to evaluation by comparison, a ready-make substitute that does the job, in this case better, has been the reward. In savings, this amounts to $70,394 for one year at a naval shipyard.

### (d) *Use Creative Thinking*

When we have milked dry the existing methods of doing a job and still have no effective improvement in the way to do it, shall we stop here? Or is it wise to go further? The costs involved and the pressure for a better way will

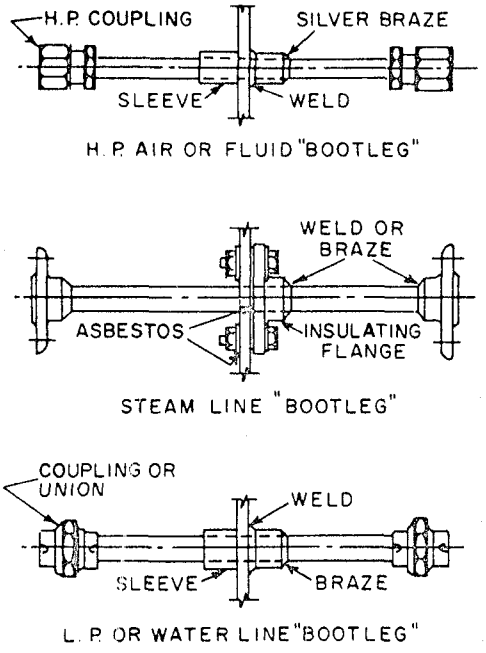


Fig. 6 Bulkhead pipe penetrations (standard)

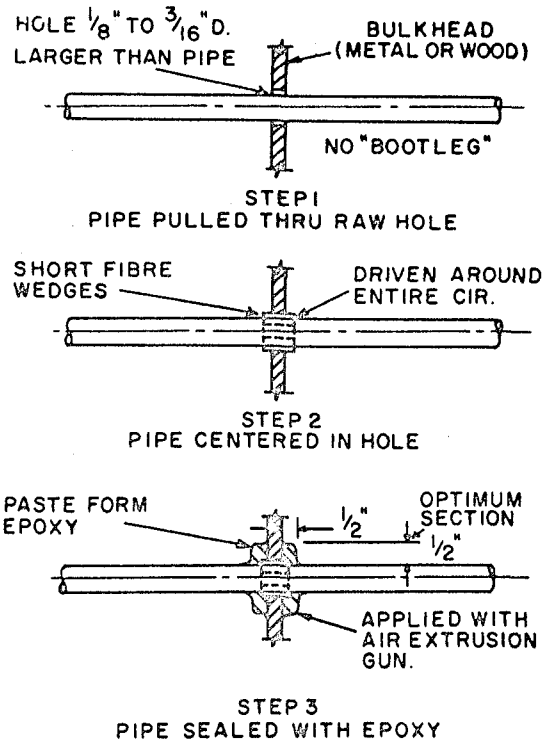


Fig. 7 Bulkhead pipe penetrations (epoxy)

determine this. If so, creative thinking is the next tool. For this purpose, we have no brief to present for either the group or the individual approach for we use both usually in combination—the group "brainstorming" for a good start or to overcome temporary roadblocks followed through by individual effort. A project that left the customary vale of marine usage by way of creative thinking was one concerning pipe penetrations through bulkheads. We are familiar with the standard varieties, such as shown in Fig. 6. Creative thinking stirred up the idea of the possibilities of using an epoxy-type resin for such purposes.

These resins are new, resist temperatures to 500 F, can be easily heat cured for temperature application or "cold cured" for room-temperature or cold service. The tensile, compression and shear values are satisfactory and they set up in 4 to 5 hr. Vibration, pressure, and seal likewise proved adequate. Prior to the recent development of epoxies, there was no product on the market of such a trowel-on material that would have permitted such use. Creative thinking here was exercised in bringing new products into our marine field. This application, Fig. 7, if approved after evaluation, will lower our costs for bulkhead pipe penetrations four fifths and has an estimated savings in one naval shipyard of $70,500 per year.

*(e) Use Vendor Assistance*

Put the other fellow on your team and particularly the one who has specialized on a given product. If you give him your problem, then show him what the prime functions and necessary secondary functions are so that he has the widest latitude in meeting your needs, many times he can help you and, indeed in so doing, discovers a wider use for his own item than previously had been the case.

As an example, the manual cleaning of oil tanks involving steaming, hot washing, sludging and wiping is an expensive, time-consuming, dangerous and disagreeable job. The tying up of equipment, men and money on such work has been an increasing matter of concern to our shipyards. Some tests in the past had been made on new detergents for such use but were inconclusive. It was when vendors of these detergents were brought in and several practical applications made to operating naval ships that progress began to appear. The project was enlarged to include bilge cleaning and attention was paid to the operational experience on commercial ship application. The vendors were acquainted with our specific needs and in turn indicated the

specific products and application procedures needed to insure their successful use. Authorization of this procedure has been gained for an average tank-cleaning savings of $800 or in a shipyard $280,000 per year. Even more important, no longer are sludge barges required and the ship can be made readily available for work upon reaching the repair yard.

### The Job Plan

As in any engineering, or indeed any analytical job, a planned approach is followed. This job plan is composed of five phases:

(*a*) Information—assemble all pertinent facts highlighting costs.

(*b*) Speculative—think of possible alternate solutions to reduce excess cost areas.

(*c*) Planning—pick the best solution and plan its developmental steps.

(*d*) Execution—carry out the planned approach.

(*e*) Reporting—assemble a clear concise report stating the problem and the solutions recommended with substantiating facts justifying the transition.

The following of such a job plan to obtain the answers to the basic questions, using as tools the techniques, should result in a complete job of high quality that sells itself; yet, we know from practical experience, a lot of additional effort is needed to help the busy line engineer answer his on-the-spot specific questions concerning the project.

### Presenting the Idea

It has been said that 25 per cent of the problem of cost reduction is concerned with things and 75 per cent with people. For this reason, a thorough knowledge of the techniques covered in the foregoing (plus others) is only the beginning! Designs and specifications are prepared by people, busy people! They are prepared using whatever education, experience, knowledge of production costs and processes the individual possesses. Generally, they are prepared using as much of the past written word on the subject as is consistent with the new design in order to get something quickly that works! In the military, especially, they are prepared with emphasis on maximum reliability at all costs!

Once a design or contract specification is prepared, it is probably reviewed up the line with the basic attention being given to the over-all design from the standpoint of "Will it work?" and "Is it reliable?." Cost is usually questioned on the basis of the over-all systems approach; i.e., turbine versus diesel; 23 knots versus 24 knots; ac versus dc; UHF versus VHF. Time and lack of detailed knowledge of all production costs included in the over-all design prohibits a challenging "Why?" to each of the detailed requirements which influence total costs!

Upon issuance of design or specification, it becomes the "Bible" and any questioning of a requirement in terms of value received, or a proposal for an alternate way of doing the job often puts the author on the defensive. His defense sometimes takes the form of a negative response which is referred to in Value Engineering as a "roadblock." Roadblocks to any idea appear in the form of such comments as:

It can't work.
It's patented.
We can't help it, it's policy.
We don't have enough time.
The specifications call for it.
Men's lives are at stake, cost doesn't matter.
We tried that twenty years ago.

A good value engineer in presenting a new idea recognizes these roadblocks, not in criticism of the designer or specification writer but in acknowledgment of his problems. He aims to provide the important tool of cost information to the engineers with the necessary facts to permit a decision by them. He further recognizes that the responsibility for the technical decision rests with the line engineer and the credit likewise should go to him.

### Organization for Value Engineering

In 1954 a Bureau of Ships committee was established to search throughout industry for a means which might be used to combat the rising cost of ships. Techniques, such as the foregoing, were included in General Electric's program of "Value Analysis" and appeared to be the most adaptable to the Bureau of Ships program of ship design, repair and construction. As a management tool, the program appeared to have the three elements which are necessary for success:

(*a*) Must fulfill a real need.

(*b*) Must take a sound and logical approach to the problem.

(*c*) Must produce measurable results.

As a result, the Value Engineering Office was established as a staff office to the Chief of the Bureau.

Initial efforts of this office were devoted to the study of specific items being procured by the Bureau in order to demonstrate the success or failure of the approach and to obtain those specific examples of "hardware" which are essential to an effective demonstration of the

program. One of the first projects attempted resulted in a savings of $3 million dollars in the procurement of 1000 LCVP's (Landing Craft Vehicle Personnel) and, at the same time, furnished the Bureau with evidence of the effectiveness of the approach. Furthermore, the difficulty of obtaining reliable cost data from the Bureau level became obvious. It was realized that a few engineers could not possibly begin even to scratch the surface on savings in an organization that currently spends over 2 billion dollars a year on shipbuilding. Therefore, it was decided to multiply their efforts and obtain field cost experience by establishing value-engineering units in each of the eleven naval shipyards. Since that time, emphasis in the Bureau Value Engineering Office has shifted from specific project work to training, administration, and education, even though some specific project work is still undertaken.

Currently the office is composed of a Captain, USN as Director of Value Engineering, eight engineers and two secretaries. Technical specialties include experience in electrical engineering, marine engineering, mechanical engineering, naval architecture, and electronics. Some of the work performed by this team includes:

*Selection and Placement*

Establishing precepts for selection of value engineering personnel by general descriptions of the type and caliber required including background variations desired in a functioning unit. These would emphasize competency in engineering, production, planning, estimating and in working with people. The placement in the organization of a value-engineering unit, preferably at a high staff level, is necessary to permit working effectively across division levels. The contractor is encouraged to so place his unit particularly in those cases where the value-engineering study is made concurrent to a production run. In a staff position, the unit will in no way infringe upon the preogatives of the line engineers.

*Training*

Following General Electric Company's lead, the Seminar approach was used. By bringing technically competent, carefully selected individuals into a new environment, taking them away from their routine work, surroundings, and so on, it was possible through intense effort to change their outlook in a matter of a few weeks, and send them home well trained and enthusiastic and to carry out the work of this new program.

Through the use of these seminars, the Bureau has trained all of its shipyard value engineers, now numbering approximately 45 Bureau personnel, some private contractor personnel, and personnel from other Government agencies, such as Maritime Administration, Coast Guard, Air Force, and so on.

*Introductory Presentations*

These presentations have been made to many shipbuilders and equipment manufacturers interested in value-engineering contracts with the Bureau of Ships as well as many Department of Defense officials and other Government agencies interested in the program.

*Monitoring*

The office takes a paternal interest in all project cards sent to the Bureau, particularly those requiring technical approval by the Bureau. Where ideas submitted through the medium of those project cards are of sufficient size dollar-wise, or require co-ordination with several technical groups or more information, this office attempts to see that the idea is given proper consideration and attention. Each of the engineers is assigned specific responsibility to monitor a group of shipyards or private concerns. His job in this area is to ensure that enthusiasm in the field units (private or commercial) is not dampened by unnecessary delays in receiving Bureau action (either yes or no) and that all pertinent facts are considered in the review of the project.

*Contracting*

The use of value-engineering incentive contracts, both in the shipbuilding and in the private equipment area is still in its infancy. There is much to be learned and many pitfalls or roadblocks to be overcome. The office is continually searching for ways to improve this operation so that the contractor and the Bureau can operate as an efficient team.

**Naval Shipyard Units**

As previoulsy stated, value-engineering units have been established in the eleven naval shipyards. These units, with from three to six engineers in each unit, are with few exceptions, administratively assigned to the Design Division but with considerable freedom to contact all shipyard departments. Their job or function is to "save money."

Ideas for a value-engineering study come from many sources; the unit itself, Production Depart-

ment, Design, Planning, Supply, Beneficial Suggestions, and so on. As might be expected, by far the largest percentage of ideas (about 50 per cent) come from the Production Department, where seemingly small details in design can increase cost greatly.

The value-engineering unit prepares a Value Engineering Item and Project Log and from this listing picks those items of hardware which appear to have the greatest potential savings to the shipyard and the greatest application to the repetitive business of shipbuilding and repair; i.e., affect specifications.

From this point on, the true value of a separate value-engineering unit using a systematic organized approach becomes most apparent. Often, progressive ideas with cost-saving features are lost merely because the originators do not have time to ferret out all the facts. Routine "fire drills" prevent working up answers to the possible conflicts with established procedures, standard plans, specifications, or Bureau of Ships directives. The value engineer has the time to overcome these roadblocks. He has the freedom to contact all possible sources of information to secure all the facts bearing on the problem. He solicits the co-operation of private industry to obtain new ideas, costs, and research data on new materials, methods, and machines.

When all possible information has been obtained, and the techniques of value engineering have been applied, the value-engineering unit will arrive at the most feasible and economical solution(s). This information is documented and reported in a brief, simple report form, Fig. 8, supplemented as necessary, by plans and additional data. Essentially, the report form consists of the following:

1 A before and after sketch.

2 The name of the person responsible for the original idea.

3 A brief and concise statement of the present way of doing the job.

4 A proposal for doing the job the new and less costly way.

5 A cost comparison of the present and proposed methods showing savings possible upon adoption. (In this connection, shipyards prepare estimates based on an individual ship basis and/or on expected application to actual work in that shipyard for a one-year application.)

The project reports are nothing more than a recommendation (value engineers have no authority to change plans nor authorize accomplishment of work on ships and components). The next step, therefore, is to obtain approval of the cognizant line authority. This approval may be:

1 Local. Wherever possible, local approval is given when permitted by the latitude of specifications, directives, or where plant or production processes are involved. Such local approval permits earlier adoption of the idea.

2 Bureau. When Bureau approval is required, the project card becomes a part of a formal letter request from the Shipyard Engineering Department to the appropriate type or technical desk in the Bureau of Ships. Again approval authority is a line function.

The project cards serve a further useful purpose in communications between other value-engineering units. When a project becomes "active," it is circulated to the other 10 Naval Shipyards, the Bureau of Ships, Maritime Administration, and the Supervisors of Shipbuilding. Often the distribution of these reports results in the receipt of notes from other activities offering information, suggestions or criticism which are helpful in working up the idea. Upon approval of a project, a revised card is sent to all the activities appraising them of the fact and quoting the approving authority. This method of communication provides a cross fertilization of ideas as well as for a rapid implementation of approved projects.

To date these units are proposing ideas which are resulting in savings in excess of $4.5 million dollars a year with an operating expense of about $500,000. A 9 to 1 ratio!

What is more important, many of these ideas are resulting in specification changes which will have a long-range effect on ship costs! Examples of some ideas submitted by these units are:

1 Welding stuffing tubes on one side only. Estimated annual savings—$5,000,000.

2 Elimination of flameproof bedding covers where fire-retardant mattresses are used. Savings—$88,000-2 carriers.

3 Filler materials for bilge keels—deleted requirements for filling bilge keels. Savings—$8,078.

4 Eliminate requirement for dynamic balancing of propeller shaft on CVA 59 Class. Savings—$145,176.

5 Substitute Thermoflex felt for fiber glass on steam valves and turbine-casing thermal blankets. Savings—$4,734 on CVA 62.

6 Change submarine access plates from portable bolted plate to welded type. Savings—$40,000 per year.

### The Contractor and Value Engineer

The successful application of Value Engineering in the Bureau of Ships and in the Naval

Shipyards has provided, and is continuing to provide a source of ideas for reducing costs without affecting function. However, about three times as much money is spent on naval ship construction in private shipyards as in naval shipyards. In addition, the Bureau of Ships makes direct procurements of large quantities of electronics and other equipments which are furnished to shipyards as Government furnished equipment to be used in construction, repair, conversion, and alteration. It was obvious, therefore, that to get maximum savings of the Bureau's funds, the aid of these industries should be enlisted.

Although there were certain basic differences between the specifications, methods of procurement, and construction (manufacture) of ships and electronics equipment (the Bureau's largest equipment purchase) there were many similarities in objectives and problems. The first of these was "Specifications." The military applies general specifications for shock, vibration, and premium materials across the board to safeguard equipment from every conceivable mishap. When applied to certain equipments, these specifications contributed nothing except cost, complexity, size and weight. For example, a filter used in the power supply of a military receiver cost $104. Its function was to eliminate radio interference in the power line from which the receiver operated over a frequency range of 50 to 400 cycles. Since these receivers were actually used in ships and stations having 60-cycle power sources the same function could have been provided by a by-pass capacitor at about $2.50. A cost of nearly $500,000 in a procurement of 5000 receivers!

In this same specification area, the military uses standard and type plans to specify repetitive items of "hardware." In spite of best intentions, these cannot always be reviewed with sufficient frequency to ensure that the item represents true value. For example, damper handles in ventilation terminals were being manufactured and stocked in accordance with a Bureau of Ships plan issued in 1918.

A shipyard value-engineering study resulted in the use of a suitable, readily available commercial handle at a cost of 45¢ in lieu of $3.00 each! In neither of these cases should criticism be leveled at the engineer or specification writer who faced with pressure of time and with existing written standards or requirements must produce a workable product. However, in both of them a feedback of production costs of requirements could produce their change!

The second objective is to obtain the "second look." Time is one of our worst enemies when trying to produce a contract specification skipping straight from design to full production as so often is required in shipbuilding or to go from a development contract, to a preproduction model, to full production of equipments! When we know that something *works*, there is insufficient time to challenge complexity, tolerances, maintenance, and repair characteristics, manufacturing procedures, cost of components and assembly! Further there is fear that changing a proven item will result in something that *might* not work! However, if time is taken and feedback information properly worked into the design, we usually can simplify, improve reliability, and reduce cost.

The third problem and probably the most important to the contractor is the question of incentive. Contractors who have proposed a relaxation in military specifications have sometimes been penalized by having the resulting savings subtracted from the contract price. In many cases, the contractor's profit, which is based on a percentage of total contract costs, is also lost to him. Contractors are well aware of this possible penalty and since business is based on profit motive, will not normally expend energy towards suggestions resulting in decreased costs.

With these three basic ideas in mind, the Bureau of Ships decided to apply Value Engineering in procurement contracts and concentrated first in the shipbuilding area where the largest proportion of money was spent and where production is paced closely with design development often without benefit of prototypes and where time was not so critical in its effect on production. Under the contract clause developed (typical clause contained in Appendix) the shipbuilder is required to furnish at his expense, two value-engineering specialists for full-time work on contract plans and specifications. Reports and project cards similar to these from the naval shipyards are forwarded to the Bureau for acceptance and rejection and, in the case of the former, the issuance of a reduced cost change order. The Bureau trains these specialists in the practice of Value Engineering. As incentive, the shipbuilder receives 45 per cent of the savings engendered by his Value Engineering project and the Bureau keeps 55 per cent.

To date, a few selected contracts have been let with Newport News Shipbuilding and Dry Dock, Electric Boat Division of General Dynamics, Bath Iron Works, Inc., Avondale Marine Ways, Inc., Harbor Boat Building and Ingalls Shipbuilding Corporation. The Maritime Administration has awarded Value Engineering contracts to additional shipbuilders. Representatives from

some of these concerns will present their experience with the Value Engineering Program. However, from the Bureau of Ships' viewpoint, there is conclusive evidence of the success of this program in the acceleration of reduced cost change orders affecting current ship construction, the modification of specifications for future ships (long-range cost savings), and the effect on working plan nonspecification area where contractors have found it to their advantage (100 per cent savings to contractor) to use Value Engineering as a tool for increased and orderly effort in cost reduction. This latter effort in many cases results in a simpler ship, easier to construct, operate and maintain and less costly in all aspects. The result should be lower bid prices on a competitive basis.

Experience in the shipbuilding area also has presented problems which must be studied to determine what corrective action or improvements are required. Some of these problems include:

(*a*) Increase in change order workload imposed on Bureau of Ships personnel presently heavily taxed under restrictive personnel ceilings.

(*b*) Necessity for decreasing time required to take action on project approval or disapproval in order to take advantage of proposals.

(*c*) Review of incentive application to ensure a real incentive exists for multiple as well as single contract holders.

Recognition of the different method of procurement for electronics equipment (usually involving a developmental model) and the shorter time cycle for quantity production of a single equipment led to a different method of contracting but with similar objectives in mind. Specification MIL-V-19858 (Specification for Value Engineering of Naval Electronic Equipment) requires the contractor to conduct a value-engineering study of all the elements of design, procurement, manufacturing, installation and maintenance of an equipment, including the specifications to achieve only necessary functions, maintainability and reliability at minimum cost. The object is to reduce *total cost*, which is the combined cost of procuring, manufacturing, installing and maintaining an equipment.

The contractor is required to perform the value-engineering study before going into production, even before he procures any parts, sets up his tooling or his assembly lines. He is to develop value-engineering proposals and submit them to the Bureau for evaluation. The approved proposals are then applied in the form of specification changes.

The amount of time allowed for the study depends upon the complexity of the equipment, and varies between one to four months. Experience indicates that a large percentage of the excessive costs can be taken out in a relatively short period of time if a concentrated study is made on a full-time basis by highly competent and experienced individuals.

In applying the value-engineering specification to a production contract, an incentive to do a good job is offered the contractor in the form of a share of the resulting savings. This share will vary from 10 to 40 per cent of the savings, depending on the quantities of equipment procured and the total dollar cost of the contract.

In the first application of the value-engineering specification to a contract involving the production of some entertainment receivers, approximately 20 per cent cost reduction was achieved. What is more important, a long-standing "requirement" was successfully challenged which will significantly affect future receivers!

In both shipbuilding and equipment areas, the application of Value Engineering by the private contractors to our specifications is still in the early phases. The initial efforts were perforce more unilateral than desired but served to get the operation started. However, with some experience now behind us, it is time to stop, take another look and determine together the best way to improve on the operation of Value Engineering. We consider this application should be in every respect a two-way street and it is only through the effective feedback of information of this nature in an easy to digest form that we can reasonably be expected to keep our specifications current, free of excess requirements, and reduce both complexity and costs. Good specifications are a team job and must be kept on that basis—our inducements in incentives we intend to be realistic. They are paced by change-order adjudication which keeps them in step with current contract developments and should represent an attractive profit increase for the extra work of developing new ideas and pointing out specification deficiencies.

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# APPENDIX

## Value Engineering Clause

The Contractor agrees to participate in the Value Engineering Program of the Bureau of Ships and to perform Value Engineering services in accordance with the principles and procedures set forth below and in the Specifications for Value Engineering:

*a*) The Contractor agrees to maintain throughout the period of performance of work under this contract, up to the date of preliminary acceptance of the last vessel, a staff of not less than two engineers in the role of Value Engineering specialists, devoting full time and effort to Value Engineering studies.

*b*) The employment of the Value Engineering staff shall be at the expense of the Contractor and no charge shall be made to the Government for these services, whether in connection with change orders or otherwise, provided that the Contractor shall be reimbursed for the costs of travel and subsistence (or per diem in lieu of subsistence) resulting from compliance with the Government's direction as regards the training of the Value Engineering specialists.

*c*) The Government shall make every reasonable effort to expedite the analysis of each study submitted by the Contractor hereunder. The Government shall not, however, be liable in any way for any delay in its action on or for any failure to act on, and study. The submission of a study by the Contractor shall have no effect on the obligation of either party under the Contract, and in particular, the obligation of the Contractor to perform the contract in accordance with the plans and specifications as written and in accordance with the contract delivery schedule shall not be affected by the operation of this clause, unless and until a change order incorporating the results of any study is formally issued by the Government under this contract.

*d*) Following review and analysis, the Chief of the Bureau of Ships may in his sole discretion apply any study, either in whole or in part, to any or all of the vessels under this contract by issuing a change order in accordance with the "Changes" clause hereof. The change order shall identify the Value Engineering study on which it is based. The decision of the Chief of the Bureau of Ships in these matters shall be final and shall not be subject to the Disputes Clause of the contract.

*e*) In the event that the Chief of the Bureau of Ships determines to apply the Value Engineering suggestion in whole or in part to any or all of the vessels under this contract, and a change order results, such change order shall be negotiated in the usual manner between the Contractor and the supervisor. The mutual agreement shall show, however, that since the change order resulted from a study submitted by the Contractor in accordance with this article, the contract price is being reduced by only 55 per cent of the amount mutually agreed upon as the total decreased cost. The Government may apply the Value Engineering to other contracts with the Contractor or to contracts with other shipbuilders, but no payment shall be made in any form to the Contractor on account of such applications.

*f*) All studies, including all supporting data, submitted pursuant to this clause shall become the property of the Government whether or not change orders under this contract result therefrom, and the Government shall have the full and unrestricted use thereof without payment of compensation to the Contractor except as provided in paragraph (*e*).

## Specifications for Value Engineering Program

### *Purpose*

The purpose of the value engineering program is to promote the development and application of design and engineering studies which will result in lowering the cost of construction to the Government without impairing any of the essential characteristics of the vessel. The performance of these studies envisages an intensive and critical review of all elements of design, manufacturing, purchasing, inspection and operational requirements to determine that only necessary materials and functions are utilized and that these are supplied at the minimum cost consistent with the construction of a thoroughly sound ship and the preservation of essential operating and maintenance characteristics. This shall not result in the loss or impairment of any required function. In many instances it is expected that the studies will produce, at lower cost, a better functioning product, with an actual improvement in service life.

### *Value Engineering Staff*

(*a*) The contractor shall employ such value engineering specialists as are required by the contract for the period of time specified in the contract. These value engineers shall be supported by such technical industrial and clerical per-

sonnel of the contractor's organization as are necessary to enable these value engineers to effectively perform the purpose of the value engineering program. The value engineers shall receive such training as the Bureau of Ships deems necessary for the effective performance of this program and shall participate in other activities considered by the Bureau to be useful for their training.

(*b*) The contractor may, at its own expense, furnish additional value engineering specialists in support of this program.

(*c*) The value engineers shall maintain such contact with other organizations as may be necessary to become familiar with new products and processes.

(*d*) Unless otherwise specified in the contract, the contractor shall maintain close liaison with the value engineering representatives of the office of the cognizant Supervisor of Shipbuilding.

### *Scope of Investigations*

The investigations to be performed by the value engineering specialists shall be limited to those areas where cost savings cannot be effected unless the contract plans or specifications are modified by the Government. Subject to this limitation, the scope of investigation includes every element of equipment, materials, production processes, purchasing, inspection, installation and use. Commercial sources, products, processes and requirements for similar use are to be analyzed and compared to Navy practice, in order to determine whether Navy departures from commercial practice where increased cost is involved are justifiable and whether the substitution of commercial materials or procedures would result in lower cost without reduction of quality or impairment of essential functioning and military serviceability.

### *Presentation of Completed Studies*

(*a*) Each value engineering investigation determined by the shipbuilder to be desirable and appropriate for submission shall be presented on Value Engineering Report Form NAVSHIPS 4629 (9-55). This completed study must be of such nature and presented in such form that it may readily, if accepted by the Bureau, be formulated as a decrease cost change order under this contract and other contracts for similar vessels, or as a revision in the specifications for future contracts. Plans, specifications and any other supporting data necessary to permit analysis by the Bureau with a minimum expenditure for design and engineering services shall accompany the form. It is not intended that formal plans be prepared specifically for these studies but that speed in preparation and presentation of the studies be promoted by effective use of mark-ups on existing blueprints and sketches wherever feasible. The completed study should compare the proposal in all respects with the present practice in order to demonstrate in full all advantages and disadvantages and to establish the anticipated cost differential.

(*b*) Studies shall avoid recommendations of products or processes restrictive to one manufacturer unless this is the only means by which the cost reduction can be effectively achieved.

(*c*) All studies and related data are to be submitted via the cognizant Supervisor of Shipbuilding. One copy of Form 4629 shall be submitted directly to the Bureau and one reproducible copy of such form to the Supervisor of Shipbuilding. The Bureau will obtain the comments of the Supervisor, design activity and other interested activities. Additional information, if required for adequate analysis of the completed study shall be submitted by the contractor upon request of the Government.

### *Reports*

The contractor shall submit a quarterly report and a final report in triplicate via the Supervisor of Shipbuilding listing all investigations made during the period, the status of such investigations, and the reasons for the discontinuance of any such investigation, and summarizing actions taken. Ideas considered but not investigated shall also be listed together with the reasons why they were not investigated. The contractor shall submit such information and data as may have been compiled with respect to the investigations as may be requested by the Bureau of Ships.

ASTE
Tool Engineering
Conference Papers

Paper 24T42

# PRODUCT CHANGE IMPROVES MANUFACTURABILITY

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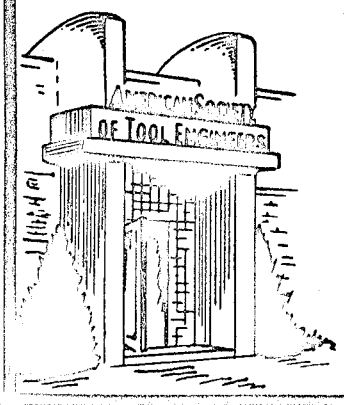


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10700 PURITAN AVE. DETROIT 38, MICH.

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# PRODUCT CHANGE IMPROVES MANUFACTURABILITY

*By*

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The concept of value, like the concept of sin, varies.

If a coat is produced for $15, but by ingenious manufacturing processes can be made for $10, is its value reduced? If a razor is purchased for $1 and the Purchasing Agent negotiates the purchase for 75¢, is its value lowered? If the hinge for the door on your car costs $2 and, by inspired creative design, one which accomplishes the same function is created for 50¢, is the value lowered? Perhaps, but probably not.

What is Value? - Value, surprisingly, is usually not determined by an intensive study but by an extensive one. Value is determined by comparison.

The value of the toaster used in making the morning's toast is not determined by its cost elements but rather by comparison with other means of making toast. The value may be the same if it can be made as conveniently and as well and as interestingly another way. Value is the lowest cost at which a function by any means, can be accomplished effectively and reliably.

Value Analysis: - Value analysis is a scientific and sensible evaluation of whatever costs money. It covers parts, assemblies, services, processes, and ideas. Under no circumstances does it ever involve any quality deterioration. It applies to all quantities from one to millions, to any product of any size. Value analysis pushes out far and fast into wide searches and broad comparisons.

We are accustomed to analyzing performance, analyzing weight, analyzing quality. Today, we will analyze value.

To analyze weight -- we study what makes up weight.

To analyze value -- we study what makes up value.

How is Value analyzed? Here is how it goes. Let's examine the cover of this control device (Fig. 1) with these simple questions.

1. What is it?
2. What does it cost per year?
3. What does it do?
4. What else would do the job.
5. What would that cost?

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Presented at the Twenty-Fourth Annual Meeting of the American Society of Tool Engineers, at Chicago, Illinois, March 19 - 23, 1956. All papers presented at such meetings are the property of the Society, from whom permission must be secured in writing to reprint or publish this paper.

The publication of this paper does not constitute approval by the American Society of Tool Engineers of the findings or the conclusions contained therein. It is published only for the exchange and stimulation of ideas.

1. It is a small molded plastic part. 2. It costs $40,000 a year for a million of them. 3. Although the control device itself is in a semi-enclosed compartment it further keeps accidental comtaminates out of the control. 4. Extensive study shows that a flat piece of laminated textolite would probably provide the same function. 5. $15,000 for a year's supply.

And so it goes:

First, gathering facts
Second, recognizing costs
Third, facing up to functions
Fourth, searching effectively for alternates
Lastly, comparing

There's more to analyzing value than meets the eye. It sounds simple - but it isn't - because human attitudes are involved. Decisions are based, not upon facts, but upon the partial information - fact and falsity - which people have, and the attitude they have toward this information.

## POPULAR CONCEPTIONS ARE USUALLY WRONG

Popular conceptions never necessarily fit specific cases; often they are no longe. even true as generalities.

"Plastics are brittle": - so is cast iron brittle--but steel made from iron is not brittle. So, plastics made for the job are not brittle. Polyethylene toys are not brittle. We have this radio cabinet (Fig. 2) that is so rubbery that nails, as you see, are driven into it without fracture.

"Plastics are weak": - So is rubber weak, but in tires you will get 30,000 miles of wear, and from the wide spectrum of plastics are materials such as this glass-reinforced polyester which is substantially non-breakable.

"If it is a thin enclosure, sheet steel is most economical": - still this die cast part 1/32-in. thick provides the same performance at lower cost in automobiles.

"Tool costs are too high for our quantities": - yet plastic dies are now made for a fraction of former die costs and low-cost tooling specialists do startling things. This welding segment (Fig. 3) was cut out individually in quantities of a few thousand a year because "dies would cost too much." Still, a low-quantity stamping company, when actually given an opportunity to bid on it, quoted $75 for dies and the cost each drops from $1.41 to 39¢.

"If it is solid material, it is better": - still, instead of this solid machined nut, the use of an available "Pal Nut" provides better function, stands more severe vibration, and the cost, instead of 8¢ is 0.8¢.

"An upsetter can't gather enough material to make a spacer this large": - still this one (Fig. 4) is accomplished by an upsetter using a

double collar and the cost goes down from $1.85 to 50¢, while this next example (Fig. 5) is accomplished by two pieces, a simple upset roll threaded part and a spacer, and the cost drops from 5¢ to 1¢, the same function for 1/10 to 1/5 of the cost.

"They can't roll an Acme thread": - still it happened that in the same city where this statement was made, a company has equipment that is rolling Acme threads.

"We are already using the best processes": - then suddenly we find that, instead of a drop forged ball stud (Fig. 6), a hot upset stud accomplishes the identical purpose at 25% reduction.

"We are doing it about right": - still we find a square washer costing 32¢ which can as well be had for 8¢ from a washer supplier. The screw machine control shaft (Fig. 7) costing 7-1/2¢ when as a miniature zinc die casting, a better part, costing 1-1/2¢. The machine brass nut (Fig. 8) which receives it, costing 3¢ when the molded nylon nut costing 1¢ does a better job. A remote tuner coil adjustment costing 3¢ when identical performance can be provided by a header and roll threader with an automatically formed loop on the end at 1¢.

"We can't do any of our jobs for half the cost": - still after decades of refrigeration and millions of refrigerators, a condenser (Fig. 9) was provided for refrigerator-type equipment which does a more efficient job than the former tube and plate and costs approximately half.

"We are up to date on what is new": - still aluminum is not used because of the "problems of copper to aluminum joints" when a specialty product can be purchased which already contains the properly made copper-aluminum tubing joint. Furthermore, stainless steel is being purchased for applications which can be as well or better performed by chrome diffusing, and designs which should benefit from the "dirty plate" process of roll bonding, do not use it because it is unknown to the designers and the methods men.

## ATTITUDES MUST BE CHANGED

The first job, then, is to improve attitudes of the embryo analyst. This is accomplished slowly by use of overwhelming new information coupled with actual experience that differs from the past. As attitude improvement starts, then the same technical skills which have traditionally been used for securing higher efficiencies and making new products are devoted to getting the "same performance for very much lower cost."

## MORE INFORMATION PLUS BETTER ATTITUDES

More information provided at the point of decision plus the attitude to use this information promptly in decision-making, brings vastly improved value.

# SOME OF THE BUILDING BLOCKS OF BETTER VALUE

Better Purchasing: - In one operation, only one product used a capacitor. The purchasing agent said, "I know we have the best supplier and the best deal for this capacitor. I have done it myself." By calling the purchasing agent at an operation using hundreds of different capacitors and stating the problem to him, the telephone call paid off with the same capacitor but changed terminals with an $8500 per year saving.

Better Materials: - A new item such as filament tape brought packaging possibilities--eliminating $40 from the packaging cost of every hundred washing machines. Plastic coated steels can be drawn and require no later finishing, providing very attractive salable items and necessitating no spray boot equipment.

Better Use of Specialty Products: - Standard cans and boxes can be bought from a catalog instead of making enclosures.

Although we are frequently told that there are no standard springs (each must be designed), there are companies with catalogs of standard springs which can be bought for pennies or dimes even in low quantities.

Laminated shims which can be peeled like onions so that, instead of the costly machining, the right thickness is secured in instants sometimes saving as much as $10 a machine.

Different forms of raw materials such as round discs of aluminum used normally as blanks in impact extrusion presses useful for structural parts--in one case the disc was flattened and drilled at a total cost of 13¢ in lieu of a former cost of $1.27 for the part made from sheet.

Rolled spacers for use where the side is relatively unimportant and the end spacing is important. In one case for a cost of 3¢ instead of 29¢ each accomplished the same function.

Terminals, functional and structural parts of wide variety can be fabricated by specialists from tubing and perform large function for moderate cost.

Better Use of Available Facilities: - Specialists with special purpose equipment for fabricating copper tubing provide small tubular parts for a fraction of their cost from general purpose machines; for example, one part (Fig. 10) which was costing, with material, labor, and overhead, 14¢, could be had in its finished form, delivered to the plant, for 1¢.

A small bracket (Fig. 11) with tapped holes costing $13/M could be had from a specialist who makes small stampings with tapped holes automatically in a labor-free process at a delivered cost of $3/M.

Functional parts made from sheet materials and strip materials can be made instead from wire and wire formed parts through the skills of specialty suppliers whose engineers are very ingenious in using this engineering material.

Better Processes: - Instead of machining items such as this pulley (Fig. 12) at a cost of 60¢ from steel bar, it is die cast for 13¢.

Instead of die casting this cover (Fig. 13) for $1.02, it is made as a steel stamping for 60¢.

Instead of machining this aluminum spacer from sheet for $1.85, it is cast for 50¢.

Instead of a second operation stamping holes to fasten this perforated drier part (Fig. 14) to the support, perforate it continuously using the same holes at a saving of 25%.

Instead of buying bolts and washers, allow the manufacturer to ship the untrimmed bolt heads which have the flash constituting a washer at no added cost.

Although it sounds most economical to make small terminals from flat copper on a multi-slide machine, the facts show that terminals can often be provided more economically and of equal strength with less copper from copper tubing by equipment specializing in that field.

Although it was felt that the ultimate was secured in nesting silicon steel on a ballast transformer, even though 42% was lost at nesting, an intense study brought new thinking which reduced the loss to 25%, making phenomenal savings in the cost of material.

Instead of buying steel rod in two sizes from which a shaft and hub (Fig. 15) were machined and later assembled with an interference fit, make the rod part only, use it as an insert, and cast on the hub, arriving at an equivalent product at half the total cost.

Newer Processes: - Instead of buying a hinge from a hardware manufacturer, have it made by a continuous roll form method saving 25% of its cost.

Instead of riveting or eyeletting to fasten relatively thin metals together, use metal stitching without pre-punched holes to literally sew the material together.

Instead of the traditional spot welding, use the new cold welding equipment and process to fasten the parts with numerous advantages.

Instead of having bulky equipment for heating parts, use an Ohms machine which conductively heats steel exactly where it is needed to the right temperature in a period of seconds.

Instead of buying rubber gaskets (Fig. 16), squirt in a self-vulcanizing material which sets up in minutes such as one application which was costing us 11¢ and by this method was reduced to 1¢.

Better Human Relations: - On the whole, the people with whom we deal are average people the same as we are, doing some things right and some wrong, constantly making mistakes and constantly concerned about protecting themselves from the consequences of what people will think if they know about these mistakes. We can build a framework of human relations in which each man knows that we all

know that he is making mistakes and we are making mistakes, so that time and money do not, to such an extent, have to be wasted.

Tests for Value: - Ten Tests for Value, which serve to point the way, have been evolved and have assisted in eliminating large amounts of unnecessary cost. Here they are:

1. Does its use contribute value?
2. Is its cost proportionate to its usefulness?
3. Does it need all of its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower cost method?
6. Can a standard product be found which will be usable?
7. Is it made on proper tooling--considering quantities used?
8. Do material, reasonable labor, overhead and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

## CONCLUSION

To conclude: - We recall that even a thousand years ago there was no general shortage of the goods to make up a high standard of living, as then known to them, but high cost denied these goods to most.

For 2000 years, the American Indians roamed the prairies of this--one of the richest lands in the world in mineral wealth and soil fertility, naked savages because they didn't have the tools and they didn't know how to develop them.

There will be no prolonged shortage of goods in our country. The only sure method of reducing the standard of living is by high costs.

There is no object in learning to design and build automatic washing machines, dishwashers, or finer automobiles, if costs become so high that few can buy.

No one more intimately controls present and future costs than the tool engineers.

You have both the tools and the knowledge--we're counting on you to help control a bright future for us all.

*Fig. 3.--Illustration not available.

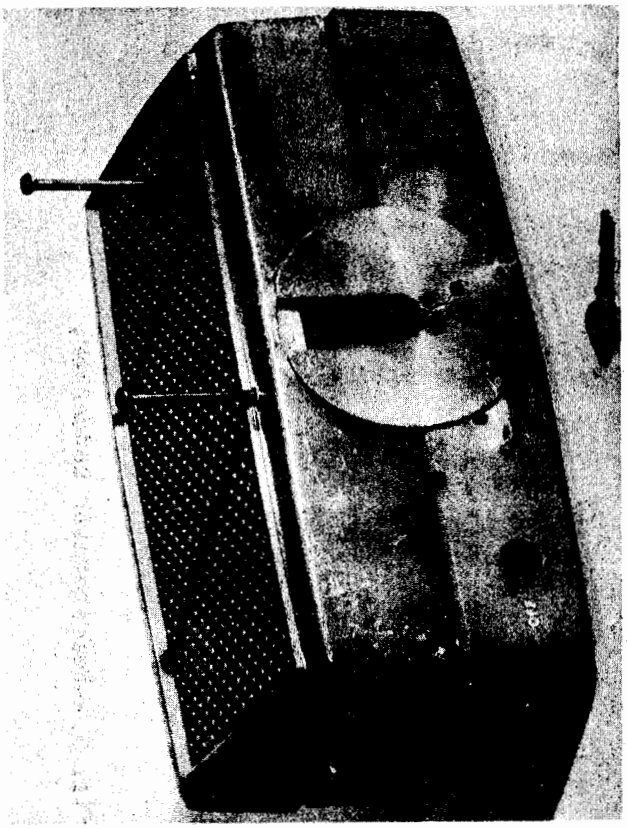


Fig. 1.--Control device cover.

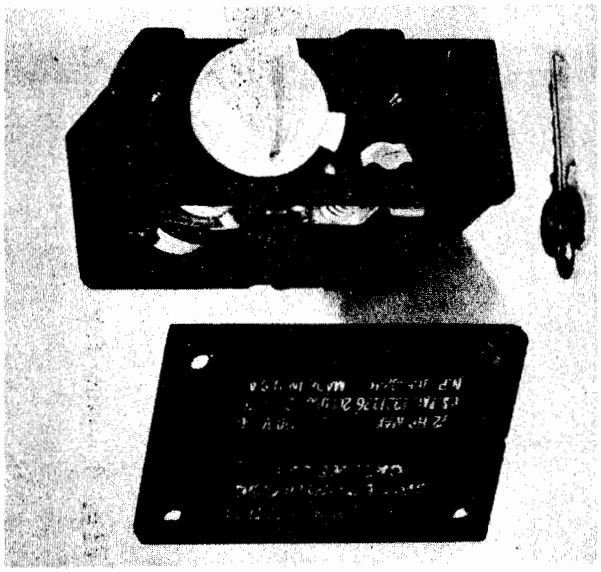


Fig. 4.--Spacer

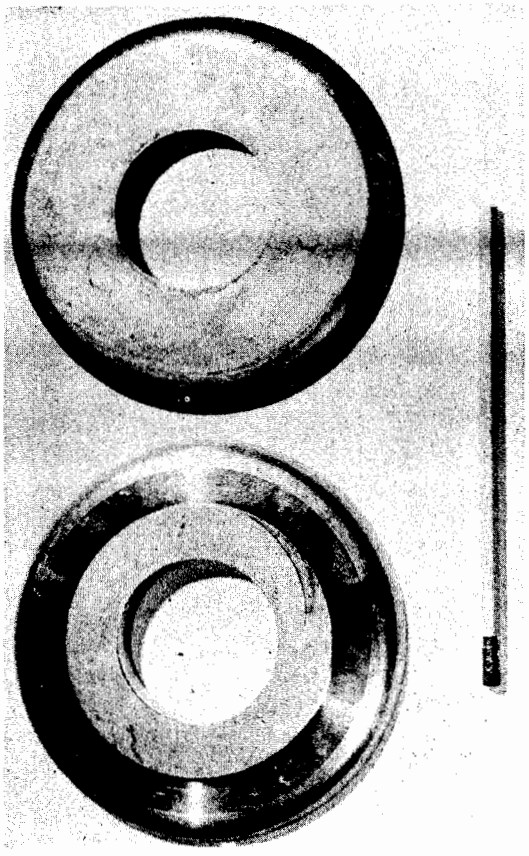


Fig. 2.--Plastic radio cabinet.

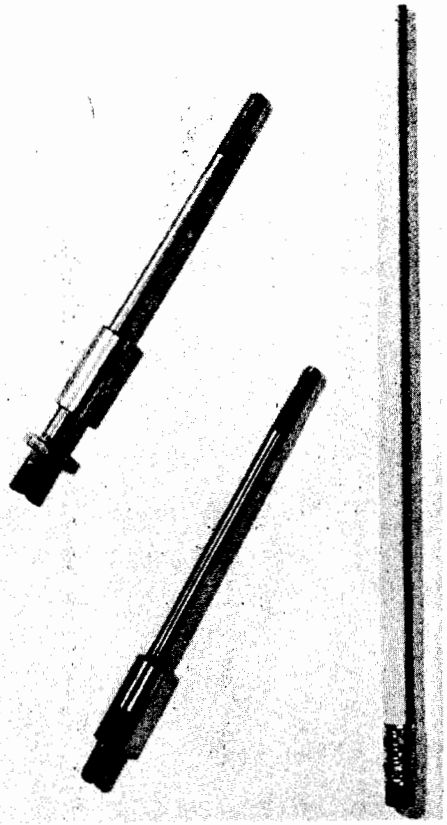


Fig. 5.--Upset roll-threaded part.

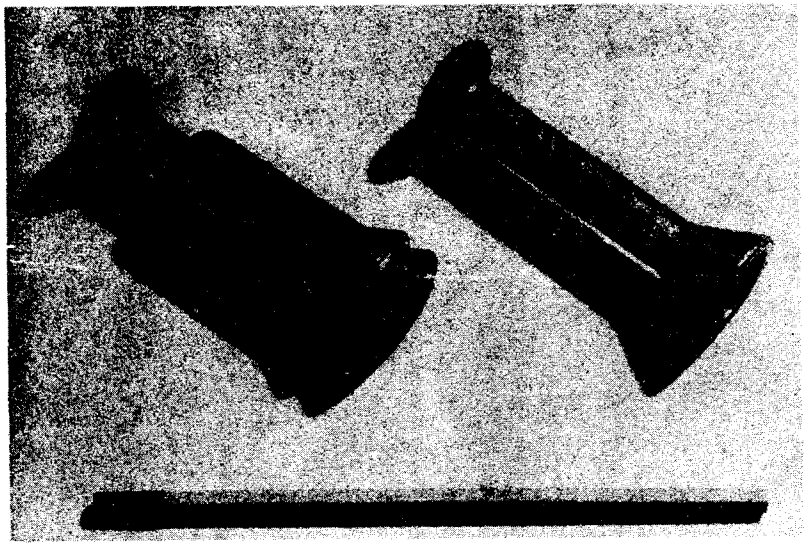


Fig. 6.--Ball stud.

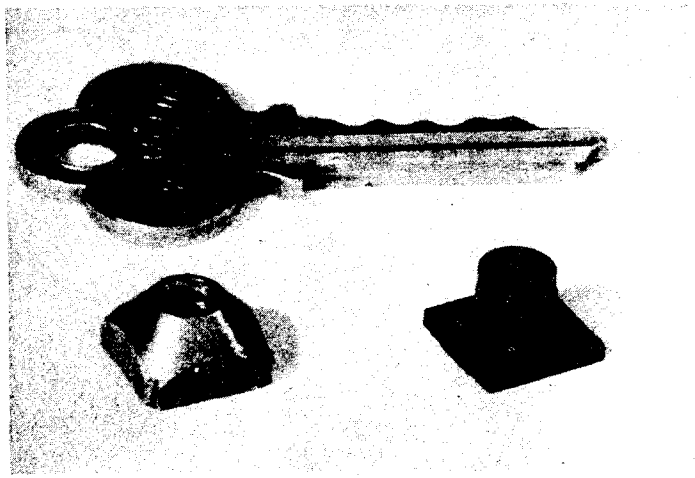


Fig. 8.--Nut for shaft of Fig. 7.

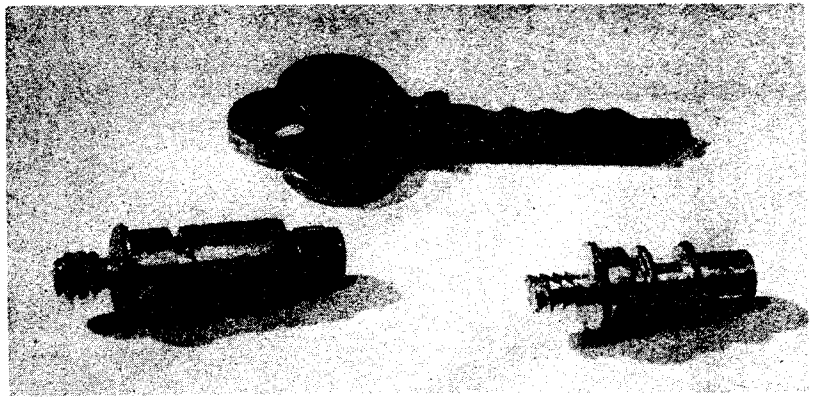


Fig. 7.--Screw machine control shaft.

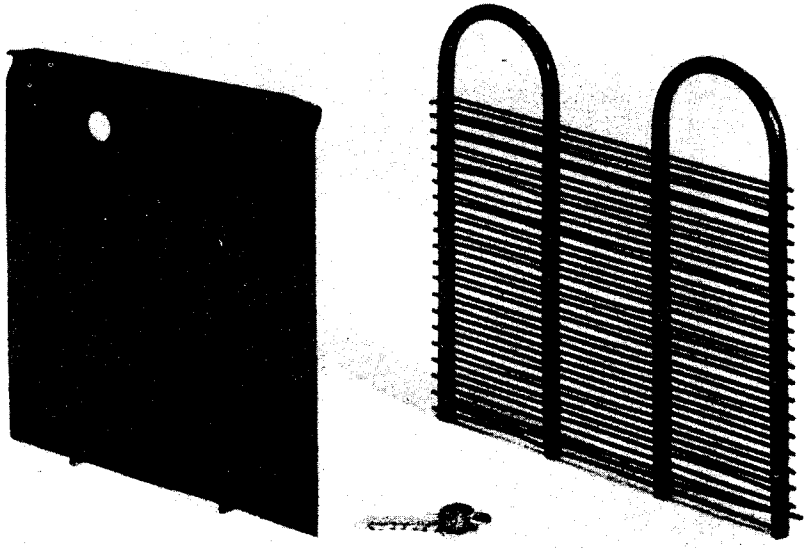


Fig. 9.--Refrigerator condenser.

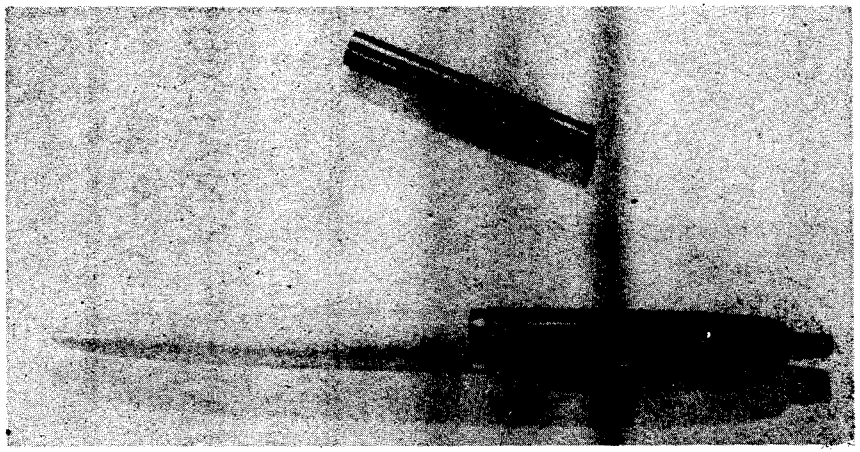


Fig. 10.--Small tubular part of copper.

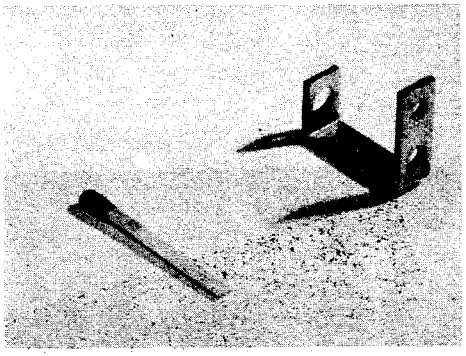


Fig. 11.--Small bracket.

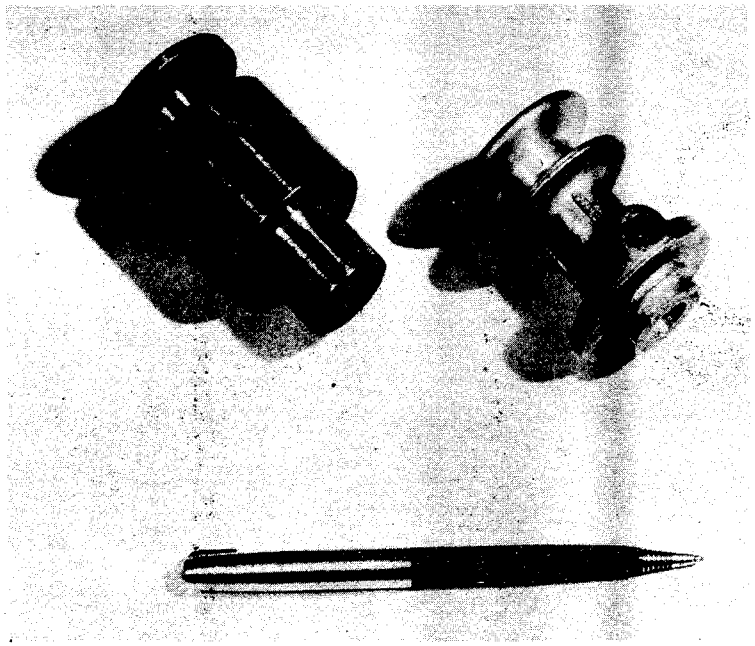


Fig. 12.--Pulley

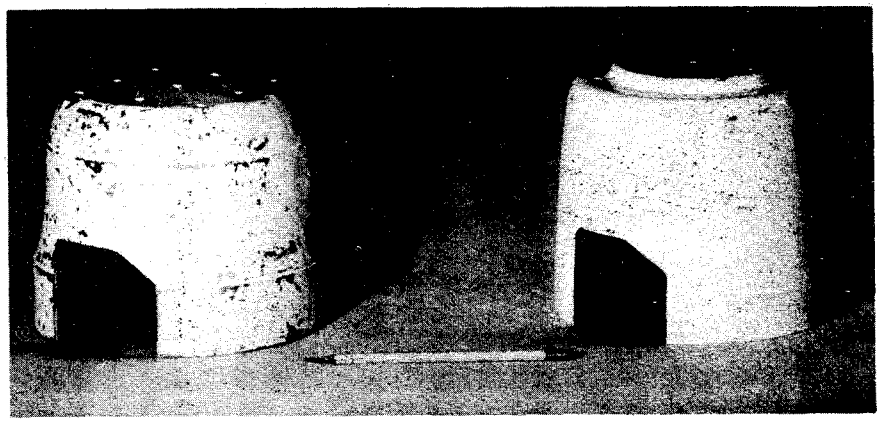


Fig. 13.--Cover.

Fig. 14.--Drier part.

Fig. 16.--Gasket.

*Fig. 15.--Illustration not available.

SMALL AIRCRAFT ENGINE DEPT.
VALUE ANALYSIS
EXT. 4555

# Payroll Engineering Versus Value Analysis

**by Louis E. Garono**

*Chief Engineer*
*U.S. Army Chemical Corps Engineering Command*

MUCH has been said about the new art or profession of value engineering, but as I see it, there is very little new in this method of analyzing problem. This is the analytical approach to design work that every decent engineer should use seven days a week.

Most value engineers believe their department should be directly under the Executive Vice-President and that they should be able to move through the organization looking over everyone's shoulders and generally disrupting organization channels.

All examples of savings and improvements used in literature on this subject indicate that the value engineers studied the finished product and then made improvements on this end product.

Is it not much more logical that these people be placed in the established engineering department where they could either review initial design or use their talents to design or eliminate items prior to original purchase?

This would mean that the first million items would not be built with an expensive component and there would not be a full series of expensive spares in the spare parts system to support a component that should have been eliminated in the first place.

Rather than use value engineers as n overhead group with all the bad feelings generated by pushing ideas down through the organization as criticism of design, it appears much better that this organization operate as follows: These people who have special know-how in plastics, mechanical engineering or gadgeteering could be assembled as a part of the engineering department for design review. After a prototype has been made, this group reviews the prototype in detail, looking at each part for necessity, functionability, and the material out of which it is constructed. Then the group makes its recommenations to the people who normally would do final drawings or the final model of the particular item.

The item then goes to the drafting room where it is drawn up for final purchase and specifications and becomes established. After this model has been made, and the first group of items procured by an outside contractor, all ideas of the contractor or manufacturing group should be collected and assembled by the same study group. Changes are recorded on the drawings so they will be ready for the next order. In this way, any new ideas are collected and made available for immediate use. This puts the whole organization on the value analysis team and doesn't single out a bunch of smart boys.

Now this kind of operation is not going to show the enormous savings normally credited to value engineering, and no particular person or group is going to get credit for saving hundreds of thousands of dollars by simple mechanical changes. But this method does make for a smoother organization and will pick up *many more savings* than a flashy high level value analysis organization.

It may seem odd that enormous amounts of money can be saved as indicated in the recent article "Who Needs Value Engineering?" by RAdm Richard Mandelkorn, telling how $18 million was saved in shipbuilding in the first year.

This means only one thing: That the Navy's attitude has changed abruptly —that the Navy is taking a closer look at their need for brass valves, portholes, and many nice but not necessary items for equipping ships.

It means that in the past Navy was building ships for a life expectancy of 20 to 30 years, and that they have all of a sudden realized that ships are no longer good for that time.

Value engineering might be a useful gimmick to shock the engineers at the various shipyards into changing to a modern concept of using materials and design for normal life of the product. While the idea may be new to some industries, it certainly is not new to the chemical or appliance business, where items are normally engineered for a life of about five years. Corrosion data indicates how long heat exchangers will last, whether it is economical to use monel steel, and what it will cost the plant to shut down if a heat exchanger is lost or how much damage it will do if a shutdown occurs.

To get down to the facts, value engineering to date seems to be almost entirely in mechanical engineering. Also, in developing any item, there is never a perfect end item. Almost all applicances, automobiles and even houses know an evolution with new techniques, new materials and new methods of assembly that never stops.

This again is the economic problem of how perfect you want the item and how soon you need to put it on the market. This, as I understand it, is product engineering.

A good example of this is the typewriter—originally a mechanical monstrosity. As we look back on it, the original model was hard to operate, inaccurate, would not make a presentable letter and certainly was not streamlined. As engineering talent and dollars were invested, the typewriter became more presentable, a motor was added to make it easier to operate, adjustments allowed for more or less copies, special carbon paper let it operate more effectively.

Some people believe we have a satisfactory piece of equipment. But the real product engineers don't see it this way. They see the typewriter as a piece of equipment that will take dictation and give you a perfect letter, no misspelled words, punctuation in the right places, grammer unscrambled so that poor dictation will come out in perfect English, and ideas clearly defined to eliminate misunderstanding between dictator and reader. It will take a long time for this to happen, and there will be more product engineering and more dollars spent in the meantime. It may prove, as the value engineers say, that the typewriter as we know it is outmoded, and a new piece of equipment may take its place. This is still product engineering; but I believe value engineering will gain all the credit for eliminating the typewriter and dollars saved with perfect letters.

In conclusion, I believe value engineering is nothing but another name for effective product engineering. I believe it can be done more effectively at a lower level than that proposed by value engineers. I mean to say that the high grade talents of these value engineers should be assigned to equally important work as product engineers, to make the savings without all the ballyhoo.

The only place I can see engineering being applied to this new art of value engineering is in what is commonly known as payroll engineering: Have a new job set up, make it glamorous, indicate enormous savings, get a high rating from the personnel analyst, set up a new department. If this is the kind of engineering the value people are talking about, they have accomplished their purpose admirably.

# Value Analysis—Worthwhile or Waste?

by L. D. Miles
Manager—Value Service
General Electric Co.

MR. GARONO'S comments represent the views of many responsible people whose understanding and whose decisions decrease or increase the amount of armament which the Nation secures per billion dollars.

What we do not understand, we ignore or discredit.

Mr. Garono—and others he typifies—seeks truth. In speaking out beliefs which many others share, he has hastened the day of truth and understanding.

A few years ago, I shared Mr. Garono's belief. I felt that, if we could continually increase engineering competence and, at the same time, increase the reliability and adequacy of information at their finger tips by improving the guides, aids and tools which help them in their design and development work, most non-contributing costs would be prevented or eliminated. It took overwhelming proof to force a change in that viewpoint.

The first shock came when the newly grouped value engineering techniques were first used on a highly competitive consumer-type product. Engineers, oriented toward special ideas, special materials, and special processes for high quality at low cost, had designed and developed it. During three years of production, special engineering, manufacturing and purchasing penetration had cut 10% of cost.

Then two men were assigned to use special value techniques on it. Their work identified another 25% of the cost as contributing neither to performance, safety, life, nor to any attractiveness or features desired by the customer. This re-kindled design work, now aided by value consultation. Within a year, a product was provided at half the original cost, containing all original performance and features. It was simpler, more reliable, and, surprisingly contained no materials or technology unavailable five years earlier.

Still, this could be "chance." Anything can happen once.

Next, an industrial product used in yearly quantities of a few thousand and made on a job shop basis was selected. It had been in production several years. Design engineering, manufacturing engineering, and purchasing men, in a depth study, had just completed modifications, changes and re-designs which showed 40% of present costs to be non-contributing.

They eliminated this. The product was ready for factory tooling. Three men, trained in value engineering techniques, applied them to the product. It was startling to find that 60% of remaining cost was identified as unnecessary. The simpler, more reliable and lower-cost alternative means for accomplishing the functions also improved appearance and customer features.

But how could these techniques apply to military products, where unknowns in performance must be pierced with every new design; where the big question in development often is if the product will perform its function at all; and where, due to short time, we must go into production with the first apparently practical solution?

To find out, a military product was chosen which had been in manufacture a year. Problems, costs and other valuable information were known; still the design was current. The function evaluation techniques were used on each assembly, sub-assembly, and component. It was found that individual functions could usually be done for between one-half and one-tenth of the cost.

Functions costing—$127 for $32; $20 for $8; $4.50 for $.50, etc.

Conclusive proof. More studies followed—with similar results.

## *Embarrassing Audits*

Value techniques developed by private industry under pressures of competitive markets produced similar results in the military. But how could they be applied? When? And by whom?

These "Value Audits" were embarrassing to engineering and manufacturing people who had done their best "the first time." They wanted better value the first time, not embarrassment from better answers after the drawings and plans were complete.

From this need, the value specialist was born. He is a trained and experienced engineer. He is further trained in the special value analysis and value engineering techniques. He accumulates vast specialized knowledge vital to his profession. When invited at the proper time and to the proper extent into the research—development—design—manufacturing—cycle, he contributes tangible, usable knowledge which shortens engineering time, provides simpler, lower cost, more reliable solutions which in military work decrease product cost by one-half to two-thirds.

Since his use is change—his benefits must be learned. Perhaps a few parallels will help.

A few decades ago, tax reports for most companies were made out by the general accountant. He had many other duties. It was a part of accounting training to provide to all accountants enough information on tax practice so that any of them could appropriately prepare the tax statement. This was when the significance of taxes was like a wide variety of other expenses.

But, as taxes increased, the need for a higher degree of excellence in preparing tax statements increased. During the transition period, accounting managers felt they could increase the tax content in regular accounting courses and qualify any good accountant to prepare a good tax statement. Later, they saw that because of special techniques, knowledge and experience needed to hold down unnecessary taxes, this plan was costly, inefficient and ineffective. Tax consultants were specially trained and used.

Parellels exist in most fields of engineering. Designing jet engines, for instance, wouldn't be considered without design engineer using the services of specialists in high-temperature metals, bearings, special lubricants, etc.

In this country today, we are in the transition stage value-wise. The degree of value secured by previous systems is often being found unacceptable. New developments are forcing improved value in the military. Attaining value is now a specialized field. Competent value engineers and consultants are required to minimize needless costs, just as tax specialists are needed to minimize unnecessary taxes.

During this transition, vastly better value in military gear is changing from something *desirable* to something *absolutely vital.*

Innovation is necessary. Something better is required. In this type of situation, experience is often a deceitful guide. "Experience teaches us how to solve yesterday's problems." But—today—*we don't have yesterday's problems.*

Industry and government has learned how to use consultants—the tax consultant, the metallurgist, the computer specialist, etc. They will soon learn how to use the value consultant. The United States, then, will receive at least twice as much armament for its defense expenditures.

# *Two sides of the coin on what has been variously termed Payroll or Payoff Engineering— I lepends on your point of view . . .*

I AM EXTREMELY interested in Mr. Miles' objective approach and his basic theme, that of seeking truth. I hope, and I am sure, that this airing of opinions and positions will hasten the day of truth and understanding.

I sincerely believe that while both of our positions have elements of truth, the truth that I am seeking is fundamental rather than expedient.

When the recriminations have subsided, and I hope they have in this search, I think there will shake out several key facts which we all must recognize. In substantiation of the value engineer's position, I think one of these sets of facts which we must admit to concerns itself with the recognition that the result of any engineering design can always be improved.

Mr. Miles cites instances of major improvement which I do not doubt took place. My criticism of the value engineering field is not that these cost improvements should not be made but that they should be made during design or certainly no later than design check-out in a mass production environment.

Another truth that Mr. Miles and his associates recognize, as do I, is that the increasing complexity of our technology necessitates the use of specialists or consultants, as he calls them. Mr. Miles brings out that engineers must use high temperature specialists and all sorts of other highly specialized people in fields of design and that, as he goes on to develop, the value specialist is in this category.

I agree that value is a very important part of an engineering job, and I will also agree that in certain applications, value knowledge may be highly specialized and consultants required by the primary design or product engineer. I leave Mr. Miles at this point and, at the risk of being called unfair, feel that his argument for the use of specialist consultants substantiates my position.

The key is the word "consultant" which means to me that the primary design or product engineer is asking specialist advice as he does in the other technological fields and takes it or leaves it as he sees fit, the point being that the prime decision belongs to the man best able to make it the primary risk-taking, decision-making, design or product engineer.

This man is the only man equipped, or who should be equipped properly, with cost versus function in all of its

**by Louis E. Garono**
Chief Engineer
U.S. Army Chemical Corps
Engineering Command

ramifications. Decisions based on cost alone obviously would be inappropriate. Decisions on cost integrated into the other engineering aspects are engineering decisions and this integration can only be performed in a knowledgeable manner by a person or group with a complete understanding of the development and product engineering and the other stumbling blocks along the way.

If the man making value decisions is this well equipped, we have duplicate competence. If he is not this well equipped, it's proper for him to advise someone who is equipped but not to make primary decisions.

I think I have belabored the subject sufficiently to be in a position to summarize. I agree with Mr. Miles and the value engineers that value is a consideration. I will even go so far as to agree that, in some instances, value might be an appropriate consulting or advisory function.

As a fundamentalist, however, I refuse to be convinced, and have not seen any plausible argument which will convince me that value considerations after the fact by specialists without the rounded out background of the responsible design or product engineer are desirable or even proper. If this after-the-fact value consideration is rounded out by complete engineering knowledge, I can see nothing but duplication.

I can think of no answer to this problem other than that it lies in the lap of the manager, not the engineer.

If the manager sanctions an environment where after-the-fact inadequate or duplicative value decisions are being made, I think he is a bad manager. If he sanctions an environment which will permit what is called an engineering job before the fact without value considerations thus leaving room for these considerations later, I think he is a bad manager.

I refuse to believe that there is any room for a field of value engineering or value analysis other than as a specialist consultant to the prime decision-making engineer. If the value engineers will admit that this is a proper dimension for their field as advisors to the primary engineer, I will welcome them to the fold and believe that good management will make a place for them and use them.

Beyond this, I feel the managers are permitting unhealthy expedients to develop which could become Frankensteins and destroy them and their organizations.

My beliefs in this area of fundamental engineering are also extended to the many other fringe specialties equally necessary to a good engineering job such as quality engineering, inspection engineering, reliability engineering, human engineering, etc. The manager's problem is the same in all these fields and I believe strongly he must recognize them and take steps to control the cancerous growth of these fringes.

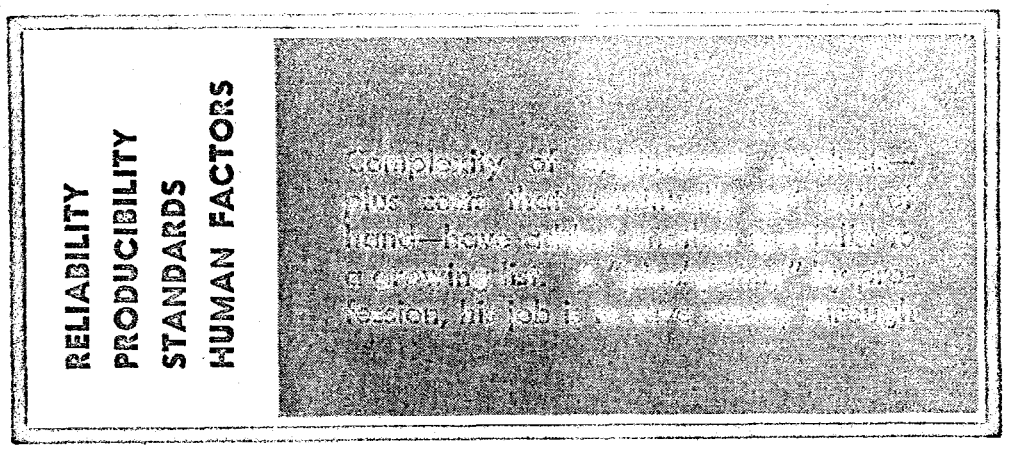
***(Besides Mr. Miles' reply, we feel the following excerpts from a letter by James L. Schuler, Assistant for Naval Architecture, Office of Value Engineering, Bureau of Ships represents a good sized segment of opinion on Value Engineering in the services.)***

Mr. Garono . . . (has) expressed doubts about the need for Value Engineering. His doubts have led him to make some criticisms which have been made before. These criticisms can be answered by repeating some of the basic concepts on which a Value Engineering program is based . . . Successful cost reduction depends on emphasis and re-emphasis. It also depends on developing attitudes based on understanding the urgent need for action to cut cost . . .

A review may be a healthy thing . . . Value Engineering studies help save the dollars that are lost in the cracks between the organization chart . . . Value Engineering is needed in every place where competition, based on cost, exists.

The Value Engineer states and restates that the credit (for money saved) belongs to the man who makes the decision. That man is the line engineer. He takes and keeps the responsibility. He deserves and gets the credit.

I'm sure we are all in favor of cost reduction. Value Engineering is not the *only* way. It may not be the best way. But it is a proven technique. In the hands of skilled management it can do a good job. If the tool fails, don't curse the tool—use it properly.




# Value Engineering

- ✓ **The concept has been in existence for about 10 years.**
- ✓ **One of the largest companies in the U. S. is sold on it.**
- ✓ **Several military establishments are actually saving money with it.**
- ✓ **Its proponents are set to form a new technical society.**
- ✓ **But there are also dissenters.**

IN 1945, an aircraft carrier cost the Navy approximately $90 million, submarines delivered for $5.2 million. The price tag on these items today reads something like $400 million for the carrier; between $60 and $100 million for the submarine. Meanwhile, the weapons budget has not risen by anywhere near this ratio. It follows that any technique promising substantial savings in the design and construction of weapons would be welcomed by the military.

Six years ago, Navy officials learned of a new approach to cost cutting called value engineering. One of the country's largest corporations (and a major defense contractor) was using the technique successfully in the design of many industrial and consumer products.

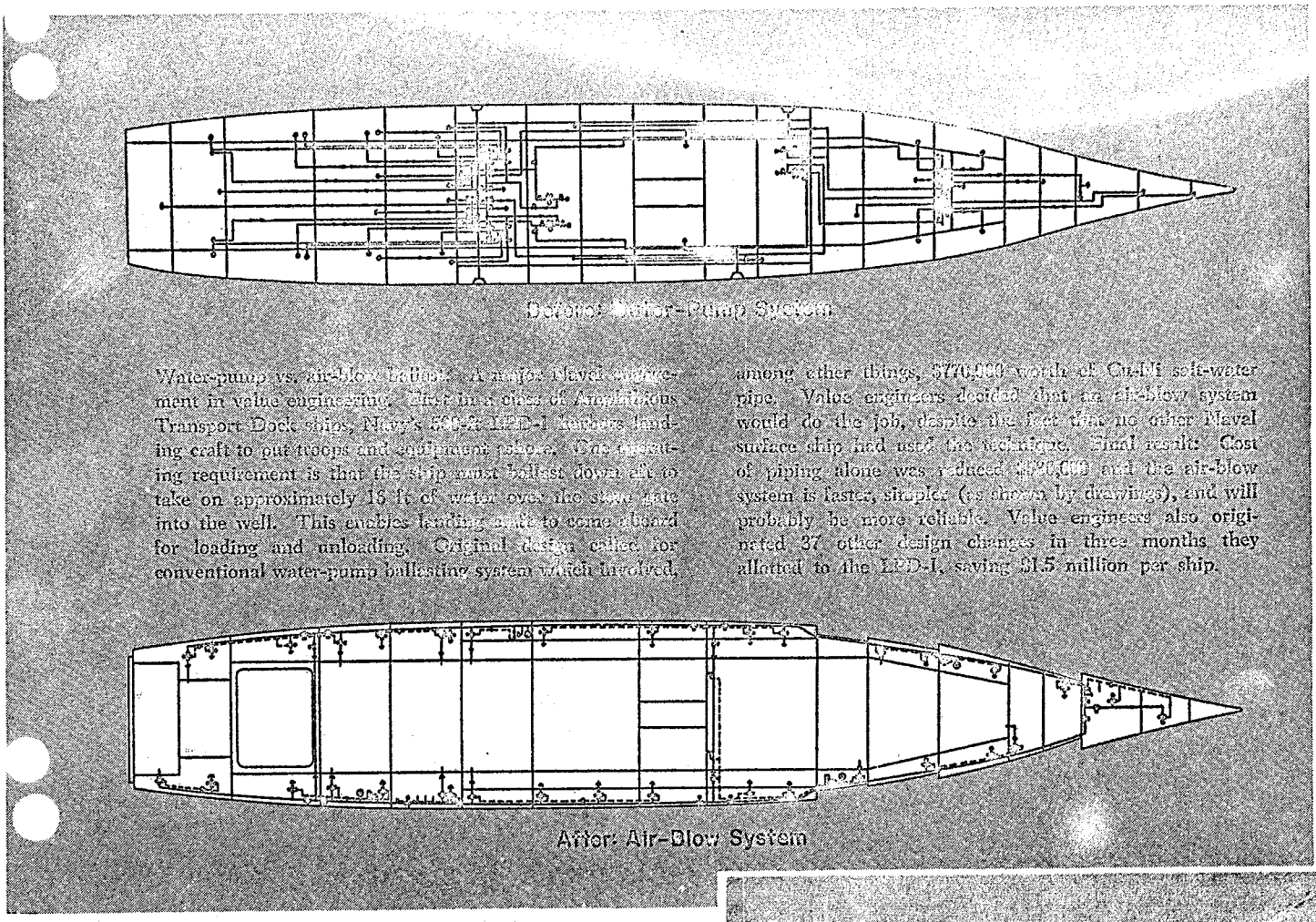
Today, all major Naval Bureaus have active value engineering programs. And since 1956, some 2000 projects have been "value engineered," resulting in savings of $5 to $7 million yearly. As savings are reported only for the first year or the first ship, these figures do not represent cumulative savings brought about by changes in specifications and designs. The total figure is estimated at $40 million.

Despite such favorable results, value engineering, until recently, was not a widely publicized activity.

## VE vs. DE

VE is a series of techniques and philosophies, combined into an analytical and efficient approach to cost reduction. It is aimed at the very heart of the problem where cost begins—*function.*

The VE techniques in themselves are not new. Most of them are used every day. What is new, is the co-ordination of many independent steps into one program headed by value-oriented people whose main responsibility is obtaining the necessary function at minimum cost.

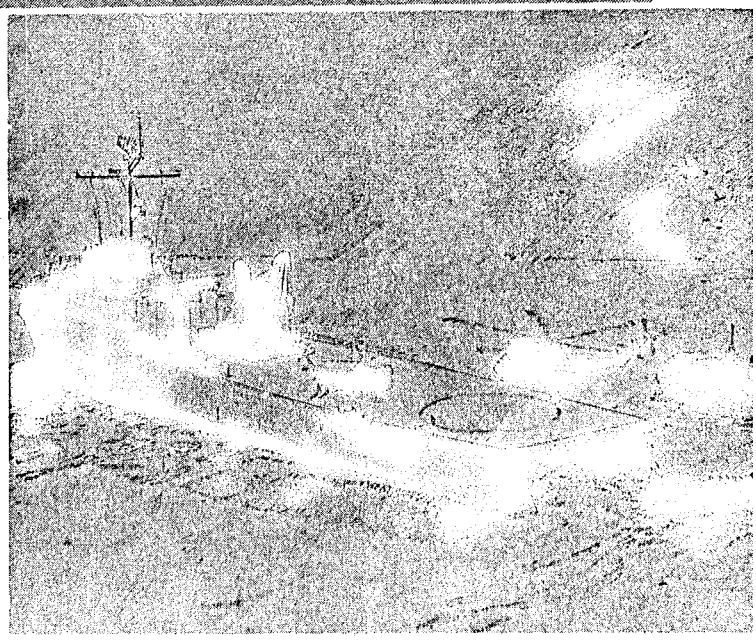


Before: Water-Pump System

Water-pump vs. air-blow ballast is a major Naval improvement in value engineering. Effort in case of Amphibious Transport Dock ships, Navy's 9,000-ton LPD-1 lumbers landing craft to put troops and equipment ashore. One operating requirement is that the ship must ballast down aft to take on approximately 15 ft of water over the stern gate into the well. This enables landing craft to come aboard for loading and unloading. Original design called for conventional water-pump ballasting system which involved, among other things, $770,000 worth of Cu-Ni salt-water pipe. Value engineers decided that an air-blow system would do the job, despite the fact that no other Naval surface ship had used the technique. Final result: Cost of piping alone was reduced $720,000 and the air-blow system is faster, simpler (as shown by drawings), and will probably be more reliable. Value engineers also originated 37 other design changes in three months they allotted to the LPD-1, saving $1.5 million per ship.



After: Air-Blow System



Since all engineers are cost conscious, the value-engineering concept would seem to imply criticism of the working design engineer. None is intended, say VE's.

The engineer who originates the initial design or improves on an existing one is *performance* oriented, and most of his design work is done with a deadline in mind. Naturally, he gives some thought to economical ways of achieving a function. He also gives thought to whether or not the product can be easily produced. But his primary emphasis is placed on creating a *workable design.*

## Professional Second Guessing

After the design is proved feasible and workable, the value engineer steps in. His job: To achieve the same function and reliability at considerably less cost. The value engineer's job encompasses the whole design from inception to maintenance. He

takes nothing for granted and frequently challenges the specifications themselves, rather than starting *from* the specifications. For this reason, the value-engineering office is usually placed at a high organizational level . . . to afford access to all management levels. The value engineer must reflect management's viewpoint.

There have been many attempts to place the value-engineering effort in the research stage or into the original design. However, it is generally conceded that at any stage before a workable, producible piece of equipment is designed, the introduction of value engineering adds one more item of compromise for the design engineer. The exception is found in military projects, where R&D, prototype development and production overlap to such a degree that VE must be in on the R&D stage.

Many critics of value engineering have said that everybody should be doing it, that eventually value engineering will die out as the designer becomes more value conscious. Not so, say VE proponents —not as long as cost is a major consideration. It's an old adage that everybody's responsibility is nobody's responsibility. One of the fundamental principles of management is that when a job needs to be done, assign responsibility for it to one individual. Thus, responsibility for value is primarily the value engineer's. He becomes a specialist and can act as consultant at all stages of design and production as would a metallurgist, a noise reduction specialist, an insulation specialist or any of the many experts now available.

# VE in Industry: Even Nuts and Bolts Are Challenged

**All roads in value engineering lead back to General Electric Co. The concept was started there about 10 years ago under the direction of Lawrence D. Miles, who now heads the company's Value Service staff.**

**In addition to furthering the program at GE, Mr. Miles and his associates have trained value engineers for a number of military establishments. VE programs in the Navy, Army, and Air Force are based on techniques developed at GE.**

**The one objective of value engineering, as stated by Mr. Miles, "is to provide equivalent performance at lower cost." He and his associates now have a highly refined and effective method of operation to reach this objective. Put into print, it would provide a textbook covering all aspects of value engineering. Their initial approach, however, can be illustrated briefly. In analyzing any product or component, the value engineer begins by asking these questions:**

1. **What is the item?**
2. **What does it cost?**
3. **What does it do?**
4. **What else would do the job?**
5. **What would that alternative cost?**

**The answers to these questions can lead to the redesign of major subsystems as occurred in the LPD-1 program, or may be concerned profitably with the smallest components, as the following examples illustrate . . .**

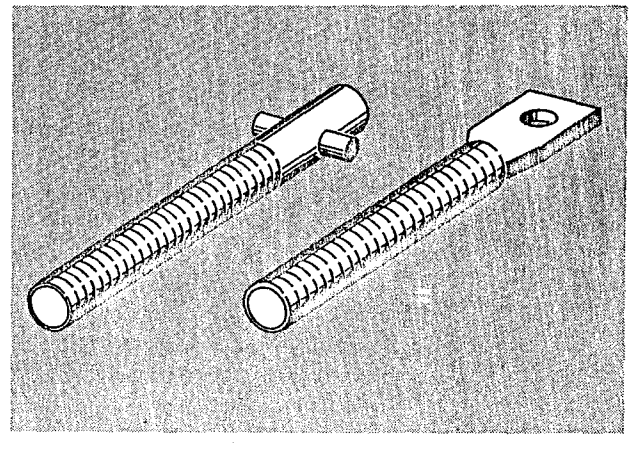
## Example 1—Adjusting screw. Cost: 8 cents.

Function: To facilitate adjustment of electrical equipment. In use, a stiff wire was hooked into the hole in the head. The screw was lifted against a spring pressure, turned as desired, and then lowered again, allowing the cross pin to drop into a slot.

Manufacture of the screw required 3/16 in. and 1/16 in. diameter steel as raw material. The larger piece required cut off, threading, and drilling of two holes. The smaller piece required cut off, assembly in hole and staking.

The part was deemed so "unusual" that it was not to be expected that a vendor made such an item.

A review of the function—not the part—brought



### In the Future: SAVE

Whether or not value engineering is old enough and specialized enough to be of professional stature is debatable. One spokesman for the defense department, Mr. John J. Riordan, Office of the Assistant Secretary of Defense, describes the position of VE like that of quality control a decade ago.

"In the late '40s and early '50s, industrial management had heard so much of quality control that it became somewhat suspicious, if not disenchanted. Quality control had been sold as some kind of statistical gimmick. Because of its theoretical foundation in mathematics, it had an aura of mystery. It was something too potent for management to challenge, but also something too expensive for management to accept credulously."

The concept was finally defined and saved by scholarship. Publication of basic economic and technical literature on the subject (namely, the classical text by Dr. Walter A. Stewart) gave it a foundation which management could accept legitimately.

Many VE proponents would agree with Mr. Riordan that the precise stature of the concept is debatable—at the present. But they would also point out that the results achieved with value engineering are far from debatable.

Meanwhile, VE's most enthusiastic admirers are at work forming an organization called SAVE. The Society for the Advancement of Value Engineering aims to be a professional society.

forth these requirements:

- A screw having a hole in the top, or other suitable arrangement, so it can be lifted and turned.
- A head arrangement that will be pulled back into the slot and held so as not to turn.

A search of specialty products having these two characteristics uncovered the spade bolt, below. It accomplished all of the functions reliably and was readily available. Cost: 3 cents.

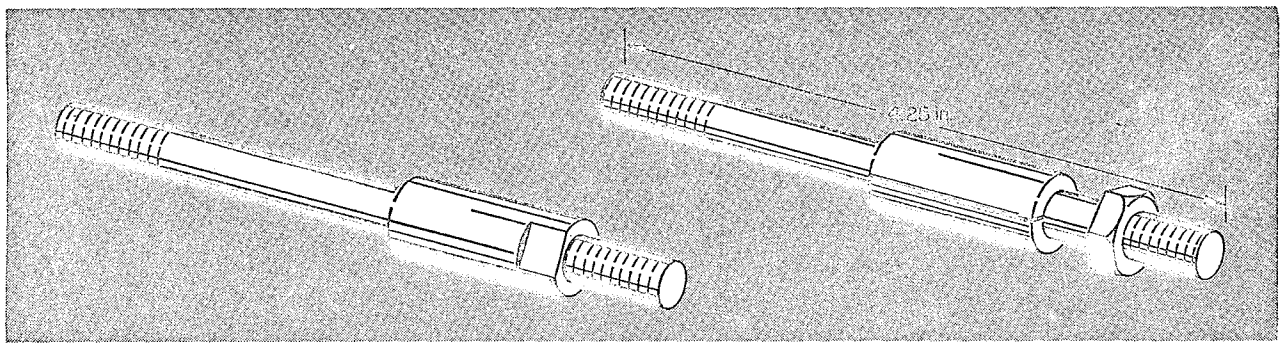
### Example 2—Spacer stud. Cost: 15 cents.

Function: To hold an electric motor on a high-volume equipment, and space a dust cover over it. It offers no appearance or "esteem" values to the customer. It is a "use" part. Quantities are 400,000 per year. Material is steel; there are no close tolerances; the part is made on automatic equipment from standard steel rod; and there are no quality problems.

With the function clearly established as holding and spacing, comparisons were made to place the value on each function. The holding function can be compared in cost to that of a screw of similar dimension which would cost about 1½ cents. The spacing function can be compared to a piece of tubing cut to proper length, or a piece of flat metal rolled to form a rolled spacer. In either case, the cost would be in the neighborhood of ½ cent. Therefore, by comparison, the sum of the combined functions is evaluated at 2 cents.

Value engineers located a supplier of cold, upset, and roll-thread parts who proposed a suitable screw as shown at 1½ cents.

A supplier of rolled spacers, which were a specialty product for him, proposed a suitable cylindrical spacer at slightly under ½ cent. This spacer and the roll-thread screw assembled together ready for use would be an equivalent part costing 2 cents. Yearly reduction in cost: $52,000.




ACKNOWLEDGEMENT

This article is based principally on material submitted by Mr. Richard C. Johnson, Washington Technological Associates, Rockville, Md. Mr. Johnson was formerly assistant manager for the Shipbuilding Program and assistant for mechanical engineering and quality assurance in the Navy's Bureau of Ships. Information concerning the VE program at General Electric Co. is based on presentations at the recent Value Analysis Engineering Seminar conducted by the Army Ballistic Missile Agency, Redstone Arsenal.

GENERAL ELECTRIC Review

# DOLLAR-SIGN ENGINEERING

# AND

# VALUE ANALYSIS

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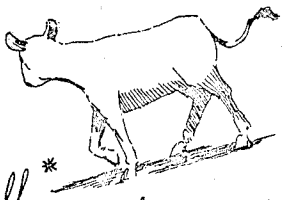
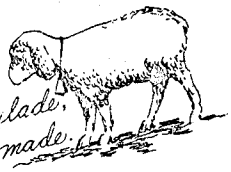
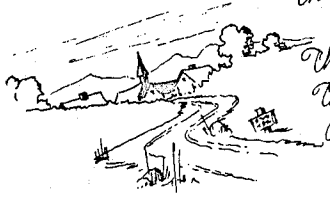


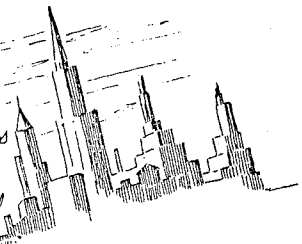
## Path of the Calf *

One day through the primeval wood
A calf walked home as good calves should;
But made a trail all bent askew,
A crooked trail as all calves do.
Since then three hundred years have fled,
And I infer the calf is dead.
But still he left behind his trail,
And thereby hangs my moral tale.
The trail was taken up next day
By a lone dog that passed that way;
And then a wise bellwether sheep
Pursued the trail o'er vale and steep,
And drew the flock behind him, too,
As good bellwethers always do.
And from that day o'er hill and glade,
Through those old woods a path was made.



The years passed on in swiftness fleet,
The road became a village street;
And this, before men were aware,
A city's crowded thoroughfare.
And soon the central street was this
Of a renowned metropolis;
And men two centuries and a half
Trod in the footsteps of that calf.
Each day a hundred thousand rout
Followed this calf about
And o'er his crooked journey went
The traffic of a continent,
A hundred thousand men were led
By one calf near three centuries dead.
They followed still his crooked way,
And lost one hundred years a day;
For thus such reverence is lent
To well established precedent.
(And now gentlemen, in the matter of cost,
Do we ever follow a calf thats lost?)





* Partial quotation from Path of the Calf — (by Samuel Walter Foss, written in 1895).

# Dollar-sign Engineering

By L. D. MILES

Six years ago the General Electric Purchasing Department undertook a new project that sent us on a widespread search for value—the basic value of every part, every item, of a piece of apparatus. What does the item do? How important is it in relation to the other parts? Can we eliminate it or simplify it? Can we replace it with a standard? Can it be combined with another part? Can it be made from some other material at a lower cost—and better value? This project intensely focused our entire efforts on each individual part to obtain one thing—the same performance at lower cost. What we did was to make a "value analysis."

The results over the six years have been impressive not only in dollar savings but in better products. The first project helped save 30 cents per unit on a control device. This figure was small in itself but, with an output of one million units a year, it added up to a tidy $300,000. In value analysis we don't overlook pennies—or even mils; one cent on one million items means $10,000. Value analysis has paid its price of admission—it has proved its ability to eliminate nonfunctional costs. It is established and operating in many General Electric plants.

A value-analysis program shows keen insight on the part of industrial management; it makes purchasing a full-time partner in cost reduction.

