Vol: 1 No: 1 April 1968

Ted Fowler

VALUE ENGINEERING

In this issue

In this issue	Page
Editorial – *L. D. Miles* – Rules of the Game	5
Low Cost Design in the Aircraft Industry *by G. P. Jacobs, Manager, Value Engineering, British Aircraft Corporation (Operating) Ltd., Weybridge Division.*	7
Value Engineering, its Contribution to Profitability *by Rex Ferguson, Engineering and Industrial Consultant*	11
The Value Engineering Association	13
Sharpen up your Selling Power with Value Analysis *by K. W. Hiles, Lecturer, St Helens School of Management Studies*	15
The Product Development Process illustrated with reference to Domestic Appliance Development *by A. R. C. Morphy, Development Manager, Portable Appliance Division, British Domestic Appliances Ltd.*	19
Value Engineering in Rolls-Royce Aero Engine Design *by L. W. Crum, Chief Value Engineer, Rolls-Royce Ltd., Aero Engine Division*	23
Purchasing's Contribution to Value Analysis *by Dennis C. Simpson, Purchasing Controller, The Rank Organisation*	27
Economic Production and its Disciplines *by Anthony R. Tocco, Director of Value Assurance, TRW Systems*	29
Value Assurance Checklist for Product Design	37
The Value Engineering Functional Approach Techniques *by Frederick S. Sherwin, Value Engineering Co-ordinator, The Plessey Company Ltd.*	43
The Importance of Search Techniques in Solving Problems of Value *by J. Harry Martin, Manager of Value Engineering and Cost Improvement Program, General Electric Company Ordnance Department, Defense Electronics Division*	49
The Technique of Value Engineering as an Aid to Profit Improvement *by J. Burnside, Value Engineer, Lindustries Ltd.*	51
On Catching the Fleeting Thought *by C. Hearn Buck, Lecturer, University of Aston in Birmingham*	53
The Value Engineer's Bookshelf	57
Selected Abstracts on Value Analysis/Value Engineering	61

Pergamon Press

The AIM of *Value Engineering*

is to encourage the wider use of value analysis/engineering techniques throughout industry.

Value Engineering

provides a link between those who are practising and studying the subject all over the world.

It is the POLICY of the journal

to contain information which promotes the wider and more efficient application of value analysis/engineering methods.

Its ABSTRACTING SERVICE

will draw attention in a conveniently summarised form to the main publications on the subject throughout the world.

* * *

Information Retrieval

To assist with the retrieval of information on various subjects keywords (shown in italics) have been given to the articles, book reviews and abstracts in this journal.
Keyword cards, 5″ x 3″, arranged in alphabetical order, may have the reference to the page on which the article, etc., appears entered upon them.
In this way the value engineer may build up a summary of references to articles, books and abstracts touching upon a particular subject.

* * *

Reprint Service

Reprints of the articles and checklists appearing in *Value Engineering* may be ordered in multiples of fifty copies and detachable ordering forms are provided opposite.

* * *

Value Engineering is published bi-monthly by Pergamon Press Ltd.

The Editor is Bruce D. Whitwell, 20 Pelham Court, Hemel Hempstead, Herts., England. Telephone: Hemel Hempstead 3554.

Advertisement Offices
Pergamon Press Ltd., 4 Fitzroy Square, London W1. Telephone: 01-387 4455

Production Offices
Pergamon Press Ltd., T. & T. Journals, Headington Hill Hall, Oxford, England. Telephone: Oxford 64881.

Subscription Enquiries
Pergamon Press Ltd., Headington Hill Hall, Oxford, England.
Pergamon Press Ltd., 44-01 21st Street, Long Island City, New York. NY. 11101, U.S.A.

Annual Subscription
£3.10.0 (U.K. only) post free.
U.S.A. and Canada $9.00.
Overseas £3.10.0 post free.

Advertisers' blocks will be retained for two years; if they are not claimed within that time the blocks will be destroyed.

Subscription Order (U.S.A. and Canada)

FOR U.S.A. USE ONLY (UNLESS IN ENVELOPE)

Please send Value Engineering every second month to:

Name
Position
Firm/College etc
Address

☐ until countermanded
☐ for 12 months beginning ....
☐ remittance herewith
☐ please invoice ....

The subscription rates are:
£3.10.0. post free for 12 months
Canada and USA $9.00 post free
Overseas £3.10.0. post free

Subscription Order (U.K. and Overseas)

FOR USE BY U.K. OR OVERSEAS READERS

Please send Value Engineering every second month to:

Name
Position
Firm/College etc
Address

☐ until countermanded
☐ for 12 months beginning ....
☐ remittance herewith
☐ please invoice ....

The subscription rates are:
£3.10.0. post free for 12 months
Canada and USA $9.00 post free
Overseas £3.10.0. post free

Subscription Order (U.S.A. and Canada)

FOR USE BY U.S.A. READERS

Please send Value Engineering every second month to:

Name
Position
Firm/College etc
Address

☐ until countermanded
☐ for 12 months beginning ....
☐ remittance herewith
☐ please invoice ....

The subscription rates are:
£3.10.0. post free for 12 months
Canada and USA $9.00 post free
Overseas £3.10.0. post free

Subscription Order (U.K. and Overseas)

FOR U.K. USE ONLY (UNLESS IN ENVELOPE)

Please send Value Engineering every second month to:

Name
Position
Firm/College etc
Address

☐ until countermanded
☐ for 12 months beginning ....
☐ remittance herewith
☐ please invoice ....

The subscription rates are:
£3.10.0. post free for 12 months
Canada and USA $9.00 post free
Overseas £3.10.0. post free

Affix
postage

Value Engineering,
Subscription Department,
Pergamon Press Ltd.,
Headington Hill Hall,
Oxford,
England.

Affix
postage

Value Engineering,
Subscription Department,
Pergamon Press Inc.,
44–01 21st Street,
Long Island City,
New York 11101,
U.S.A.

Postage
will be
paid by
licensee

No postage
stamp
necessary if
posted in
Great Britain
or Northern
Ireland

BUSINESS REPLY SERVICE
Licence No. OF.234

Value Engineering,
Subscription Department,
Pergamon Press Ltd.,
Headington Hill Hall,
Oxford,
England.

FIRST CLASS
Permit No. 663
Long Island City, N.Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

Value Engineering,
Subscription Department,
Pergamon Press Inc.,
44–01 21st Street,
Long Island City,
New York 11101
U.S.A.

In this issue:

Low Cost Design in the Aircraft Industry
G. P. Jacobs
Manager, Value Engineering at the Weybridge Division of the British Aircraft Corporation (Operating) Ltd.

Value engineering as 'organised effort directed at identifying the necessary functions to be performed, and for achieving those functions for least cost commensurate with performance and time-scale' avoids the assumption that, by defining the function, the performance of the product can be defined.
'Cost correction' or 'having a second go' at the design is a relatively expensive process.
After 'Cost correction' there is 'Cost avoidance' which is the achievement of the best value solution before excess cost is committed by determining the correct alternatives during the design stage.

Value Engineering, its Contribution to Profitability
Rex Ferguson
Engineering and Industrial Consultant.

There is need for recognition by top management that a Value Engineering Department is a top-level activity.
In management the accent is often too much on Cost Reduction and too little on Profit Improvement.

Sharpen up your Selling Power with Value Analysis
K. W. Hiles
Lecturer, St. Helens School of Management Studies.

Value Analysis can be fashioned by marketing managers into a useful 'tool' for improving the penetrating power of their salesmen.
Salesmen who are familiar with the analytical methods applied in using this technique can be of considerable assistance to their customers in helping them to arrive at a better, more functional, more reliable design for a lower cost.

The Product Development Process illustrated with reference to Domestic Appliance Development
A. R. C. Morphy
Development Manager, Portable Appliance Division, British Domestic Appliances Ltd.

Seven objectives *before* development work begins are outlined, and practical methods for obtaining optimum design solutions are set forth.
The results of the application of this approach to the 'Classic' iron are described.
Value engineering best comes in at the stage where a firm definition of the proposed product design has been reached.
'A badly conceived design cannot be retrieved by good work in the later stages.'

Value Engineering in Rolls-Royce
L. W. Crum
Chief Value Engineer, Rolls-Royce Ltd., Aero Engine Division

The company has proved Value Engineering to be 'a well-organised approach to cost reduction' and a worthwhile level of savings have been achieved.
The organisation of Value Engineering in Rolls-Royce is described.
Training is now provided for all staff who are in a position to influence costs.

Purchasing's Contribution to Value Analysis
Dennis C. Simpson
Purchasing Controller, The Rank Organisation

Special reference is made to the value of gaining the co-operation of the specialist supplier.
The help which may be obtained from the construction of comparative cost and technical data is described.
It is essential that Purchasing does much of the ground-work prior to Value Analysis workshop sessions.

Economic Production and its Disciplines
Anthony Tocco
Director of Value Assurance, TWR Systems

The increasing complexity of products and systems has forced management towards the development of new approaches for the management of resources. The writer describes four methodologies – Quality, Reliability, Standardisation and Value Engineering – which provide management with the 'tools' required to meet the challenge of domestic and international competition.

The Value Engineering Functional Approach Techniques
Frederick S. Sherwin
Value Engineering Co-ordinator, The Plessey Company Ltd.

Value Engineering does not concentrate in depth in any one area (Design, Production or Purchasing) to the exclusion of others. It starts with the definition of the customer's needs and then proceeds through an organised and systematic programme to create the optimum design.
An optimum of cost/value ratios is the aim.

The Importance of Search Techniques in Solving Problems of Value
J. Harry Martin
Manager of Value Engineering and Cost Improvement Program, General Electric Company Ordnance Department, Defense Electronics Division

A similarity in problem-solving methodology between Descartes in the 17th century and Miles in the 20th century is referred to and the need for Value Analysts – if they wish to be successful – to master search skills is stressed.
Value Engineering is a search-oriented philosophy which tests products for real value.
The three-step problem-solving philosophy of Descartes (intuition, deduction and induction) is offered as ideally suited to problem-solving in Value Engineering.

The Technique of Value Engineering as an Aid to Profit Improvement
J. Burnside
Value Engineer, Lindustries Ltd.

The article explains what value engineering is and outlines the stages in the V.E. Job Plan.
The author stresses the group nature of the activity and holds that the application of value engineering in an organisation brings a new dimension into the working lives of all who are involved in it.

On Catching the Fleeting Thought
C. Hearn Buck
Lecturer, University of Aston in Birmingham.

There is need for a relaxed state of mind for problem-solving. Fear of criticism is a form of tension which the brainstorming technique helps to overcome.
Ideas may also be stimulated by analogy and by using checklists.

CHECKLISTS

Value Assurance in Product Design
Ways in which Unnecessary Costs Arise

BOOK REVIEWS

First European Value Conference Proceedings (Leslie, H.) (ed.)
The Use of Lateral Thinking (de Bono, E.)
Glossary of Management Techniques (Barraclough, S.) (ed.)
Creativity at Work (Simberg, A. L.)
Primary Standard Data (Neale, F. J.)
Problems of Product Design and Development (Buck, C. H.)
Value Analysis/Value Engineering (Falcon, W. D.) (ed.)
The Learning Curve (Jordan, R. B.)
S A V E, Volume 1 (Ross, T. A.) (ed.)
Negotiated Purchasing (DeRose, L. J.)
Value Engineering 1959 (Mandelkorn, R. S.) (ed.)
Second European Value Conference Proceedings (Bowyer, F.) (ed.)
Work Measurement and Cost Control (Graham, C. F.)
Value Engineering and Analysis (Roderick, M. D.) (ed.)
Cost Estimating and Contract Pricing (McNeill, T. F. and Clark, D. S.)
Engineering Materials – Selection and Value Analysis (Sharp, H. J.) (ed.)
Electronics Industry Cost Estimating Data (Hartmeyer, F. C.)
Value Analysis (Gage, W. L.)
Value Engineering in Manufacturing (Wilson, F.) (ed.)

ABSTRACTS

[1] to [14]

IN THE NEXT ISSUE:

The Preparation and Use of the Value Engineering Functional Chart
by Arthur E. Mudge, Director, Value Engineering Services, Joy Manufacturing Company.

The Purchase Order Draft System used by Kaiser Aluminium International

Packaging Materials and Factors in Packaging Evaluation
by Bryan Harrison, Managing Director, Controlled Packaging Services Ltd.

Value Analysis at the Rover Company
by V. M. Hanks, Engineering Operations Manager, The Rover Company Ltd.

The Operational Characteristics of Value Engineering
by J. J. Kaufman, Manager of Industrial and Value Engineering, Honeywell Inc., Aerospace Division.

The Creative Aspects of Value Engineering
by Lt. Colonel Bert Decker, USAFR (Ret.)

Essential Factors for a Successful Value Analysis Exercise
by P. Astle, Group Value Analysis Engineer, Automotive Products Co. Ltd.

The Challenge of V.E. – First Appraisal
by Frank R. Bowyer, Consultant, Value Engineering Ltd.

How Value Analysis can Aid Purchasing
by Harry L. Erlicher, one of the founders of Value Analysis.

The Application of V.E. Effort for Maximum Effectiveness
by G. P. Jacobs, Manager of Value Engineering, British Aircraft Corporation (Operating) Ltd.

Value Engineering as Training for Management
by Frederick S. Sherwin, Value Engineering Co-ordinator, The Plessey Company Ltd.

Reprint No. 1:1:1

Editorial

Mr L. D. MILES, President of Miles Associates Inc. and one of the founders of the technique of Value Analysis and Value Engineering has kindly accepted the invitation to write the editorial in Volume One, Number One issue of Value Engineering. *Readers, Mr Miles. . . .*

Rules of the Game

Happiness, satisfaction and the gratification of man's desires stem from success in the game he is playing. The explorers of the arctic, the explorers of the atom, the establishers of a better form of government, and the discoverers and controllers of a germ all play their games by the rules of that specific game and – when successful – achieve a satisfying life in its many forms. Satisfaction is the result of success in the game a man is playing.

Success brings good life to others, good jobs to associates and employees, and often benefits to a wide circle of 'users'. Success in the game of identifying, understanding and neutralising the deadly polio virus not only brought happiness and satisfaction to the game players, but also brought research assignments for assistants, work for scores of technicians, use for and markets for many materials, much manufacturing work, communication work, and sales work – all in addition to the prevention of pain, the reduction of crippling and the saving of lives.

To lose the game in life we are playing means – at the least – disappointment, displeasure and dislocation to our families and associates, and often also to employees, suppliers, users of our product or service, and to a host of others.

In the highest sense it is incumbent on each of us to win the game in life we are playing, be that game the saving of lives, extending specific knowledge, or providing needs and wants for better human living. To win the game we are playing *we must play by its rules* – not by the rules it *did* have, or the rules we *wish* it had, or even the rules we *like*.

The rules of the commercial and industrial game have always basically been to identify a need in the sphere of human living, and to fashion the materials of nature – modified as required by man's knowledge – to fill that need. The quest for faster ships, better tools, more efficient refrigerators, more comfortable homes and more efficient motors was stimulated by the 'Rules of the Game'. The winners of that game brought great happiness and satisfaction to themselves and a host of benefits to others.

Just as the rules of the game of life change when the child moves on in age from five to seventy-five (not because he wants them to change and probably without his immediate recognition that they have changed) so the rules of the game of industry and commerce may change, and indeed now have changed.

The rules of the game of commerce and industry, and also of the game of government have changed. They now are (1) to identify needs in the sphere of human living, (2) to fashion materials of nature (modified by man's knowledge) to fulfil these needs, and (3) to consume as little of nature's materials and of man's energies as will an enlightened, effective competitor.

Businessmen throughout the world confronted with these 'Rules of the Game' are planning to make them a help instead of a hindrance in competitive business areas. Into the breach opened by this business need grew the systematic approaches and techniques of Value Analysis and Engineering. Already products (and sometimes complete businesses) by the hundreds have been changed from mounting losses and certain death to growing earnings and assured future by using these specific techniques which were created for that one specific purpose.

In the years of research which went into the development of this system it was found that the lethal shortcoming in relation to specific products or services having dangerous cost trouble was too often not receiving intense corrective study and action. Too often the 'deadly' area of need went unattended ending the life of that product or business.

It was found that overall effectiveness comparable with the resourceful competitor in any situation can be lost in any one or more of the business areas of Marketing, Engineering Design, Manufacturing, Purchasing or in management effectiveness. Basic approaches were developed to meet this need.

For centuries on end your great nation, Britain, has met challenges which, at the time, have seemed to defy solution. Each time, in the hour of serious peril, you have selected and developed ideas, methods and systems which met the need and you have won the game on the basis of its rules at that time. Now, when serious competitive situations threaten the health of your commercial and industrial life, it is most gratifying to see the developing skill in the procedures and techniques which will reverse that trend.