Why did we in the Purchasing Department organize this project? For one thing, we can bring a terrific potential of knowledge to bear on a particular problem. Besides checking into our own purchasing arrangements, we can supply specialized information on markets, materials, standard parts, and processes, and we can apply to the problem the engineering skill and ingenuity of specialized suppliers.

By reason of our value analysts' specialized abilities and training, we lengthen the arm of the engineer, the manufacturing man, and the buyer. To the engineer, value analysis offers a new outlook to component-part design. It puts a dollar sign on his ideas and so intensifies the cost-consciousness of every engineer that he makes certain the new designs include the latest ideas in low-cost production techniques. It aids the methods man by providing him with new tools and processes. Draftsmen are part of the team because every one of their decisions—selection of tolerances, bushings, fasteners, as well as many other details—has an effect on cost.

In value analysis, teamwork is not a catch-word but a vital working plan of operation. It uses highly trained specialists in the large operations, and it trains the buyers in the small units to get the same results. Value analysis ties in with, and supplements, the value-improvement activities in both engineering and manufacturing groups. Conferences or committees play very little part in the value-analysis picture; it is a highly individualized responsibility.

In beginning a value-analysis study, it has been found that a basic deficiency in value can usually be determined after a complete cost breakdown of the part under consideration has been examined. This cost breakdown should show the cost of material, labor and overhead, and all other essentials. Each of these costs is then related to the function it buys. Costs that are badly out of line stand out; thus they serve as a starting point.

By reason of his knowledge of purchasing and of what outside vendors can do, the value analyst can bring to bear upon the problem an important store of information. He knows dependable vendors and specialty suppliers who over the years have developed a high degree of ingenuity and technique, each in his own restricted field. These vendors are brought in, presented with the problem, and are requested to suggest how their particular facilities can be used to help solve the problem. Thus the best specialty suppliers become members of the value-analysis team.

*With a small group of engineers in the Mfg. Services Div., Mr. Miles has developed methods and techniques that have resulted in eliminating millions of dollars of "wasted" cost from General Electric products. In recognition of this achievement, the Company presented him with its highest award, the Charles A. Coffin Award.*

We have developed what we call The Ten Tests for Value, the main purpose of which is to indicate the absence of value. Every material, every part, every operation must answer these questions:

1. Does its use contribute value?
2. Is its cost proportionate to its usefulness?
3. Does it need all of its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower-cost method?
6. Can a standard product be found which will be usable?
7. Is it made on proper tooling—considering quantities used?
8. Do material, reasonable labor, overhead, and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

After the study has been made, suggestions are reported to the proper person for action. The value analyst does not make decisions, nor can he await decisions—he is the prosecuting attorney, indicating the lack of value. When he has set forth the best evidence as he sees it, his job is finished, and he undertakes the study of some other device. Always the decisions are made by men responsible—the engineer, the manufacturing man, the buyer, the stylist, the commercial man—usually after they have completed sufficient tests to evaluate the evidence that has been presented.

It is basic that no reports or claims of dollars saved are issued by the value analyst himself. Savings are reported by the men who make the decisions and have the responsibility.

There are many things, as I have outlined, that value analysis is, and there are many things that it is not.

Value analysis is by no means just a search for new materials and processes, because the laboratories and engineering and manufacturing organizations are constantly doing just that.

Nor is it a substitute for the effective cost-reduction committees that daily are increasing the value of our product.

Yet it does embody all of these.

Value analysis does not involve any magic—although the results may sometimes look like it. Rather, it is hard intensive work that continues, even though the first answer to a problem may be "No." It continues until the roadblock has been removed.

Over the course of the years we have added many techniques to our lore; for instance, we have found that the success of an analysis depends to a large extent upon its intensity. Intense concentration and interest cannot be continued for any length of time. We therefore make our examinations short and concentrated.

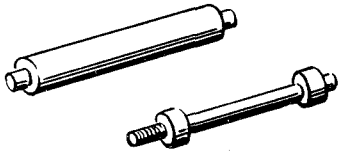
Value analysis is a new tool. Placed in the hands of the engineer, the buyer, and the methods man, it removes nonfunctioning costs from any product anywhere.

In a forthcoming issue of the GENERAL ELECTRIC REVIEW we will take you step by step through a typical value-analysis project.

THE AUTHOR, L. D. Miles *(right)*, and R. E. Fountain together attack a value-analysis engineering problem, with the subject matter under consideration between them

## THREE CASE HISTORIES

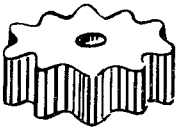
Actual value-analysis studies which showed where savings could be made



### *Standoff Stud*

The stud shown at the left above is part of a motor assembly. The annual requirement is 100,000.

Since a double-upset cold-headed part providing identical support and fastening could be obtained, saving much material between the shoulders, cost could be reduced. The original stud had a shop cost of about ten dollars per thousand. The cold-headed part could be made at a cost of $4 per thousand. This would mean a saving of more than 50 percent.

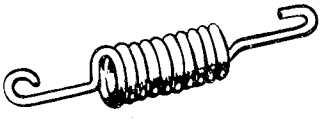


### *Pinion Gear*

This gear is part of the assembly of a timing motor. The annual requirement is 100,000.

It could be a miniature zinc casting, or could be made of nylon, or of powdered iron or powdered bronze, or cut from pinion stock—all at substantial savings.

The current gear has a shop cost of about $50 per thousand. Made by some of the new methods it would cost between eight and ten dollars per thousand, saving annually about $4000.

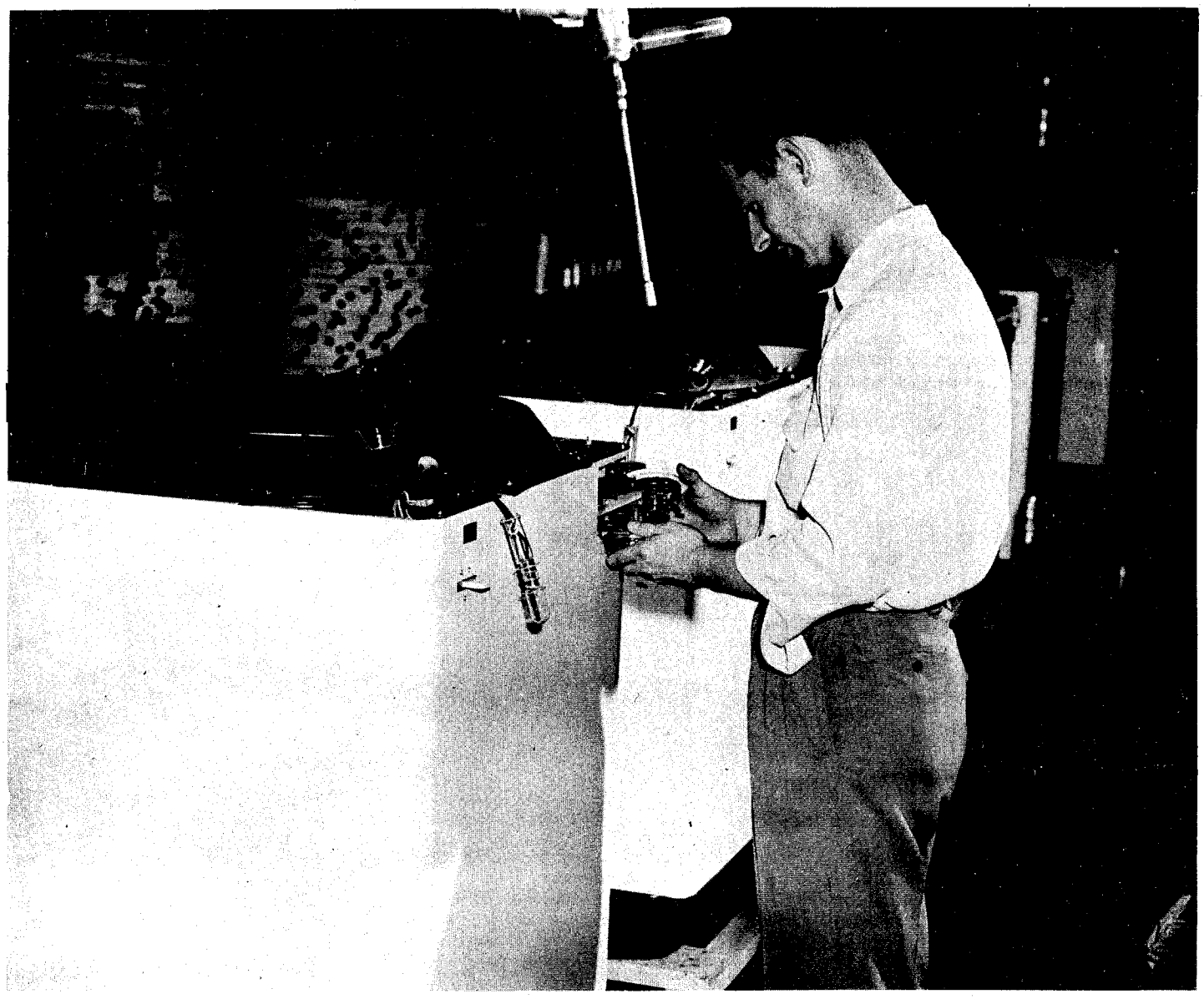


### *Spring*

This spring was used in quantities of 100,000 per year.

A specified tolerance of 0.01 inch in length was found to make no contribution to performance, and could be increased to 0.02. Also another specification, "no initial tension" made no contribution in present use.

The original cost was $18 per thousand; the cost now is under $12 per thousand, saving about one-third in production costs.



MANUFACTURING COSTS OF TIMERS OF AUTOMATIC CLOTHES WASHERS WERE REDUCED BY THE USE OF . . .

# Dollar-sign Engineering (PART II)

By L. D. MILES

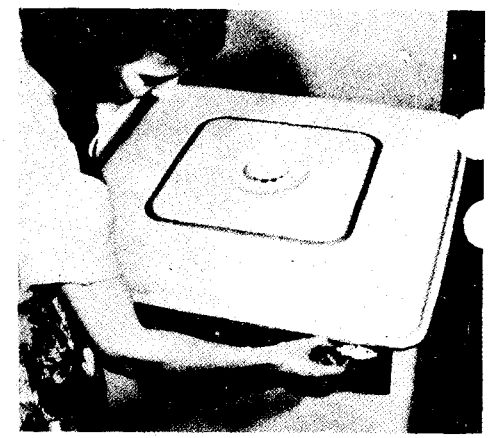
In the March issue of the REVIEW I discussed the background of a project in the Purchasing Department that is taking us on a widespread search for value—the basic value of every part, every item of a piece of apparatus. What we are doing is making a "value analysis."

What does the item do? How important is it in relation to the other parts? Can we eliminate or simplify it? Can we replace it with a standard? Can it be combined with another part? Can it be made from some other material at a lower cost—and better value?

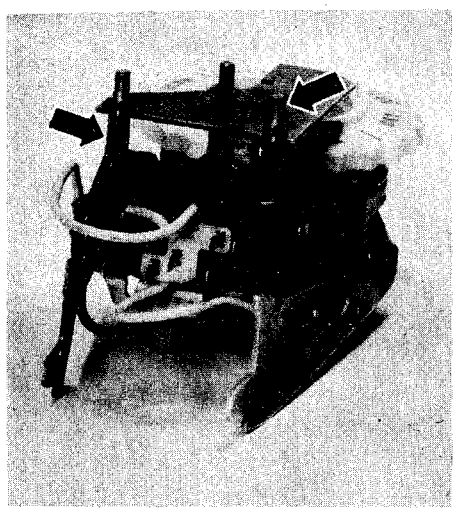
The photo sequence beginning on the next page will show you how a value analyst operates—step by step—on a typical project. Here, it's the timer for the automatic clothes washer. Because space doesn't permit us to show the results of the analysis on every part of the timer, we have selected one part as being typical. (In the actual project more than 30 individual parts of the timer were analyzed for value.)

It should be emphasized that nothing was wrong with the timer when Clarence Pace approached the Value Analysis Unit and requested a survey. The timer operated satisfactorily and costs were in line with similar products. But, as is the case with far-sighted management, they wanted to see if it wasn't possible to further eliminate any unnecessary costs.

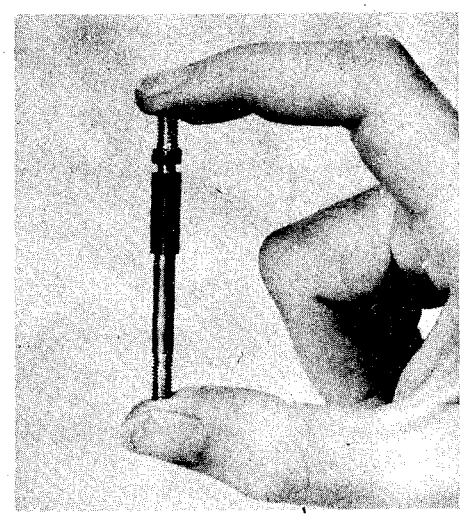
**1** Alert management is always looking for new ways to eliminate unnecessary costs in their products. Clarence Pace (right), Supervisor of Purchases of GE's automatic washer plant at Trenton, N J, discusses a problem with L. D. Miles, head of the Value Analysis Unit in Schenectady. The project involves the . . .



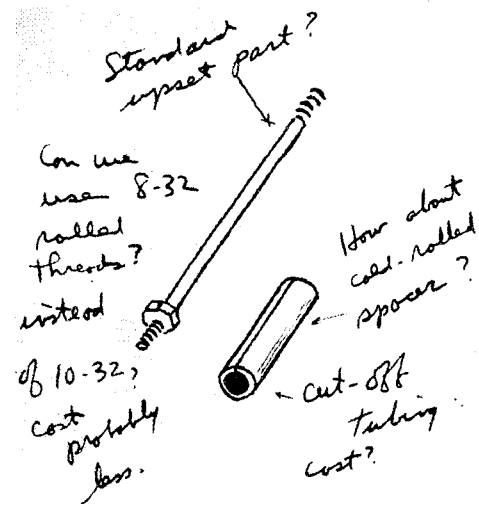
**2** Timer for the automatic washer. Pace says the present timer is doing a good job, but they'd like to see if costs could be cut



**6** To show how value analysis operates, we've selected the two stand-off studs on the timer (arrows). Quantity runs 200,000 a year, and . . .



**7** Cost is $52.50 per thousand as a screw-machine part. Material is steel, zinc or cadmium plated. After thorough study . . .




**8** Bentley suggests that possibly two parts can do the same job for less —one a cold-headed part, the other a roll-formed spacer. Next . . .

Another thing that the photographs don't adequately portray is the intensity of a value-analysis project. Examinations are short and concentrated because intense concentration and interest cannot be sustained for any length of time. For example, the value-analysis project on the timer was completed in four months.

Two other points should be emphasized. In the first place, we have found that our value-analysis men work best in teams of two—not one, not three. Another point is that strong personal contact must be established between the value-analysis man and the specialty suppliers. The value-analysis man knows dependable vendors and specialty suppliers who over the years have developed a high degree of ingenuity and technique, each in his own restricted field. By personal contact these men are brought in, presented with the problem, and are requested to suggest how their particular facilities can be used to help solve the problem. The specialty supplier becomes not only a member of the value-analysis team, but also in many instances he makes vital suggestions that help to eliminate unnecessary costs even further.

In photo 12 you will note that the value-analysis report is turned over to the responsible persons for action. The Value Analysis Unit doesn't make decisions. Our job is to indicate the lack of value and set forth the evidence. The decisions are always made by the men responsible (photo 13)—the engineer, the manufacturing man, or the commercial man. These decisions are made after they have completed sufficient tests to evaluate the evidence.

The savings that are realized by accepting the suggestions of the survey are reported exclusively by the men who make the decisions and have the responsibility. In no cases are reports or claims of dollars saved issued by value analyst himself.

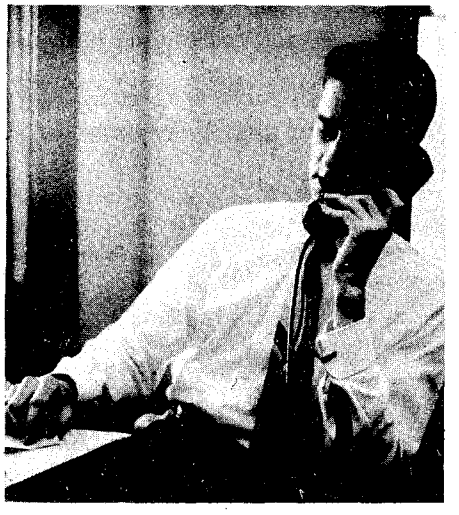
Our Value Analysis Unit usually does only one project for each product group to prove that value analysis is applicable to *any* product. After seeing that "it can happen here," the various product groups then set up their own va' analysis units for further studies.

**3** Miles turns the job over to Al Bentley, a member of the Creative Engineering Program assigned to Miles' staff. Bentley's . . .

**4** First step is to go to Trenton and get all available facts from the responsible engineer, plus costs, quantities, and so forth. Back . . .

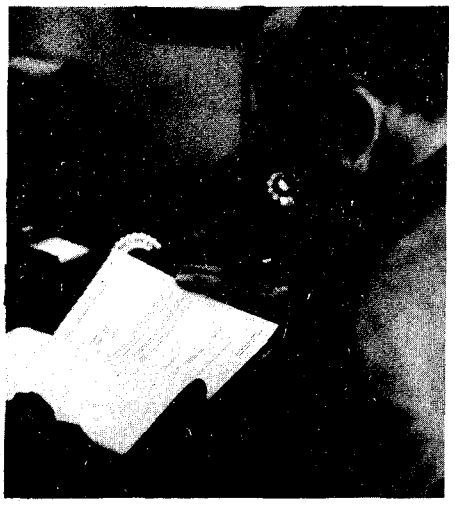
**5** In Schenectady, Bentley consults with various experts. They disassemble the timer, analyze each part to determine its "value"

**9** He takes his ideas to Doug Eagan who works with G-E buyers and knows specialty suppliers. Buyers usually call suppliers . . .



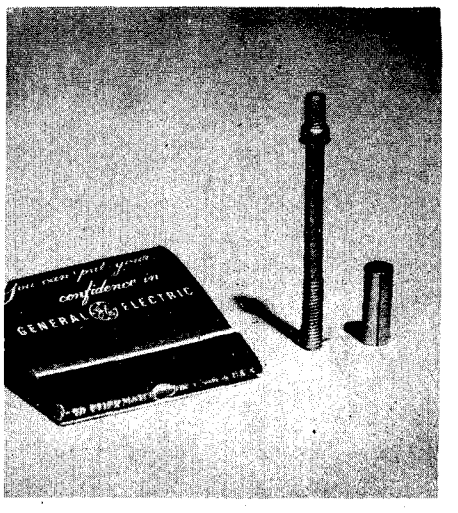
**10** In some cases buyer asks value analyst to call supplier direct. Specs follow in the mail. Experience has shown that . . .

**11** Personal contact with supplier is important. C. E. Berge of Townsend Co., New Brighton, Pa., makes suggestions for improvement.



**12** After parts of timer are analyzed, report is turned over to Pace by Miles. Value Analysis Unit suggests only—it has no authority

**13** In Trenton, Pace goes over the report with his engineers and specialty supplier. A proposal is selected and the order is placed




**14** Standard upset part and standard spacer are used at a cost of $10.50 per thousand. This compares to the original $52.50 per thousand

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# VALUE ANALYSIS PHILOSOPHY

Frederick S. Sherwin, Manager
Value Engineering Services
Raytheon Company

Product improvement is a necessary way of life. Here is a simple statement with which most people will agree, and yet let's take a closer look at the picture which these words may create in the minds of different people.

The inventor or creative designer foresees the need for the generation of new or vastly improved products to meet various functional requirements of the expanding industrial and consumer markets. Manufacturing or Production Engineering picture changes to improve producibility. Quality Control people would look for improvements which reduce scrap or rejection. Each person would visualize certain changes which would effect the product in different ways in accordance with his own areas of interest and responsibility. Some would look for product performance improvements, some would look for producibility or economic improvements.

People would consider different reasons for the necessity of these improvements, such as human welfare, competition, production capability or profit. It can be seen that even a simple statement consisting of commonly known words is open to misinterpretation and misunderstanding. If this is true, one can easily foresee the difficulties arising when new words or phrases appear upon the scene. With increasing complexities of products, industries and technologies, new words and phrases depicting areas of various new philosophies, techniques, sciences and activities are being coined almost daily.

Now we are going to be talking about two words - Value Analysis. Two words which identify various things to various people. Two words which define an area of specialized activity which has, within the past 15 years, come onto the business scene. The purpose of this presentation is to clarify in your minds the meaning of these words and the philosophy which they define.

The words Value Analysis relate to the word improvement, because they define a system which helps people make improvements, improvements primarily aimed at eliminating all unnecessary costs associated with products.

Webster defines philosophy in several ways:

1. The science which investigates the facts and principles of reality.
2. The science which combines logic and theory of knowledge.
3. The body of principles underlying a given branch of learning.

So when we talk about Value Analysis philosophy, we are attempting to identify a specific body of knowledge or principles. If this knowledge can be described in sufficient details, a common concept or picture can be created in the mind of the listener. So let's get down to facts.

First, look at the broad picture, then scrutinize the details. Value Analysis and Value Engineering are the most common terms used to identify the body of knowledge. The terms are synonomous in regard to what they identify. Some people have interpreted the words Value Analysis or Value Engineering to designate different points of application and different amounts of applied engineering skills. However, these are fine variations we are not presently concerned with nor will these differences materially alter the philosophy of Value Analysis.

Value Analysis is the organized application of a system of specific techniques. To state it another way, Value Analysis is a systematic approach using a package of basic techniques. While this gives a picture of what the words Value Analysis identify, it does not define the body of knowledge. This consists fundamentally of the "approach" and the "techniques."

The Value Analysis approach is called a Job Plan and serves as the structure which houses the techniques. To more clearly define the broad package, we can erect a structure of building consisting of the job plan and techniques. Let's review this job plan in order to establish a more uniform concept of the Value Analysis philosophy and the specific techniques which fit into the structure.

Value Analysis is a business management tool which will materially add to the profits through the increased capabilities of decision-making people to utilize the Value Analysis system. Management should review this job plan or system with a qualified Value Analysis Specialist to determine the best implementation plan for their particular business. (Photo #1)

The foundation of Value Analysis consists of several general techniques which are fundamental to the success of creating and implementing improvements. (Photo #2) These general techniques include the promotion of more effective teamwork, the capabilities to recognize and overcome the roadblocks to progress, the direction of analytical effort to specific areas of cost, the increased application of good business judgment to each decision, and finally, the utilization of good human relations in all contacts.

The first floor of the building depicts the information phase of the job plan and includes four fundamental techniques: (Photo #3)

1. The clear, specific definition of functions which occur in any product. This technique is fundamental to the philosophy of Value Analysis and must be handled with certain guide lines and approach. More will be said about the definition of functions later.

2. The techniques and ability to determine extensive and factual costs so related to various elements of the hardware and so divided into cost centers as

to make Value Analysis possible.

3. The obtaining of all known facts necessary for initial or improvement decisions which establish the product cost. These facts include all of the engineering, manufacturing and procurement background information.

4. The designation of cost necessary to achieve each desired specification and requirement.

The second floor of the building consists of the creation phase of the job plan. (Photo #4) This includes the techniques of creative thinking designed to generate large numbers of possible solutions to a particular problem. The blast and create technique concerns the elimination from one's mind of the present hardware or known solutions to the performance of required functions, followed by the positive approach creation of new solutions.

The third floor of the building represents the evaluation phase of the job plan. (Photo #5) This phase of the job plan involves both the evaluation of the worth of required functions and the evaluation of the potential of new items. Specific techniques which contribute to this evaluation include:

1. The evaluation of basic functions by artfully and scientifically assigning monetary values to the functions previously defined in terms of measurable design parameters. This technique is critical and fundamental to the Value Analysis approach and perhaps the least often applied properly. More will be said about this technique.

2. The technique of evaluating functions by comparison is an adjunct to the evaluate basic function technique. Both of these techniques are designed to create awareness of unnecessary costs and to provide specific guide lines for the achievement of lower cost objectives (better value).

3. Following the creation of ideas, comes the technique of putting a dollar sign on each idea to evaluate the desirability of developing that idea.

4. Finally, comes a technique of refining ideas which includes the modification and alteration of basic ideas to meet the practical functional requirements of the product. With this base we move into the next phase of the job plan.

The fourth floor of the job plan consists of the investigation phase (Photo #6) which includes several techniques designed to develop the refined ideas into practical solutions to the problem. Here, we are attempting to develop the design alternates for the purpose of selecting the best or lowest cost approach. The techniques which

have been proven to be fundamental to this phase of the job plan are:

1. Consultation with specialty suppliers or vendors who represent the best and most up-to-date source of information which will lead to the best value decisions.
2. The effective use, at the appropriate time, of both company and outside industrial specialists. These specialists have a wealth of latest and most complete information concerning all elements of design, manufacture and procurement which effect product cost.
3. Thorough investigation into the potential use of all specialty processes, products and materials.
4. Finally, a thorough evaluation regarding potential application and use of both company and industry-wide standards.

While these techniques in this phase of the job plan are very simply stated, the ability to effectively seek out, screen and analyze information is a complex and difficult problem with which many people have had insufficient training and experience.

It should be pointed out that the generation of the best solution involves a cyclical application of the creation, evaluation and investigation phases of the job plan. It should be mentioned here that there are certain variations to the words used to define the job plan. However, the fundamental steps or techniques and the basic approach is identical. For instance, the Evaluation Phase is sometimes called the Analytical Phase, and the Investigation Phase includes two phases called by some the Program Planning and Program Execution Phases.

Then comes the final enclosure of the building, the roof, the recommendation phase (Photo #7) which consists of buttoning up the results of the investigation phase into a factual presentation of the proposed improvement or solution which will motivate positive action to implement the change or initiate its incorporation into the design.

With the completion of this building and a brief description of what constitutes its structure, a clearer picture of Value Analysis is achieved. The building is dedicated to the accomplishment of the desired product performance at vastly lower cost. It is a system or plan which requires the support and understanding of management as well as the universal application by all elements of the industrial team. (Photo #8) To achieve this universal application of the Value Analysis system usually requires the guidance and leadership of competent Value Specialists devoting full-time to a motivational and educational effort.

Now that we have a better picture of the Value Analysis system, let us look for a minute in more detail at the objectives which the application of this system should achieve.

Primarily these techniques are aimed at helping people to realize that existing

products cost too much or to establish design cost objectives followed by the increased capabilities to create and develop solutions to accomplish necessary functions reliably for the lowest total cost. To understand and to gain some common language regarding what is meant by the term lowest total cost, we need to look into the field of Value. We need to establish a uniform concept of what constitutes product Value. The scope and time of this presentation permits only a brief summary in this area. However, it may help to clarify the meaning of the word Value and thus achieve a common realization of the objectives of Value Analysis. First, we should identify the various kinds of Value which exist in products. While there are several kinds of Value, the most significant of these are grouped into two categories. The first can be designated as "Use Value," the second as "Esteem Value." The first is objective and the second subjective in nature. Value is defined as the lowest cost to reliably accomplish function. Function is, in turn, defined as anything that makes the product work or sell. Use Values are related to work functions and Esteem Values are related to sell functions. These points may be best illustrated by some simple examples.

For instance, take a mechanical pencil costing $2.00. The function of this pencil is to "make marks." Here we are defining in simple terms, a verb and a noun, the basic function of the pencil. This basic function could be achieved by numerous other devices which constitute the various alternate ways to achieve this function and which would be used to evaluate the worth of the basic function by comparison. One known solution would be a common wooden lead pencil costing approximately 10¢. Thus, we could say that the basic work function would have a 10¢ "use value" level. The remaining $1.90 price for the mechanical pencil would be associated with esteem values such as appearance, convenience and prestige factors which would have different values to different people and be subjective in nature. Value Analysis has been primarily concerned with "use values" and "work functions." However, the same system, techniques and approach could be applied effectively to esteem values and sell functions.

Another simple illustration would be a tie clasp, the function of which is to "hold weight" (represented by the tie). Conventionally, tie clasps are priced from 50¢ to several dollars. However, the use function could be achieved reliably by a standard wire paper clip costing a fraction of a cent. While this represents an artful evaluation of the basic function, it nevertheless serves as a very effective tool to bring into clear focus the true worth of accomplishing any basic function. Scientific means of more accurately assigning monetary values to basic functions are possible, but will not be discussed at this time. An illustration of how this technique might be applied to product improvement or to product value assurance (before-the-fact Value Analysis) would be the accomplishment of the function of

holding a cabinet door open. The basic function of "supporting weight" under the specific performance and environmental conditions could be accomplished in a variety of ways. Performance Engineering requirements would be achieved with the design and manufacture of a special door stay costing "x" number of dollars. Value Engineering would involve the assignment of monetary value levels to achieve this function, and still reliably meet all the performance requirements. Value Engineering work runs parallel to Performance Engineering, helping to select the best design compromise to meet both performance and value objectives. How close the final result came to the basic value level for the function would be determined in part by the extent which appearance, sales (esteem value) features were added or deemed necessary for marketing or other purposes. These added elements of cost should be carefully analyzed and reduced to a minimum.

These cases and the above discussion illustrate the functional approach of Value Analysis consisting essentially of defining and evaluating functions and developing alternate solutions to reach the best Value based on existing production capabilities and technological knowledge. Because the philosophy of Value Analysis includes the systematic application of proven techniques to bring about improvements, it accomplishes outstanding results where conventional methods will leave considerable unnecessary cost. One example of the effectiveness of the teamwork application of Value Analysis philosophy is illustrated by the results achieved on a small magnetron tube. A three-man-week Value Analysis study led to a 50% reduction in product cos

An illustration of the type of improvement made is shown by the Photo #9 which illustrates an 85% reduction in the cost of an output flange. These and other improvements were brought about by the organized application of the Value Analysis system which is most effectively organized as a teamwork activity of all decision-making people who have had training in Value Analysis and who utilize the consultation of a qualified Value Specialist. The importance of teamwork action using the Value Analysis approach is illustrated by Photo #10 showing that out of $11,000 product cost reduction, better than 70% was accomplished through combined or teamwork action.

While there is much more that can be said to specifically create in the minds of people a true picture of Value Analysis, the above discussion may serve to somewhat clarify the concept and define the Value Analysis philosophy. It is the philosophy which is being adopted by progressive business management because they foresee the necessity to meet the demands of a world-wide competitive market. The Value Analysis philosophy can do much to meet this challenge.

Sept. 20, 1961

# VALUE ANALYSIS - A MANAGEMENT TOOL

Our business vocabulary has been enlarged by a sprightly new term called Value Analysis, the meaning of which is somewhat obscured by the glamour and intrigue which frequently accompany something new and not too well understood.

The earliest example of the use of the term, Value Analysis, so far as I know was in June of 1949 at the Chicago Convention of the National Association of Purchasing Agents, when Harry Erlicher, then Vice President for Purchases of the General Electric Company, described a Value Analysis Division, which had been established in 1947 under his jurisdiction in procurement.

In 1952, the N.A.P.A. published a manual, entitled Cutting Costs by Analyzing Values - A Practical Purchasing Program. It was prepared by a subcommittee significantly called the "Development Committee on Intracompany Activities," composed of Dan Donovan of the Pepperell Manufacturing Company, L. J. Finnan of Hercules Powder Company, D. F. Kigar of the Detroit Edison Company, Dick Kimball of the Foxboro Company, Larry Miles and W. A. Sredenschek of General Electric Company. These names and companies are mentioned to show that the manual was prepared by competent men from a wide variety of industries. Emphasis was placed upon buyer initiated programs to secure value improvement which would not otherwise result. "Value" was defined as "the lowest price which must be paid for a product, process, idea, material or service required to perform a useful function."

Quoting further, "The purchasing man, carrying the initiative, and working with others who are informed and those who are responsible, makes an intensive study, endeavoring to promote lower costs by weighing the function obtained for every expenditure on the scale of functional performance." Altogether, the Committee prepared a sizable package for any P.A.

Since the search by other divisions for better values in terms of new or substitute materials and methods had been going on long before the advent of the formalized purchasing department, the question is logically raised: How will the effort of the purchasing department to get into the act be received and what useful purpose will be served? The answer depends on what management has done in preparation for the innovation and on the competency and the personalities of the representatives of the purchasing department.

It has been doubted, and I think properly so, that purchasing is really the most suitable place for the actual direction of the Value Analysis function. If management has fully recognized the function and thoroughly appreciates that the compenent required skills are those of engineering, manufacturing, research and finance as well as purchasing, then it has full realization that the function must be administered as a whole operation. That is a top management job which may well be included in that of the executive vice president or even the president himself.

Obviously, an engineering or finance division will not accept overriding direction from a purchasing division. Even when there is complete agreement between divisions, there will be instances where projects are of such magnitude that final decision must rest only with top management, and an executive umpire is even more necessary when there is a diversity of opinion.

Whether a well qualified purchasing agent is the administrator or not is not the basic question. What is essential is that the purchasing department be adequately represented and made a part of the group conducting the studies in value analysis. Thus, purchasing may make its contribution to studies initiated by other groups and have the opportunity, as well as the duty, to initiate projects in its own field and in others that might be overlooked.

Dr. Stanley S. Miller, of the faculty of the Harvard Graduate School of Business Administration, in an article published by the Harvard Business Review in 1955, emphasized as a result of his observations that "the way organization problems are handled really determines the degree to which Value Analysis will be successful." His sub-title is appropriate, too. It reads, "There is considerable gold in the value concept; it just depends on how you prospect for it." He stated that value hinges on the relationship between quality and cost and that Value Analysis is a method of investigating materials requirements to ensure that performance, ultimate cost and the availability of supply are in proper balance.

Value Analysis has been referred to as a new way of thinking - a revolution which will make obsolete our present concept of procurement.

Are thse statements exaggerations? Are they justified? The answer probably depends on how far we have progressed in our "present concept of procurement." Is there a uniform concept of this function commonly held by all P.A.s and by all managements? I think your own observation and experience will at least raise reasonable doubt as to the uniformity of concept, and leave no doubt about the non-uniformity of the scope, the authority and responsibility assigned to purchasing agents by different managements.

What then has this difference in management's thinking about the procurement function got to do with our subject matter - Value Analysis and Cost Reduction? Simply this - management is always involved and concerned with "cost reduction," and if Value Analysis is not to be just a glamorous gimmick, but actually become a tool or means of cost reduction, then it too must involve management.

Management never has to be sold on the idea of cost reduction. Management, however, cannot be expected to adopt Value Analysis merely because it is new and heralded as a revolution in the concept of procurement. The most that can be expected is a willingness for management to investigate. That adds up to a sales job on the part of someone, and that someone could be the purchasing agent. Certainly the current urging is for the P.A. to undertake the task. Just how he goes about it, how he presents the purposes and methods of Value Analysis, will have a lot to do with the decision of management.

If a particular management is not fully sold on the concept that the skillful administration of the procurement function is a profit producing activity, then it is going to be even more wary of Value Analysis as a worthwhile activity if presented by the purchasing agent as a part of his domain. Even if presented as a company project in which the purchasing department, along with other departments, has an assigned role, management will not buy and back the idea until convincing arguments and facts have been presented as to how value analysis differs from present cost reduction methods, its applicability, its cost and added profitability. The heart of the matter is in the attitude of management itself. Is cost reduction a departmental project, each one an empire to itself, or a company-wide affair in which the efforts of all departments are directed and coordinated to a common end? Harry Erlicher stated fundamentals when he wrote in 1949, "Full value can be received only when all

people who contribute value are grouped together into a single team. The purchasing agent must be familiar with basic management principles."

That puts purchasing on the team, and connotes or raises other questions. Isn't it equally important that the rest of the team also know about these principles? Furthermore, isn't it of fundamental importance that management itself first recognize procurement as a function of equal importance with other major business functions such as sales, manufacturing, engineering, industrial relations and so on? If it has, then the purchasing department can be an effective member of the value analysis team. However, how often on the average do we find purchasing so established? How much management is really applied to procurement, again on the average? For the purpose of briefly exploring the facts to provide an answer, it is necessary to first define what we mean by "management."

"Management" is an activity that plans; it selects and states objectives not only for the whole company, but for its major functions; it organizes groups and delegates responsibilities with commensurate authority and facilities to accomplish their tasks; it directs and coordinates the efforts of the groups, sets the sequence and timing of programs; fosters communication; and because all of these preliminaries have been adequately established, then, and only then, is enabled to control through reasoned and orderly processes.

Are all of these basic phases of management universally, or even frequently, applied to the purchasing function? If applied, then we should expect to find a statement of company purchasing policies, with the objectives, scope, responsibilities and limitations of the purchasing department; its organization and relation to other departments; policies concerning the selection of suppliers, commitments, vendor relations and contacts, etc.; a road map or guide intended for the use of the internal organization and information to vendors.

How many companies have such a statement of guiding principles? I refer to basic policies, which can be stated briefly, and not to the voluminous procedural documents, which tell in detail how to perform a task of repetitive nature under the same circumstances and where judgment has previously been exercised and tested and a procedure adopted.

I believe that not more than 5% of the firms with personnel having membership in the N.A.P.A. have a manual of purchasing policies and use it as a tool of management, which will have interest and value for both the internal organization and its suppliers. This opinion is based on my research and observation during the past two years, questions to purchasing personnel participating in the many seminars and conferences in which I have been involved, and the data so generously supplied me by local purchasing associations.

It seems proper to assume that if it is a fact that no more than 5% of the 12,000 firms represented in N.A.P.A. have a manual of purchasing policies, then for the much larger number of industrial companies outside of N.A.P.A. (and that may be 100,000) the percentage is much lower than 5%.

Now what is the application of these sorry statistics to Value Analysis? The point is this - something has to come first before the whole potential of value analysis can be translated effectively into profits. That something is management itself; management and its tools; the planning, organizing, directing, coordinating and controlling to secure objectives.

If Value Analysis is to be pursued as a separate subject, it is imperative that the principles of management be applied so that only those charged with the responsibility know they are on a team, that they know the over-all objective and their own part in the team play, and have been trained and indoctrinated in the methods and skills of the game. The cooperative effort of all is needed, first to select the area where study is deemed worthwhile, then to determine the maximum potential saving from alternate programs; to choose or recommend the appropriate program; secure approval; initiate action and follow through. To get the job done and to realize maximum profits will take all of the tools of management - of which the purchasing manual is only one.

In introducing my subject by saying that "Value Analysis" is a sprightly new term, I had no intent to be derogatory. It has been useful in stimulating thought about the procurement function and orienting the components into more profitable operation. It is the term, and not the activity, which is relatively new. The search for better values

as part of purchasing has been advocated by N.A.P.A. since its beginning. The means of broadening the scope of the search for better values and coordinating the efforts of qualified searchers from the several departments involved must be a top management activity. Purchasing may or may not run the show, but certainly its contribution can be so great that it should be an important part of the show. Thus, and thus only, will the full profit potential inherent in "Value Analysis" be converted to actuality.

Reprinted from New England Purchaser, January 1959.
By F. Albert Hayes

# VALUE ENGINEERING

VALUE ENGINEERING is an organized and concentrated effort, by a team of competent personnel, to reduce the costs of a product by at least 20% without the slightest degradation of quality.....

It is an intensive and critical review to relate all design details of a product to the costs of materials, production processes and testing; and in the light of the product's end-use, determines the WORTH of each function and part.

VALUE ENGINEERING puts the spot-light on all high cost areas and submits recommendations to eliminate these excessive costs. These recommendations are supported by test data, logical engineering facts and the dollar-sign all combined to motivate the engineer and management to accept them without risk.

To do the job of VALUE ENGINEERING, we need.....

Better information on the value of our products
Better techniques to improve the value of these products
Facts that will change the habits and attitudes that keep us nailed down to costly engineering practices
VALUE ENGINEERS who can devote their full time to the job of improving VALUE

The VALUE ENGINEER.....

Brings new information into a project, on materials, processes and functions.....new possibilities and VALUE improvement opportunities.....with cost advantages.....to the designer, the production engineer and the buyer.

Shows you where you are not receiving full VALUE for the money you spend on your product.

Puts the SPECIALIST to work.....from your own company .....and from your vendors.....on YOUR product..... to improve VALUE.

Develops practical ideas that will reduce costs to the level of WORTH.

Develops an atmosphere of respect for costs..... throughout your company.

To do all this.....the VALUE ENGINEER operates with a team of VALUE ENGINEERS, each specializing in certain aspects of your company's operation. These talents, all combined, are utilized with one driving motive.....to improve your PROFIT.

What kind of a man is the VALUE ENGINEER?

He is a specialist in one or more engineering fields.
He is respected by individuals in your company.
He has a creative imagination.
He is trained in VALUE ENGINEERING TECHNIQUES.
He is enthusiastic about the possibilities of improving your product's VALUE.....He knows it can be done.....and how to do it.....
He is mature, stable and not easily discouraged.
He has a deep respect for cost.....and knows what it means to your company.
He realizes he has a job to do.....a job to develop an atmosphere of respect for costs throughout your company.....he doesn't expect management to do it for him!.....he must do it for <u>management</u>.

The VALUE ENGINEER makes these TESTS FOR VALUE.....on each function, requirement and part in your product's design.....<u>before</u> it is produced.....

1. Can we do without it?
2. Does it do more than is required?
3. Do you think it costs more than it is worth?
4. Is there something better to do the job?
5. Can it be made by a less costly method?
6. Can a standard item be used?
7. Considering the quantities used, could a less costly tooling method be used?
8. Does it cost more than the total of reasonable labor, overhead, material profit?
9. Can someone else provide it at less cost without affecting dependability?
10. If it was your money, would you refuse to buy the item because it cost too much?

The VALUE ENGINEER asks these questions.....WHAT IS IT?
WHAT DOES IT DO?
WHAT DOES IT COST?
WHAT ELSE WILL DO THE JOB?
WHAT WILL THAT COST?
WHAT IS THE MOST VALUABLE WAY?

He gets his answers by using VALUE ENGINEERING TECHNIQUES..... systematically performed in a VALUE ENGINEERING JOB PLAN.

A VALUE ENGINEER does his job when.....

1. A design is first put together in the early engineering stage.....Here he puts a dollar sign on functions..... as they relate to the <u>produced</u> item.....determines worth.....tries to simplify others.

2. The engineering model is reviewed for tooling, production, materials to be used, styling, etc..... He puts a dollar sign in all the thinking..... makes suggestions for reducing the cost..... increasing sales appeal.....improving your profit.

3. The end-item is produced.....takes another look .....for new ideas that can be used in its future design.

Here are some of the things a VALUE ENGINEER does on each job.....

1. Tries to eliminate functions and parts.....
2. Simplifies
3. Change a design so that a high speed method can be used.....
4. Change a design so that standard parts or materials can be used.....
5. Use a lower cost material that will do the job reliably.
6. Use a higher cost material, which by its nature and properties will simplify the design and facilitate lower cost assembly.....

The VALUE ENGINEER works across the board.....keeps good communications with.....The designer.....The customer.....The production man.....The purchaser.....The Quality Control man.....The packaging engineer.....

He must have free access to all these people.....be on good terms with them.....and organizationally placed to do all this..... on a full time basis.

He must work hard.....fast.....effectively.....get his proposals to the right people at the right time.....so that his proposals will PAY OFF.

# The Importance Of Value Analysis

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# The Importance Of Value Analysis

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THE CONCEPT of value, like the concept of sin, varies. For example, what is the value of a small bolt in an airplane wing if failure of that bolt would cause the plane to crash, demolishing the plane and killing the pilot? What is the value of the brakes on your car, which you use in one situation to park your car and in another situation to avoid a four-car collision? What is the value of the picture tube in your TV set, and does it have a higher or lower value than the small bolt in the airplane wing?

Value has no relation to the actual cost of producing a part or device, nor does it necessarily have any relationship to the consequences in the event of failure of that part or device.

## A METHOD OF SCIENTIFIC EVALUATION

Value is the lowest price you must pay to provide a reliable function or service. When we say "lowest price," that implies that we must compare values and compare them wisely to determine value. Value is determined only by comparison.

¶ **THE AUTHOR**

Since 1955, R. E. FOUNTAIN has held the position of Consultant–General Training and Service Programs with the Value Analysis Service Section of the General Electric Company. A graduate of Washington State, he joined General Electric in 1946 and was appointed Supervisor of Training and Service Programs in 1952. Mr. Fountain is active in civic affairs and a member of several honorary societies.





The value of a bolt in an airplane wing is determined by the means of providing the function of that bolt at the lowest cost. If the cost of the bolt in question was 25 cents and the bolt was found to be too small, the size might be increased and the cost might become 50 cents or $1, but never will the cost–or the value–be equal to the cost of the plane or the value of the pilot's life. The value of the brakes on the car is established by the lowest cost at which the braking function may be provided. The value of the TV picture tube is determined by the lowest cost at which that function can be produced.

What, then, *is* value analysis? It is the scientific evaluation of value, just as we analyze weight, performance, or quality. It is a scientific approach aimed at getting the same or better performance while still removing large amounts of cost without any deterioration in quality. But, more than that, value analysis is really a philosophy or a way of thinking that applies to all functions in a business and to all businesses, large or small.

For example, let's look at a parade of value analysis results:

- The cost of a J-bolt was reduced from 11½ to 1½ cents, a total saving of $80,000.
- The cost of a hinge was reduced from 25 to 17½ cents, a total saving of $39,000.
- The cost of a radio-type filter was reduced from $35 to $7, a total saving of $11,000.
- The cost of an arcing horn was reduced from $7 to $3, a total saving of $11,000.

## INVOLVEMENT OF HUMAN ATTITUDES

In retrospect, all these changes look simple, and the reasons for them appear to be obvious. The problem lies in the fact that human beings are involved in the development of each idea; and, more specifically, human *attitudes* are involved. Unfortunately, many decisions are based, not on facts, but on what people think the facts are. Many decisions are made with much of the necessary information lacking. All these decisions are affected by the attitudes of the decision maker toward these half-facts and partial information.

For example, you may hear someone say that plastics are brittle. Some plastics are brittle and will shatter on impact–but this statement does not apply to all plastics. Many plastics made today will withstand severe shock without damage and are suitable for a wide range of jobs. Other attitudes which reflect half-truths or outmoded thinking involve costs: "Costs are not important–just get it out the back door." Or, "You

can't take out any more costs." The best ideas in this environment are worthless.

Typical of operating on half the facts is the case of a welding segment which was being cut out and machined at a cost of $1.41 per piece. It was not punched out because the tooling necessary could not be liquidated. That reasoning, however, was based on only a part of the facts. A thorough investigation showed the tooling costs to be only $75. Result: the part is now made for 39 cents.

### THE QUESTION OF VOLUME

"If we only had the quantities," is another favorite excuse. But isn't it true that those who make one wish they could make 100, those who make a hundred wish they could make 10,000, and those who make 10,000 wish they could make 1,000,000? Yet right there it stops—the people who make a million wish they could make one (a situation which we believe prevails in every company. In any case, quantities are a relative matter, and value analysis applies equally well to high volume or low. However, I do not wish to imply that the application of the principles does not vary with quantities or that there are not some unusual problems that arise in dealing with low volume.

For example, in one of our plants we were machining a heart-shaped cam about as big as a silver dollar from 3/16-inch brass. The tolerances on the part were quite liberal, but "the volume was not high enough to liquidate a punching die." One of the methods men, who had heard about Kirksite wondered if it would work. (Kirksite, of course, is a soft Babbitt-like material used for short-run tools.)

The metallurgical laboratory believed that it *would* work. They had all the facilities available to try it, including a small punch press. A shop order for $50 was prepared, but no one would sign it because "it wouldn't work," "it would cost more than $50," etc. The decision was finally taken up the chain of command to the manager-manufacturing, but he wouldn't sign it either.

What did they do? They did the same thing that I assume would have been done in any other company. They put the charge on someone else's shop order.

They made the tool one morning and tried it out that afternoon. It worked. Then the methods man wondered what he should do. After all, he had been refused the $50 by the manager-manufacturing. He decided—hesitantly—to tell him, and the manager-manufacturing was aghast. He couldn't believe what he heard; so he was invited to see the operation. Amazed, he called the manager-manufacturing-engineering and the men from the tool room. A few pieces were produced for each



of them. Then the foremen, general foreman, planners, and methods men were called, and pieces were punched out for each of this group. All were astonished. Finally, when everyone had been convincd, one of the men said, "I wonder how many pieces we have." They counted them and found they had enough for three years' production. When the inventory control people found out about it, they were in double trouble!

### A COOPERATIVE EFFORT

There are those who feel value analysis is just a purchasing activity. Some even use the term "purchase analysis" in referring to it. Actually, however, it is an across-the-board function with more than 80 per cent of the cases where more value can be achieved requiring the cooperation of two or more functions. Truly, it is an approach which is seeking the cooperation of all within a business, so that competition will only come from our competitors.

The General Electric value analysis program seeks to change traditional "it can't be done" attitudes through the use of 20 techniques and by providing new and more information at the point of decision. This philosophy is taught to groups of employees so that they can benefit from the thinking of others and better understand their own actions.

We are careful that value analysis does not become just another name for cost reduction by making certain that men actively engaged in it are qualified, well-trained men. The goal of everyone in the value analysis activity is to improve the cost reduction effort greatly by removing large amounts of cost instead of merely 5 or 10 per cent. Such savings can be, and are being, developed within the training courses provided where actual, "live" projects are used.

### FUNCTIONAL APPROACH BASIC

Of the value analysis techniques, probably the most basic is the functional approach. Even though this is one of the oldest and most widely accepted techniques, it is not being generally used. People continue to try to make a *part* for less instead of obtaining the *function* of that part for less.

To illustrate—I recently visited a plant using large tubes through which electrical cables were passed. As these tubes cost approximately $5 each, the engineer had encouraged some individuals to find a lower-cost substitute for them. The men had studied a number of different possibilities for replacing the tubes, but none of them offered much—if anything—more than the method which was being used. Finally, the question was asked: "What do the tubes do?" A check was made with

ıe engineer, and it was found that the tubing provided an insulated ıpport for cables. Immediately it came to light that a large plastic amp would do the job for one-tenth the cost.

What is the part? What does it *do*? These are the most important uestions you can ask. Then—what else will do the job and what would *ıat* cost?

### IVISION INTO FUNCTIONAL AREAS

Another technique of value analysis is division into functional areas. his can be described by the example of a low-volume job-shop switch, ıted at 600 volts, 10 amperes, which originally cost $118. By dividing ıis cost into functional areas, the following comparisons were made:

| | |
|---|---|
| Electrical | $13 |
| Mechanical | 10 |
| Case and cover | 50 |
| Labor and overhead | 45 |

Immediately we see that the cost of $50 for the case and cover is :cessive when compared with the total electrical-mechanical function ɔst of $23. After the technique of dividing into functional areas had een applied, the cost of case and cover was reduced to $14. A by-roduct of the analysis was the reductions made in the other functional :eas. The switch, as a result of these reductions, is now produced for 35. A total of $53, or 45 per cent of the original cost, was removed.

### REATIVE THINKING—FORGETTING THE PAST

Still another technique that is widely publicized but perhaps less idely used is creative thinking. Some find it extremely successful, though many people feel it is too illogical an approach for adults.

All throughout the various types of education we are taught to use ındrails. In college, we are assigned a problem, we look back in the ıapter and find the correct formula, we plow in the facts given in the :oblem, and we get the answer—the one in the back of the book.

In industry we try to do the same thing. We are assigned a problem, ıd we look back in the files, in the blueprints, to see how we did it ıe last time. We then add a bit of new information and come up with ıe answer. In other words, we cling to the handrails of what we did the past.

Creative thinking is *forgetting* the past, casting out for solutions, oking for new and different solutions. Many casts may be necessary, ıt one good strike is all we need to pay really big dividends.



### MORE INFORMATION AT POINT OF DECISION

Another approach to changing attitudes and providing new answers to get a job done is to provide more new information at the point of decision making. For example:

- Instead of making special handles for $8, a specialist can make a better handle for $2.
- Instead of spacers made of tubing or solid bar, rolled spacers can be provided for one-half to one-tenth the cost.
- In place of molded or cut gaskets, gun-squirted rubber can be used. In one application, a molded gasket cost 11 cents, the rubber one cent—a saving of $80,000.
- Everyone knows about cold heading, but still new applications are found for it—among them a spacer stud—originally an 8-cent screw machine part, which now costs .8 cent as a cold-headed part.
- Standard extension and compression springs are now available. For instance, a large spring 8 or 10 inches long can be purchased off-the-shelf singly for $2.

### LOOKING FOR THE GOOD

Thus, through training in the use of appropriate techniques and through providing the necessary information, people can actually be changed. But, until everyone can be trained and have the experience of successful value analysis, it still will not be easy. Untrained people still will resist change; so to get good ideas accepted will require skillful handling, salesmanship, and human relations.

People continue to be more expert at finding fault with ideas than finding the good in them. This is because we are trained by management to be critical. For example, if we have an idea and are unable to find fault with it, it is adopted. If it proves successful, what happens? Nothing—this is what we are paid for. If, on the other hand, an idea is adopted and gets into production, and something proves to be wrong with it, then what happens? Field complaints—we hear about it in no uncertain terms. Management generally recognizes that we all make mistakes; but, if we make too many, there is a term for it—our continuity of service is affected.

We must recognize that *all* ideas have both good and bad in them. We must recognize that everything we use has objections but that these are minimized with respect to the good points. So, in every case, we must develop our expertness in looking for the good, then recognize the

## Costs

The attached sheets give some general information on costs including:

1. Some of the elements of cost which make up Product Cost, Manufacturing Cost and Selling Price.
2. Relative Costs of commonly used materials.
3. Cost of various machine operations.

## Caution

This material is handed out only to give indication of relative costs and the various types of cost information that should be factored into decisions which influence product costs.

It is not intended as up-to-date cost information which is accurate for any specific set of circumstances.

Cost information of this nature should be obtained from particular sources concerned with a specific product, process or material. Some of these sources are:

Manufacturing specialists.
Methods or planning personnel.
Cost accounting.
Purchasing.
Specialty vendors.

## Make Up Of Product Cost

Product Cost = Material + Direct Labor + Overhead

### Material

This consists of material in any form of completion as it is received into the division using it, either from the vendor, from another Company plant or from a contributing plant. It may be raw material or it may be a finished component.

Raw Stock
Partly finished part
Finished parts
Assemblies (From either a vendor or another operation)

### Direct Labor

The pay of the workers, who normally touch the part or the machine, who handle it, usually changing its characteristics, form, shape or size. This does not include the repair of the machines by merely the attendant who operates the machine as it changes the form of the material. This does not include merely handling the material - moving it from one part of the factory to another.

Overhead or IME = Variable Overhead Plus Fixed Overhead

This includes all necessary expense to keep direct labor operating efficiently such as power, heat, light, handling, maintenance of equipment, depreciation, rent, idle time, overtime, non-durable tools, telephones, janitor service, salaried office help, etc.

| Variable Overhead | Fixed Overhead |
|---|---|
| Supervisors | Buildings |
| Foremen | Grounds |
| Material Handlers | Watchmen |
| Clerks | Heating |
| Sweepers | Taxes |
| Maintenance of Machines | Insurance |
| Nondurable tools | Etc. |
| Supplies | |
| Fringe Benefits | |

## Make Up Of Manufacturing Cost

Manufacturing Cost = Product Cost + Engineering Cost + Box, Pack and Ship

### Product Cost

As previously detailed.

### Engineering Cost

This expense is for all engineering, cost of tooling and customer complaints. It represents engineering and drafting salaries, cost of instruction books, sample devices, jigs, fixtures, dies, blueprints, etc.

1. To liquidate development cost.
2. To continue development to improve the product.
3. Necessary Engineering on problems arising constantly.
4. To liquidate cost of similar unsuccessful developments.
5. Cost of production dies, jigs, fixtures, molds.

### Box, Pack and Ship

This covers the boxing of the completed product, packing it and transporting it internally.

## Make Up Of Selling Price

Selling Price = Manufacturing Cost + General and Administrative Costs + Profit

### Manufacturing Cost

As previously detailed.

### General and Administrative Costs

This covers the expenses of the commercial division and the administrative officers of the company.

### Profit

This is the amount which is added to provide earnings.

- Average Cost - 1953 Base

Some Commonly Used Materials Arranged Progressively

| Cost per lb. | | Dollars per unit volume | |
|---|---|---|---|
| Material | $ | Material | Per cu. in. |
| Tantalum | 42.00 | Tantalum | 25.00 |
| Silver, 16 oz. | 14.00 | Silver, 16 oz. | 5.35 |
| Molybdenum | 12.00 | Molybdenum | 4.30 |
| Beryllium Copper | 2.00 | Beryllium Copper | .63 |
| Trodoloy | 1.86 | Trodoloy | .56 |
| Textolite Fiber | 1.25 | Tin | .32 |
| Tin | 1.21 | Phosphor Bronze 8% | .25 |
| Magnesium Sheet | 1.05 | Nickel Sheet | .25 |
| Textolite, Paper | .80 | Stainless Steel, 347 Sht. | .20 |
| Phosphor Bronze, 8% | .78 | Drill Rod | .20 |
| Nickel, Sheet | .77 | Monel | .17 |
| Stainless Steel, 347 Sht | .70 | Stainless Steel, 302 Sht. | .16 |
| Drill Rod | .70 | Copper Sheet | .16 |
| Monel | .60 | Bronze, Commercial, 90% | .15 |
| Stainless Steel, 302 Sht. | .57 | Stainless Steel, 347 Bars | .14 |
| Stainless Steel, 347 Rod | .50 | Yellow Brass, Sheet | .14 |
| Copper, Sheet | .50 | Stainless Steel, 302 Bar | .11 |
| Bronze, Commercial, 90% | .48 | Cast Steel | .08 |
| Yellow Brass Sheet | .46 | Lead Pig | .08 |
| Aluminum, 24 S Sheet | .42 | Malleable Iron | .07 |
| Stainless Steel, 302 Bar | .40 | Textolite, Fiber | .06 |
| Aluminum 24 S Rod | .40 | Spring Steel | .06 |
| Aluminum 2 S Rod | .36 | Magnesium Sheet | .06 |
| Aluminum, 2 S Sheet | .33 | Zinc, Pig | .05 |
| Cast Steel | .30 | Cast Iron | .05 |
| Malleable Iron | .25 | Aluminum 24 S Sheet | .04 |
| Spring Steel | .20 | Textolite, Paper | .04 |
| 118 Plastic Mold Comp | .20 | Aluminum, 24 S Bar | .04 |
| Zinc, Pig | .19 | Aluminum,2 S Bar | .03 |
| Lead, Pig | .19 | Aluminum, 2 S Sheet | .03 |
| Cast Iron | .18 | Silicon Steel Elec | .02 |
| Silicon Steel, Elec | .08 | Carbon Steel, C.R.& H.R. Rod | .015 |
| Carbon Steel, C R Sheet | .06 | Carbon Steel, H.R. Sheet | .015 |
| Carbon Steel, Bar Plate | .05 | [illegible] | [illegible] |
| Carbon Steel, H.R. Sheet | .05 | 118 Plastic Mold.Comp. | .01 |

Note: The average costs shown above are to be used as a rough guide only. For accurate costs consult your Material Buyer.

## Relative Material Costs

### 1953 Base

| | Price/100 lbs. |
|---|---|
| Low Carbon Steel Bar<br>Hot Rolled - Cold Drawn | 4.55 - 6.55 |
| Low Carbon Steel-Plate<br>Structural - Flange Quality | 4.10 - 5.05 |
| Low Carbon Sheet & Strip<br>Hot Rolled-Cold Rolled | 3.95 - 5.45 |
| Stainless Steel Bar and Rod<br>410 - 317 (18-8) | 28.75 - 68.25 |
| Stainless Steel Sheet<br>410-310 | 40.75 - 72.35 |
| Stainless Steel Strip | |
| Hot Rolled - 410 - 310 | 26.25 - 67.50 |
| Cold Rolled - 410 - 310 | 34.25 - 78.75 |
| Copper Bar and Rod<br>Hot Rolled - Commutator Copper | 46.83 - 52.83 |
| Copper Sheet & Strip<br>Tough pitch - Brush Copper | 48.51 - 51.51 |
| Brass and Copper - Seamless Tubing<br>Yellow Brass - Nickel Silver | 45.78 - 75.71 |
| Brass & Bronze Rod | |
| Yellow Brass - Phos. Bronze | 36.68 - 53.70 |
| Phos. Bronze - Beryllium Cu. | 53.70 - 165.00 |

## Machine Speeds

| | | Operations per Minute | 1953 Base Average Cost Per 1000 |
|---|---|---|---|
| Punch Press-High Speed Auto. | 4 tons | 250-400 | $ .25 |
| Cold Header 1/8" Stock | | 175-300 | .35 |
| Punch Press-High Speed Auto. | 15 tons | 150-250 | .40 |
| Punch Press-High Speed Auto. | 25 tons | 125-200 | .50 |
| Cold Header 1/4" Stock | | 100-175 | .60 |
| 4 Slide Machine Light | | 75-175 | .60 |
| Punch Press 60 tons | | 75-150 | .65 |
| Cold Header Heavy | | 50-160 | .75 |
| 4 Slide Machine Heavy | | 50-125 | .75 |
| Punch Press-Hand Feed (Blank) | 75 tons | 50-125 | .75 |
| Punch Press-Hand Feed (Blank) | 300 tons | 40-80 | 1.25 |
| Thread Roller | | 40-80 | 1.25 |
| Screw Head Slotter | | 30-60 | 1.50 |
| Automatic Wire Cutter & Stripper | | 30 -60 | 1.50 |
| Dial Tapper | | 30-50 | 1.80 |
| Punch Press-Forming-Slide Feed | | 30-40 | 2.25 |
| Punch Press-Forming-Hand Feed | | 15-30 | 3.00 |
| Tapping Machine-Foot Operated | | 15-25 | 3.75 |
| Tubular Riveting Machine | | 8-15 | 5.50 |
| Resistance Welding Machine | | 5-10 | 10.00 |
| Centerless Grinding Machine | | 2-8 | 12.00 |
| Molding Machine-Thermoplastic | | 1-4 | 25.00 |
| Brazing Machine | | 1-2 | 40.00 |
| Molding Machine-Thermosetting | | 1/2-1 | 100.00 |

## Operation Speeds

| | Operations per Minute | 1953 Base Average Shop Cost per 1000 |
|---|---|---|
| Take Micrometer Reading | 5-8 | $12.00 |
| Use GO & NOGO Snap Gage | 10-15 | 6.00 |
| Stamp Part with Hammer | 15-20 | 5.00 |
| Stamp Part with Rubber Stamp | 20-30 | 3.00 |
| Drill Small Hole--Drill Press | 4-8 | 15.00 |
| Pierce Small Hole --Punch | 20-30 | 3.00 |
| Wrap Part in Tissue & Seal in Carton | 2-5 | 25.00 |
| Position Part in "Egg Crate" Carton | 10-15 | 6.00 |
| Pick Up & Position Part in Fixture | 15-30 | 4.00 |
| Pick Up & Drop Part in Fixture | 30-50 | 2.00 |
| Pick Up, Start, & Hand Drive Small Screw | 3-6 | 20.00 |
| Pick Up, Start, & Air Drive Small Screw | 10-12 | 7.00 |
| Power Drive Small Screw--Hopper Feed | 10-20 | 4.00 |
| Rivet with High Speed Hammer (2) Parts | 4-8 | 15.00 |
| Resistance Weld (2) Parts | 5-10 | 10. 00 |
| Tubular Rivet (2) Parts | 8-15 | 5.00 |
| Cut-Off Small Tubing - Screw Machine | 5-10 | 10.00 |
| Cut-Off Small Tubing - Abrasive Wheel | 30-60 | 1. 50 |
| Count Parts Visibly | 60-120 | .75 |
| Sort Handful of Parts (2) Stacks | 60-100 | 1.00 |
| Deburr Small Screw Machine Part | 7-12 | 10.00 |
| Polish Head of Chrome Plated Screw | 5-12 | 15.00 |
| Draw Arc & Hand Weld 1" Pass | 3-6 | 20.00 |
| Ream Hole--Drill Press | 2-10 | 20.00 |

## Relative Material Costs
Prices as of March 1961
Based on 100 lb. Quantities

| Material | Form | Price/lb. | |
|---|---|---|---|
| Copper (Hard Rolled) | Sheet | .93 | |
| Brass (Cartridge) 70% cu. | " | .88 | |
| Aluminum (5052) | " | .80 | |
| Steel C.R. (Commercial - 1010) | " | .20 | |
| Steel H.R. " | " | .18 | |
| Steel Stainless (302-304) | " | .80 | |
| Magnesium (AZ31BH24) | " | 2.12 | |
| Beryllium Copper | "(light to heavy gage) | 3.35 | 2.85 |
| Copper | Bar and Rod(extruded) | .89 | |
| Brass (Free turning) | " " " | .70 | |
| Aluminum | " " " | .85 | |
| Steel 1112 | " " C.R. | .26 | |
| Steel Low carbon | " " H.R. | .17 | |
| Steel Stainless (302-304) | " " | .82 | |
| Magnesium (AZ61A) | " " | 1.40 | |
| Beryllium Copper | small to large (3/8 up) | 2.85 | 2.60 |
| Copper OFHC up 25% | Shapes (extruded) | 1.00 | |
| Brass | " " | .90 | |
| Aluminum | " " | .76 | |
| Steel H.R. | " | .18 | |
| Steel Stainless H.R. | " | .73 | |
| Magnesium (AZ31B) | " " | 1.17 | |
| Copper | Tubing | .98 | |
| Brass | " | .95 | |
| Aluminum | " | 1.16 | |
| Steel C.R. Seamless | " small (1/2") to large(to 4"O.D.) | .80/ft. | 1.50/ft. |
| (Welded 15% less) | over 4" O.D. | 2.25/ft. | |
| Steel Stainless | Tubing small(1/4O.D.) to large (1 1/4 O.D.) | 1.00 | 4.77 |
| Magnesium AZ31B | Tubing | 1.32 | |

DEFINE FUNCTIONS

JE A 3

VALUE ENGINEERING TRAINING SEMINAR

30 July 1963

## Verbs and Nouns Used to Define Functions

The function of an item or product is best defined when the description is reduced to a verb and a noun.

There are two types of functions: those which make the product work; and those which make the product sell.

A work function is best described when the noun selected indicates a quantitative or measurable parameter.

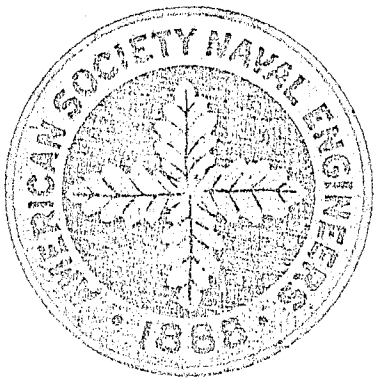
The following list is a sample of verbs and nouns used to define functions:

### Work Functions

| Verbs | Nouns |
|---|---|
| Support | Weight |
| Transmit | Torque |
| Enclose | Load |
| Collect | Oxidation |
| Conduct | Light |
| Insulate | Heat |
| Protect | Flow |
| Prevent | Radiation |
| Amplify | Current |
| Rectify | Voltage |
| Change | Pressure |
| Interrupt | |
| Shield | |

### Sell Functions

| | |
|---|---|
| Increase | Beauty |
| Improve | Appearance |
| Create | Convenience |
| Establish | Style |
| | Prestige |
| | Features |
| | Form |
| | Symmetry |
| | Effect |




# THE COST OF FINISHES AND TOLERANCES

RICHARD C. JOHNSON

Reprinted from The

JOURNAL
of the
AMERICAN SOCIETY
of
NAVAL ENGINEERS
Inc.

NOVEMBER, 1958

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# THE COST OF FINISHES AND TOLERANCES

THE AUTHOR

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## INTRODUCTION

A GREAT DEAL of time and effort has been spent in cost reduction through the use of new materials, new processes, new production methods, and many other items, once the design has been established. But surprisingly little attention has been given to some of the factors in design which set these costs.

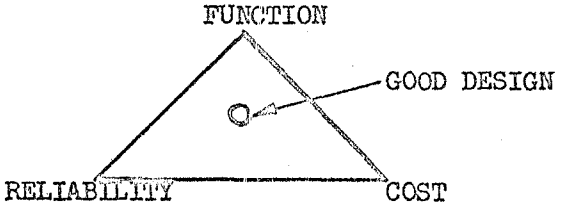
Once the designer develops the shape of his part as required by its usage, decides on the material to specify and specifies tolerances and finishes, he has pretty well set the price of his item, particularly with equipment purchased by the Government. The ultimate producer who is usually chosen by competitive bidding has very little room to use his initiative or imagination. Design, material requirements and everything else of pertinence are specified in detail. About all he has to play with is labor and overhead. Labor has become fairly standardized since the minimum wage laws, and as overhead is usually tied in directly with labor, he is pretty well strapped.

The designer usually selects his material for strength, durability, availability, and somewhere down the line is cost. As the design engineer's primary responsibility is to design a functional, reliable item, the cost becomes of secondary consideration. Even if he is conscious of cost, he usually has neither the time nor facilities to really determine the cost of his various alternatives. Practically no consideration is given to the cost of tolerances and finishes. And yet, these are two items where considerable savings can be achieved in almost every case.

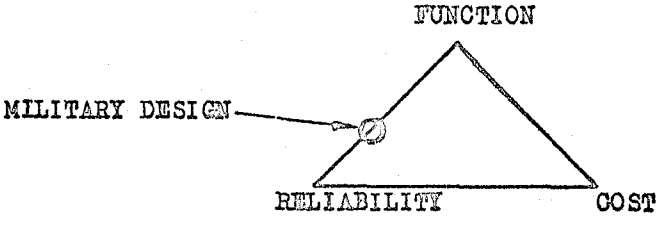
The designer has little more than common sense bolstered by limited experience and intuition to guide him in selecting finishes and tolerances required. And his judgment is many times overshadowed by his professional pride, which in an engineer makes him want to make his equipment, the results of his design, as nearly perfect as he can. In equipment this attitude is reflected in practically all specifications which carry the phrase, "best material and workmanship required." How much this phrase has cost over the years would be hard to imagine! Of course, in the interests of economy of material, machine and man hours and eventually money, we should design our equipment to be only as good as the job or function requires it to be. Anything beyond this is unnecessary waste! To quote from Doctor Vannevar Bush: "There is a common notion that during war costs do not count. There is no greater fallacy. The error comes from the belief that civilian resources are unlimited. They are not. . . . When war comes . . . only a limited amount of materials and manpower is available and the whole problem is to distribute these in optimum manner to secure the desired result."* It has been said that with enough

*From *Modern Arms and Free Men*, by Dr. Vannevar Bush.

time and money our American engineers can design anything. And again, any good engineer can reduce the cost of any piece of equipment by cheapening it, substituting materials, and in many other ways. But the real test of engineering at its finest is when the proper combination of function, reliability and cost is achieved. When equipment is designed to do its required job, no more and no less, perfection in engineering is achieved. This is very difficult to do and in an effort to make sure the function is performed or reliability achieved, the military engineer usually goes to the extreme and overlooks cost. This could be compared to a triangle with the apex of the angles being function, reliability and cost.




The proper combination of all three requirements would cause a design to be somewhat in the center. Too much emphasis on any one requirement detracts correspondingly from the other two. For example, an engineer's emphasis on reliability puts his design in a position like this:




In the automotive field, this blending of function and cost is probably more nearly achieved than in any other field of engineering. Batteries with 18 months' guarantee usually last just that long. A few give out sooner and a few last longer, but the majority last just that long. There are many other examples. But in the following paragraphs an attempt will be made to give examples of equipment that is considerably overdesigned and the resultant cost, as well as some guidelines in achieving the required function at minimum cost.

## FINISHES

In the commercial field, a metal product can be satisfactory from a functional viewpoint, but unsatisfactory from an appearance standpoint. This can be a handicap in a competitive market where any slight advantage of one piece of equipment over another can mean the difference between making or losing a sale. This has resulted in many types of surface finishes, polished, plated, enameled and many others which serve no functional purpose, but do add to appearance and saleability. Unfortunately much of this has been carried over into the military field. In designing military equipment, appearance should play a very minor part. Any piece of metal which is polished or ground to a finish finer than that required by its use is an overdesigned and overexpensive piece of equipment.

At one time it was thought that fine surface finishes, in the neighborhood of 5-10 RMS micro-inches on marine reduction gears considerably reduced noise and added to the gear's load-carrying ability. Through controlled tests this was found to be not so, and it was found that the method of achieving surface finish was more important in determining load-carrying ability than was the finish. Charts 1 and 2 show the results of these tests. Accelerated endurance tests were run on a standard nickel moly steel to determine life of the material with various types and values of surface finishes. From Chart 2, it can be seen that ground and electropolished finishes lasted considerably longer than the other types tested. From Chart 2, it can also be seen that, contrary to previous indications, the coarser electropolished finish had greater endurance than the finer ground finishes.

This is somewhat borne out by the Chrysler Motor Company's experience with superfinishing. At one time superfinishing was specified for automotive piston skirts, brake drums, cam surfaces and tappet barrels and heads. These requirements grew out of laboratory tests, which showed possible increased performance. In actual service experience it was found that fine surfaces required a longer break-in time, sometimes longer than the allowable time, and parts were scuffed. When rougher surface finish was allowed, high initial wear followed which provided adequate smoothness for stable operation.

The same basic reasoning can be applied to tolerances on machined parts, drilled holes, etc. Any tolerance that is tighter than is required for the particular function of the part is a waste of man and machine time, and thus money. In every case that a tolerance can be increased without adversely affecting the product, it will result in a real decrease in manufacturing cost. It is always the last few increments which are the most costly, whether they are in tolerances, finishes or any other field. The smaller the margin of error tolerated, the more costly the operation.

In the competitive commercial field, extreme tolerances and finishes are often encountered. But

* From Modern Arms & Free Men by Dr. Vannevar Bush

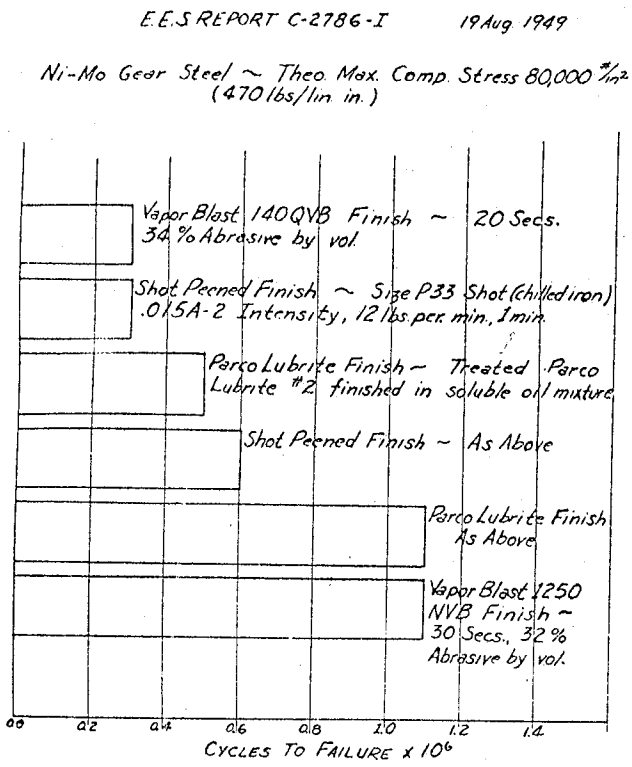



Chart 1

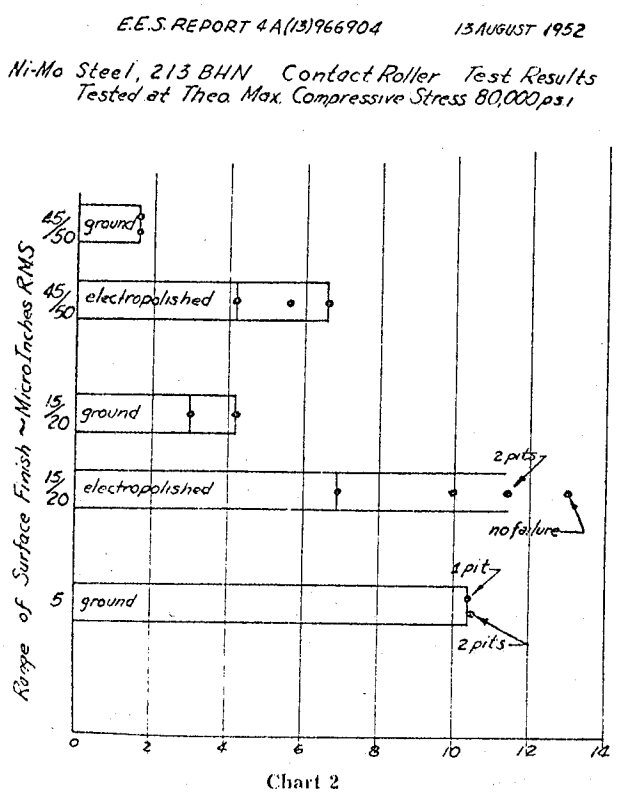



Chart 2

there, at least through the competitive process, the odds are that these areas will eventually be highlighted, evaluated as to cost versus function, and eliminated. In the field of military engineering, there is less likelihood. Once tolerances and finishes are put into a piece of equipment, and that equipment is working satisfactorily, there is a natural reluctance to change any part of it. After all, those who have been designers know many of the unforeseen and unknown factors which go to make a seemingly perfect design unworkable. So here once again, the factor of reliability comes into view to resist change and to perpetuate any overspecification.

There are many examples where sizeable savings have been achieved by recognizing these areas of overspecification and having them changed.

A. On a carrier of the Forrestal Class, there were hundreds of armored hatches which were ground smooth at a tapered surface and fitted to a sealing fit. The hatches didn't seal on the tapered surface but on the flat surface above. A burning cut would provide an acceptable surface finish for the function on the tapered surface. Something around 1000 micro inches. Yet few of the people involved were satisfied with less than a finished surface. Anything else is too expensive for the job.

B. In the installation of a reduction gear on a CVA, Naval Shipyard personnel proposed to re-assemble the unit in the shop instead of on board. There was considerable discussion with the manufacturer and the Bureau about the possibility of maintaining alignment. The requirements of plus or minus one one thousandth (±.001) on the shaft were quite extreme for service requirements. Then a mistake by the manufacturer was discovered which called for a re-alignment of more than ten thousandths (.010) of an inch. When it was found out this mistake would cost $2000, the shaft alignment was decided to be well within requirements. It is surprising how often putting a price tag on extreme requirements will assist in having them changed.

C. One more simple example. In a submarine, the Emergency Fresh Water Tanks were to be made of CRES steel sheet with a Number 4 surface finish, which cost 65¢ per lb. It was found that CRES steel with a Number 1 finish was all that was required for the job and cost 52¢ per lb. A savings of over $1000 was achieved, just by changing surface finish requirements.

Not only are tolerances of importance in the design stages, but they are also important in the interpretation of specifications. To illustrate: periodic inspection of anchor chains on all Navy vessels is required. Measurement for stretch and wear cannot be readily accomplished unless a vessel can avail itself of crane and pier facilities. On ships having a drydock period, the chain is laid out on the drydock floor, sandblasted, painted and measured. The Bureau of Ships standard drawing on anchor chains required that the overall length of six links be checked. A minus tolerance of 1/8" or a plus tolerance of 3/8" for each one-inch of wire diameter would be permitted. On this standard plan, in addition to tolerance, a maximum and a minimum dimension for a six-link shot of chain was given. Personnel involved inter-

## Comparative Charts on Surface Finish

| Surface Roughness in Micro-Inches | Approximate Relative Cost |
|---|---|
| 500 | 100 % |
| 250 | 250 % |
| 125 | 500 % |
| 63 | 1100 % |
| 32 | 1800 % |
| 16 | 3500 % |
| 8 | 6000 % |

| Symbol Designation | Comparative Micro-Inch Finish |
|---|---|
| Rough "f" (File or Grind) | 500 |
| Rough "f" (Machine) | 250 |
| "f" (Standard) | 125 |
| Fine "f" | 63 |
| Journal "f" | 32 |
| ---- | 16 |
| Lapp "f" | 8 |

Chart 3

preted this to mean nominal dimensions plus allowable tolerance. Any section of chain having 6-link sections beyond this measurement was recommended by the Shipyard for survey. This was also used for the manufacture of new chain. Any chain measuring between the maximum and minimum tolerances was acceptable. A new chain near the maximum dimension would have little stretch before it would exceed the allowable tolerance. The purpose of all of this was to interpret chain strength by the amount of stretch. In this case when it was decided to add allowable tolerance to the maximum plan dimension, it was found there were 175 shots of chain within the new allowable tolerance that had been rejected the year before. These were reclaimed at a savings of $75,560. All in all, it was estimated in 1956 that a savings of $98,000 was achieved with the more liberal interpretation of the requirement. The chain was the same as before, and satisfactorily performed its function. Yet under one interpretation it was considered unsuitable.

When tolerances and finishes are once looked at with the view of what is the *maximum* tolerance and surface finish one can accept, rather than what is minimum one can specify, progress in cost reduction begins to be achieved. You will find you are getting

## Comparative Cost on Various Methods of Machining Holes

(Based on Lowest Cost @ 100% - Quantity 200 Pieces)

| Method | Lowest Tolerance Possible | Comparative Cost Tool Cost | Comparative Cost DL Cost* |
|---|---|---|---|
| Punch (Template) | +.004 −.002 | 100% | 100% |
| Drill (Jig) | +.007 −.002 | 175% | 300% |
| Drill & Ream (Jig + Bushings) | +.0006 −.0000 | 225% | 400% |
| Bore (Fixture) Incl. punch, rough & finish bore on Borematic | +.0004 −.0000 | 540% | 700% |
| Hone or Lap (Fixture) Incl. Punch & Bore | +.0002 −.0000 | 730% | 1100% |

* The setup costs, based on 200 plate quantity (.180" thick brass plate 3.50 x 5.00 size) have been included in the direct labor costs

Chart 4

## Cost Data on Machining Operations

(Based on Quantities of 1000 Pieces)

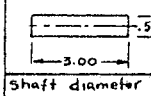
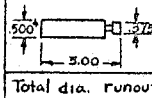
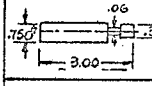
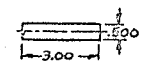
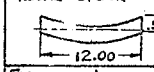
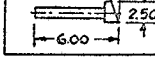
| Typical Examples (Steel) | Tolerance | Operations | Approx. Cost Labor and Tools |
|---|---|---|---|
| Shaft diameter   | ± .002 Stk<br>± .001<br>+.0000 −.0005 | c/o<br>Turn c/o<br>Turn, c/o, Grind | 100%<br>425%<br>460% |
| Shaft diameter   | ± .002 Stk<br>± .001<br>+.0000 −.0005 | Turn, Form, c/o<br>Turn, Form, c/o<br>Turn Form c/o Grind | 100%<br>130%<br>140% |
| Total dia. runout   | .005<br>.001<br>.0002 | Turn Form c/o<br>Turn Form c/o<br>Turn Form c/o Grind | 100%<br>130%<br>165% |
| Length of shaft   | ± .02<br>± .005<br>± .001 | c/o<br>c/o<br>Face, c/o | 100%<br>110%<br>150% |
| Straightness per foot Round Stock   | .005<br>.001<br>.0002 | Straighten<br>Straighten + Grind<br>Straighten + Grind | 100%<br>375%<br>1250% |
| Face run-out   | .005<br>.001<br>.0005 | Turn c/o<br>Turn, Face, c/o<br>Turn, Face, c/o, Grind | 100%<br>200%<br>400% |

Chart 5

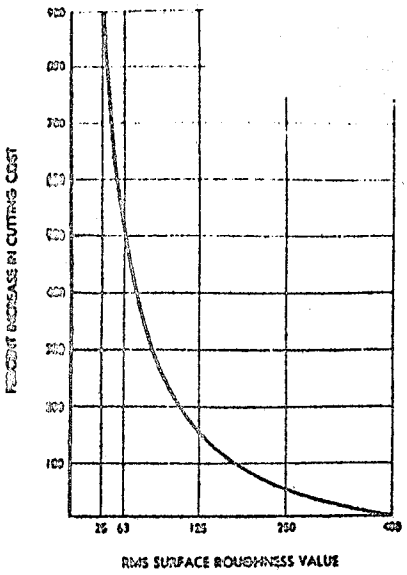
away from special parts in many cases. This means you are eliminating unnecessary variety and minor differences in component parts. This automatically leads into the field of standardization for many of these parts. Standardization is another subject and much has been written on it. It is sufficient to say that a few of the advantages are:

Fewer different parts to be purchased and stocked.

Greater production of standardized parts—less cost per part.

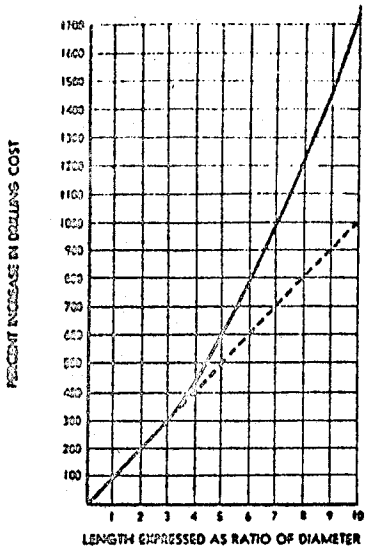
Less design time and drawings required.

There are many others of course, but these are the most important from the military engineer's view-



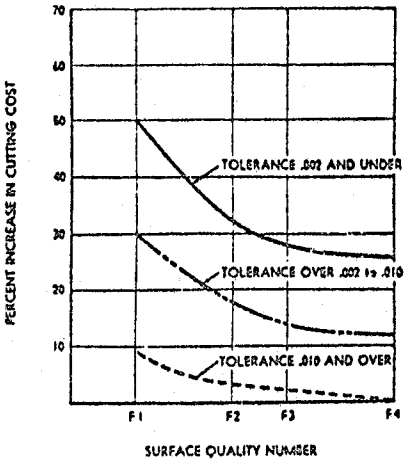

Cost Comparison Chart 1
Turning Cut
Varying Surface Quality

**Figure 1. Shows relative cost comparison with respect to surface quality standards and limited to the turning process as done on turret lathes.**



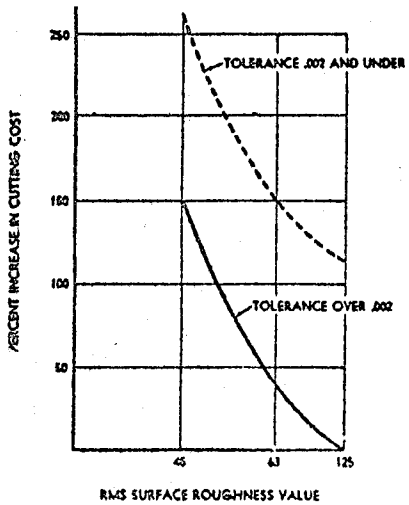

Cost Comparison Chart 2
Drilling
Varying Depth of Hole

**Figure 2. Illustrates the cost behavior of drilled holes. It is readily apparent that deep holes are expensive. Beyond the depth of three times the diameter, the cost rises more rapidly than equal increments of depth.**



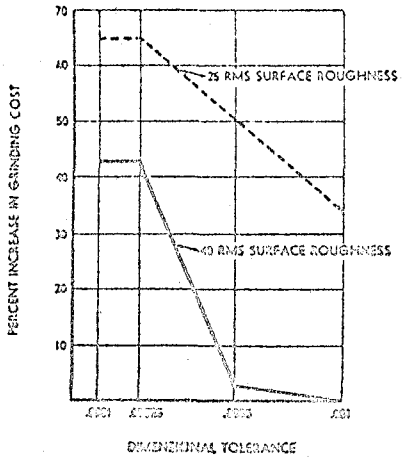

Cost Comparison Chart 3
Planing Cut
Varying Surface Quality
Varying Tolerance

**Figure 3. Illustrates a cost behavior chart on planning, demonstrating the effect of two quality variables, one—surface quality and the other dimensional tolerance. Surface quality is defined in coded numbers since RMS values do not express the desired control.**



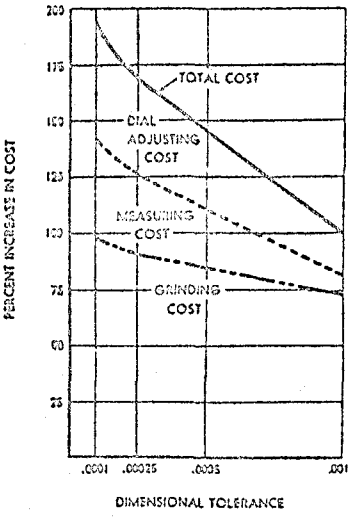

Cost Comparison Chart 4
Face Milling Cut
Varying Surface Quality
Varying Tolerance

**Figure 4. Illustrates cost behavior combining the same two quality variables as figure 3, but related to face milling.**




Cost Comparison Chart 5
Cylindrical Grinding
Varying Surface Quality
Varying Tolerance

**Figure 5. Shows cylindrical grinding cost, exposing a non-uniform cost behavior pattern.**




Cost Comparison Chart 6
Internal Grinding
Varying Tolerance

**Figure 6. Shows that reducing tolerance increases the cost of grinding, but also shows substantial cost increases occur from increased gaging and dial re-adjusting time required.**

point. One other factor the military engineer should consider when he is in the design stage is whether or not there is a standard commercial part available that will perform the same function. If not exactly suitable, could it be modified at less expense than designing a new part? Or better still, could the military requirements be relaxed without affecting function, to use the commercial part?

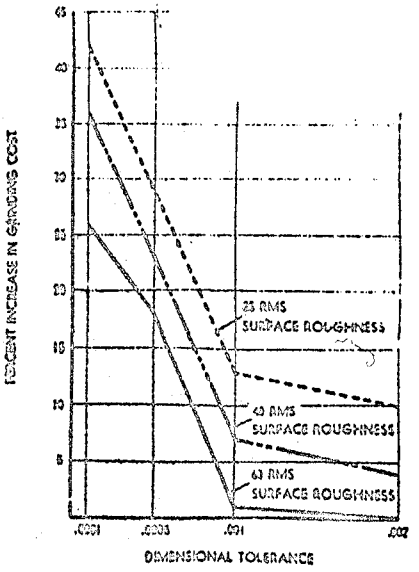
As an example, a military specification—MIL-T-18956 (SHIPS) of 4 October 1955 is in being on glass ash trays. This specification goes into detail on trueness and shape, color and marking required. In addition, a test procedure is set up for a 70° inclined test and a cigarette sliding out of its slot constitutes failure of the ash tray. A drawing is included of the ash tray with tolerances as well as of the test apparatus. These ash trays in the General Stores Supply Catalogue are carried at a cost of 30¢ each. The General Services Administration Catalogue carries a similar glass ash tray at 14¢ each, and a slightly smaller one, 4½" square, at a cost of 6¢ each.