It is my own very great personal honour to have had a part in the development of the techniques, methods and approaches of Value Analysis and Engineering which will assist your people to again slay the dragon.

Miscellany

Mr. Harry L. Erlicher

Sir,
I have been retired from the post of General Purchasing Agent with General Electric Company in Schenectady, N.Y. some twenty-one years. In response to your request concerning the early days of Value Analysis I am enclosing copies of several articles which I wrote, and I hope they will be of use.
With good wishes for your new journal,
Yours truly,
(sgd.) Harry L. Erlicher

(Ed. Mr Harry Erlicher writing on 1st February, 1968 from his home at 29 Ray Street, Schenectady 12309, N.Y., U.S.A. enclosed an article on 'How Value Analysis Can Aid Purchasing' which will be published in the next issue of this journal.
This interesting extract is from an article written by Mr Erlicher which gives 15 requisites for a salesman and concludes with this picture of the salesmen he liked most –

> 'I respect most the salesman who knows his product and the new things that are being developed by his company or his industry; the man who shows interest in my problems and can help me solve them through mutual co-operation. I will give all the time necessary to this type of salesman – yes – evenings, Sundays, or any other time.'

This was written by a man who received calls from 10,000 salesmen a year.)

International Value Engineering Conference

21st Anniversary of Value Analysis/Engineering

This year marks the 21st year after the formulation of the technique of Value Analysis/Engineering.
To mark the occasion Value Analysis Inc. and Value Engineering Ltd. (two of the foremost training organisations in the field) have arranged an INTERNATIONAL VALUE ENGINEERING CONFERENCE to be held in Washington, D.C. during the week beginning 19th August, 1968.
The Conference will also celebrate the 10th Anniversary of Value Analysis Inc. and the 5th Anniversary of its transatlantic associate – Value Engineering Ltd.
Mr Howard Leslie (Managing Director of Value Engineering Ltd.) has announced that a charter flight with Conference delegates from Europe will be leaving London for Chicago on 5th August next.
After spending two weeks in the mid-West and on the West Coast of America where delegates will have the opportunity of meeting American value engineers the group will leave Chicago for Washington to attend the Conference.
The Conference theme will be VALUE ENGINEERING AND ITS FUTURE ON AN INTERNATIONAL BASIS.
For the trip (occupying 24 days) the cost will be £235.
This includes the air fare, hotel accommodation (not meals), surface transportation and conference registration. (Wives can also be accommodated.)
Further details may be had from Mr Frank Bowyer, Value Engineering Ltd., 60 Westbourne Grove, London, W.2, England.

Government and Local Government buying

According to a report to be reviewed in the next issue of this journal the Public Sector of the economy in Britain . . .

. . . Spends 41 per cent of the G.N.P.
. . . Employs over 30 per cent of the nation's manpower.
. . . Employs two-thirds of those with full-time higher education.
. . . Owns 50 per cent of the nation's capital assets.
. . . Accounts for over 50 per cent of the nation's fixed investments.
. . . Finances about 65 per cent of the nation's research and development.
. . . Absorbs 60 per cent of the output of the construction industry.

The Public Sector plays a dominant role in the electronics, aircraft, construction, pharmaceutical, electrical engineering, telecommunications and power-supply industries.

Reprint No. 1:1:2

Basic Concepts — Functional Worth — Value Standards

Low Cost Design in the Aircraft Industry

by G. P. Jacobs*

The responsibility of employees for costs is highlighted by the Presidents of two of the major aerospace companies, and the importance of low cost design for British industry is stressed. Value engineering – the author prefers to be regarded as 'organised effort directed at identifying the necessary functions to be performed, and for achieving those functions for least cost commensurate with performance and time-scale.' This definition avoids the assumption that, by defining the function, the performance of the product can be defined.

The relationship between cost, performance and reliability is diagrammatically shown and the 'isovalue' line concept explained. 'Cost correction' or 'having a second go' at the design is a relatively expensive process.

Value standards such as those obtained by multiplying the cost per pound of weight by the cost of the item (giving cost^2 per pound of weight) as one means of selecting parts for value analysis is dealt with, and other bases for cost comparison are suggested. Over-specification, producibility problems, and order quantities also present avenues for investigation. From this work suggestions for improvement in the form of Value Engineering Change Proposals are made.

After 'Cost correction' there is 'Cost avoidance' which is the achievement of the best value solution before excess cost is committed by determining the correct alternatives during the design stage. This is aided by the availability of Cost Data.

Finally, 'cost prevention' involves the creation, through training, of an environment such that people instinctively search for the best value solution.

I would like to begin by quoting the words of the Presidents of two major aerospace companies in the U.S.A.

The first is by Moore of the Autonetics Division of North American Aviation, who said:

'Our stockholders have a right to fair profits which can only be obtained by operating at maximum efficiency.

'Every member of the Autonetics team must realise that he personally has an opportunity and a responsibility to minimise costs.'

The second is by Allen of Boeing, who said:

'For Boeing to strengthen its position of leadership, maximum cost effectiveness and improved profit relationships must be emphasised and attained.

'Boeing employees must become cost-able and value-able to ensure that Boeing will retain and strengthen its leadership in the aerospace industry.'

These statements are indicative of the general atmosphere of commercial efficiency which our competitors in the U.S.A. have built up, and which we must at least equal. They underline the absolute necessity for ensuring low cost design in the British Aircraft Industry if we are to survive.

Now, what do we mean when we talk about 'low cost design'?' Obviously, we are not interested in the narrowest definition, where 'low cost design' could be misinterpreted as that requiring the least cost in the design office.

'Low cost design' must be taken as that which gives the least total of design, development and manufacturing expenditure.

**** Mr Jacobs is Manager, Value Engineering at the Weybridge Division of the British Aircraft Corporation (Operating) Ltd., Brooklands Road, Weybridge, Surrey, England.***

This paper was presented by the author at the Value Engineering Association's Conference held at Stratford, England, in October 1967 and is reproduced with grateful acknowledgement.

However, in many cases, the operating costs must also be taken into full account, and the widest definition is that of obtaining least total cost, where total cost is the initial cost plus the cumulative expense of operating and maintaining the product throughout its life. In aircraft design, we must consider the importance of controlling the initial cost of our products, that is the expenditure which defines the price we must charge our customers, relative to that of controlling their total cost. I will return to this theme later in the text.

Of the many definitions of Value Engineering, I prefer the following:

'Value Engineering is an organised effort directed at:

(i) Identifying the necessary functions to be performed.

(ii) Achieving those functions for least cost, commensurate with performance and timescale.'

By using this definition, I avoid the assumption that, by defining the function we can necessarily define, absolutely, the product performance. When designing aircraft, some of the performance parameters can be strictly defined, whilst some of them cannot be. So there are two types of performance parameters which must be considered.

First, basic performance parameters, which are the defined and guaranteed ones of strength, speed, load, range, take-off distance, and so on. They are affected, for example, by weight changes which almost inevitably occur when a value engineer redesigns an existing component. As well as weight changes, we sometimes make minor changes to the outside profile of the aircraft as a result of introducing modifications to reduce cost, which can also have an effect on the basic performance factors.

Secondly, operational performance parameters, which are the less well defined ones of reliability, maintainability, component life, and so forth. There are many examples where value engineering has been directed at the redesign of existing components, such as mechanisms, which has resulted in a simpler assembly with fewer parts, with subsequent improvements to these operational performance aspects.

Figure 1 shows the type of performance improvements we have achieved, compared with published U.S.A. Department of Defense data. All our proposals have saved money, and most of them have improved performance in one way or another. This is not always the case, and considerable judgement is then necessary in deciding which alternative to proceed with.

This is because we are not necessarily attempting to achieve the lowest cost, nor the best performance for our products, but are seeking to establish the best value compromise between often conflicting requirements.

Let us examine this pictorially. Figure 2 shows cost plotted against a reliability coefficient. Two sets of costs are shown. Those which occur before delivery, and those occurring after delivery. Costs before delivery include charges for materials, bought-out content, labour, tests and design charges necessary to get the product to a point of delivery. Costs after delivery, are those necessary to get the product to the point of use or operation, and include the provision of spare parts, maintenance, special support and training equipment.

As one would expect, on a design standard where the initial cost is low, reliability is not inherently good, and subsequent maintenance costs are therefore high. Conversely, if the customer is prepared to pay more initially, he can purchase a more reliable product and save in lower maintenance costs.

The sum of the costs to purchase the item, and subsequently maintain it throughout its life, is frequently used in the evaluation of alternative designs, since it permits us, and the customer, to assess the relative merits of competing design features or methods, by using a realistic yardstick – money.

This form of comparison is called 'the total cost concept', and was first high-lighted by Heller of General Dynamics.[1]

In this example, the addition of the before and after delivery costs is shown by the upper curve in figure 2. From this curve we can identify the point of least total cost, which however, is not the point of highest value.

If the relationship to cost of any parameter, such as reliability, is established at a given point, we may say, as a result of dividing reliability by cost, that we obtain so much reliability for each pound sterling spent. And, if a straight line is drawn from the origin through that point, all points on the line must have the same value.

This line is known as an 'isovalue line', where,

$$\text{Value} = \frac{\text{Function}}{\text{Cost}}$$

Maximum value is achieved when the essential function is obtained for the least cost, and it is apparent that the lower the slope of the line drawn, the higher the value.

So, for best value, we must find the point on the total cost line where we will get the highest ratio of reliability to cost. We therefore draw a line from the origin to intercept the total cost line and form the minimum angle to the base.

This is the tangential line shown in Figure 3, with the point of interception marked 'best value'.

Thus, for a relatively small increase in total cost we have significantly improved the value of the product to the customer.

Perhaps a more usual choice which has to be made by the airframe design team, is that between cost and weight. If the least cost alternative is not also that giving the lowest weight, how do we decide which represents the best value? This is a difficult problem for the aircraft manufacturer to solve, as it requires the consideration of many factors. For example, the type of aircraft, whether it is military or civil; of high or low speed; how the predicted performance, in terms of load carrying capability, take-off distance and so on, compares with the guaranteed figures; how its first cost compares with that which the market will reasonably stand, and so forth. So the manufacturer's balance between cost and weight does not necessarily follow this process of minimising total cost.

VALUE ENGINEERING BAC

FALL-OUT BENEFITS OF VALUE ENGINEERING CHANGE PROPOSALS

PERCENTAGE OF PROPOSALS SHOWING IMPROVEMENT IN:–

	United States Department of Defense	British Aircraft Corporation
Reliability	44%	25%
Maintainability	40%	21%
Performance	21%	–
Weight saving	–	53%
Quality *	38%	–
Production lead time	76%	Not Assessed

*IT IS NOT KNOWN HOW 'QUALITY' IS DEFINED

Fig. 1

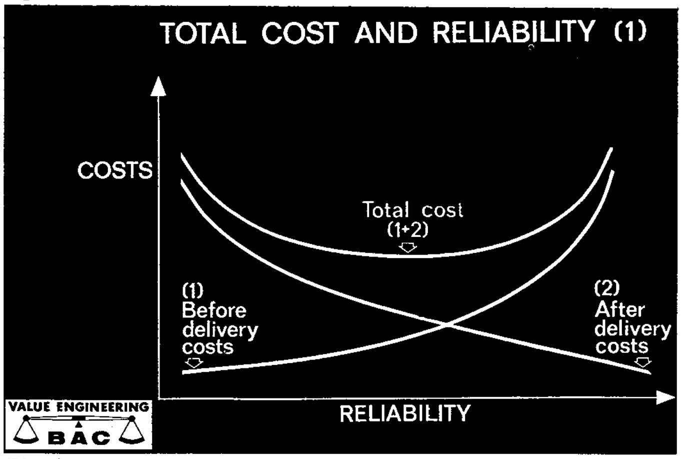


Fig. 2

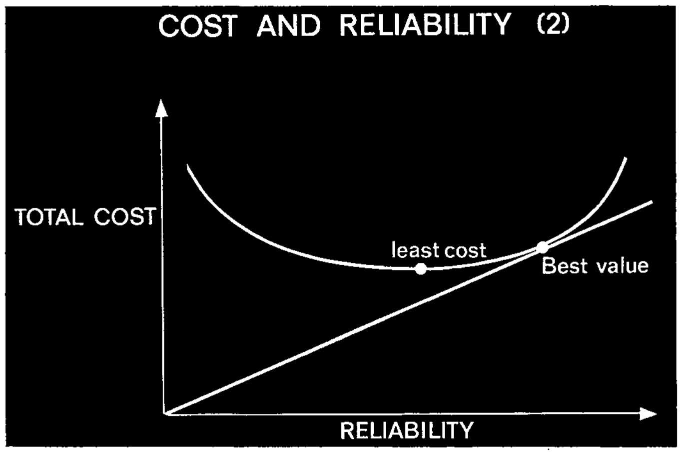


Fig. 3

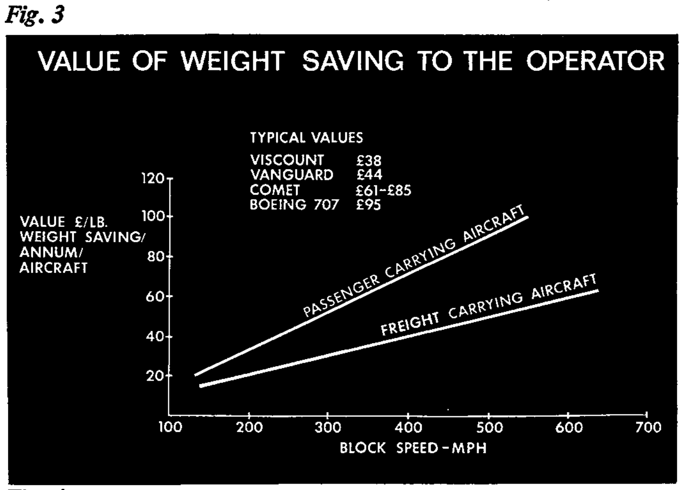


Fig. 4

The airline operators have evaluated the worth to them of a pound of weight saved. They have done this by assuming that any saving in weight is replaced by revenue earning payload. These values are shown in Figure 4.

Here the value of one pound of weight saved is plotted against aircraft block speed, which is the stage length divided by the elapsed time between doors shut and doors open. The upper curve assumes that the weight saved is directly replaced by high revenue passenger payload.

Using this datum, a maximum value of £95 is claimed for each pound of weight saved on each aircraft of similar performance to a Boeing 707, over a one-year period of operation. In other words, over a ten-year period, one pound of weight saved on a Boeing 707 could result in an increase in revenue to the operator, of anything up to £950.

As is shown by the lower dotted curve, the value of the weight saved is almost halved if freight is carried. This is a reflection of the different revenue earning rates.

These examples of cost/reliability and cost/weight interaction, demonstrate that best value can quite often be well removed from least cost. As a Value Engineer in the aircraft industry, I am paid to get the best possible value, not necessarily the least cost. The aircraft value engineer's task is a little different from that of most value engineers in industry, in that practically any change which affects cost, also affects performance. Neither is it always possible to define 'function' in measurable terms. Furthermore, the aircraft value engineer has more flexibility, and more responsibility in choosing the level of abstraction at which he can define his functional requirement.

Now to consider some of the general activities undertaken by aircraft value engineers.

A constant, three-pronged attack, with the objectives shown in Figure 5, must be maintained if we are to eliminate unnecessary costs from our products.

First, *cost correction* is the process of replacing existing designs by alternatives that will do the job at lower cost. This is a relatively expensive process, both in cost and time, as we are 'having a second go' at the design. A continual problem is that of identifying low value parts, or assemblies, which are suitable candidates for redesign following the job plan process. The procedures we follow in the aircraft business are, basic value engineering product evaluation, advice from design and production departments of apparently unnecessary expenditure of material or labour, complaints from our operators of high cost spares, possibly associated with high usage rate, and so on.

Our value engineers maintain a constant programme of appraisal aimed at highlighting unnecessarily expensive functional solutions. This work involves plotting the cost of structural, and other parts, against some pertinent parameter, in order to identify expensive groups of items, or expensive individual parts in a reasonably inexpensive assembly.

Figure 6 is an example of this type of analysis, and shows the cost of machining light alloy components, manufactured for us by one of our sub-contractors, plotted against finished part weight. Parts of similar function can be identified by the use of a colour code or suitable symbols.

In order to make an efficient selection we need to know the answers to two important questions regarding each item. First, 'How specifically expensive is it?', and secondly, 'How much of it is there?'