### SOME DESIGN CONDITIONS

*Is the finish specified too extreme for the end use?*

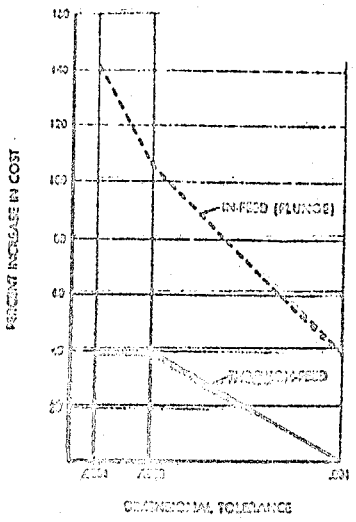
Mating metal parts are frequently machine finished. Could a throw-away rubber or other type of washer be used to get a seal? Example: A Philadelphia Naval Shipyard Value Engineering Project substituted throw-away rubber gaskets in submarine globe and angle valves in place of machined fit. Saves $99,360 yearly overhaul costs.

Is the finish specified too extreme for the production method? For example: many finishes are specified for castings, which are not only unnecessary from the use standpoint, but are very uneconomical in the production method. As a result much wastage of parts results, which



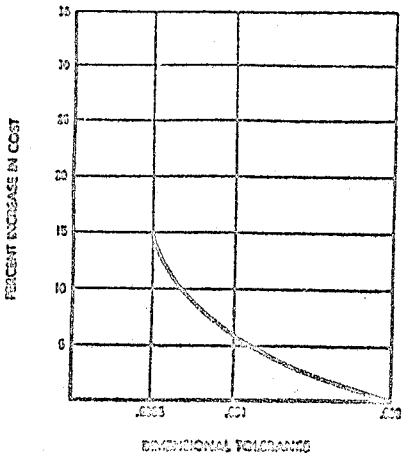

Cost Comparison Chart 7
Surface Grinding (Reciprocating)
Varying Tolerance
Varying Surface Quality

**Figure 7. Illustrates that in reciprocating or surface grinding, the dimensional tolerance range has greater cost effect than the surface quality range. It is apparent that cost rises sharply with tolerances less than 0.001 in.**




Cost Comparison Chart 8
Grinding (Centerless)
Varying Tolerance
Varying Design

**Figure 8. Demonstrates, as does Figure 2, the possibilities of incorporating quality features other than surface roughness or tolerance. The difference between the two curves is governed by the design of the part. In order to gain the benefit of the low-cost "through-feed" method on the centerless grinder, the ground diameter must be the largest dimension on the part. Should such design be impracticable, the engineer is guided toward selection of a generous tolerance for the resulting "in-feed" method in order to minimize cost.**




Cost Comparison Chart 9
Surface Grinding (Rotary)
Varying Tolerance

**Figure 9. Covers rotary surface grinding and demonstrates primarily that not in all cases is cost severely affected by quality variation. The full cost increase over the whole tolerance range is 15 percent and is by far the smallest of all the illustrations. Yet even here it is seen that more than half the cost increase occurs between the 0.001 and 0.0005 tolerances.**

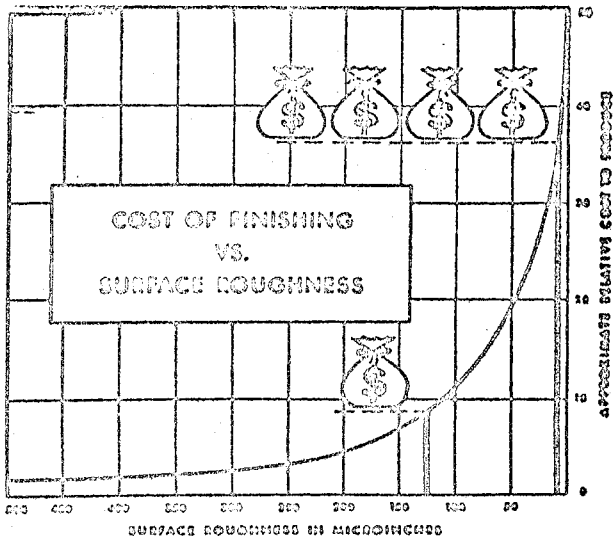



Figure 10. General Chart on Surface Roughness versus Cost.

the customer, of course, pays for. Consult the casting experts before specifying finishes and tolerances.

*Are tolerances specified practical and economical in view of end use?*

Many times in the past, on catapults, 12 sections, 40 feet in length, were machined with extreme accuracy, then installed and pulled out of shape by welding them together.

*Is the design restricted to one production method only, or is it flexible enough to lend itself to several methods enabling the most economical method to be used?*

One possible way of emphasizing the cost of finishes would be to have comparative surface finish blocks available to design engineers and shop personnel. In addition, charts should be made up to accompany these blocks showing the comparative costs of the different surface finishes. This would give those concerned a more realistic view of finish requirements vs cost.

*And finally to repeat, are all finishes and tolerances specified to the* maximum *allowed by the functional use?*

REFERENCES

1. "Manufacturing Costs as Related to Product Design"—Lad J. Bayer, Tooling and Production, August 1956
2. Radio Corporation of America, Shop Practice
3. Surfaces Can Be Too Smooth—C. R. Lewis & A. L. Thompson—The Tool Engineer, July 1956
4. Value Engineering and a Production Shop—William Wehrmann, Master Machinist, Marine, New York Naval Shipyard, Speech at Bureau of Ships Value Engineering Seminar, 19 January 1956

CHARTS

Charts 1 and 2—Engineering Experiment Station, Annapolis Credit

Charts 3, 4 and 5—RCA Corporation Shop Practice Credit

Figures 1 through 9—From Reference Number 1

RAYTHEON

CORPORATE OFFICE
OF
ENGINEERING SERVICES

ENGINEERING NOTES

19 Jan 61

# TOLERANCES AND COSTS - SURFACE FINISH

1. Performance and Profits. - The assignment of tolerances is the most important single engineering decision to affect product performance and cost. The inexperienced engineer plays it safe by adding an ignorance factor - tighten the tolerance, improve (?) performance, let the shop worry about making it!

2. Luxury of Perfection. - Surface roughness limits are one important form of tolerance. The mature engineer recognizes he must balance the need for smooth surfaces against the manufacturing costs of attaining them. Figure 1 shows the relative manufacturing costs for varying surface roughness limits (roughness height ratings). Must you have:

ABSOLUTE PERFECTION? AT INFINITE COST?

3. Typical Practice. - Figures 2 and 3 show the surface roughness resulting from typical manufacturing processes in normal good shop practice. Note that the less demanding your engineering requirement, the more flexibility there is available for manufacturing to meet your needs on time, at minimum cost.

4. Bibliography. - Data in this note are based on recent survey by American Standards Association Sectional Committee B46 and:

Tool Engineer's Handbook, 2nd edition, 1959,
American Society of Tool and Manufacturing Engineers,
Detroit, Michigan

Sheet Metal Manual, Section S2-4.2,
Raytheon Missile Systems Division

"The Cost of Finishes and Tolerances," R. C. Johnson,
Journal of the American Society of Naval Engineers,
November, 1958.

Process Handbook, Section V, Raytheon
Missile Systems Division, Lowell Plant

IF YOU LEAVE IT ROUGH
IS IT GOOD ENOUGH?

H. K. Sedgwick, Manager
Engineering Standards

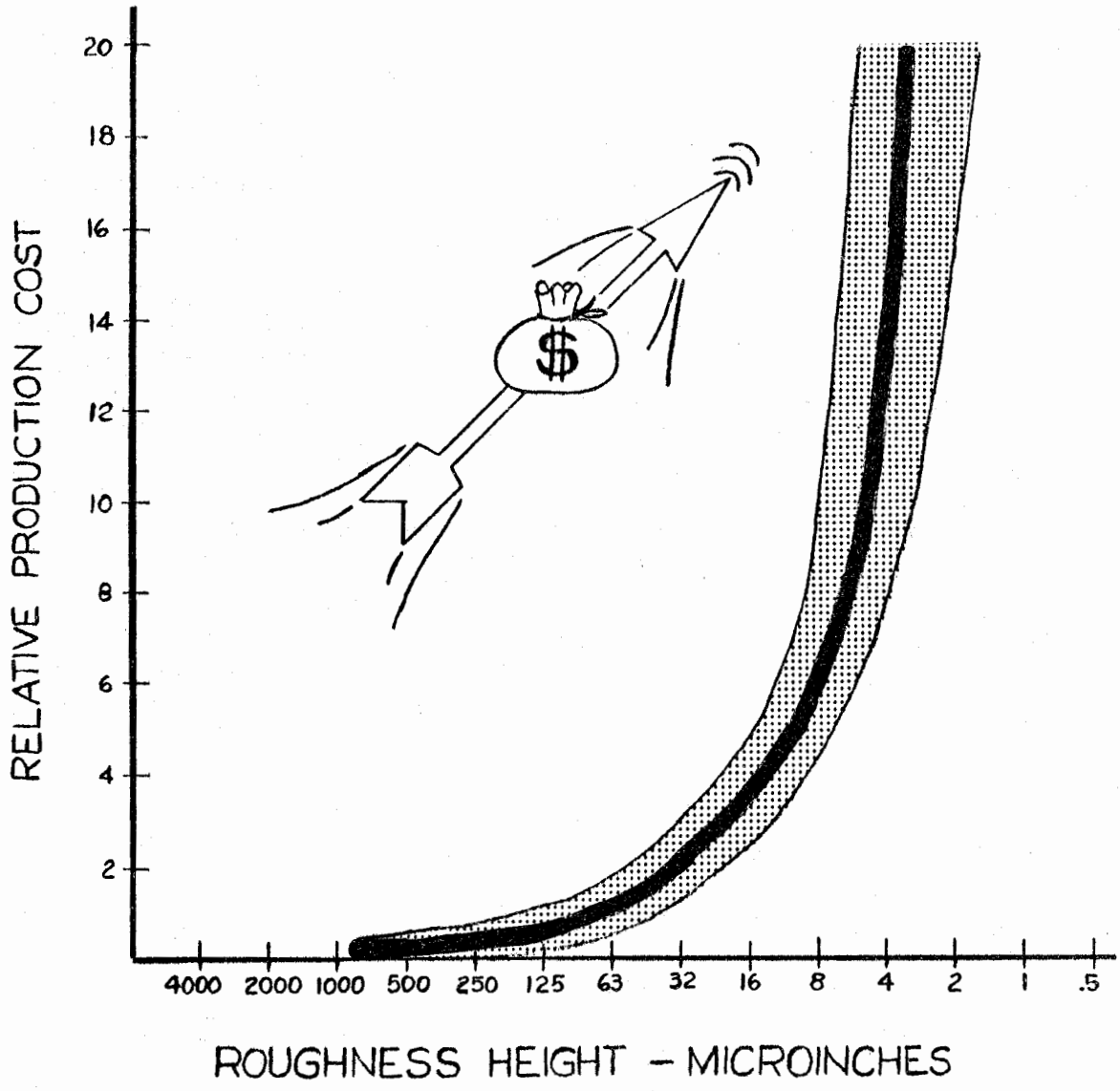



FIGURE 1. – SMOOTH SURFACES = HIGH COSTS

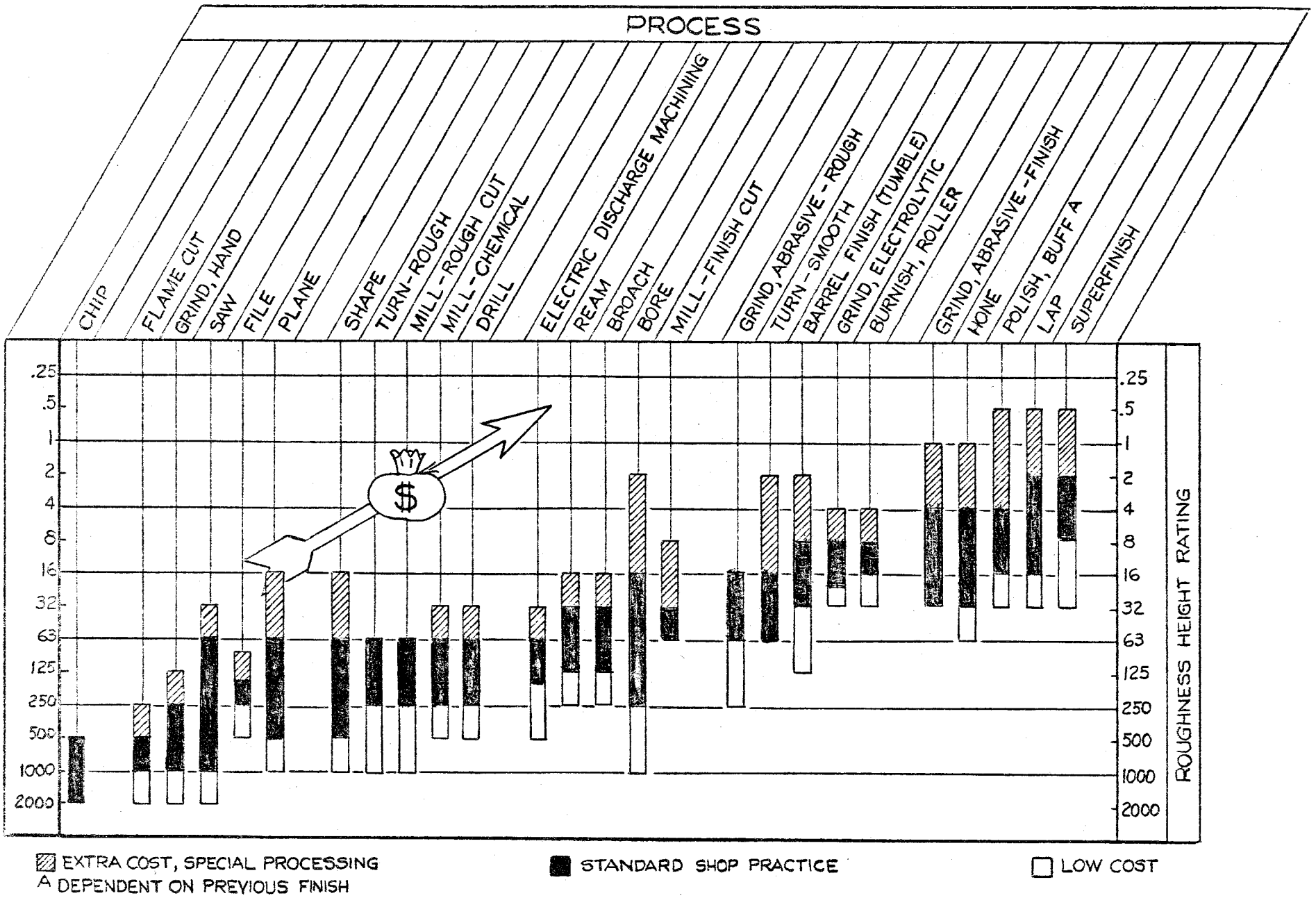



FIG. 2.-ROUGHNESS HEIGHT-MACHINED FINISH

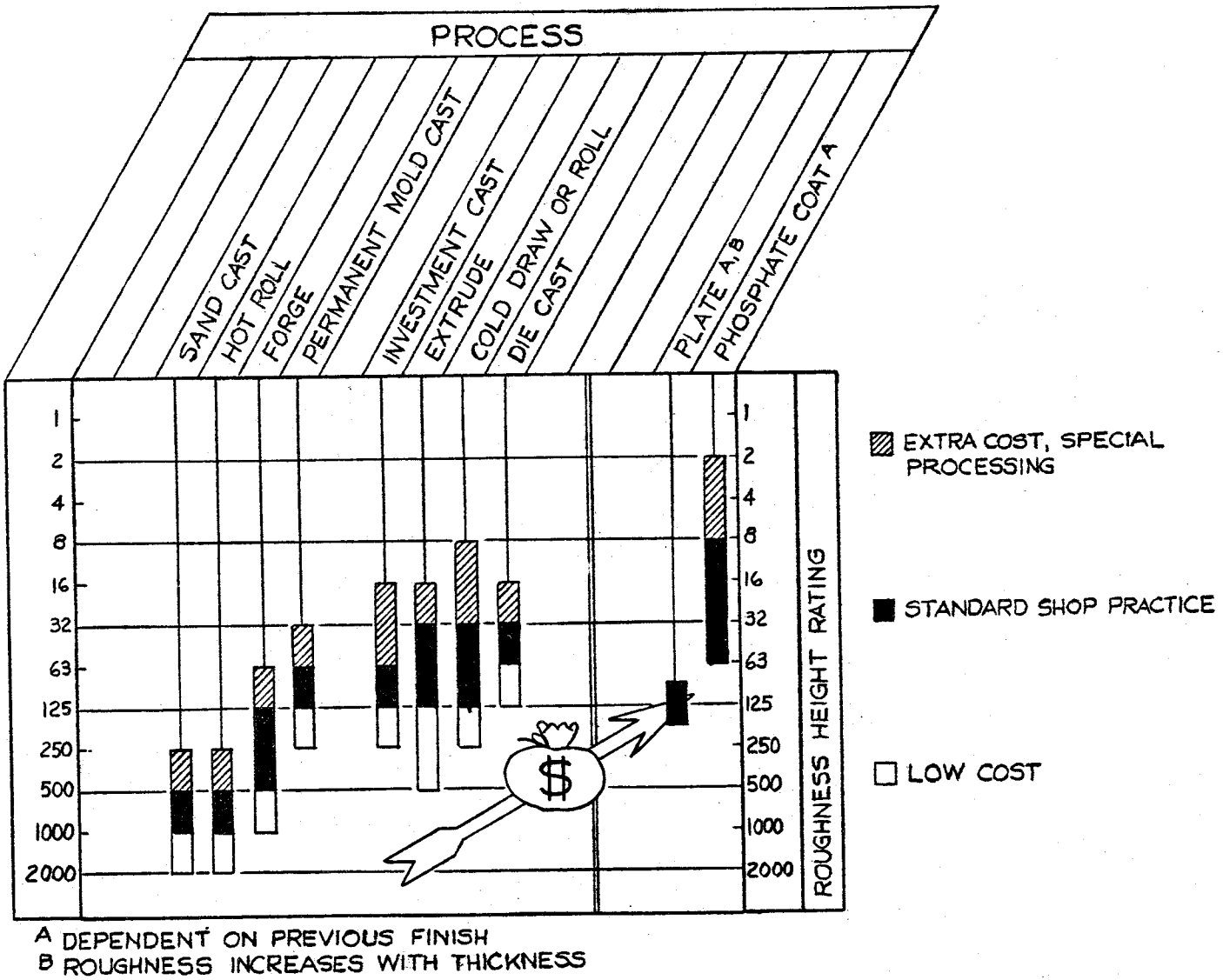



FIG. 3. – ROUGHNESS HEIGHT – MISCELLANEOUS FINISHES

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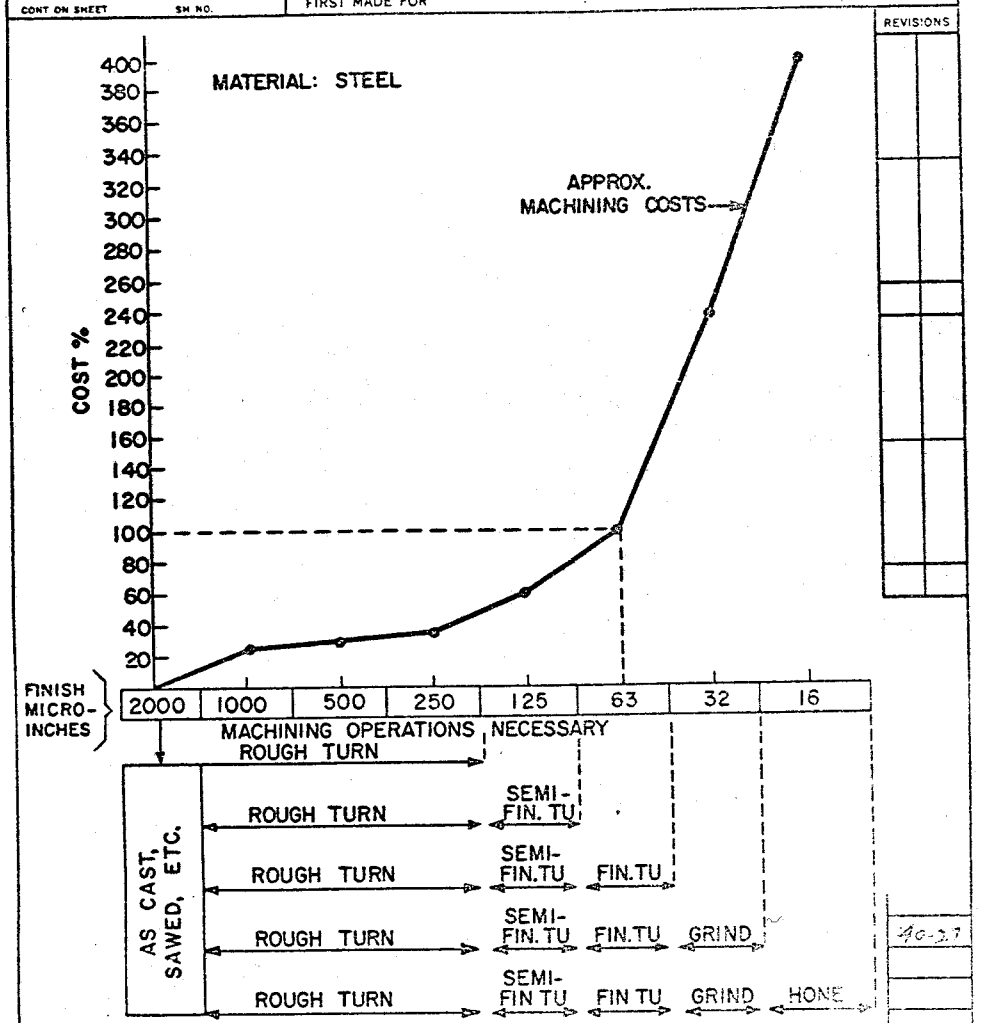
TITLE

# RELATIVE MACHINING COST

SURFACE - FINISH

FIRST MADE FOR

REVISIONS




NOTE: THIS CHART IS INTENDED FOR USE AS A GUIDE IN SELECTING THE MOST ECONOMIC SURFACE FINISH THAT WILL MEET A DESIGN REQUIREMENT. COSTS SHOWN ARE APPROXIMATE AND COULD BE GREATER OR LESS DEPENDING ON VARIABLES NOT CONSIDERED HERE.

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PRINTS TO

MADE BY B Rini ISSUED June 27, 1958

APPROVALS

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SCHENECTADY, N.Y. LOCATION

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SYN

GENERAL ELECTRIC

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946A556 CONT ON SHEET SH NO.

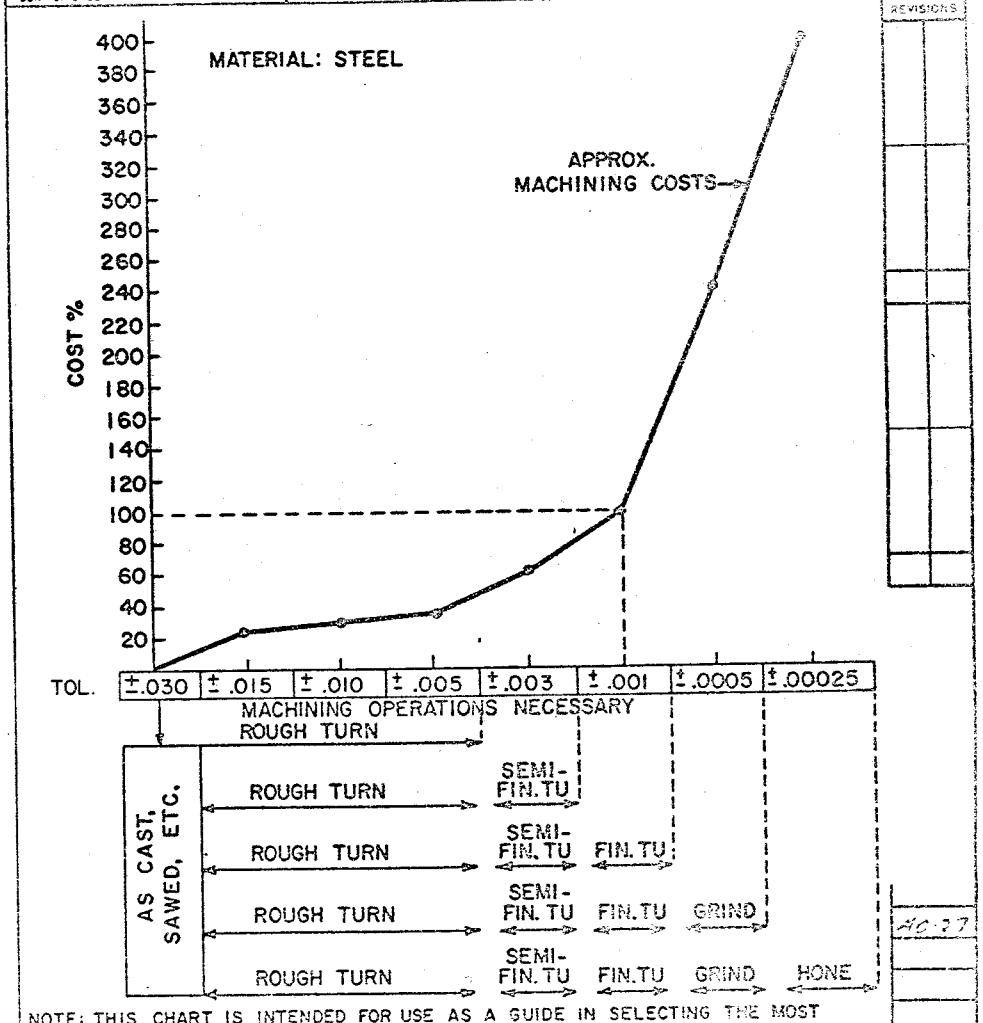
TITLE

# RELATIVE MACHINING COST

TOLERANCE

FIRST MADE FOR

REVISIONS




NOTE: THIS CHART IS INTENDED FOR USE AS A GUIDE IN SELECTING THE MOST ECONOMIC TOLERANCE THAT WILL MEET A DESIGN REQUIREMENT. COSTS ARE APPROXIMATE AND COULD BE GREATER OR LESS DEPENDING ON VARIABLES NOT CONSIDERED HERE.

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SYN

# CREATIVE THINKING GUIDE

## Rules For Deferred Judgment Ideation (Brainstorming)

1. Criticism is ruled out:
   Judgment is suspended until a later screening or evaluation session. Allowing yourself to be critical at the same time you are being creative is like trying to get hot and cold water from one faucet at the same time. Ideas aren't hot enough; criticism isn't cold enough. Results are tepid.

2. Free-Wheeling is welcomed:
   The wilder the ideas, the better. Even offbeat, impractical suggestions may "trigger" in other panel members practical suggestions which might not otherwise occur to them.

3. Quantity is wanted:
   The greater the number of ideas, the greater likelihood of winners. It is easier to pare down a long list of ideas than puff up a short list.

4. Combination and Improvement are sought:
   In addition to contributing ideas of their own, panel members should suggest how suggestions by others can be turned into better ideas, or how two or more ideas could be combined into a still better idea.

## Idea Spurring Questions

PUT TO OTHER USES? New ways to use as is? Other uses if modified?

ADAPT? What else is like this? What other ideas does this suggest?

MODIFY? Change meaning, color, motion, sound, odor, taste, form, shape? Other changes?

MAGNIFY? What to add? Greater frequency? Stronger? Larger? Plus ingredient? Multiply?

MINIFY? What to subtract? Eliminate? Smaller? Lighter? Slower? Split up? Less frequent?

SUBSTITUTE? Who else instead? What else instead? Other place? Other time?

REARRANGE? Other layout? Other sequence? Change pace?

REVERSE? Opposites? Turn it backward? Turn it upside down? Turn it inside out?

COMBINE? How about a blend, an assortment? Combine purposes? Combine ideas?

I. Operational Techniques to Stimulate Creative Thinking

A. Attribute Listing

1. List all major characteristics - attributes
   Product, object, idea

2. Each considered in turn - and changed in all conceivable ways

B. Input - Output Techniques

1. Establish desired output or end result

2. Various forms of energy to provide initial stimulus

3. Specifications or conditions (may be too restrictive) (inhibiting effect)

C. Forced Relationship Techniques

1. Catalog techniques
   a. Select two words at random
      " " items " "
   b. Force relationship

2. Listing techniques
   a. list of objects or items
   b. give each a number
   c. consider each number in relation to all other numbers

D. Focused Object Technique

1. Select the fixed element

2. Focus attention on some other items

3. Force relationships of attributes of 2nd item on first

Device to initiate creative thought

E. Checklists

Generalized checklist better than specialized
   Latter may restrict imagination or thinking

I. Operational Techniques (cont.)

F. Morphological Analysis

1. Define problem - in terms of dimensions or parameters

2. List all solutions - in each of different variables

3. Evaluate each suggested solution - in combination with each other variable solution

More difficult with increasing number of variables
Example: Box - size, material, shape

G. Modification

Modify or twist ideas

H. Simple Free Association

Word on paper
Develop chain of free associations

I. Brainstorming - Deferred Judgment

See attached rules
6 - 12 people for group

J. Gordon Technique

Select problem associated with that to which solution desired.
For instance: cut grass - separate
park cars - store things

Only instructor knows true nature of problem

Then discuss problem - How to separate, etc.

People of different backgrounds - 3 hours long

Variations

a. Some people know true problem
b. Tape first session - have 2nd in which problem revealed
c. Use two groups - one knows - one doesn't

I. Operational Techniques (cont.)

K. Phillips 66 Buzz Session

Take large group, divide into small groups (6)

L. Reverse Brainstorming

Think of all possible limitations, failings
Then try to find solutions for each

M. Crawford Slip Writing

Slips paper
All write down ideas

F. S. Sherwin, 7/23/62

II. Idea Evaluation Techniques

1. Screening Process - Rate: good, fair, poor, danger
2. Establish Criteria - Cost, feasibility, etc.
3. Does it stimulate other ideas?
4. Judge by another group
   Two or more evaluating results in sounder evaluation

III. Presenting Ideas

1. Select proper person
2. Select right time
3. Know your audience
4. Style and content
5. Make it factual
6. Make it clear and simple
7. Make it well balanced
8. Be able to defend it - anticipate questions
9. Emphasize cost savings - return on investment
10. Use audio visual - graphic devices
    (humor and showmanship to some degree)

IV. Educational Techniques to Develop Creativity

1. Suggesting alternate uses for common article
2. Suggesting captions or titles for pictures
3. Short stories, 20 questions, charades

Can be overdone

Better to teach operational techniques by practicing solving oral problems.

F. S. Sherwin, 7/23/62

# THE CREATIVE THINKING PROCESS

by

JOHN F. MEE

BUREAU OF BUSINESS RESEARCH

SCHOOL OF BUSINESS •• INDIANA UNIVERSITY

Reprinted from the *Indiana Business Review*, Vol. XXXI, No. 2 (February, 1956).

# THE CREATIVE THINKING PROCESS

JOHN F. MEE*

The creative thinking process is in wide use today for purposes of stimulating scientific research in both the physical sciences and the social sciences. It is used also to help executives and employees discover better ways to achieve desired results. Individuals can use it to solve personal problems. There is strong evidence that anyone can increase his creativity if he has the desire and patience to master the creative process. The success of numerous creative thinking training programs for executives supplies the evidence.

## Operative Definition

Creative thinking is the process of bringing a problem before one's mind clearly as by imagining, visualizing, supposing, musing, contemplating, or the like, and then originating or inventing an idea, concept, realization, or picture along new or unconventional lines. It involves study and reflection rather than action.

## Subject Areas for Creative Thinking

Some of the most fruitful areas for applying the process of creative thinking are:

*Good.* The creation and introduction of a new good or service which is unfamiliar to consumers.

*Method.* The invention and introduction of a new method of production, one not yet tested in the branch of manufacture concerned. A new method also may be a new way to market a product commercially or a new method for financing.

*Market.* The creation and opening of a new market into which the particular branch of manufacture or product has not previously entered.

*Supply.* The creation and conquest of a new source of supply of raw material or manufactured goods.

*Organization.* The establishment or formulation of a new way of organizing, such as the trend toward organizational decentralization into many individual profit centers with central policy and decentralized authority for decision-making by individual managers, indicating that creative thinking has been done in this area.

*Management or Administration.* The creation and development of a new philosophy for more effectively achieving objectives through human effort is a possible area for consideration. For example, attention given to the administrative point of view or the management process may result in creative thinking in this area.[1]

## Examples of Creative Thinking

*Creation of a New Good.* In Hamilton, Ohio, a young man who had inherited a strongbox factory looked at a minnow bucket. He got a new idea. He brought into his mind clearly the visualization of insulation between the two cans, a cover, and ice cubes. He imagined a picnic container that would keep drinks or food cold for a long period of time. He brought into his mind the concept of the now well-known Skotch Kooler. His factory now has a gross volume of over $5 million a year.

*Creation of a New Method.* A former second baseman of the Washington Senators at the end of his playing career got a job with the Consolidated Vultee aircraft plant

* Professor and Chairman, Department of Management, School of Business, Indiana University

1 The areas presented were adapted from Schumpeter's *The Theory of Economic Development* (Cambridge: Harvard University Press, 1934).

in Nashville, Tennessee. He had only a high school education and worked on the assembly line. The plant was not meeting its quota of engines, and the obvious waste of manpower irritated him. In his spare time, he designed a new assembly line procedural method which gave each worker a simple, timed assignment. When the general foreman was on vacation, he obtained consent to try his procedure. The result was the meeting of the plant's quota with less manpower. This man had no formal engineering education; but he did have the ability to use the creative process of thinking.

*Creation of a New Market.* A salesman some time ago was forced to spend the night in Harrisburg, Pennsylvania. He looked in vain for a television set to see a special program. There was none. Although Harrisburg was within normal reach of several television stations, the mountains cut off the signals. This salesman brought into his mind the idea of a community antenna on a nearby mountain top which could serve those homes desiring television. He formed a new business which has erected over 290 community antennas and is a million-dollar business. He created a new market for television as well as a new product.[2]

Many examples could be given of products, methods, and markets with which we are now familiar but which first had to be created in someone's imagination. Without composers, musicians would have to make up their own music to play on instruments. Without architects, builders would be very limited. Without engineers, we could not shift so well from physical to mechanical energy. However, creativity is not limited to mechanical or artistic inventiveness. Creativity is being sought and used in marketing, advertising, production, transportation, financing, real estate, and personnel relations. A. C. Monteith, Vice President of Westinghouse, has stated, "Creative thinking has become the spark plug of American business. If we don't find enough imaginative men to supply that spark plug, the machine will run down."[3]

## Main Levels of Thinking

Three main levels of thinking have been advanced by Professor B. H. Jarman of George Washington University. They are the habit level, the problem-solving level, and the creative or insight level.[4]

The habit level of thinking results from either the conditioned response or trial and error methods. It is routine and unimaginative. Those who work at the habit level are following "beaten paths for beaten men." They work from plans of other men's minds by performing standard operating procedures or methods. They depend upon memory of techniques and formulae. The well-known poem by Sam W. Foss, "The Calf-Path," describes the thinking of such individuals.

Thinking on the problem-solving level is logical because it proceeds from facts which are either given or obtained. The scientific method of attack may be used at this level. The well-known "case study" approach to education, in which certain business situations are simulated, is used to provoke problem-solving thinking. A problem is discovered. Analysis and evaluation of the facts are made. Then a decision is made to resolve the problem.

Thinking on the creative or insight level may not be logical because it is done when only some facts are known and others are missing. Creative thinking occurs when sound conclusions or judgments are reached when some important facts or data are either unknown or withheld. Creative thinking results from a partial knowledge

2 The preceding three examples were adapted from Bill Davidson, "How to Think Your Way to the Top," *Collier's*, CXXXV, No. 3 (February 4, 1955), pp. 26, 27.

3 *Ibid.*, p. 26.

4 B. H. Jarman, "Can Executives Be Taught to Think," *Advanced Management* (January, 1954), p. 6.

of a situation. Combinations and eliminations of associated facts begin to clarify the imagery or idea that will lead to a solution. Insight then provides the imagination with the searched-for concept or idea. The imagination is required to set up a number of hypotheses that can be checked, compared, and evaluated, so that a superior solution can be developed from the best elements of the competing hypotheses. Examples of such insight were Trudeau's flash of inspiration that tuberculosis could be cured if a victim's environment could be controlled; and Reed's insight that yellow fever was associated with mosquitos.

There is a close relationship between these levels of thinking and the levels of management practice as described by Barnard.[5]

*Levels of Management Practice*

1. Job know-how
2. Specific organization practice
3. Principles and fundamentals

*Levels of Thinking*

1. Routine or habit
2. Problem-solving
3. Creative

## Steps in the Creative Thinking Process

The creative thinking process has been described in the literature of the field by numerous authorities and practitioners. The presentation here represents a selection and combination of the best elements of all these methods for creative thinking.

> When 'Omer smote 'is bloomin' lyre,
> He'd 'eard men sing by land an' sea;
> An' what 'e thought 'e might require,
> 'E went an' took—the same as me!
> —KIPLING,
> "When 'Omer Smote 'is Bloomin' Lyre"

[5] Herbert A. Simon, *Administrative Behavior*, Foreword by Chester I. Barnard (New York: The Macmillan Co., 1948), pp. x-xii.

*Attitude and Concentration.* There should be established in one's mind a positive attitude toward complete freedom of ideas even though they may seem impractical or unorthodox at first. Attempts to criticize or evaluate should be held in abeyance. Concentration for periods of about 30 minutes' duration should be practiced each day. To become proficient in the creative thinking process, it is essential that one develop the desire and the will to concentrate on a problem for a period of time without interrupting by getting a drink, turning on the radio or television, making a phone call, or looking out the window. A positive attitude and the ability to concentrate are basic essentials for a climate friendly to creative thinking.

*Selecting or Defining a Problem.* First, determine your purpose. Ignore ideas until you have determined why you want or need ideas. Find out what needs to be done or what you want to accomplish. You will not get started on the creative process by looking around for ideas that are new. To try to be creative by random search for original ideas will result only in futile frustration. C. F. Kettering, a very creative person, once stated that "All research is simply finding out what is wrong with something, and then fixing it." Therefore, start by selecting a problem in your area, and make sure that you know what the problem is. Define the problem clearly; then write it down as a "fix point" for the start of the creative process. It is suggested that "limiting factors" be listed and a "difficulty inventory" and a "difficulty analysis" be used in getting a "fix point" on the problem at the start of the creative process.

C. F. Kettering set out to develop the electric self-starter for motors, and he did it. In a demonstration, objection was made to his invention because he used more

current through the wires than established formulae allowed. Kettering stated that his problem was to start an automobile. He was not interested in formulae. He had defined and picked his problem; then he stayed with it until a solution was reached. Previous failures of others to develop the electric starter did not bother him. He considered other failures an opportunity for him.

In selecting a problem, remember that the positive attitude and concentration climate are important. Regardless of the difficulty or the apparent impracticability of the problem, a solution can be reached through the creative process. Have the courage to depart from traditional formulae or thinking. Remember the plight of the bumblebee: "According to theory of aerodynamics and as may be readily demonstrated through laboratory tests and wind tunnel experiments, the bumblebee is unable to fly. This is because the size, weight, and shape of his body, in relation to the total wing spread, makes flying impossible. But—the bumblebee, being ignorant of these profound scientific truths, goes ahead and flies anyway—and manages to make a little honey every day!" The world of business is filled with opportunity for those who will and can select problems that impede economic or technological progress and solve them through the process of creative thinking.

*Exploration and Preparation.* New or unconventional ideas are not created by wishing. They must be laboriously and carefully created from raw materials. The raw materials may be called knowledge. In the creative thinking process, ideas are originated by associations of existing ideas and factual information. New combinations and eliminations are brought about. Facts are matched against facts.

The exploration and preparation step in the creative process involves gathering, refining, and organizing all of the obtainable raw materials and knowledge that bear upon the problem selected. The purpose is to enable one to soak up information that will be grist for the mind later. One is not concerned with new ideas in this step—they come later. Raw materials and knowledge may be obtained from journals, books, magazines, research reports, associations with informed people, personal observations, lectures, and experience. In the exploration and preparation step, one should search for knowledge over as broad a field as possible. Every effort should be made to determine what underlies the facts and whether or not fundamentals or principles are apparent. For best results the raw materials or knowledge gathered should be written down for proper organization and refinement.

The exploration and preparation work is probably the most difficult of all of the steps in the creative thinking process because it involves a great amount of painstaking mental and physical effort. There are no short cuts. One must force oneself to gather, refine, and organize raw material and knowledge pertaining to the problem until every source is exhausted. This requires great self-discipline and tenacity of purpose. The lazy or the indolent will fail in this step. One must continue the exploration and preparation step until no new or additional raw materials and knowledge are obtainable. Remember, in creative thinking some facts are known and some are missing. Therefore, all possible facts and information must be obtained. Furthermore, the facts should be classified on some logical basis for later analysis and evaluation. Otherwise, the gaps in the later mental configuration may be too great for insight to bridge.

*Hypotheses, Brainstorming, or Wild Thinking.* This step involves the application of all existing ideas or knowledge to the solution of the problem in all possible combinations. Pareto's concept of "instinct of combinations" in *Mind and Society* describes

the method for this step.[6] It is during this step of the creative thinking process that one gives his mind full freedom to range for a new idea to resolve the problem.

All possible relationships of existing raw materials and knowledge are combined. Some will be very wild and impractical; but the more the better, because of the increased probability that one will hit on the solution. All should be written down and preserved for later reference. Charles S. Whiting of McCann-Erickson, Inc., has described some operational techniques for this step: the analytical technique, the forced relationship technique, and the free association technique.[7]

The analytical technique involves the use of a pattern for establishing all possible relationships of knowledge to a problem. Alex F. Osborn's check list illustrates this technique by asking the following questions. Let's take an existing product or service as an example. (1) Can it be put to other uses? (2) Can it be adapted? (3) Can it be modified? (4) Can it be magnified? (5) Can it be minified? (6) Can it be substituted for others? (7) Can it be rearranged? (8) Can it be reversed? (9) Can it be combined with something?[8] This technique is well known for methods work and work simplification.

The forced relationship technique involves making a list of objects or ideas which may have some possible relationship, and then considering each object or idea in relation to every other one on the list. An example of this technique in action would be forcing the combination of all chemical elements in all possible relationships in an attempt to find a cure for cancer or the common cold. Obviously this is a laborious and time-consuming effort, although the use of electronic machines can be helpful.

The free association technique involves wild thinking or brainstorming. This technique is based on values which come from allowing any idea which comes to mind on a problem to be recorded. No attempt is made to evaluate ideas until all possible ideas have been expressed. A positive attitude and a receptive climate are essential for this technique because the purpose is to write down all possible ideas generated on a problem regardless of how silly or impractical they at first seem to be.

If a brainstorming session is to be held, the exploration or preparation step is minimized because the raw materials or knowledge obtainable exist in the experience and minds of the members of the group that participates. The group is presented with a problem, and everyone is encouraged to contribute ideas. For example, in the General Motors A C Spark Plug Division, one brainstorming session produced over 100 ideas on how to finish off a casting. The Ethyl Corporation got 71 ideas in less than an hour on a new booklet for employee benefit plans.

The digestion of the raw materials and knowledge obtained in exploration and preparation should continue by wild thinking on relationships, the establishment of possible hypotheses, brainstorming, and the like until a feeling of frustration appears. When all possible relationships have been combined and mental fatigue occurs, it is time for diversion—the next step. When Sherlock Holmes seemingly ceased work on a case and dragged his friend, Dr. Watson, to a concert or played his violin, he was actually moving up a step in his brilliant creative thinking.

*Incubation or Gestation.* This step involves unconscious cerebration. One can contribute little to this step directly. One must either arrange to think about other subjects or problems, or even rest from any form of conscious thought by seeking recreation or

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6 Vilfredo Pareto, *Mind and Society* (New York: Harcourt, Brace, 1935).

7 Whiting, "Operational Techniques of Creative Thinking," *Advanced Management*, XX, No. 10 (October, 1955), p. 25.

8 Adapted from Alex F. Osborn, *Applied Imagination* (New York: Charles Scribner's, 1953), p. 284.

entertainment. When those responsible for assignments requiring creative thinking indulge in reading wild West or detective stories, or listen to jazz music, don't malign or belittle them. They are probably engaging in this step of the creative process. Likewise, a hobby is a valuable asset to a creative thinker. During this step of incubation or gestation, one's mind will continue to operate on the problem unconsciously. However, it is important to prevent emotional or mental blocks by some form of diversion which will result in one's not thinking about the problem or associated ideas. This is important because the next step should result in illumination or insight which brings to mind the idea sought to solve the problem.

*Illumination.* This step often occurs when least expected. The idea will appear when one is eating, bathing, relaxing, driving, or engaging in some similar activity. If the previous steps of exploration and preparation, digestion of relationships, and incubation or gestation have been accomplished properly, the new idea will be brought to mind. However, other ideas will follow in quick order. Many fail in the creative thinking process on this step because ideas come to mind faster than one's memory can absorb or retain them. Therefore, it is important that some means of writing down the ideas as they occur be devised. Otherwise, they will be lost and the previous work in the creative process nullified.

*Verification and Application.* The final step in the creative process of thinking is that of verifying, modifying, or applying the idea toward the solution of the problem selected and defined. However, the same freedom of thinking and imagination should be used in verifying or applying the new idea brought to mind as in the other steps of the creative process. This step is essential if one is to get his ideas accepted and used.

The creative thinking process is based upon three essential elements: knowledge, proficiency, and attitude. Knowledge supplies the grist for the mental process. Proficiency in all steps of the creative thinking process is vital for success in using it. There must be a positive attitude and a receptive climate for using the process.

> They copied all they could follow,
> but they couldn't copy my mind,
> And I left 'em sweating and stealing
> a year and a half behind.
> —KIPLING,
> "The Mary Gloster"

## Business Research and the Creative Thinking Process

Willard A. Pleuthner, Vice President of BBD&O, has stated:

> In too many cases, nothing is done creatively about research findings. Sound research has provided the knowledge which is a potential power for the business. But research itself seldom puts that power to work in providing all the answers, or the best answers, to the problems. This is exactly where creative thinking should move into the research picture. In that move, the mental climate should change. . . . some of the faces around the table should change. The transmission of thinking should shift from the third gear of judicial judgment into the free wheeling of creative imagination.

Sound business research carried on according to valid methods is essential to the creative thinking process. The all-important step of exploration and preparation in the creative thinking process depends upon research to provide the basic knowledge upon which the subsequent steps depend.

One may be able to follow a career and earn a living by operating on the routine or problem-solving levels of thinking. However, the highest rewards in recognition and income will be offered to those who will contribute to economic, business, and technological progress through creative thinking about the world's problems. Fortunately, the process of creative thinking is not patented or withheld from anyone. It is available and free for all to use.

# IDENTIFY your CREATIVE PEOPLE

## Research supplies guidelines which all companies can use

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IMPORTANT PROGRESS is being made in the search for an answer to one of the most nagging questions in business management:

How do you identify the creative worker and then encourage his creative drive before group pressures in an organization maim or kill it?

Tentative answers are included in a new report, "Creativity and Conformity," which is to be published this month by The Foundation for Research on Human Behavior, Ann Arbor, Mich.

The report summarizes extensive research conducted at the University of California's Institute of Personality Assessment and Research at Berkeley, and the Research Center for Group Dynamics at the University of Michigan.

The studies show that:

1. The creative worker can be pinpointed through testing procedures.
2. Group pressures can be controlled to encourage creativity rather than stifle it.
3. Conformers, and the degree to which they conform, can now be identified.
4. Business can effect an intelligent and productive balance between creativity and conformity.

The Foundation is publishing its report with the cautionary note that it is by no means the last word on the related problems of individual creativity and group pressure.

Nonetheless, the research represents a significant step toward ultimate solution. It reflects business' increasing use of social science and embraces a subject of pressing current interest to all business organizations. Most important, it outlines some steps which business can take immediately to achieve more effective management of the creativity-conformity problem.

### *Pinpointing creative workers*

Business generally is getting far less than optimum benefit from the latent creativity of its employes.

At the same time, business needs creativity, or originality, in virtually all of its endeavors. It must consider creativity in promoting and placing personnel at all levels. It must maintain an inventory of the total creative resources at its disposal.

But what is creativity?

According to researchers, creativity means getting out of a mental rut and looking at things in a new and different way. It results from what the social scientists call "divergent thinking"—the kind of thinking which is constantly attuned to new possibilities. It's the thinking behind discovery, it is insight, intuition. It contrasts with "convergent thinking" which is more orderly and logical progressions.

Both kinds of thinking are necessary in an organization. But creativity, or originality, occurs only when divergent thinking takes place.

No one of us is a creative thinker in the pure and absolute sense, says Dr. Samuel P. Hayes, Jr., Foundation director. Every person has elements of both divergent and convergent thinking in his make-up. The important thing is to determine which of these two strengths predominates in an individual. Knowing this, it is possible to put him in a position where his strongest talent is free to function.

The research suggests that people strong on divergent thinking might best be used in positions where their creative thrust can operate freely.

Such positions include basic research—the search for the new; sales work—the development of new markets; advertising copy writing—the creation of new and unusual ideas; in organization staff work—in devising ways to accomplish what less creative people might consider to be impossible.

Individuals strongly inclined to convergent thinking make good organizers, the research indicates. They are useful in posts where they validate the findings of divergent thinkers. In assembling, refining and improving raw data they can exercise a secondary creativity of great value.

Dr. Hayes says these implications extend from the highest to the lowest levels of organization. "Even on the assembly line, the creative, or divergent thinker, exists and can be better used. His suggestions might be sought on such things as how to perform his job more simply, more efficiently, how to cut costs or use waste products."

While science does not yet know why some people are more creative in their thinking than others, it has—through research—developed tests which identify original thinkers and provide the first objective measurements of originality.

At the Institute of Personality Assessment and Research eight tests are used:

*Unusual uses:* The person being tested is asked to list six uses to which a common object such as a newspaper can be put. The less often the answer is given, the higher the score.

*Consequences:* The participant is asked to write down all the things he can think of which might happen if a stated change took place. Such a

## IDENTIFY YOUR CREATIVE PEOPLE

# Tests show that original person has more energy, drive and effectiveness

change might be: "What if suddenly everyone could read minds?"

*Plot titles:* Two short stories are given. The object is to make up suitable titles.

*Rorschach ink-blot-test:* The subject gives responses to 10 ink blots.

*Anagrams:* The object is to make up as many words as possible, using the letters of a test word.

*Thematic apperception:* The participant is given pictures and asked to make up stories about them.

*Word rearrangement:* The object is to compose a story using as many of the words as possible from a random list.

*Achromatic ink blots:* Similar to the Rorschach test, this also is scored for infrequency of response.

These tests require different kinds or originality. The ink-blot tests call for visual originality. The thematic apperception test and word arrangement tests call for verbal originality. Consequences and unusual uses bring out the bright idea kind of originality. Plot titles require adeptness at slogans. Anagrams require word fluency.

The testers have found that people usually are better at one kind of test than another. Visually original people are not necessarily verbally original as well. But those who do well on one kind of test usually have higher than average scores on most of the others.

At Berkeley, the eight tests for originality are supplemented by other testing procedures. Staff psychologists observe those being tested over a three-day period, noting their various personality traits, including creativity. A second check is made by asking colleagues and superiors to rate subjects on creative ability.

Originality appears to be characterized by a preference for complex problems. The original person, the researchers find, sees a great variety of things and takes all of them into consideration. He resists putting them into an organized pattern until they can all be accommodated, and then he forms a complex solution.

The less original person either doesn't see as many elements, or ignores them in favor of arriving at simpler, quicker solutions.

The more original person emerges as an individual with more energy and drive, more striving for mastery, more effectiveness in his performance. He is more impulsive and responsive to emotions. He is less rigid and is able to tolerate ambiguity. He is dominant and self-assertive.

The Foundation, interpreting the findings of the research on creativity, suggests that management can even now put to good use some of the admittedly still-crude tests used at the Institute of Personality Assessment and Research. The unusual uses and consequences tests might provide useful information in the selection of creative personnel, beyond that based on other judgments.

Moreover, a company might wish to administer the entire test battery to its employes, both those known to be original and those known to be unoriginal, "thereby determining the effectiveness of the battery as a measurement device for a particular kind of originality valuable to the company."

### *Encouraging creativity*

Scientists confirm that group pressure can block the expression of creativity by the individual worker. Groups tend to resist changes in the *status quo* and the creative thinker is likely to be one who proposes change in the *status quo*.

Workers who deviate from group standards may be subject to punishment by the group. A test by the Research Center for Group Dynamics conducted in a clothing manufacturing company disclosed that when a new female employe in the pressing department increased her production above the standard rate of 50 units per hour her sewing was deliberately knocked from her work table and other actions impeded her production.

Similar group pressures can inhibit originality, but the direction of pressures can be changed by making originality a goal of the group.

In the clothing manufacturing case scientists and management tried still another approach which has proved to be useful. They sought to increase the participation of the workers in decision-making in the belief that lack of such participation often has been the cause of hostility toward management and—as a consequence—of worker opposition to initiative and creativity.

Here's how the experiment worked: Three work groups were selected. (The standard rate of production for all groups had been 60.)

Group A received the usual treatment at a work changeover. The need for the change was explained, and the new rates and job descriptions announced.

Group B was given "representative participation" in decision making. It was called together and asked to select representatives to set up the new jobs and the new rates. The representatives worked with company engineers on all details and reported back to the group.

Group C was allowed "total participation." The entire group sat down and worked out the job changes needed. They consulted with the engineer in setting the pay rates and job standards.

"In all groups," the report relates, "the job descriptions which evolved were approximately equal. Everything was approved by the engineer. But the results were very different."

In Group A, production dropped from 60 to 50 and stayed there. Morale nosedived, absenteeism and quitting increased.

Group B, on the other hand, returned to the 60 level of productivity in two weeks. Morale improved; absenteeism and quitting declined.

In Group C—the group with total participation in decision-making—production did not drop at all. Within a short time it climbed to 70 and stayed there. There was no quitting and morale was high.

### *Conformers*

Having isolated the significant characteristics of the creative thinker, the research then turned to an exploration of conformity.

Few terms have been so widely used in recent years, and yet so little understood.

The researchers in California and Michigan use this definition of the term: Conformity is a conflict between what a person says or does and what he really thinks or would like to do. It is more than uniformity, or cooperation, or common beliefs, or conventional behavior. It is a conflict between internal belief and external manifestation.

There are three kinds of conformers:

*The cognitive conformer* is looking for a solution, or information, and accepts the opinion of the group as being the most likely source. Most people fall into this category.

*The expedient conformer* believes he has the right answer but will adopt a wrong group answer anyway. He is sensitive to authority and is himself authoritarian.

*The passively suggestible* person

# Conformers without creative talents can be of great value to businesses

lacks confidence in himself and his opinions. He will readily accept the group's opinion, in the belief that its members must be right and he must be wrong. He has inadequate self perception; he is high on scales of doubt and anxiety. He feels inferior and is often unable to bear up under stress.

Conformists—even extreme conformists—can be of great value to a business organization once their tendency to conform is recognized. They can be used constructively in positions involving organizing, controlling, or in some other work where a high degree of creative thinking is not required. The conformist makes a good team player; he is predictable; he can be used in directing the work of others and in carrying out programs effectively.

Nonconformers are either persons who are sure they are right and stick to their convictions, or persons who always adopt the opposite point of view. The second type, the researchers say, are not truly independent. They are suggestible, but "contra-suggestible," like a child going through the negative phase of growing up. This type of individual uniformly rejects group standards and pressures, right or wrong. The research scientists say that firing may be the only practical way to deal with such a person since keeping him on the payroll would invite a chaotic effect on company procedures and the creativity of others.

A rather simple experiment has been used at Berkeley to measure conformity. Five people are seated at panels. They know the others are participating, but they cannot see or talk to each other. Each person is asked to answer questions by throwing the appropriate switch on his panel. He sees lights on his panel which, he is told, indicate the votes of the other four persons being tested.

The subjects believe these lights are a communication system between the test booths. Actually, all lights are controlled by the experimenter. Each of the participants can be confronted with an apparently unanimous group opinion contrary to his own. Questions are projected on a screen and those taking part are asked to select the correct answer from the choices given.

The slides vary in content from simple perception questions (which line is the longest) to factual-logical questions (vocabulary, completion of number series) to attitude and opinion questions. Each person can be subjected to group pressures by manipulation of the lights. He sees that line one is the longest; the group, however, is voting for line two, which is obviously shorter. How will he vote?

Here's what the experimenters found on 12 standard items of which four were clear, three ambiguous and five somewhere in between:

| *The Group* | *The percentage of times they conform with the wrong answer of the group* |
|---|---|
| College sophomores (female) | 36.5% |
| Air Force captains | 32.4 |
| Mills College seniors (female) | 32.0 |
| Medical school applicants | 27.3 |
| College sophomores (male) | 25.9 |
| Vassar alumnae (average age 40) | 22.4 |
| Engineering students (seniors, honors) | 22.0 |
| Research scientists | 16.0 |

These are group scores. Within the groups wide individual differences were found. Some persons don't conform at all, others conform most of the time. But—even discounting these individual differences—some interesting trends in group scores should be noted:

Women appear to conform more than men.

Women of 40 conform less than female college seniors.

College seniors conform less than sophomores.

Nonconformists are likely to rate high in intelligence, ego strength, dominance, ascendancy, masculinity. They make high marks on tests of social acuity—the ability to understand other people.

It also has been found that people who are high on originality conform less than people who are low on originality.

Other findings of the research are these:

Most people need some support before they will express a contrary opinion.

Conformity tends to increase sharply when people work on a group task. Apparently conformity increases when people know their actions will affect others.

People who feel rejected by a group to which they wish to belong—such as members of racial minorities—are especially sensitive to group pressure and will conform to group standards much more than people who feel accepted.

Conformity increases when the task or issue is relevant to the group's goals.

Groups with discussion leaders tend to have a better record in problem-solving than groups with no leaders; discussion leaders can insure a fair hearing for minority views.

Another finding which is of particular interest in the research on conformity is the tendency of groups to be inhibited by positions taken by superiors. In a test involving Air Force crewmen, for example, the accuracy of groups improved considerably when a lower status person (a gunner) gave his answer first. In groups where pilot leaders answered first, accuracy fell off. When the pilot was wrong, the other members tended to suppress their true views and go along with his incorrect answers. Accuracy and effectiveness of groups increase when all true opinions are expressed.

### Help for business

The social scientists stress that conformity pressures in an organization are not necessarily bad. They keep the wheels turning smoothly. Without some conformity, "production lines would erupt in turmoil and social machinery would collapse. Group pressures serve positive ends, for society and industry."

The important thing is to achieve a balance between creativity and conformity.

"Management," the Foundation report concludes, "can adopt tests which will identify both the people who give in readily to group pressure and the people who don't.

"Management can also develop groups which counteract the negative consequences of conformity. Participation in decision-making can be used to shift the goals of groups to positive ends. Groups can be formed in which originality becomes a major goal. Machinery can be installed to insure a full hearing of minority opinions. Differences in status can be reduced, made less obvious; the place a member holds in the hierarchy can be consciously eliminated from the standards for judging member contributions.

"Groups can be formed which

bring together many different kinds of people; originality seems to flourish under these conditions. Groups can be made aware of the impact they have on their individual members, and they can work to reduce those pressures. Discussion leaders can be trained. Experts can be used as resource people and can be recognized as such by group members.

"If management realizes the impact of conformity pressures and begins to counteract their negative aspects, then some of the ready reserve of originality should begin to appear. The impact of these reserves can be far-reaching and can pay off handsomely for the business which takes time to find and free creativity." END

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**A USEFUL LOOK AHEAD**

# EIGHT KEYS TO CREATIVITY

## New research shows businessmen how to identify imaginative workers

WHAT MAKES some people more creative than others?

Seven years of research at Pennsylvania State University have shed new light on this question of prime importance to business.

Here are some of the Penn State findings that are of immediate value to managers:

▶ There are eight distinct attributes that significantly differentiate creative people from those who are less creative or noncreative.

▶ These attributes do not register on standard intelligence tests. But they can be detected by a battery of special tests developed at Penn State and elsewhere.

▶ A person who consciously cultivates these attributes can substantially raise his own creativity potential.

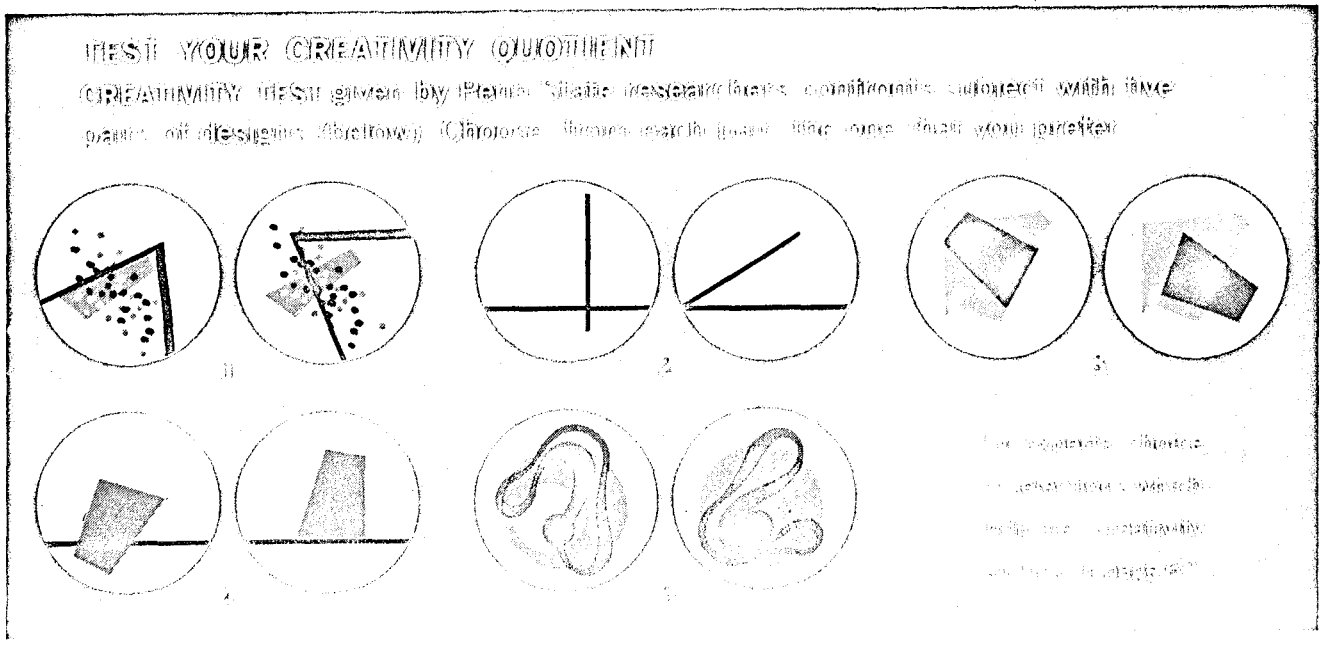
The Penn State research team, headed by Prof. Viktor Lowenfeld, does not claim to have all the answers. The studies are continuing. But they have already gone far toward solving the riddle of creativity —the precious but elusive quality of mind and spirit that is responsible for all real progress in business, technology and the arts and sciences.

Dr. Lowenfeld, a native of Vienna who came to this country in 1939, is head of Penn State's Department of Art Education. He is a world authority on art education as well as a trained psychologist. He began his research on creativity in 1951 because he was convinced—six years before Sputnik aroused other Americans to the same realization—that "our existence as a nation may hinge on the efforts of creative people."

He emphasized in an interview that the Penn State studies are not aimed primarily at categorizing individuals as creative or noncreative. Although he acknowledges the existence of inherent differences among individuals, he believes that "virtually every person has more creative ability than he is actually putting to use." His goal is to find ways to release this latent creativity.

The first step was to find measurable criteria which reliably distinguish persons of high creative performance from those of low creative performance. Dr. W. Lambert Brittain, a former student of Dr. Lowenfeld now teaching at Cornell University, reviewed all previous research and came up with 36 tests which covered every conceivable trait of mind or personality that might affect an individual's creativity.

These tests were given to students who had previously been grouped,



on the basis of their actual performances in the arts, as highly creative or noncreative.

The results (which many repeat experiments have since corroborated) showed that eight criteria consistently differentiated the two groups.

At this point, Dr. Lowenfeld made an exciting discovery. Unknown to the Penn State researchers, a group under Prof. J. P. Guilford at the University of Southern California had been conducting similar studies on creativity in the sciences. Dr. Guilford had also identified eight attributes of the creative person.

His list proved to be virtually identical to the Penn State findings.

The striking similarity between these two entirely independent studies seems to warrant the conclusion that creativity has common attributes, whether it is expressed in the arts, the sciences or in a business environment.

Being a careful scientist, Dr. Lowenfeld does not take this conclusion for granted. Penn State has applied for a research grant from the National Science Foundation to prove the point with a controlled interdisciplinary study which will expose engineering students to the same creativity tests which have already proved valid for artists and scientists.

Meanwhile, less skeptical businessmen may apply to themselves and to the younger managers they are seeking to develop, some of the helpful insights that have emerged from the research already done:

Here are eight attributes of creativity defined by Dr. Lowenfeld:

### *Sensitivity*

The creative person, says Dr. Lowenfeld, always exhibits an unusual degree of sensitivity—to problems, to needs, to the attitudes and feelings of other people, to the experiences of life. He has trained himself "to use his eyes not only for seeing but for observing, his ears not only for hearing but for listening, and his hands not only for touching but for feeling." He has a heightened awareness of anything that is odd, unusual or promising in the person, material or situation with which he is dealing.

At first, the researchers thought there might be a difference between perceptual sensitivity and social sensitivity. But repeated studies have shown that one closely relates to the other.

That is, indeed, one of the more significant findings of the Penn State research.

There are a number of good tests for perceptual sensitivity. One, which is highly regarded at Penn State, was developed by the late Prof. L. L. Thurstone of the University of Chicago. It tests ability to recognize a word in which part of each letter has been erased.

Social sensitivity—the ability to identify with people and problems—is tested by giving the subject a statement of some present-day trend, and asking him to list four possible effects of this trend at some specified future time. For example:

"More girls have been born in the past five years than boys. What effects will this have 20 years from now (in addition to the obvious effect that there will be more women than men)?"

Possible answers:

"A growing number of spinsters."

"Agitation for polygamous marriage."

"More women taking up careers."

"Women will do the courting."

### *Fluency*

Dr. Lowenfeld defines fluency as "the ability to take continuous advantage of a developing situation . . . to use each completed step as a fresh vantage point from which to plan your next move."

Penn State researchers polled 160 distinguished painters, writers, sculptors and composers to find out how they go about the creative work which has earned them world renown. One point which consistently stood out in their answers was that they usually do not begin with an elaborately preconceived plan. They start with an idea and let the creative process develop, step by step.

Since fluency involves the ability to think rapidly and imaginatively, it can be tested by asking the subject to list quickly as many words as possible that meet a specific requirement, such as expressing "enthusiasm."

### *Flexibility*

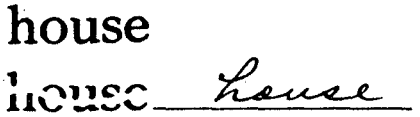
This means the ability to "adjust quickly to new developments and changed situations."

Dr. Lowenfeld points out that happy accidents are likely to occur in carrying out any project. A sculptor's chisel may slip—and produce a striking, if unintended, effect. Or a businessman may discover that a sudden shift in public taste has greatly expanded the market for a product. Noncreative people tend to be distressed by such developments; they were not part of the plan. But the creative person moves swiftly to take advantage of them, to adapt his plan to include the fullest exploitation of this welcome windfall.

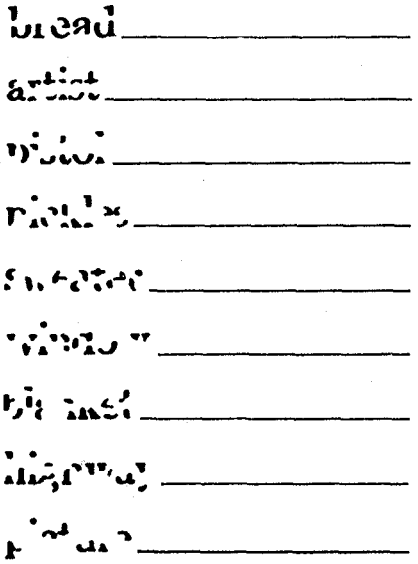
Unforeseen obstacles—the bad breaks—also give the creative person an opportunity to display flexibility. Dr. Lowenfeld likes to play a trick on his art students. He has them rough out sketches for murals. They naturally assume the murals are to be painted on flat wall surfaces, and plan accordingly. But they find that the wall space assigned to them is in a corner—or is broken by some ugly object such as

**MUTILATED-WORDS** test assesses an individual's perceptual sensitivity. Point is to identify partially obscured words.

Example:




TRY your hand on the mutilated words below. Answers in box on page 62.



a radiator or pipe. The less creative students are thrown for a loss. But the creative ones quickly rise to the challenge, modifying their plans to turn the obstacle into a striking feature of the composition.

Give the matter a little thought and you probably can think of a way, within the context of your own business, in which you can put junior managers over a similar hurdle to see how agile their minds are.

### *Originality*

This is the best-known attribute of creative persons—the one that some other researchers have tended to treat as the only significant attribute.

So much has been written about originality that it requires no further definition here. But it is interesting that this quality, for all its familiarity, proved to be one of the most difficult to measure.

After repeated experiments, the Penn State researchers found the answer: Originality can be tested by the "uncommonness of a person's responses to a given stimulus."

One good test, now used in many places besides Penn State (see "Identify Your Creative People," NATION'S BUSINESS, Sept., 1958), requires the subject to list six unusual uses to which some common object can be put. Take, for example, a newspaper. "To start a fire" or "to wrap garbage" are garden-variety responses. "To make a kidnap note" is an uncommon response that betokens a creative mind.

### *Skill at redefinition*

This is the ability to rearrange ideas, concepts, people and things, or, as Professor Guilford puts it, "to shift the function of objects and use them in a new way." The inclusion of this attribute in the list is a useful reminder, Dr. Lowenfeld says, that "creativity is not based altogether on new invention—it also involves the imaginative use of old things for new purposes."

This kind of creativity is particularly valuable in the business world, where success often hinges on management's ability to dream up new uses—and hence new markets—for old products. A dramatic example is the way Du Pont has developed ever proliferating uses for Cellophane. Skill at redefinition is also reflected in the kind of business thinking that turns waste products into salable commodities.

Penn State measures this attribute with a clever little test that, incidentally, makes an entertaining parlor game. It goes like this:

You are given a problem, and a list of five objects. You are told that you can use a part of one of the objects to solve the problem. You are also warned that the solution "may require ingenuity."

For example, the problem may be "to start a fire." The objects are a fountain pen, an onion, a pocket watch, a light bulb and a bowling ball.

The answer? You can use the crystal from the pocket watch as a burning glass to start a fire.

(If you want to try this on your friends or associates, you'll have to make up your own problems from that sample. Penn State is currently using this test and doesn't want to spoil it by publishing all of the questions and answers.)

### *Ability to abstract*

This attribute might be called "skill at analysis." It connotes proficiency in breaking down a problem or a project into its component parts and comprehending the specific relationships among them—in Dr. Lowenfeld's words, "abstracting details from the whole."

It may surprise some to find analytical ability listed among the attributes of creativity. Analysis is often thought of as a sort of plodding, logical process, which requires intelligence but not necessarily a creative spark. But this attitude simply reflects the popular tendency to think of creativity solely in terms of spontaneous invention or originality.

"Without analysis, no truly creative work is possible," says Dr. Lowenfeld. "Analysis prevents us from making shallow generalizations, and allows us to penetrate into the nature of a problem or an experience. The noncreative person keeps looking at the whole problem as one big stubborn mass. The creative person starts breaking it down into bite-size chunks the moment he sees it."

Although Penn State uses several rather complicated tests to measure this attribute, there is a simple one you can try on yourself or your friends.

It is based on the fact, established by Penn State's studies, that there is a close correlation between a person's ability to abstract and his observance of the details of his everyday environment.

Where is the green signal on a vertical stop light?

If you don't know, you are not very observant, according to Dr. Lowenfeld. The green signal is *always* on the bottom, for the benefit of the color blind.

### *Ability to synthesize*

This is the other side of the coin, the reverse process of the ability to abstract. It means the ability to combine several elements in a creative way to form a new whole. It can be tested by presenting the subject with words in a scrambled order, and asking him to combine them into a meaningful sentence. Another test, which is more perceptive when administered by an expert judge, is to give the subject a lot of unrelated objects—such as steel wool, strips of cardboard, pipe cleaners, tongue depressors, wire screen and scraps of yarn—and ask him to combine them into an aesthetically interesting three-dimensional composition.

Both of these tests may sound far removed from the business world. But a man who does well on them probably will also prove to be creative in, for example, bringing together a lot of different manufacturing operations to form one smoothly integrated production process.

### *Coherence of organization*

This trait is hard to define, but Dr. Lowenfeld says that it invari-

## ANSWERS TO TEST

The design test on page 58 not only shows creativity, Dr. Lowenfeld says, but indicates an individual's sense of "organizational coherence." This is the ability to grasp things in a way which eliminates the superfluous.

Here are the selections made by Dr. Lowenfeld:

1-*Right*
2-*Left*
3-*Right*
4-*Left*
5-*Left*

The words in the word-mutilation test on page 59 are as follows: bread, artist, pistol, pickles, sweater, window, blanket, highway, picture.

Please DO NOT write to Penn State asking for copies of these or other creativity tests. Dr. Lowenfeld does not regard any of the tests now in use as being in final form. He is constantly revising and refining them. They have not been mass-produced and no facilities are presently available for making large numbers of copies.

## KEYS TO CREATIVITY

# Is your solution original or is it stereotyped?

ably shows up in creative people. Essentially, it is the ability to organize a project, to express an idea, to create a design in such a way that nothing is superfluous. It is getting the most out of what you have to work with, doing a job "as economically as is consistent with the objective to be reached."

Penn State's test for this attribute confronts the subject with six pairs of designs. In this test, developed by Dr. Alfred Kiesselbach, the subject is asked to choose, from each pair, the one he prefers. Though both designs are abstract, one combines the symbols in a more imaginative way.

Although the tests are not available to businessmen, there is, however, an immediate use to which the Penn State findings can be put.

"I believe that any person can heighten his own creativity," Dr. Lowenfeld says, "simply by carefully studying these eight attributes and consciously setting out to cultivate and practice them in his everyday life."

In other words, check yourself out on these attributes. Think back to some recent problem or situation in which you were involved. Were you really sensitive to the issues? Did you identify with the other people concerned? When you started working toward a solution, did you use one step as a springboard to the next —or try to bull through a preconceived plan?

Did you take advantage of the happy accidents? Was your solution original or was it stereotyped? And so on.

Don't expect to make too high a score on this self-evaluation—if you are honest with yourself.

"We can all be a lot more creative than we are," says Dr. Lowenfeld. "The first step toward improvement is to find out where we are weak."

—LOUIS CASSELS

**REPRINTS** *of "Eight Keys to Creativity" may be obtained for 10 cents a copy or $6.75 per 100 postpaid from Nation's Business, 1615 H Street N. W., Washington 6, D. C. Please enclose remittance.*

Nation's Business

February 1959 Vol. 47 No. 2
Published by the Chamber of Commerce of the United States
Washington, D.C.

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Nation's Business is published monthly at 1615 H St. N.W., Washington 6, D.C. Subscription price $10 for three years. Printed in U.S.A. Second class postage paid at Washington, D. C., and at additional mailing offices. *Copyright, 1959, by Nation's Business—the Chamber of Commerce of the United States.* Nation's Business is available by subscription only.

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NATION'S BUSINESS-FEBRUARY 1959

19, 20

REMARKS BY CHARLES F. KETTERING

ON RECEIVING

AWARD OF MERIT OF THE AMERICAN ALUMNI COUNCIL

AT ANN ARBOR, MICH., JULY 13, 1948

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Transcribed from a radio broadcast by

Station WJR, Detroit

July 15, 1948

Charles Kettering at 10:30 P.M. over WJR (Detroit)

BUD GUEST: "Good evening, ladies and gentlemen. One of America's greatest living citizens, CHARLES F. KETTERING, engineering research genius, received the Award of Merit of the American Alumni Council this week. The Award was presented to Mr. Kettering for his work as a scientist, humanitarian, inventor, philosopher, a college graduate and an American by Mr. Kenny L. Ford, president of the American Alumni Council at a luncheon in the Michigan League Building on the Ann Arbor Campus of the University of Michigan. Mr. Kettering is the third holder of the Council's award of merit, the other two being Madam Chiang Kai-Shek and General Dwight D.Eisenhower. Mr. Kettering's acceptance address was an inspiring message for all Americans punctuated with rare good humor and unfounding faith in the future.

"As a service in the public interest, WJR presents at this time a recording of that message by Charles F. Kettering!"

KETTERING" "Mr. Chairman, ladies and gentlemen. I want you to know how very greatly I appreciate this honor. I'm not quite sure after I read Dr. Ford's letter to me whether this award was given for accomplishment or whether it was given for not taking your college education too seriously. In the particular phase of work which we have done for a great many years as engineers and inventors, I believe that we can pass back to you some factors that are quite interesting from the standpoint of fundamental education. I have made this statement many times and maybe a lot of you want to counteract it - it's all right if you do - that the consensus of studied opinion is always wrong, especially if it has to do with a new project. Now that is quite simple because that consensus of studied opinion, when taking a new thing into consideration, will always be handicapped on two counts. The consensus of the opinion of the people will be, first, a very amateurish opinion if it's a new thing, and next, most of those committee people have their own faces to save and therefore they'll be ultraconservative on the side of safety.

"Now, an inventor is a fellow who doesn't know anything about the subject at all and therefore is willing to try something. I have said many times that I can train anybody to be an inventor. Now, this will interest you very much as educators and as educated. I think it was the Brookings Institute that made the study and said that the more education a man had, or a woman, the less likely he was to be an inventor. Well, now, I said if that's so, it's wrong. Something is wrong. Now why is it then that the more education we have the less likely are we to be inventors? I think the reason is quite simple. I sat down and analyzed it and I have acted upon this analysis and find that at least from our experimental point of view it works very well.

"The kid from the time he enters kindergarten or maybe a little farther up is examined two or three times a year and, of course, if he flunks, that's awful. Well, now an inventor flunks all the time and if he succeeds once, he's in! You see, instead of being out. By the time this boy graduates from college, he's so afraid of the word failure that he doesn't want to enter into any zone where there's even an atmosphere of failure. So the first thing we do is to guarantee the failure. Now, what you want to do is learn how to fail intelligently. After you've failed, analyze it and find out why you've failed because every failure is one of the steps that leads up into the cathedral of success

and you can't make that final step unless you come all the way up.

"Why do we always fail in these things? Well, the thing is very elementary again! Because the first time you do anything you're doing it as a very rank amateur 'cause that's all an amateur is - a person doing a thing for the first time. And his ability to succeed on the first time would be purely accidental on anything outside of the most mediocre attempts. So this question then of practicing how to make each step. Sometimes you have to practice, practice, practice, practice. That's the reason why we can never tell you how long it's going to be after we start a project before you get the answer because we don't know how much practice we have to do on the road. You can call it experimentation - anything you want to - research is only a word of giving failure a respectable nomenclature. That's all.

"I want to get some sort of an award for the inventor. We give a patent. People don't understand patent. Now, patent is simply saying that this guy is the first fellow that ever did this and he's entitled to the use of it for 17 years. See? Because if he hadn't done it, we wouldn't have had it at all. After 17 years, which is a very short space of time, the country has it from then on.

"But the fellow who turned the thinking of people around, he should get some sort of a reward, too, see? Because it's much more difficult to reverse the thinking of people than it is to give them a new idea. We have that problem stepping up here a little bit on a new type of engine which we developed. The new type of engine is exactly like the old type, but we rearrange certain parts of this engine differently from what it's been. We went out and got the consensus of studied opinion on that, just for fun, and even in our own organization, where people are paid to be open minded (laughter), the consensus of studied opinion was no good.

"Well, now there's one thing that we ought to realize, that fundamentals of nature, fundamental laws of nature, don't care what we think about them. And the greatest failure that some people have in this world is to think that they can edict something. The only thing you can do is to follow things. Let the job be the boss and you follow it around and run errands for it and that's the way you get things done. In this thing of studied opinion, there is no possible way in which you can overcome the negative attitude or the wrong attitude to a thing by any argument, philosophy, logic or anything of the kind. Any time you are arguing on a thing like that, you're just wasting time. The only thing that will solve that problem is a sample - a working sample. And the working sample - people seem to regard the working sample not as a propagandist of any kind because it's an immaterial thing and that is the thing. We have had some very interesting things in the development of certain hydro-carbons that are used in fuels. There are certain very definite rules and regulations. You can get them in all the textbooks of chemistry. And part of our difficulty comes from the fact that we don't recognize why those are rules. And here's some of the great difficulties. If two lines are almost parallel to each other, they're still going to have to cross out here some place. If, in the zone of which we have worked, Line A has always been below Line B, it becomes a terrible shock when you cross - and Line B becomes below Line A. Therefore, after you go across the junction, you still want to apply exactly the same formula you used before.

"Well, in making one of these peculiar hydro-carbons, one of nine of which either were on the one side of the crossing and the ninth on the other, we naturally invited in some of the people who built apparatus of that kind and asked them to take a look at this thing and they did. They said, "We wouldn't want to tackle that job because our reputation is very good, and that system won't work and we don't want to be associated with it." We said, "How do you know it

won't work?' 'Well,' they said, 'our chemists have gone over it very thoroughly and they said it was wrong.' 'Well,' I said, 'don't you think you ought to have the chemists come down and take a look at it?' And they did, and the fellow took a blackboard and wrote out all the formulas and everything else and said, 'Now, there's the reason why this thing won't work.' 'Well,' I said, 'what are you going to do about the fact that just on the other side of the wall is an apparatus working?'

"He picked up the erasers, started to erase it. I said, 'Don't do that; don't erase that. You ought to go back and see where you missed the turn in the road, and right back here was where it was, see? Because you pre-supposed that this thing had to work like the other eight of them did, and that's the reason why you've had difficulty in making it. This is just as easy to make as the other eight. The only thing is that you have to make it the way this one wants it to be made. And that's the way you think it ought to be made.' So we developed an awful lot of theoretical difficulty.

"In your citation here you mentioned the Diesel engine and the locomotive. Now, we didn't invent the Diesel engine. It's a very, very old thing. The Polynesian Islanders invented the diesel engine about 600 years ago. The Indians, you know, strike a flint to make fire or rub sticks together to make a fire. Well, the Polynesians took a section of bamboo, we'll say a foot long, with a node at the end of it that made it a dead end, put a little wooden plunger to it like most of the fellows here in the North know about making the pop guns and squirt guns, and they took that little plunger there, wrapped a piece of string around it to make it tight, drilled a hole in the end of the plunger, put a little piece of dry moss in there and then hit it like that. That compresses the air suddenly and quickly enough so that it ignites the moss due to the heat of our compression and that's the way the Polynesians started fire. It's what you call 'compression ignition.'

"Now, Rudolph Diesel saw those - they're called fire pistons - in the Deutsches Museum in Munich and if you ever happen to go to London, Bryant and May, who are the large match people over there, have a complete museum. I suppose there are two or three hundred of these fire pistons of various types in there. Now, Rudolph Diesel said, 'I am going to make an engine that will work that way, which will be ignited by compression.' And that's where he came into the picture. That was 40 or 45 years before we had anything to do with the thing. The business had never amounted to much because it had gotten into the idea that they had to be big and heavy and all that kind of stuff, and the books had been written and people read the books, unfortunately, so that if you went out and made a Gallup survey today of what the people think of Diesel engines they'd all say they're big, heavy and have slow speeds. Not a thing of it is so. The kind that were built were like that, but they had nothing to do with it, because the Diesel engines are just as light as any other kind of engine in the world.

"After the war was over, some of our friends from Switzerland came over to see us, and they were amazed at this terrific development that we had made over here in the way of locomotives and various other things. Finally they came over to see me. I knew these fellows very well, and they said, 'Ket, will you get sore if we ask an impertinent question?' I said, 'No, I never get sore about anything.' I said 'What's your question?' They said, 'Well, how did you get yourself into the state of mind that you could design such a cockeyed engine as this.' 'Well,' I said, 'it's only cockeyed because it's not conventional.' They said, 'That's right.' 'But,' I said, 'we didn't design it.' I said, 'All we did was run errands for it. We built a single cylinder engine and we said to the engines 'Now, here's a half

a dozen pistons. You try them out and tell us which ones you like the best, see? Here's a half a dozen valves, try them out to see.' Now, that stands in the intellectual world as a very low grade of doing things. The educator wants to call it out and try. We're not that dumb, see? We call it experimental evaluation. That gives us a much higher standard in the educational world. We said we'll let the engine evaluate this thing and we ran errands for this engine for four or five years; then finally we put it together. We made it into a 16 - or 12 - 16 cylinder engine, put it on a locomotive and it went out and did pretty well. 'Now,' I said, 'if that engine doesn't work, it's not our fault, 'cause that's the way it wanted to be and all we did was to try to help it along.'

" 'Now,' I said, 'I want to show you how much smarter the engine is than the engineer, because that's important Because we think we've got a slide rule, you know, why, that's all right.' I said, 'The best that any engineer would guarantee the pistons and rings for a locomotive engine was 50,000 miles. But, I said, 'the engine picked out a piston that would run one million and a half miles, thirty times as long, see? And the rings run ten times as long in these engines as any engineer would venture. Well, now, why - simply because we let the engine decide.' We're not so smart you know, and especially if we get a formula. That's when we get dangerous - when we get a formula written down, because a formula is a very narrow road.

"I have this old story that I have told a great many times and its only good because it's true. I live in Dayton. That's where my home is. I can't get a job there, so I have to work in Detroit. And naturally I drive back and forth an awful lot between Dayton and Detroit and fly a lot, and this friend of mine, who also lives in Detroit, said to me one day, 'I understand that you drive from Dayton to Detroit in four hours and a half.' I said, 'Yes, I do.' He says, 'I don't believe it,' I said, 'Why,' 'Well,' he said, 'I'm a much better driver than you are and I can't do it in four hours and a half.' 'Well,' I said, I'm going down Friday afternoon. Why don't you ride along down?' And so we drove down and got into Dayton in four hours and a half and he says, 'Well, 'my God, no wonder you can do it in four hours and a hal you don't stay on Route 25!'

"It is that phase of education that worries me. If you're a stranger you ought to stay on Route 25. If you're in a hurry you should get off it. We have to teach by example. We have to teach by sample. But I sometimes think we over-estimate the particular sample, so we disregard the whole countryside on either side of the sample. And we get into some very peculiar situations. As you know, of the last 15 or 20 years we have developed the so-called glass fabrics to a very high degree. You've seen them in tablecloths and all that sort of thing-beautiful fabrics. And we have begun to use the glass tape as the insulation for wires in electric motors and so forth.

"Now, part of the things of education and of engineering are supplied by nature and part of them are supplied by convention. I mean, we write down that it's going to be so and so. So we've written down that the rating of a motor shall be made in this way. You drill a hole in the motor frame, put some oil in it, and then put a thermometer in and when that thermometer goes 50 degrees above the temperature of the room, that is the horsepower rating of that motor. But if you wrap the wires with glass tape, the glass is too thin. It's a very good insulator, and the very next thing is that it's a much better conductor of heat; consequently, you do that with the idea that you're going to take more horsepower out of the motor instead of less. And if you put the thermometer in that thing, you can only carry about three-quarters as much horsepower as you did before while you expected to carry

25 percent more. Simply because the rule says that when the thermometer gets 50 degrees centigrade above the room temperature, that's the rating of the motor.

"Well, over in England - it took them a year and a half to get that rule off, so that they could rate it up because they said you can't reverse a fundamental rule of electrical engineering. That didn't have anything to do with electrical engineering. That had to do with the characteristics of cotton and that's all, because if you heated cotton tape much hotter than that, it decomposed and got brittle and fell out. So here we were handicapping an electrical concept by the nature of a cotton insulation. You haven't any idea how much of that we do. It's terrific! We say you can't do this and so because of - well, you can take that away but we write that in as a fundamental rule. We had one in this country on a rule in the electrical engineer's meeting of taking out what we call split phase motors. I won't go into detail on that but I'm going to tell you a story.

"Now, they named it split phase motor, said that we can't have split phase motors because when the refrigerator starts then the lamps wink and we don't want that Well, I said, 'You don't mean that at all. All you mean, that no motor that takes more than six times as much current to start it as it does to keep it running should be used on the line, but don't give it a name, see? Because maybe we could lick that.' But a fellow says, 'But you can't.' Ninety-eight percent of all motors today are split phase motors and they don't wink their lights. Because the reasons that they put up has nothing whatever to do with electrical engineering.

"Another thing we've had. We like to take people who are not educated in their line and put them on to research because then they don't know what can't be done and they'll try.

"First, in the Ethyl gasoline which was mentioned in the citation here, the man who did that work was a fellow by the name of Thomas Midgely. Thomas Midgely came to me as a mechanical engineer and I put him on hydrometers because I wanted to try out a number of different kinds of hydrometers. He had been making hydrometers for the determination of the temperature to which the anti-freeze would go. You'd take a sample of it out and that would tell you how cold it could get without freezing. Well, that business hadn't gone very well so he came over and got a job with me. But I had a hydrometer job. So, after he got that job done, he said, 'Boss, what do you want me to do next?' And I said, 'I want you to go over in my office in the old Delco plant and get a box and I want you to open that box up and you'll find some instruments in there, and some old greasy papers and so forth.' I was doing some work on engines because I wanted to find out why engines knocked. Now I took a whole Saturday afternoon to sell him the idea that this was quite an important project. And I said, 'Everything that's in the books and everything that everybody thinks about this thing is wrong. So you've got a perfectly clear slate to start with so don't read any of the books because you're going to get into trouble for sure if you do.'

"Well, now, Midge had never had any chemistry at all, and he went along for a little while and finally he said. Don't you think we want a chemist? and I said, 'No, What do you want with a chemist?' I said, "He doesn't know any more about that than we do.' And I said, 'He's going to come in with a pack on his back, and we're going to make a very steep climb here and it may be that that very pack is going to keep us from getting up. Let's you and I go up and survey the road without any packs on our backs and then we'll get some chemists.' Well, Midge died as president of the American Chemical Society. With all the medals that Europe and America could hang on one guy, see? So, I wrote the Dean. I hope there's a Cornell man here because this is very complimentary to him - I wrote the Dean of Engineering of Cornell. I said, 'I have a friend who

wants to take electrical engineering, what course do you recommend? Because, I said, Midge took mechanical engineering and turned out to be a chemist. Don Brown took electrical engineering and turned out to be a financier. So what course do you take if you want to be an electrical engineer? He came right back and said, 'If you've got a degree from Cornell, you can do anything.' And that is what I think engineering education or any education should be.

"Well, now a few people you can't type so easily. I mean it. But we take a lot of people who have no knowledge whatever, because after all, education is not knowledge. I used to have a lot of arguments with friends of mine about what constituted it, encyclopedic knowledge or whether it was ability to analyze and so for a Christmas present I sent him an encyclopedia that wasn't printed, just the white paper and pencil and said, you fill it out.

"If you know what you want to find out, if you know how to use it, if you know how to put it into the pictures, then it's very easy to do - these new things. The greatest difficulty that we have in doing a new thing is always to make it like something else. In other words, I think you can have anything new if it looks like something else. The Diesel engine was made for 20 years to be like a steam engine and then it was made 20 years to be like a gasoline engine and now all we did is let it be like a Diesel engine and you ought to see how. What a happy thing it was when we did that. But we have that idea that it must be like something else.

"Perhaps there was never a time in the world when there was such an opportunity for people who had knowledge and understanding as there is today. I find people very much depressed. I think they're worried about the Russian situation, about the Democratic Convention, the Republican Convention. These don't have anything to do with the long range thinking of the world at all because they all wash out afterwards. We've always had that kind of stuff to contend with. I'm thinking about the long range things that we've done and the long range opportunities that we have today because we're just becoming conscious of the fact that we don't know very much.

"And we know practically nothing. I mean it's pitiful. If you had to try to run yourself for three minutes by any knowledge that the medical profession could furnish you, you'd be dead simply because - and yet the doctors have done just as good a job as the rest of us. Now, about the best education from our point of view that we have is education in music because if a fellow is going to study the violin, when he comes to school he brings the violin and he practices the violin from the time he starts to school. He learns something about the history of music and so forth. But that is good education because you're doing the thing. So much of it we do by symbolism. We write the thing down on the blackboard and we don't work with the thing. A friend of mine said to me the other day. 'Well, inventors look at things differently because . . .,' I said, 'No, what you meant to say is no; inventors look at things and if we can understand the thing better by looking at a symbol on the wall, or on the blackboard, we do it. But we have to do the thing.' Now, if you studied music in the engineering department, and I hope there are no engineering people here, you would have to learn all about differential equations before you could ever pick up your violin and try to play it and then you would do a terrible job, see? But you practice, and the fellow who plays in Carnegie Hall is the fellow who starts to practice when he's a kid six years old. Most accomplishments have to be done that way. It doesn't make a difference what the reason. So we say, we've been working on that thing 10, 15 or 20 years. If the fellows say aren't we discouraged, we say no, why should we be discouraged? That isn't very long.

"I've got some researches going that I hired a bunch of young fellows to do

and I said, 'Now, I hope you get married and have a lot of children because it's going to take us about three generations to do this job.' The great trouble with the reformers is that they want to reform a fundamental of nature, which is human psychology or human behavior in about four or five years. It doesn't work that way. But you have in your hand in the institutions which you represent, the possibilities of painting the most magnificent future for the young men and women of America that ever has been made. There's nothing in the world to be discouraged about. You don't necessarily need to read the commentators to tell you how bad everything is, how fast it's going to where it shouldn't go, and all that at all. The paper says - about the land being exhausted. It said the other day we're going to have a billion more bushels of wheat or corn this year than they had last year. Well, that's because the weather shifted on us. They say we're exhausting the land. I say well, where's it going? We know where it is. It's all out here in the sea. Let's all go and pump it back! If we starve to death, if we let the land run down, that's just plain stupidity. And I'll guarantee that you don't have to worry about it at all. But you'll have to do something about this.

"So, let's don't live in this frightful idea that everything is going bad, because it isn't. Your mental attitude and the mental attitude you teach and the mental attitude that's grasped by your students is the difference between us going bad and going into the most unbelievable fantastic future that human mind can imagine. Thank you so much!"

# *Some Psychological Factors Favoring* INDUSTRIAL INVENTIVENESS

By ELLIOTT DUNLAP SMITH

MASTER OF SAYBROOK COLLEGE, YALE UNIVERSITY, NEW HAVEN, CONN. MEMBER A.S.M.E.

The inventiveness needed in industry today is more than "Yankee ingenuity." The old homespun resourcefulness is still as valuable as ever, but to be useful in modern industry the inventor must be both intuitively resourceful and scientifically sound. An example will make clearer what this combination means.

Greeting cards for generations had been printed from steel dies with linseed-oil inks. Then a trend in style made it necessary to have deeper cuts in the dies to make more dramatic effects. This meant that, when the card was printed, the ink, instead of being thinly spread, was massed on the card in thick ridges. Since linseed-oil ink dries by oxidization from the air, the drying of the outer surface of ink created a skin which made the penetration of oxygen from the air to the ink inside these ridges extremely slow.

To speed up the drying, mechanical engineers devised various schemes, utilizing heat and draft, but without solving the problem. Each color that was printed still took several days to dry. Then an invention was made. Instead of working upon the problem of air-drying at all, a young man conceived the idea of using inks which would dry internally through chemical reaction and, in a short time, an ink base was developed that dried almost instantaneously regardless of the size of the ridge. As a result the cards could go on a belt directly from press to press.

This problem was clearly a technological one and the inventor had to be scientifically competent in order to deal with it. Yet the act of inventiveness which achieved the solution was not logical scientific thought at all. It was a flash of intuition which showed the problem in a new light.

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, New York, N. Y., Nov. 29-Dec. 3, 1943, of The American Society of Mechanical Engineers.

What I fear most as an obstacle to inventiveness in industry is that as a young engineer pursues the long slow path of education and experience, he succumb to the past. . . The most important way out of this dilemma is to make education and experience more fundamental. If in school and at work the resourceful young engineer is required to shun memorized formulas and to go back to basic principles for the solution of his problems, the process of developing technical competence will in itself give him the basic understanding and way of thought essential for inventiveness. When logic thus goes back to fundamental origins, and is in that sense original, logical development and inventive insight come close together. Both made possible fundamental shifts to more profound bases of approach.

## INTUITION AND LOGIC BOTH ESSENTIAL

Such intuitive insight, even though scientific, differs sharply from the systematic explicit process of logical scientific thought. The logical thinker consciously works out his solution. He does so step by step in orderly sequence. He thinks principally in words or symbols, and he can put his logic into language so that others can follow it. The intuitive thinker gets his answer unconsciously by all-at-once insight into the problem as a whole. He cannot put his process of thought into words for he is unaware of the means by which his insight came. Today the inventor must be able to do both types of thinking.

The process of creative insight has much in common with the intuitive formation of images in customary thought. For example, if a curve like this ) is displayed with the statement that it is part of a whole the rest of which is concealed, most people will see the whole in their mind's eye as a circle. But some will probably see it as a segment as in Fig. 1(a), or as a sector, Fig. 1(b). If, however, some of the group have been working with lenses,

they might see it as one of the following lens forms, Fig. 1(c), (d), or (e).

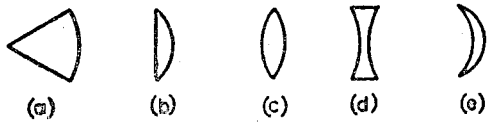


FIG. 1

Whatever the conception, rarely will it result from the logical deduction. Of those who saw a circle, probably none will have plotted perpendiculars to tangents and found that they met at a point, and then having found that every point on the curve was equidistant from this focus concluded that the figure was a circle. Instead, the hint provided by the fragment caused each person to see some figure as the whole, without conscious reflection.

It is important to realize that this type of unconscious all-at-once identification permeates our daily life, and that without it we would be helpless. It is important also to realize that a single hint or clue, depending upon the angle of approach, may give rise to a wide variety of conceptions even in a single mind. This is true even when, as here, the element giving the hint is mathematically precise. Moreover, if one conception fails to satisfy, the mind can shift quickly to another.

What an inventor must do is similar to this. He must resourcefully create out of obscure clues vivid and varied configurations. If configurations of one sort fail, he must be able to view the problem from a completely different angle, such as viewing the curve fragment shown, from the point of view of lenses in case a geometrical approach fails.

Curiously, what the mind recognizes with either hints or wholes, is not the exact patterns which are formed on the eyeball but their structural form. For example, if one holds a circle first at 10 and then at 11 inches from one's eyes, the different-sized images made on the eyeball can have in common only one point of tangency or two points of intersection. Nothing more! And yet at any distance where the image is clear, and even if the sheet is viewed at an angle, no one has difficulty in seeing that the form is circular. This is even true with such complex patterns as chairs, or a person's face. Thus a child has no difficulty in recognizing its mother at different distances or angles.

Intuitive recognition occurs even when there is no common external stimulus; merely different instances of variable structural form or type. For example, there are almost no characteristics common to all Jews. Yet people can ordinarily intuitively recognize a Jew, no matter in what ways he varies from type. This is of fundamental importance because it makes possible intuitive thought in regard to generalizations and abstractions. It thus enables intuition to deal with problems of abstract science.

## APPLYING INTUITION SCIENTIFICALLY

There is no fundamental difference in intuitive recognition when scientific knowledge is involved. Two men, for instance, are walking in the woods. There is a flash of lighter green in the trees. One man sees nothing but a flash of lighter green. The other says "That's interesting. I have never before seen a yellow-breasted flycatcher in this part of the world." In his well-trained mind, the hints of changing color had been unconsciously associated with what he knows of the bodily structure, way of flight, and color patterns of birds, into a meaningful whole, so that what he actually observed was not the flash of color noticed by his friend, but an actual yellow-breasted flycatcher in flight.

If he is not sure that his observation was right, the ornithologist will begin a process of logical reflection, comparing point by point the family characteristics of the flycatchers and then those of the different species, with what he can recall of what he saw. But what made him aware of the bird at all was not logical thought but the creation, through the unconscious aid of scientific skill, of the configuration of a yellow-breasted flycatcher out of clues that to the other man were not only meaningless but not even fully observed.

The point I wish to stress here is that, in scientific identification where no invention is involved, what the scientific knowledge first does is to take the same hints which to other men have no meaning and intuitively complete them into a meaningful whole. Even though the process is scientifically exact, the intuitive element is creative.

In invention this creative aspect assumes predominant importance. Unless the inventor is willing to relax the meticulous step-by-step procedure of logical science and let scientific clues suggest generous, or even extravagant, technological conceptions, he will get nowhere. For what the intuitive process of invention does is to lift reason out of the established paths of technology, when they have become ruts, and to put the mind upon a new road leading more directly to its goal.

It is thus when the various habitual images, arising from the clues given by experience, fail to give satisfactory results, that the problem shifts from one of recognition to one of inventiveness. How this occurs is well illustrated by Professor Kohler's studies of

problem solving by anthropoid apes.[1] In one of his experiments, he placed an ape in a cage where food was temptingly near but out of its reach. The ape immediately applied its former practice of reaching through the bars. This failed. It tried the habitual method again and again without result. Then it sat down in discouragement. But the food was tempting. Suddenly it picked up a stick which had been in sight all along and which it had never before used as a retrieving implement. Without any awkward trial and error, without any preliminary steps, it reached out with the stick beyond the food and brought it in.

As with recognition, this intuition consisted in instilling meaning into otherwise unrelated clues. But it further involved creating, out of formerly unrelated hints, a conception which not only fitted the situation but which the ape had never conceived of before. It is in this creation of novelty by intuitive contrivance that the essence of invention lies.

Now it is interesting that during all the preliminary struggle the stick had been in plain sight, but had had no significance to the ape which later solved the problem. It was only when a flash of insight combined into a new meaningful whole the hints provided by the presence of the food, the stick, the ape's arm, and by its unsuccessful attempts at reaching, that success came. Even in this very low order of invention, it was necessary to use the wisdom of past experience to escape from the bondage of past experience, and it is that which makes invention so difficult.

If the stick is placed in such a position that it and the food cannot both be seen at one time, many apes cannot solve the problem. With very simple minds, all elements of the solution must be visually present at one time for the clues to be sufficiently strong for the new whole to be conceived. Even with skilled engineers and scientists, the influence of such a favorable setting is great.

## PASTEUR DISCOVERS PREVENTIVE INOCULATION

Often the accidental proximity of the component elements of the solution have been the prelude to great invention. Thus just before he discovered preventive inoculation, Pasteur's illness caused him to neglect a culture of chicken-cholera microbes that he was studying. In this study, he had already observed that those few chickens which became infected and yet somehow survived the disease were thereafter immune against further infection. When after illness he returned to work he found that the undernourished microbes had lost most of their vitality. Thus by chance, the knowledge that infection gave immunity against reinfection and that protracted malnutrition produced attenuation of microbial vitality were brought to his mind when it was actively engaged in seeking means of preventing infection.

This enabled him to see a startling possibility. Might it not be possible to find means of so attenuating the microbes which caused disease that a person could be inoculated with them with no risk and only minor discomfort? Then might not the fact that the person had had the disease even in a mild form render him immune to it thereafter? He inoculated his chickens with the enfeebled microbes. The chickens displayed only the mildest symptoms of cholera. But thereafter they were immune to infection by germs of full virulence. Preventive inoculation had been discovered.

Most experimenters would have thrown the neglected microbes out as unsuitable for experimental use. Even if they had bothered to examine them under the microscope the feebleness of the microbes would have made their unfitness for experimental use seem all the more clear. Only to a mind peopled with vivid concepts of disease, and sensitive to implications quite outside its own expectations, would the apparently disconnected elements of this problem come together as a richly meaningful whole.

Unquestionably, this favorable setting occurred by chance but as Pasteur so often said, "Chance favors the mind which is prepared," and well might he have added, "but only if the mind has retained its freedom and resourcefulness in spite of the discipline of preparation." It is the need of this combination of discipline and freedom that makes scientific and engineering invention so difficult.

## INVENTION OF THE AUTOMATIC LOOM BY NORTHROP

Let me take a concrete example. About 1860, loom manufacturers began trying to devise an automatic loom. By 1890, all the elements of an automatic loom had been devised except that no way had been found automatically to thread the bobbin yarn through the eye of the shuttle. Without this, an effective automatic loom could not be made.

One day a machinist named Northrop, who had been working on spinning machines, went to his chief and said he thought he could invent an automatic loom. At some time in his work a flight of inventive intuition taking off from his background of knowledge of spinning had given him a vision that the problem of threading the shuttle could be solved if the old conception of threading the yarn through the circular shuttle was abandoned and instead the yarn was wound into an open eyelet.

[1] "The Mentality of Apes," W. Kohler, Harcourt, Brace, New York, N. Y., 1925, pp. 32-40.

This inventive insight was followed by a long period of experimentation until he devised a shuttle in which a curved entrance into the eyelet was so patterned as to correspond with the whirl of the yarn as it came off the spindle. Then by merely anchoring the yarn and sliding the shuttle across the loom, the yarn as it unwound from the spindle wound itself into the eyelet. Thereafter, the faster the shuttle flew back and forth in the loom, the faster the yarn unwound and the more the twist of unwinding held the yarn in the shuttle eyelet.

With Northrop, as with the ornithologist who recognized the flycatcher, clues were meaningful which to others had been without meaning in spite of years of searching. Everyone who had ever worked on looms knew that the shuttle yarn whirled into a cone as it came off the spindle, but did not think of it in relation to the problem of threading the shuttle eye. But with Northrop, the nature of his past work caused him to approach this problem from an angle other than that from which his predecessors had looked. This enabled him to see the old factors in a new light.

As this case illustrates, the process of logical engineering development often comes to an impasse because the engineer is following principles that worked at the beginning but have come to the end of their utility. He is like a man who has planned to climb a mountain and has followed a trail which leads him near to the top but not necessarily into the best position to attain the top. To go on, he must see the mountain as a whole, recognize that he must go back and start from another point of departure in order to surmount the obstacle. Thus inventive insight often involves seeing that the problem itself is not what has been assumed, but is of another sort involving another angle of approach.

To do this is difficult especially for the highly trained mind. For just as a man who has made the wrong turn on a detour finds it hard to make himself return to the place of deviation, so it is hard for anybody who has long studied and worked along one line of approach to try another. This is particularly true if the needed idea involves a fundamental change. In that case, to make the other approach involves more than going back and thinking from another angle. It involves reorganizing the complex structure of knowledge which he has developed with such care and pains.

The situation is very like that of the electrical current in downtown New York. In that part of the city, due to the fact that it was one of the places first wired for electric lights, direct current has been provided from the start. Every electrical device is adjusted to it. If Mayor La Guardia were to state the unquestioned fact that for ordinary commercial uses alternating current is better than direct current, and add that "effective next week alternating current will be installed in downtown New York," a storm of protest would break out. Most electrical devices would be useless until adjusted to this fundamental change.

Just as with direct-current installations, the greater and more intricate the structure of thought involved, the greater the difficulty of change. With a man who for a long time has followed one angle of approach, a fundamentally new approach may even involve changing from an expert who is working in an area where he is highly skilled and completely at home into a novice who is feeling his way. Thus the approach to the problem of drying ink through internal chemical reaction instead of mechanical drying meant that all the work on that problem which the mechanical engineer had done and the ability which it had given him were made obsolete. The problem was no longer even in his department. The internal resistance to this is inevitably great. Every habit of thought and every desire involved unite in opposition.

If others are similarly placed, the united opposition may be insurmountable even after the discovery is a well-established fact. Thus when Pasteur, looking through his microscope at what had been known for decades – the appearance of active microbes in the course of disease – saw this not as the result of disease but as its cause, he rendered obsolete much of existing medical science. Since he had no formal medical education, he had little internal resistance to overcome. But the announcement of his discovery marshaled against him the organized and bitter opposition of the whole medical profession. Their thinking processes and their practices had all been developed on a different stem. To accept the new point of view involved giving up most of their previous ways of thought and practice, admitting that they had been wrong, and then starting the slow painful path of learning new ones.

The influence of established scientific opinion upon the inventor through the power of suggestion is strong even when overt opposition does not deter him. To invent he must so free his mind from the influence and the logic of his own past and that of his fellows, that his unconscious intuition can see clues which he and others have overlooked, and build out of them novel conceptions.

Often in order to get sufficiently away from the effects of stereotypes of thought he must utilize some external means of releasing his mind from too self-conscious and logical control. Thus new insight often comes to an inventor when he is relaxed or diverted; when he is out walking, when he is working on something else, when he is about to go to sleep, or when he wakes up in the night. Only

then is his mind sufficiently relaxed to free insight from bondage to the habitual.

## FAITH AN ESSENTIAL DRIVING FORCE

When, as is often the case, the initial insight is vague and obscure – just a hint itself that something lies in a new angle of approach – the inventor must have great determination and patience in order to keep on until he has achieved success. What brings this about? Certainly not inborn "sticktoitiveness" alone. When, for instance, Pasteur's insight told him that the germs might play a major part in disease, he kept on largely because of faith – because he was convinced that, if his intuition were true, the power of medical science to cure disease would be tremendously changed and the welfare of mankind immeasurably served.

His determination, however, rested upon more than this – it rested upon his conviction that if he persisted, he could probably accomplish the result. He knew his experimental method. He was skilled in it and aware of his skill. He saw the relation of his particular abilities to the solution of his problem. It was because he not only had faith in the value of what he might discover, but faith in himself as the person to make the discovery that he kept on. Little inventive persistence occurs unless both aspects of faith are present; and as with Pasteur, faith in one's insight and in oneself is essentially a by-product of technical understanding and high intuitive skill. The pathway to developing the drive that keeps one going until success is the slow hard one of developing the wisdom and skill that makes success possible.

Quite apart from the driving force of faith is that of inner tension. To make this clear let me again cite a very humble example. When a person has seen an acquaintance whom he once knew well but cannot place, he feels a sense of strain. He has a clear image of the man he has seen. He knows that he has somewhere in his mind a clear configuration of who he is. Both are there. But he cannot bring them together into a common conception. This makes him restless. He keeps turning the problem over in his mind even when he is trying to think of something else. The more nearly he seems to "get it," the more strain he feels. Then in some moment of relaxation just who the person is comes to him in a flash and he has a great sense of relief.

So with incipient invention. If the knowledge of the inventor and the clues which will bring the invention into being have been brought nearly into position to provide the inventive insight, the inner tension will be strong. The man will keep turning the problem over in his mind. He will not be able to get away from it by day or night. As he nears his goal he will become increasingly excited. He will be impatient of the interruption of his work even for sleep or food. It is no wonder that the sudden release of such inner tension is often described by inventors as a "flash."

## INTUITION VERSUS LOGIC

Curiously, in spite of the invaluable part that intuition plays in human affairs, it is common for people, especially if technically trained, to consider it as of a lower order than logical thought and to pride themselves on being exclusively logical thinkers. Logic is so much more tangible and systematic, and so easy to put into words, and hence to teach, that mute unconscious intuition is decried as unintellectual and emotional.

What are the facts? Shakespeare, Bach, Pasteur, Edison, in their moments of greatest originality, were not logical but intuitive. The genius of a great musician in sensing the structure of a composition, the insight of a great doctor in diagnosing an obscure disease, and the insight of a great inventor are intellectual attainments of as high order as any logical deduction.

True, insight can also be of a very low grade. Even apes can exercise it. But as Vannevar Bush, in developing his integrating machine, has shown, complicated logical processes can be performed even by a machine.

Nor is intuition more emotional. Unquestionably, as when a thirsty man in a desert suddenly sees a mirage, emotion and desire can corrupt intuition. But emotions also lead reason astray. Indeed the process of logical reason is so effectively subject to emotional manipulation that self-deception is known the world over as "rationalization."

But isn't scientific logic quantitatively exact while intuition is quantitatively indeterminate? It is. But if one examines the application of quantitative science to reality, one finds that the exactness of scientific logic is limited. Logical quantitative methods are accurate only in regard to abstractions or when applied to "abstract materials"; to unnatural creations of man such as iron and steel; beams and railroad rails; things from which all the variables of Nature have been carefully excluded.

When one deals with normal natural phenomena the realistic precision of intuition is often greater than any which abstract quantitative methods can provide. This is of course true in identifying the workmanship of an old master or recognizing a long-lost friend. But even with so simple a phenomenon as a batted ball, no scientist or mathematician can predict its flight as it leaves the bat with either the speed or the precision of a major league fielder who

sees the ball hit, turns back, and runs almost to the exact place where it alights, integrating by intuition the whole complex of unmeasurable variables. In much of modern life, the most effective understanding is when scientific quantitative accuracy and scientific intuition both play a part.

It is important to bear in mind the high intellectual quality, the unemotional soundness, and the realistic integrity and precision of refined insight. For insight is the father of invention far more indisputably than necessity is its mother.

## PSYCHOLOGICAL REQUIREMENTS OF INVENTIVENESS

What then, to recapitulate, are the psychological requirements of inventiveness and the factors which favor them?

First, it is essential that the inventor "know his stuff." If his inventions are to be of use in modern industry he must be well equipped with scientific understanding. This doesn't mean that he should have endless rules and formulas at the tip of his tongue. Such inert knowledge will be a burden to him. What he needs to have is a vital knowledge of basic scientific principles and have developed realistic creative skill in using them, by practice and experience.

As a second qualification the inventor must have, and must continuously develop against the encroachment of custom and habit, the capacity to construct bold effective and varied configurations and concepts out of the clues which lie concealed in technological problems. The more he knows, the more difficult it will be for him to do this. What I fear most as an obstacle to inventiveness in industry is that as a young engineer pursues the long slow path of education and experience, he succumb to the past as New York has to its direct-current installations.

The most important way out of this dilemma is to make education and experience more fundamental. If in school and at work the resourceful young engineer is required to shun memorized formulas and to go back to basic principles for the solution of his problems, the process of developing technical competence will in itself give him the basic understanding and way of thought essential for inventiveness. When logic thus goes back to fundamental origins, and is in that sense original, logical development and inventive insight come close together. Both make possible fundamental shifts to more profound bases of approach. Even so, with truly baffling problems, logical exploration can only do the groundwork for the flight of intuitive insight. If such insight is to occur, the process of education in school and industry must make provision for its exercise. Again and again the formal paths of logic must be abandoned and the relaxation provided which permits insight unconsciously to find its way.

## CHANGE OF MENTAL SCENE

Another aid to the freeing of inventiveness from the confining influence of learning is to assign to resourceful young men creative problems outside of their customary field of work. Such an alien approach, as it so often has with great inventions, may provide a suggestive setting which will lead to a solution of the particular problem. But more important is the fact that it will tend to free able minds from the confining adhesions of their customary thought.

Since inventiveness is not confined to major discoveries such change may be more frequently provided in less formal ways. Any engineer or executive who is worth his salt should show inventive talent in his daily work and be required to do so. Even in reading, rumination, and talk, the power of creative intuitive thought should be exercised and developed. Much can be done to stimulate this by bringing young engineers into frequent serious-minded association with able men of other backgrounds. By so doing they will be caused to see their own problems from new slants and in the light of different practices and principles.

Far more than senior executives usually realize, what they do, what they are, and what they admire in their subordinates determines what those young men who work for them do, think, and become. Through example, they can keep their juniors in the habit of resourceful yet sound intuitive judgment. They can inspire in them admiration for and determination to imitate the people who have the daring and ability to abandon traditional ways of thought, and who while doing so arrive at conclusions which logic may at first refute but later accept. A third psychological factor favoring inventiveness is thus widespread admiration for sound intuitive thought.

A fourth is determination. But if a young man has vital and profound scientific understanding, if he is resourceful in its intuitive use, and if he admires and cultivates these qualities, I have little fear that he will lack the faith which gives determination. Few men who have attained high scientific intuitive skill through the hard path of study and experience lack the determination to use their skill well. By example and by the work they assign and by the qualities to which they give recognition, executives can do much to cause their outstanding subordinates to revere and study fundamental science and also to cherish and develop the intuitive spark within them which enables them to put this science into richly creative use. Young men of promise can do even more to accomplish this for themselves.

# A CREATIVE APPROACH TO DESIGN PROBLEMS

There has always been a good deal of discussion on the subject of whether creative ability is born in a man, or whether, possessing certain characteristics and traits, he can consciously and deliberately develop this ability. The Creative Engineering Program is in existence today because the Company believes in the latter theory. Successful creative engineering is in part a combination of: 1 - an active and inquisitive mind; 2 - an inner drive which enables a man to get a job done; 3 - a broad background of fundamental knowledge; and 4 - a creative approach to any problem. These first two are inherent characteristics of the individual while the latter two are the ones that can be stimulated and developed. This paper concerns itself only with the fourth quality, the method of approach to a design problem.

Before discussing a creative approach to design problems, it may be well to consider how problems are obtained. Generally you confine your attention to the problem presented to you by your supervisor or someone else. In order to be most effective as a creative engineer, you should learn to sense a need rather than to have someone else do this for you. An individual actually makes a true invention when he not only creates the form of the device but also is the one who recognized the need for such a device.

In order to develop to positions of engineering leadership, an engineer must learn to discover and develop new devices and concepts beyond the expressed needs of industry. A feeling of constructive discontent must be fostered. This means developing the habit of asking yourself - what other ways can we do this? - how can this be improved? - or, why don't we have a device to do this? It is only by looking for new fields to conquer they will be found.

When Fleming observed the absence of bacteria around a spot of penicillin he was examining, he saw the same thing that many other scientists had seen. Fortunately, he did not stop with simply recording this phenomenon, but asked himself - what is the nature of this phenomenon and can it possibly be of some use to mankind? Fleming was not only curious about the laws of nature, he was also willing to make an effort to carry on research and development of the ideas he had.

A willingness to contribute, accompanied by a mind prepared to explore new avenues, is essential to creative thinking. Being content to devote full time to solving other people's problems is a form of mental laziness. As our efficiency in thinking up "new" practical solutions is generally quite low, it is necessary to be most prolific of ideas in order to produce a number of good inventions. The same is true in recognizing "new" problems. For example, hundreds of new ideas for new product lines were probably considered before the suggestion was made to produce the disposall. Still, it was a result of continual searching for new conveniences for the consumers before the one idea that "paid off" was found.

Deliberate and organized thinking is a vital part of creative thinking. It is especially important in the early years of an engineer's experience that he learn how to improve his creative ability.

He must increase his effectiveness to solve problems assigned to him and thus prove his ability before he is allowed to carry out his own projects.

The approach to almost any design problem may be broken down into four basic phases:

a. Definition of the problem
b. Search for method
c. Evaluation and selection of method
d. Solution

These constitute only the idea stage of the solution, the remainder of the design procedure will be omitted from this discussion. If one is to produce consistently usable and worthwhile solutions to problems, he will have to employ a creative approach.

## A. DEFINITION OF THE PROBLEM

When the design engineer tackles a new project, he must pay particular attention to specifications. This is the first phase of solving a design problem. It is also a highly important phase that is often overlooked by engineers. By specifications we mean the actual definition of the problem, wherein the engineer is required to consider many more factors that the rating, weight, size, and other quantities that we normally consider as specifications. He must endeavor to investigate the fundamental problem involved.

Recently a division in the Company desired to increase the rate at which the paper capacitors were wound. The machine in question winds the alternate layers of paper and tinfoil on a bobbin thus making a basic part of a paper capacitor. In considering how these capacitors could be made at a higher rate, the immediate solution seemed to be to increase the speed of rotation. When this was tried, the paper would tear. From this the people experienced in capacitor manufacturing concluded the difficulty was caused by moisture conditions, etc., which weakened the paper in some manner that it would not stand the high speed. Actually, on closer study it was discovered that speed had very little to do with it. The whole problem was a matter of acceleration. This problem was easily solved by using Thymatrol to limit the acceleration of the machine.

After all this work had been accomplished, no appreciable increase in capacitor production resulted. It was at this stage that someone decided to make a time and motion study of the operation. Then it was discovered that most of the time consumed by the operation was spent in threading the machine and in feeding in the two little tabs which make the electrical connection between the plates and terminals on the finished capacitor. Thus, months after the program to develop a faster capacitor winder was started, the real problem was discovered.

In discussions on defining the problem, Mr. E. A. Raney of the Pittsfield Works Laboratory has used the example of pyranol capacitor leak testing to show how more basic problems are often present. For example, if the container can be made leakproof there is no need for leak testing - even more basic would be a capacitor with the desired characteristics that does not use a fluid and hence has nothing to leak.

Not always is the more basic problem easier to solve. The inventor of the revolutionary "Long Play" records took a more basic approach to the problem of producing continuous music than have those who developed the record changers. Likewise in the considerations of means of removing snow from the city streets, it might be well to investigate Dr. Schaefer's man-made snow storms as a means of keeping the snow from even falling on city streets. From these few examples we can see the wisdom the saying "The more fundamental the approach, the simpler the solution." This is generally true if it is realized that the "more fundamental the approach" does not always mean that the solution presented is for the basic problem. Instead, it may mean that the problem was thoroughly defined and the basic factors were considered in the forming of the solution.

After making a complete definition, the problem can be broken into three main groups of desired characteristics and requirements. As applied to a dynamic system they may be classified as 1 - input, 2 - limiting requirements or specifications, and 3 - output. A slightly different breakdown might be applied to static systems.

The three groupings may be explained by considering a typical design problem. For example, consider the design of a new type "noiseless" wall switch. The specifications can be subdivided as follows:

1 - Input

a. Mechanical motion of activating knob

b. Only a small force desired to activate the switch

2 - Limiting requirements

a. Must fit into standard outlet box

b. "Noiseless" operation

c. Must work satisfactorily and safely with 110 or 220 volts a-c or d-c

d. Cost must be in range of standard switches

e. Long trouble-free life

f. Allowable drop across the contacts

g. Current rating, etc.

h. Appearance

3 - Output

a. Mechanical movements of contacts

b. Required time and motion characteristics to break arc

The above is not complete and detailed but serves to show how the groupings can be made. In a relatively simple design as illustrated, complete quantitative data may not be necessary. In general, all dimensions, forces, voltages, etc. should be known quantitatively. If experience has been gained in the field, design sense or "feel" may give adequate measures, but to depend heavily upon mental extrapolation of past designs quite often results in costly failures.

## B. SEARCH FOR METHODS

With the problem completely analyzed and broken down, means of bridging the gap between input and output are sought. This is the point where experience and background knowledge play the leading role. For it is here that a keen mind with a true sense of design curiousity can reveal its vast store of facts on materials, processes, phenomena, devices, mechanisms, etc., and more important, the sources of such information.

Some inventors believe there are at least eight ways of doing everything and strive to find out most of them before making a final selection. In a sense this belief is

held by all highly creative people. As soon as a person becomes satisfied that a certain procedure is the only way, he is no longer creative. A creative mind is an active, nonhabitual mind that always seeks new and better ways of doing things. Not merely criticizing the present systems but weighing the "other seven ways" that might be employed.

As there are so many ways that things can be done, dependence upon memory alone is often an inefficient way of uncovering the possible means of solution. A notebook of ideas and devices seen or conceived in the past, serves as an excellent refresher. Any publication on inventions or mechanisms will often suggest ideas and stimulate thought toward a new system.

Another way to stimulate creative thinking is to "search for power." This is the attempt to perform the required motivation or sensitivity by electric, mechanical, hydraulic, electronic or chemical means. For example, in measuring temperature it is possible to use energy converters such as thermopiles to produce electricity, bimetal to produce mechanical energy, expansion of fluids and gasses to produce hydraulic or pneumatic pressure changes, etc.

More complex problems can seldom be solved by a single step. Then the method of attack becomes one of successive development or synthesis leading from the input to the final output by successive stages. All basic or fundamental theories and phenomena that might be applied to the solution should be sought. The creative engineer must approach this synthesis unbiased by leaning toward a particular field of engineering.

As an example of syntheses, consider the design of a thermal cutout for a motor. The input would be heat. The first part of the synthesis would be a search for all phenomena that respond to application of heat. The next phase would be to consider the "output" from these individual phenomena as the "input" to the next successive stage. This method recently led to the invention of an improved thermal cutout based on a radically new application of the fundamental concept that mercury will boil when enough heat is applied.

By using the method of synthesis a more creative and successful combination may be produced. A young engineer attempting to visualize the solution in one step will often adopt a standard system despite the fact that a new combination might be better. Only after considerable experience can an engineer expect to think of a complete system with much consistency unless he has made a thorough synthesis.

It is most important that the search for method not be hindered by judicial thinking.

Note all ideas no matter how fantastic - the imagination works best when unrestrained. Consider the amount of skepticism, reason could have introduced in the early consideration of releasing the almost unbelievable amount of energy available in the atom. As another example, not too long ago very capable engineers "proved" that the ram jet engine "would not work." In this case, fortunately, the engine didn't know that. Besides at this point methods are being sought not selected.

## C. EVALUATION AND SELECTION OF METHOD

The next step is the evaluation of the various methods. Each system must be thoroughly considered as it affects all the design requirements. Particular emphasis is placed on time and economic factors. Each problem will largely determine the weight a given factor carries in the final selection. Some of the considerations are as follows:

1 - Cost

   a. Development program
   b. Finished product

2 - Time allowed

   a. For development
   b. For reaching production stage

3 - Accuracy

   a. Sufficient for specifications
   b. Better than specifications

4 - Power requirements

5 - Space requirements

6 - Tools and machines available

   a. Adequate for production
   b. New machines required

7 - Materials required

a. Common and easily obtained
b. New materials of scarce materials

8 - Production difficulties

a. Standard tolerances and procedures
b. High tolerances and involved processes

9 - Patent difficulties

a. All patents involved held by Company
b. Patents held by competitors

10 - Appearance

11 - Complexity

a. Operation (type of people who will operate it)
b. Maintenance (type of people who will maintain it)

12 - Consequence of faulty operation

13 - Versatility of application

a. Coverage of field desired
b. Supersedes predecessor and competitors device

14 - Operating environment effects

a. Corrosive atmosphere
b. Dust
c. Vibration and shock

15 - Safety features

The considerations listed do not apply to all development and design problems. Often in the early stages of a development program such points as the requirement of new tools and machines may be set aside until models have been built and tested. Then the test results can help determine if retooling is feasible. The engineer usually must decide at what part of the development program he should consider all factors of evalution. He may even recommend a change in the specifications when his evalution shows that a better product would result from such a change.

Sometimes the evaluation of the methods listed will show the necessity of redefining the problem and a new search for method. Preliminary tests and mathematical calculations should be made to verify expected results. Poor application of engineering fundamentals in the early stages will usually result in loss of time, money and prestige.

D. SOLUTION

When working out the details of the method selected, the steps outlined above are repeated on the various components required. Thus the various phases are used simultaneously in other than simple problems, and each portion of the design is evaluated as the details are solved. Component designs should be checked with the specifications of the over-all design as well as the listed requirements of the component.

Beware of the fascinating tangents that lead the unwary astray. When building a better mousetrap do not become a connoisseur of fine cheeses when ordinary store cheese will do. Stop your digging details occasionally and look at them in the light of the over-all job. Keep your nose to the grindstone, but do not become cross-eyed to the rest of the subject.

When the problem involves primarily test work or calculation, you should remember that the numbers you obtain are seldom a salable item but rather pose the question: "So What?" In other words, you are not finished until you can show how the results effect the finished product. Having lived with the details of the analysis or test, you should be able to make recommendations to improve quality and price of the device.

Strive to meet all specifications and time schedules by proper planning. Have parts completed in sequence and that will best permit partial testing. Do not delay design and construction of one part that will needlessly prevent proper testing of many other parts. Keep in mind the fact that instructions for manufacturing and operation can be as important as the design itself. The customer may not know exactly how to operate your brainchild unless you tell him.

Little details are important, too. Nuts, bolts, washers, and bearings are part of the design. Perhaps the draftsmen can select these for you, but it is your responsibility to check and approve all of these "minor" details. Little things like insufficient wrench clearance to requiring special adjustment tools can destroy the market for a particular model. In the final analysis the proof of the solution is in customer acceptance and profit to the Company.

SUMMARY

The processes as outlined here are recommended as a guide for the individual in establishing his own approach. After practical experience is gained in a given field, early methods of attack will be modified accordingly. Time and effort spent on the analysis, search for method and evaluation will often be reduced by previous consideration of similar problems.

The first four stages of a creative approach are 1- definition of the problem, 2- search for method, 3 - evaluation and selection, and 4 - solution. These stages are somewhat flexible in application and must be employed as dictated by the problem. Such organization of mental effort will aid rather than hinder creative thinking.

The definition must be a complete breakdown and study of the design data and requirements. The fundamental or basic problem should be sought. A grouping of facts and characteristics might be 1 - input, 2 - limiting requirements, and 3 - output. This stage must be well considered if the final design is to meet specifications.

The second stage, "search for method," is the place where creative thinking can be stimulated. Here the use of synthesis in the search for a method is apt to be most creative. Fundamental theories and phenomena are the keynotes of this synthesis. The basic plan might be the search for power or the seeking of the "eight ways." Keep your judicial mind suppressed in this phase.

In the evaluation stage the engineer picks the most practical system from the standpoint of engineering and economics. His choice is not overly influenced by the novelty and ingenuity of a method or by the established acceptance of a method. In short, he picks the best solution for the problem at hand thus striving to be a practical creative engineer and not a Rube Goldberg.

The solution of the problem in a form suitable for practical use is the prime function of an engineer. All the factors determining the quality, adherence to specifications, and salability at a profit of a product stand as a composite rating of the engineer that made it. As he enters by the front door he makes room for himself by sending products out the back door.

# HOW CAN WE DEVELOP INVENTORS?

By CHAS. F. KETTERING

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I think this question of how can we develop inventors, or inventions, because that is the real problem, is one that should concern us greatly. There are many different ideas of what an invention is. The inventor has one idea, the manufacturer has a different one, and the patent attorney has still another. Sometimes it takes quite a high order of intelligence to detect any similarity between them. I mean this seriously – it is a common thing for an inventor not to understand the patent on his own invention.

Likewise, there is no sharp line of demarcation between invention and research except for this distinction – that invention has to do with a specific result, while research is concerned with the determination of those factors which may be necessary in the development of that result.

Some years ago a survey was made in which it was shown that if a person had an engineering or scientific education, the probability of his making an invention was only about half as great as if he did not have that specialized training.

Now that is very interesting, and I have spent a great deal of time wondering why it is so. As a result, I have arrived at a definition of what an inventor is. An inventor is simply a fellow who doesn't take his education too seriously.

You see, from the time a boy is six years old until he graduates from college he has to take three or four examinations a year. If he flunks once, he is out. But an inventor is almost always failing. He tries and fails maybe a thousand times. If he succeeds once, he is in. These two things are diametrically opposite.

We often say that the biggest job we have is to teach a newly hired boy how to fail intelligently. We have to train him to experiment over and over and to keep on trying and failing until he finally learns what will work.

We also have to teach him that everything is not in the books. In his education he invariably gets the idea that this is so because his textbook is always the last word and final authority on whatever he is studying. If we fail to do this, sooner or later he will say, "There is no sense trying this experiment because page 284 of this book says it won't work."

Then we have to explain that these things we are doing have never been done before. If they had, we wouldn't go to all the trouble of repeating them. The books used to say we couldn't built a Diesel injector to operate at 20,000 pounds per square inch. What it really meant is that an injector couldn't operate at that pressure if it was built as the book specified. Today we have hundreds of thousands of injectors operating at pressures much higher than that. The point is simply that no matter what we are doing, if it is new we can always find a book that will tell us it can't be done. Any time we want to stop a project, all we need to do is assemble a committee and tell them about it. Immediately they will tell us we were crazy to start it. So to protect ourselves we have made this very simple rule: When you start a new problem, stay away from the library because it may handicap your thinking.

In training an inventor, how closely do we want to work with the library? Should he see what has been done first, or should he start out with his own ideas and then go back to the books after he has got a little way along?

The first step is always to set up the problem. When we have done that, we say, "Here's the way we think we ought to proceed," and then go to the library to see what others before us have thought about it. But if we go to the library first, few of us are strong enough to stay out of the rut that may be set up. So another thing we must do in developing an inventor is to teach him to analyze his problem. If he decides that it is worth working on at all, what is the probable first experiment he should try?

Many people want to go beyond the first experiment in their predictions. "If this experiment works,"

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, New York, N. Y., Nov. 29-Dec. 3, 1943, of The American Society of Mechanical Engineers.

they say, "we will do such and such next." But we should not worry about that. If we knew what was going to happen, we wouldn't need to experiment in the first place. We should realize that prior to the first experiment our ignorance factor may be as much as 100 percent.

"But suppose the experiment doesn't work the way we think it should?" they ask us.

The chances are ten to one it won't. That shouldn't deter us, however, from going ahead and trying it. After all, an experiment that fails is simply an experiment in which we are wrong. Rarely does an experiment mislead us, providing we are intelligent enough to follow as it directs.

If an experiment doesn't work the first time, it must be tried again; and when a successful experiment is obtained, a continuity can be laid out for going on to the next step. We can then decide what second experiment should be and go through with exactly the same manner. Since none of us is ever smart enough to arrive directly at the final result, we must work our way very laboriously from experiment to experiment and from test to test until we finally get there.

A lot of people don't want to do this. They would like to find a short cut for the tedious trying and failing of experimentation. They think they are smart enough or educated enough to get the result directly. Unfortunately, the only people who have ever accomplished anything in science or engineering are the ones who never thought they were smart enough to get irked by having to try things to see if they would work.

A man who had seen a test of one of our Diesel engines came to see me the other day. "That is a very efficient engine," he said. "I would like to talk to your thermodynamics expert about it."

"I am sorry," I replied, "we don't have anyone here who even understands the word 'thermodynamics,' much less be an expert on it. But if you want to know how we developed this engine, I'll be glad to show you."

I took him to our dynamometer room and showed him our single-cylinder setup and told him how we had tried one thing after another for about six years until the engine itself finally told us exactly what it wanted.

"Goodness," he said, "that's an awfully tedious way to design an engine."

"It is," I agreed, "but it is the only way we know."

We don't know how to do any new job without going through all that tedious cut-and-try. Therefore, the next thing we must tell these young engineers is that tediousness is something they must endure and not resent even though they have a technical education.

These things seem extremely simple, but they are basic to the problem of developing inventors.

The point is that we don't solve a technical problem or make an invention in the laboratory. We do these things in our heads. All this laboratory apparatus is simply to help us get an understanding of the problem we are working on. I think the thickness and density of the human skull can be very well represented by the amount of apparatus we sometimes need simply to force an idea through a quarter inch of skull bone. That is why it is so important that we develop proper attitudes in the people we are training to be inventors.

About ten years ago we started a new study of the strength of materials which was based entirely on testing a production piece under simulated working conditions. In other words, if we were interested in a crankshaft, we would build a testing machine that would load that crankshaft exactly as it is loaded in the engine, that is, a load fluctuating so fast with so much tension, so much torsion, at such a temperature, etc. We did that because we had learned that tests on standard test specimens gave us information of a very unsatisfactory kind and that when we tried to test a piece to failure in an actual engine the resulting debris was such that we couldn't tell just what had happened.

In our machine we put anticipators on a piece so that the instant a failure started the load would be released automatically and we could see exactly where the trouble had started.

With this machine we have been able to improve the fatigue life of many mechanisms as much as 500 percent simply by seeing how and why the failure starts and by then making very small changes in fillets or slight shifts in temperature during heat-treatment.

We couldn't have calculated these things. No one is smart enough to make such calculations. It has to be a very primitive sort of study which goes back to the very elementary process of trying a thing, learning its weaknesses, and then trying something else.

One of the problems which a research laboratory will always have is how to get along with the manufacturing end of the particular organization to which it belongs. The production man has a problem, and he brings it to us to solve. We analyze it and write a report on our solution. If we use a lot of logarithmic curves and fancy nomenclature the production man never heard of before, he gets mad because

he can't see that we have helped him very much. I don't blame him.

To avoid that difficulty, we have worked out a very simple procedure. Before a special report is distributed, it is carefully read by someone in our organization who knows the person for whom the report is intended, and a little circle, or goose egg, is drawn around every word that he thinks may be misunderstood. Then we call in the research engineer and ask him to read the report aloud – but skipping the words that are circled. He starts reading and then exclaims, "My goodness, if you are going to leave out all those words, it won't make any sense at all!"

"All right," we say, "perhaps the reader won't understand those words, so it is just the same to him as if they weren't there at all. If we are going to help with this problem, we must use words that will be understood."

One of these reports had to do with noise and the word "decibel" appeared several times on every page. The boys couldn't find a simpler word for decibel, so with every copy of that report we supplied a little noise box that had ten keys on it. If the report said the noise level was seven decibels, the reader just punched the key marked "seven" and he could hear exactly what seven decibels of noise was.

This question of words and the meaning that we attach to words has always been very interesting to me. It is like the formula problem in which, if a fellow knows the formula for something, he thinks he understands all about it. A lot of people think that if they know the name of something, that's the whole story.

As an illustration, I once asked a famous scientist this question: "Why can I see through a pane of glass?"

"That's very simple," he said. "Glass is transparent."

"I'm afraid the word 'transparent' means nothing at all to me," I replied.

"The word 'transparent' simply means anything you can see through," he said. "Why do you want to know that?"

"I would like to know why I can see through a pane of glass. I would like to know whether light waves travel through the glass as light – or whether they are received and rebroadcast in some other form from molecule to molecule. If I knew that, I would be better able to decide some other things I would like to know."

"The trouble with you," he said, "is that you are a modelist; you want an image of something. Modern science doesn't form images any more. We stopped that a hundred years ago. Give me a better problem – something a little more practical."

"All right, here's one: When I rub my hands together, why do they get warm? Why shouldn't they get cold?"

"Oh, that is quite simple – it is due to friction."

"Yes," I said, "now what is friction?"

So we argued back and forth for three quarters of an hour and finally we came to the profound conclusion that we don't know anything about friction – except that friction is a thing that makes your hands warm when you rub them together – and we don't even know how it does that.

A few years ago I assigned a young man to work on this friction problem and had him rub little pieces of metal to see how much they wore away, how much heat they generated, and so on. After he had been working on it for a little while, I stopped in to see him. "How are you coming along?" I asked.

"Not very well," he replied, "Don't you think this is an awfully childish problem for a fellow who has the kind of education I have?"

I didn't think so, or I wouldn't have assigned him to it, so I asked what the trouble was.

"It wouldn't be so bad," he exclaimed, "if it wasn't all in the books!"

"I'm glad you mentioned that," I said, "because if we have you working on this thing when it's all in the books, like you say, then we ought to stop right away. But before we do that, I want you to show me that book. If you can find that book or any book like it, I will give you a medal."

I saw him about a month later and asked how he was progressing on the medal business.

"Awful," he said, "I haven't been able to find anything. And I can't understand that, because it's something so fundamental I should think a lot would be known about it. I can't understand it at all. There's not a thing in the books about it."

I want to tell you something of the outcome of this episode because it shows how much we can accomplish if we don't place ourselves too high above our jobs. This same young fellow soon discovered some very interesting fundamental facts about friction and wearing surfaces which have enabled us to produce better piston rings for Diesel locomotives than we ever had before. When we first started to run our locomotives, we had to change rings every 50,000 miles. No one objected to that. They thought 50,000 miles was about as long as piston rings ought to last. Now we have rings that will run 500,000 miles, and

I think we ought to be able to get them to last 1,000,000 miles before we're done.

It was in connection with these same engines that someone once asked how it happened that we were making most of the Diesel-electric locomotives in the country. "You must have awfully good patent protection," he said.

"Well, here's the reason," I said. "You see, a great many people think we're crazy. That is much better protection than any patent."

I would rather have my competitor think I am crazy than have a stack of patents a mile high, because he can easily get around my patents, but if he thinks I am crazy, he won't even bother to check up on them. I was in the automobile starting, lighting, and ignition business for five years without any patent protection at all to speak of, because everyone knew that the breaker mechanism in my ignition system was crazy, and that it wasn't worth copying. They infringed every patent I had, but they didn't infringe my ignorance factor.

I often tell the boys this story: I have been making inventions and taking out patents for many years. When I first began to apply for patents, most of my inventions had been patented 50 or 60 years before. Later I was only 40 years behind – then 30 years – and so on. So I drew a set of co-ordinates and plotted just how far behind I was on each invention. There was a gentle slope to the curve, so I could extend it to the base line to see how old I would be when I made an original invention. It comes to about 125 years.

If we can succeed in eliminating from a young man's mind the idea that just because he thought of a thing it must be very good, then we can go ahead without the danger of temperament getting into engineering.

We have a little rule in our laboratory which we think solves this problem. It's a very simple rule and the only rule we have. It is just this: "The Job Is the Boss." What does the engineer think of this new piston? That doesn't matter. What does the engine think about it? That matters. The engineer's opinion is worth very little. The engine's opinion is worth a great deal.

If the engine says, "I like this piston," and it happens to be contrary to the engineer's pet idea, that's too bad. It simply proves that the engineer was wrong. After all, as we said, the only reason for all this expensive research is that it corrects our ignorance factor so that we can see the problem in its true light.

Opinions are not the only things that lead us astray. Sometimes we are led into difficulties by certain aspects of the so-called practical side of our educations. We accumulate rules of thumb, arbitrary constants, and formulas. We accept these as fundamental. We should question them whenever we encounter them. They are the stumbling blocks of progress.

There is a formula by which we can calculate the fatigue life of a piece of spring steel which is being stressed under certain conditions. This formula tells us how many thousand cycles of stress the spring will undergo if its surface is perfectly mirror-smooth, how many less if it is slightly rough, and how many still less as its roughness increases. We take a flat piece of smooth spring steel about three inches wide and two feet long and put it in a test machine and bend it back and forth until it breaks. We find that the standard spring, as furnished by eight or ten different steelmakers, will break in about the same time – at a couple thousand cycles. That checks very closely with the formula. We ask each of the steelmakers to run the same test and their results check with ours. The formula and the experiment agree. Everyone agrees that it is a wonderful proof of the formula and shows there is no use trying to run a spring any longer than the formula says.

Then we say, "Suppose we bang up this piece of spring steel until it is rough all over – then how long will it last?"

After thinking about this for a while, they say, "We don't know how many cycles of stress it will stand, but we all agree that its fatigue durability will be seriously impaired."

So we asked them to make us some more samples. "Put a little mark on them so you can identify them as your pieces," we say. Then we give these samples a little treatment which we call shotblasting, or surface peening, in which we shoot a lot of little hard steel balls at each sample until it is thoroughly roughened. That done, we send the samples back to the steelmakers to be tested.

Then a surprising thing happens. Instead of breaking at 2000 cycles, the samples are flexed up to 2,000,000 cycles and still they don't break. The formula still says they will break at 2000, but they don't know that. They keep right on flexing at 2,000,000. That is quite a gain in percent.

We have learned that in most problems there is a normal time rate of development which corresponds very closely to the normal yearly increment of improvement made by industry. There is not a great deal that we can do to speed up such improvements, because they are so intimately geared into the whole system that they can be assimilated only at a certain rate. But in other problems, such as certain medical problems, the question of how long

it is going to take to solve them is of relatively little importance. The results will justify any expenditure of time. All that is necessary is that the man who is going to work on the problem be shown that it is worth solving, or he won't want to try it.

We had some experience with this in the early days of the ethyl-gasoline development. We had been working on the so-called aromatics for a number of years and had some pretty good results, but nothing really exciting. So some of the boys came up to my office and said, "We are young yet, and we would like to do something in the world, and we don't want to be kept on this problem forever, because we don't see any hope of ever working it out."

I was leaving for New York that afternoon, so I said, "Let me have a couple of days to think this over, and when I come back I'll see if I can't work out something for you."

I thought that it would be wrong to stop this work, even though they had been correct when they said our progress to date was very discouraging. When I got on the train to go back to Dayton, I noticed a newspaper lying on the seat beside me and I picked it up. On the first page there was a little item entitled, "University Professor Discovers Universal Solvent."

That interested me because I happened to know an amusing story about two chemists who were trying to discover a universal solvent. It seemed they talked a banker into loaning them some money and set up a little laboratory just outside of town. One winter morning a farmer had a blowout outside their place, so he came in and asked if he could use their telephone to call up the garage. They said, "Sure, go right ahead." When he was through telephoning, he asked if he could wait there until the garage brought him a spare tire and they said, "Sure, you can." So he stood there watching them for a while, and finally he asked what they were doing.

"We are working on the most important thing in the world," they said. "We are developing a universal solvent."

"What does that mean?" asked the farmer.

"Well, that is a liquid that will dissolve anything you put into it."

"My goodness," said the farmer, "that is marvelous, but what in tarnation are you going to keep it in?"

Because I happened to know that story, I was interested in this so-called universal solvent and I read the newspaper story in its entirety. The material referred to was selenium oxychloride.

The next morning when I got to the laboratory I showed this newspaper item to the boys and said, "Here's one we'd better try before we quit," so they went ahead and got some. It turned out to be almost a universal solvent in its action on valves and rings, but it did something that none of us had anticipated. Theoretically, selenium oxychloride should have made the knock worse because it contained both chloride and oxygen, which had been knock-inducers in every other compound we had tested. But instead of inducing knock, selenium oxychloride turned out to be a powerful knock-suppressor. That was our first step into the study of the metallo-organic compounds, which led us through a great many experiments until we finally arrived at tetraethyl lead.

The point of this story is that we must always know whether a problem is worth solving. There will always be dark days, but if your conviction of the value of the problem is such that you go right ahead in spite of the difficulties, the chances are that you will achieve success in the end.

I like to think that we can take even a highly educated young man and teach him to be an inventor without ruining his education. I have only one complaint against our educators and it is that they haven't always told us the complete story.

A friend of mine who teaches general medicine at one of our large universities once told me this story about education. He is an old hand at teaching medicine. He lectures to the classes, teaching the boys to be general practitioners. His system is sound and doesn't differ radically from similar courses in other universities, except for the last lecture he gives the group. That lecture is unique. On this occasion, he says, in part:

"Young men, we are together for the last time. We have had a very pleasant time. You have been a good class and I have enjoyed working with you.

"I have given you the best information available – the best case histories I could find. The textbooks we have used are the most widely accepted and reliable. But before we part company, I want to caution you that the science of medicine is developing so rapidly that in a few years from now perhaps half of the things I have taught you won't be so. Unfortunately, I don't know what half that will be."

I have been very interested in co-operative education because I feel that by bringing a boy in contact with both the school and industry we can lap-weld him to a job instead of butt-weld him. I worked with Dean Schneider at Cincinnati for a number of years. I have also been interested in a co-operative system at Antioch; and right before Dean Schneider died, I helped to get him to go out to Northwestern University to set up the co-operative system there.

My interest in co-operative education is not [illegible] to [illegible] school half time and

work in industry half time. I don't care how it is done, but I would like to see the university and industry work closer together because I think they should understand each other's problems. I think if we could do that, it would be much less necessary to teach trade subjects in school. We could spend more time on the fundamental broad principles of physics, chemistry, and mechanics.

There are several other ways that this result can be achieved. One is by alternating the professors instead of the students. The instructor could teach half time and, as I once said, work half time. Somebody objected to my saying that, so I apologized, but you know what I mean.

I don't care how we achieve this co-operation, whether it is half-timing the boys or half-timing the instructors, or doing research, just so the educational institutions can teach these boys the fundamentals they will need in their work, and industry can teach them the practical applications it will need from them in its work.

If we can just achieve the broad outlook and be honest with ourselves and admit that the things we know are so small compared with the unknown, I think we will see that there is no end to progress. I am not worried about the libraries we have today – I am worried about those infinitely greater libraries that haven't any books in them yet. Every year is going to add new things and new books that we don't know. I am interested in getting some of those books written.

We should date-line every bit of information we have. We should say, "This is what we know as of today." We shouldn't worry about what it was yesterday – or what it is going to be tomorrow. We should recognize that ideas change and grow, and we should gear ourselves to the most progressive thinking. If we can do that successfully, we will have no difficulty in teaching men to become inventors, because inventing is simply a state of open-mindedness.

# IDEA NEEDLERS

How much of this is the result of custom, tradition, or opinions?
Why does it have this shape?
How would I design it if I had to build it in my home workshop?
What if this were turned inside out? Reversed? Upside down?
What if this were larger? Higher? Longer? Wider? Thicker? Lower?
What else can it be made to do?
Where else can this be done?
What if the other were changed?
Suppose this were left out?
How can it be done piecemeal?
Can this be multiplied?
What if this were blown up?
What if this were carried to extremes?
How can this be made more compact?
Would this be better symmetrical or asymmetrical?
In what form could this be?
Liquid, powder, cast, or solid?
Rod, tube, triangle, cube, or sphere?
Can motion be added to it?
Will it be better standing still?
What other layout might be better?
Can cause and effect be reversed? Is one possibility the other?
Should it be put on the other end or in the middle?
Should it slide instead of rotate?
Demonstrate or describe by what it isn't.
Could a vendor supply this for less?
How could this be changed for quicker assembly?
What other materials would do this job?
What is similar to this but costs less? Why?
What if it were made lighter or faster?
What motion or power is wasted?
Could the package be used for something afterwards?
If all specifications could be forgotten, how else could the basic function be accomplished?
Could these be made to meet specifications?
How do noncompetitors solve problems similar to this?
Can another part perform the function?
Can this part or function be combined with another?
What if the present design or method were prohibited?
How can secondary operations be avoided?
Can it be straight instead of curved?
How can it be adapted to a high speed method?
How could this be made easier to use?
Can it be made safer?

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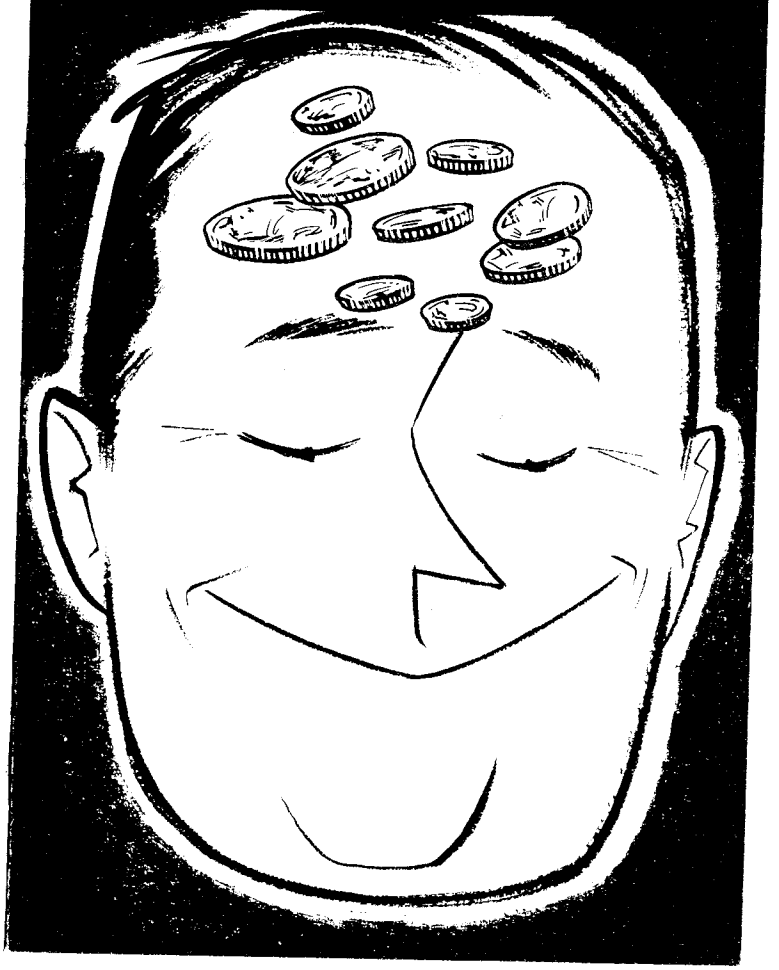
CREATION PHASE - IDEA NEEDLERS

What if this were larger? higher? longer? wider? thicker?
How much of this is the result of custom, tradition, or opinions?
Why does it have this shape?
How would I design it if I had to build it in my home workshop?
What if this were turned inside out? reversed? upside down?
What else can it be made to do?
What other power would work better?
Where else can this be done?
What if the order were changed?
Suppose this were left out?
What if this were divided?
How can it be done piecemeal?
What happens before or after?
How can it appeal to the senses?
How about extra value?
Can this be multiplied?
What if this were blown up?
What if this is carried to extremes?
How can this be made more compact?
What if this were lower?
Would this be better symmetrical or asymmetrical?
In what form could this be?
Liquid, powder, paste, or solid?
Rod, tube, triangle, cube, or sphere?
Can motion be added to it?
Will it be better standing still?
What other layout might be better?
Can cause and effect be reversed? Is one possibly the other?
What if it ran the other way?
Should it be put on the other end or in the middle?
Should it slide instead of rotate?
From what angle should this be viewed?
Demonstrate or describe by what it isn't.
What should it look like?
Has a search been made of the patent literature? trade journals?
Could a vendor supply this for less?
How could this be made easier to use?
Can it be made safer?
Can two parts be combined?
How would a competitor change or improve this?
How could this be changed for quicker assembly?
What other materials would do this job?
What is similar to this, but costs less? Why?
Why does this have to be done that way?
What if it were made lighter or faster?
What motion or power is wasted?
Could the package be used for something afterwards?
If all specifications could be forgotten, how else could the basic function be accomplished?
Could these be made to meet specifications?
Which non-competitors have problems similar to this?
How do they solve them?

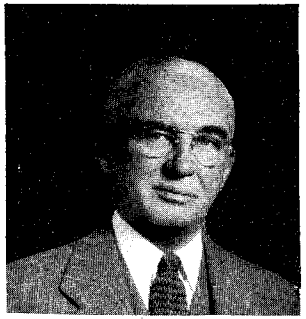
# THE GOLD MINE BETWEEN YOUR EARS



# THE GOLD MINE BETWEEN YOUR EARS

How to Think up More and More Ideas

by **Alex Osborn**



## ABOUT THE AUTHOR

Born and brought up in the Bronx section of New York City, Alex Osborn helped to earn his way through college by serving as a construction worker, as a bank messenger and as a hotel clerk.

At 21 he became a police reporter on a metropolitan newspaper. Then he took a job as a salesman, and at the same time taught school three nights a week.

During the following years he served as assistant manager of a small plant, where his duties included product design and factory production, as well as marketing.

In 1919 he joined Bruce Barton in founding the firm of Batten, Barton, Durstine and Osborn, an advertising organization which now employs 1800 people in 14 offices.

In the past 10 years Alex Osborn has gained fame as an authority on creative thinking. His four great books on this subject have run into 26 editions.

He is now devoting nearly all of his time and considerable money to the encouragement of a more creative trend in education. His textbook called *Applied Imagination* is already in use on the campuses of about 300 colleges and universities.

According to Osborn, his success grew out of his discovery of ways to make himself better and better able to think up more and more ideas. His principles and procedures (which take up over 300 pages in his textbook) are outlined in this booklet, for quick and easy reading.

As you will see, the author proves that you have a gold mine between your ears—a mine from which you can dig rich rewards, not only in hard cash, but also in the coin of contentment.

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Surely you would like to:

. . . make more money by winning promotions.

. . . think up more cash-winning ideas.

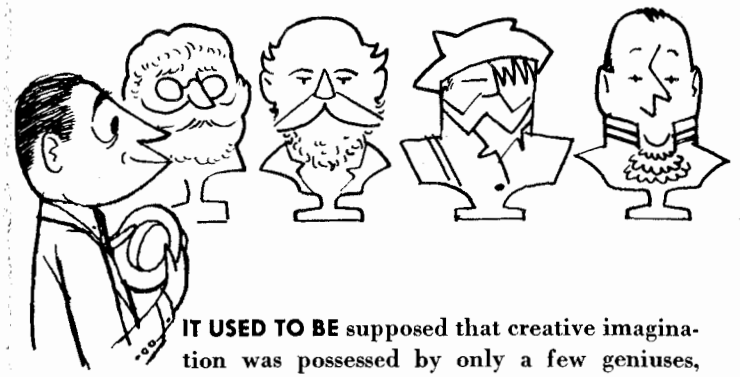
. . . become a better parent and spouse.

. . get more FUN out of life!

Are there ways you can help yourself toward those goals?

Yes there *are* — just as there are knacks to pitching a baseball or tossing a horseshoe.

The key in this case is a gift you were born with — your ability to *think up ideas.* And this is an ability which you can utilize much more intelligently if you read this booklet.



**IT USED TO BE** supposed that creative imagination was possessed by only a few geniuses, blessed with higher education. But men like Thomas A. Edison proved otherwise.

He was virtually untutored. He started out as a "butcher boy," selling candy and pop and magazines on trains. But by building up his ability to think up ideas, he earned riches and fame.

Creative imagination is no longer the secret of a few happy, successful men and women. Its mysterious workings have been taken apart so that anybody who wants to can now see how ideas are produced.

### EVERYBODY IS BORN WITH CREATIVE IMAGINATION!

You were born with it — probably with a greater degree of it than you have ever realized. And you can develop this natural talent of yours. You can make it more and more productive.

### THERE'S NOTHING TO HOLD YOU BACK!

If you fear that you may be blocked by lack of education, read what a great psychologist has said:



"Students with high intelligence are not the ones who produce the most original ideas. The Quiz Kids are often referred to as geniuses . . . but it is doubtful whether they are also fluent in producing ideas!"

The Human Engineering Laboratories studied the talents of different groups of professional and non-professional people. It was found that mechanics rate well above average in their latent ability to think up ideas.

Dr. Albert Einstein says: "Imagination is more important than knowledge." And it can be more profitable, too. Just look at all of those who have won fortunes with their ideas, regardless of whether they had any diplomas.

### AGE NEED NOT MATTER, EITHER —

It's not always true that younger people think up better ideas than older people.

The most creative period of Oliver Wendell Holmes' life was between the ages of 50 and 75. Both Benjamin Franklin and Thomas Jefferson turned out some of their best ideas when they were in their 80's.

The great writer, Somerset Maugham, now in his 80's, says: "Imagination grows by exercise. Contrary to common belief, it is more powerful in the mature than in the young."

### WOMEN CAN THINK UP IDEAS WITH THE ABLEST OF MEN!

Women may lack the muscles of men; but they are plenty powerful when it comes to inborn imagination.

They often put it to use to make housework easier — like the woman who found that the average housewife walks four miles and spends 25 hours every year just making one bed. She thought up a way to cut the distance to one mile and the time to 16 hours per year. Here's how:

"Start at the head, smooth and tuck in one corner completely, from bottom sheet to bedspread. Move to the foot on the same side, tuck in that corner and work across the footboard. Now move up the opposite side, from bottom corner to top." (Show this to your wife and see if it won't save time for her!)

Then there was the woman, who saved herself a lot of work, *and* made a fortune — by thinking up an easy way to scour toilet bowls.

It's a mop fitted with a replaceable pad, filled with detergent. Swish it around the bowl, flick off the pad, flush it, and the job's done!

## LACK OF EXPERIENCE NEED NOT HOLD YOU BACK

Perhaps you've worked for years on a certain mechanical operation. Or with a special office routine.

Don't think for a minute that this limits your power to think up ideas outside your own field.

History shows that many great ideas came from people who had no special training in the problem involved.

Who worked out the telegraph? Morse — a portrait painter!

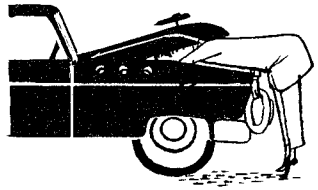
Robert Fulton was an artist, too. His invention was the steamboat.

Eli Whitney created the cotton gin. He was a school teacher.

When Alexander Graham Bell started to invent the telephone he had almost no knowledge of electricity.

Many a life was saved in the last war by a shell-fragment detector. It was thought up by an unscientific employee of the New York City transit system!

Yes, you'll be surprised how far-ranging YOUR imagination can become when you limber it up with the help of this booklet.



## LET'S GET STARTED

For the ordinary, everyday driving you don't *have* to *know* what goes on in the engine of your car.

But if you were a racing driver, your success would depend on that engine . . . So you'd surely want to know just how it worked!

## GET A "RACING-DRIVER ATTITUDE" TOWARDS YOUR CREATIVE IMAGINATION!

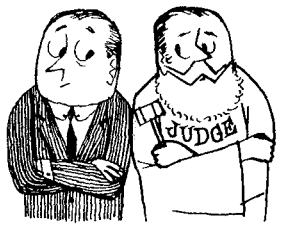
The human imagination — *your* imagination — can be more powerful than anything that ever roared across the Salt Flats of Utah.

To increase your creative power, the *first* step is to understand how your mental engine works.

Let's over-simplify — let's picture your mind as mainly consisting of three servants — your Loader, your Judge, and your Thinker-Upper.

**LET'S FIRST CONSIDER YOUR LOADER.** He packs your mind by bringing knowledge in through the doors of your eyes, your ears, and your other senses. He stores all this knowledge—especially your experience—in your memory.

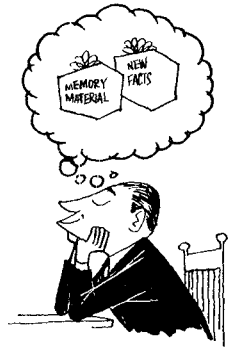
**SECOND, THERE'S YOUR JUDGE.** Your Judge *reasons* — he analyzes, compares and makes decisions. He is indispensable to your mental workings.




But when thinking up ideas, you have to watch out for the Judge. Unless kept in his place, he will too often nip your ideas in the bud.

**THIRD, YOUR THINKER-UPPER.** Your Thinker-Upper works on material brought in from the storehouse of your memory, plus the new facts you dig up when tackling a problem.

He puts these materials into one fresh combination after another and thus helps produce good ideas.




The ideas you spark may even go beyond what you have stored up in your mind. That's one reason why your knowledge best serves as a guidepost rather than a hitching post. Here are two examples that make this clear:

A paper manufacturer was stumped by a production bottleneck in the form of a certain machine. His engineers tried and tried to think up ways to remedy this but they failed.

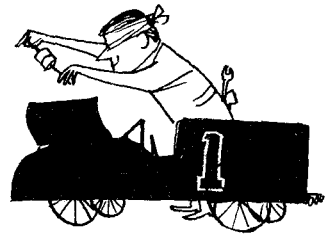
A new employee was assigned to the problem. He had no engineering degree — just some mechanical aptitude. Never before had he done any work on a paper machine . . .



. . . but that young man thought up changes that made the balky machine produce more — and at less cost. How those engineers did blush!

What's the *second* way to step up your creative power?

## GETTING THE WILL TO WIN!



A racing-car driver might know his engine so well that he could take it apart and put it together again blindfolded. His eyes, his nerves, his reflexes, might be perfect. He might also have a brilliant grasp of the techniques of driving a race.

But all that wouldn't add up to a hill of beans unless he had THE WILL TO WIN.

Any realistic, sensible person will put as much *effort* into an endeavor as the *reward* he or she hopes to reap from it.

How much *effort* should you apply?

Well, just take a look at the enormous showcase of rich rewards that are waiting to be won by ideas!

How much effort is your promotion worth? How much driving-force and will-power would an extra cash income be worth to you?

E. M. Statler founded the nation-wide hotel chain which bears his name. He was thought of by outsiders as a *genius*. But his private secretary told me: "I know that every one of his great ideas came from sweating and sweating hard."

Because a man named Lester Pfister kept slugging away at an idea for years, America now has a finer, fuller corn crop. He got the idea of inbreeding stalks of corn in order to kill off weaker strains and build up a hardier species.

He started with 50,000 stalks.

Five years later, he had only four ears of corn left — out of the original 50,000.

But he also had a fortune. Those four ears of corn, untouched by disease after five generations, were the source of seeds for which farmers ever since have gladly paid a premium!

You may never get going on as long a pull as Lester Pfister's. But just remember this advice of a great rowing coach:

> "If you hang on two strokes longer than your opponents, you will lick 'em!"

Hanging on a little longer with creative effort can often turn a brassy idea into gold.

## SQUARE OFF WITH THE PROBLEM

Did you ever hear about the lucky plumber who dropped a piece of steel pipe into a batch of molten glass — and found a way to make glass tubing?

That's the story-book way of solving a problem — by accident.

The surer way is to pick a problem just like you pick a target when you're out hunting.

Draw a bead by stating your problem in its simplest term. Here's an example — the case history of the multi-million-dollar idea called "Sanforizing."



Manufacturers had trouble giving customers as good a fit in shirts as in collars. Collars were washed after being made. But if the shirts were washed, they would lose some of their attractive finish — would look like they weren't quite new.

The problem, Sanford Cluett decided, was to find a way to shrink cloth without putting it in water!

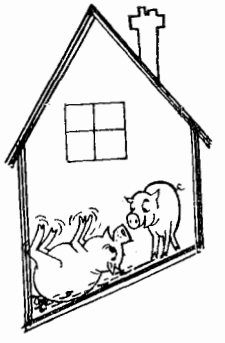
At the cotton mills he studied the finishing process. He saw that the cloth — in strips as long as 14 miles — was being *pulled* through the various processes. Naturally, this pulling distorted the fabric.

Cluett found that if that distortion were taken out, nearly all of the shrinkage would be overcome. So he designed a machine which automatically restored the cloth to balance — in other words, pushed the stretch back in place!

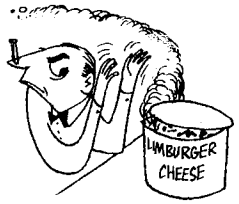
What has a clearly-stated problem got to do with the price of bacon? Plenty, according to the U. S. Department of Agriculture.

A man with a lively creative imagination noted that baby pigs were often crushed by their mothers rolling over on them. So he asked whether this couldn't be stopped by simply tilting the floor in the farrowing house.

Yes, it could. Since mama pigs like to lie with their backs uphill, and piglets like to travel downhill, the tilted floor tends to keep the baby from under the old lady. The Department of Agriculture says that these tilted floors have cut this cause of pig mortality as much as 25%



Once you've got your problem narrowed down, pointed up, and stated, you can then start flying with your imaginative wings.




### TRY EVERYTHING!

When Edison was looking for a filament for his first lamp, he tried 6000 varieties of plants before he found the right fibre.

"Try everything," Edison said, "even Limburger cheese!"

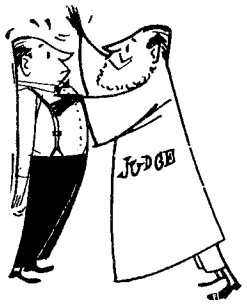
When you look at your problem from every angle, you buckle on one of the sharpest sets of spurs in the thinking-up process. This is the gift which you and everybody else possesses. It is called:

### ASSOCIATION OF IDEAS

Whenever you say, "That reminds me of something," you're using association of ideas. One thought leads to another, like a string of popping firecrackers.

**LET YOURSELF GO!** You certainly couldn't walk very far if you kept "both feet on the ground." But the Judge in your mind tends to scoff: "No, that won't work" . . . "That doesn't sound very good" . . . "That's just plain foolish!"

Send your Judge back into his chambers whenever you set out to think up ideas. When you let him prematurely throw ice water on the wings of your imagination you just can't soar as high and wide as you should.




*Later* you can call in the Judge to evaluate your ideas with all his judicial might.



After you've got the problem narrowed down, you will want to attack it with a barrage of ideas.

### TAKE NOTES AND USE CHECK-LISTS

In each of these ways you can gather fuel and can accelerate your power of association of ideas.

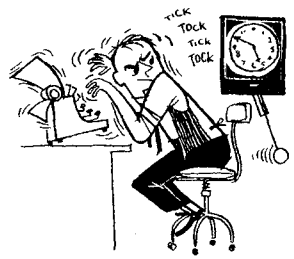
Clement Kieffer is in charge of window displays for a big store. He's won more cash awards, more medals and cups, than anybody in that competitive field. He has *33* windows to fill every week. So he thinks up at least one new idea every day of the month. For his "check list" he uses a big box into which he has tossed 3000 idea-starters — clippings from papers and magazines, notes and sketches of his own.

### CARRY A PAD AND PENCIL WHEREVER YOU GO

Millions of dollars worth of valuable ideas have been lost because of the want of a stub pencil and a scrap of paper!

Keep your notes. Put them in a cigar box, or in your bureau drawer.

Maybe they may lead to nothing at the time you make them. But it may amaze you how you can pull out a note — a week, or a month, later — and find that your imagination has been chewing on a problem and has found a key to its solution.




**SET A DEADLINE!** The need for meeting deadlines has turned many an average newsman into an ace reporter. How? By showing him that he *can* work under pressure — by showing him that he *can* produce with the clock ticking away at his ears!

The founder of one of America's biggest fortunes started work as an apprentice in a railroad shop .One day he was asked if he could fix a locomotive in two hours.

"Yes," he said.

And he did.

Here's what he said afterwards:

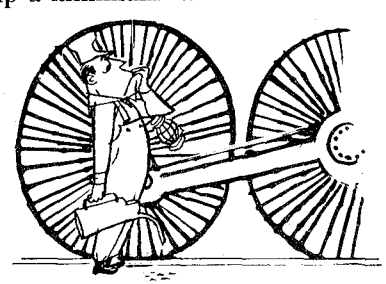
> "If I hadn't *promised* to fix that locomotive in two hours, I wouldn't have made it — I wouldn't have put in so much mental sweat."

The need to succeed — the fear of failure — can be a powerful prod to your imagination!

Another way to step up your imagination is this:

## SET YOURSELF A QUOTA!

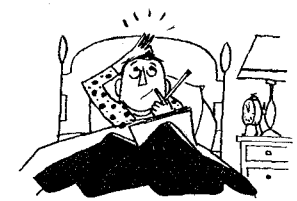
Bind yourself to think up a minimum number of ideas within a certain time. Start with one idea a day. Soon you'll find you can take on bigger and bigger stints.



To get the best and brightest results try this:



## MAKE DATES WITH YOURSELF!



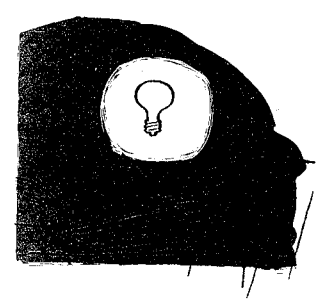
Set certain times for thinking up ideas.

Early in the morning is usually the best, for then your mind is freshest. But it's also a good practice to keep a pad and pencil beside your bed.

By conceiving the idea of landing mats which could be made into airfields overnight, Walter Irving did much to enable our armed forces to win out in the invasion of North Africa. What does Mr. Irving say about the time and the place for thinking up ideas?

"The bed, the bedside pad and pencil," says Walter Irving, "are great aids to thinking up ideas. Only last night, I scrawled over four sheets of paper in the pitch dark — notes that could be solutions to a current problem.

"A few months ago in a Washington hotel I awakened from a dream about 2:30 A.M. Then and there I sketched a simple idea that has since started an important new product. Had I just turned over and gone to sleep, I am sure I never would have thought of it again."



And now we come to a series of machine-guns with which you can pepper your problems—machine-guns in the form of QUESTIONS.

## QUIZ YOURSELF

Questions are great unlockers of ideas — especially ideas that are valuable in industry. Questions like these:

## IN WHAT NEW WAY COULD THIS PRODUCT BE USED?

Production of Neoprene has been built into great volume through a steady stream of new-use ideas.

A toymaker makes a chocolate-flavored bone out of Neoprene for dogs to chew on!

A doll-maker covers some of his dolls with a skin of Neoprene — so natural-looking that a child thinks it is a real baby!

The list is endless.

Take Nylon. Because of a "wild" new-use idea, this is now taking the place of catgut on most tennis rackets. It is also being used for fishing lines — and fishing rods — as well as for clothes-lines and 1000 other purposes which were unthought of when Dr. Charles Stine first started to create this new material.

In the steel industry, slag used to be costly waste. Now it is used for ballast in railroad beds, for making cement, for processing into building blocks.

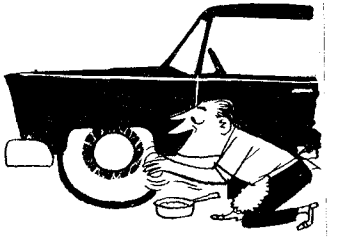
L. A. Conley, a rubber company employee, saw pieces of surgical tubing being thrown into the waste barrel. "Why not cut them into rubber bands of the size and width which are used by the millions to hold small items together?" he asked.

L. A. Conley got a fat check for that new-use idea of his.



## TO WHAT OTHER USES COULD THIS BE PUT?

A well-known scouring pad got its start in the kitchen sink. And then somebody thought up the idea of using it to clean white sidewall tires. Result — a great new market in the twelve and a half million cars with white sidewalls!



Could a telephone have a new use? Sure — transcribed records that announce correct time and latest weather reports have brought millions of extra revenue to telephone companies.

A rat-poison that is successful because it kills rats in a *different way*. For some reason, rats like to lick their feet. This poison is sprinkled where the rats walk, Then — when they lick their feet — they seal their doom.

## WHY NOT ADAPT OR BORROW?

Here are four samples of questions along that line — questions which could help to flush your ideas:

What else is *like* this?
What ideas does *it* suggest?
Does the *past* offer a *parallel?*
What could I copy *outright?*

This design of the new glassdomed railroad cars was probably borrowed from taxicabs with "sky tops." That's how an idea can be *adapted*. If you reborrow the same idea and turn it upside down, you get glass-bottom boats for under-water sight-seeing.

We can even borrow ideas from Mother Nature — as did the Jap who found that pearls grow because oysters become uncomfortable when sand gets in their shells. So he made sure they were uncomfortable — by *sticking* sand

in their shells. And thus he found a way to produce oodles of natural pearls at low cost and high profit.

### HOW ABOUT A NEW TWIST?

Personalized pretzels bent to form your initials? That might sound silly — unless you remember that the sky's the limit when you're piling up possible solutions to a problem.

Here are some questions that could help you think of new twists:

What new *look* could this be given?

What could color do?

How about another form or another shape?

Remember the story of the hardware dealer with a stock of shovels he just couldn't sell? He painted red stripes on the bottoms. This attracted attention — gave the shovels a *different* look — and he sold them out!

How about another *form?*

It wasn't so long ago that all soap came in bars — then somebody suggested that it be flaked.

How about other *shapes?* How about *odor?* How about *motion?* We now have Christmas-tree lights which not only shine colorfully, but also bubble with lively movement.

Some stores put odor to work by spraying perfume in the air outside their stores to attract customers!

### HOW CAN WE SUBSTITUTE THIS FOR THAT?

What other part instead of *this?*

Driving-gears show the value of such questions. Transmission was improved on trucks by substituting metal worms for conventional cogs.



"Why not use a fluid instead of metal gears on automobiles?"

That may have sounded crazy. And yet that was what has made our newest cars so easy to drive!

What other *ingredient?*

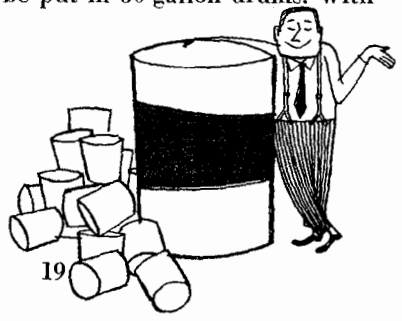
"Could we put *glue* in a cleaning compound?" That was the secret of the fabulous success of two Milwaukee men who were paid a fortune for their new product when bought by a great soap company!

### MORE-SO . . . AND LESS-SO?

How about a "more-so"?

Westclox went for that idea 20 years ago when Big Ben was given *two* alarms — one a shout, the other a whisper. Now Westclox has added a blinking beam which calls you silently. But if you ignore that kindly light, the bell starts ringing angrily.

**HOW ABOUT A BIGGER PACKAGE?** A rubber factory formerly had its rubber-cement packed in one-gallon tins — used once and thrown away. Then an employee suggested that the cement be put in 50-gallon drums. With each operator using a refillable can, oodles of waste and tons of tin were thus saved.



That employee was rewarded royally for his big-package idea!

## HOW ABOUT STRONGER? . . . HIGHER? . . . LONGER? . . . WIDER? . . . FATTER?

How about more units in a package?

Women's stockings were always sold in pairs until a food-chain operator decided to sell hosiery. He wanted to give extra value. So he thought up the idea of selling *three* stockings in a package. "You buy a pair and get a spare!" he advertised. He made a ten-strike.

## HOW ABOUT LESS-SO?

Why not *smaller?*
How about *miniatures?*
Why not *condense?*
What if it were *lower, shorter, lighter?*

One example of good ideas along this trail is the full-size umbrella which can be folded up to fit a woman's purse!

Another is the new vest-pocket book of filmy sheets of soap, with pellets which expand into washcloths when dropped in water!

What could be *eliminated?*

Many a valuable idea is to be found in the field of streamlining. Ideas by way of simplification can be golden.

## HOW ABOUT PULLING A SWITCH?

This is the "man-bites-dog" approach. Here are a few of the kind of questions that could help lead to ideas along this line:



Transpose positive and negative?
What are the opposites?
What are the negatives?
How about up-ending?
Should it be turned around?
Why not up instead of down?
Why not down instead of up?

Why does a successful furrier sew the labels in his coats upside down? So that, when the coat is draped over the back of a chair, his name is right-side up and easy to read!

The nub of Howe's invention of the sewing machine was this: Instead of putting the eye of the needle at the end *opposite* to the point — he put the eye at the point.

## WHAT CAN WE COMBINE?

Here's another powerful set of questions:

What ideas can be combined?
How about an alloy? — A blend?
Combine units?
Combine purposes?
What about an ensemble?
What about an assortment?

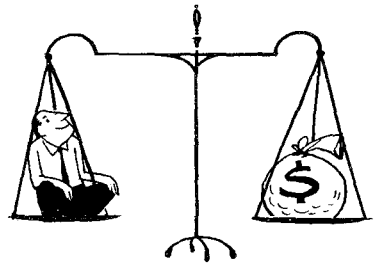
The newest in cameras is a combination that not only takes the picture but also produces the print, all within a minute!

A new lawnmower includes a "mulcher" which can pulverize 30 bushels of dead leaves per minute.

No longer do you have to bail out your motorboat. Drop a little attachment in the bottom and let your outboard motor do it for you.

## LET'S GO

Up to now, lots of new ideas — lots of successful new products — have probably seemed to you like "strokes of genius" or "pure luck."



But now you see how many of them can be traced back to ordinary people who asked their minds question after question — until their imaginations sparked and handed them answers worth their weight in gold.

## WHY CAN'T YOU DO IT?

Why can't *you* think up more ways to win the rewards that await you — quicker promotion, more money, more happiness, more fun out of life?

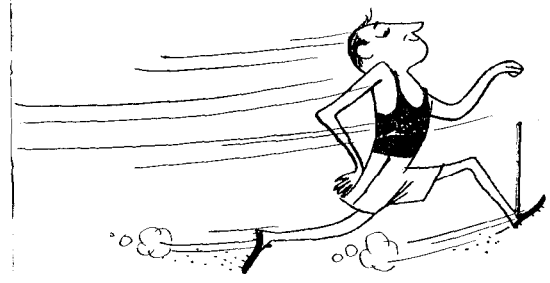
You were born with imagination. Neither your age, nor your experience, nor your education is any excuse for your not trying to make more profitable use of your creative talent. It is the greatest gift you possess — the gift that can do *most* to help you get ahead and to brighten your life in every way.

## HOW ABOUT STARTING NOW?



***Books by Alex Osborn***

HOW TO THINK UP (McGraw-Hill 1942)
YOUR CREATIVE POWER (Scribners 1948)
WAKE UP YOUR MIND (Scribners 1952)
APPLIED IMAGINATION (Scribners 1953)



# EVALUATE THE FUNCTION

## VALUE ANALYSIS RELATES COST TO FUNCTION

Value Analysis attempts to relate cost to the function of each part, assembly or device.

## VALUE -- DEFINED

Before considering this further, we should first understand what "Value" really is. Value may be defined as the lowest price we must pay for the function or service required, at the time, place, and with the essential quality.

## FUNCTION -- DEFINED

Function may be defined as anything that makes the product work better or sell better.

## TECHNIQUES MUST OVERCOME HABIT & ATTITUDE

Reviewing for a minute, we have said that many of the unnecessary costs exist because of our habit and attitude. Thus, all of the Value Analysis techniques are aimed at overcoming these habits and attitudes. For example, if we are convinced that something costs too much, we will do something about it, but all too often we say to ourselves, "That cost is about right", or "we don't think we can do it much better."