The answer to the first question may be derived from the cost per pound of weight, and that to the second from the total cost of the item. It will readily be seen, from an examination of Figure 6, that the cost per pound of weight of the items invariably gets higher as size is decreased. So, on its own, specific cost per pound of weight is of little use. Also, an item having a high cost may be very efficient and have a low cost per pound of weight.

We can combine these two aspects by multiplying together the cost per pound of weight and the cost of the item, which will give cost^2 per pound of weight, and then select those parts with

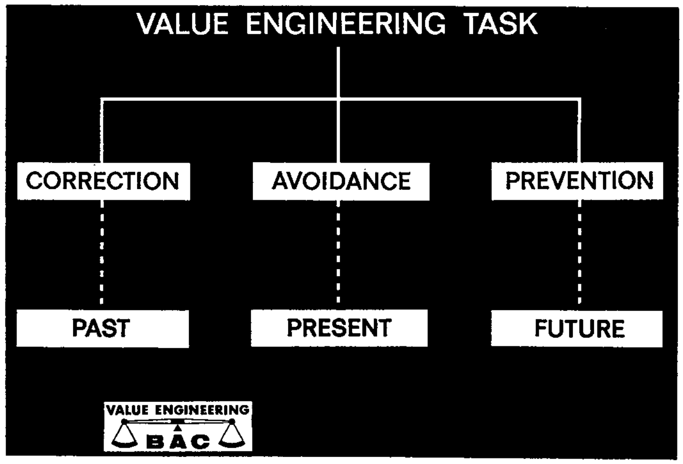
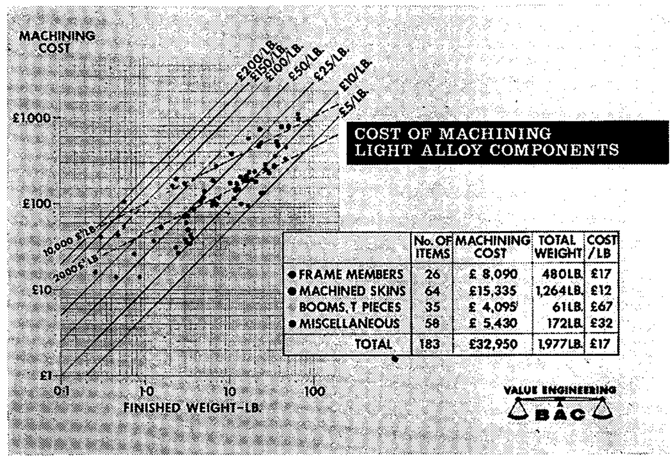


Fig. 5



	No. OF ITEMS	MACHINING COST	TOTAL WEIGHT	COST /LB
● FRAME MEMBERS	26	£ 8,090	480LB.	£17
● MACHINED SKINS	64	£15,335	1,264LB.	£12
BOOMS, T PIECES	35	£ 4,095	61LB.	£67
● MISCELLANEOUS	58	£ 5,430	172LB.	£32
TOTAL	183	£32,950	1,977LB.	£17

Fig. 6

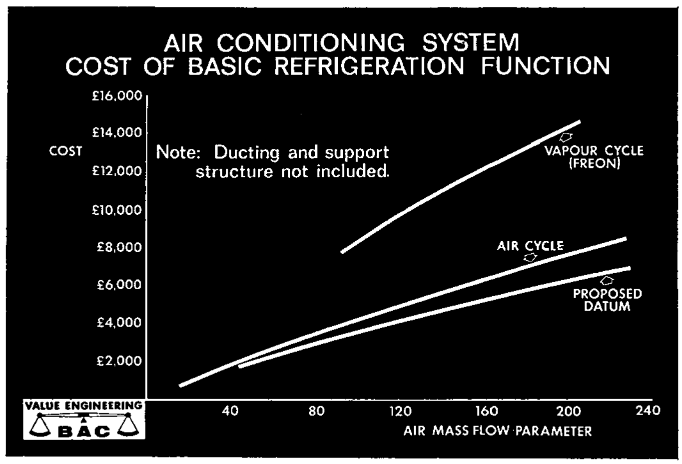


Fig. 7

the highest product in order to establish satisfactory priorities for our investigations.

Similar analytical work has been carried out on aircraft systems. For example, we have plotted, cost against work done for hydraulic sub-systems, cost against rate-of-flow and pressure for fuel systems, and cost against a heat load or mass flow parameter for air conditioning systems. Figure 7 is an example of this type of work.

As mentioned earlier, value engineers must also investigate the disclosure of poor value examples received from commercial, production and design sources. This work embraces the revealing by our specialists of seemingly over-elaborate specifications; complaints from production departments of extra cost imposed by apparently superfluous design requirements, and so on. Also, the policy of ordering may be such that small batches are produced, giving repeated setting-up operations which result in additional costs, and this may require investigation.

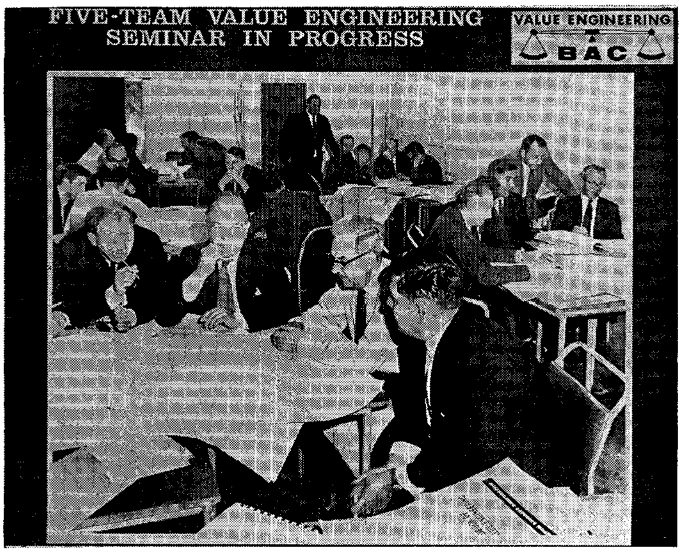


Fig. 8

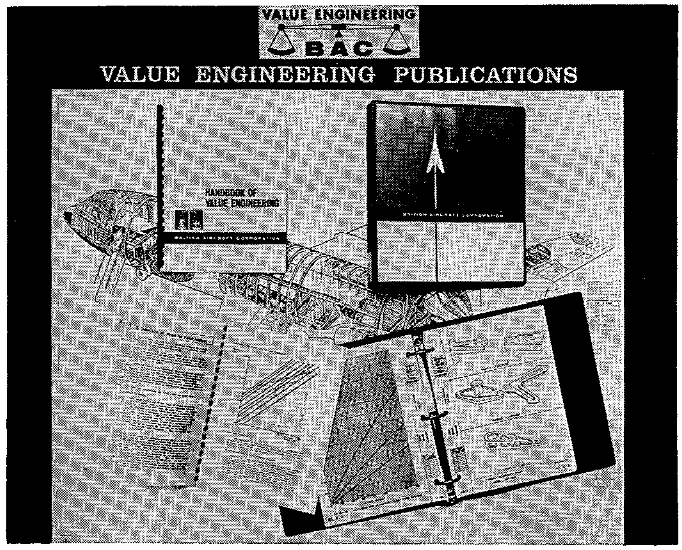


Fig. 9

Having sorted out the tasks to be undertaken, alternative solutions are evaluated, following the value engineering job plan process. 'Before' and 'After' costs, weights and introduction costs are obtained from the appropriate specialist departments, and from this technical and financial analysis, the best value solution is selected. A Value Engineering Change Proposal Form is then prepared, and the lower cost alternative is embodied as rapidly as possible into the production line.

Work leading to V.E.C.P. changes has a significant part to play in any balanced value engineering activity. However, our production runs are relatively short, and, because of this, two factors emerge:

(i) Development costs are high relative to total project spend.
(ii) The development period is long relative to total production life.

These considerations make this type of work in the aircraft industry not as rewarding when compared with that of other industries.

Secondly, *cost avoidance*, which is the achievement of the best value solution before excess cost is committed, by determining the correct alternative during the design scheming stage. The task of the Value Engineering department is to assist the designer to select the right design. Specific data on the cost implications of alternative solutions are provided, such that balanced optimisation work, with cost as a key parameter, can be carried out. Assistance is also given to ensure that the best manufacturing and procurements methods are used, and so on.

At B.A.C. we have prepared and produced a Cost Data Manual. The contents include the cost of alternative materials, the cost of various forms of attachments together with their assembly times, and manufacturing costs which include the cost of forgings, castings, extrusions, platework and machined from the solid parts.