## WHAT DOES EACH FUNCTION COST?

One of the first techniques in overcoming this attitude is to evaluate function. When we are given the cost of any product or part, we are usually given the shop cost, and this may be broken down into terms of material, labor, overhead, etc. This breakdown in itself may give us some ideas on how to eliminate cost, because the labor cost may be out of line with material -- or the overhead may be out of line. If we are not successful in reducing the cost, however, with this breakdown, the next approach is to arrange the cost into functional areas, i.e., relate cost to function, find out how much we are paying for the cover, for the support, the base, the appearance, the electrical part, the mechanical part, etc. By assigning costs to these various functional areas, we may immediately find that some of the costs are too high.

## VALUE ANALYSIS QUESTIONS

In relating cost to function, we may ask ourselves a set of very simple questions:-

1. What is the part?
2. What does it do?
3. What does it cost?
4. What else will do the job?
5. What will that cost?

## EXAMPLE -- COST OF SHOCK AND REQUIRED SUPPORT

Correctly using this simple technique will very often pay tremendous dividends. For example, in analyzing a particular device costing $4.00, it was found that the support cost $1.00. When the function of support is intensely analyzed, it was found that this high cost was because the device was designed to resist the shock, that was inherent in the design.

Thus, it became apparent that the thing to do in order to eliminate unnecessary costs was not to work on the support itself, but to eliminate the shock or to minimize its effect, so that the support could be provided in a lower cost manner.

## EVALUATE FUNCTION -- SYSTEMATICALLY

A systematized approach to evaluating a function has been developed by Burr Stanton of Erie, using the following charts.

## EXAMPLE -- THE END CAP

(Samples required to illustrate talk) - As an example of the use of this systematic approach, let us study the end cap assembly from the household refrigerator compressor. As all of you know, the refrigerator compressor unit is hermetically sealed so that no gas can get out or harmful elements get in. This is the function of the end cap. With that, you have the problem of getting the current through the case of the compressor to the motor. This is solved by the use of these metal-glass leads. Three leads come from the compressor case, across which there is 110 volts. These leads must be protected, and this is accomplished by this metal-glass lead cover.

Now referring to the first page of "What Is It" put down the name of the complete assembly(in this case, end cap assembly) and the drawing number. Then in the chart that follows list the various components of the assembly noting the drawing number, the material, annual quantities, vendors, etc. This is the information or the facts needed to start the analysis.

Now under Item II, "What Does It Do", list the functions desired of this assembly in order of importance. List only the basic--customer--value functions. That is only those of value to the customer. Basic functions can be expressed in a maximum of two words, and if it requires more, the chances are you do not have basic functions. The basic--customer--value functions for this end cap are such things as mechanical support, excluded substances (which may include water as well as the customer), pressure seal, etc. As the second step list in Chart II the functions performed by each of the components of the assembly. For this particular study let us select from the assembly the metal-glass lead cover. What is the function of this cover. Exclude the customer is the basic function, so we would check Basic in the basic column. Next assign the value of this function. Think of something that does that same job. For example, the cover on a glass jar keeps you out of the jar. What does that cost? Let's assume for the time being that it costs $.50 per hundred for doing that particular job. Write that down in the value column. What other function is performed by this cover? The other function that must be performed is to exclude water. Again in the case of the jar lid you have a rubber washer so that when you tighten it down, it seals against water and moisture. What would that cost? In the quantities that we are talking about, probably not more than $.50 per 100 again.

Now let us investigate each item that goes to make up this cover. First we see the Mortel - the black gooey substance similar to that put under your automobile. The primary purpose of this material is to deaden the sound. That's the function. Is it basic? No, it is not. Why isn't it? It's a second degree function because the reason we have to deaden the noise resulting from the cover is because we have chosen to perform the first function by using the metal cover. Therefore, the fact that we get noise-deadening from this material is not a true basic function that we need in the operation of the assembly. The customer doesn't care, because perhaps we might have used some other material which would not have required the noise-deadening.

What else does the Mortel do? It resists corrosion. Is that basic function? Absolutely not. It is something that we have introduced because of our choice against other materials. So it is second degree and has no value.

On the basis of function, then, if we add up the values so far, we have $1.00 per hundred.

Next, what do we have to pay for it? That's the cost. These are the actual costs of making this whole part - $3.59 per hundred. The addition of the Mortel brings the cost up to $4.96 a hundred. Then we add paint - $.68 a hundred, clips, grommets, etc. The grommet is determined by the choice of the cap and, in addition, because of our choice of the grommet, we have to dip the assembly in glycerine to get the wires through the grommet. When we add up all the costs, we find that it is costing us $16.00 per hundred, whereas we say that it is worth only $1.00 per hundred.

Having arrived at this point, your information indicates that you should really blast.

You then proceed with the line of thinking - what else will do the job, and what will that cost, according to the chart? (See remainder of charts and continue as explained therein.)

## EVALUATE EACH FUNCTION

DATE _____
ANALYST _____

I. WHAT IS IT?

1. Part Name (end cap assembly) Drwg. No. _____
Complete Assembly

Components (List as separate items, paint, sound deadening mat'l., etc.)

CHART I

| Component Name | Drwg. No. | Material | Annual Qty-M | Vendor or Mfg.Dept. | Special Specifications |
|---|---|---|---|---|---|
| Cap | | | | | |
| Leads | | | | | |
| Metal-Glass Lead-Cover | | | | | |
| Paint | | | | | |
| Mortel | | | | | |
| etc. | | | | | |
| | | | | | |
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| | | | | | |
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II. WHAT DOES IT DO?

1. List functions desired of the assembly in order of importance. (List only basic-value-customer functions. Basic functions can be expressed in a maximum of two words, examples: Mechanical support, exclude substance, sense temperature)
   a. Mechanical support
   b. Exclude substance
   c. etc.
   d.
   e.
   f.

2. List functions performed by the components. If that function contributes to any of the functions listed above, it is basic. If not, it is second degree function. Assign a value to each basic function using your past experience or by comparison with other items of known cost that provide a similar function. Second degree function has no value.

CHART II

| Component Name | Function | Basic | 2nd Degree | Value | Actual Cost (S.C.) |
|---|---|---|---|---|---|
| Cover | Ex.customer | X | | .50/C | $3.59/C |
| | Ex.water | X | | .50/C | |
| Mortel | deaden sound | | X | 0 | 1.37/C |
| | resist corrosion | | X | 0 | |
| Paint | prevent rust | | X | 0 | .68/C |
| Clips | attach cover | | X | 0 | |
| Grommets | protect wire | | X | 0 | |
| Glycerine Dip | facilitate assem. | | X | 0 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | TOTAL | | $1.00 | $16.00 |

III. WHAT DOES IT COST?

1. Enter the full shop cost of each component in the analysis box above only after the value column is completed and totaled. By your own analysis you have now set up a target saving you should be able to realize on this assembly. You should completely understand the function of the device and have separated out the cost items that do not represent value.

IV. WHAT ELSE WILL DO THE JOB?

1. This is a creative stage. Enlist the aid of at least one other person and form a "Brainstorm Session." Penalize anyone that throws up a roadblock during this period with judicial thinking. In a half hour session you should generate at least 50 different methods, processes or schemes to fulfill the functions you have distilled as basic.

CHART III

| | | | |
|---|---|---|---|
| | | | |
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| | | | Do not write below this line until Step 2 below |
| | | | |
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| | | | |

2. After filling the space above with creative ideas, put this analysis aside for a time (the exact length of time you will find by experience). Do other, relaxing, routine work. Jot down immediately any new ideas that may occur to you, but do not reapply yourself conciously to the problem.

3. Judicial analysis of the ideas in the "Creative Block." List below the five that are most promising. Do not become discouraged because none of these seem to be the ultimate in economy or function. Few designs ever represent the ultimate. You are trying to do the best job you can this time. Enter next the advantages and disadvantages for each of the five ideas.

CHART IV

| IDEA | BASIC ADVANTAGES | DISADVANTAGES |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

4. Re-examine each disadvantage listed with the following analysis:
   1. Is it inherent in the design?
   2. Is it impossible to minimize or compromise?
   3. Do the other ideas contain the same disadvantage?
   4. Have other designers met the same disadvantage?
   5. Have you discussed this problem with your company specialists?

   If the answer to any of these questions is no, the idea should not be shelved.

5. Sketch the resultant good ideas. Add such detailed information as needed to describe the sketch completely.

# CHART V

V. What Does That Cost?

| COMPONENT | BASIC FUNCTION | INTERIOR PLANNED COST | VENDOR QUOTATION | VENDOR QUOTATION | VALUE FROM II | % ACCOM-PLISHMENT |
|---|---|---|---|---|---|---|
| | | | | | | |
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# PUT A DOLLAR SIGN ON EACH IDEA

You have a bunch of ideas - so what!

One of the screening processes or techniques in the evaluation phase is

## Put $ On Each Idea

After the creation phase, this is one of the first steps.

In the evaluation of the basic function, we attempt to place a monetary objective on the worth of the function. After the creation of ideas or possible means to accomplish the function, we need to estimate the worth of each idea.

This technique should give an indication of the return on investment. Return in the way of potential savings weighed against cost in time and manpower to develop and implement the idea.

In essence we are trying to evaluate the potential benefit of each idea. This is no easy task and generally no one individual has the capability to put a $ on every idea. How, then, do we go about this, and what information is necessary.

First, let's understand the scope of the task. What do we mean by $ as used in this technique.

Several elements of cost are to be considered here - they fall into two categories:

1. Implementation Costs
   a. Idea development
   b. Implementing expenses
2. Product Costs
   a. Cost of hardware, method, etc. for quantity required
   b. Service costs, documentation costs, etc.

We can, with this information, compare the potential worth of one idea against other ideas and existing solutions to the problem.

A second aspect of this technique is emphasized in the word each. While at first glance this would seen to make the task monumental, actually it should add only a moderate amount of time at this stage of evaluation.

On the other hand, if not done, it could result in:

1. Overlooking of good ideas
2. Misdirection of effort
3. Failure to gain the greatest results

Now it is often one thing to recognize the need to do something and another to actually do it. So it is with "putting $ on ideas."

It is done by the application of vast amounts of information on Materials, Methods, Processes, Machine Capabilities, Vendors, Tooling Costs, Engineering Costs, Specialty Products, Standard Products, Catalog Products, etc. Because of the broad knowledge required to put the $ on ideas, we find the increased need and effectiveness of:

1. Teamwork
2. Specialists or Consultants

Some people with a wealth of experience can come close to estimating costs (implementation and product). Others, because of limited experience, would need to consult with specialists to get assistance in evaluating ideas. In either case the latter is a good approach. In effect, teamwork embodies both approaches since it involves the effective utilization of specialized talents of a variety of people both from line and service (or staff) functions of the business and vendors. The increased effectiveness of the teamwork approach will be demonstrated in the Value Engineering Seminar.

In the application of this technique, bring together information from a variety of sources to estimate the $ Value of Ideas and make sure your source of information is the Best One with the latest up-to-date information. A key factor in the continuation of unnecessary product costs has been the failure to get information from the most qualified person. Everyone is ready to give opinions or advice and we must distinguish between opinion and fact.

For instance, a person not acquainted with the short run stamping field would be unable to evaluate an idea to use sheet metal as a solution for low volume applications. Putting a $ on the idea to use plastics would be difficult without extensive knowledge of a complex and rapidly changing business. The potential of using cold heading, extrusion, eyeletting, castings or other processes would be in question without knowledge of dimensional, finish and other specification control.

In Value Engineering, the $ must be put on each idea by bringing together information from many sources. Learn to do this rapidly and efficiently. Develop good sources for information and use these sources. In the use of this technique in the Evaluation Phase, we are attempting to get a ball-park estimate of the ultimate potential of an idea. We are not trying to get a detailed breakdown of costs. The latter is generally impossible at this stage because the idea is not thoroughly refined and defined. This will come during the Investigation Phase. However, the importance of Putting the $ on Each Idea cannot be overemphasized since it is an important step in the critical phase of determining which road to travel in the pursuit of better Value.

F. S. Sherwin
Sept. 19, 1961

# WORKSHEET

# EVALUATE BASIC FUNCTION

DATE _____
ANALYST _____

I. WHAT IS IT?

1. Name (Of assembly (end cap assembly) Dwg. No. _____ being evaluated)

CHART I

| Parts of Assembly | Drwg. No. | Material | Annual Qty.-M | Vendor or Mfg. Dept. | Special Specif. |
|---|---|---|---|---|---|
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II. WHAT DOES IT DO?

1. List only basic-value-customer functions of the assembly selected. Basic functions can be expressed in a maximum of two words, examples: Mechanical support, exclude substance, sense temperature. List and cross out those you decide do not apply.

a.
b.
c.
d.
e.
f.

2. After the basic function or functions of the assembly are established, then list the functions performed by the components. Next indicate whether they are basic or second degree. Assign a value to each basic function using your past experience or by comparison with other items of known cost that provide a similar function. Second degree function has no value. (See text where second degree regarding evaluation of second degree function).

CHART II

| Parts of Assembly | Function | Basic | Second Degree | Value | Actual Cost (S. C.) |
|---|---|---|---|---|---|
| | | | | | |
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| | | | TOTAL | | |

III. WHAT DOES IT COST (See Chart II)

1. Enter the full shop cost of each component in the analysis box above ONLY AFTER the value column is completed and totaled. By your own analysis you have now set up a target saving you should be able to realize on this assembly. You should completely understand the function of the device and have separated out the cost items that do not represent value.

IV. WHAT ELSE WILL DO THE JOB? (See Chart III)

1. This is a creative stage. Enlist the aid of at least one other person and form a "Brainstorm Session." Penalize anyone that throws up a road-block during this period with judicial thinking. In a half hour session you should generate at least 50 different methods, processes, or schemes to fulfill the functions you have distilled as basic.

CHART III

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2. After filling the space above with creative ideas, put this analysis aside for a time (the exact length of time you will find by experience). Do other, relaxing, routine work. Jot down immediately any new ideas that may occur to you, but do not reapply yourself conciously to the problem.

3. Judicial analysis of the ideas in the "Creative Block." Using a chart similar to Chart IV list the ideas that are most promising. Do not become discouraged because none of these seem to be the ultimate in economy or function. Few designs ever represent the ultimate. You are trying to do the best job you can this time. Enter next the advantages and disadvantages for each of the ideas.

CHART IV

| IDEA | BASIC ADVANTAGES | DISADVANTAGES |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

4. Re-examine each disadvantage listed with the following analysis:
    1. Is it inherent in the design?
    2. Is it impossible to minimize or compromise?
    3. Do the other ideas contain the same disadvantage?
    4. Have other designers met the same disadvantage?
    5. Have you discussed this problem with your company specialists?

If the answer to any of these questions is no, the idea should not be shelved.

5. Sketch the resultant good ideas on next sheets. Add such detailed information as needed to describe the sketch completely.

FOR SKETCHES

## V. WHAT DOES THAT COST?

As a conclusion fill in the chart below -

CHART V

| Parts of Assembly | Basic Function | Interior Planned Cost | Vendor Quotation | Value From II | %Accomp-lishment |
|---|---|---|---|---|---|
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# A SUMMARY

# OF

# DESIGNING FOR FUNCTION

A Value Engineering technique--to assist engineering in achieving lower cost designs.

The Design Engineer has the prime responsibility of creating devices which will perform the required function with the essential quality.

This in itself is a tremendous task under modern technical complexities. However, the task is further intensified by a competitive business situation which necessitates a low-cost, producible design in addition to high quality performance and reliability. It is toward this objective that the technique of "Designing for Function" can be of invaluable aid.

The time at which this technique is applied to a new design effort is important. The first functional review should be conducted by qualified Engineers with Value Skill Training at the time the "breadboard" model, early layouts, and packaging concepts are completed.

The steps of this "Functional Review" are:

1. Divide the equipment into functional areas suitable for analysis.
    a. It is preferable to have groupings with several component parts, although in some instances this can vary from individual parts to complete units.
2. List the components of these functional areas on Functional Review Chart.

3. Write down all the functions of this assembly and determine on a separate page the basic function.

   Function is defined as anything that makes a product work or sell.

   Basic Function is the specific purpose that is accomplished by the part or device; the prime reason for its being. All Functions not Basic are called Second Degree, by relating to previously established Basic Function.

   Function should be defined in two words, verb and noun, such as conduct current, support weight, dissipate heat.

4. List the function of each component and determine whether it is Basic or Second Degree.

5. By comparison to other means that provide the same basic function, assign a Value to the Basic Function in the Value column. (Cost to perform Basic Function in simple fundamental way, such as, bare wire to conduct current, hose to transmit fluid, mild steel or wood to support weight.)

6. List actual or estimated cost of each component in last column. Compare total of Value and Cost columns to indicate areas of the greatest cost reduction potential.

The above Functional evaluation is designed to highlight areas of excessive costs and point the way toward better value.

7. The next step in "Designing for Function" is to answer the question "What else will do the job?" or "How else can this Basic Function be performed?" Here the engineer, keeping the Functional Review Chart in mind, attempts to reduce costs by:

    1. Combining or eliminating parts
    2. Simplifying
    3. Utilizing Specialty Products, Processes, Materials, Vendors
    4. Using standards
    5. Redesigning

It is necessary to generate a large number (20 or more) ways of accomplishing this Basic Function. One of the most effective tools to help generate a large number of solutions is to use the "brainstorm" or creative thinking technique.

8. Now evaluate each of these solutions to extract those which offer the best potential. This is done in part by estimating the cost to develop and produce this new solution and comparing to the existing cost, or estimated cost of the initial approach.

9. Finally, the most important step of "Designing for Function" is to plan and execute a program to refine each of these possible solutions to develop the best solution which will meet all the necessary requirements and perform the required function for the lowest total cost.

Frederick S. Sherwin, Manager
Value Engrg. & Analysis Services
March 1, 1961

Functional Review Chart

Name of Assy. _____ Dwg. #_____ Quant. /Equip. _____

Basic Function _____

| Parts of Assy. | Dwg. # | Q/Assy. | Function | Basic | 2nd Degree | Value | Actual or Estimated Cos |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

# VENDORS + V.E. = New Ways to Join Vent Ducts

**By Value Engineering Staff,**
*Bureau of Ships*

An outstanding example of the use of vendors in developing value engineering projects is that which resulted in the elimination of type C Navy flanges in ventilation duct work. This project is unique because it resulted in alternative solutions, each of which depended upon the use of a vendor's product not necessarily designed for the specific application; but which, when applied to eliminate flanges, resulted in savings to the Navy. In addition, other intangible benefits resulted from the adoption of some of the proposals.

Early in its existence, during an analysis of some of the areas of shipboard practices, the value engineering unit at the Long Beach Naval Shipyard hit upon the Navy type C flange (figure 1A) as being functionally expensive. The total cost, which included material, labor and overhead, and installation, labor and overhead, of $13.12 for joining two ducts together (which is the function of the Navy type C flange) appeared excessive.

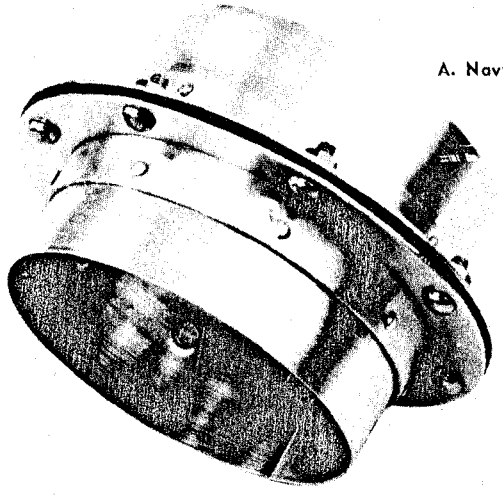
An examination of the general specifications at the time indicated that the use of this flange was implied in the specification write-ups for non-watertight duct work. As a matter of fact, the flange had been the standard method at Long Beach and (as was learned later) at many other shipyards for joining non-watertight duct work as well as watertight duct work.

The search began for a less expensive way of joining the duct work. The initial solution to the problem proposed by Long Beach was the use of a standard commercial type of clamp, shown in figure 1B. This clamp is used after the ends of the ducts are formed to provide right angle flanges, in effect, to the duct work. The gasket is inserted between the spacers and, with the use of adhesive, is permanently attached to one piece of duct. The clamp is then fitted over this form section and, by means of a screw and clip arrangement, the clamp is tightened.

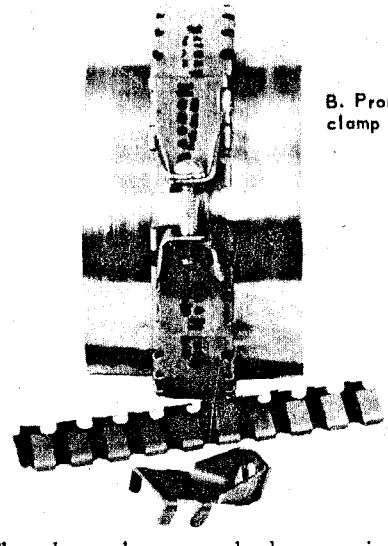
**Savings Run to Thousands**

Long Beach's initial tests and evaluation indicated a satisfactory joining of ductwork at a total cost of only $4.23 per joint. A savings of approximately $9.00 per joint, or a $25,000 annual savings at their yard for the number of joints replaced or installed each year.

Figure 1.



A. Navy type C flange.



B. Proposed clamp arrangement.

The clamp, however, had one major drawback; it could not be used on rectangular ducts. The Long Beach value engineering unit, therefore, continued the search for another means of joining two ducts. As an outgrowth of the simple suggestion of "why not glue them together," the value engineering people hit upon the idea of taping the joints. Because of the development of special and unique types of tapes and adhesive backed material, and by going to a vendor who specializes in this type of material, the value engineering unit was able to come up with the tape joint shown in figure 2. This joint was suitable for use with not only round ducts, or obround ducts, but also with the initial problem type duct—the rectangular duct.

- The cost for installation per joint: Only $1.14.
- The average annual savings at Long Beach: Over $60,000.

*(Continued on page 8)*

# A SERVICE AVAILABLE—Specialty Vendors

**By Value Engineering Staff**
*Bureau of Ships*

The naval shipyards' efforts in Value Engineering Programs are realizing more than $5,000,000 in new savings each year. These figures are presented to indicate that the program is operating on a profitable basis. Nevertheless, it can, will, and *must* improve.

The success achieved so far, while due in part to the people in the program, may primarily be credited to the concept of Value Engineering and the techniques used. As the program evolves, it becomes obvious that more and more support and aid from specific value engineering techniques are utilized, not only in developing specific projects but also in being directed to project areas. One important value engineering technique, the "Use of Specialty Vendors," is of great assistance. This article describes the use of specialty vendors as well as the related service that value engineers can provide to achieve the goal of the program—Necessary Function at Minimum Cost—and how you, too, can benefit from the use of this service directly or indirectly.

Of course, other engineers utilize the same service, and the reader may accurately maintain that he also uses vendors. There is nothing new in this aspect. What is considered significant is the use of the technique by a staff group, without regard to the technical area involved and without technical authority, to achieve by way of recommended projects, change in technical areas.

The value engineer always has and always will use vendors to help you answer the basic questions, "What else will do the job?" and "What will it cost?" The great majority of the value engineer's project output is not the result of his creation but rather the utilization of the creations of others.

There is not a project developed that at some stage could not benefit by determining how else it might be done and finding out who is doing it. From the simplest shop practice to the most complicated machinery, there is someone doing it or making it for less. The value engineer must find him. Even in those cases of project development solely by value engineering effort, the use of vendors is necessary to assist in determining costs for comparison. The vendor is the value engineer's greatest source of assistance, and can be of assistance to any engineer.

**What Actually Is a Vendor?**

In a general sense, American industry is composed of vendors. The basic material supplier, the fabricator of materials, the owner and user of a particular process, the producer of a particular component or product, and the producer of a particular assembly, each of these is a vendor to the value engineer. Each can contribute the special knowledge and experience to the problem posed by the value engineer. Each can be considered a specialty vendor because each has specialized in one minute phase of industry. Each firm, whether large or small, can contribute specialized knowledge to the value engineer.

When these abilities are combined and found in partial or complete combination in one company, the benefit to the value engineers increases tremendously. Initially, this knowledge is presented to the value engineers by the salesmen or sales agents of the company. They are the "walking encyclopedia" of American industry.

Vendors introduce "new" products, processes, or materials. Too often we find that "new" to the Navy or to shipbuilding means the introduction of something that has been in use commercially for years but for similar applications. Value engineering has helped open the door wider in many cases to the acceptability of commercially available products for shipboard use. BuShips Notice 4120 Ser 640-25 of 17 July 1959 is an expression of the Bureau of Ships desire to relax requirements of standard naval drawings by permitting the use of substitute or commercial materials rather than those specified.

**V. E. Forte**

The value engineer's contacts with vendors stems from the description of products in trade journals, visits to trade and design shows, referrals from or to the field, contact with several hundred different firms during previous Value Engineering Seminars, and, it is hoped, from the growth of value engineering.

The immediate concern of the value engineer is the determination of the need for the product, process, or material offered, and its cost relationship with what exists and is being done. Naturally, the more aware the value engineer is of high-cost areas, the quicker he will recognize the need for something "new" or different. When this need is determined, the next step is the referral of the vendor to the appropriate technical, design, or production supervisors. It is these people who will ultimately approve or reject the item in question, and they must determine a course of action. In developing the final course of action, the value engineer offers and is available to provide assistance wherever possible.

The vendor is made a part of the value engineering effort in another manner. Vendors are shown our ships and facilities so that they may know the how and the why of what is being done.

What then is the relationship of value engi-



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neers and vendors? Basically, it is one of mutual assistance and interdependence. On one hand, value engineers expect honest, timely, and complete information. The vendor, on the other hand, expects a fair evaluation of his product by those primarily concerned with it. It is the value engineer's job to see that this is done. The value engineers will rely heavily on the information received. The vendor will rely heavily on the value engineer's objectivity and his ability to convince by facts and figures.

**For Your Benefit**

A more important question is, "What does the Value Engineering-Vendor relationship mean to you?" The answer is simple. The service provided to the value engineers can be provided to you. As a staff group, part of value engineering's job is to furnish you with more information to permit you to do your job better.

Because of the close relationship of Value Engineering-Vendors, the Value Engineering staff has developed extensive files of literature and referenced material. This information covers not only the material and products of vendors in businesses related to your organization's efforts, but also from allied and totally different fields. In many instances this information is supplemented with samples of the product. Thus a broad spectrum of knowledge is available to you. In addition, the Value Engineering office usually maintains standard reference catalogues and industrial handbooks.

Whether you are in design, engineering, production, supply, planning and estimating, or in any other phase of your organization's operation, the Value Engineering staff is available to help you. American industry and your Value Engineers stand ready to help you reduce your organization's costs. USE THEM!

# Post Cards For Submitting Suggestions

This issue of the *Journal* contains two postcards which ask for your suggestions to reduce the cost of ships and ship hardware and equipment. The cards are addressed to the Value Engineering Branch of the Bureau of Ships. The card has been inserted in the *Journal* in an effort to solicit your aid in achieving the over-all goal of the Bureau of Ships to reduce costs.

The current article concerning Value Engineering (and those that have appeared and will appear in the *Journal)* describes a method of attacking and reducing high costs. You can use the Value Engineering techniques in making your suggestions. However, any ideas should be submitted to the Bureau if you feel money can be saved. Changes that have been made aboard ship to reduce maintenance should also be submitted because they may be suitable for Navy-wide application.

Remember, the *dollars saved* provide that *much more Navy* and *Defense.*

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*(Continued from page 6 )*

By means of the cross-fertilization process of the value engineering program, that of distributing value engineering project cards to all interested activities and the Bureau of Ships, other shipyards came in with their recommendations for joining duct work together, or the elimination of the type C flanges. The high cost area discovered at the Long Beach Naval Shipyard was also present in all other shipyards; and substantial savings across the board could result from the adoption of the proposals presented.

The Bureau of Ships, realizing the potential on these projects, authorized tests of each type of proposed connection at the Material Laboratory, New York. Interim approvals and in-service evaluation were authorized by the Bureau's technical people, so that in addition to the laboratory report, actual service conditions and usage of each connection could be determined.

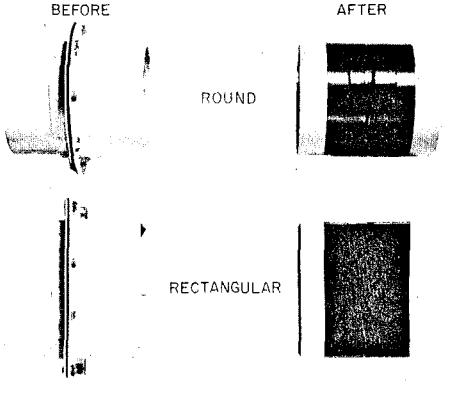



**Figure 2. Long Beach Naval Shipyard value engineering project No. 26. Left, Navy type C flange joint; unit cost for average size installation, $13.12. Right, pressure sensitive adhesive tape joint; unit cost for average size installation, $1.14. Saving to shipyard per year for full application, $62,000.**

**ll Shipyards Contribute**

Some of the other shipyard proposals are shown n figure 3.

• The Puget Sound Naval Shipyard proposal incorporated still another commercial item which had been successfully used in hanging electric cable. That is the cable band, as used in packaging. This band, when used over a preformed strap as shown in figure 3, provides a satisfactory means of joining two ducts together.

• The Portsmouth Naval Shipyard proposal is also shown in figure 3. It consists of the tape, as proposed by Long Beach, and the banding material, as proposed by Puget Sound, which together result in another satisfactory means of joining the duct work.

On three submarines, savings of over $5,000 resulted from using the tape and band method. The Puget Sound Naval Shipyard estimated a $25,000 annual savings from the use of their proposed method. Adaptations of these proposals at the Pearl Harbor Naval Shipyard, the Philadelphia Naval Shipyard, and the San Francisco Naval Shipyard indicated an additional $50,000 could be saved by these yards, if their proposals were approved.

As a result of the tests at the Material Laboratory, the Bureau of Ships has authorized the use of the Marmon clamp and the Puget Sound proposal with tape under the formed strap, as an alternate to the type C flange.

Thus, through the use of a functional analysis .o determine the high cost area, and the obtaining f information from vendors, the use of the approved type of duct work connection can result in approximately $100,000 savings a year to the Navy.

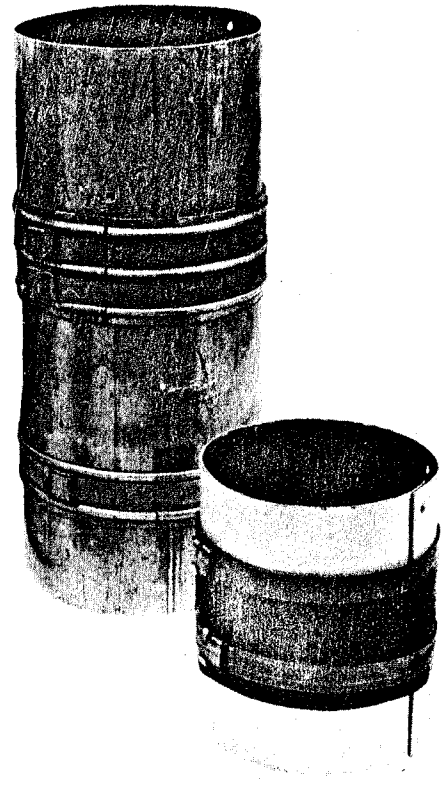


**Figure 3.** At back, Puget Sound Naval Shipyard proposed connection. In front, Portsmouth Naval Shipyard proposed connection.

# PROFIT-MAKERS FROM COMPANY STANDARDS

## INVENTORY & PROCUREMENT

- Reduce variety
- Reduce total parts
- Reduce record keeping
- Reduce storage area
- Reduce materials handling
- Larger quantities of fewer items
- Increased use of standards and decrease in specials
- More routine activity
- Reduction in P.O.'s, receipts, inspections, payments
- Reduced lead time
- Reduction in need for special tooling, training, layout, procurement, test

## PRODUCTION

- Familiarity in fabrication & assembly
- Less rework
- Reduced spares
- Reduction & simplification in inspection (sampling plans, etc.)
- Improved basis for vendor competition
- Improved quality control based on accepted & explicit specs
- Improved mechanization
- Economies of special purpose machines
- Reduced production - methods - industrial engineering effort & manpower

## MARKETING

- Ease of selling design composed of customer-approved or recognized devices, reliability, maintainability

## ENGINEERING

- Greater reliability
- Reduced redesign, redrafting
- Ease of design based on standard parts & techniques
- Reduction in needed waivers and non-standard part testing and approval
- Reuse of known items improves reliability & reduces debugging
- Reduces need for special communication between engineers, draftsmen, production, etc.
- Improved interchangeability of parts - designs - packages - tests
- Use of accepted standards vs. untried specials
- Provide basis for built-in product improvement

## GENERAL

- Reduction in special negotiations
- More accurate & predictable planning & budgeting
- Improved user & customer confidence
- Customer service - spares, manuals, operator training, repair & training
- Provides basis for data mechanization, handling, reduction in errors
- Reduced capital requirement
- Improved general communication
- Provides basis for new bidding
- More routine work frees higher skilled people for unique aspects of project

Prepared by: ARNOLD M. ROSENWALD
August 15, 1962

# THE COMPATIBILITY OF VALUE ENGINEERING ANALYSIS AND RELIABILITY

By Richard M. Jacobs

Value engineering and reliability are often thought to be in conflict with each other, a belief predicated on the basis that reliable design is expensive design. Indeed, justification for this expense is obtained by demonstrating the reduction in maintenance, installation, operation and logistic costs which result from improved equipment reliability. It is my intention to demonstrate that the initial cost can sometimes be reduced by a value engineering analysis at the same time the reliability of the equipment can be improved. The compatibility of value engineering and reliability is not a dream - it is a proven fact.

Value engineering analysis can be and is a tool for improving the reliability of equipment without necessarily reducing its initial cost. The converse is also frequently found to be possible.

Before we examine how compatible reliability and value engineering actually are, it may prove beneficial to discuss what these two terms mean to us in the electronic industry.

## RELIABILITY

Reliability can be defined as the probability of success or operation of particular equipment to perform its function as it was designed to do. This includes the environmental conditions under which the equipment operates, the time period the equipment is to operate and the specific functional responsibility of that equipment. Reliability studies under this definition include consideration of such items as down time, maintenance, marginal checking, modularization, human engineering, component part failure analysis, packaging, heat dissipation and a host of other items. It is therefore axiomatic that reliable equipment will have the degree of completeness required by the optimization of each and every characteristic that may affect the reliability of that equipment.

## VALUE ENGINEERING ANALYSIS

"What does all this reliability cost?" is a common question heard among members of our industry and members of the military services. We are assessing these costs and value engineering analyses are being made to evaluate the function and its requirement for the expense involved. A value engineering analysis is defined as "an objective appraisal of all elements of the design, construction, procurement, installation, and maintenance of equipment, including the applicable equipment specifications, in order to achieve the necessary functions, maintainability and reliability of equipment at minimum cost" (10) (11). Thus value engineering is not simply cost

reduction - it is an analysis of function versus cost.

Total cost is another way of expressing the definition. Total cost is made up of the initial or procurement; installation, operation, maintenance, logistic, replacement parts cost and the amount of time needed to install, maintain, and await the arrival of special parts not readily available. A value engineering analysis is a study of each operating function to determine its contribution to the overall worth of the equipment. Each characteristic is evaluated to optimize reliability and is reviewed to determine if modifications can be made that will substantially reduce the cost of providing that degree of operability, level of reliability, etc., which was originally thought necessary. Increased reliability is a natural by-product of equipment simplification, a value engineering analysis goal, hence it is an indication that value engineering and reliability go hand in hand.

## RELIABILITY ACHIEVEMENT

Reliability can be enhanced by many different yet specific and coordinated efforts. A few of these efforts are:

1. Reduce complexity of electronic systems.
2. Reduce the number of parts in the system.
3. Provide redundant circuits or assemblies.
4. Include standby facilities.
5. Use marginal checkout techniques.
6. Reduce maintenance time by modularization, easy location of test points, built in or wired in test apparatus.
7. Improve component life.
8. Improve use of components.
9. Standardize circuits, parts and assemblies.
10. Install environmental controls.
11. Train higher skilled maintenance personnel.
12. Schedule periodic maintenance.
13. Prepare better instructions on operation and maintenance.
14. Perform systems operation analyses.

In each of these areas costs are involved. In some initial costs will be reduced; in others such costs will increase. Where the initial cost is increased, it must be justified by reductions elsewhere or reliability is substantially improved.

## RELIABILITY PROGRAM

At RCA the reliability program has been a management function these past five years. We have instituted various concepts and techniques used in the prediction, measuring and evaluating of our equipment reliability. The organization depends heavily on design reviews (1), standardized parts and circuits, and feedback of

information derived from failure reports, and the analyses of the mechanisms of failure to provide more reliability in our equipment. The reliability program is an integrated function of all divisions of the corporation. All groups affecting reliability such as engineering, quality control, purchasing, standards and manufacturing are represented and participate in directing the reliability program (3). The reliability program employed at RCA has been the subject of many other papers (2) (4) (5) (8) (9) (12).

## VALUE ENGINEERING PROGRAM

The value engineering program like the reliability program depends upon design review and information feedback loops. Value engineering, operating as a specific effort for little over a year at RCA, is a studied and systematic approach to cost reduction.

The approach taken by RCA is vital to the electronic industry. Second looks and redesigns cost money, take time and are psychological barriers to an engineer's effective thinking. We have in our design review program united value engineers, maintenance personnel, operators and reliability experts as well as design specialists. At the design reviews, we give the designer all the pitfalls he should avoid before he starts his design; then, after his sketches and/or models are finished, his design is reviewed to evaluate his design in relation to the function required. After the third review, accomplished after complete prototype tests, the drawings are released for the first time. In other words, the design review program helps the engineer avoid costly engineering changes and field modification kits.

These are the steps taken in the value improvement program:

1. We help everyone concerned appreciate the need for improvement.
2. We organize to do the job.
3. We set goals.
4. We develop cost prevention techniques and train ourselves to use them.
5. We develop price prediction aids as an important tool in meeting our goals.
6. We continue to improve and use our cost reduction techniques.

The work falls into three areas, with equal responsibility for action delegated to:

Engineering - Value Engineering - optimum simplicity and lowest cost for required performance.

Purchasing - Value Analysis - better value parts, materials, and sources.

Production - Methods Improvement - development of improved fabrication and assembly processes and values.

In our value improvement tests, which are guides to better value, the following questions are asked:

In the selection and application of parts, materials, and processes have you

1. Challenged specification requirements?
2. Eliminated unnecessary parts or functions?
3. Simplified the design as much as possible?
4. Made maximum use of standard items?
5. Used least costly materials?
6. Designed for lowest manufacturing cost?
7. Relaxed tolerances as much as possible?
8. Used lowest cost finishes?
9. Used company component and material specialists?
10. Fully utilized purchasing's assistance to gain suppliers "know-how?"

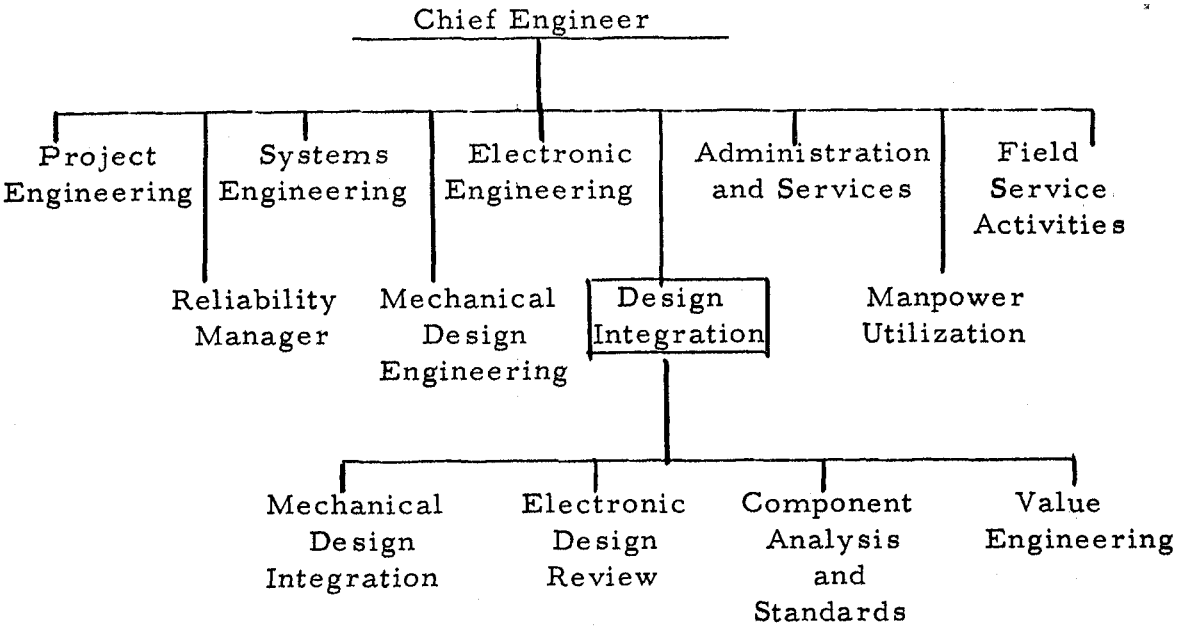
The following critical value improvement techniques have been developed and proven by experience:

Get all the facts.
Use the best sources for information.
Be specific and omit generalities.
Evaluate design by comparison.
Consider the functions of every part.
Make use of specialty products, materials, and processes.
Think creatively.
Be completely open-minded to new ideas.
Weigh dollars against each major idea.
Use standard parts and materials.
Use company services.
Employ your own judgment.

The entire program is integrated by a value engineering council made up of all working department representatives including purchasing, quality control, manufacturing and engineering. Each working department has organized a team which includes responsible, decision-making personnel from those activities having cognizance over major cost elements.

ENGINEERING ORGANIZATION

An organization chart showing the major functional groups of an engineering section is shown in Figure 1.




Organizational Chart of Missile & Surface Radar Engineering

Reliability can be improved by value engineering analyses when the analyses bring to light situations which are not to the best interest of the customer. Some of these situations may be:

1. Over designed structures.
2. Under designed structures.
3. Highly stressed components, heat, load, pressures.
4. Non-essential refinements.
5. Extra functions duplicated elsewhere.
6. Drawing inconsistencies.

COMPATIBILITY

In order to show that these two management techniques are compatible, it is felt that some specific examples would be helpful.

EXAMPLE 1: "OVER FLEXIBLE"

The initial design on a large ground radar system permitted a high degree of flexibility in the placement of the physical components of the system. Cable ducts were used throughout the design and interconnecting cables were used between the sections. The length of these cables could vary depending on the need. However, the production units of this system were subsequently decided to be for similar placement of components in each system. Each

production unit was to have a building built to specifications for housing the system where this was not expected in the R&D design. Since flexibility was not needed, why were these cables required? Couldn't we use one less set of connectors and perform the same task?

The cost aspects of this example show that material (cable connectors and cable length) cost $2,037, labor (making the connections, installation, etc.) costs $3,600, while the new design requires $242 for material and $36 for labor. The total per unit savings amounted to $5,359. However, certain engineering costs to make the change had to be accounted for, and when these were prorated over the number of units on order, the unit savings amounted to $5,030.

The reliability aspects are such that two soldering operations per wire and two connectors (male and female) were eliminated. The possibilities of human error in soldering and wiring and the unreliability that the connectors contributed to the circuit were eliminated. Actually there were 24 pairs of sets of connectors eliminated in each of 4 banks of connectors per system. Here is an example of value analysis contributing a major cost reduction and a substantial improvement in the reliability of the circuit.

EXAMPLE 2: IS A SUBSTITUTE AVAILABLE?

A prototype of a portable radar set we designed five years ago for the government underwent a complete value analysis by a team of design engineers, manufacturing experts, packaging engineers and field maintenance men. This analysis was performed primarily to reduce costs in order to bid on a large procurement contract

From the analysis that reduced the overall material costs by 11%, the following three examples have been extracted for your consideration.

1. The plant was to use two Selenium rectifiers in series with each other. They were currently priced at $31.60 each. A new silicon rectifier developed within the last five years performed without a measurable difference when compared to the previous two units used. The material savings amounted to $50.80 per system. There were additional savings estimated at $3 per system by the elimination of mounting holes, wiring and miscellaneous hardware and assembly costs. The cost of the investigation and drawing changes amounted to $1,000 which was prorated over the ordered quantity.

The reliability of the system was enhanced by the reduction of the number of parts used, the number of soldering joints needed, and the elimination of the ever-present human error factor in wiring.

2. A complex electro-mechanical Rectipot costing $75 was used as a tuning indicator. Here, our value analysis team investigated the use of a standard potentiometer available on the open market that met military specifications. It could be used with a simple gear train. The cost of the investigation, the designing and procuring the necessary gears, shafts and other hardware plus the standard potentiometer amounted to $31 per system. The savings, therefore, amounted to $44 per system. Reliability was improved by having the standard pot readily available from large production runs, which gave us

longer life, and a less unique part to replace in the field by maintenance personnel. Replacement time was reduced by having the pot more easily removed. It was smaller in size than the sealed Rectipot and could be removed with less probability of damaging adjacent components. If the gears of shafts became worn they could be more readily adjusted or replaced in the field rather than discarding the entire sealed unit. It is obvious then that greater value, lower cost, and a higher reliability were obtained in this case.

It should be remembered that the more standard the unit, the larger the production run and therefore, the more easily the manufacturing process can be controlled. This usually results in a better quality unit with a greater stability and more reliability than the special component produced in small quantities..

3. A simple knob used to control hand rotation of the antenna of this unit was priced by our vendors at $22 each. After the mechanical engineering member of the team reviewed the requirements for this expensive knob he located a standard knob. The standard knob required a different size shaft and could perform the same function just as well as the special knob. The standard, oddly enough, costs only $2.20 when the cost of changing shaft sizes and appropriate drawings was added. The total savings in this case amounted to $19.80 per system.

System reliability was not altered as both knobs performed the same function. But, if the knob were broken in transit or handling, it could be replaced by a standard already stocked by the military. Thus, additional savings by the customer would accrue by eliminating one item in his logistic support centers and warehouses. By having a standard readily available, downtime is decreased and the system reliability measured in terms of system availability is improved.

EXAMPLE 3: IS THERE ANOTHER METHOD?

A large ground-based Instrumentation Tracking Radar System going into quantity production by RCA's Missile and Surface Radar department employs a boresight target for calibration purposes.

The mechanical engineer and the manufacturing methods members of the value analysis team reviewed the Engineering Model Boresight Target assembly with the express purpose of reducing its cost. The current cost of procurement is $3672 per assembly. As noted, the original design contained many castings specially fabricated for this design, a rectangular box beam and complex leveling mechanisms. The team members asked themselves - are there standard parts that will do the job? The answer of course was yes, and the complex truss work was changed to a round aluminum pipe of standard size and all clamps, levels and threaded castings were changed to standard commercial hardware.

The cost was reduced by $1412 per assembly. The reliability of the assembly was altered only in that accessibility for adjustment of the targets is more rapid. We also know that assembly quality is much higher, the availability of replacement parts is no longer a major concern of our logistics group, and installation procedure is less cumbersome and therefore more rapid.

EXAMPLE 4: ARE THE SPECIFICATIONS REALISTIC?

In some instances a value improvement analysis results in a second look at the original specifications. It may be required that to save a considerable amount of money all that is needed is another interpretation of the customer's specification. This is due to the definitions of words or phrases used in a legal document. In one particular case the specification states "that there shall be no flicker." If we chose to say there shall be no flicker at any time, the cost was estimated at $12,000 for an indicator and particular power supplies. However, if we chose to say there shall be no flicker 99.5% of the time, the cost of the indicator and its power supply would be about $7,000. The function would not be impaired by a flicker only .5% of the operating time and the customer readily agreed to the modified interpretation when he saw the possible cost reduction.

EXAMPLE 5: GUIDE LINES

An analysis was undertaken to determine the ratio of vacuum tube cost to total material cost for electronic systems. Three basically different types of circuits were studied, and the costs per tube turned out to vary widely among the three groups. Costs per tube decreased for each circuit studied as the number of tubes increased; but more important, the analysis showed that regardless of system, when the number of tubes was 15 or more, the costs per tube approached the same level. This technique promotes reliability as well as cost reduction by reducing the number of inter-chassis connectors, cabling, special heat dissipating ducts and blowers to remove heat from the large masses of metal, reduces the number of solder joints and allows more point to point wiring reducing the human error factor, makes circuit tracing easier, allows for more rigid construction of the chassis to withstand vibration and shock environments. The equipment may also be reduced in total weight using this technique. This cost-saving packaging method does not rule out the use of modularization, printed circuitry, or other automated manufacturing processes. These are still available, but the fewer connectors needed the better the reliability of the equipment.

EXAMPLE 6: A PLANNED PROGRAM

A complete system underwent a value improvement analysis. A program was set up with the knowledge of the basic manufacturing cost accurately based on five years of prior production on the unit. A cost reduction goal was established by marketing considerations at 20%.

The program through the efforts of the team members actually reduced costs 19.8%. The estimated cost of the analysis was $20,500 (estimated because some team members were not direct labor and the best estimates of the time used by these members are from their own estimates of time.) Even though $20,500 sounds high, each dollar spent in the program reduced the cost of the equipment by $11.40.

Due to changes in the state-of-the art, the customer authorized a design evaluation of the equipment, so that the new unit would be more reliable, and thus more valuable to the services.

During the analysis many components were eliminated or simplified. Examples of the parts eliminated include thermistors, diodes, spacers and sleeving. Substitutions included relays, transformers and toggle switches.

These programs to improve the reliability and value-analyze the equipment are not confined to one group at RCA; it is a corporate venture. The two examples of the compatibility of value engineering and reliability shown below are an indication of what the other groups are doing in these areas.

1. The section is producing a system consisting of 15 racks or cabinets for the military. The design engineer in the R&D stage devised his wiring for ground and RF shielding through silver-plated beryllium copper spring-finger stock. Later, in the production design, ground wiring was adopted but the spring fingers were not removed. They were retained to provide RF shielding for the cabinet. One of the mechanical engineers seeking to reduce the cost of manufacture asked why the strips were needed. He wasn't convinced that there was a need for these strips to provide RF shielding. He then obtained two completed cabinets and removed the shielding strips from one, and had RF emission tests conducted on both. There was no measurable difference in the RF emission between the units. His curiousity and persistence brought about a saving of $122 per system. Engineering changes to drawings etc., cost $100. Therefore, on the total production run of over 100 systems, a savings of over $12,100 was made possible.

This value analysis not only reduced costs, but reduced the maintenance required on the system. Because of their location, frequent breakage of the spring-fingers occurred and they required repair in the field, since the service man was not aware that the loss of even all fingers would not be harmful.

2. The re are in this large ground equipment 16 identical electro-mechanical parts which are quite complex in nature. We were in the market for some 1700 of these parts. Suitable bids were received from component vendors. The lowest price submitted was $60 each.

The engineers felt that this price, although properly submitted by the vendor, was rather high for the function to be performed by the unit. Serious consideration was being given to designing this component out of the system. One engineer was sent to see the vendors that bid, to see if their manufacturing methods and/or design could be altered without affecting the function or reliability of the part. After discussing the general problem with those vendors, new bids were requested. The results showed that value improvement and value engineering can be contagious because the low vendor's final price was

$25 under his original quotation, with no detectable difference in performance or reliability or overall configuration. The cost of the trips and the securing of new bids approximated $300. The total savings to the taxpayer on this one item alone will be in excess of $42,000.

## SUMMARY

Let me stress that last phrase: "Savings to the Taxpayer." Every value engineering item cited in this paper has been realized on either a cost plus fixed fee contract or on a fixed price redeterminable downward contract.

As such, these savings do not accrue to RCA but directly to the taxpayer in the form of lowered procurement costs for the equipment ordered by the military.

Reliability was not adversely affected but rather enhanced. Delivery, availability and maintenance problems were not altered to the detriment of the purchasing activity.

I hope that the foregoing examples have demonstrated that value engineering analysis goals are compatible with the military requirements of increased reliability for the service's equipment.

It should be noted that all value engineering analyses do not result in a cost reduction or a reliability improvement. The purpose of this paper was to indicate that value engineering and reliability are not in conflict with each other as has been generally supposed.

The value of reliability is a most important item, and is the primary characteristic that is considered in RCA's Value Improvement Program.

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# VALUE ENGINEERING - A NEW TOOL?

by C. R. Olsen
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An infant becomes a Value Analyst when he decides a bottle of warm milk is more desirable than a cuddly Teddy Bear.

We have been analyzing value ever since. When our wives picked us out, they weighed the cost against the contribution. Each one of us has a different standard by which we compare values.

We are continually changing our standard of value. When we were young we wanted a Sport's car, then a Station Wagon to carry camping equipment and the entire family, then later in life, a compact sedan -- but what make of car should we buy?

The claims of manufacturers about their product, be it cars, washing machines, radios, televisions, etc. are fantastic. Our knowledge of the products is insufficient to judge accurately. The basic facts of quality, endurance, and serviceability are not apparent on the surface. So there have sprung up professional Value Analysts, such as Consumers' Research, to give us facts on which we can base our judgment. We can then apply our own standard of value to be sure we get the product that will meet our requirement for the least money.

People - you and I - are waking up to the fact that we can get reliable, serviceable products for less money if we analyze carefully and buy carefully.

Manufacturers - your employer and mine - are waking up to the fact

that they can produce reliable, serviceable products for less money. This takes more than the concepts which the R & D Engineers, Product Engineers, Methods Engineers, Quality Engineers can contribute. It takes the contribution of a Specialist, highly trained in the art of saving cost while maintaining quality and serviceability. It takes the contribution of a Value Engineer.

At the time of the Roman Empire, there was only one type of Engineer known as an Architect.

Vitruvius in 35 B.C. described the job requirements for an Architect as follows:

"He must be talented as well as willing to learn. Theory and Practice must go hand in hand. He must be educated, versed in Drawing, schooled in Geometry and History, not ignorant in the Laws of Optics and be acquainted with the Philosophers of Medicine and must know the decisions of Jurists. He must be acquainted with Astronomy." In other words, an Engineer was a diversified individual with many attributes.

What is today's Engineer? The definition I have always preferred is "An Engineer is a maker of tools" - tools for living, or in the case of some of us in the Ordnance Field, tools for survival.

What is the product of an Engineer? Is it the iron lung or the machine gun? No! These are the products of the Artisan or Mechanic. The one and the only product of the Engineer is a piece of paper, a paper that enables someone else, someone skilled in a different field to build the product he has defined. Many people tend to think the development is over when a model has been made. This is not true, unless documents, drawings that will let someone else

reproduce the model have been made, the development has just begun. An Engineer's only product is a piece of paper.

Let's examine the kind of man who makes this piece of paper that enables someone else to build the design, today it's often not one man, it's a team -- a team made up of specialists. Today it doesn't always start with the creative engineer, the designer, or inventor. It often moves back one stage to the systems designer, who conceives a complete system and whose product may only be a paper specification which breaks the system down to component parts so that digestible bits can be assigned to different designers.

These designers design parts in the system which may go together properly if the paper assigning the bits to these Designers was correct. From these parts' designs, a model is built from sketches. It seems inevitable that most mechanical models are fabricated on a Milling Machine from a solid block of stainless steel, but is the development finished at this point - No! The development has not been completed until the Model Shop revisions and the test results on the model have been fed back into the paper design.

One of the commonest traps at this point is to have the models built in a fine Model Shop - a Model Shop with the best of technicians - men capable of working from a description on the back of an envelope or from a waving of the hands. These highly skilled Model Makers can be the Designers worst enemy. By relying upon them and their ability to make a working model regardless of completeness of the drawing, by making working models and not utilizing the range of tolerances shown on the drawings, a Design Engineer is often deluded into thinking that he has a proven product in his piece of paper - when, in fact,

he has only a working model and a paper design which will not permit that model to be reproduced by less skilled personnel.

It is characteristic of Model Shop operations; to be over conservative in using better materials than may be required for the job; to use the first part finished as a gage for the manufacture of the mating part rather than use the drawings' dimensions and to, in general, do a splendid job in the tradition of the finest Craftsmanship. Without control this can add years of high cost manufacture to a production item.

At some point, after the model and design documents are completed, the item is released to the production operation where the Product Engineer, the Methods Engineer, Quality Engineers, and Production try to literally follow the drawings and specifications. There is seldom sufficient time at this point for any major redesign effort. Minor substitution of materials and substitution of castings or stampings for milled parts is generally the extent of allowable effort.

The product must now be manufactured, tested and inspected: but, wait! so far we have created a system, broken it down into bits, completed and tested the designs of the bits, and placed them in production. Each bit and sub component is described on drawings and specifications; but, who has read these specifications. Did the Systems Engineer? -- No! He created an overall specification which described the system; the Design Engineer? -- it is doubtful - he doesn't have the time to even read the detailed specifications he is applying to the part. Some of you may take issue with this statement - I would like to show you one specific example:-

Here is a simple #6, 32 thread, Fillister Head Machine Screw - a standard item which is used in many of our products. It is a simple item in its final form, however, there are thirty-two Company specifications, a Federal Screw Thread Standard Handbook and a Federal Test Method Standard, which apply to this simple screw.

These various documents are used to control the process for passivating stainless steel - the process for cadmium plating - the materials that are used in the processes - thread form - tolerances - surface finish, etc.

Now, who applied these specifications to this screw - in fact - who selected the screw - was it the Design Engineer - a Designer - or a Draftsman. Which one of the individuals who selected this screw read all thirty-two specifications. Surely, there is room here for a functional look at the requirements for fastening, which this screw is intended to serve.

At the beginning of the century, we had Civil and Mechanical Engineers as well as the new Electrical Engineers. Then the efficiency expert developed. He was the forerunner of today's Industrial Engineer, Product Engineer, and Methods Engineer. Today the existing classifications of engineers are too long to enumerate. Specialization has become the order of the day.

Why bring forth this new specialist, the Value Engineer? It is said he has a new and exclusive tool which he uses - the tool of "Value Analysis." What is this tool? Is it really a new tool or is it a plain old hatchet which he uses to cut costs?

The Stone Age man made his axe from stone. It took him days or even

months to make a good axe. The tools with which Solomon built his temple were made of bronze. Then came the iron and steel axes. The woodsman in the North Woods treasured his axe above all his possessions. He would not lend his axe or his wife, and in that order, to anyone - even his best friend. He sharpened his axe and honed it to a razor edge. He prided himself on being able to cut more wood with it than anyone within miles, and yet it only cut wood. Today in the North Woods, the chain saw has replaced the axe.

----ILLUSTRATION----

In the hands of the Value Engineer, the chain saw has replaced the hatchet. The chain saw has many links and many teeth to bite deep and hard. The cutting edges on this new tool are very selective, however, - they only cut material, parts and processes which will not affect required functions or operations.

There are a number of basic links the Value Engineer must have in his saw as well as the others. These basic links are:

1. Materials
2. Tools
3. Equipment
4. Processes
5. Standards
6. Operation
7. Functions
8. Reliability

9. Costs

10. Market

Above all, he must keep his saw sharp and well lubricated. No function in an organization will last without the lubrication of understanding and good will. His saw will quickly deteriorate, rust, and eventually fall apart without oil.

Let us pause before we go on and examine the basic links.

1. Materials - is an extremely important link. The properties of Materials must be considered carefully. Our background knowledge must be combined with expert advice from Metallurgists, Plastics Engineers, Process and Testing Laboratories. The link may be too heavy, can it be made of plastics? There are many new materials on the market. Your knowledge of these and their properties must be up to date. The chemistry of materials is advancing at a terrific rate. The R&D Engineer hasn't time to keep up to date in this field. This is a fertile field for the Value Engineer to save money. Pick a suitable material - one that will save money. Pick a suitable material - one that will save processing labor.

2. Tools - This is normally an expensive link - expensive in its first cost or maybe in its upkeep. But it may pay to expend more money in this link to save money in manufacture, assembly or testing of the product.

Are there standard tools adaptable to your use? Can the parts be changed to simplify your tooling?

Consult your Methods Engineers, Tool Designers and make your tool cost compatible with the quantities to be manufactured.

3. Equipment - Is your plant equipped to handle, economically, the product to be manufactured? It might pay to invest in equipment to shorten manufacturing time. Or possibly send the work out to a well equipped source.

4. Processes - New techniques, new processes for the manufacture of your links are being developed almost daily. You must be up to date on applicable techniques and processing possibilities.

A good Value Analyst must consult capable people in his own company, he must read and read, he must talk and talk to others outside of his own plant.

New processes for painting, plating, heat treating may cut processing time and give better results.

The worlds of organic materials and modular construction are just opening up. Get acquainted with them.

5. Standards - If you can use standard links your product becomes cheaper. The Value Engineer must be well acquainted with all standard items which are available on the market and keep his eyes alert for places to use them to replace specially designed parts and equipment. Not only nuts, bolts, eyelettes, washers, but dimensions and tolerances, materials and processes. They are all documented - use them.

Line your walls with standards - keep them before your eyes at all times. Learn to recognize where they can be used. Learn to adapt assemblies to use standard fastenings, parts, assemblies.

6. Operation - As you view this link, look carefully at the construction. Maybe it is designed far beyond its requirements for strength. Check back to the drawings and specifications to make sure it

will operate as specified. Are the operating parts built to do the job? Can better materials be used to improve operation and cut costs?

7. Function - Your link has a definite function to perform. Its function is called out in the specifications. Does it perform as specified? Then look further and see if the specifications call out requirements beyond the actual needs. Big links and more intricate links cost more than small links and simple links. Use the small and simple links when these will perform the actual function required. Read and study the specifications, talk to R&D Engineers, Product Engineers and ask a lot of questions. It may disclose the inclusions of nice secondary functions, nice to have but not necessary.

8. Reliability - This must be built in to every link. If one link breaks the whole chain saw is useless. The Value Engineer must realize that he must do nothing to jeopardize reliability. All changes and contemplated changes must consider, "Is reliability being jeopardized?"

You must also take a realistic view of the reliability requirements. Does the purpose of the link and its natural life justify a high expenditure for greater reliability?

9. Cost - This is the major link in the chain and yet cost cannot be cut without full consideration of all the other links or elements we have discussed. To fully analyze this link we need the help of Cost Accounting, Purchasing, Inventory Control, and Methods. The Value Engineer must have an innate sense of cost of materials, and purchased parts, and be able to discuss, intelligently, details with vendors and manufacturers'

representatives. He must seek out the lowest cost items to fulfill all requirements.

10. Market - There is no use making links if you cannot sell them. The Value Engineer must keep a close association with competitive articles on the market. Is your saw sharper and more effective than your competitors? Talk to your marketing people. Are they striving for a certain part of the market? Is your product adapted to that section of the market? Should it be designed to cut a lot of big trees and last indefinitely? Or is it designed to cut a few small trees in the course of a year and sell for less? Keep looking at your competitors product, it may give you some good ideas. He has probably gotten some ideas from your product. You can get many ideas from all manufactured items you see. Look them over carefully - see how other people are saving costs. This will be one of the brightest links in your saw.

The effective operation of all of these moving parts in our chain saw is not dependent on one link - one person or one tooth in the saw - it is the coordinated action of many links - many people and much help from outside sources. It is important then that the whole working unit be well lubricated, so that the sources of information will not dry up. The function of the Value Engineer must be defined and understood by all his sources of information. The motives of the questions and the insistence for information must be understood as a means to an end and not be interpreted as criticism. Much of the reaction to the Value Engineer from his colleagues will depend on the Value Engineer himself and the type of oil he uses.

What is our motive for creating a system of Value Analysis? Why do we bother with a chain saw, an axe always used to do the work satisfactorily? Why do we bother with Value Engineers - our previous engineering system was quite satisfactory?

If you are in the consumer product business, your competition is answering the questions for you. They are continually producing more desirable products at lower cost. To stay in business, we must use every means at our disposal to improve our product - to make it more attractive, more durable, and more serviceable, as well as less expensive.

If you are doing Government work and have been comfortably living in the world of cost-plus-fixed-fee contracts, let me warn you that it is time to wake up and use all of your modern tools - use a chain saw instead of an axe. Let us not be known as a generation of CPFF Engineers and Manufacturers. I don't know how many of you have been working on CPFF type contracts, however, in the future there will be fewer.

In a recent speech Rear Admiral J. E. Dodson said, "The Navy is vigorously pursuing a strict policy of placing all possible procurement in the hands of competitive firms... Follow-on contracts will be fixed price contracts. ... We feel that our contractors should suggest ways of reducing costs. ... Unless we control production costs, we will be hard put financially to maintain the weapon system we are now producing. ..." The other Armed Service Units are taking similar attitudes.

It seems to be customary at affairs of this sort for the speaker to proceed to the front of the room with a large brief case from which he drags

forth samples of items which he worked on, generally while he was with General Electric.

In order not to disappoint you, I would like to show you an item from my past. In the early 1950's, I was a strong advocate of what I called "Functional Engineering." I was engaged in Research and Development in the fuzing field - the field which incidentally practically invented the term, "Reliability." This fuze is for a Navy Rocket. It will withstand all of the standard Military environments plus the environments unique to the fuzing field such as impacts of 275 g's repeated 1750 times in each of three axis. A forty foot drop on a steel plate without becoming dangerous, temperature and humidity cycles plus vacuum and steam pressure testing. This fuze is completely hermetic sealed after loading by means of a solder seal.

The safety mechanism inside is an acceleration integrating device capable of sensing acceleration and arming at a constant distance whether it is subjected to a 20 g or a 500 g acceleration. There are approximately 47 parts in the safety mechanism and instead of asking the Class to guess the price of the safety mechanism, I would like to ask the instructors -- I hear $12 - $6 - No! This mechanism cost less than $2 and was manufactured in the millions.

I use this illustration to show that every man is a layman outside of his own field. When you enter a field which is different than the one to which you are accustomed, it is easy to be wrong in your cost estimation by several hundred per cent. When you must enter such a field, get the advice of an

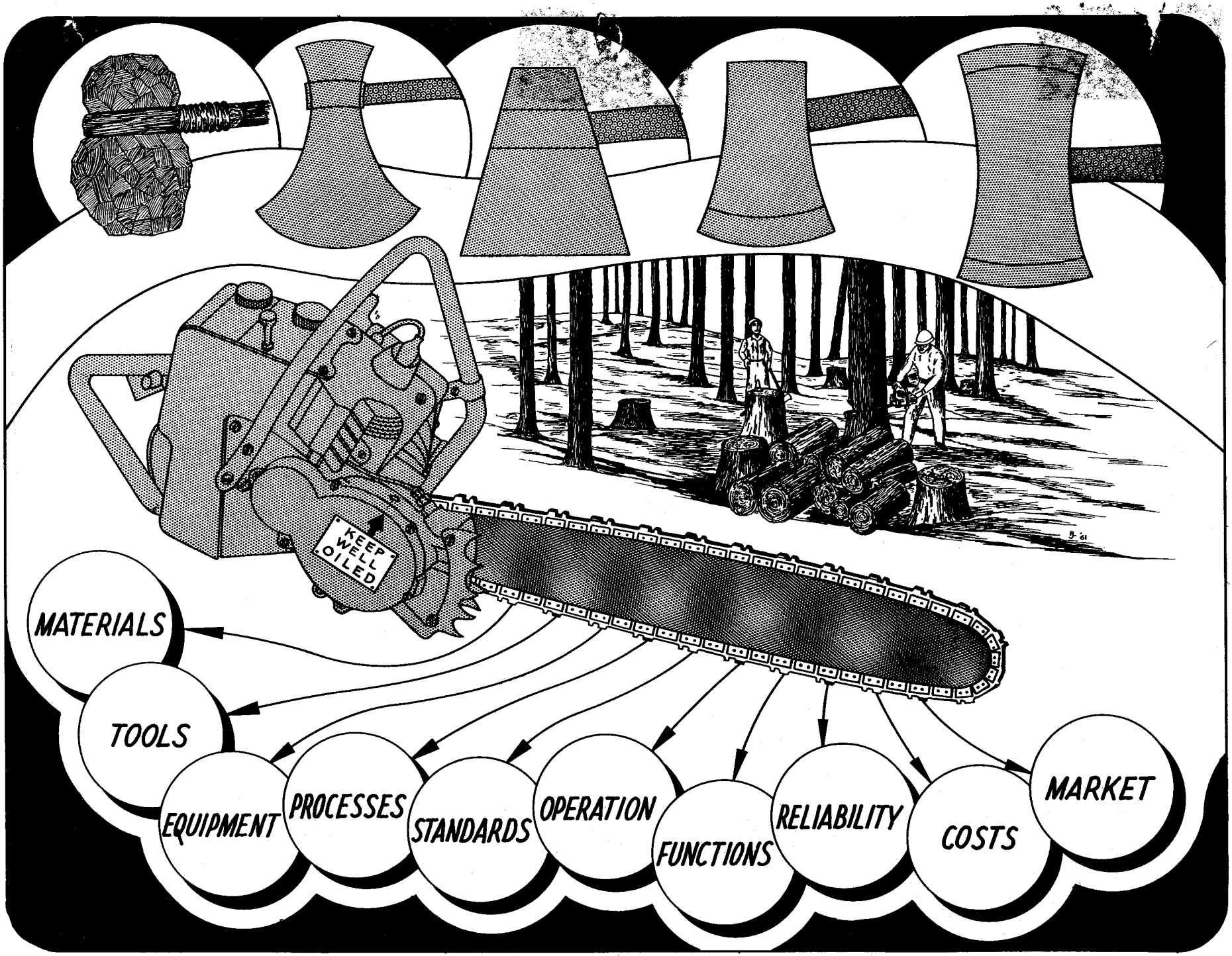
expert in that field. If possible, use the services of vendors to that field - they are available experts, but don't assume that anyone can give valid estimates in a field outside his own or that anyone can be an expert in all fields.

Do Value Engineers need any more motive power to get them moving? Does Management? No! The need is there, in both commercial and government work. There is a broad field of activity to enter and serve. A field in which personal satisfaction will be in accordance with your success and success will depend on how well you have developed the ten links in your saw, and how well lubricated you keep it.

In closing, let me again stress the ten links in your saw:

1. Materials
2. Tools
3. Equipment
4. Processes
5. Standards
6. Operation
7. Functions
8. Reliability
9. Costs
10. Market

Remember that all these links are connected together and must be well lubricated with understanding to be used together. A weak link may cause the whole project to fail. To succeed, a Value Engineer must develop strength in all the links and operate his saw with discretion.


KEEP WELL OILED
MATERIALS
TOOLS
EQUIPMENT
PROCESSES
STANDARDS
OPERATION
FUNCTIONS
RELIABILITY
COSTS
MARKET

# THE APPLICATION OF VALUE ENGINEERING DURING DESIGN

## PRELIMINARY DESIGN STAGE (Proposal Design Concept and Electrical Breadboard)

Applied to the Equipment or System:

1. Establish product cost target for the production rate based on the actual or anticipated selling price.
2. Review the product specifications for areas of high cost.
3. Define the functions of the equipment.
4. Determine which functions relate to work or sell.
5. Determine what items in the product specifications are:
    a. Essential
    b. Desirable
    c. Unnecessary

   based on the functions of the equipment.
6. Evaluate the functions.
7. Relate the functions and their cost to operating vs. non-operating environment.
8. Review the design concepts in relation to cost range, state of the art and alternate concepts.
9. Determine what scope of engineering work will be done by the Company, i.e., detail design vs. sub-system or unit specification sub-contracting.

## PRODUCT DESIGN STAGE (Circuit Design, Design Layout and Detail Drawings)

Applied to Unit and Sub Unit, Assembly, Sub Assembly and Components or Parts:

1. Review the cost targets established in the Preliminary Design Stage.

2a. Sub-divide the above cost targets for the equipment into targets for the Units.
  b. Define the functions of the Units.
  c. Evaluate the basic function of each Unit.
  d. Develop alternate design concepts to perform these basic functions.
  e. Evaluate these alternate concepts.
  f. Develop alternate production approaches.
  g. Evaluate these alternate methods.

3a. Sub-divide the above cost targets for the units into targets for the sub-units.
  b. Define the functions of the sub-units.
  c. Evaluate the basic function of each sub-unit.
  d. Develop alternate design concepts to perform these basic functions.
  e. Evaluate these alternate concepts.
  f. Develop alternate production approaches.
  g. Evaluate these alternate methods.

4 a. Sub-divide the above cost targets for the sub-units into targets for the assemblies.
  b. Define the functions of the assemblies.
  c. Evaluate the basic function of each assembly.
  d. Develop alternate design concepts to perform these basic functions.
  e. Evaluate these alternate concepts.
  f. Develop alternate production approaches.
  g. Evaluate these alternate methods.
5 a. Sub-divide the above cost targets for the assemblies into targets for the sub-assemblies.
  b. Define the function of the sub-assemblies.
  c. Evaluate the basic function of each sub-assembly.
  d. Develop alternate design concepts to perform these basic functions.
  e. Evaluate these alternate concepts.
  f. Develop alternate production approaches.
  g. Evaluate these alternate methods.
6 a. Sub-divide the above cost targets for the sub-assemblies into targets for the components and parts.
  b. Define the functions of the components and parts.
  c. Evaluate the basic function of each component and part.
  d. Develop alternate design concepts to perform these basic functions.
  e. Evaluate these alternate concepts.
  f. Develop alternate production approaches.
  g. Evaluate these alternate methods.
7. Review the cost targets relative to layouts and detail drawings.

PROTOTYPE AND DESIGN EVALUATION STAGE(Engrg. Model Construction & Test)

Applied to the PreProduction Prototype:

1. Obtain manufacturing cost estimate on the Engrg. test (preproduction) quantities.
2. Obtain manufacturing cost estimate on production quantities.
3. Compare the production cost estimate to the product cost targets.
4. Evaluate other cost elements such as: Equipment assembly & test, maintainability, serviceability, etc.
5. Evaluate the functions from the standpoint of work and sell.
6. Evaluate second degree functions added for assembly and test.
7. Incorporate lower cost designs to meet or reduce the established product cost targets.
8. Measure the effectiveness of the Product Cost Control Program and the Value Engineering contribution to this program.

## Eliminate redesign with this

# Design guide to value

Here's how to find the lowest cost process for making a metal part, classified by shape; all basic metalworking processes are compared for two basic shapes.

*HOWARD L. G. LESLIE, executive vice president, Value Analysis Inc*

EVERYONE knows (or is it an article of faith?) that for making any particular metal part there is a best, or lowest cost, manufacturing process. The problem is time. Who has the time to research the 50 or 60 standard processes (not counting the new ones that keep cropping up) whenever he designs a part? And who has enough data available to make a competent analysis? Besides, how do you organize such an analysis?

This article shows how; it gives a method and enough data so that you can quickly examine every possible process, eliminate the inappropriate ones, and narrow your search to a couple of alternatives that you can research in detail.

Since the process for making the part depends primarily on the shape, basic shapes are grouped into categories. The two categories shown on this page cover about 25% of all possible designs. Accompanying each category is a table comparing the appropriate processes for size limitations, material, surface finish, tolerance, and cost.

The important thing is the method. Additional data can always be compiled by anyone wishing to complete the structure for all design shapes. But the method is a powerful tool which, when used in conjunction with other Value Engineering techniques, can meet the goals of value control: a better, less costly design within the time limits imposed on the designer.

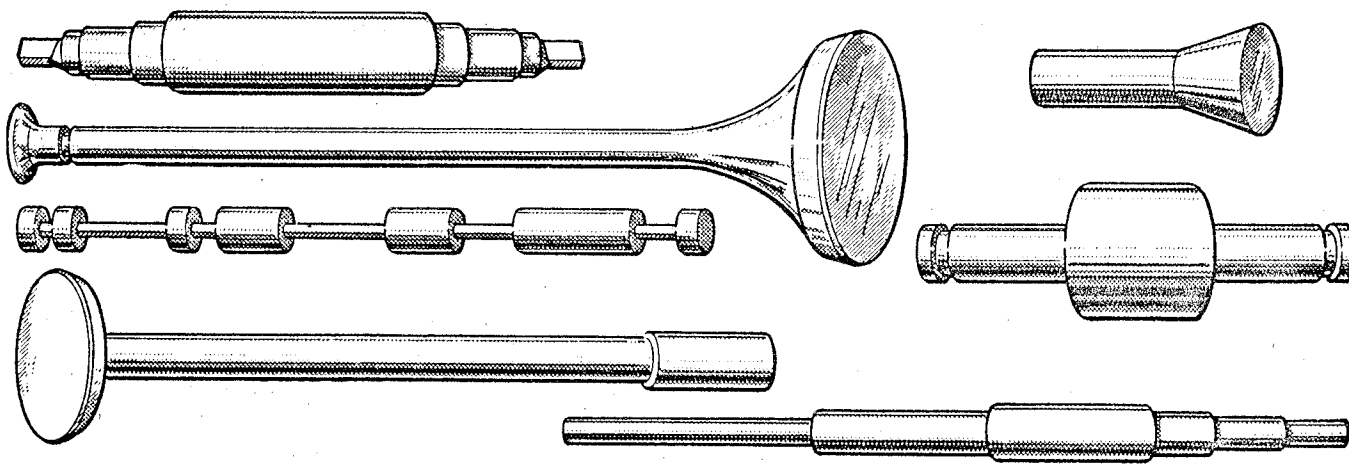
### The method

A simple step-by-step procedure lets you quickly examine all possibilities, eliminating inappropriate processes until only the applicable ones remain. These must be investigated in more detail before you make a final choice.

**Select the proper shape** classification for your design from the illustrations.

**Eliminate all inappropriate processes** by referring to the table keyed

## 1..Solid concentric shapes (refer to Table I)



into your selected shape category. For example, if your part is solid and tube-like, the proper category would be Fig 1, Solid Concentric, referring you to Table I (p 82). Check size, tolerance, and surface finish columns to eliminate processes which obviously do not apply. Classify the processes in three groups: looks good, marginal, and not applicable. Do not eliminate borderline cases because you may be overlooking a good bet since the data contained in the table become obsolete every few months.

**Rate all applicable processes** in a matrix. Across the top list the column headings—tooling, labor, waste, optimum production, quantity — and down the left side list the "looks good" and "marginal" processes. Start rating with the optimum production quantity columns because this factor is based on all the other ratings. Once you eliminate processes that have a high cost for the desired quantity move on to other factors such as tooling, labor, material waste. Don't forget to consider any secondary operation that may be necessary. And, be sure to consider any new processes just coming on to the market. Do not reject a process just because you are not familiar with it. Evaluate *all* applicable processes. You may uncover one that will help you leap-frog your competition.

**Compare alternative processes.** If appropriate, refer to Tables A and B (pp 86-89) for a closer look at the remaining processes. A few more can be eliminated at this point.

**Final selection** must not be made until you evaluate the latest information on your alternative processes. You must obtain this information yourself, but at least you have narrowed your search to two or possibly three choices, and you now know what questions to ask. Here's where you must also consider "make" or "buy" decisions depending on availability of "in-house" equipment and the policy of your company.

**The data**

The selection guide charts (Tables I and II) are keyed in with the shape classification illustrations (Fig. 1 and 2). They serve as preliminary selection tables, listing every known process for their particular shape categories. Tables A and B compare some of the processes in finer detail.

It cannot be overemphasized that because of continued improvements in various processes, the relative data provided here might be obsolete by the time you read it. What was a "special" job yesterday may be "standard" today. Here's what the columns mean:

**Process:** Only those that provide a basic shape are listed. Processes for secondary operation, such as providing specific finishes, are not included.

**Typical size range** covers maximum and minimum limitations under normal conditions. Most processes can produce larger or smaller parts under special conditions, but price will be higher. For example, under the optimum production quantity column, sand casting appears to cost more per piece than shell molding in large quantities, yet engine blocks for the automotive industry are sand cast rather than shell molded. The answer is in the size of the parts. In this case, the piece is larger than the optimum range for shell molding, so cost of the shell process is higher.

**General tolerance** shows the range that can be produced under normal operating conditions. Again, this range can be exceeded in most cases, but it will affect costs.

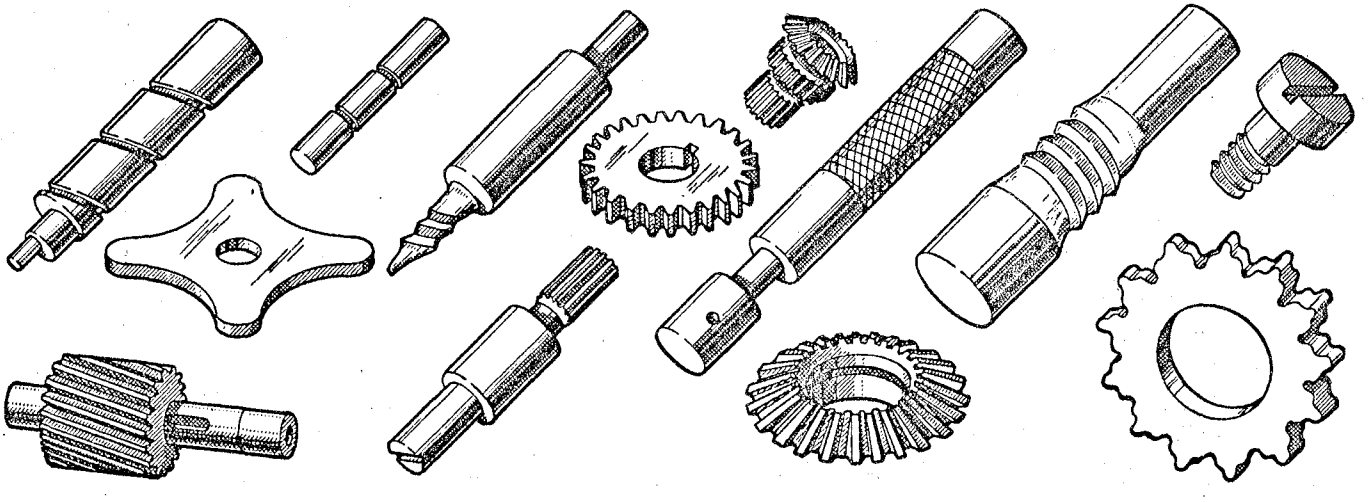
**Surface finish** is a measure of roughness in terms of the arithmetical average of repetitive or random deviations from the centerline of the nominal surface. Deviations include rough-

This article contains proprietary information extracted especially for PRODUCT ENGINEERING from the Value Analysis Inc Value Control Design Guide. The Guide classifies all possible shapes for metal parts into eight categories and compares all basic manufacturing processes for making each category.

We have selected two of the most common shape classifications and compare all appropriate processes.

Value Analysis Inc is a consulting firm founded five years ago by Mr Howard L. C. Leslie, the author, and Jack K. Fowlkes. The firm now has offices in Schenectady, Chicago, Los Angeles, and London.

## 2..Spiral shapes, repetitive, irregular concentric (refer to Table II)



# Table I..Processes for solid concentric shapes

**(For additional process comparisons, see later tables referenced by letter)**

| | PROCESS | See table | COMMENTS | TYPICAL SIZE RANGE | GENERAL TOLERANCE, IN. |
|---|---|---|---|---|---|
| C | Sand | A | Usually requires machining | Under 1 lb to foundry capacity | 1/16 to ⅛ |
| A | Die | A | For intricate shapes; non-ferrous alloys | Under 1 oz to 30 lb | 0.002 to 0.010 |
| S | Centrifugal | A | For long or large hollow shapes | 2 ID x ¼ in. wall to 54 OD x 342 in. lg; 1000 lb | 1/16 to ⅛ |
| T | Permanent mold | A | For aluminum, gray iron, copper alloys | Under 1 lb to 300 lb | 0.010 to 0.030 |
| I | Shell molding | A | Close tolerance, excellent finish | 25 lb avg; under 1 lb to 200 lb (0.0020 in. slot) | 0.005 to 0.015 |
| N | Investment | A | For intricate shapes, hard-to-machine metals | Under 1 lb to 100 lb; avg less than 10 lb | 0.003 to 0.005 |
| G | Plaster mold | A | Similar to permanent mold | Under 1 lb to 15 lb; to 12 x 18 x 4 in. flask | 0.005 to 0.015 |
| | Die forging | B | Increases steel strength; for high stress parts | Under 1 lb to 1000 lb | 0.008 to ⅛ |
| | Powder metallurgy | A | Best for parts under 4-in. dia | Under 1 lb to 8 in. dia x 8 in. lg | 0.001 to 0.005 |
| | Impact extrusion | B | Aluminum, zinc, copper, some steel parts | Under 1 lb (0.004 in. wall) to 5 dia x 12 in. | 0.0005 to 0.002 |
| | Continuous extrusion | B | For complex cross-section contours | 0.050 in. section to 12 in. dia | 0.003 to 0.020 |
| | Die rolling (hot) | B | For long narrow parts; requires machining | 1½ to 75 in. lg; 23 in.$^2$ cross section | 1/64 to 3/32 |
| | Hot upsetting | B | For complex, small parts; requires malling | 1/16 to 10 in. dia; to 8 in. lg | 0.003 to 1/32 |
| | Rotary swaging | B | Excellent for symmetrical parts | 1/16 to 4 in. rod; to 7 in. tubing | 0.001 to 0.010 |
| | Cold heading | B | High prod, exacting tol, metal improve | 0.020 to 1 in. dia x 9 in. lg | 0.002 or better |
| | Vertical turret lathe | | For large parts, small quantities | 4 in. dia to 6 ft dia table | 0.001 to 0.015 |
| | Horizontal turret lathe | | General machining; low to medium production | ½ in. to 3 ft dia x 8 ft lg | 0.100 to 0.015 |
| | Automatic screw machine | | For small parts, high production | 1/16 to 2 in. dia | 0.0005 to 0.003 |
| | Swiss screw machine | | Small precision parts, excellent finish | 1/32 to ½ in. dia | 0.0002 to 0.001 |
| | Crush grinder | | High prod, precision parts, exc tol control | 1/16 to 16 in. dia x 80 in. | 0.0001 or less |

RELATIVE PROCESS COSTS: IN PRODUCTION QUANTITIES

| SURFACE FINISH, MICROIN. | PIECES PER HOUR | TOOLING Low High | LABOR | MAT WASTE | 10 | 100 | 1000 | 10,000 | 100,000 |
|---|---|---|---|---|---|---|---|---|---|
| 250 to 2000 | 1 to 20 | | | | | | | | |
| 16 to 125 | 20 to 300 | | | | | | | | |
| 125 to 1000 | 1 to 5 | | | | | | | | |
| 32 to 250 | 10 to 100 | | | | | | | | |
| 32 to 250 | 10 to 75 | | | | | | | | |
| 16 to 250 | 100 | | | | | | | | |
| 32 to 125 | 5 to 10 | | | | | | | | |
| 125 to 500 | 10 to 500 | | | | | | | | |
| 32 to 63 | 100 to 6000 | | | | | | | | |
| 8 to 250 | 500 to 7200 | | | | | | | | |
| 63 to 125 | 2 to 700 ft/min | | | | | | | | |
| 125 to 250 | 1000 to 3000 | | | | | | | | |
| 125 to 250 | To 2500 | | | | | | | | |
| 15 to 125 | 100 to 400 | | | | | | | | |
| 16 to 63 | 2000 to 20,000 | | | | | | | | |
| 125 to 250 | 1 to 10 | | | | | | | | |
| 125 to 250 | 1 to 20 | | | | | | | | |
| 63 to 125 | 20 to 100 | | | | | | | | |
| 32 to 125 | 30 to 300 | | | | | | | | |
| 8 to 32 | 20 to 1200 | | | | | | | | |

## Table II. . Processes for spirals, repetitive, irregular concentric

**(For additional process comparisons, see later tables referenced by letter)**

| | PROCESS | See table | COMMENTS | TYPICAL SIZE RANGE | GENERAL TOLERANCE, IN. |
|---|---|---|---|---|---|
| C | Sand | A | Usually requires machining | Under 1 lb to foundry capacity | 1/16 to ⅛ |
| A | Die | A | For intricate shapes; non-ferrous alloys | Under 1 oz to 30 lb | 0.002 to 0.010 |
| S | Centrifugal | A | For long or large hollow shapes | 2 ID x ¼ in. wall to 54 OD x 342 in. lg; 1000 lb | 1/16 to ⅛ |
| T | Permanent mold | A | For aluminum, gray iron, copper alloys | Under 1 lb to 300 lb | 0.010 to 0.030 |
| I | Shell molding | A | Close tolerance, excellent finish | 25 lb avg; under 1 lb to 200 lb (0.0020 in. slot) | 0.005 to 0.015 |
| N | Investment | A | For intricate shapes; hard-to-machine metals | Under 1 lb to 100 lb; avg less than 10 lb | 0.003 to 0.005 |
| G | Plaster mold | A | Similar to permanent mold | Under 1 lb to 15 lb; to 12 x 18 x 4 in. flask | 0.005 to 0.015 |
| | Die forging | B | Increases steel strength; for high stress parts | Under 1 lb to 1000 lb | 0.008 to ⅛ |
| | Powder metallurgy | A | Best for parts under 4-in. dia | Under 1 lb to 8 in. dia x 8 in. lg | 0.001 to 0.005 |
| | Continuous extrusion | B | For complex cross-section contours | 0.050 in. section to 12 in. dia | 0.003 to 0.020 |
| | Die rolling (hot) | B | For long narrow parts; requires machining | 1½ to 75 in. lg; 23 in.$^2$ cross section | 1/64 to 3/32 |
| | Stamping | | Good uniformity; high production | 0.010 to ¾ in. thick; ⅛ in. wide up | 0.001 to 0.010 |
| | Electro forming | A | Extreme accuracy for thin sections | 0.005 in. or less to ½ in. section (built up) | Note 1 |
| | Broaching | | For high prod; excellent tolerance control | Under 36 up to 90 in. broach length | 0.0005 to 0.003 |
| | Milling | | Very flexible | Wide range, limited by fixtures | 0.001 to 0.010 |
| | Contour sawing | | High speed has greatly increased potential | Light sheet to 6 in. plate | 0.005 up |
| | Horizontal turret lathe | | General machining; low to medium production | ½ in. to 3 ft dia x 8 ft lg | 0.100 to 0.015 |
| | Automatic screw machine | | For small parts, high production | 1/16 to 2 in. dia | 0.0005 to 0.003 |
| | Swiss screw machine | | Small precision parts, excellent finish | 1/32 to ½ in. dia | 0.0002 to 0.001 |
| | Flame cutting | | Excellent for large sheet or plate | Light sheet to 12 in. thick | 1/16 up |
| | Punching (turret) | | Fast set-up; great flexibility | 2 in. square to 10 x 15 ft | 0.005 |
| | Gear shaper | | For high production gears, splines, dovetails | 1 to 120 in. dia gears; 6 in. face | 0.001 to 0.005 |
| | Crush grinder | | High prod, precision parts, exc tol control | 0.016 to 16 in. dia x 80 in. | 0.0001 or less |
| | Hobbing | | To generate forms on cylindrical parts | 0.125 in. to 10 ft dia gears; 14 in. face | 0.001 to 0.003 |
| | Thread and form rolling | | — | 1/16 to 12 in. dia x 20 ft lg | 0.001 or less |

**Note 1: 0.020 in. wall thickness, 0.0001 in. part to part duplication.**
**Note 2: 0.001 to 0.003 in. copper per ½ hr; 0.001 to 0.003 in. Ni-iron per 1 hr.**

## shapes

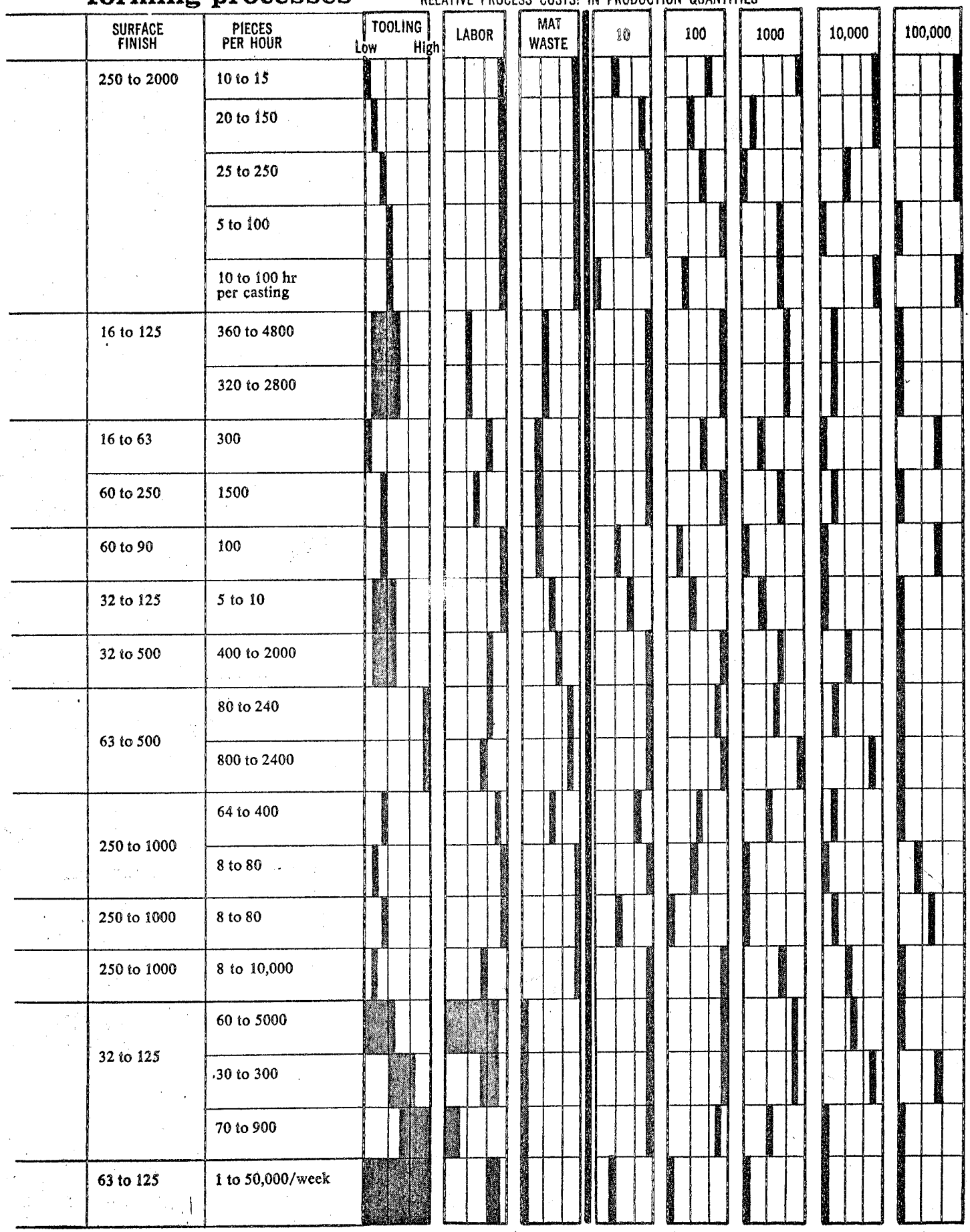
RELATIVE PROCESS COSTS: IN PRODUCTION QUANTITIES

| | SURFACE FINISH, MICROIN. | PIECES PER HOUR | TOOLING Low High | LABOR | MAT WASTE | 10 | 100 | 1000 | 10,000 | 100,000 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 250 to 2000 | 1 to 20 | | | | | | | | |
| | 16 to 125 | 20 to 300 | | | | | | | | |
| | 125 to 1000 | 1 to 5 | | | | | | | | |
| | 32 to 250 | 10 to 100 | | | | | | | | |
| | 32 to 250 | 10 to 75 | | | | | | | | |
| | 16 to 250 | 100 | | | | | | | | |
| | 32 to 125 | 5 to 10 | | | | | | | | |
| | 125 to 500 | 10 to 500 | | | | | | | | |
| | 32 to 63 | 100 to 6000 | | | | | | | | |
| | 63 to 125 | 2 to 700 ft/min | | | | | | | | |
| | 125 to 250 | 1000 to 3000 | | | | | | | | |
| | Governed by stock | To 12,000 | | | | | | | | |
| | 63 or better | Note 2 | | | | | | | | |
| | 16 to 250 | 3 to 2000 | | | | | | | | |
| | 8 to 1000 | 1 to 100 | | | | | | | | |
| | 250 to 1000 | 2 to 20 | | | | | | | | |
| | 125 to 250 | 1 to 20 | | | | | | | | |
| | 63 to 125 | 20 to 100 | | | | | | | | |
| | 32 to 125 | 30 to 300 | | | | | | | | |
| | 500 to 1000 | To 60 in./min. | | | | | | | | |
| | 125 to 250 | 3 to 30 | | | | | | | | |
| | 16 to 125 | 1 to 60 | | | | | | | | |
| | 8 to 32 | 20 to 1200 | | | | | | | | |
| | 16 to 125 | 1 to 200 | | | | | | | | |
| | 16 to 32 | 80 to 3000 | | | | | | | | |

## Table A.. Comparison of casting, powder metal, and electro-

| PROCESS | METHODS | COMMENTS | RAW MATERIAL | TYPICAL SIZE RANGE | TOLERANCE, IN. |
|---|---|---|---|---|---|
| Sand | Loose patterns | Low production; changeable design; most designs require considerable machining | All metals | Under 1 lb to 75 lb steel, 25 lb aluminum | 1/16 to ⅛ |
| | Gated loose patterns | | | | |
| | Match plate patterns | | | | |
| | Cope & drag pattern plates | | | Under 1 to 500 lb steel, 170 lb alum | |
| | Loose patterns floor moldings | | Usually alloy steel | Limited only by handling equipment | ¼ to ¾ |
| Die | Hot chamber | Easy machining; readily plated; multiple cavity dies increase production | Tin, lead, zinc alloys | Under 1 oz to 65 lb alum | 0.003 to 0.005 in./in. (small parts) add 0.0015 to 0.003 in./in. (large) |
| | Cold chamber | | Copper, alum, lead, zinc, mg | | |
| Investment | Wax patterns | High accuracy; intricate shapes; moderately high prod | Most metals | Under 1 oz to 25 lb | 0.003 to 0.005 in./in. (small parts) add 0.0015 to 0.003 in./in. (large) |
| | Plastic patterns | | | Under 1 oz to 2 lb | |
| | Frozen mercury patterns | Not in common use today | | Under 1 oz to 25 lb | 0.005 to 0.010 in./in. |
| Plaster mold | Plaster mold | Low machining; good finish; low tooling cost | Nonferrous metals | Under 1 oz to 2000 lb | 0.005 to 0.010 in./in. |
| Shell mold | Shell mold | | All metals | Under 1 lb to 200 lb | 0.003 to 0.005 in./in. |
| Permanent mold | Gravity | | Grey iron and nonferrous | Under 1 to 20 lb iron, 100 lb nonferrous | 0.015 to 0.060 |
| | Rotary machining | | Grey-iron and nonferrous | | |
| Centrifugal | Horizontal | Long hollow tubes | All metals | 4 in. dia x 4 in. lg to 4 ft x 30 ft | 1/16 to ⅛ |
| | Vertical | Short hollow tubes | All metals | 4 in. dia x 4 in. lg to 6 ft x 2 ft lg | |
| Semi-centrifugal | Semi-centrifugal | Disks, gears, etc. | All metals | 4 in. dia x 2 in. lg to 6 ft x 1 ft lg | 1/16 to ⅛ |
| Centrifuge | Centrifuge | Multiple parts on center sprue | All metals | Under 1 lb to 150 lb | 1/16 to ⅛ |
| Powder metal | Mechanical compacting press | On coined parts, tolerances are 0.005 on dia, and 0.001 on height | Almost all metals | Under 1 oz to 6 in. dia x 6 in. lg | 0.003 to 0.004 on dia, up to 0.005 on height |
| | Hydraulic compacting press | | | Under 1 oz to 8 in. dia x 8 in. lg | |
| | Rotary compacting press | | | Under 1 oz to 2½ in. dia x 5 in. lg | |
| Electro-forming | Tank | 0.001 wall thick tolerance | All conventional plating materials | 0.000008 in. thick to 28 in. dia x 24 in. long | 0.0001 to 0.002 |

# forming processes



## Table B . . Comparison of forging, swaging, extruding and

| PROCESS | METHODS | COMMENTS | RAW MATERIAL | TYPICAL SIZE RANGE | TOLERANCE, IN. |
|---|---|---|---|---|---|
| Die forging | Board drop hammer | 200 to 1000 lb impact; for parts to 15 lb | All forgeable metals | Under 1 lb to 100 lb | 1/32 to ⅛ |
| | Steam drop hammer | 1000 to 50,000 lb impact; for parts over 15 lb | | Under 1 lb to 1000 lb | |
| | Mechanical press | 100 to 10,000 tons; for cu, brass, al | | Under 1 lb to 30 dia x 10 in. thick | 0.008 to ⅛ |
| | Hydraulic press | 100 to 18,000 tons; for large, deep cyl parts | | | |
| Roll forging | Gap mill | | | ½ dia x 6 in. lg to 5 x 96 in. | Dia: 1/32 to 3/32, lengths ⅛ to ¼ |
| | Die rolling | | | ½ dia x 1½ in. lg to 5 x 96 in. | |
| Smith forging | Open die | 100 to 15,000 tons; low prod; large parts | | Under 10 lb to 80 tons | ⅛ to 2 |
| Hot upsetting | Hot upsetting | Uniform cross sections; hollow, oval, square, hex | Most metals | Under 1 lb, ⅞ dia to 500 lb; 10 in. dia | 0.003 to 0.090; 1/64 to ⅛ lg |
| Cold heading | Cold heading | High prod (bolts); very good tol control | | 0.020 in. dia to 1 x 9 in. lg | 0.001 dia, 0.010 to 0.032 |
| Extrusion (hot) | Continuous | Simple or intricate long hollow or solid parts | Al, cu, mag, and steel alloys | 3/16 x ½ in. cross sect to 8 or 12 in. circle | 0.005 to 0.020 |
| Extrusion (cold) | Impact or backward | Symmetrical cross sect oval, sq, round | Al, brass, cu, and deep drawing steels | ½ dia x 4 lg x 0.005 wall to 5 x 12 x 0.075 in. | 0.0002 to 0.003 wall thickness 0.003 to 0.005 OD |
| | Forward | | | 3/16 dia x ¼ in. lg x 0.004 to ⅜ x 14 x 0.010 in. wall | |
| Swaging | Rotary swaging | For pointing, forming or attaching sym shapes | Most metals | 1/16 in. rod, 0.005 wire to 3¾ or 7 in. dia | 0.001 to 0.002 |

ness, waviness, lay, and flaws. As in the case of tolerance and sizes, surface finish given here is under normal conditions and can be exceeded in many cases for a premium.

**Pieces per hour** is shown as a range because many factors can influence the rate.

**Tooling** costs include setup, tools, and all other expense items to produce the part. The position of the vertical bars shows relative ranking of tooling costs on an arbitrary scale. A bar at the left side of the column means that tooling cost is low; a bar at the right side means tooling costs are high relative to other processes in this production range.

**Labor** cost means all direct labor costs, including costs such as cleaning. It does not include setup costs. A vertical bar on the left means labor costs per piece are low; a bar on the right means costs are high.

**Material waste** is based on the more common materials like carbon steel, ordinary aluminum, zinc or copper alloys. This factor becomes significant when high-priced or difficult-to-machine materials such as titanium, beryllium, and stellite are used. Even though some waste can be reused, it was not factored into this ranking.

**In production quantities** show the output range that is optimum for the process. Within this range you will find the minimum price per piece. Output levels of 10, 100, 1000, 10,000, and 100,000 are listed. Remember, the vertical bar shows relative ratings under normal conditions. Costs will increase whenever the part exceeds one of the normal factors for the process: size, tolerance, surface finish, etc.

**EDITOR'S NOTE:** Future articles in our alternative processes series will cover various manufacturing processes in detail. Next issue will include an article on shell molding and coring. Other processes to be covered shortly are weldments and powder metallurgy.

This special report is the second article in our current series on the concepts and practical applications of Value Engineering. Next article in the series will be a teaching program (similar to Binary Logic series) called First Lesson in Value Engineering. It will introduce and teach a fundamental technique in VE.

For more information on Value Engineering, see these earlier articles:

**What VE can do for you,** Sept 30 '63, p 52—Value Engineering is cost prevention—not just cost reduction; the techniques used to guide you into asking the right questions.

**A practical approach to value analysis,** Feb 5 '62, p 67—What causes poor value? How can these causes be eliminated?

**Why and how to compute VE savings,** Aug 7 '61, p 86—To prove the savings before the fact isn't easy. Here are approaches to document the economics.

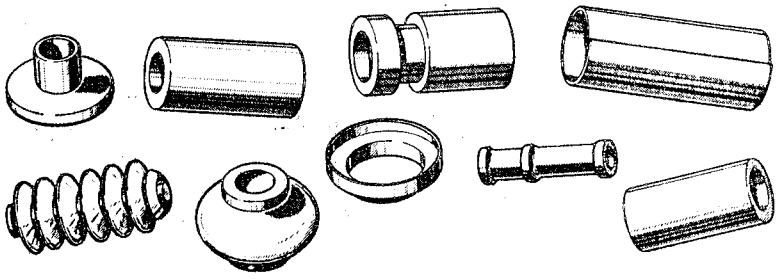
**Value—the emerging emphasis in design,** May 15 '61, p 79—A special report on present and future potentialities of specialist services in design engineering—reliability, value analysis, value engineering, quality assurance, etc, based on interviews with and comments from some 80 executives and engineers.

*—Frank Hall*

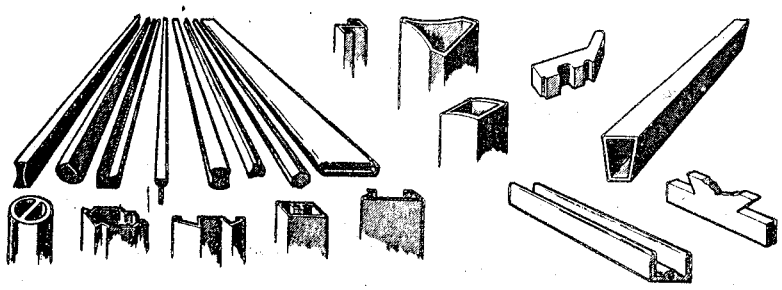
## heading processes

| | SURFACE FINISH | PIECES PER HOUR | TOOLING Low–High | LABOR | MAT WASTE | RELATIVE PROCESS COSTS: IN PRODUCTION QUANTITIES 10 | 100 | 1000 | 10,000 | 100,000 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 125 to 500 | 50 to 200 | | | | | | | | |
| | | 100 to 400 | | | | | | | | |
| | | 10 to 200 | | | | | | | | |
| | 250 to 500 | 30 to 100 | | | | | | | | |
| | 500 to 1000 | 1 to 10 | | | | | | | | |
| | 125 to 500 | 10 to 2500 | | | | | | | | |
| | 16 to 63 | 2000 to 20,000 | | | | | | | | |
| | 63 to 125 | 2 to 700 ft/min | | | | | | | | |
| | 8 to 250 | 500 to 7200 | | | | | | | | |
| | 15 to 125 | 10 to 600 | | | | | | | | |

### Hollow concentric shapes



### Hollow or solid non-concentric shapes

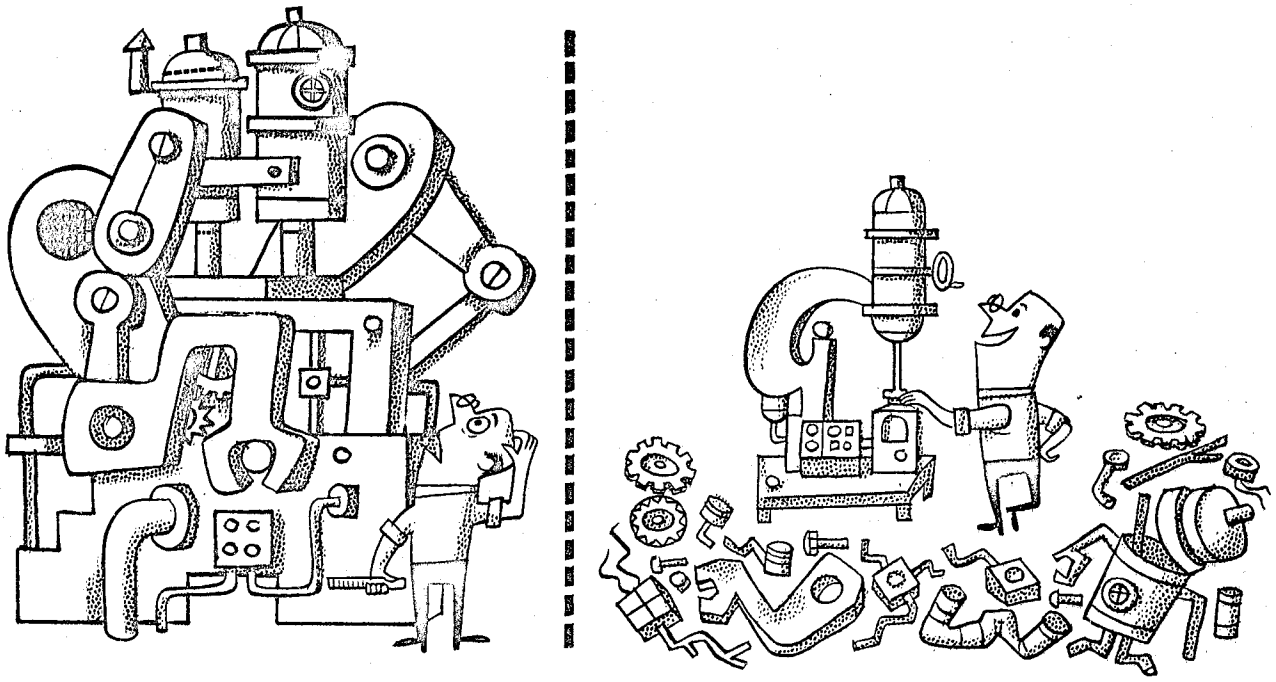


**More to come**

These two shape categories will be the basis for a second special report offering tables similar to Tables I and II in a forthcoming issue. Each table will show every applicable process with comments, typical size range, tolerances, and surface finish, along with graphical cost data on tooling, labor, and waste for a full range of production quantities.

In addition, process comparisons will be tabulated as in Tables A and B but for milling and sheet forming. Relative process costs will be presented graphically.

Reprint From June 1958 Issue Of
Electromechanical Design Magazine



# VALUE ENGINEERING:

## Design For Profit

In value engineering every material, every part, every operation in a design must pass these tests.

Can we do without it?

Does it do more than is required?

Does it cost more than it's worth?

Is there something better to do the job?

Can it be made by a less costly method?

Can a standard item be used?

Considering the quantities used, could a less costly tooling method be used?

Does it cost more than the total of reasonable labor, overhead, material and profit?

Can someone else provide it at less cost without affecting its dependability?

If it were your money, would you refuse to use it?

If the answers to any of these questions is yes, then you are not getting good value.

What is value engineering? In simple terms it is a technique for providing accurate yardsticks for measuring the true value of everything that goes into a product before production investment is made. It involves objective appraisal of equipment, systems and programs to achieve essential requirements of a product at lowest possible cost. It appraises a design in terms of the question: "Is it worth it?" It measures the value of each piece of material, each part, each component that goes into a product before the design is finalized. It is not only an important tool of cost information for engineers, it is also a way of looking at design problems to obtain new ideas for doing a job at less cost. The value engineering approach is characterized by five questions applied to each item of cost.

- What is it?
- What does it cost?
- What does it do?
- What else will do the job?
- What will that cost?

As an example of how these questions may be applied to a specific item, consider an ordinary cap for a fire hose. It consists of two pieces, each of which is secured to opposite ends of the hose. What is it? A brass casting, threaded, and slotted for hand gripping. What does it do? It keeps dirt out of the hose. What does it cost? A little more than $2.00 for each cap. What else will do the job? From a specialty supplier we obtain neoprene caps. What do they cost? $0.50 each. These caps will do the job of keeping dirt out of the hose. Now, apply a little creative thinking. What do we usually do to keep dirt out of our

lawn sprinkling hose? You guessed it. We couple the two ends together. Now we have accomplished the required function at no cost.

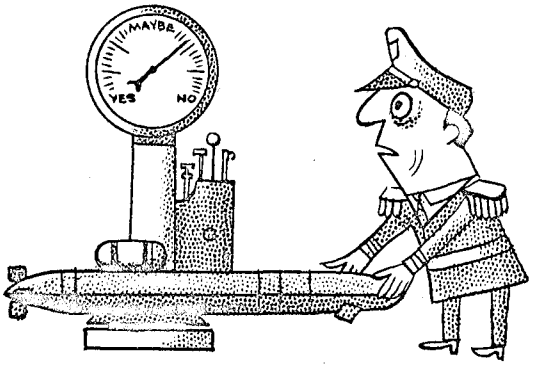
Answers to these basic questions are obtained by use of value engineering techniques, systematically performed in a value engineering job plan.

These techniques will be taught in a series of one-day seminars presented by the Industrial Education Institute of Boston, Mass., in cooperation with industrial organizations and government activities in major cities throughout the country. Special emphasis will be given to dramatic savings from these techniques achieved by BuShips of the U.S. Navy, General Electric, Philco, Raytheon, Westinghouse, Stromberg-Carlson and Ford Motor Co. Instructors will include Albert Sikorsky, Value Engineer, BuShips, USN; Jack Scheinman, Advisor to Small Business Administration; and Bernard Eades, Chief Value Engineer, Stromberg-Carlson.

Background of the development of value engineering, some of its techniques, and examples of its application were described to us by Mr. Sikorsky.

## BACKGROUND

The concept of value engineering, Mr. Sikorsky said, arose out of a search by the Navy Bureau of Ships for a way to combat rising costs that were pricing them out of a proper defense build up. Surveying industrial approaches to cost reduction, the Bureau found the value analysis program at the General Electric Co. to be adaptable to their needs. They applied the GE analytical approach to obtain value appraisals of equipment during its design and development.




The early application of value engineering within the Bureau, its Naval Shipyards and then with private shipbuilding contractors encouraged them to apply it in their procurement contracts for electronic equipment. The voluntary establishment of value engineering departments by many of the Navy's contractors was evidence to the Bureau that value engineering is a profitable management-engineering tool for private industry as well as the military.

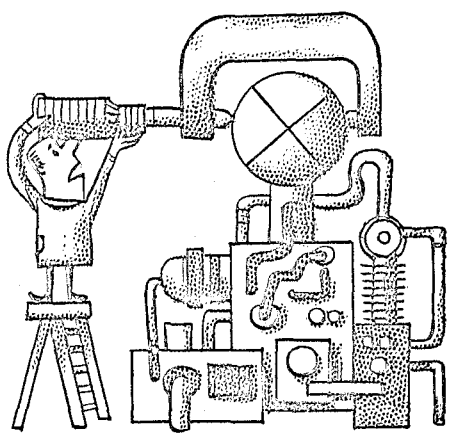
## TECHNIQUES

Value engineering uses at least seventeen well-defined techniques. Mr. Sikorsky described four of the most important for us.

- *Get the Facts and Know the Cost.* Question requirements, specifications and design details that appear to be unnecessarily restrictive or are not essential. Establish the cost of each component, including the price of procurement, maintenance and operation. If properly done, this technique brings into sharp focus the high cost areas to be given attention later on.

As an example, consider the facts of cost in the practice of treating electronic equipment with fungicide spray. This

practice came about during World War II when many of the Bureau's electronic equipment components were made of organic materials, and as such, were fine nutrients for fungus. Under certain conditions of temperature and humidity found in many combat areas, fungus would attack these materials and destroy their usefulness. The spray treatment was an effective way of fighting this destruction. After the war, the electronics industry developed inorganic materials now universally used in electronic components. These new materials don't support the growth of fungus under any conditions. Yet, until quite recently the Bureau was still using the spray treatment. Those who opposed its continued use ran into the argument that the spray treatment afforded some measure of insurance, "just in case someone laced a cable with cotton cloth" and furthermore, "it obviously doesn't cost much." Just how much was the Bureau paying for this insurance. The average annual expenditure was found to be $350,000. Obviously this was too much to pay for a function that was rarely performed.



- *Evaluate the Function.* Try to describe function using just a verb and a noun. Determine the primary function and then list the secondary function. For instance, a small transformer cover used in a very large quantity was found to cost $0.42. The primary function of the cover was to *provide shielding.* A film of paint applied to the cover served a secondary function to resist corrosion of the metal cover. When costs were detailed, it was found that it cost $0.17 to make the metal cover that provided the primary function, but it cost $0.25 to paint the cover to satisfy the secondary function. It seemed logical to try to make the secondary function less expensive. In answer to the question what else will do the job, it was found that corrosion protection could be achieved by chemical treatment of the cover at only $0.03, a 53 percent reduction in total cost.

- *Evaluate by Comparison.* Compare the function and cost of one item with the function and price of something comparable. You do this every day. You compare the cost of clothing, transportation and so forth. Once you have decided on what you need, you choose a way or a thing that satisfies your need at the lowest cost. Mr. Sikorsky illustrated this technique applied by the Bureau in a study of a military receiver. By comparison, this receiver was priced at twice the cost of another that was considered by many to be equally as good. It contained many expensive features including a complex system of projecting a frequency dial reading on a frosted glass. This system consisted of a projection lamp, plus a spare in case the one in use burned out, a lense and a mirror that reflected the dial image on the frosted glass attached to the front panel. Even the function of using the spare projection lamp was intricate. When the lamp in use burned out, you merely twisted a little lever and the spare would move into position to do its job. No doubt someone had considered the important factor of maintenance when he designed this intri-

cate little feature, but he forgot that people didn't bother to replace a lamp until both had burned out. The little unit cost well over $200.00, and added to the overall complexity. By comparison, a single straight-forward frequency dial would have cost one tenth the price and would have performed the same job. The elimination of the extra parts would have added to the receivers reliability.

● *Creative Thinking.* This technique is an obvious requirement in the solution of any type of problem. Obvious or not it belongs on a check list of value engineering techniques as a reminder of its importance. An example of how value engineering highlights creative thinking is illustrated by the Navy's new method of securing electrical cable aboard its ships. The old method, standard practice for many years, was to form individual black iron straps to fit the shapes of various cable runs. A master electrician conceived the idea of applying the technique of metal strapping so commonly used in commercial packaging. The idea lay dormant until value engineers determined the cost savings. Now the method is universally used in the Navy. In the conversion of one large aircraft carrier this new method saved well over $100,000.

## JOB PLAN

In applying his techniques, the value engineer uses a step by step approach, called the job plan, as guide lines in planning and carrying out a project with efficient use of time and effort. With these phases to guide him he will avoid the trap of holding out for a perfect solution.

*Information Phase.* Define well the various functions and costs and determine the high cost areas that need attention.

*Speculative Phase.* Attack the high cost areas and propose alternative ways of doing the job.

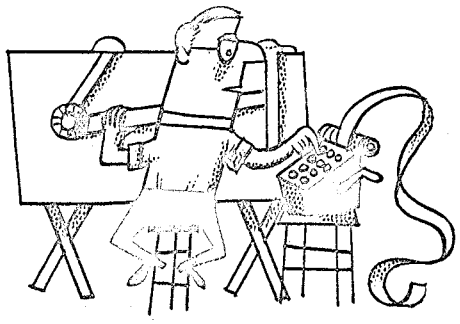
*Planning Phase.* Select the best of the alternative solutions for final processing.

*Execution Phase.* Prove the value of the selected alternatives, i.e., show that they do the required job at less cost.

*Reporting Phase.* Properly document the technical and cost data to support acceptance of the alternative ways chosen.

## CAUSES OF HIGH COSTS

Before the Bureau applied value engineering to its procurement contracts for electronic equipment it conducted a study to find out why its equipment was costly and overcomplex. For the answers they went directly to their contractors who gave them three very good reasons.

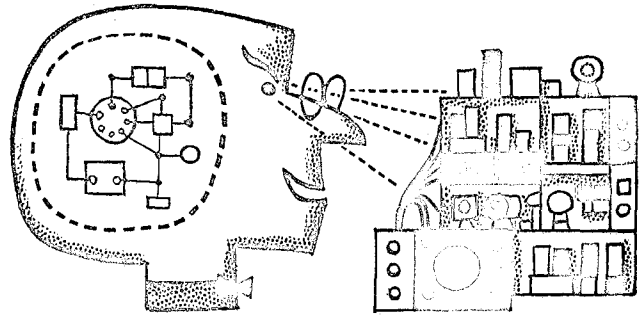


The first reason given for high cost was the Bureau's specifications. The military applies general specifications for shock, vibration, and premium materials across the board to safeguard their equipment from every conceivable mishap. When applied to certain equipment, these specifications contribute nothing except cost, complexity, size and weight. Quite often the environmental conditions from which the equipment is protected by these specifications simply does not exist at points of installation.

The second reason given for high costs is lack of time

in development contracts. Every early design such as a developmental model, contains a certain number of design features that can be simplified, eliminated or redesigned for reasonable cost if time is allowed for a fresh second look. Too often the cost and complexity for meeting a requirement is not justified by the marginal technical advantage it provides.

Using an acceptable developmental model as a guide for production specification is general practice. The specification writer hesitates to deviate from the developmental model, afraid the equipment coming off the production



line will not meet the original performance requirements. For this reason, Mr. Sikorsky said, every effort must be made to remove the high cost and over complexities in the design before production specification is written.

The third and probably biggest reason given for high cost is lack of incentive. Contractors who have proposed a relaxation of military specifications have sometimes been penalized by having the resulting savings subtracted from the contract price. In some cases, the contractor's profit, which is based on a percentage of total contract cost, is also lost to him. Contractors are well aware of this possible penalty and consequently shy clear of any suggestion that might save the government money.

## PROCUREMENT CONTRACTS INCLUDE VALUE ENGINEERING

With these three reasons for high cost in mind the Bureau set out to apply value engineering in its procurement contracts. They established a specification for value engineering of naval electronic equipment, which required the contractor to conduct value engineering study of all the elements of design, construction, procurement, installation and maintenance of an equipment, including the specifications, to achieve only necessary functions, maintainability and reliability at minimum costs.

The contractor is required to perform the value engineering study before going into production. Even before he produces any parts, sets up his tooling or assembly lines, he has to submit value engineer proposals to the Bureau for evaluation. The approved proposals are then applied in the form of specification changes. The cost of the value engineering study is borne by the Bureau as part of the overall contract cost. An incentive to do a good job is offered the contractor in the form of a share of the resulting savings. The share will vary from 10 to 40 percent of the savings depending on the quantities of equipment procured and the total dollar cost of the contract.

Value engineering proposals submitted to the Bureau involve only changes in specifications or contractual requirements. All savings made to improve efficiency within the specifications are retained by the contractor.

The second value engineering seminar will be held in Chicago, June 25th at the Sheraton-Blackstone Hotel. For more information on future value engineering seminars, write to Mr. Jerome Glass, Industrial Education Institute, 25 Huntington Ave., Boston 16, Mass.

FROM THE JOURNAL OF ACCOUNTANCY - JULY 1953

# CREEP

by Robert L. Dixon, Ph.D., CPA
Professor of Accounting
University of Michigan

Creep occurs when a business moves, slowly or speedily, into areas not fully explored. When this happens, a lot of problems arise. Do you want the enterprise to creep away from its original purpose or size? Have you set up your organization, control facilities, records, to enable you to deal with the spontaneous new creature your company can come to be? Creep is almost always found in successful companies, though it is sometimes the cause of failure. The accountant is the best, often the only, person able to detect creep he may be the person to deal with the problems created.

A BUSINESS ENTERPRISE, typically is established for a limited purpose, such as the production of a single product or product group, the production of services, or the marketing of certain products. Usually this newly-established enterprise is simple in form, with specialized objectives. The profit motive leads to its creation, and it is expected that profit will be realized through pursuit of this specialized activity.

The case histories of some of the larger corporations, on the other hand, would undoubtedly show that a considerable proliferation of activities accompanies the aging process.

The addition of new activities to the one of initial specialization appears in various ways. Commonly it will appear in the form of intergration through taking on the production of component parts formerly delegated to outsiders, or through extending back to the production of raw materials for use in the plant. The sales organization may be expanded to include wholesaling activities and may even be extended forward to include ownership and operation of retail outlets. This process may at the same time be accompanied by a horizontal expansion of activities in which an array of new products is added to the original specialty. In fact, the expansion, diversification, and proliferation may reach the stage where the original objective, through the multiplication of side activities, has become an obscure element in the total activity of the corporation.

Going along with this expansion process one is likely to find another, less spectacular but none the less significant, factor leading to the variegation of enterprise activity. This is the piecemeal attachment of relatively minor activities of service and supply. Examples of this are the establishment of a department for the production of tools, a department for the maintenance of machinery and electrical equipment; a department to service company-owned trucks and automobiles; an engineering department a legal department; a carpentry and upholstering shop; a printing shop, and so on.

In many instances these accouterments are not added full grown as the result of a formal analysis and decision, but rather they edge into the picture, starting with the incidental, part-time activity of one or more employees, but ending up later as full-fledged departments of the plant.

In other instances these added activities are undertaken because they seem to offer cost-saving opportunities. The reasoning is somewhat as follows: because we have an established plant and organization an important portion of our costs is pretty well fixed these costs will go on at approximately the same level whether our plant is fully or only partially used; it follows then that we can add odd jobs here and there, call them sideline or self-service activities, without causing increases in these fixed costs. In fact, in order to determine whether we should provide our own services and supplies in a particular case, we need consider only the variable costs of our existing organization, the variable costs of the added activity and, in cases where new equipment and new permanent personnel are required, certain added fixed costs. But the bulk of the fixed costs can be ignored since they will not be affected by the attachment of the additional operation. In many cases when the addition of a new activity is being considered, the management may go so far as to exclude overhead costs altogether in the computation of the costs to be added. They reason that addition of new activity should not relieve the old activities of any overhead costs.

Under the circumstances of this kind of cost calculation few vendor bids may hope to be successful, since by the self-service activity not only are the middlemen's profits and the distribution costs eliminated, but also the outside producer's profits, and even, in a sense, the producer's fixed costs. In fact, the situation practically offers a bonanza for the manufacturer. The added activities appear to be real bargains.

We are all aware of the advertising slogan, Direct from the factory to you, but here we are able to go one step farther, in effect bringing the factory right into the home.

In some cases the opportunity for cost saving is so obvious that the self-service activity is allowed to develop, or is taken over in toto, without any preliminary, formal cost studies.

But in other cases the margin of saving may not be so obvious, and the cost accountant may prepare detailed cost studies. In these, if he follows the more orthodox theory, his report will be based on the estimated incremental costs, rather than the total costs, of the added activity.

CREEP FACTORS

It was noted above that minor side activities tend in some cases to edge into the operations of a business firm where no special thought has been given to their short-run or long-run effects upon costs and efficiency it is also true, however, that such activities are frequently added by positive action on the basis of cost studies.

Attention is directed to the proposed exclusion of fixed costs in the decision-making process. Certain observations with respect to this exclusion appear to be in order.

First, if the company is in a position to make permanent additions to its side activities without adding to its fixed costs, something must be out of order. Fixed costs reflect capacity to operate, and they appear throughout the entire business organization. Evidently if the fixed costs can be ignored in such a calculation, the company is overequipped and overstaffed for its regular work.

Second, although it is probably impossible to have a condition of absolute balance of staff and equipment throughout the organization, the situation would be rare in which the added activity can be imposed upon the below-capacity segments of the company without in any way impinging on the fully active segments.

Third, equipment to some extent, and human beings to a considerable extent, are capable of being pressed beyond capacity limits for periods of time, but beyond these time limits something must be done to relieve them.

Finally, if idle capacity does temporarily exist throughout the company, the addition of extracurricular activities may so pre-empt that available time that it will be difficult to re-establish full-time regular operations when business conditions come back to normal.

All of this means that the fixed costs simply cannot be ignored in making the produce-or-purchase decision, unless one is to be satisfied with a very short sighted analysis. Fixed costs commensurate with the added activity will inevitably "creep" into the total cost picture, because even though there may be no immediate addition to the fixed costs, the added activity will encroach upon the available capacity, and sooner or later this will lead to an actual, though unanticipated and perhaps unrecognized, increase in fixed costs.

The creep effect upon fixed costs can develop in three general ways.

First, if the added activity is allowed to get out of hand in its growth it is obvious that more building space, more equipment, and more salaried personnel must eventually be added. This will be true even though the regular activity of the enterprise is maintained at a fairly fixed level. The question then is, would we have added this activity had we anticipated the fixed cost addition?

Second, even if the added activity is kept at a moderate level, when the main activity is increased fixed-cost increases will again be encountered. Thus, suppose a dozen men and some equipment are added in order that the company can repair its own transportation equipment. This may lead to no immediate addition of employees in the personnel department, the accounting department, or in the other administrative segments of the company; however, the later addition of one person to regular activities can bring into operation a chain of reactions in the form of salaried employee increases, salary increases, and fixed asset additions. The probabilities are that no one will recognize that the factor which really caused the fixed cost increases was the apparently bargain-price addition of the repair operations sometime earlier.

Finally, if the added activity is either kept level, or increased, it will be all the more difficult to cut down on fixed costs should subsequent reductions in the regular operations be necessary.

SIDE EFFECTS OF CREEP

The principal aim in the section just concluded was to point out that the exclusion of fixed costs in the contemplation of a produce-versus-purchase decision constitutes a dangerously shortsighted treatment of the problem; that a full quota of fixed costs will almost inevitably creep into the picture regardless of the subsequent activity trends of the regular and added operations.

What might be called a side effect of creep, although it is actually a direct evidence of creep, is a tendency for the company to compensate unconsciously for overloads resulting from piecemeal additions of "bargain" activities. If, for example, an officer is hired to perform an administrative task under a particular set of conditions, and if then one by one a number of minor, peripheral activities are taken on by the company, the accumulation of these activities may more and more infringe upon the officer's time until through sheer necessity he is forced drastically to neglect his primary responsibilities.

Although no poll of managements has been taken on this point, it is suspected that they are not immune from creep, and one may well wonder if business efficiency and competitive vigor is not often impaired through the accumulation of these barnacles which appear to be bargain activities; in other words, activities which apparently do not add to the fixed costs.

ARGUMENTS AGAINST BARGAIN ACTIVITIES

At this point it may be well, again, to make clear just what sort of activity is being examined. This article does not pretend to weigh the wisdom of a decision to produce rather than purchase where the decision rests primarily (1) upon a question of public relations, or (2) on the basis of guaranteeing adequate supply when needed, or (3) on safeguarding quality, or (4) even decisions to produce rather than purchase during periods of depressed business conditions where the aim is to keep the working-force intact and to minimize idle capacity losses. Also it is recognized that new lines of production may properly be undertaken, and old ones dropped, in order to keep pace with changing market conditions. Rather, this is an appraisal of the wisdom of adding an activity, formerly provided by an outsider, on the basis of cost studies which appear to justify the added activity on the ground that fixed costs can be ignored.

The theme of this article is that a major danger in the addition of bargain activities is the creep danger. And this danger is likely to be overlooked in the case of any added activity, whether or not cost saving is the prime motive. In fact it is all the more likely to be overlooked where factors other than cost savings guide the decision.

Another type of danger lies in the fact that the company is not a specialist in the added activity, and that after it has become tied to it, with added personnel and equipment, the discontinued vendor may through research develop cost and sales price reductions which make the decision to produce completely untenable when looked upon with hindsight. Then it may be too late. Reversion to the purchase status is then blocked by prospective sacrifices in the disposal of equipment and the need for discharging personnel.

Public relations may constitute an argument on each side of the question. For instance, an entirely unsupportable contention may be made, particularly in the smaller community, that the local manufacturer should make himself as nearly autonomous as possible, since this means that he will thereby provide more jobs for local labor. Needless to say this is pure bunk. It is a form of disguised charity without the slightest scientific justification.

From the opposite point of view, it is evident that the maintenance of good public relations may actually dictate the avoidance of certain productive activities simply because the good will of the community compels the patronizing of small business firm suppliers.

From the economist's point of view, and unfortunately this argument is not likely to be very compelling with individual businessmen, it may be argued quite conclusively that a decision to produce, when based on a partial cost compilation (that is, with fixed costs excluded), is contrary to the public economic interest. In short, it constitutes mismanagement of economic resources. Just realize that the vendor's price, against which is being matched only a partial summation of costs, is high enough for him to cover not only his variable costs, but also fixed costs, and a profit margin on top of it all. If the vendor's offer, under this assumption, comes within gunshot of meeting the purchaser's variable cost computation, we are doing serious injury to our economic system if we make a decision to produce rather than buy from that vendor.

Another observation is this: activities are usually annexed, with cost saving as the reason, only when they are more or less intimately related to the primary functions of the company. Actually, however, it might be more reasonable, from the standpoint of impact on total profits, to take on completely extraneous operations -- again with the assumption that the fixed-cost factor need not be a matter of concern. Thus, the automobile company might just as reasonably open a public restaurant, a dance hall, or a bowling alley, confident that the present executives can soak up such minor administrative burdens as would be involved, and that thereby they have an edge over existing recreational establishments which require a full complement of personnel.

CREEP AVOIDANCE

As has been mentioned, earlier, some activities are added with clear recognition that no cost saving is attainable, simply because certain non-cost factors are of pressing importance. Others, the ones under consideration here, are annexed because, with fixed costs ignored, bargain rates appear to be achieved. Both kinds cause fixed cost pressures, and lead to unanticipated cost increases-although they may not be recognized in some cases until years later. The important question is then, having brought the nature of creep into the open, what can be done to avoid it?

Among a number of defensive measures undoubtedly existing, four will be suggested here.

First, in the company's organization chart make notations of the number of individuals in each department or other subdivision of the company. From these notations calculate a series of ratios which may be called responsibility indexes. Thus, calculate the ratio of productive and non-productive employees to foremen in each of the productive and service departments of the plant; then, the ratio of foremen to plant manager or other personnel at the level above foremen. Similarly compute such ratios of responsibility through to top management, in each case using as the numerator of the ratio the number of persons who report, or for whom the person reported to is responsible.

Since the number of reporting persons will fluctuate, particularly at the lower levels of the organization, as productive activity fluctuates some judgement must be exercised in establishing certain of the ratios. Whether to use average ratios or ratios to reflect capacity might be debated; however, for present purposes it would seem that the ratios should be computed on a capacity basis. If, for example, the planned description of a given supervisory job is that it shall involve responsibility for receiving and analyzing reports from five persons, or responsibility for supervising the productive activities of twenty-five persons, any contemplation of additional

activities should include recognition of probable immediate as well as long-run effects on the responsibility ratios. So far as possible this change should be taken into consideration in arriving at a decision.

A second safeguard in the insurance against creep consists of the exercise of caution that the comparative statement of costs is complete and correct. The costs of purchased supplies, services, etc., are likely to be compiled fairly completely, including an allowance for freight, handling, purchasing, and other incidents of the purchase. Certainly there is no justification for excluding, or overlooking, similar costs which will be incurred if the decision goes in favor of production rather than purchase. Interest on the additional investment should not be overlooked. If the question is one of production of component parts, the acquisition of raw materials is likely to cause a set of costs similar to those incurred in the purchasing of finished parts. A real risk is the likelihood of underestimating even the immediate costs of production.

A third factor to be considered in determining the advisability of adding a new activity is the relative merit of that particular activity as compared with alternatives. It would obviously be illogical to devote available equipment and energies to an operation which would provide a cost saving of a few hundred dollars when the same facilities, otherwise used, could accomplish savings of thousands. Even more foolish would be the addition of an activity of the minor cost-saving variety which might interfere with, or preclude, the later expansion of the company's main operations at a profit in excess of the expected cost-saving. Mistaken decisions of this sort constitute a principal creep danger, leading to a condition of overcrowded facilities and neglected responsibilities.

Creep, as has been emphasized, is not a short-run problem. It consists of the more or less gradual, unrecognized, cluttering up of business activity, accompanied by a parallel deterioration of company efficiency a building up of fixed costs, and the undermining of profit potential. A fourth factor in the protection against creep is that of flexibility. New activities which are clearly temporary, which can be added and discarded on short notice without significant disruption, are much less likely to cause future trouble than are those which are less flexible. It is pretty well agreed that it is more difficult to dislodge an activity than it is to add one. For the classic object lesson on this point, consider the bureau of our federal and state governments. But, if an addition is to be made, at least as between two alternative activities which are otherwise equally attractive, the one which can later be abandoned the more easily is certainly the one to be chosen. It is therefore suggested that, among other things, serious consideration be given to the degree of permanence of any new plant, equipment, and especially, personnel, which may be required in undertaking an added activity.

If careful analysis indicates that the proposed activity meets the test of flexibility--that is, if it can be dropped on short notice without serious sacrifice of personnel or of investment in inventories and fixed assets--and if the contemplated addition is purely and unquestionable for a short-run period, than a "partial costs" schedule is appropriate. In other words, under these circumstances it <u>is proper</u> to prepare a schedule which is limited to the incremental costs, <u>the costs which would be added</u>, and to ignore prorations of existing fixed overhead items. Because of the importance of situations of this class, the point will be considered further under the next section heading.

If, on the other hand, it is contemplated that the new activity may be more or less permanently attached, as where the company will take on its own full-scale

printing operations, its own engineering, or toolmaking, or component parts supply, a partial costs schedule is entirely inappropriate. In fact, this point is the crux of the whole situation. For purposes of making the decision to add an activity which may be fairly permanent, the schedule of estimated costs of production should include not only an exhaustive list of the probable added costs, but also a complete assignment of all of the overhead charges, even including administrative overhead, which through regular cost accounting techniques are properly prorated against any regular segment of the enterprise.

ADD ALLOWANCE FOR PROFIT

But this is not all. In addition to the full charge for prorated and added costs, an allowance should be added for profit. That is, in order to justify the addition of a permanent new activity on the grounds of cost savings, the best available supplier's price must be shown not only to exceed the estimated full cost of production, with no apportionable costs omitted, but it should be higher by an amount at least equal to the rate of profit which the company is able to make through its principal operation.

The reasons for this fairly extreme view have been expressed earlier in this article, and it should be repeated that the requirement that full costs plus profit be included is, in fact, no more than a minimum protection against creep. Clearly the relationship between today's costs and today's purchase prices may be only a temporary one, and it is altogether too probable that the nonspecialist producer will lag behind the specialist supplier whom he has discarded in the hope of achieving production economies. Thus, the decision can easily turn sour in spite of all of the measures which have been suggested by way of protection.

JUSTIFIABLE BARGAIN ACTIVITIES

It was stated above that where the added activitiy is clearly intended to be temporary it is proper to base the decision on a partial list of costs. The point here is that the nonpermanence of the activity tends to insure against the creeping up of fixed costs and managerial overloads. However, resolutions are too often forgotten, and unless positive plans are made in advance for the early abandonment of the activity, it will turn out to be a "sticky", if not permanent, activity, and the fixed costs will flow in to fill up the gaps in the cost analysis.

One form of added activity which, for example, may well be justifiable is that which can be started and stopped repeatedly to serve as fill-in work during periods of temporary lull in the principal activity of the company. Such fill-in work may even extend as long as the depression period of a business cycle, provided it can be stopped conveniently at the time of resumption of normal operations. Under such circumstances the presumption is that the regular working-force should be maintained and, from the cost point of view, the recovery of any portion of costs in excess of variable costs is preferable to their nonrecovery.

One may also justify the addition of activities on a partial cost, or bargain basis, when it is evident that substantial cost reductions will be achieved after a period of experience. In fact, costs during the initial period may be so unrepresentative of the future that they may in effect be disregarded.

Also, where a company is chronically operating below capacity, and has found itself absolutely unable to expand its market, there is justification for taking over certain activities of its suppliers, provided that an already unfavorable position is not further weakened, and provided that existing fixed costs cannot be cut down to a level commensurate with existing activity. Again, however, it should be emphasized that the company should not take over "just any old activity" in which its variable costs will be less than the best outside price. A very careful survey of all opportunities for cost saving should be made before any is chosen.

ELIMINATION OF CREEP

Assuming that one has already suffered a good case of creep, what steps can be taken to cure the situation? Can we apply the same tests in deciding upon the elimination of activities that we use when consideration is being given to the addition of such activities? Are the same tests applicable in reverse?

Obviously a fringe activity should not be eliminated if the potential cost of acquiring the supplies, services, etc., from outsiders is so far in excess of the costs of self-service that over-all profits would thereby be diminished. But, in exploring this possibility, what costs of production should be included?

It was pointed out above that perhaps the most potent defense against creep is a requirement that outside suppliers be used, in the case of any relatively permanent program, unless it can be proved that their offering prices are higher than the buyer's total costs plus a margin of profit. Does this mean that an existing activity should be dropped in favor of outside supply if it is found that the existing activity when charged with full costs would not show profit if it were given credit for its output at regular market prices?

In general the answer would appear to be yes, although subject to one exception. The rule may be expressed somewhat as follows: A company should divest itself of any activity which has been undertaken because of its cost-saving potential if such activity would not be added under the suggested rules for the prevention of creep. The only exception is this: If specialized machinery, equipment, housing, or other specialized fixed assets have been purchased, and are of such nature that they have no alternative full use, the depreciation and other non-separable costs of such assets can be eliminated from the calculation except to the extent that the assets have a significant present market value. In other words, the cost of such assets is "sunk" to the extent that such cost cannot be retrieved by sale or through other employment in the business, the cost may be said already to be invested in future production of the related product, and the sacrifice cannot, therefore, be avoided by the discontinuance of the activity. If, with depreciation of specialized assets modified or eliminated, it is found that a given activity, when charged with all costs usually prorated to a routine operation and "loaded" with a profit margin, is not able to compete with the price of comparable service as offered by outside suppliers, the activity should be abandoned.

The term "activity audit" might be adopted to describe a more or less continuous study of the ancillary activities of the business firm for purposes of detecting existing or potential creep.

SUMMARY

A business firm, as it matures, is likely to accumulate an array of productive activities which were never contemplated when the company was founded. Many of

these activities are added on a self-service basis as a matter of convenience, or they are added during periods of short supply, or to assure reliable quality, and for other reasons; such activities may well be continued provided that their full costs are adequately recognized and provided that management realizes what cost sacrifices are being made to achieve such convenience, etc. Many other activities, however, may have been taken on solely because of apparent cost savings, and additional activities may from time to time be contemplated. All such activities should be subjected to frequent activity audits to determine whether or not real cost advantages exist. Unless these activities are purely temporary, idle-time fillers, their continuance or addition cannot be justified on the grounds that they need be charged with only a part of the list of costs normally charged to regular, principal operations. This is true because fixed costs commensurate with the activity will inevitably creep into the operating costs structure.

Equally important, though not examined in detail in this article, are the additions of new lines of products which can be demonstrated to show a profit only because they are charged with costs on a partial, or incremental, basis. In course of time they too will cause creep.

Added activities, ranging all the way from minor service items to the production and sale of new product lines, not only create fixed costs but also tend to distract operating management from its principal objectives, and it may be no exaggeration to state that many business firms owe to creep not only the decline in their profit rates but also their ultimate failure.

END

September 9, 1954

SUBJECT: THE PART OF VALUE ANALYSIS IN "MAKE-IT OR BUY-IT" STUDIES
(This answer was judged also very pertinent to "make-it" or "buy-it" problems in the United States)

Mr. W. F. Elliott
Canadian General Electric Company, Ltd.
212 King Street, West
Toronto, Ontario, Canada

Dear Bill:

Of course, Value Analysis as we are developing it here is not primarily concerned with "make-it or buy-it" decisions. Those are management decisions. What we in Value Analysis want is the opportunity in all cases to develop the facts and provide the facts concerning Value to management so that whether the decision be to manufacture parts which were formerly purchased or purchase parts which were formerly manufactured, the decision will be based upon the facts.

Quite apart from Value Analysis, however, I am pleased to advise you concerning the thinking of some of our management on particular problems with which we have had contact during recent months.

It was logical when a ready market existed for any reasonable quantity of our products which we could produce to reckon our costs as we have, to figure that, if we had a machine which was not working, the overhead costs continued anyway and we should make certain sacrifices to keep all of the machines busy. It was logical then, in considering whether to make or buy a part, to compare the purchase cost of the part with the sum of material plus labor plus variable overhead rather than full overhead because the fixed overhead would continue even if the part were purchased and would, in effect, be an added burden on other parts of the device.

It is just as logical now, as we face a competitive market, to accept the fact that the value of a part or component or material is established by the lowest cost at which it can be dependably provided where and when needed whether it be provided from our own machines or from the equipment of specializing vendors; or, in fact, the value ceiling may be established at a level even lower if some other material or part or product will, at lower cost, accomplish the same functional result.

It is equally logical that, in order to hold, and in certain areas, improve our percentage of the available business, we cannot accept costs in the various parts of our products which are above value. We cannot charge our customers more for a part or material to perform a function than our competitors would be and are obliged to charge.

It then becomes basic under today's competitive conditions that every part or component in our product stand on its own feet and represent the best value obtainable in the market whether that Value results from little or much work on the part in our company.

Following this basic competitive conception, it will be found that machines in our own factory which do not competitively, considering full overhead--shop cost vs. purchase price, deliver parts and components to our assembly lines at Value, will become idle.

At first glance, this again appears contrary to self-interest--it appears to result in a shifting of the fixed overhead and increasing the cost of other parts while admittedly it accomplishes the objective of providing a specified part or component at its value.

A second look shows that soon this and other machines which are indeed marginal or sub-marginal operations but have not necessarily been recognized as such in the past due to our former policy of keeping them busy, are standing idle. The management then will strip out these marginal and loss machines and put in their place profit making operations. In innumerable such cases, we have found this space adequate to meeting our needs for increased production.

Some benefits which stand out are:

1. The product is competitive and our markets will be expanding rather than contracting.

2. Every foot of floor space in the factory is contributing its share to the profit side of the balance sheet.

3. It is often unnecessary to make large capital expenditures for additional floor space.

As an example, one of our operations has for a decade followed the policy of making every possible part or component in the factory as a matter of policy in order to provide more "liquidation" and provide continuous labor load. The "Value" of the components was not examined by a search of competitive means for securing the same part. The profit position of the Department turned into a loss which increased yearly. The company placed new management in charge. They first asked the question...

"What is the 'Value' of these various parts we are making?"

As a result, the management selected and sent twelve parts which we had the opportunity to evaluate. It was found that two of them represented good value and ten did not. It was not unusual for parts to cost two or three times their "Value."

For example:

| | Quantity | Cost/C | Cost/Lot | Unnecessary Cost/Lot |
|---|---|---|---|---|
| Thumb Screws | 5000 | $23.00 | $1150 | $ 925.00 |
| The Value was found to be------- | 5000 | $ 4.50 | $ 225 | |
| Another example was a part made in lots of---------- | 3000 | $49.00 | $1470 | $1230.00 |
| The Value was found to be------- | 3000 | $ 8.00 | $ 240 | |

As a result, they immediately cleared this area and, since they did not need it, rented it to another General Electric operation which at once pressed it into profitable service making it unnecessary for the other unit to build another building.

We think that, in today's competitive market, we must hold one thing inviolate; namely, the costs of the various parts, components, and materials which go into our product must not go in at prices higher than our competitors would pay for identical parts. Any other policy results in "riding" the monogram which means weakening it. It can only remain strong if, instead, we, in each case, "support it" which means to provide at least as much and preferably a little more value in each part, component and product as our competitors do.

In our country, our taxes of all nature are becoming extremely high and the difficulty of getting large amounts of capital for new buildings, and of liquidating those expenditures once made, are becoming increasingly difficult. It is accordingly sharpening our wits in decisions regarding marginal operations.

Our various competitive departments have for a considerable period operated on a basis of competitive value. In our radio and television operation, for example, unless a part or component can be made for the equivalent of or less than the purchase cost, it is purchased.

Thus, it seems unthinkable in this day of high taxes, small return on capital investment, and extensive labor problems to employ the services of labor which we have provided through long and costly negotiations, on unnecessary marginal or loss operations; or to use their valuable manufacturing space to unnecessarily make simple parts which we could readily obtain for their Value--with no possible profit return, for the space, when it is so urgently needed for expanding our profitable operations.

Very truly yours,

L. D. Miles, Manager
Value Analysis Services
Materials Services Dept.

LDM:AEM

# CONTROL TECHNIQUES CUT COSTS

Increasingly important in raising operating efficiencies and lowering costs of manufacturing are:

1. Suggestion systems
2. Standard cost analysis
3. Direct and indirect time studies
4. Proper machine utilization

## Suggestion Systems

A suggestion system, to be successful, must attract and maintain the interest of the employee. Extensive publicity and cash awards are the two most common methods of doing it. In addition employee interest is maintained by rapid processing of suggestions and by supervisors well-versed in Suggestion Committee procedure.

The success of the entire program depends on employee participation - which in turn, depends on the publicity and on ingenious promotional devices. One large aircraft firm, for example, gave away a large color print of its latest plane to anyone who submitted an acceptable suggestion during a specific month. This inexpensive inducement resulted in a 500% increase in suggestions for that month.

The selection of a "Man-of-the-Month" has also been used to considerable advantage. The individual submitting the most valuable suggestion each month is honored and employee interest is greatly stimulated. A picture of the award ceremony is displayed throughout the plant, with the name of the employee and the dollar value of the award prominently indicated.

A first step in developing any suggestion system is to determine an appropriate money award. Most systems pay a percentage of annual savings, with a limitation set on the maximum award. An added inducement may be provided by having the company pay any taxes which might be associated with the employee's award.

Processing ideas simply and rapidly is of basic importance, too. Excessive time discourages the employee from submitting additional ideas. All suggestions should be returned with an explanation of why the idea was accepted or rejected. Whenever a suggestion is rejected, it is important to convince the individual that every effort was made to utilize the idea and to indicate the factors which prevented its adoption.

Closely related to the processing method is need for a thorough understanding by supervisors. The system is a logical subject for discussion in any supervision

training program. One large firm has several supervisors attend the Suggestion Committee meetings each week, to give them a first-hand knowledge of the system's operation. This approach enables supervisors to answer accurately employees' questions about the system.

Savings resulting from a suggestion system can and should be of major import in the constant fight to lower costs. A suggestion system can also help in labor relations. It is one way to demonstrate to all employees the common interest in producing better products at less cost.

Standard Cost Analysis

Maximum returns result from standard cost systems when foremen on the line receive data pertinent to their respective operating units. Cost and efficiency data should be provided on a frequent and current basis. The foreman then has the information for controlling and improving performance.

Measurements at the lowest level of supervision eliminate guesswork and permit correction of high or unexplained costs.

Standards should be developed for each measurable and controllable cost. The standard represents the best attainable performance under good practical operating conditions.

Goals are established and performance reported regularly for each organizational unit. These reports enable management to spot variances from the standard. A study is made of such variances and corrective action taken. For example, excessive labor costs may require a revision of methods or, quite possibly, induce more mechanization.

Direct and Indirect Time Studies

Clerical costs can be reduced by:

1. Labor saving equipment
2. Paperwork coordinators
3. Job standards

In clerical operations, application of the latest labor saving equipment has proven beneficial wherever established.

The purpose of paperwork coordinators is to eliminate as much paperwork as possible. Special attention is given to reports. They are to be kept to a minimum

but must be so effectively designed that any valuable control information is provided on a current basis.

Clerical jobs should be measured and standards set. This requires the definition of each individual's job and an estimate of his work load. The responsibilities may be divided into:

1. Things that must be done
2. Special projects
3. The balance of regular work

Engineering work requires complete objectivity in achieving minimum costs. An industrial engineering group to review designs is one way to cut costs. Coordinating with the designer, this group can arrive at a part design which may be manufactured most economically.

Once all individual jobs and activities are time studied, it will be possible to predetermine manpower requirements. This then provides the same effective control measurements as are now available to management for direct labor. With this data, cost reduction projects can be organized to effect increased output per employee.

Proper Machine Utilization

Maximum utilization of machines involves efficient layout, decision on the number of shifts to be operated, and when to use single-purpose and when multipurpose tools. The results of maximum utilization, properly measured, give management an important cost control device.

What is "efficient layout" in a particular factory, depends, of course, on the requirements of the particular operation. In some cases, for example, a generic type layout (which groups machines together by types) will be best. In others, a progressive production type (where the machines are arranged to handle specific parts) should be chosen. Sometimes, a combination of the two will be most effective.

One-, two-, and three-shift operation each has its special advantages. Theoretically, three-shift operation provides the maximum utilization of the machines. It is also the most effective method of combating obsolescence costs. However, this type of operation is not always practical. This is due to such factors as the nature of the business, seasonal and cyclical demand influences, and the rapidity of technological advances in the industry.

Singleshift operation, on the other hand is profitable under most circumstances

because it:

Eliminates shift differential pay
Gives more effective control
Provides constantly availability of service departments

Selection of tool types also is vital to maximum utilization. The problem with single-purpose tools, for example, is this:

A particular machine will be used only 10% of the available time, yet the precision required will dictate its use.

Then, certain standard tools, with special fixtures or attachments that remain on the machine change its classification to a special machine tool. Cost reduction and control is accomplished by determining where such excess machine capacity exists. Steps can then be taken to bring in parts from vendors which will utilize this surplus capacity.

To get the proper measurement of utilization required to make results is not always easy. The actual power rating of all machines or specific groups of machines may be related to the electrical energy actually consumed. If the rating of machines is considerably in excess of the energy consumed by these machines, it reflects an over-powered condition. However, this finding must be tempered with the requirements for light cuts, special machine application, and other factors which would lower the amount of electricity required.

It allows the use of most efficient machines and disposition of old or excess machines. This assures that capital investment in machines is kept to a minimum and that capital invested is in machinery which provides the maximum rate of return.

This report was taken from a panel discussion held as part of the 1955 SAE Aeronautic Production Forum.

# KEEPING CONTROL OF INDIRECT MANUFACTURING

Controlling and reducing indirect manufacturing costs are necessary if a manufacturer is to stay competitive. There are several ways to do this:

(1) Using flexible budgeting as a tool of management
(2) Controlling engineering costs
(3) Controlling indirect labor costs

Indirect manufacturing costs usually do not appear on the design engineer's blueprints or on the methods engineer's operation sheets. However, they must be allocated to the product. Unlike specific raw materials and clearly designated labor operations, they are difficult to relate directly to cost of the product.

These costs are the wages of supervisors, material handlers, machine maintenance mechanics, setup men, and other service personnel. Other indirect costs, such as cutting tools, abrasives, lubricants, and power, are equally important to the manufacture of a product. Like indirect wages, it is not feasible to control them as a cost of a specific unit of product.

Finding out what your indirect manufacturing costs are will do more than merely show where money has been spent. It will provide data which will bring out weaknesses in operation, and give management the data it needs to reduce costs and increase efficiency.

Indirect costs can be divided into (a) those costs which are inelastic and remain fairly constant regardless of volume, and (b) those costs which fluctuate in relation to volume of goods produced. A flexible budget is an expression in dollars of the sum of a and b. Changes in the character of work, working conditions, or methods will require an adjustment of standard costs.

## 1. USING A FLEXIBLE BUDGET

Each supervisor who authorizes expenditures for supplies and other costs must be responsible for planning these indirect costs and for controlling them. No supervisor should be expected to assume responsibility for costs he does not control.

The supervisor estimates the amount of money which should be spent on indirect costs. These are checked and approved by his supervisor. Then, during normal operations, the budgeted amounts are compared with actual costs. If there is serious deviation, the operation and budget is analyzed and revised.

Top management controls costs by measuring the performance of each man in successively lower levels of responsibility down to the department supervisor. He, for example, may recommend that three material handlers are needed instead of four. He thereby assumes the responsibility for reducing his material handling costs when volume drops to the three-man level. To reward him for reducing indirect manufacturing costs, there should be a foreman's incentive plan.

Flexible budgeting, used as an over-all tool of management, becomes a profit plan and has these other advantages:

1. It requires each foreman and supervisor to think ahead and make definite plans for his own operations.

2. It provides a means for co-ordinating the plans of departments within a division and between divisions of a company.

3. It allows planning for varying volumes of production.

4. It can provide a natural line of communication upward as well as downward within the organization. It provides an impersonal means of correcting mistakes and presenting constructive criticism.

5. It makes use of the "management by exception" principle.

6. It trains personnel for greater responsibility by giving them practice in planning.

7. It controls decentralized operations without undue restrictions.

## 2. CONTROLLING ENGINEERING COSTS

Control of engineering costs through budgeting is usually best accomplished by segregating research and development engineering from product and industrial engineering. Research can often be budgeted under development projects, the cost of which may bear no relation to anticipated sales or production volume.

Cost of product engineering (the normal changes in a product rather than development of new products) may be based on annual production or sales volume.

Use of free engineering services offered by vendors of materials and equipment is one way of reducing both development and product engineering costs.

## 3. CONTROLLING INDIRECT LABOR COSTS

Indirect labor costs often exceed costs of direct labor. Up to 50% reduction of indirect labor costs are possible if an adequate incentive system is devised. But it is difficult to establish a standard measure of productivity.

So that indirect labor costs do not get out of hand, many companies use a special timecard rack. Then the supervisor can tell at a glance the number of men doing indirect labor. Some companies use special colored timecards for productive workers doing nonproductive maintenance jobs. They remind the supervisor that he is losing money until the productive worker is given a direct labor job.

Another indirect manufacturing cost which must be controlled is supervision. Sometimes one supervisor can be used for several small departments, thereby cutting costs.

Manpower ratios will tell the effectiveness of supervisors in controlling indirect labor costs. They are directly related to a company's profit planning and the development of manpower requirements. They can substitute for daily dollar-amount budget reports. The following chart may be typical of an entire company or of a single department:

Hourly Manpower Ratio Objective

| | | |
|---|---|---|
| Sales | | $3,500,000 |
| Desired profit before taxes | | 350,000 |
| Balance available for costs | | $3,150,000 |
| Deduct -- | | |
| Sales, administrative, engineering, etc. | $ 124,000 | |
| Direct material costs | 1,704,000 | |
| Conversion costs, exclusive of payroll | 615,000 | 2,443,000 |
| Balance available for payroll and fringe benefits | | $ 707,000 |
| Breakdown of payroll -- | | |
| Fringe benefits | $ 85,000 | |
| Salary | 67,000 | 152,000 |
| Balance available for hourly payroll | | $ 555,000 |

| | | |
|---|---|---|
| Hourly payroll attendance hours (A) $555,000/$2.50 average hourly rate | $ 222,000 | |
| Standard direct labor hours in shipments (B) | 128,000 | |
| Allowed attendance hours per standard hour (A/B) | | $ 1.73 |

The actual manpower ratio is reported to each supervisor daily and can be compared with target ratio so that trends can be seen in each area of supervision.

This report is based on a panel session of the 1954 SAE Production Forum held at the SAE National Tractor Meeting, Milwaukee, September 13, 1954.

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# QUALITY CONTROL AND VALUE ENGINEERING

Capt. J. M. Reigart, USN, and A. Sikorsky
Value Engineering Office
Bureau of Ships
Navy Department

## QUALITY CONTROL IN THE BUREAU OF SHIPS

Quality Control has always been of prime concern to the Bureau of Ships. Charged with the effectiveness of the fleet's ships and safety of its men, this Bureau has long recognized its responsibility to provide the fleet with equipment that has met rigid tests and operating requirements. Traditionally, the Bureau of Ships has placed its reliance on the first line supervisor to assure good quality of work. Final inspection and operating tests have been the predominant measures used to carry out the Quality Control function.

The increasing complexity of ships design has recently redirected the Bureau of Ships attention to the Quality Control procedures of the Bureau and our Naval Shipyards. In this connection, a Bureau of Ships Instruction was issued assigning the administrative responsibility for the various phases of Quality Control. The Assistant Chief for Field Activities has the task of reviewing the Quality Control procedures in the Naval Shipyards and developing a formalized Quality Control program to meet the revised needs of todays ships.

To date, this is what we have accomplished in this "new look" at Quality Control.

1. A little over a year ago, Dr. J. M. Juran, an eminent authority in the field of Quality Control, was invited to address top management in the Bureau of Ships. He gave us an extremely valuable insight to the functions of Quality Control, and, based on a very brief visit to one of our largest Naval Shipyards, pointed out some of the necessary steps to be taken and pitfalls to be avoided in revitalizing our Quality Control methods in Naval Shipyards.

2. The Bureau has completed a study and has developed a plan for installing a formalized Quality Control program in the Naval Shipyards. The requirements of such a program have been spelled out. Attention has been given to other aspects of Quality Control than just final inspection and tests such as, statistical analyses leading to sampling techniques as applicable, and assurance of a proper feedback system to apply the results of the program to new design, purchasing, specifications, and manufacturing methods. The "traditional" reliance on first line supervisors of the Production Department has been re-examined and the desirability of establishing the Quality Control function as an authoritative group separate from the Production Department has been investigated.

All of these revised approches have been incorporated into specific projects to be investigated by various Naval Shipyards as task assignments leading to the development of detailed operating procedures which other yards will be able to follow. Guide lines have been outlined for this mission. The Bureau's aim is to develop an operation which will assure good quality as opposed to correcting poor quality. We need more emphasis on prevention instead of cure. We have no delusions about the training job ahead of us or the usual resistance to change.

## WHY TALK ABOUT VALUE ENGINEERING AND QUALITY CONTROL?

I can be more specific about Value Engineering. We define Value Engineering as an "objective appraisal of all elements of the design, construction, procurement, installation, and maintenance of an equipment, including the specifications, in order to achieve necessary functions, maintainability and reliability at minimum cost." Now this is a very broad definition and a general interpretation can raise many questions about its relationship to the programs, particularly Quality Control. You can sense a similarity of aims in at least some areas. However, as you will realize, there are many roads that take us to good management.

The day when an artisan received an order from his customer, priced, planned and performed his own work, and then had his customer inspect that work, has long since passed. In the complexity of modern industry, people write specifications, design equipment and produce it without ever seeing the customer. To assure maximum customer satisfaction and reward itself with a reasonable profit, management has had to turn to methods of control, inspection, and various other management programs that were never visualized by the artisan of the past. Like all such programs, Quality Control and Value Engineering bear some very striking similarities. Both require the services of full time people; they must have access to top management and be free to contact all areas of design, procurement and production. The programs must be influential and its engineers must be adept at handling the problems of human nature. Both are essential to good management.

## SPECIFICS AND DIFFERENCES

A little while ago, I said that there were many roads to good management. I would like to discuss the road of Quality Control, as I see it, and compare it with that of Value Engineering. By Armand Feigenbaum's definition, "Quality Control is an effective system for coordinating the quality maintenance and quality improvement efforts of the various groups in an organization so as to enable production at the most economical levels which allow for full customer satisfaction." In essence, it is conformance to design at the lowest possible cost.

Value Engineering is a system which insures only necessary functions and reliability at minimum cost. In brief, it is conformance to the customer's actual need at minimum cost. We work from the precept that a customer, in this case the Bureau of Ships, puts forth many requirements which cost us a great deal more in terms of dollars and complexity than we had visualized at the time those requirements were made. We have also been too prone to accept a first design without asking our contractors to simplify it or consider the cost of the materials, processes or truly necessary functions inherent in that design. Through Value Engineering, we ask for and assure ourselves of a second look with costs in mind, and by reviewing the price for each of our specified requirements, we can reduce the designs to those functions which are absolutely necessary, and to those which give us a desirable feature at a reasonable price. The big difference here is that Value Engineering is not limited by the boundaries of specifications, and actually questions the design. Big cost reductions start by eliminating functions which add no significant advantage, but pile on disproportionately high costs and complexities.

The core of Quality Control is the control of product quality during the process of design and manufacturing so as to prevent poor quality rather than correct it after a product is made. Someone who is responsible for process engineering specifies the process to be used to achieve the design. Operators are trained to use the process and instruments to make the product conform to design. Through Quality Control we assure conformance to those processes and thereby prevent the high cost of rejects.

Routine attention to processes is not a function of Value Engineering. It approaches this area only when the excessive cost of a component or part can be laid directly to a specific process. Value Engineering is not bound by the specified material nor by the prescribed tolerances or finishes. Sometimes a material, even though manufactured to good quality standards, is costly because it cannot be processed easily. --If so, Value Engineering will try to change the design and the specification if at all possible. If necessary, we go directly to the customer if his requirements predetermine the need for that part.

Another area which Quality Control plays an important part is in inspection. Inspectors examine a product to judge its conformance to design. Through Quality Control you establish precise steps, procedures, and criteria which the inspector uses to ensure "conformance to design." Again, Value Engineering plays no routine part in this area. Only when the high cost of a part can be directly attributed to an expensive and tedious inspection, will Value Engineering seek to effect a change in design.

Another important factor to be considered when comparing Value Engineering to Quality Control, is the degree of emphasis each of these programs places on cost. Quality Control has many jobs which are necessary to achieve good quality. Some of these are:

1. New-design control -- There you try to eliminate potential rejects or manufacturing difficulties before they start.

2. Incoming material control -- This involves the selection of materials which conform to the specification requirements.

3. Product control -- This prevents departures from the quality specification so that corrections can be made before defective products are manufactured.

4. Special process studies -- Locating causes of defective products and determining the possibility of improving quality.

5. Statistics -- Wherever they are useful to Quality Control, you prepare charts on frequency of failures, control of processes, make up sampling tables, and so forth.

Now this is a big order. If we examine these jobs closely, you will note that the major emphasis is on quality. That is as it should be.

You do save a lot of money in the process because you eliminate costly rejects, inspect only those items which actually need inspection, and pave the way for changes in tolerances that might otherwise increase production costs. In Value Engineering, the major emphasis is on cost. We have no other function except to insure that a

less expensive part or the elimination of a function will not detract from the essential requirements of a customer. We do not exercise any controls in manufacturing or testing. Value Engineering is strictly a cost function, always related to actual needs. It can be further explained as a dynamic process which continually seeks to keep management informed of the properties and costs of new materials that research and engineering are making available to us, and promoting their use in our designs wherever they will meet the essential requirements of a customer at lower cost. It also keeps informed of the actual needs of the consumer, limits functions to those needs, and eliminates those others whose costs and added complexity are not justified by the marginal technical advantages they offer. In short, the design and "quality characteristics" of all the parts within a design are boiled down to simplicity and low cost, but "conforming to the need."

We can now summarize the important differences in the functions of Quality Control and Value Engineering.

1. The major emphasis by Quality Control is on quality -- by Value Engineering it is on costs and simplification.

2. Quality Control primarily means "conformance to design" -- in Value Engineering it means "conformance to need."

3. Quality Control is exercised by controlling processes and inspection -- Value Engineering studies the costs of a design and any part in that design. It exercises no control.

4. Quality Control reviews a design to avoid possible rejects and manufacturing difficulties. Value Engineering reviews a design to simplify, reduce functions, introduce less costly materials, and recommend changes in design details that will bring costs down.

5. Statistical data, control charts, sampling data, and knowledge of production methods and measuring techniques are the tools of Quality Control. In Value Engineering, our aids are costs, a knowledge of consumers' needs, new materials and processes.

6. A quality Control engineer should know:

   A. How good quality should be,
   B. How good quality actually is,
   C. What should be done about the difference.

A Value Engineer should know:

   A. What is it?
   B. What does it do?
   C. What does it cost?
   D. What else will do the job?
   E. What will that cost?

## WHY BOTH ARE NECESSARY

Quality Control and Value Engineering are important tools of management. Just as we cannot afford to be without Quality Control, neither can we afford to be without Value Engineering. The skyrocketing costs and complexities tell us we must have it. Value Engineering and Quality Control together can give us the essential ingredients of maximum cost and acceptable quality. Both will give us better value. Facts on the cost of a product are often precisely ascertainable. Facts on its value are more nebulous, and consequently overlooked. Value Engineering concentrates on this nebulous factor. As a rule, higher quality of design means higher costs. Quite often it also means higher value. However, in numerous instances a design can be both better and less expensive than some other.

Quality Control can team up with Value Engineering to close the circle for design simplification, low cost, and good quality. The Quality Control engineers should advise the Value Engineers in order to ensure acceptable quality when Value Engineers suggest less costly materials or inquire about the possibilities of simplifying assembly. Similarly, the Quality Control engineers should seek the help of the Value Engineer on materials that are less costly to process or to get the facts on a requirement which is difficult to meet in production. Armed with facts and costs, the Value Engineers and Quality Control engineers can present a logical argument for profitable design changes.

## CONCLUSION

Through Quality Control, much has been done to reduce costs by such matters as increasing the latitude of tolerances and degrees of finish, by simplifying tests and reducing the number of rejects. Fundamentally, however, this has been accomplished within the customers' specifications for the design. The many other functions of Quality Control, such as developing criteria and tests and exercising constant control for quality prohibit you from giving maximum attention to every element of cost and to the many other materials now flooding our markets which can do an equal and sometimes better job at less cost. Nor have you the time to question user requirements and determine their values. All these are important factors which govern a good value design.

Value Engineering will ensure a low cost design and Quality Control will give us assurance that our design limits are economically maintained throughout production.

# WORKING WITH SUPPLIERS TO CUT COSTS

Lack of proper supplier-customer confidence is costing industry millions of dollars a year. Utilize fully the knowledge and experience of suppliers to cut this loss. This is the lesson Orrin B. Werntz, executive secretary of the National Screw Machine Products Association, is continuing to preach to buyers of industrial components. His suggestions are applicable to parts other than those turned out by screw machine shops, and worth reviewing. Specifically, Werntz suggests:

When possible, guarantee a total production run, even if this total quantity is not completed in any single run, so the supplier can absorb extra tooling costs and thus deliver the parts at a lower price.

Explain inspection requirements thoroughly. This tends to smooth delivery schedules and can often eliminate unnecessary costs.

Don't over-specify dimensions which add unnecessarily to the final cost of the part. Consult with the supplier to see if tolerances, concentricities, and surface finishes can be expanded in certain key areas, thus reducing costs of both machining and inspection.

Give sufficient lead time so the supplier can eliminate the need for multiple setups.

Determine longer range requirements for a given part so the supplier can take advantage of less expensive mill shipments of raw material.

Ask the supplier if a piece can be completed on a screw machine without need for costly secondary operations.

Ask if substitute materials can fit part requirements. Many times his knowledge of the machinability of metals, for example, can lead to savings.

VII C

# Value Engineering

## Aid to Improved Purchasing and to Lower Product Prices

by: Harry Ritzel
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Presented at A.M.A.-V.E. Seminar
October 17, 1961

GOOD MORNING GENTLEMEN!

There's an old adage I'm sure you've all heard before that goes like this, "We grow too soon OLDT, and too late SCHMART."

Now I don't specifically know what was on the author's mind when he made that statement, but I'm inclined to believe that the "Growing too soon OLDT" portion, closely parallels the time we often spend speculating the path of action we plan to pursue relative to a particular problem. It's the time spent deciding whether or not we should act on a problem, whether or not we should become involved, and perhaps, even questioning why and how we got involved in the first place.

The getting "SCHMART" phase of life never really starts until we become ACTIVELY engaged in the pursuit of problem solving; until we begin to pursue and investigate what has gone before, what is being done at present, learning from others' mistakes and profiting by their successes. Then, putting to practice on our own particular problem those techniques that we believe will be most beneficial to its speedy and proper solution.

By your very presence here, you've indicated your desire to do something more than just grow old. It is in the sincere hope that I may contribute in some way, however small, to the getting smart phase of YOUR life, that I offer an insight into how the Heavy Military Electronic Department of the General Electric Company operates its Value Program.

Of course, time just won't permit me to discuss all the various phases of our Value Program, let it suffice to be said, that the program conducted in the HME Department runs the gamut from Value Engineering thru Value Analysis.

As you no doubt have already gathered from attending this seminar, an effective value program must, of necessity, involve the TOTAL CORPORATE BEING. It requires intense and active participation in every phase of a business operation.

This morning I shall attempt to acquaint you with a few of the programs undertaken, by the HMED Value practice staff, which have resulted in noteworthy cost savings to the department, and greater overall purchasing operating efficiency.

1. PURCHASE SPECIFICATION CHANGE & CHARGE ANALYSIS

The nature of our department's business often dictates that we subcontract special equipment items to vendors who possess the unique skills and resources to provide those items reliably and economically.

Where known, of course, the specific engineering parameters, to which the vendor must fabricate the particular equipment or item being subcontracted, are carefully detailed in the purchase order specifications, by our engineers. But as in most

development contracts, either an error on our part, or the need for additional components, etc., requires that the original spec. be revised.

If the vendor believes the changes warrant extra charges, he submits to purchasing a request for approval to incorporate the changes as specified by engineering, and attaches his bill.

In the past, the engineer, not being too familiar with detailed manufacturing processes and costs, would rely on the buyer to verify the billing. The buyer, on the other hand, due to work load, etc., was not always in a position to fully compare technical requirements with cost, and as a result frequently merely passed the charges on to billing.

The value specialists with their specific knowledge of component sources, costs, production techniques, etc., working in cooperation with engineering and purchasing, have been able to effect a bridging of this gap.

Reviewing with the vendor, the specific engineering intent of the changes, and soliciting information relative to his method of fabricating and incorporating, has frequently resulted in reduced charges and in some instances voiding them entirely.

SLIDE #1. A Typical Example is shown is this first slide --

Here a gear train was being fabricated which required some late changes to comply with revised engineering specifications. The changes resulted in an increased billing of $90/Unit. Before approving the price increase, purchasing asked engineering and the value specialist assigned to that particular engineering sub-section to review the technical proposal and the charges to determine if they were reasonable. A review disclosed some misunderstandings which might have resulted in even greater additional costs, but finally resulted in a reduction of 23% of the charges, as originally submitted.

In another instance some hole changes were required, to a specific series of cabinets, which resulted in an extra charge billing of $40/cabinet. Consultation with the Vendor indicated that the charges were warranted, since, they were based upon plugging and refinishing holes which had already been fabricated. Additional consultation with the Designer brought to light the possibility of utilizing the holes, as originally specified, for mounting recent component additions. Those holes not so utilized were not located where serious appearance or functional problems were incurred. Total result was a voiding of the charge entirely.

The effect of such effort is two edged

(1) The Heavy Military Department profits by reduced subcontracting costs while;
(2) The Vendors competitive position for future orders is preserved and in many instances, enhanced.

## 2. INTENSIVE VENDOR INVESTMENT UTILIZATION

The adoption of a program of Intensive Vendor Investment Utilization has netted some startling returns.

We at General Electric pride ourselves on the capability we possess to design and fabricate fine and reliable electronic equipment. Many, many, dollars have been invested, in both capital equipment and personal salaries, toward the end of providing our customers with the very finest, up-to-date, designs and products available on the market today. Is it then not foolish for someone requiring an item of our product line to duplicate our investment, in time and money, when it is so readily available to him? Yet, in many instances, we are guilty of just such folly. Enthusiasm of our own capability often clouds reason. We take the task of designing and then dictating to a vendor, the specific parameters to which he should build an item common to his product line, as a great achievement. When, in reality, the ability to utilize the suppliers investment and skills to our best advantage is the real mark of achievement. The engineer should, most certainly, determine the specific FUNCTIONAL requirements that must be met. This, however, does not imply that the wheel must be re-invented every time its use is dictated. One of the prime achievements of the HMED Value Practices staff has been to strengthen buyer, vendor, designer relationship. By constantly reminding the engineer of the vendors' capabilities, and encouraging frequent association and familiarization with the vendor sales and engineering personnel, great strides have been made which have proven mutually profitable.

On the Advanced Missile Range Instrumentation System program, for example, a design engineer was assigned the task of reviewing cabinet construction, as it had been applied to a previous short run production order, with an eye toward reducing costs. The value specialist was invited to assist in this review. The basic principles, which were stated before, of letting the man with the know-how make the recommendations for design, were immediately employed. Vendors were invited to review the present design and to ask any and all questions they had relative to specification parameters. They were then asked to submit their own construction recommendations, and costs, for review by our engineering staff.

SLIDE #2. Shows a few of the typical construction change recommendations that were made which resulted in eliminating many inches of welding and reduced associated straightening and finishing costs.

A model was produced, employing these construction recommendations, and then tested to determine if it would function reliably and meet all military specifications. It passed with flying colors. The result is that the new order received, for additional Systems, will employ the new cabinets.

What was the Total Cost result?

SLIDE #3. Shows that a saving of 45% was effected on the double cabinets, and a saving of 25% on the single cabinets. This, gentlemen, amounts to many thousands of dollars savings even for a one-system order. Certainly is proof that utilizing the supplier's skills to supplement your own makes good DOLLARS AND CENTS.

## 3. COMPONENT UTILIZATION ANALYSIS

Component Utilization Analysis is another technique being applied by Value personnel to maximize product value and Control Cost expenditure.

Working in conjunction with standards and purchasing personnel, a system which invites vendor review of component utilization prior to engineering design release, is employed to good advantage.

Engineering, after having determined the specific design parameters and then testing out their working feasibility, conducts pre-release design reviews. At this stage, vendors are invited to scrutinize the application of their products and determine the UTILIZATION FACTOR. In many instances, a simple function is being performed by an item which embodies compound capability. The substitution of a less expensive, but equally reliable component in the place of that originally selected, provides substantial cost reductions. In many cases, the vendor can specify less complicated construction and fabrication processes than those originally scheduled to produce a functionally suitable item, thus reducing his costs and, in turn, our costs appreciably.

As an example, HMED is presently conducting a utilization factor analysis on all transformers, employed in a particular system order, which is pointing the way to some substantial savings.

In instances where not all the TAPS commonly provided on stock transformers are being employed, the vendor has suggested deleting these taps and their associated windings during construction. Savings of 20 to 25% of the transformer cost in a number of instances is not uncommon.

## 4. TOTAL RELEASE PURCHASING

Another technique employed in HMED which is paying dividends is total Release Purchasing.

For some time TOTAL release purchasing was considered a mere dream not feasible in development type production which dominates our business. Value Practices, not content with this decision, set about proving to the contrary. An examination of the department's annual order makeup indicated that a sizeable percentage of the business, which at one time was cost plus, had gradually developed into fixed price. Total release purchasing, therefore, was not only feasible, but provided cost savings potential that could not be ignored in the light of today's competitive market.

Today in HMED, accumulating total order requirements for purchase part items as dictated by production, test, Engineering and Logistics, is common practice. After attaching scheduled need dates, this list is forwarded to purchasing. Coordination of all user inputs is, of course, required, but some of the results accrued more than offset this effort.

(1) - Purchasing, armed with an accumulation list, is provided with the bargaining capability to achieve maximum quantity discounts. This is especially critical where the direct material content of the system cost is high.
(2) - Well defined bogeys can be established against which overall purchasing performance on the contract is measured.
(3) - Inventory control and warehousing effort is greatly reduced.

THE VENDOR TOO BENEFITS BY:

(1) - Improved factory scheduling and loading control, and
(2) - Greater control over meeting delivery commitments so vital to business survival.

## 5. SUMMARY COST IDENTIFICATIONS

Summary Cost Identification is a FIFTH value technique being applied to engineering designs which plays an important role in Cost Control.

Traditionally, a design engineer's responsibility runs the gamut of performance, reliability, delivery, and cost. His proficiency in any one of these areas tends to be directly proportional to his availability of related information. It, therefore, follows that to improve his cost control capability, his ready access to reliable and detailed cost information must likewise be improved.

The Value Practices Staff, realizing that the engineers' access to such cost information was not always ideal, launched a program for accumulating detailed and specific design cost information and disseminating this data to the associated and responsible engineering personnel.

Wherever possible, this cost information was made available at early stage design reviews, prior to production release.

Items and their costs were reported in descending order of magnitude as Slide #4 shows.

This results in quickly highlighting those items which require greatest concentration of effort to reduce overall project costs.

Slide #5 shows how, in one particular study, 7% of the items equalled 75% of the total material cost. Certainly worth reviewing to assure maximum utilization of dollars invested.

Such a cost identification program achieves the purpose of highlighting critical cost areas, for the particular program under study, but also acquaints the designers with cost information which can be utilized to good advantage in future design efforts.

A question that is probably plaguing you at this point is: What is the sum total effect of all this effort? is it really meaningful?

A typical example of what has been achieved at HMED, by diligent Value Practices Application, can be seen in a project study just recently completed.

Slide #6 shows the equipment originally employed in HIPAR Acquisition Radar, used with the Army's NIKE HERCULES Improved System.

NOTE the size and quantity of equipment utilized to satisfy the system functional requirements.

Slide #7, in contrast, shows the revised system structure. Here complete functions and cabinets have been married or combined to effect a system size reduction.

The new system cost has been substantially reduced, while the operating capability has been greatly increased.

Proof positive that the application of Value Principles to our tasks does, indeed, give a fair return on investment.

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Now gentlemen, I've reviewed but a few of the Value Techniques being employed at HMED to Control Costs. The constant application of these and many other tools, applied to combat unnecessary and profit-robbing costs, go to make up what we in HMED refer to as our "QUEST FOR VALUE."

The agenda states that this presentation will stress integrating Value Engineering in an over-all cost reduction effort. Well, I've brought a film along which I hope will satisfy that part of the presentation. With your permission, I'd like to show it to you now.

FILM - RUN 20 MINUTES
"Quest For Value"

In summary, you may say that many of the Value Techniques described here today are just good business practice, and are normally being performed daily by personnel in your particular organization. Why do you need value specialists? The real truth of the matter is that they are not being performed, or the value specialists could never achieve the results they have time and time again, wherever such capability has been established.