We also provide a service for identifying good value design. For example, the best value method of operating air-brakes, of manufacturing a plug door, a flying control surface, a rudder pedal assembly, and so on.

The third objective is *cost prevention*. It involves all those varied activities which are necessary to create an environment such that new design work is instinctively tackled to provide the best value solution.

This requires continual programmes of education in order to break down the barriers of tradition and habit. People 'must be made to welcome change; they must be made aware of the fact that the reason for their employment is to improve their company's business potential, and that they all can make a significant contribution to the achievement of a good return on the money invested in the company.

The B.A.C. value engineering department is responsible for the following activities.

(i) *Workshop seminars*. These are of one week duration, and are organised on the Tell/Show/Do principle. Up to 40 personnel are selected for attendance from design, commercial and production departments. Adequate instruction is given, supplemented by suitable films. The participants are then divided into balanced teams and given selected high cost, in production, products to analyse. The results of each team's efforts are presented during the final session.

Figure 8 shows one of our training sessions in progress. The team in the foreground advocated a cost saving of 64 per cent on the large component which they studied.

(ii) *Training lectures*. These are normally of half a day duration, and are designed to acquaint those unable to attend workshop seminars with the principles and methodology of value engineering. Similar lectures are given to apprentices as part of their training.

(iii) *Personnel on loan*. Selected personnel from the design departments are seconded to the value engineering department for a familiarisation period of not less than three months.

(iv) *Training Manuals*. We have produced two publications, which are shown in Figure 9. The one on the left is the *B.A.C. Handbook of Value Engineering*, and the one on the right the *Cost Data Manual* referred to earlier in the text.

The other aspect which is of great importance, is the effective demonstration of the large cost savings which can be achieved through value engineering. A return of between 10 to 15 to 1 on the investment in value engineering is commonplace. In any other commercial context this is unbelievably good, and efficient publicity is a necessary ingredient to our success. Of course, we are most efficient when operating in the 'upstream' areas, but unfortunately tangible 'before' and 'after' comparisons can seldom be obtained. Hence, we suffer from the ironic situation that the more efficient we are, the more difficult it is to demonstrate our efficiency! Perhaps the advent of incentive contracts, such as those awarded by the U.S.A. Department of Defense, would improve this situation, as they would demand some form of 'upstream' book-keeping.

However, I want to stress that, especially when given energetic managerial support, and perhaps better incentives from our major customers, value engineering will always make a significant contribution towards improving our competitiveness. It costs little to promote, and the financial returns are many times the direct investment.

Reference.

[1] E. D. Heller. *Professionalism in Value Engineering*. Proceedings, Fifth National Meeting, Society of American Value Engineers, Boston, Mass., U.S.A., 21st to 23rd April, 1965, volume 1.

Reprint No. 1:1:3

Basic concepts — Management Appreciation — Methodology

Value Engineering, its Contribution to Profitability

by Rex Ferguson, C.Eng., M.I.Mech.E., Mem.A.S.M.E.*

The author emphasises the need for recognition by top management that a V.E. department is fundamentally a top-level activity. It is a separate entity level in status with other sections – a point to be emphasised at the initiation stage of V.E. effort. The accent is often too much on Cost Reduction and too little on Profit Improvement.

The ultimate objective of all activity is to achieve profitable return on expenditure of effort. Applying this concept of profitability to product exploitation, three major areas of concentration are involved –

1. Research into market demand – both existing and envisaged – in terms of performance, quantity and price, and the production of a provisional design and/or model;

2. Determination and Evaluation of the functional activity of each part in relation to the whole product; and

3. Development and Conversion of this approach to profitability into actual profit through the production of a final design, and employment of appropriate production equipment.

In practice these three areas are intimately related and to a degree overlap, but for the purpose of clarity in this presentation such overlapping will be ignored.

In this approach to the problem of product profitability, responsibility lies heavily upon Value Engineering, for it bridges the gap between the predominantly theoretical proposal initiated at the research stage, through development, to the final product design for production.

The Value Engineering Approach

Effective Value Engineering results from the co-ordinated efforts of a team of qualified members, each member by virtue of specialist knowledge and experience being empowered to make decisive statements commitments within the team appropriate to the department he represents. Thus the path to product profitability would bear the approval stamp of Research, Design, Manufacturing and Marketing, with Costs being a co-opted contribution as occasion demanded.

Throughout the team's deliberations the Company's established standards of quality, reliability and maintainability must be the bases of all decisions – quality in regards materials and workmanship, reliability in undeviating performance in operation, and maintainability in low servicing demand during a long product life or that fixed by a policy of planned obsolescence.

There are four main avenues of approach in the team's contribution –

1. Definition in detail of the market need in functional terms of the proposed product and its components,

2. Translation of those terms into preliminary and practical specifications,

3. Implementation through developing alternative designs to meet those specifications having paid due regard to the Company's standards of function and material, and

4. Assessment of manufacturing cost covering each alternative design, for submission to an appropriate authority for final choice and approval. Cost assessments at this stage are not final and binding, but are sufficiently accurate to permit a justifiable choice of design having an acceptable market potential of profitability.

This choice having been made, the chosen design is finalised, full manufacturing drawings prepared, and true estimates of cost compiled in regard to both product and production equipment. These costings exercise a control on equipment expenditure and establish a basis on which to measure manufacturing performance.

Value Engineering in Action

All solutions to the problem of a product's profitability must conform to a definite pattern of manufacturing cost geared to a specific performance and time/quantity ratio. This cost is limited to the sum remaining after deducting from the proposed selling price the acceptable profit and recognised overhead burden, and sets the target to be reached through Value Engineering.

The boundaries of price, performance, quantity, and general outline of the product are dictated by the state of the market, and these criteria provide the broad terms of reference to which the Value Engineering team must conform. To these terms the team relate its activities, and it is at this stage the true penetrating effect of Value Engineering is initiated, and progressed as indicated by the Flow Chart, Figure 1.

Definition in detail

From data provided by the Sales department, to which is co-ordinated as necessary a theoretical design approach from Research, the team define in detail and in capacity-form the functional demand of the product and its component parts.

Mr Rex Ferguson is an Engineering and Industrial Consultant who, for many years, carried out value engineering projects for Joseph Lucas Ltd. Most recently he was the spearhead of a fundamental study in the rationalisation of steel.

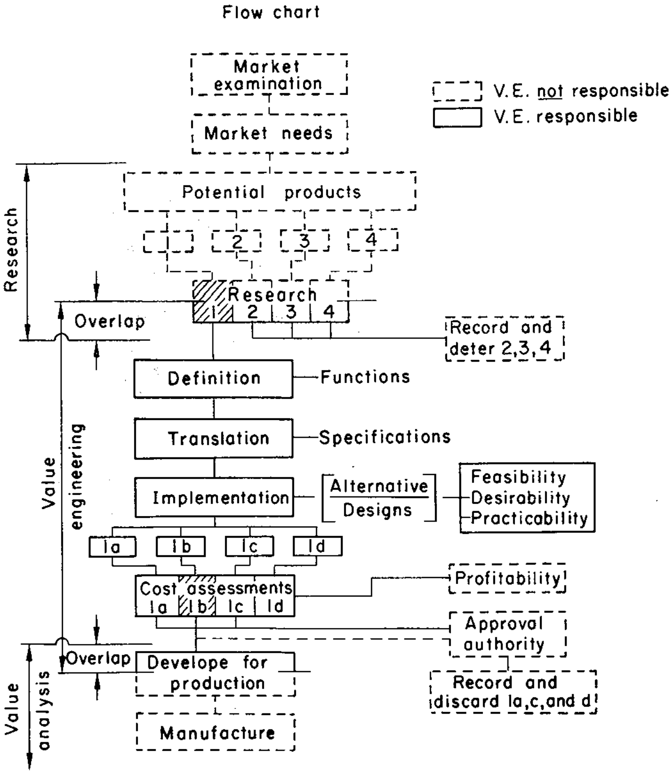


Fig. 1

Functionally as a whole the product must extend in performance a service to a market currently covered by competing units, or provide a service hitherto neglected.

In detail, each component must progressively and successively function toward the complete and effective functioning of the whole. Only clear definition and evaluation of the task each component is called upon to perform can provide the terms of reference on which a product's success depends.