For instance, on the Advanced Missile Range Instrumentation System cabinets, without the value approach to the problem, it is doubtful if much of note would have been accomplished. The old review technique of looking at the present design and knit-picking it to death does not pay off in substantial savings or cost reductions. Discarding the original design and setting forth to provide the function in the most reliable and economical manner possible is the real answer to affecting savings each and every one of you wants and needs to continue your business growth.

Now I realize that most of the efforts I described were related to engineering problems. That's because our department is heavily engineering-oriented. The basic value techniques and principles, however, are equally as applicable to manufacturing and/or materials problems; such as those you are confronted with daily.

Can you afford to ignore an operational concept that may be giving your competitor a greater edge day by day?

Weigh the facts, gentlemen; then, give serious consideration to the establishment of a value program in your operation to help you resolve Knotty Cost problems which plague you daily.

# Two Ways Value Analysis Can Aid The Purchasing Man

by Frederick S. Sherwin, Manager
Value Engrg. & Analysis Services
Raytheon Company

How many people today are in the market for $100 pair of shoes? Even if I were to guarantee that they were top quality, were hand stitched with gold thread, were the most comfortable you had ever worn, and that they would outwear your present shoes ten times; I doubt that I would find many customers. Why? The price is obviously out of line. Everybody knows from experience that you can buy a satisfactory pair of shoes for from one-tenth to one-fifth this cost.

I bring this up to make the point that in most American Industry today we are buying $100 pairs of shoes. While it may not be as obvious, nevertheless, we are paying more than we should to obtain the desired function. For instance, an aircraft engine manufacturer was buying hundreds of thousands of these small stainless steel washers. They were screw machined out of solid bar stock, chamfered, deburred, tumbled, and cost 15 cents each. It was found that a washer stamped out of sheet stock would do the job just as well for a cost of 2 cents, a yearly saving of $80,000. A case of the $100 shoes.

Or, how about the case of the 85° elbow? This was a common, small bulkhead aluminum elbow -- standard in every sense except it was not 90°. Now everyone knows that you can't buy an 85° elbow so this had to be machined out of solid aluminum stock at a cost of $3.50. Sometime later when someone thought to question this cost, it was found that a manufacturer who made standard fittings would make this special for 52 cents.

What about this chart which bolts to the front of a piece of electronic gear? Would you pay $36.50 for this small piece of paper and plastic? Industry is. A careful analysis of costs revealed opportunities for reducing the calibration curve drafting time, elimination of a photo reduction process, and the substitution of plastic laminating for vacuum bag molding with a final cost of about $5.00. $100 shoes?

These things may look pretty simple after the fact, but the fact is, they didn't look ridiculous at one time. They were accepted. How many things which represent poor value are accepted in every business? Only careful analysis of costs will answer this question.

As one of the key people in any business, the Purchasing Agent is in a great position to highlight opportunities for better value. In many businesses as much as 50%-60% and even 75% of the money spent funnels through purchasing. It is the buyer's job to see that this money doesn't funnel down the drain. This is no easy task. Today's buyer has to be something of an expert in many fields. To be more than just a paper

work pusher, he has to be able to understand the technical aspects of the product; he has to know methods, materials, processes, hundreds of good suppliers, their ability and capabilities to meet his needs, and many other things. Because of the complexity of the business world today, the buyer needs help from many areas to be able to do an effective job.

One of the new programs that has been developed in recent years to help the buyer is Value Analysis. Briefly, Value Analysis is a systematic approach to finding lower costs by the use of certain basic techniques. Rather than stumbling into ways to buy more for less, Value Analysis uses an organized approach to show up areas of excessive costs, and points the way to better value.

There are two ways purchasing can make the best use of Value Analysis. The first is: Every purchasing man should gain a working knowledge of Value Analysis techniques and methods so that he can apply them in his everyday work.

There are some twenty of these techniques, but I will only touch on five of the more important ones here. They are:

1. The Job Plan. This is the planned approach to finding unnecessary costs and developing new ways to obtain the same function for less. Every job is done better when tackled with plan in mind.

2. Functional Evaluation. Here is a powerful technique designed to tell you when things cost too much and help you set cost objectives. A good example of functional evaluation would be the analysis of a cigarette lighter. Its main function is to provide heat. What else will provide heat? Obviously, a book of matches at a much reduced cost. Someone must make the decision whether to pay the extra cost for the lighter to perform this function. Good purchasing considers the function it is buying.

3. Evaluate by Comparison. All value is determined by comparison. A case in point .... the lighter and its cost compared to the matches and their cost.

4. Creative Thinking. The generating of many possible solutions to a problem before evaluation. There are hundreds of possible ways to do every job. The more you have to select from, the greater the chance of selecting the right lowest cost one.

5. Blast -- Then Refine. Search for the entirely new way to do the job. Get out of the habit rut.

Value Analysis is generally a questioning process. For example, the analyst asks himself five questions: What is the part? What does it do? What does it cost? What

else will do the job? What will that cost? Let's take a look at this wavemeter used in communications equipment and see how the process works. What is it? A wavemeter. What does it do? It measures the frequency of the R.F. signal. See how simple it is? Now you know all about this complex, highly technical device. What does it cost? $75. What else will do the job? Now we come to one of the more difficult parts of the job, and to answer this question it is necessary to break the device down into components, study each intently in the same manner, finding all the facts and answering these questions on each part and functional area. For example, it was found that this special Co-ax Tee was costing $24 while a standard commercially available Tee which would perform the same function would cost only $1.25 . . . that this specially hardened and plated stainless steel shaft could be replaced by a 303 SS shaft at a savings of $2.50 and so forth down through all the components until we have a wavemeter costing $40 instead of $75. Another case of the $100 pair of shoes, but who could tell at first glance.

Now the buyer can do a certain amount of this by developing his value-ability skills. He can learn to pick out case after case of poor value. He can find better vendors. However, this sort of complete analysis requires time, and when pushed to get orders out, a buyer, even though he would like to, many times just doesn't have time to search for the better value.

So we come to the second way Value Analysis can help purchasing. It consists of having a team of value specialists who can devote their full time and energy with no buying responsibilities, to point the way to opportunities for better value. With the proper support of management, such a specialist group within the purchasing area serves a very essential function: the analyzing of each dollar spent to make certain it buys Value. The results of these value studies are directed to management in the form of a suggestion for action by persons responsible for product design, manufacture or procurement. Value Specialists do not implement, they spend full time spotlighting opportunities for lower cost. Most progressive companies are establishing programs of this type to better help them meet competition. It is absolutely essential that American industry devote more energy to reducing costs if they are to meet the increasing challenge from foreign goods. With proper use of Value Analysis by competent people, it has been shown time and time again that from 25% to 75% of costs can be removed. High or low volume business, these techniques are equally effective. For instance, at Raytheon Company a recent four-man, five-week value analysis team study in the Receiving Tube Division resulted in 66 proposals for better value with $685,000 a year potential savings. $210,000 a year savings were achieved; a better than 20 to 1 return for the effort. In Raytheon's Government Equipment Division, a four-week Value Analysis Task Force effort showed opportunities for a 30% reduction in product cost.

To be most effective, Value Analysis must operate as a teamwork effort in all areas of business, purchasing, engineering and manufacturing. Wherever you turn, there are opportunities for better value if you look for them. Value Analysis and Standardization can help cut down those $100 shoe bills.

Talk given by F. S. Sherwin at New England Purchasing Conference, Providence, Rhode Island, on October 22, 1958.

Reason for these sessions.

I Need for V.A.
- Competition
- More Mil Equip.
- Product Complexity
- Split Responsibility for Cost

II History of V.A.
- G.E.
- Navy.
- Industry.

III What is V.A.
- Package.

Organized use.

IV Two ways V.A. Help Ranch
1. Techniques
2. V.A. Specialists.

V Unnecessary Costs — 5 Reasons.

VI ~~Job Plan~~ — Value —
Examples

VII Function —
Examples.

VIII Job Plan. Techniques —

MILITARY SPECIFICATION

# VALUE ENGINEERING OF NAVAL ELECTRONIC EQUIPMENT

## 1. SCOPE

1.1 This specification covers the study and evaluation of the design and manufacture of a particular electronic equipment or system (hereinafter referred to as the "equipment"). This includes an intensive and critical review of the operational and maintenance requirements, specifications, design, manufacturing processes, materials, inspections, and testing by the contractor of the equipment to determine the minimum functions and parts, and the least expensive materials, processes, and procedures necessary to produce a functional, maintainable and reliable equipment. It is intended that the total cost of the equipment be reduced without adversely affecting the essential characteristics.

## 2. APPLICABLE DOCUMENTS

2.1 Not applicable.

## 3. REQUIREMENTS

3.1 Definitions. - For purposes of this specification the following definitions shall apply:

3.1.1 Value engineering study. - An objective appraisal of all elements of the design, construction, procurement, installation and maintenance of an equipment, including the applicable equipment specifications, in order to achieve necessary functions, maintainability and reliability of an equipment at minimum cost.

3.1.2 Value engineering specialists. - Competent engineers and other personnel of the contractor's staff who conduct a value engineering study. A value engineering specialist should have the ability to relate the design of an equipment to its total costs as defined herein and to promote value engineering proposals to reduce the total costs. Preferably, the value engineering specialist shall not have participated in the original design if such participation would hinder him from making proposals for change.

3.1.3 Value engineering proposals. - Proposed changes, supported by factual technical and cost data, which result from a value engineering study. An acceptable form for the submission of value engineering proposals is shown in APPENDIX I.

3.1.4 Essential characteristics. - Characteristics of an equipment representing the minimum operational, functional, maintenance and reliability needs of the user which must be fulfilled.

3.1.5 Desirable characteristics. - Characteristics which are not essential but improve performance, reliability or maintainability without excessive cost or complexity.

3.1.6 Undesirable characteristics. - Characteristics which are not essential and which will result in unduly high cost or complexity, or will degrade the essential characteristics. Specifications may contain undesirable characteristics which are apparent only after the complexity of the design and total costs involved are established by the contractor.

3.1.7 Contractor costs. - Allowable costs as defined in Armed Services Procurement Regulations, Chapter XV, which represent the total unit price of a complete production equipment, including packaging, maintenance parts, accessories and technical manuals delivered at the contractor's plant.

3.1.8 Supporting costs. - Costs which represent the operating, installation, supply and maintenance expense to the user, estimated for the useful life of the equipment.

3.1.9 Total costs. - Combined contractor and supporting costs.

3.1.10 Maintenance. - The servicing, adjustment and repair of an equipment at the operating location, a repair ship or repair activity ashore, with consideration for the environment in which performed.

3.1.11 Test points. - Terminals located in various accessible locations of the equipment which enable the observation and measurement of electrical parameters in order that adjustments or repair of the equipment may be facilitated.

3.2 General. - The contractor shall fulfill the objectives of the contract as follows:

3.2.1 Performance. -

3.2.1.1 The contractor shall use his best efforts to utilize value engineering specialists as defined in paragraph 3.1.2, who shall be assisted, as necessary, by other personnel of the contractor's organization to enable them to perform effectively.

3.2.1.2 The contractor shall confer with the bureau or agency concerned as specified in the contract schedule on the operational, design and maintenance requirements of the equipment under study and on the techniques of value engineering.

3.2.1.3 The contractor shall maintain contact, as practicable, with other organizations, manufacturers and suppliers to become familiar with new methods, processes and products applicable in their performance under the contract.

3.2.2 Value engineering study. - The contractor shall perform a value engineering study of the equipment specified in the contract or order and the equipment specifications, and shall submit value engineering proposals, where possible, to accomplish a maximum reduction in the total costs of the production version of the equipment without loss of any of its essential characteristics. The value engineering study shall cover but shall not be limited to, the following:

3.2.2.1 Contractor cost reductions. -

3.2.2.1.1 General. - Value engineering proposals resulting from the value engineering study in this area shall not cause an increase in the supporting costs to the extent that the total costs are thereby increased.

3.2.2.1.2 Excess functions. - The contractor shall submit value engineering proposals to eliminate controls, functions and circuits which will be utilized in only a few operating locations of the equipment or which will duplicate functions of ancillary equipment normally available at most operating locations. However, such value engineering proposals shall include recommendations for methods of fulfilling the requirement of the equipment at those few locations referred to herein in the absence of any controls, functions or circuits eliminated by the proposal.

3.2.2.1.3 Tolerances and technical requirements. - Excessive "safety" margins incorporated in the equipment and any tolerances or technical requirements in the equipment specifications, which do not provide essential or desirable characteristics shall be eliminated.

3.2.2.1.4 Parts and materials. - Equipment parts and material lists shall be reviewed by the contractor so that economies, if possible, may be effected by substitution or elimination of certain parts or materials.

3.2.2.1.5 Circuit redesign. - The contractor shall investigate the use of different circuitry from that used in the equipment under study to simplify units and sub-units.

3.2.2.1.6 Mechanical design. - The contractor shall investigate the mechanical design and arrangement of the equipment, including sub-assemblies, and the use of standard hardware in order to simplify the fabrication of the equipment.

3.2.2.1.7 Production processes. - The contractor shall investigate methods of assembly, processing and tooling, for example, extrusion techniques, precision casting, plastic molding, printed wiring and circuits, and automation, which will reduce the contractor costs, and shall submit value engineering proposals which will permit the use of these methods, provided that these methods will not materially limit the supply sources for the equipment.

3.2.2.1.8 Patented items. - Consideration shall be given to the use of patented circuits, parts, devices and processes if a saving in total cost, with royalty fees included, will result or the increased reliability or maintainability will justify any additional cost.

3.2.2.2 Supporting cost reductions. -

3.2.2.2.1 General. - Value engineering proposals to reduce supporting costs shall be submitted by the contractor even though an increase in contractor costs results, where it can be shown that the total costs will be reduced.

3.2.2.2.2 Reliability. - The contractor shall submit value engineering proposals which will provide longer trouble-free operation of the equipment in keeping with the essential characteristics.

3.2.2.2.3 Ease of maintenance. - The entire equipment design shall be reviewed by the contractor to determine ways and means by which maintenance may be facilitated and reduced. Each unit, sub-assembly and major assembly of the equipment shall be examined and value engineering proposals submitted, if possible, to simplify the replacement of parts and units. The inclusion of test points not present in the equipment under consideration and elimination of unnecessary test points shall be studied. Self-testing and marginal testing features shall be investigated by the contractor. (See 3.2.2.1.2).

3.2.3 Value engineering proposals.

3.2.3.1 Wherever a saving in the total costs of the equipment is discovered in the performance of this contract, such shall be submitted in a value engineering proposal by the contractor to the bureau or agency concerned.

3.2.3.2 Supporting data. - The contractor's value engineering proposals involving major design change changes, abridgement of performance requirements, or the introduction of parts and materials not specified in the equipment specifications and standards shall be supported by circuitry, test data and test procedures verifying the statements of item 4 of APPENDIX I.

3.2.3.3 Each value engineering proposal submitted will be reviewed by the bureau or agency concerned and comment or approval will be forwarded to the contractor in approximately 30 days after receipt thereof. Proposed equipment changes involving a change in specifications, price, delivery or other contract requirements shall not be made until authorized by the contracting officer.

3.3 Tests. -

3.3.1 Tests necessary because of the requirements of this specification shall be in accordance with the equipment specification and any amendments or modifications resulting from approved value engineering proposals.

3.3.2 Unless otherwise authorized by the bureau or agency concerned, and performance criteria for evaluating the equipment performance after value engineering changes shall be the same as those used in the evaluation of the prior design.

3.3.3 Test equipment. - Available commercial and military test equipment shall be used to the greatest practical extent in evaluating equipment performance. Special test equipment shall be developed only when specifically authorized by the Bureau of Ships.

4. QUALITY ASSURANCE PROVISIONS

4.1 Not applicable.

5. PREPARATION FOR DELIVERY

5.1 Not applicable.

6. NOTES

6.1 Not applicable.

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Preparing activity:
Navy - Bureau of Ships

APPENDIX I

VALUE ENGINEERING PROPOSAL

Value Engineering Proposal #_____ Date:_____

Contract_____

Contractor _____

_____

Equipment Nomenclatures

_____

1. Brief description of proposal:

2. Type of change: (check one or more as appropriate):

   (a) Manufacturing process _____

   (b) Substitution of parts or units _____

   (c) Circuitry _____

   (d) Tests _____

   (e) Other (identify) _____

3. Circuits, units and parts involved: (Give nomenclature, circuit symbol and part numbers):

4. Does proposed change deviate from equipment specifications? _____

   If answer is yes, answer (a), (b) and (c) below.

   (a) List specifications changes required.

   (b) Describe effect on equipment.

      (1) Physical

      (2) Performance

   (c) Explain why conformance to specifications is not essential in this instance.

   (d) Submit supporting data as specified in 3. 2. 3. 2

5. Would adoption of this proposal make the equipment more reliable? If so, explain in terms of mean-time-to-failure or ratio of on-time to total time (on-time plus down-time) or decrease in down-time

6. Other beneficial effects of the proposal. (Check)

(a) Eliminates proprietary items _____

(b) Expedites production _____

(c) Reduces cost of maintenance parts _____

(d) Reduces labor required for diagnosis of trouble, replacement of parts, adjustments and repair _____

(e) Reduces or simplifies training of operating and maintenance personnel _____

(f) Eliminates or conserves the use of critical material _____

(g) Other (explain) _____

7. Is the acceptance of this proposal contingent on the acceptance of any other value engineering proposals? Which ones?

SAMPLE

COST DATA SHEET

Proposal will result in cost change as indicated:

Contractor costs:

Labor costs

| | Present hours per unit | Increase(+) or decrease(-) | (+) Unit (-) hours | Rate per hour | Price change per unit |
|---|---|---|---|---|---|
| Circuitry engineering | | | | | |
| Drafting | | | | | |
| Lab technicians | | | | | |
| Parts fabrication | 20.0 | - | 2.0 | 1.75 | 3.50 |
| Sub-assemblies | | | | | |
| Production assembly | | | | | |
| Production test | | | | | |
| Packing and packaging | | | | | |
| Other _____ | | | | | |

Material costs

| | Present unit cost | Increase(+) or decrease(-) | Unit estimate |
|---|---|---|---|
| Purchased parts | 7.50 | + | 1.10 |
| Raw material | | | |
| Dies/forming jigs | | | |

| Support costs: | Present unit cost or hours | Increase(+) decrease(-) | Unit estimate | Unit hours | Class labor | rate |
|---|---|---|---|---|---|---|
| Installation | | | | | | |
| Parts and material | | | | XXX | XXX | XXX |
| Labor | | | XXX | | | |
| Maintenance | | | | | | |
| Parts and material | | | | XXX | XXX | XXX |
| Labor | | | XXX | | | |
| Operator labor | | | XXX | | | |

Bureau of Ships
17 June 1959

SPECIFICATIONS FOR VALUE ENGINEERING PROGRAM

1. Purpose

The purpose of the value engineering program is to promote the development and application of design and engineering studies which will result in lowering the cost of construction to the Government without impairing any of the essential characteristics of the vessel. The performance of these studies envisages an intensive and critical review of all elements of design, manufacturing, purchasing, inspection and operational requirements to determine that only necessary materials and functions are utilized and that these are supplied at the minimum cost consistent with the construction of a thoroughly sound ship and the preservation of essential operation and maintenance characteristics. This shall not result in the loss or impairment of any required function. In many instances it is expected that the studies will produce, at lower cost, a better functioning product, with an actual improvement in service life.

2. Value Engineering Staff

(a) The Contractor shall employ such value engineering specialists as are required by the contract for the period of time specified in the contract. These value engineers shall be supported by such technical, industrial and clerical personnel of the contractor's organization as are necessary to enable these value engineers to effectively perform the purpose of the value engineering program. The value engineers shall receive such training as the Bureau of Ships deems necessary for the effective performance of this program and shall participate in other activities considered by the Bureau to be useful for their training.

(b) The Contractor may, at its own expense, furnish additional value engineering specialists in support of this program.

(c) The value engineers shall maintain such contact with other organizations as may be necessary to become familiar with new products and processes.

(d) Unless otherwise specified in the contract, the contractor shall maintain close liaison with the value engineering representative of the office of the cognizant Supervisor of Shipbuilding.

3. Scope of Investigations

The investigations to be performed by the value engineering specialists shall be directed to those areas where cost savings cannot be effected unless the contract plans and specifications are modified by the Government. The scope of investigation includes every element of equipment, materials, production processes, purchasing, inspection, installation and use. Commercial sources, products, processes and requirements for similar use are to be analyzed and compared to Navy practice, in order to determine whether Navy departures from commercial practice where increased cost is involved are justifiable and whether the substitution of commercial materials or procedures would result in lower cost without reduction of quality or impairment of essential functioning and military serviceability.

4. Presentation of Completed Studies

(a) Each value engineering investigation determined by the shipbuilder to be desirable and appropriate for submission shall be presented on Value Engineering Report Form NAVSHIPS 4629 (9-55). This completed study must be of such nature and presented in such form that it may readily, if accepted by the Bureau, be formulated as a decrease cost change order under this contract and other contracts for similar vessels, or as a revision in the specifications for future contracts. Plans, specifications and any other supporting data necessary to permit analysis by the Bureau with a minimum expenditure for design and engineering services shall accompany the Form. It is not intended that formal plans be prepared specifically for these studies but that speed in preparation and presentation of the studies be promoted by effective use of mark-ups on existing blueprints and sketches wherever feasible. The completed study should compare the proposal in all respects with the present practice in order to demonstrate in full all advantages and disadvantages and to establish the anticipated cost differential.

(b) Studies shall avoid recommendations of products or processes restrictive to one manufacturer unless this is the only means by which the cost reduction can be effectively achieved.

(c) All studies and related data are to be submitted via the cognizant Supervisor of Shipbuilding. One copy of Form 4629 shall be submitted directly to the Bureau and one reproducible copy of such Form to the Supervisor of Shipbuilding. The Bureau will obtain the comments of the Supervisor, design activity and other interested activities. Additional information, if required for adequate analysis of the completed study, shall be submitted by the Contractor upon request of the Government.

5. Reports

The Contractor shall, upon preliminary acceptance of the last vessel under the contract, submit a report in triplicate via the Supervisor of Shipbuilding covering all value engineering studies made with respect to each vessel under the contract. The report shall list all investigations made, the status of such investigations, and the reasons for the discontinuance of any such investigation, and shall summarize actions taken. Ideas considered but not investigated shall also be listed together with the reasons why they were not investigated. The Contractor shall submit such information and data as may have been compiled with respect to the investigations as may be requested by the Bureau of Ships.

COPIED FROM THE BUREAU OF SHIPS JOURNAL
September 1958

## A MESSAGE FROM THE CHIEF

In a recent speech Admiral Arleigh Burke, USN, Chief of Naval Operations, has pinpointed the nature of the challenge facing the nation today. His remarks apply in some measure to each of us.

"We are living in a competitive world," Admiral Burke said. "The very basic way of American life - competition - is what has made us strong.... The United States reached its position of primacy in the world because it was able to meet the world's best competition - and beat it."

This pre-eminence stems not only from competition with foreign nations, but also from friendly competition among ourselves. The competitive spirit is a stimulus to greater achievements by the Bureau and its field activities in serving the Fleet. Competition is also an important means by which we strive to reduce ship costs. We actively encourage the maximum number of qualified contractors to compete for Bureau contract awards. Those contractors who constantly forge ahead in technological innovation and production efficiency can expect to be most successful in obtaining Navy work. Rising ship costs, caused partly by increases in labor and material costs and partly by complex and costly technological advances can thus be offset to some extent by economies obtainable through competition.

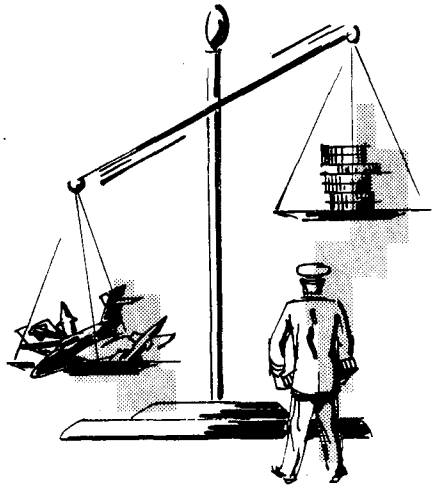
Our country is presently confronted, from abroad, with the stiffest competition we have ever faced. There is now, as never before, a critical necessity for reducing costs and improving efficiency. We were forced to cancel seven much needed ships in our current building program. Our ability to hold the line against rising costs will determine to a large degree the number of ships we can add to the Fleet in future years. This is a job we will have to work at constantly. As Admiral Burke points out, we are in first place in the world, but, "To stay there we will have to retain those qualities that got us there in the first place - mostly hard work."

/s/ A. G. MUMMA

4/11/61

# Value Analysis and Navy's Air Weapons

***The need for more value per dollar is no longer simply good management—it is an absolute necessity, dictated by rising costs and a level budget This is how Navy's Bureau of Aeronautics is combating the problem —with an organized, across-the-board effort.***



**By RAdm. Robert E. Dixon, USN**
*Chief, Bureau of Aeronautics*

THE INCREASING complexity and enhanced fighting power of modern weapons do not come at low cost. With few exceptions, each new weapon introduced to the Fleet is more expensive, more complicated and more difficult to maintain and operate than the one it replaces.

Cost reduction in airplane and guided missile programs has long been and continues to be of prime importance to the Navy. We must always keep within budget limits and at the same time keep pace with new developments. In pursuing these ends, we in the Navy's Bureau of Aeronautics continually strive through our Research and Development, Production, Maintenance, Contracts and other divisions to attain all practical economies consistent with production of superior Naval air weapons.

In a recent effort to get things done more economically, and promote a still higher regard among our people for what funds we have to spend, the Bureau has adopted what I term "a more vigorous approach to more planes for less dollars." This stepped-up concept we call Value Analysis to differentiate from BuAer's normal evaluation approaches to value buying. Through a formal program, by incorporating value analysis in the Bureau's contracts on a selective basis, we hope to avoid being pressed to the wall by inflationary prices.

Value analysis has been practiced formally for several years. The goal throughout the military has always been to get a better buy for every dollar. What was needed was a new approach—organized to emphasize particular aspects of value through special analysis techniques and organizational devices. The new concept requires the creative skepticism that is present in every first-rate purchasing man, the mechanical ingenuity of the top aeronautical engineer, and their melding with manufacturer capabilities. A concerted program for value buying began in industry about 1947, and in the Navy with the Bureau of Ships in 1954. The Bureau of Ordnance and the Bureau of Supplies and Accounts recently instituted similar programs.

A value analysis presentation was made to me in July, 1958, by representatives of Bureau of Ships. I was very much impressed by the results they had obtained by investigating dollar-value buying of ships hardware. After much study and searching review of other methods to combat high costs, I was convinced that a planned, intensive value analysis program could be applied constructively to BuAer procurement. I thought we should go a step beyond and apply it to weapons while still in the design and development stage. It is in this phase that applying cost reduction principles is most rewarding, and the savings gained continue through the life cycle of the weapon.

A formal Value Analysis Committee, to serve as review and evaluation group for the Bureau of Aeronautics, was set up in October, 1958. Logically, its Chairman is the Director of the Contracts Division, Capt. Thomas D. Davies.

Permanent members and division representatives on the Committee include officers and engineers from the Office of Assistant Chief for Research and Development; Office of the Systems Director; and the Production, Power Plants, Aircraft, Guided Missiles, Avionics, Airborne Equipment and Maintenance Divisions. Each division representative is responsible for keeping project engineers in his division fully informed on the progress of pertinent value analysis projects, and for working closely with them in actually applying the concept.

The functions and authority of the Committee are these:

a. To initiate specific value analysis projects where feasible.

b. To assign detailed value analysis work to Bureau technical personnel.

c. To evaluate analysis suggestions from all sources and recommend to me, as Bureau Chief, adoption and implementation of those it approves.

d. To direct the work of the Committee to evaluating cost reduction recommendations proposed by industry and to a value analysis review of Bureau generated specifications. Secondly, to conduct a value analysis of selected hardware items under Bureau cognizance.

The Committee actually has a two-phased operation: (1) value analysis through a formal contracting technique in BuAer procurement; and (2) specialized treatment of value analysis ideas suggested by designers and aeronautical engineers in research and development, and by other sources.

The scope of the BuAer Value Analysis Committee encompasses all naval aviation weapons, equipment, components and parts. Design and en-

gineering studies under the program envisage an intensive and critical review of all elements of BuAer controlled equipment, materials, design, development, production processes, purchasing, inspection, installation, use and management. Commercial sources, products, processes and requirements for similar use are analyzed and compared to Navy practice to determine if Navy departures from commercial practice where increased cost is involved are justifiable, or if commercial materials or procedures would result in lower cost without reducing quality or impairing essential functions and military serviceability.

A Contracts Study Group, reporting to the Committee Chairman, was set up in the Contracts Division early in the program. It evaluated the concept as it is applied to contracts, and now is getting such a program into full swing in the Contracts Division. This group prepares data for discussion at Committee meetings, and keeps things moving in line with the Committee decisions.

The Study Group can organize subtask groups as needed to examine various aspects of the over-all problem in a given case. The group also, at times, seeks advice from outside sources, and uses industrial consultants as needed.

## Working with Industry

The Contracts Division is now formulating standard guides and procedures for our contract negotiators to use in applying value analysis to BuAer contracts.

Contractors are an integral part of the BuAer value analysis team. Policies under the program, sound decisions, effective procedures and controls—all depend on vendor cooperation and performance, and must be worked out in agreement with them.

Capt. Davies has reported to me that the Value Analysis Committee meetings promote closer liaison between negotiators and engineers. The BuAer engineers also visit contractor's plants and company representatives visit BuAer facilities to help iron out any bugs in the program. This adds up to a better understanding by all hands of the need to apply the value analysis concept in the earliest phases of design and development. The importance of interchanging information cannot be overemphasized. In practice, the more closely this pattern is followed, the bigger the payoff.

The plus values of active cooperation in value buying may be even more important. The Committee Chairman and individual members of the Value Analysis Committee have discussed in broad terms with several manufacturers the present BuAer approach to value analysis. The majority have appeared enthusiastic, and many have welcomed the opportunity to participate.

Without doubt, the Bureau of Aeronautics is sold on the Committee approach to value analysis as the quickest means of disseminating value buying ideas in the Bureau. Also, through this means we get the best thinking of people working most closely with the problems.

The Value Analysis Committee meets monthly, and oftener if a hot project warrants it. The atmosphere is informal. The only Committee rules have been set by the Chairman:

1. To create and pursue ideas actively.

2. To provide leadership in value analysis in all areas of operation, particularly where the breaking down tradition is required.

3. To make all hands in BuAer aware of costs.

4. To interest contractors in negotiating value analysis clauses in their contracts, in operating as the program is envisioned, and in assuming leadership with their subcontractors in promoting dollar savings.

The prime Committee mission is encouragement and introduction of the concept of value analysis as a team operation, mutually beneficial to Navy and industry. It aims at Bureau and company-wide cooperation to create better value buying. It also strives to bring about BuAer-industry understanding of realistic requirements, simplified specifications, and reduction of voluminous paper work that can engulf a program to no useful purpose.

Our current concentrated value analysis program is generally similar to a less formal value engineering system which has always been necessary to BuAir philosophy. It differs only in that it is handled as a planned, active program with a Value Analysis Committee to coordinate and direct all Bureau effort.

Actually, there are two phases in the Bureau's current approach: (1) as applied to procurement; and (2) as applied in research and development.

1. Under the procurement phase, the Contracts Study Group first investigated to find out where value analysis could be applied most effectively to new and existing contracts. For production-type procurement, it was found that firm fixed price contracts are most suitable. However, most high dollar procurement in BuAer is placed under incentive fixed price contracts.

Inherent in these contracts are many aspects of cost reduction used in value analysis, since the contractor shares in savings realized by effective operations. Notwithstanding, the investigation revealed that there are other areas susceptible to cost reduction under the incentive type contract which would not disturb the incentive sharing arrangement already established. The Study Group has drafted appropriate contractual language for both firm and incentive fixed price contracts.

Essentially, this is the procedure for value analysis in fixed price contracts covering production procurement: (1) The contractor submits value analysis proposals suggesting modifications requiring Contractor Officer approval, which would result in less costly articles without adversely affecting function, quality or reliability; (2) Under fixed price contracts, the contractor shares in a percentage of the savings generated by his cost reduction proposals. The percentage is negotiated when the value analysis clause is incorporated in a contract; (3) Under incentive contracts, the contractor also shares in savings through means of a negotiated percentage. But due to the built-in cost reduction program in this type of contract, the contractor's share of savings is set aside as additional compensation beyond the incentive clause, and is not subject to price redetermination.

As an instance of procurement application, negotiations between the Study Group and the McDonnell Aircraft Corporation resulted in the first value analysis amendment to a BuAer production contract. The amendment followed preliminary studies designed to gain Government savings without decreasing aircraft performance or reliability. The original $61.8 million F4H fighter production contract was executed in March, 1959.

## Why Letter Contracts?

When applying value analysis to BuAer contracts was first considered by the Study Group, there were reservations regarding the practicability of the concept in Letter Contracts, because of unknown elements inherent in this type of contract. However, much major procurement susceptible to value analysis is under Letter Contract, and unless such a program begins at the inception of the contract, substantial savings may be lost.

Further evaluation by the Study Group showed that a more effective plan was possible by extending the program to Letter Contracts. The Committee Chairman was briefed, and was receptive to the idea. The group then began work on the necessary details and on suitable contractual language to implement the undertaking.

2. In the research and development

*(Continued on page 38)*

## *Value Analysis in BuAer . . .*

*(continued from page 19)*

ea, value analysis applies to either the fixed price or cost type contract. Pursuing this thought, in June, 1959, the Bureau signed its first development contract calling for value analysis. The cost type contract, for $508,190, is with Westinghouse Electric Company for airborne radar target simulators. It carries a clause calling for the contractor to conduct a value analysis study at its plant in Baltimore, supplemental to the overall development project. By including value analysis in this type of contract, I feel we can reduce costs at an early stage, before the item goes into production, and save substantial sums.

The objectives of the work to be performed under the analysis clause are: (a) to reduce costs to the bare minimum by applying strict cost preventive and cost reduction effort, without sacrificing essential functions; and (b) to guide planning for development of the simulator towards minimum cost for ensuing production, so that total production cost, plus operational maintenance and logistic support costs shall be the lowest consistent with meeting essential equipment functions.

Continuing engineering effort in research and development areas uses methods virtually the same as those used before by BuAer and by other Bureaus and industry. They are focused on basic questions which can be asked about any product or process: What is its function? Is it necessary? Do performance specifications fit the job? What does it cost? Where can engineering and manufacturing costs be reduced? Would a cheaper alternate item do the job? What does the alternate cost? What other suppliers should be contacted to give a different approach to design? What other possibilities are there for reliably accomplishing functions at lower cost such as simplified design or assembly, or reduced weight? Will proposed changes advance the state of the art? What risks are there in changing design to reduce costs?

The answers to these questions show whether dollar buying is economical for the item analyzed. Results of the engineer's value analysis can be intangible, as when a design is screened before it gets beyond the drawing board. Primary benefits can come from having a contractor question Bureau specifications, particularly where the specification, in his opinion is inadequate. Other typical examples are where old specifications, written for the aircraft industry cause overdesigning guided missile components with resultant increase in costs; and where design re-evaluations and modifications produce considerable cost reductions.

Since the Bureau's Program began, I am conscious of more general awareness of value buying throughout the organization. However, the dollar saving changes required for a successful program entail considerable time and effort. They involve design, production and supply details. They require close collaboration among the various divisions of the Bureau and the manufacturer. Changes must be tailored to each case analyzed. As weapons systems costs increase, I believe organized value analysis in all phases of the BuAer research and development program will be of increasing importance. To keep costs within reasonable bounds, we must find all available ways and means to minimize expenses, and to inrease dollar value in our buying.

Wherever feasible, aeronautical equipment specifications are being waived or changed when significant dollar savings will accrue, and when the Navy will get equipment with equal functions. This effort is a continuing one.

In proposing a value analysis project, the committee has tried to pick out expensive and/or high-volume items that can pay off in substantial savings. It is soliciting aid from all sources in its search for better value in future materials and equipment. It is particularly interested in information from material, parts and equipment suppliers about poor value areas in BuAer specifications and standards requiring study or corrective action. Consideration also is being given to suggestions for follow-on contracts which could result in savings where it is impractical to incorporate the change in the existing procurement.

While the Value Analysis Program has progressed satisfactorily, I expect it to accelerate considerably in the coming months. To accomplish this, joint Navy-industry action is needed. The contracts I have mentioned above, with McDonnell and Westinghouse, are the first concrete actions under the new program. The Bureau is negotiating with other manufacturers on inserting value analysis clauses in existing [illegible] procurement contracts. The [illegible].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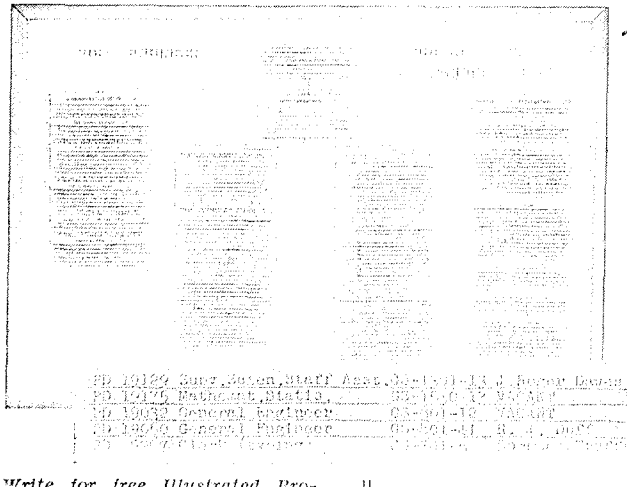

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A case history study of a typical military project. Examples are given of changes where (1) specification changes were required and (2) where specs were not required to be changed.

# Value Engineering of Military Equipment—A Case History

**Albert Sikorsky**
Bureau of Ships, U.S. Navy

and

**J. B. Singel**
Westinghouse Electric Corp.
Baltimore, Md.

**Incentives for Contractors**

". . . Those contractors who constantly forge ahead in technological innovation and production efficiency can expect to be most successful in obtaining Navy work . . . There is now, as never before, a critical necessity for reducing costs and improving efficiency."—Rear Admiral A. G. Mumma, USN, Chief, Bureau of Ships.

". . . We suggest that the Navy ask its contractors having contracts of this type to inform us of that fact in renegotiation proceedings, and to be prepared to describe and document their value engineering accomplishments thereunder. This will enable us to explore the matter fully in each individual case, obtaining from the Navy pertinent facts and opinions through the performance reporting procedures already established between our agencies.

"Having developed the facts in each case, all due consideration will be given thereto under the statutory factors in the determination of the case. As you know, the factors in the law are quite comprehensive of this type on the part of defense contractors."—Thomas Coggeshall, Chairman, The Renegotiation Board.

VALUE engineering studies by Westinghouse on the Navy WRT-1 and 2 communications transmitter resulted in huge savings. When applied to the design and specifications, the proposals will save over $3 million in future procurement. These first few examples illustrate value engineering proposals where specifications had to be changed. These results are presented in condensed form, and represent only a small fraction of the total investigation done on each item.

### Lifting Eyes

Lifting eyes (Fig. 1) used only during installation and removal have always been provided with equipment. Yet, these same lifting eyes are standard items carried by professional rigging crews that hustle the equipment from the dock to point of installation aboard ship. Eyes were packed in a bag attached to the equipment when shipped.

More often than not, the rigger uses his own lifting devices or resorts to other types of carrying cradles. Their elimination is hardly noticed. Cost of each eye is small, yet, total saving on future procurement runs to $20,000.

### Two-Piece Frame

In Fig. 2, hand points to split in frame which is characteristic of the two-piece assembly of transmitter that is to be installed in submarines. Disassembly into two pieces enables the transmitter to go through submarine hatch and down into compartment where it is finally installed. This particular equipment was originally intended for both submarines and surface vessels.

Later on, it was decided to use a different equipment for submarines and use this one for surface vessels only. Since design was already suitable for surface vessels, no changes were contemplated until value engineering team at Westinghouse put the spotlight on this feature. Redesign to a one-piece frame now saves $130.00 per equipment.

### Drop MIL Spec

Transformers and chokes (Fig. 3) required obtaining qualification approval to MIL-T-27A. Since a large number of the same type transformers and chokes have already been installed on other military equipment and are performing satisfactorily, the value engineering team suggested the deletion of the qualification test requirement.

Furthermore, these transformers are tested as part of the over-all performance and durability tests of the pre-production and production equipments. Bureau project engineers, who had been looking at this requirement critically for some time, took quick action to approve the proposal and are now looking at the prospect of applying the idea to a much broader area. The resulting savings of $16,293 on this contract alone gives them justification to do this.

### Nonessential Extras

Items that were eliminated as nonessential result in savings of more than $1/4 million in future procurement of transmitters. Cam latch (Fig. 4) was installed on development model as a "fix" to give extra leverage when securing drawer assembly to frame. This was needed on the development model because tolerances were not too well maintained in the early model. In

**Fig. 1.** Value engineers found that these lifting eyelets weren't needed.

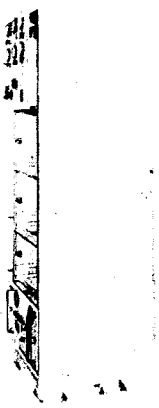


**Fig. 2.** This two-piece cabinet design, made to facilitate installation in submarines was eliminated when the units were allocated to surface ship use only.

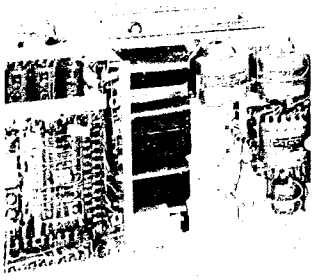


**Fig. 3.** Expensive testing to MIL specs was avoided after investigation showed these units had performed to specs in other equipment.

production version, units slide in and out with more positive action because of better quality control.

The latches would have gone unnoticed however, until value engineering team put the "unnecessary cost" spotlight on them. Their elimination not only saved money but got rid of a safety hazard as well. The latches would strike down when unit was slammed into frame and gashed hands and fingers that were in the way.

The filament on the time meter (Fig. 5) was eliminated as an unnecessary embellishment. The running time meter on the right in Fig. 5 was considered adequate since life of the tubes is based primarily on the length of time high voltage has been applied rather than duration of the filament supply voltage which meter to the left indicated.

Left in Fig. 6 is a tool kit of standard Allen wrenches and one special tool formerly supplied. Now, only the special tool is supplied with a simple retaining clip, as shown to the right.

### Spec Changes Not Always Needed

Following are a few examples not requiring specification changes. When and if any of these items are implemented depends on the scheduling of the various stages of engineering, drafting, and manufacture which ultimately depend on the schedule delivery date. Some items effect substantial cost reduction, whereas others save only a nominal sum.

### Machined Casting vs Machined Plate

A bearing plate was needed as part of the mechanism for rotating the equipment drawers to provide fast and easy maintenance by always working from the top. The design called for the plate blank to be cut from a large 7/8 in. thick aluminum sheet and then "hogged out" and machined to final dimensions. The value engineering group's investigation disclosed that a saving of about $10.00 would result if the plate were machined from a casting. This includes amortizing the cost of the pattern.

### Machined Thumbnut vs Wingnut

The drawers of the equipment under study are moved in and out on slides on which the rotating mechanism is mounted. When closed, a drawer is held in place by means of a latch beneath the drawer, but the final tight takeup to prevent leakage radiation is made by means of the wingnuts. A small item, but perhaps not so small when one considers that one equipment contains 32 pieces.

Fig. 7 shows five different fasteners which were considered. The large one on the left is the most expensive, and the small one on the right is the least expensive, with numbers 3 and 4 being almost the same price. The wingnut, second from the left, is the one called for by the manufacturing information. The design calls for machining the stem from stainless steel and welding it to a wing blank purchased from a vendor. The wing it then given a rubberized finish. In a finger tightening comparison between numbers 2 and 4, number 4 could be tightened as tightly as number 2, and could be made extremely tight, of course, by the use of a screwdriver. The elimination of the wings also gives more finger clearance when grasping the drawer handles. Number 4 is made on an automatic screw machine from stainless steel rod and has a cost of about $1.00. Number 5 was considered inadequate.

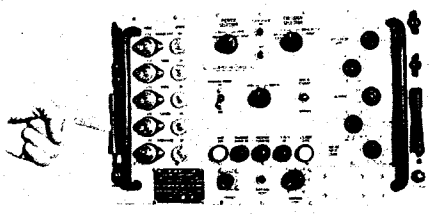


**Fig. 4.** Handle latch, needed on developmental models, was eliminated on production models when closer tolerances were held.

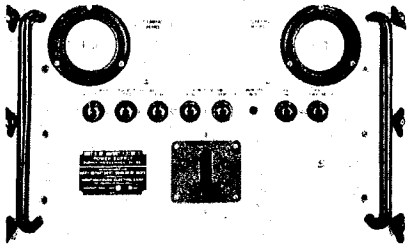


**Fig. 5.** Filament on time meter function was being duplicated by running time meter (right). It was eliminated.

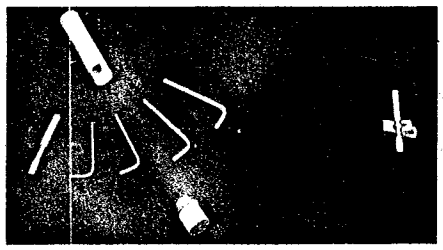


**Fig. 6.** Tool kit was simplified by substituting set of wrenches (left) with special tool (right).

## VALUE ENGINEERING

### Smaller Cable

In the equipment under investigation shielder cables are of the RG-62/U variety and due to their size as well as the size of their connectors cause some congestion in several places. In the cable helix, (Fig. 8), the use of the smaller cable will reduce the "wear" on the cable group and thereby promote reliability. Easier servicing of the helix as well as drawer units is also a resultant benefit of the smaller cable.

No appreciable change in impedance is involved since the smaller cable has very nearly the same rf resistance, capacitance, and inductance. The voltage rating is more than adequate. Consequently, no circuits are affected electrically. In the implementation of the smaller cable, the benefits dervied were deemed to be sufficiently worthwhile to increase the cost by approximately $12.00 per equipment.

### Grommets—Metal or Rubber

A cable group, passing through a notch in the chassis was protected by a metal grommet. To the value engineering group, it appeared that the metal grommet was very likely far more expensive than a rubber grommet. An investigation disclosed that to construct the metal grommet the following operations were usually required: Shear to size, mill the small notch, mill the radius slot, drill mounting holes, tap mounting holes, tumble to remove rough edges, and apply finish. Deducting implementation costs such as changing manufacturing information and accounting for the cost of the rubber grommet, the net saving approximates fifty cents per grommet.

### Tube Shield Finish

This example illustrates, in a small way, how a cost reduction can be made by using a vendors

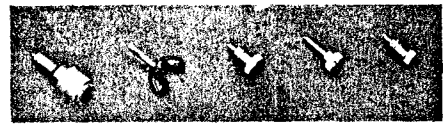


**Fig. 7.** Economics of manufacturing of these thumbscrews showed that the second from the right was least expensive and could perform same functions as any of the others.

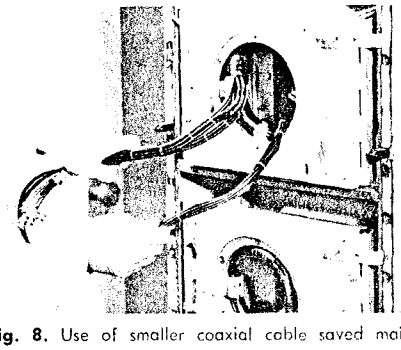


**Fig. 8.** Use of smaller coaxial cable saved maintenance costs by reducing wear and permitting easier servicing.

product. Fig. 8 shows a small portion of one drawer in which several miniature tubes are mounted and covered with tube shields. The tube shield, of course, is mainly to provide electrostatic shielding, but its black paint provides corrosion resistance as well as improved heat dissipation by means of radiation. In tests conducted by the Material and Standard Engineering Section on painted tube shields purchased from a vendor, it was indicated that the vendor's shields met the requirements of the appropriate *MIL-STD Specification for corrosion* resistance, and the ability to radiate thermal energy was equal or superior to the finish applied locally.

Accordingly it was deemed worthwhile to purchase tube shields that were already painted instead of buying them unpainted and applying the finish locally. The approximately seven cent net saving per tube shield, although relatively small, can represent a substantial saving when considering the number of tube shields used in the course of a year.

### Stop Washer Problems

For a number of years, turns-counting stop washers have been made in a multitude of designs by many different manufacturers. To a large extent, the design is dictated by the total job quantities required as well as by the number of washers required per shaft, and the available mounting space. Several design attempts were made (Fig. 10) to filfill a particular requirement. The washers are used in stacks to limit the rotation of control shafts to a predetermined number of turns for the purpose of protecting tuning elements. Since as many as 12 or more washers may be used in a single stack, close tolerances are necessary in order to provide the required accurracy. Furthermore, great strength is necessary because hand cranking speed and momentum cause the mechanism to bang against the end stop with considerable force. All washers are made of stainless steel.

After testing, it was obvious that #3 washer and #5 washer would be satisfactory for the application. Number 3 washer is machined from stainless steel bar stock to close tolerances and is an expensive operation unless special machinery is available. To be considered, however, is the fact that the manufacturing information for the use of #3 is complete whereas to use #5, the information would require some changes because of the difference in width of the projection. The summary of costs (both local as well as quoted bids) is still to be made and will consider

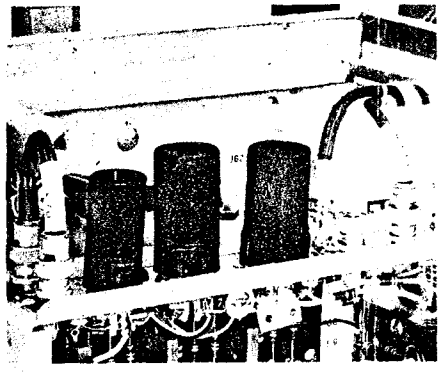


**Fig. 9.** (left) Tube shields painted by the vendor saved about 7¢ each over finishing them to rigid standards within the shop.

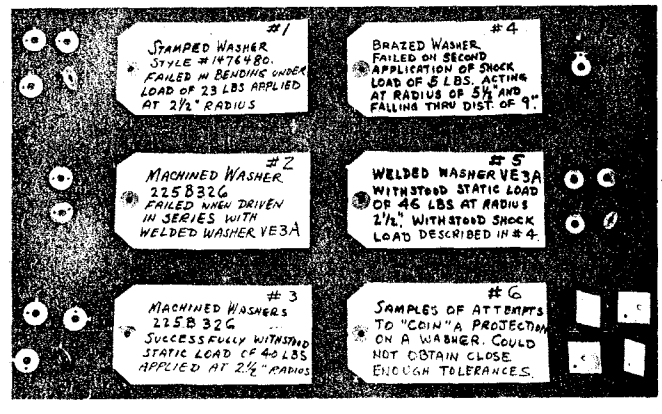



**Fig. 10.** (right) Results of tests on various stop washers to determine the one least expensive which would meet tolerance limits.

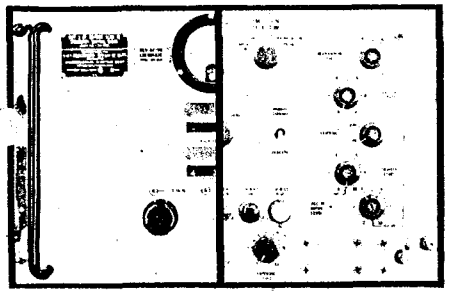


**Fig. 11.** Special drawer handle (left) was not really needed and was replaced with a better, less expensive handle (right).

implementation costs of washer #5 Preliminary figures indicates a worthwhile cost reduction resulting from the investigation.

### Drawer Handles

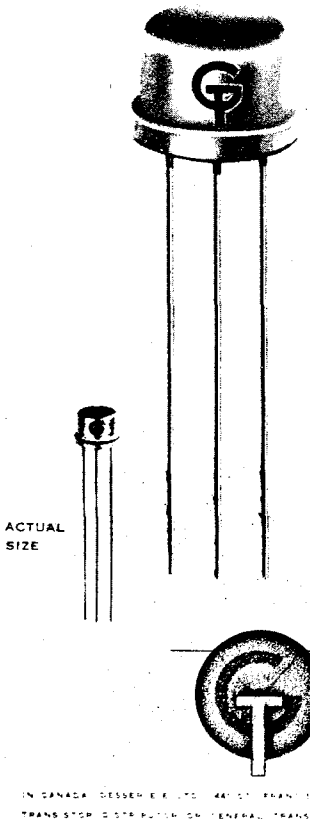
Drawer handles shown at the left of Fig. 11 is covered with a special black coating. The handle has an offset bend at top and bottom to provide greater clearance to controls. Some of the supposed features of the black coating are that it improves the appearance, protects against corrosion, and makes the handles thicker to give more comfortable fit when grasping them. To large degree, these facts are a matter of opinion, except that the coating will give some protection against corrosion. This however, is a doubtful necessity since the handles are stainless steel to begin with.

On the other hand, to make the offset bend without exposing the die to breakage with every operation requires that the end of the handle be suitably annealed. When all of these things were considered, it seemed that there was room for improvement.

Accordingly, it was proposed that a bare stainless handle without the offset bend be provided. The additional clearance could be accounted for by moving the handles ¼ in. toward the outer edge of the panel. Further, the handle rigidity could be improved by encasing both ends in a bushing, which would also improve the appearance. The single bend can easily be made by the die and no annealing is necessary.

The proposed handle is shown in Fig. 11, right. The two cam-latch mounting holes, as well as the slots would be removed and an additional stainless steel thumbscrew would be added to the panel in the general neighborhood of the lower ...le. The approximate saving to be realized by use of the handle on the right as opposed to the handle on the left is approximately $2.50 per handle.


# NEW HIGH VOLTAGE NPN TRANSISTORS ALLOW TUBE REPLACEMENT AND CIRCUIT COMPATIBILITY




GT's new high voltage germanium alloyed junction transistors now allow the same optimization as formerly could be realized only with vacuum tubes. These characteristics plus conventional "transistor" advantages offer new design opportunities in computers, magnetic memory cores, data processing equipment, gas filled indicator tubes and other applications where reduction of space, weight and high reliability are prime requisites.

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| | | | GT 1200 |
|---|---|---|---|
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| Emitter to Base Voltage (Collector Open) | $I_E$ | 25 μA | 20 Volts Min. |
| Collector to Emitter Voltage (Punch Through) | $I_C$ | 25 μA | 90 Volts Min. |

Supplied in TO-9 case

GT 1201 – GT 1202, in addition to driving gas filled display tubes, are ideally suited for driving high inductance loads, driving transformer coupled loads and allow more nearly perfect impedance matching. These transistors are fast devices capable of handling high impedance loads and large signal swings.

| | | | GT 1201 | GT 1202 |
|---|---|---|---|---|
| Collector to Base Voltage (Emitter Open) | $I_C$ | 25 μA | 75 Volts Min. | 45 Volts Min. |
| Emitter to Base Voltage (Collector Open) | $I_E$ | 25 μA | 20 Volts Min. | 20 Volts Min. |
| Collector to Emitter Voltage (Punch Through) | $I_C$ | 25 μA | 75 Volts Min. | 45 Volts Min. |

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CIRCLE 388 ON READER-SERVICE CARD

Reprint from "Ordnance," May-June 1959.

# ORDNANCE VALUE ANALYSIS

H. R. Lowers

Mr. Lowers is in the Industrial Division, Office of the Chief of Ordnance, United States Army, Washington, D. C.

In the spring of 1958, representatives of the Watervliet Arsenal made a presentation to the Chief of Ordnance and high-ranking members of his staff. They showed the results of a 2-year experiment with a program known as value analysis. During this period a 2-man value-analysis staff, working with procurement, manufacturing, and engineering organizations at Watervliet, had generated savings of almost $200,000 in the cost of equipment procured or manufactured on a few current orders.

Typical of the successful projects undertaken was a muzzle plug for 155-mm. guns and howitzers. Purchased by Ordnance for years as a complicated combination of aluminum, rubber, and brass parts and linkages, its function was to keep the gun tube free of contaminants when not in use. Its cost was $64.

In seeking the answers to such questions as: What is the item? What does it do? What does it cost? What else will do the job? What will that cost? -- the value-analysis team found that a molded neoprene plug would perform the same function at a cost of only $5.95, a unit cost saving of 91 per cent. Based on current order quantities, a total reduction of $64,500 resulted.

Value analysis is not new. Pioneered by the General Electric Company in 1942, other companies, including Westinghouse, Radio Corporation of America, and Raytheon have adopted similar programs. In 1954 the Navy Bureau of Ships was the first Government agency to exploit the potential of this new approach to cost reduction. Known as value engineering in the Navy, every naval shipyard has this program in operation.

Value analysis may be defined as "a technique that starts with a verification of essential function and systematically develops a means of achieving this function at the lowest over-all cost. It normally involves a full-time team effort."

There are two main features that set value analysis apart from design engineering, product engineering, and other functional activities. First, the value analyst questions requirements. He makes sure that the functions

the equipment has been designed to perform are really required by the user or whether, if the cost of their attainment is too high, something else might be acceptable. Secondly, he employs a definite system in relating cost to necessary function.

This system is known as the value analysis job plan. The plan is divided into six phases: information, speculation, analysis, programming, program execution, and summary and conclusions.

Application of this plan to an actual ordnance project will help to show how it operates. The bore brush M12 used with the 105-mm howitzer and 105-mm. and 106-mm. recoilless rifles is illustrative of the tremendous savings possible even in noncomplex items of military equipment. If this item had been value-analyzed in 1951, the total savings would have been over $200,000.

During the information phase, samples of the brush, cost, quantities involved, drawings, specifications, and manufacturing methods were obtained. The exact function was determined -- in this case that of cleaning the gun bore. The brush was found to consist of five parts and to cost $13.70 in quantities. In the past seven years, 26,026 had been procured.

In the speculative phase, many possible solutions to the problem were considered. Some of the questions used to stimulate ideas were: How much of this is the result of custom, tradition, or opinion? Why does it have to have this shape? What other materials would do this job? What is similar to this that costs less? Does it need all of its features?

During the analytical phase, cost estimates were assigned to each new idea and compared with the old. Those ideas showing the most promise were then pursued in greater detail. A standard shoulder eye bolt, plain half-inch cut washer, and an adapter, costing a total of $1.88 were found to be a possible replacement for the existing ring, nut, and body assembly costing $2.78. The brush holder and nut costing $5.63 could be replaced with a chemically treated laminated cardboard costing 70 cents or with a molded plastic holder at approximately $1.00.

In the program-planning phase, the brush holder was broken down into a progression of functional areas. It was determined that the assembly constituted a number of holding operations. Certain design features were found to add nothing to these basic functions and could be eliminated.

The results of the previous phases were put into effect during the program-execution phase. All promising solutions were checked out. It was determined that a bore-brush assembly, of which the body is a standard eye bolt and the brush holder is formed from a 2-piece plastic cylinder, provided exactly the

same function at greatly reduced cost. Use of a brush holder made from chemically treated laminated cardboard reduced the cost even more but was somewhat less rugged.

Finally, the value analyst wrapped up the results of the study and presented it to the engineering group. The proposed solution was furnished as a recommendation on standard format. Before-and-after sketches, quantities required, and a complete breakdown of cost, including tooling, were included.

In the case of the bore brush, the plastic design was accepted by engineering following extensive service testing. The new design was favored by the user because of its lighter weight, and actually provided longer brush life than the original design. The new cost is estimated to be $6.00 -- a 55 per cent reduction over the original brush. Adopted also in the 90-mm. size, a saving of $16,500 was realized on one recent order.

At Watervliet Arsenal the value-analysis staff found that such basic barriers to good value as lack of information, want of an idea, and temporary condition frequently handicapped the designer. When the procurement office was asked to procure some special socket-head shoulder screws normally costing $1.44 each, value analysis was asked to investigate the high cost of tooling for a small order. Lack of information on the part of the designer had caused the creation of a special crawing of the screw. The value analyst found the identical item, plus an added Ny-Lock feature, in a specialty supplier's catalog at a price of sixty-seven cents for a saving of fifty-three per cent.

For want of a better idea, the bore sight for the 106-mm. rifle had been designed as an aluminum casting requiring extensive machining. When value analysis found that it cost $3.21 to perform the simple function of holding a peep sight on the axis of the rifle tube, a simple sheet-metal stamping was devised. At a production cost of only thirty-six cents, a reduction in cost of eighty-nine per cent was achieved.

During the fall of 1958, Watervliet Arsenal, at the direction of Brig. Gen. F. J. McMorrow, Assistant Chief of Army Ordnance, Industrial Division, conducted a 2-week Ordnancewide seminar. Thirty-six "middle management" personnel from seventeen different Ordnance installations received value-analysis training. Approximately half of the seminar was devoted to the teaching of fundamentals; the remainder was devoted to project work.

Typical of the participants were three representatives from the Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala. Upon their return to their organization, they immediately began to apply their training to missile systems currently in production.

Were heat-treated handles designed to life 2, 500 pounds on a particular missile container really necessary? A field investigation showed that the containers were usually moved by fork lift truck. In infrequent instances a wire sling could be substituted. The handles were eliminated at a saving of $24 per container.

By substituting phenolic plastic potentiometer locking sleeves for the machined metal sleeves used by the thousands on missile electronic ground equipment, the unit cost per sleeve was reduced from 25 cents to 5 cents. This small item alone will account for yearly savings of $4, 000.

A striking example of the savings inherent in simple components of missile systems was a fuse holder used in ground-control vans. Carried over in essentially the same form from early ground-control systems, it consisted of a drilled stainless-steel bracket on which thirty-seven machined and threaded bolt, nut, and washer assemblies were mounted. The sole function of the assembly was to hold spare fuses.

Although it was immediately obvious to the team that cost was out of proportion to the necessary function, confirmation was supplied during the information phase. The cost per holder was found to be $195. 00.

Brainstorming, a common value-analysis technique, was employed in the speculative phase. A stenographer in the value analysis office asked: Why can't you drill holes in a metal sheet and put in rubber grommets to hold the fuses? A hand-built model was easily constructed and found to be suitable for the purpose. Production cost was estimated at less then $1. 50 -- a 99 per cent cost reduction.

Although many spectacular examples of savings of 50 per cent and more of the original cost have been generated by Ordnance value analysts working with engineering, procurement, and manufacturing personnel, the Ordnance Corps feels that the surface barely has been scratched.

A short time ago, Maj. Gen. J. H. Hinrichs, Chief of Army Ordnance, directed that all his field installations having engineering and procurement missions establish permanant value analysis staffs. To further the training of these personnel, and others in Ordnance with whom they must work, a permanent course of instruction is being established at the Ordnance Management Engineering Training Agency, Rock Island, Ill.

The bulk of the Ordnanceequipment budget is placed with industry for engineering, procurement, and manufacture. In order to achieve the maximum potential that value analysis offers, the Ordnance Corps realizes that it must enlist the help of value analysts on industry's payrolls.

This phase of the program, soon to be implemented, involves the provision for this work in major weapon-system contracts placed with industry.

It recently was observed that "it isn't a cheaper automobile the American public wants; it's an expensive car that costs less." In a sense this is the Ordnance Corps' philosophy. It's not cheaper equipment the troops need, it's expensive equipment that costs less -- and value analysis is one important means of achieving this goal.

# SPECIFIC ACTIONS NEEDED BY DIVISION TOP MANAGEMENT FOR IMPLEMENTATION OF A FULL-TIME VALUE PROGRAM

1. Establish an open position for competent Value Specialist (or Specialists) placed in the most effective location within the organizational structure of the Division.

2. Issue a requisition to fill the position. Seek out and select qualified personnel for this position.

3. Provide proper facilities for the Professional Value Engineering function.

4. Give strong support for function by:

    a. Organizational announcement
    b. Definition of relationships
    c. Create receptive climate
        Stress responsibility to line management for cost and increased profitability.
    d. Give credit to line management for
        1. Cooperation with Value Program
        2. Implementation of suggestions
        3. Positive approach
        4. Acceptance of change

NOTE: Corporate Value Services will be available to give you aid by:

1. Making specific recommendations on organizational matters after a study has been made of the Division's particular needs and desires.

2. Helping to select competent Value Specialists and training of qualified candidates for Professional Value work.

3. Assisting, on a continuing basis, the operation of your Value Program to insure its effectiveness.

4. Guiding Divisional Management in decisions and actions needed to improve the effectiveness of cost reduction and cost prevention through their Value program. This includes consultation in area of -

    1. Work of Value Specialists
    2. Value Climate
    3. Divisional Value Training
    4. Product Cost Control

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MAKE A DECISION FOR VALUE - TAKE THESE SPECIFIC ACTIONS TODAY

September 9, 1954

SUBJECT: THE PART OF VALUE ANALYSIS IN "MAKE-IT OR BUY-IT" STUDIES
(This answer was judged also very pertinent to "make-it" or "buy-it" problems in the United States)

Mr. W. F. Elliott
Canadian General Electric Company, Ltd.
212 King Street, West
Toronto, Ontario, Canada

Dear Bill:

Of course, Value Analysis as we are developing it here is not primarily concerned with "make-it or buy-it" decisions. Those are management decisions. What we in Value Analysis want is the opportunity in all cases to develop the facts and provide the facts concerning Value to management so that whether the decision be to manufacture parts which were formerly purchased or purchase parts which were formerly manufactured, the decision will be based upon the facts.

Quite apart from Value Analysis, however, I am pleased to advise you concerning the thinking of some of our management on particular problems with which we have had contact during recent months.

It was logical when a ready market existed for any reasonable quantity of our products which we could produce to reckon our costs as we have, to figure that, if we had a machine which was not working, the overhead costs continued anyway and we should make certain sacrifices to keep all of the machines busy. It was logical then, in considering whether to make or buy a part, to compare the purchase cost of the part with the sum of material plus labor plus variable overhead rather than full overhead because the fixed overhead would continue even if the part were purchased and would, in effect, be an added burden on other parts of the device.

It is just as logical now, as we face a competitive market, to accept the fact that the value of a part or component or material is established by the lowest cost at which it can be dependably provided where and when needed whether it be provided from our own machines or from the equipment of specializing vendors; or, in fact, the value ceiling may be established at a level even lower if some other material or part or product will, at lower cost, accomplish the same functional result.

It is equally logical that, in order to hold, and in certain areas, improve our percentage of the available business, we cannot accept costs in the various parts of our products which are above value. We cannot charge our customers more for a part or material to perform a function than our competitors would be and are obliged to charge.

It then becomes basic under today's competitive conditions that every part or component in our product stand on its own feet and represent the best value obtainable in the market whether that Value results from little or much work on the part in our company.

Following this basic competitive conception, it will be found that machines in our own factory which do not competitively, considering full overhead--shop cost vs. purchase price, deliver parts and components to our assembly lines at Value, will become idle.

At first glance, this again appears contrary to self-interest--it appears to result in a shifting of the fixed overhead and increasing the cost of other parts while admittedly it accomplishes the objective of providing a specified part or component at its value.

A second look shows that soon this and other machines which are indeed marginal or sub-marginal operations but have not necessarily been recognized as such in the past due to our former policy of keeping them busy, are standing idle. The management then will strip out these marginal and loss machines and put in their place profit making operations. In innumerable such cases, we have found this space adequate to meeting our needs for increased production.

Some benefits which stand out are:

1. The product is competitive and our markets will be expanding rather than contracting.

2. Every foot of floor space in the factory is contributing its share to the profit side of the balance sheet.

3. It is often unnecessary to make large capital expenditures for additional floor space.

As an example, one of our operations has for a decade followed the policy of making every possible part or component in the factory as a matter of policy in order to provide more "liquidation" and provide continuous labor load. The "Value" of the components was not examined by a search of competitive means for securing the same part. The profit position of the Department turned into a loss which increased yearly. The company placed new management in charge. They first asked the question...

"What is the 'Value' of these various parts we are making?"

As a result, the management selected and sent twelve parts which we had the opportunity to evaluate. It was found that two of them represented good value and ten did not. It was not unusual for parts to cost two or three times their "Value."

For example:

| | Quantity | Cost/C | Cost/Lot | Unnecessary Cost/Lot |
|---|---|---|---|---|
| Thumb Screws | 5000 | $23.00 | $1150 | $ 925.00 |
| The Value was found to be------- | 5000 | $ 4.50 | $ 225 | |
| Another example was a part made in lots of---------- | 3000 | $49.00 | $1470 | $1230.00 |
| The Value was found to be------- | 3000 | $ 8.00 | $ 240 | |

As a result, they immediately cleared this area and, since they did not need it, rented it to another General Electric operation which at once pressed it into profitable service making it unnecessary for the other unit to build another building.

We think that, in today's competitive market, we must hold one thing inviolate; namely, the costs of the various parts, components, and materials which go into our product must not go in at prices higher than our competitors would pay for identical parts. Any other policy results in "riding" the monogram which means weakening it. It can only remain strong if, instead, we, in each case, "support it" which means to provide at least as much and preferably a little more value in each part, component and product as our competitors do.

In our country, our taxes of all nature are becoming extremely high and the difficulty of getting large amounts of capital for new buildings, and of liquidating those expenditures once made, are becoming increasingly difficult. It is accordingly sharpening our wits in decisions regarding marginal operations.

Our various competitive departments have for a considerable period operated on a basis of competitive value. In our radio and television operation, for example, unless a part or component can be made for the equivalent of or less than the purchase cost, it is purchased.

Thus, it seems unthinkable in this day of high taxes, small return on capital investment, and extensive labor problems to employ the services of labor which we have provided through long and costly negotiations, on unnecessary marginal or loss operations; or to use their valuable manufacturing space to unnecessarily make simple parts which we could readily obtain for their Value--with no possible profit return, for the space, when it is so urgently needed for expanding our profitable operations.

Very truly yours,

L. D. Miles, Manager
Value Analysis Services
Materials Services Dept.

LDM:AEM

# STAMPINGS

## Make Them?

## or

## Buy Them?

●

By —

**Clement C. Caditz, President**

Northern Metal Products Co.
Franklin Park, Illinois

●

Distributed by —

**PRESSED METAL INSTITUTE**

**Cleveland 20, Ohio**

## THE PRELIMINARY PATTER

Back in 1782 the King of France loaned $470,000 gold guineas to our new Confederation of States.

We won't go into a credit manager's appraisal of the transaction but regard it only as the cause of one of the first American Make or Buy decisions.

Some of the coins had been clipped before they were shipped to America —(This was in the days before Senate Investigating Committees). If those coins had been put into circulation the lack of uniformity would have been noted and soon the full weight coins would have been clipped by the public to match.

The Government decided to clip these coins to a uniform weight before releasing them and issued a formal order to the Quartermaster General of the Army, Timothy Pickering, reading partially as follows:—

> "The pieces must be clipped. The price demanded by a Goldsmith is one penny for each piece . . . It only remains for you to say whether you will pay it out or cut the pieces to the standard weight yourself."

Today when a manufacturer needs a metal fabricated part it still only remains for him to do one of those two things—Make it or Buy it.

No matter which the choice the question is asked, "Why?"

Here are some answers I've heard stressed over the years by company presidents, purchasing agents, comptrollers and production men. They were expressed in punch press departments, bars, drafting rooms, night clubs and other interesting places.

My objective in reporting them is less important than your objective in reading them for many of the same arguments were advanced to prove both sides of the Make or Buy question. So I have no missionary-like expectations that this presentation will make anyone see the light—as I see it.

I'll refrain from promoting a magic formula or a "this is it" answer —neither of which exist.

If you want a detailed scientific coverage of the whole broad problem (not just metal stampings) let me recommend that you send a dollar and a half to the Harvard School of Business Administration, Soldiers' Field, Boston, Massachusetts. Ask for a copy of "MAKE OR BUY" by Professor James W. Culliton. It is "A Consideration of the Problems Fundamental to a Decision Whether to Manufacture or Buy Materials, Accessory Equipment, Fabricating Parts and Supplies."

Another article—on the cost approach—appeared in the Journal of Accountancy, July 1953. It was entitled *Creep* by Robert L. Dixon, Ph.D., C.P.A. Professor of Accounting, University of Michigan. You don't have to be an accountant to understand his presentation. It's simple and readable. It's worth writing for.

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## SO YOU DON'T BUY STAMPINGS

THE COST OF A STAMPING, whether it is made or bought, depends upon how good a buying job is done.

Every metal stamping is bought.

A frequent—and costly—misstatement is the one "Yes, we use stampings—but we don't buy any."

Actually how good a buying job is done determines the cost of a part —whether it is Made or Bought.

If a buying transaction is involved a Make or Buy comparison becomes possible.

First, what are we buying? It's the following:

THE RIGHT PART—AT THE RIGHT TIME—
IN THE RIGHT QUANTITY—AT THE LOWEST
COST.

There are some reasons for Making which in themselves are so basic as to eliminate any necessity for a Make or Buy decision.

There are projects—usually with peculiar cover names—which are so hush-hush that every production process must be controlled in the interest of secrecy.

Some requirements are so complex and demand such a tremendous capital investment that the normal competitive advantages of having a choice of many sources would not exist for the customer. An end product manufacturer can assume large special machinery investments and project them over many years of use. He might not find an outsider to take that kind of a risk.

But such valid reasons do not back up most Make decisions.

Too often they are based on comments like:—

"Punch Presses—they aren't expensive—let's buy one."

"Let's make those parts here—the presses in my department aren't doing anything."

"These stampings are going to take real tolerances. We'll just have to make those parts ourselves."

"I don't care how low the prices are, but we can save the supplier's administration and sales expense and make his profit, too, can't we?"

"We've got to do our own stamping—we can't afford to have our production lines stopped."

Or the President looks out of his window—sees his supplier drive up in a new Cadillac and decides that making stampings must be profitable.

There is a school of thought in the stamping business which holds that no matter how illogical the reasons there's nothing a contract stamper can do about it.



Those stampers assume that manufacturers do not arrive at Make or Buy decisions with making money as the objective.

They believe the contract stamper is at the mercy of unpredictable and unreasonable marketing factors.

They hold that it doesn't pay to fight "City Hall."

So they look for a way to become an end product manufacturer themselves.

The stamping industry must not go along with that philosophy.

In our production economy there is a money-making justification for the contract metal stamper.

It is not logical to believe that any end product manufacturer will knowingly throw out money.

The stamping industry ought to go out and let them know.

## IN THIS CORNER

**"In MAKE vs. BUY the former has usually been the favorite but the fight has been fixed"**

—Reprinted by the courtesy of "Iron Age"

In "Make can Lick Buy" and vice versa comparisons Make has been the popular favorite over the last few years. In fact, many executives regard the fight as No Contest.

Too often, however, the fight has been fixed. That condition doesn't lead to developing good fighters or determining the better man. It usually costs the bettor money.

In this discussion on company costs we'll skip over the individuals who, conversationally, winds up with machines and buildings that carry no fixed charges—material that is scrap—labor that is standing around anyhow —and supervision and management that is looking for something extra to fill in their time—and therefore he can obviously make his stampings for free.

This is an extreme viewpoint and most companies recognize there are some costs involved in Making.

There is little disagreement on including direct labor and raw material items but wide differences when it comes to the variable and fixed costs.

Many manufacturers do *not* include their full, or any of their fixed costs on the theory which is best expressed in the question "after all, we have them anyhow, don't we?"

Here's General Electric Company's answer to that approach—it's in the form of a quote from a letter written by Mr. L. D. Miles, Manager of G.E.'s Value Analysis Unit — Material and Purchasing Department in Schenectady:

> "It was logical when a ready market existed for any reasonable quantity of our products which we could produce to reckon our costs as we have, to figure that, if we had a machine which was not working, the overhead costs continued anyway and we should make certain sacrifices to keep all of the machines busy. It was logical then, in considering whether to make or buy a part, to compare the purchase cost of the part with the sum of material plus variable overhead rather than full overhead because the fixed overhead would continue even if the part were purchased and would, in effect, be an added burden on other parts of the device.
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> It is just as logical now, as we face a competitive market, to accept the fact that the Value of a part or component or material is established by the lowest cost at which it can be dependably provided where and when needed whether it be provided from our own machines or from the equipment of specializing vendors; or, in fact, the value ceiling may be established at a level even lower if some other material or part or product will, at lower cost, accomplish the same functional result.
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> It is equally logical that, in order to hold, and in certain areas, improve our percentage of the available business, we cannot accept costs in the various parts of our products which are above value. We cannot charge our customers more for a part or material to perform a function than our competitors would be and are obliged to charge.



> It then becomes basic under today's competitive conditions that every part or component in our product stand on its own feet and represent the best value obtainable in the market whether that Value results from little or much work on the part in our company.
>
> Following this basic competitive conception, it will be found that machines in our own factory which do not competitively, considering full overhead—shop costs vs. purchase price, deliver parts and components to our assembly lines as Value, will become idle.
>
> At first glance, this again appears contrary to self-interest—it appears to result in a shifting of the fixed overhead and increasing the cost of other parts while admittedly it accomplishes the objective of providing a specified part or component at its value.
>
> A second look shows that soon this and other machines which are indeed marginal or sub-marginal operations but have not necessarily been recognized as such in the past due to our former policy of keeping them busy, are standing idle. The management then will strip out these marginal and loss machines and put in their place profit making operations. In innumerable such cases, we have found this space adequate to meet our needs for increased production.
>
> We think that, in today's competitive market, we must hold one thing inviolate; namely, the costs of the various parts, components, and materials which go into our product must not go in at prices higher than our competitors would pay for identical parts.
>
> Taxes of all nature are becoming extremely high and the difficulty of getting large amounts of capital for new buildings, and of liquidating those expenditures once made, are becoming increasingly difficult. It is accordingly sharpening our wits in decisions regarding marginal operations.
>
> Cost determinations for the purpose of "make-it or buy-it decisions" are based upon the comparison of the sum of "material" and "labor" with the Value of the part as established on the market.
>
> "Material" is the actual price which would be paid for the material.
>
> "Labor" is the actual amount the workman gets *plus full overhead.*
>
> Unless the part can be manufactured for its Value as determined by this direct comparison, it is provided by purchase."

This approach takes into consideration that when you Make and try to fool the buyer you are only fooling yourself.

As one interviewee wistfully pointed out it's only when you Buy that you benefit from mistakes or mistaken conceptions.

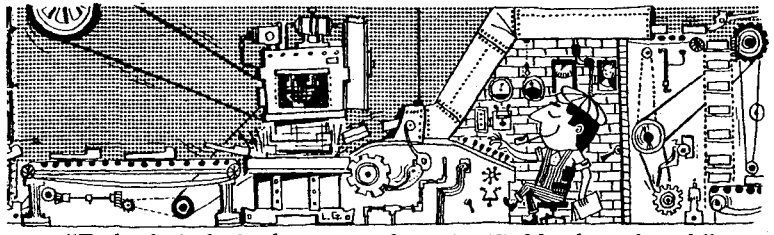
Getting comparable figures on Made parts is, at best, a tough job.

It's easy to measure sugar when it's in a sack. Dump that bag of sugar into a swimming pool and you have a much more difficult weighing problem. In truth, you can easily overlook the fact that it is even there.

The costs of Making are in suspension throughout your organization. The costs of Buying are still in the sack—with the weight printed on the package.

Weighing the sugar in the pool is such a big job that it is seldom done. Yet, in light of good purchasing procedures, it should be done with every change in market or production conditions.

## LET'S CUT COSTS



**"Technological miracles are not always justified by the end result"**
Reprinted by the courtesy of "Iron Age"

When a part is Made the purchasing department—the buying expert—is usually left out of the picture. No one else steps in to do the buying job.

Once a press is set up and the operation becomes an incidental part of a larger operation the justification for its existence is often overlooked.

There's nobody around constantly asking "What are we paying for the operation? What are we getting for that cost? Can we buy it for less?"

As market, or other conditions change, a purchasing department does just that on the Buy decisions. The price on the bought part is always under control.

The four minute mile was run because of competition.

New lows in cost are reached the same way.

On every new part—and sometimes even on new releases—the purchasing department makes the supplier race for his prize. He has to prove himself every time.

It is impossible—even with the best of intentions—for a captive stamping operation to be so competitively whipped and controlled.

Track records are not set at company picnics.

That loss of control and competition should be a major factor in the decision "Make or Buy."

Under a reduced volume of business a big job is to get the break-even point down. Yet you will hear the statement: "Buy stampings? Don't be crazy. We're pulling in all the parts we've got farmed out now. We've got a big capital investment and we've got to absorb our overhead."

It sounds good only if you say it fast enough.



Eliminating the luxury of a captive press department might be the more logical approach to a serious break-even point reduction program. Here's why:—depreciation on equipment and rent or depreciation on buildings would be eliminated; general insurance costs could be decreased; Workman Compensation rates would go straight down; supervision could be eliminated; die repair and machine repair expense would disproportionately be reduced; factory expense items would melt and a mass of handling costs would disappear. In other words much of the stuff in suspension would be precipitated.

In addition fixed assets and inventories could be converted into cash and working capital ratios improved. This always looks good on a balance sheet.

Remember, too, that any general drop in business probably also results in lower prices in the highly competitive contract stamping field. This could make comparisons even worse.

In a Make situation can savings be affected where the largest costs are—in labor and in material?

The end product manufacturer can save in labor costs only by paying a lower hourly rate or by producing the part with less labor.

In my interviews I found that the hourly rate paid to press operators in plants where stamping was incidental had nothing to do with the going market price for punch press operators. It was almost always based on the hourly rate of the main body of employees in the plant. This ran as high as twenty-five percent over the prevailing rates paid in stamping shops.

Where an end product manufacturer does not go into an expensive single purpose special machine set-up it is not too reasonable to suppose he can out-engineer a whole field of specialists on the general run of stampings. In other words, he is not likely to make the part with less labor hours.

It takes crane operators; die setters; stock-handlers; machine repair men; die repair men; inspectors; and other types of labor to keep press operators effective—in any plant.

The control of that indirect labor is tremendously important to the overall cost factors.

That control, as expressed in daily reports showing the ratio of indirect to direct labor hours; the ratio of die repair hours to hours of press time; daily percentages of operator efficiency; machine load reports and other reports of that type, is not likely to exist in a diffused situation. In a contract stamping operation none of those figures are hidden. They are total. They are definite. They are recognized as part of cost.

Any major differences in raw material costs are unlikely. Prices generally will be at mill levels. However, where an end product manufacturer might use only a small amount of some gauge and be buying it at a higher than mill basis the contract stamper might be pricing at mill due to his general accumulated requirements.

Pulling in stampings because of patterned thinking might raise break-even points rather than lower them. It can be as unreal an approach as was that of the Pensioner who for years had the job of polishing the town canon. When in an economy move the job was cut out, the old man in high temper sputtered "Let them do it . . . I'll buy my own canon."

## WHO'S WHO

There was a time, when autos were young, when a manufacturer had no choice but to make his own parts when he needed them to close tolerance; or he needed particularly large parts; or where his whole company's existence depended on a daily flow of tremendous quantities of parts.

But, because of advantages of specialization, there grew up in this economy of ours several thousand contract metal fabricators. Within this field a manufacturer can find competitive sources of almost anything he needs—automatic production of millions of pieces at pennies per thousand—shops that will make a few pieces—intricate assemblies—close tolerances—almost anything.

The decision to Make or Buy should normally rest on something other than availability of facilities.

Not every source available to a buyer is a contract metal stamping specialist and whether a Buy decision is a good one or not might well depend from whom the parts are bought.

The validity and value of arguments for or against Buying must take into consideration whether or not the source is a true contract stamper. That means that his entire organization is devoted exclusively to contract stamping —not using stamping as a fill-in or sideline.

There are end product manufacturers who, having once made the decision to make their own stampings, find they need outside work to keep their press room organization together during slack periods or seasonal fluctuations.

There are companies such as tool and die shops, where presses are auxiliary equipment. These, too, become available to a prospective buyer of stampings as a potential source.

During the last shortage of steel there were press room set-ups in steel "warehouses" operated by brokers.

There are those stampers who are so busy developing their own products that they are not really doing a job of contract stamping.

A buyer could get his fingers burnt in such situations and falsely assume the failure was one inherent in the industry.

It isn't only the fact that a manufacturer doing stamping work incidentally might put other requirements first that makes him a less than desirable source.

But it takes more than punch presses to give a customer the right part —at the right time—in the right quantity—at the lowest cost.

To make the part right takes engineering and inspection; to ship it at the right time takes scheduling and controls; to ship the right quantities requires inventories and space; to know costs requires systems and accounting.

Contract metal stamping shops must be geared for such service mentally and organizationally.

A contract metal stamper wouldn't consider closing his plant down for a week or two week vacation period—no matter how attractive such a move might be costwise.



Even when business is at a very low level a contract stamper keeps a night shift—he needs it for the fast passes—for the guy who's got a production line starting at seven the next morning and who at three in the afternoon finds he's over-looked a bracket.

A stamper's paperwork system is designed on the theory that no customer knows what he wants or when he wants it—that an order when it is placed will be increased in quantity or decreased or both; that there'll be new issue numbers; revised shipping schedules; holds; engineering changes; and, after all of that, cancellations.

And a contract stamper is ready to give quick cost estimates.

Perhaps the most distinctive characteristic is the attitude of the production staff. In a contract stamping plant everyone is conditioned to sudden changing demands. They cannot hang up "do not disturb" signs on plans or presses. They must be flexible above all else.

## LOOK, MA, NO HANDS

When fashion decrees that skirts be worn short women will wear them short despite bowlegs, piano legs, or spindly legs.

There are fashions in industry, too, which have a tendency to be followed willy-nilly.

Automation is the magic word today.

The production ideal is to feed raw material in at one end of a machine and have finished parts flow out the other end—untouched by human hands.

Here is a quote from an article which appeared recently:

> "Among the products is the punch press with the built-in electronic brain. It is wholly automatic. The punch press carries the move toward pushbutton factories one step farther. Its 'brain' directs it in adjusting itself to different production processes.
>
> Here's how it operates: An electronic device receives instructions from perforated cards, whose perforations represent a code describing the size, number and location of holes or other shapes to be punched. The electronic device, or 'brain', then feeds impulses based on this information to the press's mchanical parts, causing the automatic positioning of the materials to be punched and the performance of the punching chores with great accuracy."

There are few comptrollers or purchasing agents who, reading that article, won't visualize their parts coming out of that machine.

If they are having their parts made on the outside some will regard the fact that their parts are not run that way as the fault of sub-contracting.

Technological miracles are not always justified by end results.

Not too long ago a manufacturer built a tremendous and complex die for making radio chassis automatically. The theory was fine but did not take into account the normal flood of engineering changes and the need for die removals which in this case automation made more difficult. In fact, to meet their production requirements, they purchased these chassis from a contract manufacturer. He retooled the chassis in a manner more consistent with the objective—"The right part—At the right time—In the right quantity—At the lowest cost."

Special purpose machines have another, sometimes less visible, disadvantage.

To illustrate: A manufacturer sets up a line of punch presses to stamp out a series of parts. Along come new parts which can better be made on larger presses.

At that point the tendency is to design and make the operations on the equipment available. That can be done but it could result in not making the parts in as few operations as possible.

Human nature and complex organizations being what they are, that sort of condition is extremely difficult for company management in a "make-it-ourselves" condition to pin down and correct.

A company who farms out such work has a choice of a tremendous range of facilities. If one contract metal stamper does not have the best suited equipment another will.

I received a memorandum from our sales department which dramatically illustrated this point:—

> "We have just had a chance to observe some of the methods used by a captive press shop.
>
> We were asked to quote on the stampings for the Blank Automobile Company auto radio. This contract had been running at the Blank Radio Company for a number of years. They have their own stamping department.
>
> The quoting was done in two phases:
>
> 1. Parts and Tool costs were to be established from piece part drawings supplied by the Blank Automobile Company.
> 2. Part prices were to be established from operation sheets supplied by the Blank Radio Company based on the tools in their plant.
>
> In checking the first set of figures against the second an extremely wide variation was seen. Because of basic differences in operations the parts quoted from scratch were cheaper than the prices from the radio manufacturer's existing tools. The Blank Radio Company has more operations than were necessary.
>
> In discussing this with engineers from the Blank Radio Company it was brought out that their part design was tied into their equipment. They had extra operations because they didn't have the presses to do the work any other way."



## LET'S FEEL THE MATERIAL

In any discussion on Make or Buy there is a one word argument which is tossed in as conclusive—Quality. It's the clincher.

This is the most difficult of all points to discuss. It can become as unanswerable as the word "Because."

It is easy to imagine a situation where standards of finish or tolerances are so abnormal that the manufacturer would have no real competitive market in which to shop.

That point, however, is used to justify a Make policy on parts with average quality requirements. Even when it is pointed out that a direct competitor is Buying the answer is "Well, our quality standards are higher."

That is not a logical, nor generally a truthful, conclusion.

Control is less absolute when a part is Made. If the part varies from specification, but is usable, there is a natural reluctance to throw it out or to rework it. Why create more production problems; more indirect labor; more tool room time; more set-ups; and more costs for yourself? John and Joe are fellow members of the profit sharing plan—remember?

### Rejects Are Expensive

If a contract stamper ships a part that isn't up to specifications he gets it back.

Spoilage and rejects are expensive. They are items easily hidden and overlooked in a cost analysis when the part is Made and the costs are in suspension throughout the organization.

When you buy a part the cost of quality is absolute. You pay only for good parts.

Specialization is important to quality, too. To the metal stamper his operation is the whole show. He has been exposed to many situations. He has learned a lot of techniques. He has a varied experience on presses, auxiliary equipment, material and methods which might not be available where a stamping operation is only incidental.

When higher quality standards must suddenly be imposed it is easier to find a new contract stamper with the necessary quality standards than to try to raise—or lower—quality standards in your own plant.

Incidental press operations in a plant can lower the quality of a product. Presses are noisy and dirt producing. They can distract other workers.

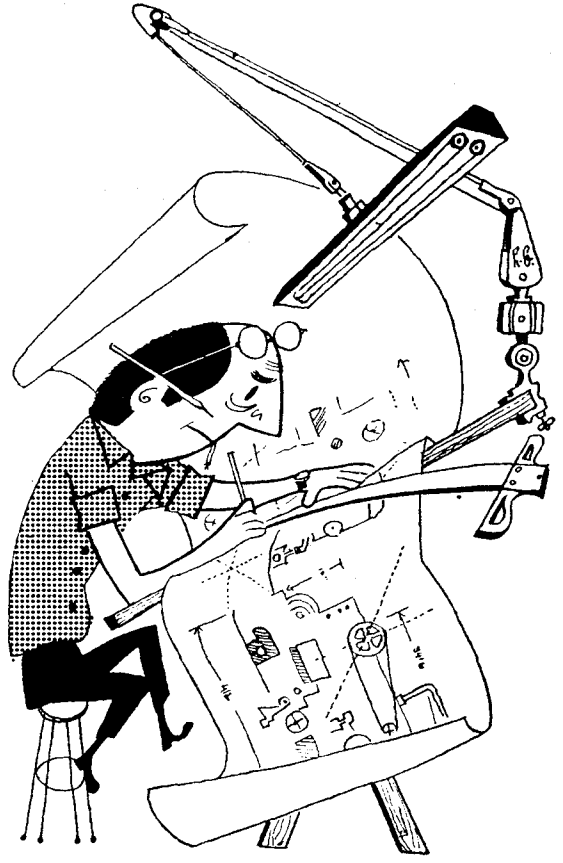
Generally speaking Quality is a weak argument for Making.

## LET'S PLAY ENGINEER

There is a belief, widely held, that metal stampers don't have to do any engineering and have no engineering expense.

But "getting the right part at the least possible cost" takes a lot of engineering whether the stamping is made or bought. It takes engineering for part design, die design, and the estimating of die costs and part costs.

An end product producer needs and deserves that service when he buys a stamping—whether from his own plant or a contract stamper.



**"It takes a lot of engineering . . . "**

—Reprinted by the courtesy of "Iron Age"



Many manufacturers regard this engineering service as available "for free." Perhaps this is because manufacturers tend to regard the stamping company representative as a salesman rather than as an engineer even though he might be working daily with their own engineering and production departments on design and mechanical problems.

Traditionally, too, much of the engineering in the form of operational sequences, die costs and part cost estimates is "free"—all you have to do is have a sketch or a print and write "Kindly Quote" on the face of it. If anyone is ever going to be killed by kindness it will be the metal stamper. That "Kindly Quote" will do it.

For instance, the head of an in-plant fabricating department confronted the purchasing agent who had requested cost estimates from him. He had submitted no quotations but wanted his company's work on the basis of the prices the purchasing agent secured from contract stamping sources. "Man," he commented to the buyer, "You're not going to stick us with the big cost of estimating—are you? Why burden us?" Value determination and Cost determination are two different things.

Tooling is another phase of stamping engineering. A contract stamper usually has a large die shop. He needs it for building new dies and maintaining those in production. In the fields in which he has a lot of experience the contractor stamper develops special die construction skills.

A stamper regards his tool shop as a means to an end. He generally prices his tools at a cost figure.

It is for those reasons that a contract stamper feels a deep sense of injustice when he builds a die and then has the customer remove the tool for fabrication in his own plant.

The point perhaps can be illustrated by the story of the woman who at about 6:00 P.M. rushes up to the manager of the local movie house and asks, "Have you seen a boy, about ten years old, wearing glasses and a baseball hat . . . ?" "Ah," interrupted the Manager, "Is he the kid that's been here for three shows already—and with adenoids yet so that he breathes like a teakettle . . . ?"

"Yes, that's the one," says Mama. "Please give him this package . . . it's his supper!"

A lot of valuable engineering is included in the contract stamping price.

It is less likely to be in the package if the manufacturer buys his parts from companies not contract metal stampers. It is less likely to exist where the stampings are bought on an emergency or peak load basis only.

It becomes an important plus factor where there is a close relationship between the customer and the supplier.

## SOME CLOSING COMMENTS

There is a disease, which for want of a better name, we should call Industrial Gout.

The symptoms of an advanced case of Industrial Gout are: cluttering miscellaneous activities, lower efficiency, higher fixed costs and lower profit potentials.

It is caused by a too rich diet of added activities taken in on the theory that each offers cost saving opportunities. The anticipated saving is, generally, in the area of fixed costs.

Fixed costs in a successful company reflect capacity to operate. It wouldn't be a successful company if it were over-equipped and over-staffed.

Added activities put an added strain, therefore, to all administrative departments if they are absorbed. This interferes with their prime responsibilities and jobs. Eventually, however, the pressure results in salaried employee increases, salary increased and fixed asset additions none of which are directly traced to the addition of bargain activities.

General, or long range, arguments are not likely to be as compelling as they are important. However, they, too, should be mentioned.

Our country's defense needs a strong contract stamping industry. It can't spring up full blown during the war. It must be cultivated and used as a part of our every day business economy.

If stamping was only an incidental operation in our industrial economy there would be no ground for the growth of a trade association. Technical progress, standardization, data, safety programs, and other important advancements flow through such a channel.

From the standpoint of public relations the contract stamping industry is a good thing for so called "Big Business." Suppliers are a social asset in the present day political and business world atmosphere.

There is a statement frequently made which should be answered. It's the one "Let's try Making for awhile—we can always go back to Buying."

There are dangers in that remark.

There are extra values which result from the Good Will factor between Customer and Supplier. They are in the form of engineering services, and such shock absorber functions as happen during periods of sudden high production demands or severe material shortages.

The dollar saving approaches to his customer's problems by a contract stamper can only happen if the customer has the same approach to the supplier's problems. The Contract Stamper needs continuity of business. He needs consideration, too.

It's not easy to go from a Make to a Buy status. You have to overcome vested organizational self interests. You have the problem of discharging personnel. You have the problem of disposing of equipment.



Many companies therefore find that they can Buy cheaper than Make but that they can't take advantage of the situation.

It's like the waiter who, having taken the order of the glamorous blonde —and she had ordered every high priced a-la-carte item—turned to her escort and asked "And what do you wish, Sir?" Looking up glumly the man answered, "I wish I hadn't brung her!"

Despite all this I have never met up with a customer afflicted with oniomania. That's a disease where the victim has an uncontrollable urge to Buy. To a stamper it seems everyone is afflicted with exactly the opposite symptoms. Ask your psychiatrist what he calls an uncontrollable urge to Make.

❦

ABOUT THE AUTHOR —

Mr. Clement Caditz, better known as Clem, is President of Northern Metal Products Company in Franklin Park, Illinois. He is well known in metal stamping circles for his sincere interest in the stamping industry and in the numerous activities of the Pressed Metal Institute.

He has written several articles and has spoken before stamping meetings in various parts of the country. His current extra-curricular activities are speaking at District Meetings of PMI in Chicago, Cleveland, Detroit, Hartford and Philadelphia. Fellow stampers who come to Chicago on Business are always welcome at Northern Metal Products.

# THE FULL TIME VALUE SPECIALIST IN ACTION IN INDUSTRY

What specifically does business management have to do? --Does the professional Value Specialist do? --Do people in Engineering, Manufacturing, and Purchasing have to do to make the Value program most effective?

To answer some of these questions, let's take a look at the Professional Value Specialist in Action in Industry. Let's assume that he has management support for his activity, that he is so situated within the organization that he can properly perform his function, that he is well qualified by training, experience, and personality to carry on his work as a Value Engineering or Analysis Specialist, and that he can give adequate coverage to his assignment.

What sort of action can be expected then of this Value Specialist? What does he do? How does he justify his pay? How can he assure Management that they are getting a good rate of return on their investment? These questions will now be answered for you.

Since we are talking about a relatively new field, some concise definitions may be beneficial. We use the terms Value Engineering and Value Analysis as titles for a new area of professional activity which embodies the application of certain techniques in a systemmatic approach to find better value. The distinction between these two titles is not always clear even to those of us engaged in the field. Generally speaking, the difference seems to lie in the realm of timing of application of the effort. Value Engineering connotates more extensive application of the effort in the design and preproduction stages of a product cycle. There seems to be general agreement, however, as to the context and scope of the activity; so for the purpose of this paper, the two terms will be used synonymously.

## Value Analysis Defined:

Value Analysis is a full-time, professional service activity aimed at generating lower cost methods of accomplishing specific functions within an equipment, product or device by strengthening the capabilities of all line operating personnel (Engineering, Manufacturing, and Purchasing) in the Value field. Specialists who work full time in this field provide a unique service which stimulates others, who have product responsibility, to greater accomplishments to lower costs, better product value.

Value Defined:

A product is said to be the best Value when it can be procured for the lowest cost and performs to the user's satisfaction throughout the desired life cycle with the lowest service cost. To meet this objective, each functional component must be produced for the lowest cost with the essential quality to meet performance requirements.

This is the Value Field. It is toward this objective that the work of the Value Specialist is oriented.

The Work of the Full-Time Professional Value Specialist falls into four general classifications:

1. Integration
2. Evaluation
3. Education
4. Consultation

The performance of each of these elements by the Value Specialist is absolutely essential to the fulfillment of his responsibilities. While the Evaluation position of the Value Analyst's job is the one often receiving the greatest emphasis, unless supplemented and supported by activities in each of the other areas, the company will not receive the maximum benefits from its Value program. Now what does each of these work elements include?

1. Integration--

   This element involves the establishment of correct relationships and practices with all business functions, managers, and personnel. Included in this work is:

   a. Gain management support for Value Activity, education, and organization.

   b. Demonstrate how Value Analysis can offer specific assistance to management and operating personnel.

   c. Establish procedures by which the ways and means to implement Value Analysis proposals are established in all functional areas of the business. Generate receptive climate for the review and positive action on proposals.

   d. Integrate and liaison other Value activities within one's own company and throughout industry.

e. Create the desire and means for integrating Value Analysis activities into other functional areas of the business. Assist in planning and budgeting for Value Specialist activities.

f. Work with other functional area personnel for the purpose of developing improved systems, procedures, and data flow which will benefit value activities.

g. Help promote and develop a unified teamwork effort of all groups within the company for the over-all benefit of all.

h. Provide continual personnel motivation for Value.

2. Evaluation--

Here is the very important analysis work element by which the Value Specialists can point the way to lower costs through their expert application of proven techniques in their evaluation of company products. Practical cost reduction potentials are directed to those responsible for action by means of one page factual proposals. Value Analysis Specialists are proven to be extremely effective in this evaluation area because they:

a. Make extensive analysis of costs without interruption caused by performance of other line responsibilities.

b. Are value or cost oriented in their work and training.

c. Have time to delve into a complete functional and total cost analysis using special techniques in which they are proficient.

d. Have broad extensive backgrounds developed by full-time effort in the Value Field.

e. Know where and how to go about getting the best information from the best source. Furthermore, they have the time to do it.

In doing their evaluation work, the Value Specialists should never do anyone else's job. They are a service function designed to stimulate others by presenting factual suggestions for the evaluation and decision by the responsible people in engineering, manufacturing, or purchasing. The Value Specialist should never do the engineer's job by involving himself with extensive testing, complex mathematical proofs, detailed design drafting, or other work the engineer must do to prove and describe

any design. The Value Engineer or Analyst is not a parallel or duplicate effort of any function, he is a supplemental effort designed to strengthen each area he services. His proposals should be based on sound thinking and facts with a high probability of acceptance.

The Evaluation work of the Value Analyst can take many forms, be conducted at different intervals in the product cycle, and have several different objectives; some examples of these are:

A. Forms--

1. The daily effort of the full-time Value Specialist.
2. The group effort of a team of Value Specialists.
3. The task force teamwork effort by people from different functions on a part or full time basis led by the Value Specialist.
4. A large scale seminar type operation involving several teams guided by Value Specialists.

B. Timing--

1. Evaluation of specifications and other design requirements during the early engineering phase.
2. Evaluation of breadboard models, design layouts and early details during the design engineering phase.
3. Evaluation of designs and parts during the development phase.
4. A continuing evaluation on the product during production.

C. Objectives--

1. To reveal conditions of design requirements which will result in excessive product costs.
2. To assist engineering, manufacturing, and purchasing people by providing them with specific information at the appropriate time to guide them in decisions for better value.
3. To provide functional personnel with large amounts of information properly timed to permit them to make substantial reduction in product cost.
4. To demonstrate the effectiveness of Value Analysis techniques; to sell management on a program; to demonstrate to all personnel that there are new and different, lower cost ways to perform the function; to stimulate greater cost consciousness; to arouse a constructive discontent; to improve value-ability; to reduce costs; to improve profitability; to increase productio and sales; to help the company stay competitive.

These are a few of the reasons the Value Specialist works in the field of product evaluation. There are all combinations of the various Forms, Timing, and Objectives.

3. Education--

This work element involves both formal and informal training of management and line personnel to improve their Value-ability and cost consciousness. The Professional Value Specialist should teach both Value Techniques and Value Information.

Value Techniques--include all the Value Engineering or Value Analysis Techniques and Systematic Methods used by the Specialists.

Value Information--includes information on manufacturing, methods, processes, products, vendors, standards, materials and designs.

The formal methods used by the Value Specialist to teach both are:

a. Lectures
b. Seminars--fulltime, part time, multiple session
c. Vendor seminars
d. Task force operations
e. Displays
f. News sheets
g. Published articles
h. Brochures
i. Value Proposals

The informal methods include:

a. Personal contacts
b. Group discussions
c. Letters
d. Case histories

4. Consultation--

In this work element, the Value Specialist must serve his company as a consultant or expert in the field of Value, Value Techniques, and Value Information. By not having line responsibilities, he can keep abreast of new developments in materials, processes, machines, standards, vendors, methods, and products. He is a Specialist in knowing where to go and how to go about getting specific information and bringing New Knowledge into functional areas.

He can keep up-to-date catalogue files. He can help extend the arms of manufacturing, purchasing, and engineering by assisting, guiding, and directing to sources of information; bringing in specialists from all areas; helping to get information on costs and other items as requested: The Value Specialist maintains a reservoir of information available to all on request. He keeps abreast of activities in the Value field throughout Industry and Government.

Summation --

There's the Value Specialist in Action in Industry. It's a big job, a full time job; a job that no other individual or group is doing; a job that needs to be done; a job of human relations and salesmanship; a challenging and stimulating job. There is a tremendous need in industry for dedicated, capable Professional Specialists in this field.

A separate person or group, working exclusively in the Value field stimulates greater efforts and achievements from all line operating personnel with whom they associate. Their work provides the motivating force which arouses the desire of all people to do a better job and generates a constructively competitive spirit.

This stimulation comes from a continual emphasis by the Value Specialists on the importance of lower costs, the promotion of the application of Value Analysis Techniques, the demonstration of Value by examples, case histories and factual proposals, the seeking out and introduction of new information from all sources for potential application to company products; and the effort of these specialists to cultivate a climate of harmonious teamwork dedicated to obtain each functional component and product for the least cost.

By Frederick S. Sherwin
Manager, Value Engineering and Analysis Services
Raytheon Company
Waltham 54, Massachusetts

FSS:bc

TKD

## What would the Professional Value Specialist do if he started work tomorrow?

A. He would proceed on an intensive fact-finding program. This would entail becoming acquainted with:

1. Organization
   a. Division and corporate
   b. Personnel
   c. Functional relationships and responsibilities
   d. Policies and procedures

2. Product
   a. Nature
   b. Scope
   c. Applications

3. Marketing
   a. Customers
   b. Sales volume

4. Financial
   a. Cost system
   b. Profitability
   c. Cost reduction

5. Engineering
   a. Design approach
   b. Requirements
   c. Product improvement

6. Manufacturing
   a. Facilities
   b. Make or buy policy

7. Purchasing
   a. Working relationship
   b. Vendors

8. General
   a. Labor relations
   b. Communications
   c. Training programs
   d. Services

B. Throughout the above phase of the Value Specialist's work, he should be working constantly to:

1. Gain acceptance as a Service Specialist by Divisional Management for his functions, organization, and program.

2. Stimulate a unified teamwork effort among all functions.

3. Develop ways and means by which Value proposals will be implemented.

4. Accumulate a background of technical and specialty information applicable to division products.

## NOTES TO MANAGEMENT

This procedure, if carried out correctly, will lead the Specialist and the Division to a successful Value Program, encompassing all phases of the Value Engineering work scope.

Value Services will give concentrated assistance to the Value Specialist during this starting phase of his program.

V.E. Worksheet #1

# VALUE ENGINEERING
# INFORMATION WORKSHEET I

Product _____

Assembly or Part Name _____ Drawing #_____

Quantity required _____/ year, lot, contract

Application & Marketing Background:

Engineering Background:

Manufacturing & Procurement Background:

Team Members: _____ Team # _____ Date _____

V.E. Worksheet #2

# VALUE ENGINEERING
## INFORMATION WORKSHEET II
## DEFINE THE FUNCTION

Product Name _____

Assembly or Part Name _____ Drawing # _____

Basic Function (s) _____

_____

| Component Parts or Elements | Function (s) | | Degree | |
|---|---|---|---|---|
| | Verb | Noun | Basic | Secondary |
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |
| 7. | | | | |
| 8. | | | | |
| 9. | | | | |
| 10. | | | | |
| 11. | | | | |
| 12. | | | | |
| 13. | | | | |
| 14. | | | | |
| 15. | | | | |

Team Members: _____ Team # _____ Date _____

V. E. Worksheet #3

# VALUE ENGINEERING
## CREATION WORK SHEET

Assembly or Part Name _____ Drawing No. _____

Basic Function of Assembly or Part _____

Creative Ideas (Don't evaluate!) Aim for more than 20

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Getting Started

11.
12.
13.
14.
15.
16.
17.
18.
19.
20.

Warmed up

21.
22.
23.
24.
25.

Let's Get Rolling

V.E. Worksheet #4

# VALUE ENGINEERING
## EVALUATE WORKSHEET I
## EVALUATE THE FUNCTION

Product _____

Assembly or Part Name _____ Drawing #_____

Basic Function _____

Source: Make _____ Buy _____ Vendor _____

| | Value | Cost | Notes |
|---|---|---|---|
| overlap Work-sheet #2 | | | |
| Material Total | | | |

Cost Summary

Material $_____ Direct Labor $_____ Overhead $_____ Total $_____

Team members: _____ Team #_____ Date _____

V.E. Worksheet #5

# VALUE ENGINEERING
## EVALUATION WORKSHEET II
## IDEA EVALUATION & DEVELOPMENT

Product _____

Assembly or Part Name _____ Drawing # _____

Basic Function _____

| Best Ideas from Creative Worksheet | Advantages | Disadvantages |
|---|---|---|
| | | |

Plans for Action on Idea (s)

Team members: _____ Team #_____ Date _____

An Idea Is What You Make Of It

V.E. Worksheet #6

# VALUE ENGINEERING
## INVESTIGATION WORKSHEET I
## CONSULTATION SUMMARY

Product _____

Part Name _____ Drawing # _____

Idea Being Developed _____

PROGRAM

| Source of Information | Information Received | Action Taken |
|---|---|---|
| | | |

Team Members: _____ Team #_____ Date _____

V.E. Worksheet #7

# VALUE ENGINEERING
# INVESTIGATION WORKSHEET II
# VENDOR QUOTATION SUMMARY

Product _____

Part Name _____ Drawing # _____

Basic Approach _____

Vendors Name & Address:

1. _____
2. _____
3. _____

Additional Data for Vendors:

| Vendor Quotation | Vendor 1 | Vendor 2 | Vendor 3 |
|---|---|---|---|
| Unit Price/Quantity of | | | |
| _____ | $ / | $ / | $ / |
| _____ | $ / | $ / | $ / |
| _____ | $ / | $ / | $ / |
| Tooling | | | |
| Delivery | | | |

Vendor Remarks:

Team Members: _____ Team # _____ Date _____

# VALUE ENGINEERING
# INVESTIGATION WORKSHEET III
# PROCESS COMPARISON SUMMARY

Product _____

Part Name _____

Drawing # _____

## QUOTATION SUMMARY

| VENDOR & PROCESS | PRICE/QUANTITY | | | | | | | TOOLS | DELIVERY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

Team Members: _____ Team # _____ Date _____

V.E. Worksheet #9

# VALUE ENGINEERING
## RECOMMENDATION WORKSHEET SUMMARY

Product _____

Assembly or Part Name _____ Drawing #_____

Ideas Investigated

1. _____
2. _____
3. _____

| Recommended Vendor or Source | Price | | |
|---|---|---|---|
| 1. | $ / | $ / | $ / |
| 2. | $ / | $ / | $ / |
| 3. | $ / | $ / | $ / |

Other Sources of Information

1.
2.
3.

| Implementation Action to be Taken by | Estimate Implementation Cost |
|---|---|
| 1. | _____ |
| 2. | _____ |
| 3. | _____ |

Remarks:

Team Members:_____ Team # _____ Date _____

V.E. Worksheet #10

# VALUE ENGINEERING
# RECOMMENDATION SHEET

Company Name _____ Division or Plant _____

Product _____ Team & Recommendation # _____

Assembly or Part Name _____ Drawing # _____

Qty. per Product _____

POTENTIAL NET SAVINGS per year lot contract $ _____ Qty. Products per year lot contract _____

| PRESENT | % cost savings | RECOMMENDED |
|---|---|---|
| $ _____/part or assembly | | $ _____/part or assembly |

SAVINGS $_____/ Assembly Part

TOOLING COSTS $_____ ESTIMATED ENGRG. COSTS $_____

---

Comments:

Team Members & Other Contributors _____

For Further Information Contact: _____ Phone _____ Date _____

# VALUE -- CASE HISTORIES

One of the best ways to assist people in all areas of the Company to better contribute to profitability is by showing examples of where and how cost savings have been achieved. You can help improve the Value-ability of others by passing along examples and case histories of cost savings.

If you know of such cases where equal performance was obtained for lower cost through redesign, material substitution, dimensional or specification change, new or specialty vendors, or improved methods or processes - take a few minutes, fill out the following form and return to Value Engineering Services office. You will get the credit, others will benefit from your experience, and the Company will gain by better Value products.

## Case History

Part # and Name _____
Equipment or System _____
Quantity/System or/Year _____

Past or Former Method _____ Present or New Method _____
(In here put sketches or descriptive information)

Past Cost _____ Present Cost _____

Savings/System or/Year _____
Comments (Brief statement or history of how change came about)

Your Name _____ Ext. _____
Division _____ Dept. _____

NOTE: If sample parts are available, please notify or send to Value Services.

Return to: Value Engineering Services
Department 1360
Lexington 73, Mass.
Extension 244, 245

RAYTHEON

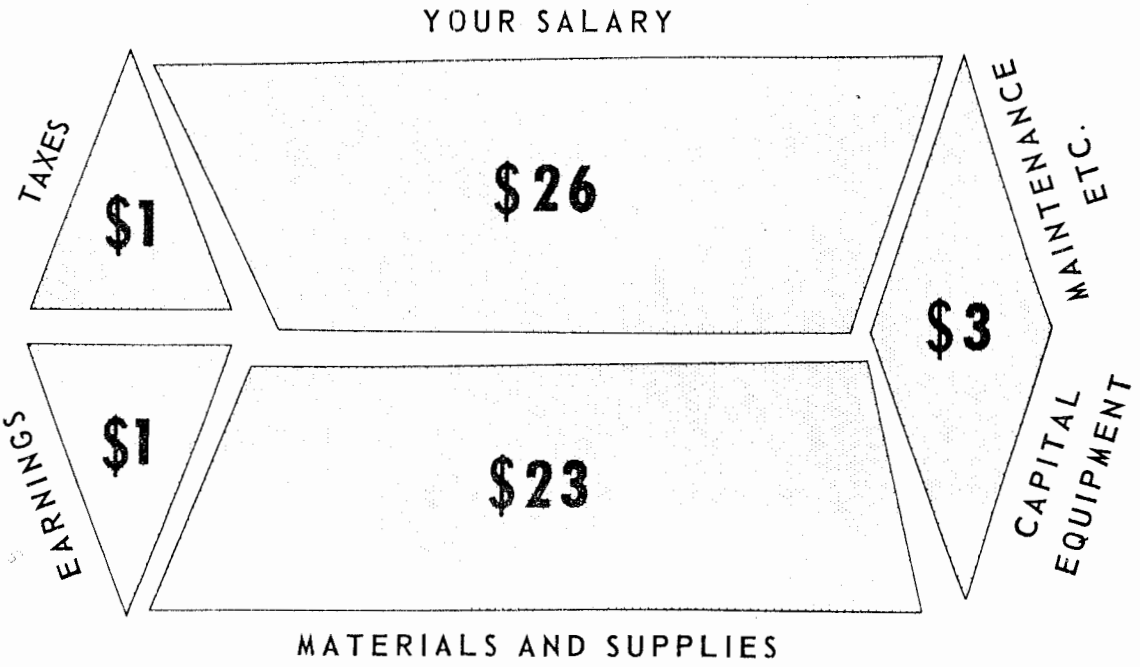
# FOR BETTER VALUE

NO. 3 VALUE ENGINEERING, GOVERNMENT EQUIPMENT DIVISION AUGUST 8, 1958

# What is the value of a dollar?

YOU MAY BE FAMILIAR WITH THE SAYING, "A PENNY SAVED IS A PENNY EARNED." BUT, DID YOU KNOW THAT EACH DOLLAR YOU SAVE BY REDUCING COSTS HAS THE SAME AFFECT ON THE COMPANY'S EARNINGS AS THE SALE OF FIFTY-FOUR DOLLARS WORTH OF OUR PRODUCTS?

**$1 EARNED BY REDUCING COST = $54 IN NEW SALES**




**COST REDUCTION IS EVERYBODY'S BUSINESS**

RAYTHEON

# FOR BETTER VALUE

NO. 10 VALUE ENGINEERING, GOVERNMENT EQUIPMENT DIVISION SEPTEMBER, 26, 1958

# The Customer Wants Better Value

MIL-V-19858(SHIPS)
15 March 1957

MILITARY SPECIFICATION
VALUE ENGINEERING OF NAVAL ELECTRONIC EQUIPMENT

MIL-V-21237(NOrd)
5 February 1958

MILITARY SPECIFICATION
VALUE ENGINEERING OF NAVAL ORDNANCE EQUIPMENT

MORE AIR FORCE PER DOLLAR

NO. SCL-2768
6 June 1955

SUPERSEDING NO.
SCL-2768
2 March 1953

SIGNAL CORPS
TECHNICAL
REQUIREMENTS

LEAST UNIT COST IN PRODUCTION OBJECTIVE

Bureau of Ships Journal July, 1958

A Message
From
The Chief

Our Value Engineering program deals with a problem of fundamental importance to all of us. Rising price levels plus expensive technical advances have pushed ship costs steadily higher since World War II. Nuclear propulsion, missile armament and improved electronics systems have given us ships of tremendously increased firepower and operational effectiveness, but they cost far more than ships of conventional design.

Value Engineering is a major factor in our effort to counteract rising costs. It seeks to obtain required functions at less cost through redesign, and through utilization of the stock item, the standard part, or the commercial product rather than special equipment. Combat serviceability is not impaired; in many instances it should be enhanced.

Considerable progress has been made since 1954 when the program was started. Value Engineering units have been established in the naval shipyards. The operating forces have provided helpful suggestions. Sizable savings have already been realized. However, the potential is virtually unlimited, and we have made only a beginning.

The Bureau has devised an incentive plan by which our contractors can retain a share of cost reductions realized from applying approved Value Engineering concepts. This plan is being extended to include electronics and components contracts, as well as ship construction. I am gratified by the excellent cooperation of Navy contractors in the program, and by the highly effective efforts of Bureau and naval shipyard personnel. I believe that our accomplishments to date presage even more worthwhile gains in the future.

A. G. Mumma

## If We Don't Give Better Value Our Competitors Will

RAYTHEON

# FOR BETTER VALUE

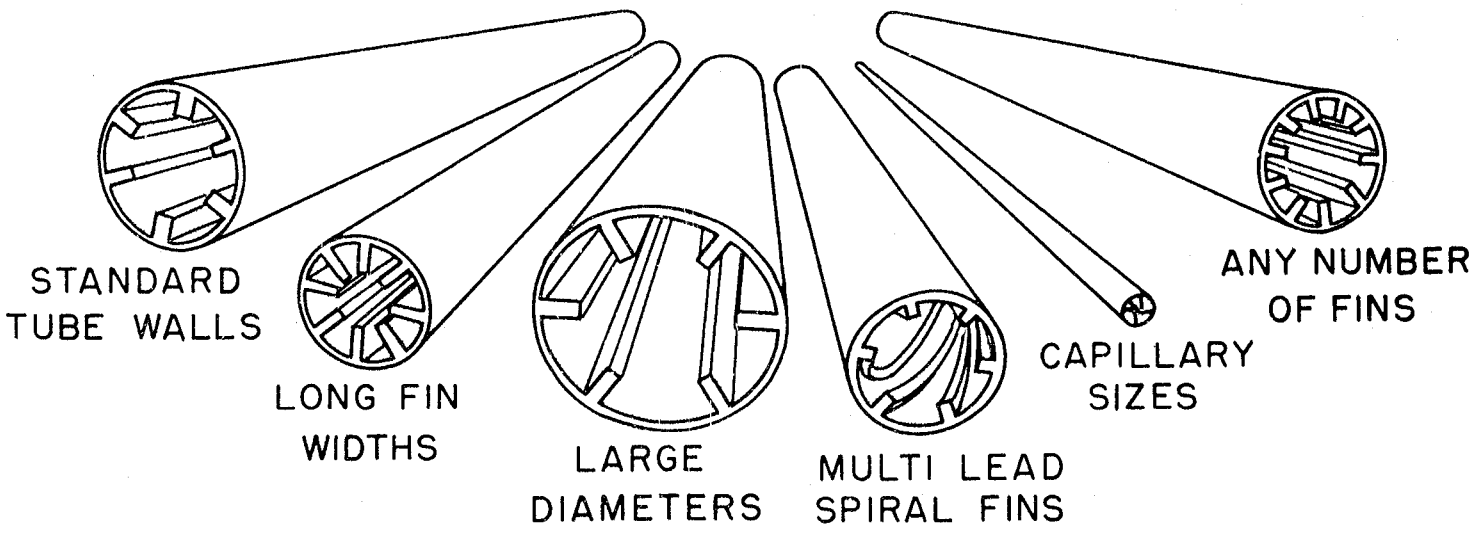
NO. 27 VALUE ENGINEERING, WAYLAND LABORATORY JULY 22, 1959

# TUBES WITH INTERNAL FINS

## FOR HEAT TRANSFER APPLICATIONS *

## A NEW TECHNIQUE BY

F.W. French Tube Co.




— FINS COLD FORMED FROM TUBE WALL – NO INTERFACES

— MADE TO YOUR SPECIFICATIONS

— LOW TUBE COST

CALL VALUE ENGRG 2625 FOR MORE INFO

* AS APPRAISED BY THE LAB'S MECH-CHEM CONSULTING SECTION

PLEASE POST ON ALL BULLETIN BOARDS

# VALUE ANALYSIS

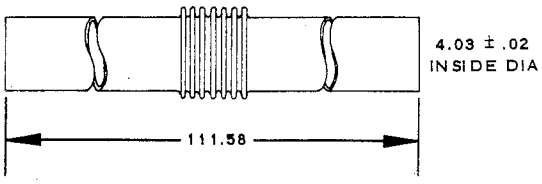
## A METHOD FOR PROFIT IMPROVEMENT

NORTHROP CORPORATION / NORAIR DIVISION

A STRONG VALUE ANALYSIS EFFORT PRODUCES COST REDUCTION

## VALUE ANALYSIS BULLETIN FOR OCTOBER 1960

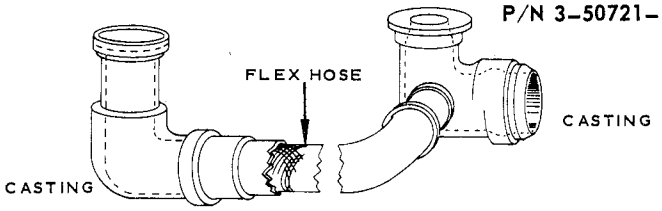
**EXAMPLE NO. 1 — CASE NO. 38–105**
**SHROUD P/N 3–54356**




The original stainless steel tube fabrication was costly and appeared fragile. Therefore, the design engineer requested the Value Analysis unit and the buyer to assist in locating speciality suppliers who could provide alternate materials or methods of manufacture to accomplish the required function with greater reliability at lower cost. Two promising lower cost possibilities were submitted for consideration, one a rigidized stainless steel tube with an integral bellows, and the other a fiberglass lay up with a stainless steel bellows. Both were under consideration at the time a failure occurred during fuel cell pressurization tests. The fiberglass proposal was determined by Engineering to be the most rugged and lowest in cost, with the additional advantage of saving one-half pound in weight; consequently, it was approved.

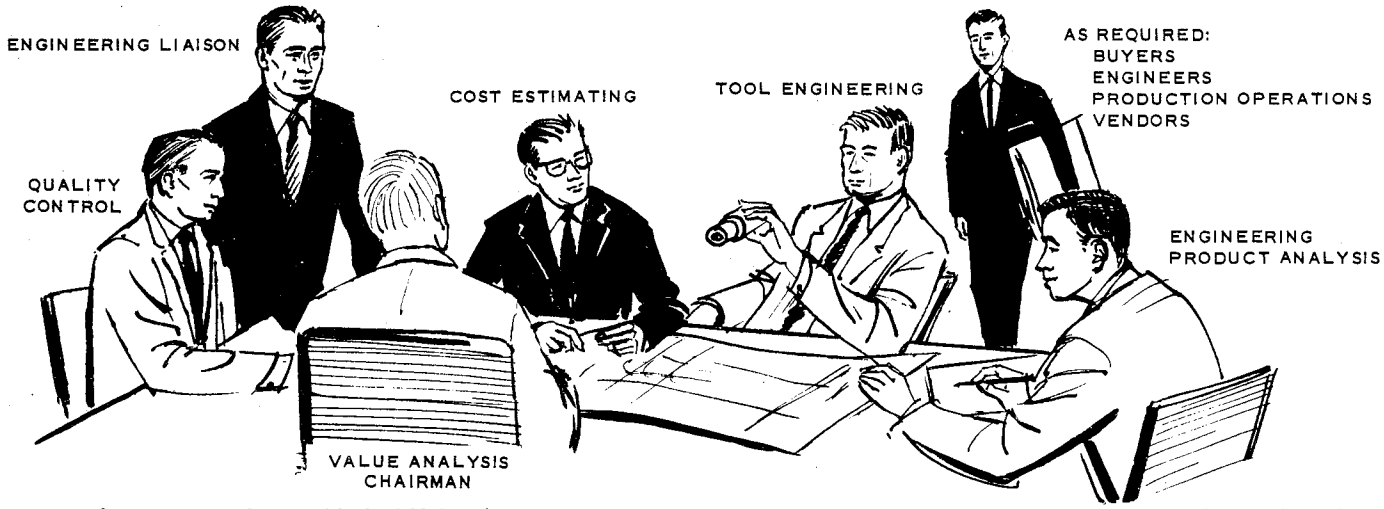
**Cost reduction — 30 percent**
**Savings on 50 ship sets — $3200.00**

**EXAMPLE NO. 2 — CASE NO. 38–126**
**CASE NO. 38–127**
**FUEL HOSE CROSS OVER ASSEMBLY P/N 3–50720–1**
**P/N 3–50721–1**




The buyer questioned the value to cost ratio of vendor designed items and referred to the Value Analysis unit for study. A brainstorming meeting was arranged consisting of cognizant Design Engineers, Product Analysts, the Buyer and Value Analysts. It was found that high costs existed because of the welded assembly of formed metal parts in the elbow. After considerable discussion it was tentatively determined that substantial cost improvements would result from a complete re-design to incorporate cast elbows. The proposal was referred to the supplier, who objected because of the possibility of leakage through the pores of the casting. Another meeting considered this objection and developed a recommendation to study various methods of impregnation. The proposal was again referred to the vendor who ultimately designed acceptable impregnated castings.

**Cost reduction — 38 percent**
**Savings on 50 ship sets — $15,119.00**




**As a means of augmenting the established Value Analysis program, this committee was recently formed to functionally analyze highly complex systems and other such high cost items of manufacture or procurement, as may be required, in order to develop recommendations for lower cost methods of accomplishing the essential functions.**

VALUE ANALYSIS IS A PROGRAM IN WHICH EVERYONE FROM THE PRESIDENT TO THE OFFICE BOY PARTICIPATES. RESULTS ARE, THEREFORE, ACHIEVED THROUGH THEIR COOPERATIVE EFFORTS. FOR THIS REASON SAVINGS ARE NOT CREDITED TO ANY INDIVIDUAL OR GROUP, BUT TO THE PROGRAM. HOWEVER, THOSE WHO QUESTION THE VALUE OF AN ITEM AND REFER IT FOR STUDY ARE GIVEN CREDIT FOR INITIATIVE.

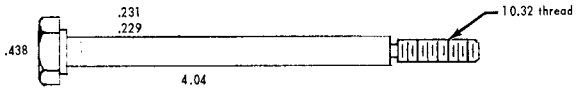
# VALUE ANALYSIS

A STRONG VALUE ANALYSIS EFFORT PRODUCES COST REDUCTION

**APRIL 1960**

## TYPICAL EXAMPLES OF VALUE ANALYSIS CASES

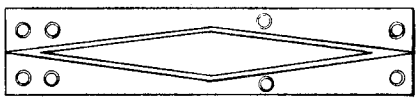
**EXAMPLE NO. 1 SHEAR PIN FOR F-89 TOW BAR**




Designed to be machined from 7/16" hex steel. On a recent re-order for 6200 the buyer requested a value analysis. An analysis of the function indicated that the pins could be produced equally as well as by cold heading 1/4" round stock, then finish machined. This was verified by the supplier. Therefore, a DCR to that effect was approved.

Cost reduction — 54 percent
Total savings — $1860.00

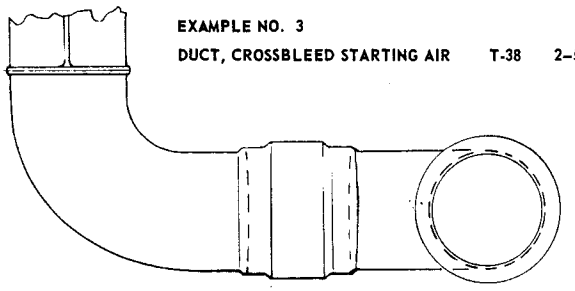
**EXAMPLE NO. 2 T-38 BLADE ANTENNA 2-61907**



Buyer requested value analysis due to high costs involved. The analysis confirmed that the cost was disproportionate to the function. A brainstorming product analysis meeting was then arranged in engineering to discuss alternate designs. Several alternate approaches were devised, one being to cast the mounting plate and blade as an integral part. Similar meetings were then held with specialty suppliers. From these meetings a lower cost, higher quality design emerged.

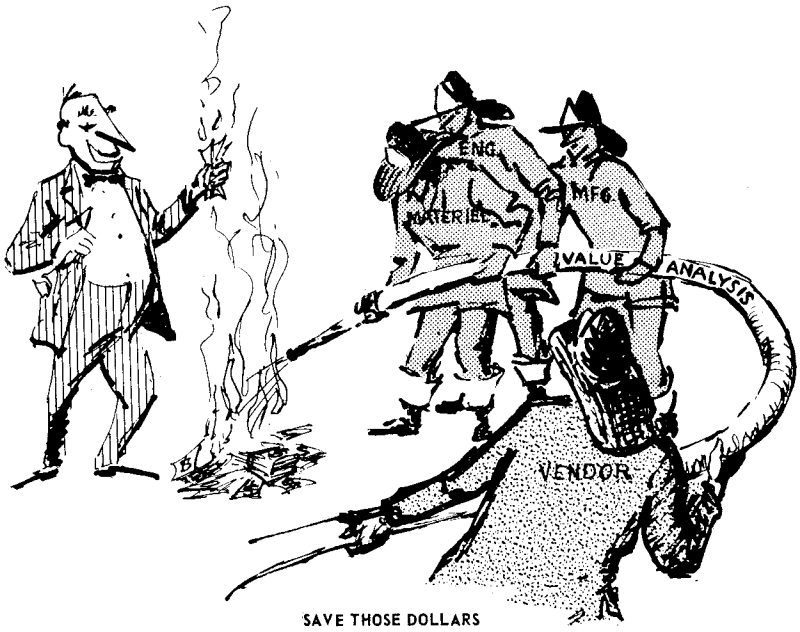
Cost reduction — 48 percent
Total savings — $9000.00

**EXAMPLE NO. 3**
**DUCT, CROSSBLEED STARTING AIR T-38 2-50303**



In response to a Value Analysis questionnaire, the supplier suggested that the elbow design be changed from a single piece forming operation to a welded assembly. Engineering evaluation found the proposal acceptable.

Cost reduction — 16 percent
Total savings — $1068.00




SAVE THOSE DOLLARS

**ABOVE ARE TYPICAL EXAMPLES OF SAVINGS PRODUCED BY APPLYING THE TECHNIQUES OF VALUE ANALYSIS. THE SERVICE IS AVAILABLE TO ANY EMPLOYEE OR SUPPLIER WHO QUESTIONS THE COST OF AN ARTICLE IN RELATION TO THE FUNCTION IT PERFORMS. (COST = DOLLARS OR MAN HOURS.)**

YOUR QUESTIONS ARE SOLICITED

MATERIEL SECTION, VALUE ANALYSIS 6000-71 STATION 3-621

# TESTS FOR VALUE

## *Our Challenge — Our Obligation*

***Every material, every part, every operation must pass these tests***

★ ★ ★

1. Does its use contribute Value?
2. Is its cost proportionate to its usefulness?
3. Does it need all of its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower cost method?
6. Can a standard product be found which will be usable?
7. Is it made on proper tooling—considering quantities used?
8. Do material, reasonable labor, overhead and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

VALUE ANALYSIS SERVICES

**Courtesy of Value Engineering Services**
**RAYTHEON COMPANY**

## 50 questions to give you pause

# Designer's checklist

Lest you forget—here's a set of reminders pointing to the little things that breed waste and inefficiency.

*WALTER R. SCHERB, Western Electric Co, Kearny Works, Kearny, NJ*

### GENERAL

- ☐ **1.** Is this a proposal or an actual design project?
- ☐ **2.** To what extent should we consider annual requirements?
- ☐ **3.** Is the new design necessary, or would a simple modification of an existing one suffice?
- ☐ **4.** If the new design supersedes an existing one, are the economies sound with respect to tool and machine investment, etc?
- ☐ **5.** Are the engineering requirements, limits, and tolerances specified necessary or are they unnecessarily strict and likely to result in excessive manufacturing cost?
- ☐ **6.** Are the requirements consistent with those for similar equipment so that gages and test facilities can be used?
- ☐ **7.** Can the engineering requirements be interpreted in only one way so costly discussions do not result?
- ☐ **8.** Are those dimensions of component parts which affect their assembly properly related to a common base point?
- ☐ **9.** Are additional drawings introduced when information could just as effectively be added to existing drawings?
- ☐ **10.** Are new parts called for where existing parts could be used, either with or without modification?
- ☐ **11.** Has the minimum number of parts been used to reduce assembly effort?
- ☐ **12.** Are assemblies in the most practical stage for economical and safe shipping?
- ☐ **13.** Is wiring style correct—local cable, surface wiring, direct wiring?
- ☐ **14.** Can length, diameter, number of threads, material, and finish of screws, bolts, nuts, washers, etc, be simplified to reduce the number of parts?
- ☐ **15.** If stamping is to be performed after assembly, is the location convenient?
- ☐ **16.** If cost estimates are required, are they accurate enough for their intended purpose? Do they reflect the uncertainties?

### RAW MATERIAL

- ☐ **1.** Have standard raw materials been specified so they are obtainable without special order?
- ☐ **2.** Can a cheaper, thinner, or more workable material be used?
- ☐ **3.** Can grained or ground surfaces be eliminated by obtaining a prepared surface or a better-grade material?

- ☐ 4.. Can plated or prepared surface on steel be used where more costly solid material is specified?
- ☐ 5.. If a high-grade fiber is specified, will the electrical requirements allow the use of a lower and less expensive grade?
- ☐ 6.. Can specially rolled or formed stock, supplied directly from the mill, be used advantageously?
- ☐ 7.. Where sheet is specified, can strip stock be used to reduce manufacturing cost?
- ☐ 8.. Would a standard width of sheet be more economical than a special width?

## MANUFACTURING

- ☐ 1.. Is there an application for any of the highly productive molding processes such as forging, die casting or powdered metal?
- ☐ 2.. Can formed punching replace castings, etc, or would a casting eliminate the assembly of a number of parts?
- ☐ 3.. Do castings have surfaces suitable for easy clamping for machine operations or should these be specially provided?
- ☐ 4.. Are holes too close to edges or shoulders, causing difficulty in die design or maintenance?
- ☐ 5.. Can the number of sizes of holes, taps, or screws be reduced? Can the sizes themselves be larger to facilitate manufacture?
- ☐ 6.. Do hole sizes correspond to standard drill sizes?
- ☐ 7.. Have blind tapped holes been specified where through holes would be satisfactory?
- ☐ 8.. Have standard threads been specified for screws and tapped holes and are they preferred sizes?
- ☐ 9.. Are screws, bolts, or other fasteners accessible without special wrenches, screwdrivers, etc?
- ☐ 10.. Are countersunk screws used where others would be satisfactory?
- ☐ 11.. Are screws adaptable to power-driven assembly methods?
- ☐ 12.. If an irregular hole is shown, which would necessitate filing or broaching, can it be changed so milling or drilling can be performed?
- ☐ 13.. Can engraved characters be replaced by depressed stamped characters or rubber-stamped inked characters protected with shellac?
- ☐ 14.. Will the requirements justify or permit metal etching instead of engraving or stamping?
- ☐ 15.. Can arc or spot welding be used to replace riveting or other more costly fastening methods?
- ☐ 16.. Can weld nuts replace embossed tapped holes, or similar threaded studs replace riveted ones?
- ☐ 17.. Can deburring be replaced by tumbling?
- ☐ 18.. Are jigs and fixtures designed so both left and right hands can be used to advantage?

## FINISHING

- ☐ 1.. Can specified finishes be eliminated?
- ☐ 2.. Can a less expensive finish be used?
- ☐ 3.. Can the surface preparation for a subsequent finish be eliminated or simplified?
- ☐ 4.. Does the design permit finishing as specified?
- ☐ 5.. Is the required finish specified at the proper stage of completion to avoid damage to the finish in subsequent handling?
- ☐ 6.. Will an electrochemical finish penetrate all recesses?
- ☐ 7.. Can the finish specified be applied economically in the lots anticipated?
- ☐ 8.. Has an electrochemical finish been specified on a partial assembly where purging at joints will occur?

# TESTS FOR VALUE

## Our Challenge — Our Obligation

### *Every material, every part, every operation must pass these tests*

★ ★ ★

1. Does its use contribute Value?
2. Is its cost proportionate to its usefulness?
3. Does it need all of its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower cost method?
6. Can a standard product be found which will be usable?
7. Is it made on proper tooling—considering quantities used?
8. Do material, reasonable labor, overhead and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

VALUE ANALYSIS SERVICES

**Courtesy of Value Engineering Services**
**RAYTHEON COMPANY**

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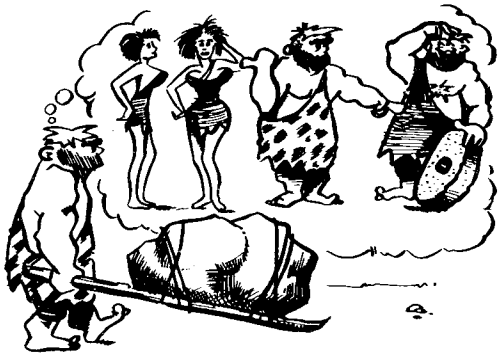


Is its cost proportionate to its usefulness?

Does it need all of its features?

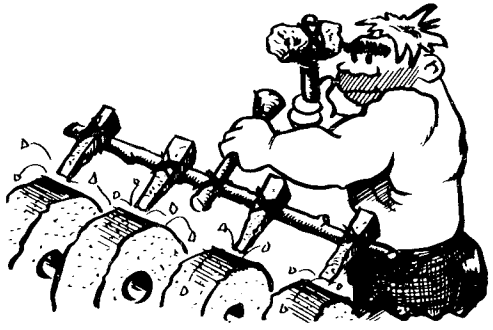
Is there anything better for the intended use?

# VALUE ANALYSIS
# TESTS FOR VALUE
## . . . GUIDE FOR SAVINGS . . .
## and
## . . . SUGGESTIONS . . .

**Courtesy of Value Engineering Services**
**RAYTHEON COMPANY**

Can a usable part be made by a lower cost method?

Do material, reasonable labor, overhead and profit t[illegible] its cost?



Is it made on proper tooling-considering quantities used?

Can a standard product be found which will be usable?

Hamilton Bros

# VALUE ANALYSIS CHECK SHEET

## "CHALLENGE THE FUNCTION"

What Is The Function? - Is The Function Really Necessary?
Does It Cost More Than It is Worth? - Is The Cost Proportional To The Usefulness?

### SPECIFICATIONS

Are specifications unrealistic?
Does it do more than specifications require?
Do specifications contain unnecessary requirements?

### DESIGN

Are requirements justified?
Does it exceed the functional requirements?
Are all features necessary?
Is there a better way to perform the function?
Are tolerances unreasonable or too costly to maintain?
Is there something else available that can do the job better and/or at lower cost?

### MATERIAL

Can a less costly material be used?
Is there a better material for the job?

### MANUFACTURING METHODS AND PROCESSES

Can parts or operations be combined, simplified, or eliminated?
Are any nonfunctional or appearance only items required (surface finishes, machining operations, etc.)?
Can any part be made by a less costly method (cast, forge, weld, form, etc.)?
Will changes to finish requirements reduce cost?
Is proper tooling being used (considering quantity to be made)?

### RELIABILITY, QUALITY, PERFORMANCE, MAINTAINABILITY

Can it be made simpler to improve reliability, quality, or maintainability?
Are quality and/or reliability higher than necessary to meet functional requirements?
Does it meet or exceed performance or environmental requirements?
Are all inspection, test, or qualifying requirements necessary?
Can maintainability be improved?
Can a change in material or design reduce weight?

### PURCHASED ITEM

Can available standard parts or catalogued vendor parts be used or adapted at lower cost
Can a specialty supplier product or process do the job better or at less cost?

### DOCUMENTATION, OTHER

Do specifications, test procedures and requirements include more than is necessary to meet functional requirements?
Are procedures clear, concise and implemented with minimum time and effort?
Are packaging and/or handling requirements too high?
Can operation or installation be improved?

F. S. Sherwin
Aug. 28, 1962

# Value Engineering

## PRELIMINARY INFORMATION CHECK SHEET

1. Functional Information
   - a. Can this function be eliminated? ☐
   - b. Does this do more than is required? ☐
   - c. Is it over-designed? ☐
   - d. Can it be simplified? ☐
   - e. Can something do the job better? ☐

Comment: _____

2. Design Information
   - a. Is a severe environment involved? ☐
   - b. Must this be highly reliable? ☐
   - c. Is there an installation problem? ☐
   - d. Will this be difficult to operate? ☐
   - e. Can a standard be used? ☐
   - f. Is there a strength problem? ☐

Comment: _____

3. Special Requirement Information
   - a. Are special platings required? ☐
   - b. Are special finishes required? ☐
   - c. Are special procedures required? ☐
   - d. Does this require special quality? ☐
   - e. Are special safety considerations required? ☐

Comment: _____

4. Materials Information
   - a. Can special materials be eliminated? ☐
   - b. Will a special material do it better? ☐
   - c. Are materials difficult to obtain? ☐
   - d. Are these materials hard to process? ☐
   - e. Is material treating a problem? ☐

Comment: _____

5. Specification Information
   - a. Are the specifications unrealistic? ☐
   - b. Will modification simplify design? ☐
   - c. Does design do more than specifications require? ☐

Comment: _____

6. Processing Information
   - a. Is this difficult to manufacture? ☐
   - b. Is there a less costly method? ☐
   - c. Does this require special tooling? ☐
   - d. Is special equipment required? ☐
   - e. Can a specialty vendor do this at less cost? ☐
   - f. Are processing requirements too strict? ☐

Comment: _____

7. Supplementary Information
   - a. Are there particular packaging problems? ☐
   - b. Are there other supply problems? ☐
   - c. Does this require costly accessories? ☐
   - d. Will this be difficult to transport or handle? ☐
   - e. Will maintainability be difficult? ☐
   - f. Are instruction manuals required? ☐

Comment: _____

8. Value Summary
   - a. Is this function unimportant? ☐
   - b. Does this cost more than it is worth? ☐
   - c. Does it cost more than the total of reasonable labor, overhead, material and profit? ☐
   - d. If it were your money, would you refuse to buy it? ☐

Comment: _____

Is Additional Analysis Recommended? _____ yes or no

Value Engineer: _____

Date: _____

Reason for study: _____

Drawing No. _____

Detail No. _____

Title: _____

Used on Drawing No. _____

Form No. VE-2

# CHECK LIST FOR PRODUCT DESIGN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## SUMMARY

With the placing of increased importance on product design assurance and reliability, considerably more attention must be given to the details of designing military electronic equipment.

This report presents a Check List of questions to be used by design engineers and others for examining and evaluating the design of electronic equipment in order to ensure the optimum design for a customer's requirements.

## INTRODUCTION

The increasing cost and complexity of military electronic equipment justifies the expense and engineering time required to analyze designs thoroughly in as early a stage of development as feasible.

The Check List is intended to serve primarily as a guide to engineers during the design of military electronic equipment. However, the list is sufficiently basic that it may be used for non-military design as well. In fact, the questions frequently lead to others which are uniquely applicable to the type of equipment being considered.

The questions were grouped to facilitate their use in an orderly fashion while considering the various facets comprising a total design. With continued use, additional groupings or changes in the present ones will undoubtedly suggest themselves.

Since the Check List has evolved through experience, its use permits the design engineer, junior and senior alike, to avail himself of the experience of others. It is a means for advance consideration--and avoidance--of design pitfalls.

In addition to its use by the design engineer, the Check List may be utilized by those called upon to review a design at any one of several stages. These may be 1) prior to building the breadboard model, 2) at the completion of breadboard tests, and 3) at the completion of prototype tests.

# CHECK LIST FOR PRODUCT DESIGN

## PART I - ELECTRICAL

### 1. PARTS SELECTION AND EVALUATION

1) Have the appropriate standards been consulted for selection of standard electrical components?

2) Can a redesign omit a nonstandard part or replace it with a standard part?

3) What parts are nonstandard?

4) Have requests been initiated for approval of nonstandard parts?

5) Have environmental tests been started on nonstandard parts?

6) Have potted circuits been subjected to environmental testing?

7) What are the parts having the highest failure rates?

## 2. PARTS APPLICATION

### A. RESISTORS

1) What is the operating ambient temperature?

2) What power dissipation is estimated in this application?

3) Is the resistor properly derated?

4) What tolerance limit is required for satisfactory circuit operation?

5) What tolerance buildup (due to temperature, aging, electrical stress, etc.) can be allowed?

6) Has the rated wattage been adjusted in cases where short mounting leads are used?

7) Can any potentiometers be replaced by fixed resistors?

8) Has the voltage limit been exceeded on any fixed composition resistors?

## B. CAPACITORS

1) What is the operating ambient temperature?

2) What is the working voltage expected in this application?

3) Is the capacitor properly derated?

4) Is the capacitor subject to surge voltages which exceed the rated operating voltage?

5) What tolerance limit is required for satisfactory circuit operation?

6) What tolerance buildup can be allowed?

7) What derating factor was used for a-c ripple or pulse voltages on MIL-E-25A paper capacitors?

8) Have capacitors with adequate temperature ratings been used wherever possible?

9) Have temperature-compensating or low temperature coefficient capacitors (mica or ceramic) been used wherever high stability is required?

10) Have high dielectric ceramic capacitors been restricted to bypass usage?

11) Are tantalum capacitors bypassed for high frequencies (above 100 kc)?

12) Are all capacitors heavier than 0.5 oz. securely mounted in accordance with specification MIL-E-5400, Para. 3.1.3.5?

## C. TUBES

1) Does the specification of the tube type selected define the required characteristics?

2) Does the operation of the tube approach any absolute rating under any usual variation of supply voltage or load.

3) What is the operating ambient temperature?

4) What electrode ratings are of critical consideration in this circuit application?

5) Is the heater voltage within rating? What variations are expected?

6) Is the heater-to-cathode voltage within rating in this circuit application?

7) Are the plate and screen grids properly derated?

8) What tolerance buildup can be allowed?

9) Has Gm variation been considered?

10) Were maximum grid resistance ratings observed?

11) Is input and/or output capacity a critical consideration in this circuit application? What variation in input and/or output capacity can be tolerated?

12) Does circuit operation depend upon a tube parameter not controllable by the designer?

13) What is the maximum rated vs. maximum expected bulb temperature?

14) Will the circuit perform satisfactorily with randomly selected tubes? - with tubes operating at their upper or lower MIL limits?

15) Has tube approval data been taken?

16) If a printed-circuit board is being used, have adequate cooling measures (convection to cooling air or conduction to a heat sink) been taken to prevent damage to the board or components mounted on it.

17) Have standard tube shields been used?

## D. TRANSISTORS

1) Does the specification of the type of transistor selected define the required characteristics?

2) Does the operation of the transistor approach any absolute rating under any usual variation of supply voltage or load?

3) What is the operating ambient temperature?

4) What is the maximum rated power dissipation? What is the maximum power dissipation expected in this circuit application?

5) What is the maximum rated collector voltage? What is the maximum collector voltage in the present application?

6) What is the maximum rated collector current?

7) What deviation in Beta is tolerable?

8) How much deviation in Beta is expected due to tolerance buildups?

9) Will the circuit perform satisfactorily with randomly selected transistors? - with transistors operating at their upper or lower MIL limits?

10) Is power gain a critical consideration in this application?

11) What deviation in power gain is tolerable?

12) What deviation in power gain is expected due to tolerance buildup?

13) Is noise figure a critical consideration in this application?

14) Is the noise figure tolerable at the operating ambient temperature?

15) How much leakage current is expected at the operating ambient temperature?

E. SEMICONDUCTOR DIODES

1) Does the specification for the type of diode selected define the required characteristics?

2) What is the operating ambient temperature for each diode?

3) What is the power dissipation within the diode? What is the maximum rated power dissipation?

4) How much reverse recovery time does the diode require?

5) What is the rated peak inverse voltage?

6) How much reverse current can be tolerated?

7) How much reverse current will flow at the operating ambient temperature?

8) Does the circuit perform satisfactorily with randomly selected diodes? - with diodes operating at their upper or lower MIL limits?

9) What Zener voltage reference is required? What Zener reference voltage is expected?

## F. TRANSFORMERS, CHOKES AND COILS

1) What is the operating ambient temperature?

2) Is Q a critical consideration in this circuit application? What deviation in Q can be tolerated?

3) What deviation in Q is expected due to tolerance buildup and to temperature changes?

4) What is the maximum current carrying capability of the choke or coil? What is the maximum current expected in this application?

5) How close is the highest operating frequency to the resonant frequency of the choke or coil?

6) Has a requirement for shielding been established?

7) When a hum problem exists, has special consideration been given to core construction?

8) Do transformer specifications conform to MIL standards?

## G. RELAYS AND SWITCHES

1) What "quality level" does each relay or switch represent?

2) How many actuations per hour are expected?

3) How many actuations per mission are expected?

4) What percent of rated current does each contact carry?

5) Is relay closing time or opening time a critical consideration? If so, how much increase is tolerable?

6) What are the pull-in and dropout voltages or currents?

7) What is the manufacturer's tolerance for initial coil resistance?

8) How much will the coil resistance vary with temperature?

9) How much change in coil resistance is tolerable?

10) Has arc suppression been used?

11) Has the possibility of dry circuit operation been considered?

## H. ELECTROMECHANICAL DEVICES

1) Have the adverse effects on brushes at high altitudes been considered?

2) What consideration has been given to variations of d-c motor speed-torque characteristics due to temperature and altitude?

3) How critical to proper operation is the speed-torque characteristic?

4) Can the associated circuitry tolerate increased loads caused by variation in motor characteristic?

5) Have the appropriate specialists been consulted on the use of rotary solenoids and timing motors?

6) Have you depended solely on manufacturer's data for force-movement characteristics of solenoids?

7) Are meter windows sealed to prevent moisture formation?

8) Has the possibility of charge formation on meter windows been investigated?

9) Are resolvers checked for accuracy and phase shift at elevated temperatures?

## I. CONNECTORS AND PLUGS

1) Does the number of active pins per connector conform to the recommended limit?

2) Is a sufficient number of spare pins available on each connector? (At least four spares for connectors over 26 pins per MIL-E-5400C, paragraph 3.1.5.3)

J MISCELLANEOUS PARTS (PRINTED CIRCUITS, WIRE, ETC.)

1) Has consideration been given to the current rating of wire?

2) Has the current rating of wire been reduced in cases where voltage drop is important?

3) Is wire color coding required, and, if so, is it in accordance with the proper standards or specification?

4) Has the placement of components on printed-circuit boards been considered from the cross-talk point of view?

5) Does a heat dissipation problem exist on printed-circuit boards?

6) Is a keying scheme employed to prevent interchanging printed-circuit boards?

7) Are transistor, diode, and tantalytic capacitors properly polarized on printed-circuit boards?

8) Are large potential gradients possible between adjacent pins or connectors on printed-circuit boards?

9) Do circuit breakers conform to MIL-C-5989B?

## 3. SYSTEM AND CIRCUIT CONSIDERATIONS

1) What variations in input signal can be tolerated? What variations are expected?

2) What variations in the impedance presented to the input terminals can be tolerated? What is expected?

3) How does the input circuitry contribute to input tolerances?

4) Is a-c power supply distortion a critical consideration?

5) What percentage of distortion can be tolerated? What is expected?

6) What tests have been performed to confirm the answers to questions in Para. (5) above?

7) What variation in B+ voltage(s) can be tolerated?

8) What variation in bias voltage can be tolerated?

9) What design features protect the circuit against excessive variations in line voltage?

10) What design features protect the circuit against loss of B+ or bias voltage supplies?

11) What cable length was assumed on inputs and outputs?

12) How much change in the assumed cable length can be tolerated?

13) Is over-all protection provided against overload, excessive heating, pressure changes, etc?

14) Do the self-test features of the unit meet the requirements?

15) What problems were observed when the circuit was tested in conjunction with other units?

16) Has the unit been subjected to environmental testing? What problems were observed with respect to temperature, moisture, vibration, shock, altitude?

17) Have all problems highlighted in the preliminary design review been resolved?

18) Has a separate list of recommendations for product improvement or redesign been compiled?

19) What alternate circuits or systems were considered?

20) Have "preferred circuits" been used wherever possible?

21) What factors influenced the choice of this particular circuit or system?

22) Are there firm specifications for this circuit, including test specifications?

23) Have all specifications been met unconditionally?

24) Does any specification require modification?

25) Can any unreasonable or unusually difficult requirement be relaxed?

26) Can a simulation study be of assistance?

27) What marginal testing has been performed? Was marginal operation indicated in any case? What are the critical parameters affecting marginal operation?

28) Have heat runs been made on electrical components which are either thermal emitters or otherwise heat sensitive?

29) Have phase margin checks been performed on all feedback loops?

30) What decoupling or neutralization schemes have been implemented to avoid regenerative feedback loops?

31) What analyses have been performed to determine the existence of feedback loops and their effects on other circuits?

32) Is circuit operation contingent upon the proper positioning of more than one switch or control; i.e., are several adjustable components necessary in the circuit?

33) Can any circuits be simplified and still operate within requirements? (On a value improvement basis)

34) Is the unit capable of satisfactory operation after the minimum required warm-up time?

35) What system adjustments are required when a unit is replaced?

36) What means are employed to decouple the power supply?

37) Do parasitic oscillations exist?

38) What design features have been incorporated to suppress parasitic oscillations?

39) What are the required tolerances on output signals? What are the expected variations?

40) How does the circuitry contribute to output tolerances?

41) Do weight reduction considerations affect reliability?

42) Have static and dynamic power drains been determined?

## 4. RELIABILITY ANALYSIS

1) What is the estimated required mean life of this circuit?

2) What is the calculated mean life.

3) What is the mean life, based on bench or other tests?

4) Is there a history or record of bench failures?

5) Have random failure rates and wearout rates been established for all parts?

6) What parts have an excessive failure rate?

7) What assumptions were made in calculations with respect to derating and temperature?

8) Are any parts operating near or above their recommended ratings?

9) Has a statistical analysis been conducted to determine effects of drift in component parameters and of component tolerance buildups?

10) Has a fail-safe design philosophy been utilized?

11) Is protection against secondary failures (resulting from primary failures) incorporated where possible?

## 5. SAFETY FACTORS

1) Is there adequate protection against dangerous voltages?

2) Are high-voltage warning plates necessary?

3) Have interlocks, safety switches and grounding bars been considered?

4) Are all external metal parts at ground potential?

5) Are discharging rods necessary for large capacitors? (at least 10,000 ohms)

6) Are bleeder and current limiting resistors used in power supplies?

7) Are there burning hazards?

8) Are "hot" terminals exposed when plugs or connectors are not connected?

9) Are adjacent plugs or connectors keyed to prevent interchanging connections?

10) Can maintenance or adjustment be performed safely?

## 6. MAINTENANCE

1) Are the maintenance and test equipment requirements compatible with the concept established for the system?

2) Does the unit require special handling?

3) Can the unit be readily installed and connected to the system?

4) Are factory adjustments such that they do not require readjustment when units are replaced in a system or when parts are replaced in the unit in the field?

5) What adjustments are necessary after a unit has been installed in the system?

6) Are adjustments capable of compensating for all possible tolerance buildups?

7) Is periodic alignment and/or adjustment recommended? How often?

8) Are all requirements for maintenance tests such that the specified time limitations can be met?

9) Has the number of factory adjustments been minimized?

10) Has the number of field adjustments been minimized?

11) Are interconnected circuits in the same package, thus providing minimal inputs and outputs at each maintenance level.

12) Is the interaction between adjustments and other circuit parameters minimized?

13) Is the design such that damage to the circuit cannot result from careless use of an adjustment or combination of adjustments?

14) Are all adjustments and indicators of the "center zero" type where possible?

15) Is periodic testing necessary? How often?

16) Are the test points adequate? Are they accessible in the installed condition?

17) What overhaul testing is required?

18) What specific test equipment is necessary?

19) Have factory and maintenance test equipment requirements been minimized and coordinated with the requirements for other units?

20) What special techniques are required in the repair, replacement, or alignment of the unit?

21) Are parts, assemblies, and components placed so there is sufficient space to use test probes, soldering iron, and other tools without difficulty? Are they placed so that structural members of units do not prevent access to them?

22) Are testing, alignment and repair procedures such that a minimum of knowledge is required on the part of maintenance personnel? Can trouble shooting of an assembly take place without removing it from a major component.

23) What special tools and/or test equipment are required?

24) Can every fault (degrading or catastrophic) which can possibly occur in the unit be detected by the use of the proposed test equipment and standard test procedures?

25) Have parts subject to early wearout been identified? Have suitable preventive maintenance schedules been established to control these parts?

26) Are the components having the highest failure rates readily accessible for replacement?

27) Are parts mounted directly on the mounting structure rather than being stacked one on another?

28) Are units and assemblies mounted so that replacement of one does not require removal of others?

29) Are limiting resistors used in test point circuitry; i.e., is any component likely to fail if a test point is grounded?

30) Can panel lights be easily replaced? (Panel lights should not be wired in series)

31) Have voltage dividers been provided for test points for circuits carrying more than 300 volts?

32) Will the circuit tolerate the use of a jumper cable during maintenance?

33) Are controls located where they can be seen and operated without disassembly or removal of any part of the installation?

34) Are related displays and controls on the same face of the equipment?

35) Are all units (and parts, if possible) labeled with full identifying data? Are parts stamped with relevant electrical characteristics information?

36) Are cables long enough to permit each functioning unit to be checked in a convenient place?

37) Are plugs and receptacles used for connecting cables to equipment units, rather than "pigtailing" to terminal blocks?

38) Are field-replaceable modules, parts and subassemblies plug-in rather than soldered?

39) Are cable harnesses designed for fabrication as a unit in a shop?

40) Are cables routed to preclude pinching by doors, covers, etc?

41) Is each pin on each plug identified?

42) Are plugs designed to preclude insertion in the wrong receptacle? Are plug-in boards keyed to prevent improper insertion?

## 7. ELECTRICAL INTERFERENCE

1) Do all the provisions of specification MIL-I-26600 apply, or should some waivers be sought?

2) What tests have been performed for electrical noise?

3) Has the chassis or frame been grounded? Have shock mounts been bypassed with ground straps? Has the insulated protective finish been removed where a metal-to-metal contact is required?

4) Are openings (such as those for access, ventilation, and case-mounted components) shielded to prevent case leakage? Are access doors of the metal textile or finger strip type?

5) Are heaters wired with twisted or isolated leads?

6) Are oscillators isolated from other stages and from antennas? Is oscillator power kept to a minimum? Is the oscillator heater decoupled from B supply sources?

7) Do parasitic oscillations exist, and is suppression necessary?

8) Is undesired signal transfer reduced by means of interstage decoupling networks and link or parallel-tuned circuits?

9) Are pulse networks and transformers isolated? Are the leads associated with the pulse networks decoupled? Are these leads kept as short as possible?

10) Is pulse energy fed to succeeding stages in coaxial leads where possible? (Guard against waveform distortion caused by coaxial cable capacitance.)

11) Are sharp projections avoided in high-voltage circuits? (They are possible sources of corona and arcing.)

12) Are sharp bends avoided in high-voltage wiring? (The possibility of insulation breakdown is increased.)

13) Are the magnetic fields associated with indicators adequately isolated? Are indicator control and power leads decoupled by the use of feed-through bypass capacitors?

14) Are blower motors of the a-c noncommutating type?

15) If it is necessary to use d-c rotating electrical equipment, is the design such as to minimize the effects of the commutation process? To this end, does the equipment employ such devices as interpoles, laminated brushes, as large a number of armature coils and commutator bars as possible, and good mechanical design and contruction?

16) Is relay or switch operation likely to create power supply transients in other units or circuits?

17) Has consideration been given to arc suppression during the making or breaking of switches or contacts? (Several methods are available, e.g., a simple RC network across the switch or contacts, a high resistance or rectifier across the inductive circuit, negative voltage characteristics resistors. If these are inadequate, shielding and feed-through capacitors in the input and output leads may be required.)

18) Are gas tube heater supplies and output leads well decoupled and isolated?

19) In power supplies using gas-tube rectifiers, is use made of line filters, electrostatically shielded transformers, and hash-suppression chokes in the plate and cathode leads?

20) Are electronically regulated power supplies provided with decoupling circuits to prevent oscillations in the regulator? Are long leads avoided in the plate and grid circuits?

## PART II - MECHANICAL

### 1. GENERAL DESIGN

1) Has use of cantilever mounting for parts and assemblies been minimized, and, where used, is the center of gravity located near the mounting?

2) Has the chassis been properly designed for its application?

3) What are the locations and load ratings of mounting points?

4) Where are the heaviest parts located?

5) Are all large parts and assemblies securely mounted?

6) Has the center of gravity been considered in terms of the proper distribution of shock mounts?

7) In the case of terminal boards, are the critical components mounted at the edges rather than at the center, and are they properly supported?

8) In the case of lead-mounted parts, have weight, lead weight, thermal expansion, supplementary support, bend rate, and other mounting considerations been evaluated?

9) Have clearances been provided with due consideration for vibration, shock and noise stresses?

10) Can electrical instability be caused by vibration of mechanical parts?

11) Have shock and vibration tests been performed? If not, are they scheduled?

12) Has the cooling design been analyzed to provide a temperature contour?

13) Are heat dissipating elements properly located with respect to heat sensitive parts? Is there suitable flow of air?

14) Have component parts, subassemblies and assemblies been supported and clamped properly with adequate consideration for heat dissipation?

15) Is the unit of the lightest weight consistent with sturdiness, safety and reliability?

16) Are all items visually and physically accessible when the unit is on the test stand?

17) Is the possibility of physical damage due to misuse of adjustments minimized by the design?

18) Is the possibility of damage to the unit during handling and installation minimized by the design?

19) Can the unit be removed and replaced within the required time limit?

20) Is the packaging scheme such as not to impose unrealistic spare parts requirements?

21) Does each part of the unit designed as non-field repairable meet the minimum reliability requirement for this classification?

22) Have suitable heat treatments been called out?

23) Has design been based on standard tooling wherever possible?

24) Have radii, fillets, curves and straight lines been sufficient to give all possible freedom to manufacturing?

25) Have the most economical parts satisfactory for the application been specified in all cases?

26) Are all purchased components called out by MIL, AN or RCA (not vendor) numbers?

27) Are the components arranged and mounted for the most economical assembly and wiring?

28) Are all fasteners large enough for their application?

29) Are guide pins, keys and latches of sufficient strength?

30) Is the basic structure of sufficient strength for the application?

31) Is the design such as to prevent excessive radiation into or out of the unit?

32) Are parts located to provide for logical wiring?

33) Are lubrication points minimized? Where required, are they accessible and clearly marked?

34) Is the predicted reliability within the unit requirement?

35) Have unit environmental tests, including temperature measurements at key points, been completed? If not, are they scheduled?

36) Have all problems highlighted in the preliminary design review been resolved?

37) Has there been compiled a separate list of recommendations for product improvement or redesign?

38) What alternate designs were considered?

39) Have the appropriate standards been consulted for materials, components, drafting, manufacturing and workmanship?

40) What factors influenced the choice of this particular design?

41) Do firm specifications exist, including test specifications?

42) Have all specifications been met unconditionally?

43) Does any specification require modification?

44) Can any unreasonable or unusually difficult requirements be relaxed?

## 2. WORKMANSHIP AND MAINTAINABILITY

1) Is soldering adequately specified? What provisions have been made to prevent cold joints and to ensure removal of flux?

2) Are proper screw lengths and locking provisions specified?

3) Are designs such as to prevent damage to components during installation?

4) Have guide pins been provided to facilitate installation of plug-in units?

5) Are plug-in units keyed (by some means other than the connector) to prevent accidental insertion in the wrong location?

6) Have tolerances of component mounting provisions and mating holes been coordinated?

7) Have all holes been located far enough from bends to prevent distortion?

8) Are bend radii specified to be large enough, in accordance with appropriate standards?

9) In reference to wiring and cabling, have the following items been considered?

   a. Does the design make provision for properly leading cables around corners and sharp edges?

   b. Are grommets provided where needed?

   c. Is the design such as to minimize soldering iron burns during both manufacture and maintenance?

   d. Is lacing properly and adequately specified?

   e. Have harnesses been properly routed and has sufficient clamping been provided to prevent cables hanging loose?

   f. Has adequate space been allowed for harnesses and for breakouts to connectors, etc?

   g. Are heavy wires being brought to terminals of adequate size?

h. Are stranded wires properly secured close to solder joints to prevent flexing?

i. Is any cable (or wire) overly taut, with strain being placed on the connector (or connection), the cable (or wire) or the clamps?

j. Do any cables or wires lie across removable units or across fasteners of any type?

k. Are all connectors visible, and are they easily accessible to tools and hands?

l. Have cables (wires) and connectors (connections) been properly identified? Can wrong connections result from cable layout and connector type?

m. Do any cable (wire) runs permit contact between the cable (wire) and moving parts ?

10) Are all items (parts and subassemblies) visually and physically accessible for assembly, wiring rework and maintenance?

11) Are all test points accessible when the unit is properly installed?

12) Are all field adjustments accessible when the unit is properly installed?

13) Has sequential assembly been avoided which results in involved sequential disassembly in order to make repairs and adjustments?

14) Is the design such that no unrealistic requirements for special facilities for maintenance, storage or shipment are imposed?

15) Is the design such that no unnecessary requirements for a special maintenance environment (e. g. , ground power carts, cooling, special primary power, etc.) are imposed?

16) Does the design provide for adequate protection of maintenance and test personnel against accidental injury?

## 3. MATERIALS AND PROCESSES

1) Have standard materials been specified in all possible cases?

2) Have the most economical materials and processes suitable for the applications been specified in all cases? (Material cost, fabrication cost and finishing cost should be considered.)

3) Have corrosion-resistant materials or finishes been provided?

4) Are there dissimilar metals in contact?

5) Are all materials satisfactory for the temperatures involved?

6) Is the possibility of flaking considered?

7) Has moisture protection been provided where necessary?

8) Are all materials fungus resistant or inert?

9) Are electrically conductive finishes provided where necessary?

10) Have machine finishes been reviewed for the most economical processes suitable for the requirements?

11) Have rivets or spot welds been specified where possible in preference to welding, furnace brazing, etc. ?

12) Has each sheet metal piece been examined to determine whether it has too many bends for economical fabrication?

## PART III - HUMAN ENGINEERING

1) Are visual indicators mounted so that operator can see scales, indices, pointers or numbers clearly? Are scale graduations, design of numerals and pointers, and scale progressions presented so that accurate reading is enhanced?

2) Do visual displays have adequate means for identifying an operative condition?

3) Have ambiguous information and complicated interpolations been eliminated from visual indicators to minimize reading errors?

4) Do controls work according to the expectation of the operator? (Naturalness of movement direction is derived from previous experience as well as certain handedness factors.)

5) Do functionally related controls and displays maintain functional or physical compatibility, such as direction-of-motion relationships or proximity to each other?

6) Are controls designed so that the operator can get an adequate grip for turning, twisting or pushing?

7) Does console design provide knee room, optimum writing surface, height, or optimum positions for controls and displays?

8) Do equipment design and arrangement allow space for several operators to work without interfering with each other?

9) Do arrangement and layouts stress the importance of balancing the workload, or do they force one hand to perform too many tasks while the other hand is idle?

10) Is the illumination designed with the specific task in mind, rather than with a general situation? (Many instruments are practically useless because of lack of illumination.)

11) Have extreme glare hazards been eliminated, such as: brightly polished bezels, glossy enamel finishes, or highly reflective instrument covers?

12) Are assemblies and parts stacked so that some have to be removed to repair or replace others, thus complicating maintenance?

13) Do fasteners for chassis and panels require special tools which hamper maintenance?

14) Do chassis door slides have means for holding the unit extended for servicing? Are the slides too loose, or do they bind?

15) Are handles provided, and are the chassis or units light enough to be moved without undue strain?

16) Is calibration indexing provided for maintenance adjustment and calibration adjustment controls? (Screwdriver adjustments are often too sensitive.)

17) Do the coding and symbols on equipments and in instruction manuals coincide? (Too few books tell what or how to check, what to expect, or how to correct, and when covered, the information is not organized so that it may be found quickly.)

18) Is illumination provided for the maintenance technician?

## PART IV - VALUE ENGINEERING

### 1. SPECIFICATION REVIEW

1) Have the customer's specifications been critically examined to see whether they ask for more than is needed?

2) Has the cost of any overdesign been defined for its effect on production as well as on the R&D program?

3) Has the cost effect of contract-required overdesign been discussed with the customer?

## 2. GENERAL

1) Does the design give the customer what he requires and no more?

2) Could costs be radically reduced by a reduction of performance, reliability, and/or maintainability to the minimum specified?

3) Could costs be radically reduced by a reduction of resistance to high temperature, shock, vibration or other environments to the minimum specified?

4) Have circumstances changed (changes in concept or specification, progress in the art, development of new components or processes) so that the design includes unnecessary or expensive circuitry, parts or processes?

5) Have unnecessarily high cost items been included as a result of their availability when the breadboard or model was constructed?

6) Can any variable devices such as potentiometers included for breadboard or model operational adjustment be changed now to fixed component parts or semiadjustable designs?

## 3. PRODUCTION COSTS

1) Are the quantities to be built on this order known?
Are the estimated quantities to be built on future orders known?
Have these factors been considered in the design decisions?

2) Will tooling costs be in line with present and anticipated production?

3) How much do you estimate the design will cost in production?

## 4. ELECTRONIC DESIGN

1) Does the design represent optimum electrical simplicity?

2) Is circuitry overly complex or conservative?

3) Have standard "preferred circuits" been reviewed to see how many can be used beneficially?

4) Has the field of commercially available packaged circuits, power supplies, etc. been reviewed against your requirements?

5) Can circuitry be eliminated by having one circuit do the job of two or more?

6) When specifying special component parts, have potential vendors been consulted for alternatives or modifications that would hold costs down?

7) Have all high cost components such as transistors, semiconductor diodes, magnetic and high power devices, motors, gear trains and decoders been examined to determine whether lower cost substitutions can be made?

8) Are the components the lowest cost meeting the design requirements?

9) Can any electrical tolerance be liberalized to allow specification of lower cost parts?

10) Have nearly identical parts been made identical to gain the advantage of quantity buying or manufacture?

11) Has coax cable been specified when hookup wire or shielded cable will do the job?

12) Has silicon been specified for transistors or diodes when germanium will do the job?

13) Can metalized Mylar be substituted for tantalum or Cerafil capacitors?

14) Have automated techniques been used to the maximum?

15) Is Teflon wire specified where other insulation will suffice?

## 5. MECHANICAL DESIGN

1) Does the design represent optimum mechanical simplicity?

2) Is every part absolutely necessary? Can any part be eliminated or combined with another part to reduce total number of parts and cost?

3) When specifying special parts, have potential vendors been consulted for alternatives or modifications that would hold costs down?

4) Are mechanical tolerances within the limits of normal shop practice defined in RCA Spec. 96400?
Can any tighter tolerance called out be changed to agree with RCA Spec. 96400, or be liberalized to hold costs down?

5) Are the surface finishes the coarsest that will do the job?

6) Are the fabrication processes the lowest cost meeting the design requirements?

7) Have nearly identical parts been made identical to gain the advantage of quantity buying or manufacture?

8) Are the materials the lowest cost meeting the design requirements?

9) Does the combination of material and protective finish specified result in the lowest cost combination?

10) Has cognizance been taken of relative workability of materials?

11) Have standard alloys, grades and sizes of stock been specified whenever possible?

12) Can the design be altered in any respect to avoid the use of non-standard tooling? See RCA drafting standard 8-224-200 series.

13) Has the 1/10" grid drafting system for sheet metal parts been used wherever applicable?

14) Can the design be modified to enable the use of the same tooling for right and left hand or similar parts?

15) Are drawings for fabrication of parts which are similar to parts already produced cross referenced so available tooling can be used?

16) Can the design be altered to avoid unnecessary handling and processing resulting from such things as riveting and spot welding on the same subassembly part?

17) Have automated techniques been used to the maximum?

18) Are casting bosses of adequate size, considering the large tolerances which apply to casting dimensions?

19) Can cores or complex parting lines be eliminated from any casting by moderate redesign?

20) Is impregnation of castings called out when it would aid processing? (Castings should be impregnated after machining if they are to be electroplated. This impregnation prevents absorption of plating acids or salts. Castings should also be impregnated if they are to hold liquids or gases under pressure.)

21) Have engineering and factory specialists been consulted for castings, forgings, weldments, heat treatment and other specialties?

22) Have standard sizes, grades and alloys of fasteners been specified whenever possible?

23) Are all manual welding operations specified absolutely necessary? Can furnace brazing be substituted?

24) Are the assembly processes the lowest cost meeting the design requirements?

25) Has adequate clearance between parts been provided to allow for easy assembly? (Parts have become smaller but hands have not.)

26) Are all parts designed for assembly at the earliest possible time? Assembly costs go up as the buildup of the system progresses.

27) Are markings adequate to guide the assembly processes?

28) Have the engineering and factory specialists been consulted on any unusual assembly problems?

29) Has datum line rather than multiple surface dimensioning been used on all drawings?

30) Can any four-place dimension be changed to a three-place dimension?

31) Can any three-place dimension be changed to a two-place dimension?

32) Can heat treating after forming sheet metal parts be eliminated by change of design or material to avoid straightening problems?

33) Is all masking from finishing materials (such as plating solutions and paint) necessary?

## 6. STANDARDIZATION

1) Have you coordinated your design with those who may be using similar (or have used in the past) designs, circuits, parts or components to get optimum benefit from standardization and past experience?

2) Are the standard circuits, standard components and standard hardware the lowest cost standards which will supply the minimum required characteristics?

3) Can the use of each nonstandard part or circuit be adequately justified?

4) Can any new nonstandard part be replaced by a nonstandard part which has already been RCA E-Form approved?

5) Do control drawings leave no question that a vendor standard part is being specified when such is intended?

6) Has standardization been carried too far until the cost of excess function is greater than the gains resulting from high quantity?

# TESTS FOR VALUE

## OUR CHALLENGE - OUR OBLIGATION

EVERY MATERIAL, EVERY PART, EVERY OPERATION MUST PASS THESE TESTS:

1. Does its use contribute Value?
2. Is its cost proportionate to its usefulness?
3. Does it need all of its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower cost method?
6. Can a standard product be found which will be usable?
7. Is it made on proper tooling--considering quantities used?
8. Do material, reasonable labor, overhead and profit total its costs?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

Answer these questions in your search for Value.

1. What is the part?
2. What does it do?
3. How much does it cost?
4. What else would do the job?
5. How much would that cost?

For further information on Value Analysis call:

Fred S. Sherwin, Manager
Value Engineering and Analysis Services
Gore Building
Waltham 54, Massachusetts
TWinbrook 9-8400, Ex. 4647-4648

# VALUE ANALYSIS

## SOME CONCEPTS THAT WILL HELP YOU TO SEEK OUT VALUE IN OUR PRODUCTS AND METHODS

# VALUE ANALYSIS - A PHILOSOPHY AND A SCIENCE

Value Analysis is a philosophy - it's a systematic approach - it's a system of techniques - it's a creative study of all the elements of cost in a product or method. The application of Value Analysis techniques will give you a scientific approach to finding unnecessary costs and eliminating them.

## WHAT IS VALUE

Value is a relationship of what things cost to what that service or function is worth to the operation or the customer. Value is the lowest price you must pay for the desired function or service at the time, place, and with the essential quality.

## VALUE IS ESTABLISHED BY COMPARISON

Value is not inherent in anything. Value has no relation to cost. Value is established by comparison - no other way.

# THE KEY VALUE ANALYSIS TECHNIQUES

## EACH TECHNIQUE AN AID

Each technique in Value Analysis will aid each man to do his job better and reduce cost

## CREATIVE THINKING

The first technique is creative thinking. By creative thinking we generate the greatest number of ideas from which to select the best lowest cost method.

## THE VALUE ANALYSIS JOB PLAN

Second - follow the Value Analysis Job Plan - all jobs can be broken down into simple steps and any job is better carried out by a planned program one step at a time.

## REMOVE THE ROADBLOCKS

Third - remove the roadblocks - don't be stopped by shadows.

## USE SPECIALTY PRODUCTS AND MATERIALS

Fourth - use specialty products and materials - you will see how they can aid you in obtaining more value.

## BRING NEW INFORMATION INTO EACH FUNCTIONAL AREA

Fifth - use company specialists and outside specialists to apply new information to the problem.

## USE SPECIALTY PROCESSES

Sixth - use specialty processes, if applicable, before our competitors.

## KNOW THE JOB COSTS

Seventh - know the shop costs (material, labor, and overhead) of every part and operation - no business can operate without good cost figures.

## EVALUATE EACH FUNCTION

Eighth - evaluate each function, that is, divide the product into functional areas, relate the cost of each area to the function it performs.

## EVALUATE YOUR DESIGN BY COMPARISON

Ninth - value is determined by comparing one method of performing the function against another.

## GET ALL YOUR INFORMATION FROM THE BEST SOURCE

Tenth - get your information from the best source not just the normal source - not the one you are in the habit of using - but the best source.

USE MUCH BETTER HUMAN RELATIONS

Eleventh - by using better human relations we can make a job succeed where it might have failed.

GET ALL THE FACTS

Twelfth - get all the facts - you can't work without them - you can't make a sound decision without all the facts.

FIRST BLAST THEN REFINE

Thirteenth - rather than picking away to get pennies out of the cost of a design, blast it for a completely new and different solution, and then refine as necessary to meet the needs. This way the biggest savings are made.

GET A $ SIGN ON EVERY GIVEN TOLERANCE

Fourteenth - get a $ sign on every given tolerance - let's find out what close tolerances are costing us.

USE YOUR OWN JUDGMENT

Fifteenth - if you don't think a job is right do something about it - use your own judgment.

PUT A $ SIGN ON EACH MAIN IDEA

Sixteenth - know how much your ideas are worth - don't try to evaluate them until you have knowledge of their cost.

SPEND THE COMPANY'S MONEY AS YOU WOULD YOUR OWN

Seventeenth - most everything you do is committing our company's money. If it were your own money, would you be willing to pay that much for it?

USE THE COMPANY'S SERVICES

Eighteenth - Raytheon Company has a great number of specialists, make the best use of the services which are available within the company.

WORK ON SPECIFICS NOT GENERALITIES

Nineteenth - work on specifics not generalities - single out certain items upon which to work and clean them up systematically one at a time.

USE STANDARDS

Twentieth - search diligently for a standard - we have them and wherever possible use standard parts.

# VALUE ANALYSIS JOB PLAN

## INFORMATION PHASE

The first part of any program is a fact finding stage. Many times three-quarters of any job is getting all the information, all the facts you need to study the project.

## SPECULATION PHASE

Here is where we put our creative ability to use, the creative approach. What else will do the job? The more ideas or solutions that are generated, the better the chance that one or more will be the answer to the problem. Use Brainstorm Sessions.

## ANALYTICAL PHASE

After all the ideas are written down, it's time to analyze them and pass judgment on them. Remember, don't try to eliminate ideas but try to analyze them to see how they can be made to work. A positive approach must be used.

## PROGRAM PLANNING PHASE

Here is where you take the best ideas and plan a program to get the information you need to develop these ideas into sound usable suggestions. Search for a person or specialist who can help you. Draw in help from the outside in the form of company vendors or specialists.

## PROGRAM EXECUTION PHASE

This is a natural continuation of the program planning phase. Here we see that certain ideas are really beginning to develop. Your planned program should be followed up in this phase.

## SUMMARY AND CONCULSION

This last and one of the most important steps is buttoning up the project, doing something with the facts you have, taking action on the results of your study, promoting your idea with the sound facts and analysis to those who can do something about it.

# FUNCTIONAL EVALUATION

Here is a technique which will tell you if a part costs too much.

## FUNCTION

Function is something that makes the product work or sell.

## BASIC FUNCTION

Basic function is that prime or specific purpose that is accomplished by the particular part device or assembly. All functions, not basic, we call second degree.

## FUNCTIONAL EVALUATION APPROACH

In this technique we divide the cost into functional areas. To do this we break the component or assembly down into its functional areas then determine whether these functional areas are basic or second degree, then assign a value to the basic functions and compare this with the actual cost of each component part. Now ask the question - What else will do the Job? - and in here use the creative approach to develop other methods to perform the basic function. Then determine the costs of these ultimate methods and compare them with the cost of the original component assembly.

One of the best ways to assign a value to the basic functions is by comparison. In doing this we must think of something that will accomplish the basic function in the most simple fundamental way, and use the cost of this as the value of the basic function. Remember, costs are everyone's business and costs can be reduced.

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