Translation

These definitions of function provide the data from which are derived the performance specifications for the complete product assembly, its sub-assemblies, and its component parts. Too much attention cannot be given to this task for upon its detailed completeness the success of the product in operation depends, from which stems its ultimate measure of profitability.

Implementation

From these specifications the basic performance structure of product design is developed. Thence, if available, the theoretical design from Research is examined and alternative proposals produced and measured against the scheduled manufacturing cost.

In the preparation of these designs existing material standards and product components should be incorporated wherever possible. It is appropriate at this stage to emphasise the importance of this procedure for frequently their use permits achievement of specified performance at a minimum material cost.

In addition to meeting the specified overall performance through the media of effective sub-assemblies and component parts, the alternative designs are developed with the following major considerations in mind –

1. Feasibility. Having the essential quality, reliability, and maintainability, has the proposed design feasibility to permit realisation of the desired margin of trading profit? Will its cost be within the manufacturing target?

2. Desirability. Does the overall design promote or create market desirability? In appearance is it in line with contemporary appeal? Although Value Engineering as such is not responsible for advertising media the product *is* the 'hard core' of a sales campaign.

3. Practicability. Has the design manufacturing practicability in terms of simplicity? Can it be produced with standard rather than special-purpose equipment thereby limiting capital expenditure? Will inspection procedures be simple? Does the design permit simple packaging for despatch to both home and export markets?

It is the responsibility of the Value Engineering team to provide satisfactory answers to these queries, and if properly constituted it can do so.

4. Cost Assessment. Before a final choice of design for manufacture can be made it is essential an accurate estimate of the cost of production and related equipment be compiled in detail for each of the alternate proposals, and the merits and demerits of each be annotated. Combined and in report form, together with appropriate sketches – preferably of an advertising nature, this information is submitted to an approval authority for selection of the design best suited to create or expand the envisaged market. Having this approval the final development of the accepted product is effected and the design released to production.

It is here Value Engineering as such clears its responsibility, further activities being transferred to the Design department for the provision of all necessary drawings, and to the Production department for the compilation of procedures and control paperwork.

The Place of Value Engineering in the Organisation

By the very nature of Value Engineering activities, with a team of men with specialised experience in various though interrelated fields of operation, it is often detrimental to its success to impose control within the structure of a main operating division. Value Engineering is essentially creative and must therefore in its approach be entirely free from individual departmental practices and restrictions.

Through its leader the team must however be responsible to a member of top management if its proposals are to carry the weight of authority in regard to implementation. This authority is usually vested in the Managing Director or the General Manager whose everyday responsibility covers all aspects of Company operation, and by virtue of that fact is an appropriate approving medium for the final review of the team's submissions.

With his selection of design and on his recommendation, the Board of Directors give consideration to the full factors involved, and approve or call for modification to the expenditure on what has now become an established project.

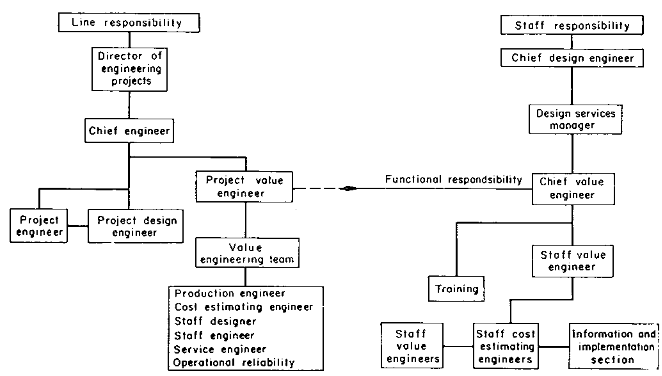


Fig. 2

With this code of operation and chain of responsibility what relationship does the Value Engineering team bear to the organisation as a whole? Much depends on the size of the Company – whether a single or group structure; the number of projects involved – whether a single unit or a number diverse in design; and whether it is the policy of the Company to 'go with the stream' or to pursue a course of dynamic expansion. At the lower end of the scale intermittent Value Engineering attention is invariably enough, whereas the other end of the scale justifies a full-time team application. However, in both cases a full-time leader is required, not only to control the team's operation but also to maintain close contact during implementation. The place of Value Engineering in an organisation is best shown on a functional basis and in diagram form as in Figure 2. Bearing in mind its importance in the aim to achieve profitability the positional status as shown is firmly justified, the status of the team leader being correspondingly high.

The Value Engineering Team

The permanent members of the team are described in the section 'the Value Engineering Approach' and is so limited since the functional areas quoted cover the overriding principles involved. It is obvious that specialised knowledge beyond that available through the permanent members will at times be called for, in the which case additional appropriate personnel are co-opted into the team – chemists and metallurgists are examples of this.

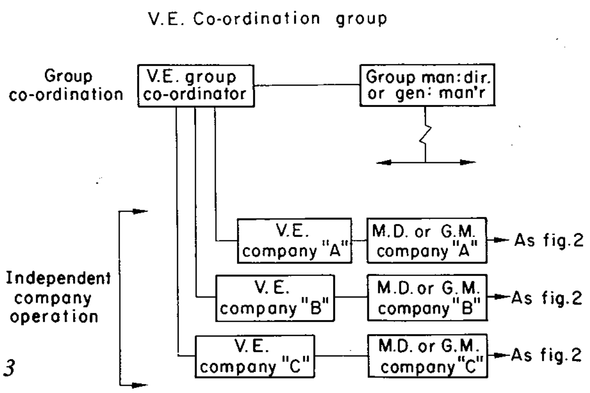


Fig. 3

The effectiveness of the team is always a reflection of the calibre of its members, and of its leader to co-ordinate the individual effort extended into a constructive approach to the problems arising from the project in hand. Care must be exercised to solve each problem as it is presented, only modifying them individually as necessary when bringing all into a cohesive whole.

General Remarks

For the purpose of clarity this submission has been based on the operation of Value Engineering in a single unit Company concerned with a single project, and to that end Figure 4 is so compiled. With a similar Company with a number of projects being progressed concurrently, the same Value Engineering organisation applies, the multiplicity of projects merely demanding a commensurate extension of time spent by the team on its deliberations.

With a group of Companies responsible in operation to an overriding Board of Directors it is advantageous also to co-

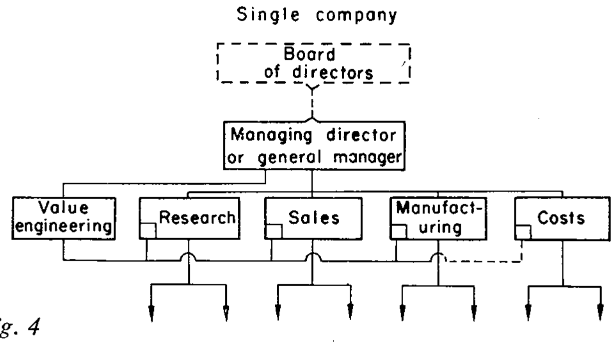


Fig. 4

ordinate the work of the individual Company teams through a single full-time Value Engineering executive directly responsible to the approval authority of the main Board. This condition is shown in Figure 3. Operating in this way, each member Company of the group is kept fully aware of new functional and manufacturing approaches made by the individual teams in the solution of their own problems. Much time and effort can be saved in effecting group dissemination of knowledge and experience, with appreciable benefits arising from common functional and material standards and manufacturing procedures.

The successful integration of a Value Engineering department into an organisation arises from an environment of complete co-operation in which all Company members participate. It has no authority beyond that of its own administration. Its creative approach to product profitability is its detailed planning to that end, the realisation of the scheduled profit being achieved through the co-operative efforts of **all** concerned.

The Value Engineering Association

The Association, with a current membership of over two hundred and fifty, is growing rapidly.

Four meetings were held in London during 1966/67 and the Association's year ended with a combined Conference and Annual General Meeting at Stratford in October. Eighty people attended the Conference at which twelve papers were presented dealing with four aspects of Value Engineering –Value Engineering Techniques, Low Cost Design, Value Engineering in Practice, and the Future of Value Engineering. The speakers provoked lively discussions on the application of value engineering to a wide variety of products (from ships to domestic irons) and a wide range of industries (coal mining to aero engine manufacture). The Association is publishing the papers delivered at the Conference.

The 1967/68 season has begun well with a talk by Mr W. L. Gage on 'How to Run a Brainstorming Session' which attracted members from as far afield as Manchester, Bournemouth and Bristol. The talk underlined the need for considerably more work to be done in studying the psychological stimuli required to promote the free flow of creative thinking, and the Association is arranging to explore the subject more fully in future meetings. The first regional branch of the Association has now been formed in the Midlands and meetings have been held at Birmingham and Derby. There are also regional branches in the North West and Bristol area in the course of formation.

The Conference Sub-Committee of the Association has started to plan for the 1967/68 Conference details of which will be announced in a later issue of this journal.

A working party has been set up to investigate the requirements for cost standards and data sheets, and to liase with the Ministry of Technology and other national bodies to see how best Value Engineering can serve the nation's industry in helping to reduce costs.

With a target membership for the end of 1968 of six hundred the Association is becoming firmly established, and it welcomes the co-operation of other bodies with similar objectives.

Any suggestions and offers of help will be welcomed by Mr P. Higson-Smith, Secretary, Value Engineering Association, c/o Glyn Mills & Co., Bankers, 25 Millbank, London, S.W.1.

Miscellany

Question the Function of the Finish

Mr P. Astle, Group Value Analysis Engineer, Automotive Products Co. Ltd. at Leamington Spa, uses a comparative finishing cost table. Headed 'Is that Finish necessary?' that table asks two questions of *the function of the finish:*

Is it to give protection?

Is it to give customer appeal?

The table then lists the various finishes in order of their increasing cost –

1. Oiling for storage (Whizzer)
2. Oiling for storage (Dipping Tank)
3. Chemical Black Barrel and Basket
4. Chemical Black Jigs
5. Barrel Bonderising
6. Still Vat Bonderising – Jig Work
7. Still Vat Bonderising – Basket Work
8. Auto Bonderising and Enamelling
9. Bright Zinc Barrel
10. Tin-Zinc Barrel
11. Copper Barrel
12. Cadmium Barrel
13. Bright Zinc Vat
14. Tin-Zinc Vat
15. Copper Vat
16. Chrome Vat
17. Auto Tin-Nickel Vat.

As Mr Astle points out the list should only be used as a general guide. Individual component process cost comparisons should be obtained from the Estimating Department.

Considering People

Considering people *is* part of a Value Engineer's job. The Value Engineer may draw the designer's attention to the more obvious improvements required in a man/machine working relationship. This is not where the problem ends.

Working conditions imposed by machine-operating requirements often have a great effect on the health of people – especially older people. In a *Sunday Times* article (19/11/67) a New Zealand psychologist surveying world-wide ergonomics could not find a single example in Britain of jobs redesigned for older people. Such elementary provisions as better lighting and higher workbenches were almost invariably lacking. 'In Sweden,' the psychologist records, 'the Volvo car firm has a resident doctor whose *one* function is to suggest ways of making life more pleasant for older or disabled workers.

Industry's Tribological Needs

The 1966/67 report of the Ministry of Technology's Committee on Tribology (the science and technology of interacting surfaces in relative motion) mentions the work being done to close the gap between the tribological needs of industry and the demand by industry for improved services and education in the sphere of tribology.

It is of interest to value engineers to note the Committee's comment that 'better application of tribology could lead to a saving by industry of over £500m a year.'

Designers should note that a National Centre of Tribology has been established at Risley (Lancs.), the Imperial College is running courses on tribology in London, and the Institution of Mechanical Engineers is compiling a bibliography on the subject.

Reprint No. 1:1:4

Marketing — Training

Sharpen up your Selling Power with Value Analysis

by K. W. Hiles, M.A.A., M.B.I.M., M.Inst.M.*

Companies find it increasingly difficult to buy for less or sell for more in order to increase their earnings. Even when vendor prices have been forced down to their competitive minimums and product prices cannot be increased, the marketing manager's responsibility to increase profits remains the same. Thus he cannot afford to overlook any means of increasing his sales volume.

Purchasing, manufacturing and engineering have generally reserved Value Analysis for themselves and the idea of a marketing man instigating a value programme is a little unusual.

However, Value Analysis can be fashioned by marketing managers into a useful 'tool' for improving the penetrating power of their salesmen. In the design and development of new products Value Analysis is a method of seeking the best ratio between desirable qualities and their cost. Salesmen who are familiar with the analytical methods applied in using this technique can be of considerable assistance to their customers in helping them to arrive at a better, more functional, more reliable design for a lower cost.

About fifteen years ago the Americans coined a new phrase: 'Marketing Concept'. They coin many new phrases, most of which disappear from usage after a short, if hectic, currency. 'Marketing Concept' did not disappear. On the contrary it is still increasing its following and it seems likely to find a permanent place in the language of business. It appears in the carefully-worded annual reports of old-established companies: 'we are adopting the marketing concept as the guiding philosophy in our affairs', they say. The Norcross Group, reorganising for growth after a serious set-back, announced that it would follow the marketing concept in its operations, including those handling capital equipment. Pure Chemicals, a subsidiary company of Rio Tinto Zinc Corporation quotes the marketing concept as its guiding light.

The marketing concept is, of course, a whole philosophy of business; a belief that success in the rapidly-changing commercial/technological world of today can only be achieved by identifying and satisfying customer needs; that it is no longer sufficient to focus attention inwards on products and manufacturing processes but imperative that we look outwards at markets and customers.

Many experienced sales executives view this talk about the marketing concept with considerable cynicism. 'We've been using it for fifty years' is not an uncommon reaction, and it is true that some companies recognised many years ago that industry is primarily a customer-satisfying process and only secondarily a goods-producing process: that a company which builds its operations on the basis of customer needs is less likely to be caught in shrinking, unprofitable markets than one that centres its thinking round products and processes. But many companies are only just beginning to recognise the relevance of the marketing concept, and many who now accept it are finding that a good deal more is required when adopting it than a simple statement of intention. The minimum requirement is a change in the attitudes and thinking of management throughout the business. Usually reorganisation is also necessary and frequently the marketing people have to search out new marketing strategies and techniques for getting business.

The Clear Conception of Customers' Needs

This is where value analysis can play a most important role, for it can be a powerful tool in the hands of the sales team of a company which is determined to be fully customer-oriented. Used with skill and tact by a company's sales engineers, value analysis can contribute significantly to improved customer-relations, enhanced general reputation, a better motivated sales team, livelier product planning and increased business. How can such results be achieved? **By training the sales team so that they can help customers with their value analysis.**

Competent sales executives have always recognised that commercial benefits accrue from action based on clear perception of customer needs. 'Let's do what we can to help our customers; if we do we will help ourselves' is a simple statement of policy which has served many companies well. With value analysis as a tool a sales team can really get down to the task of helping customers without taking its eye off the main objective of increased business.

Interesting idea – but expensive, time-consuming, difficult to control, special skills required, you may be thinking. Of course there are problems, difficulties. But already some progressive companies have faced up to them, made the idea work, got results from it. In 1964 the British Productivity Council published sixteen case studies in Value Analysis. In seven of these cases reference is made to the benefits obtained from involving suppliers' sales engineers in value analysis discussions. In several of the cases the actual ideas adopted came from suppliers' representatives.

Mr Hiles, a former Managing and Marketing Director, now teaches Management and Marketing at St. Helens School of Management Studies, St Helens, Lancs., England.

Assisting the Customer in his Value Programme

Your customer may already have a value analysis programme. The buyer will be involved in this (in many companies he plays a leading role in the value analysis team). So suggest to him that you can help: you have a wealth of information not only about your own products and their applications, but also about the industry generally. By drawing on your wide experience of materials, fabrication methods and equipment, tolerances, finishes, etc., he will be better equipped to engineer maximum value into his products.

This approach to the buyer has to be tactfully handled, but following the salesman's rule of always asking for an order (you may be surprised and get one!) do not hesitate to make the suggestion that you should join his value analysis team. Emphasise that you recognise that value analysis discussions necessitate the disclosure of a good deal of inside information. You know what a sensitive area this is and your company's policy is to be scrupulously careful in safeguarding such confidences. Point out how much more valuable your contribution can be if you are involved early in the value analysis procedure before commitments to methods and materials are made.

A good buyer will welcome the idea. During the past twenty years, the buying function has, in many companies, been brought to a new level of professionalism. The increasing speed and complexity of technological development with consequential difficulties in communications has pointed up the need for a closer working relationship between customer and supplier. The enlightened buyer looks for this, and encourages contact between his own company's technical staff and suppliers' representatives. The value analysis team is a ready-made medium for initiating and developing a close working arrangement beneficial to both sides. We see these relationships working to maximum advantage with Marks & Spencer in the consumer goods field. There the commercial/technical staffs of sales and buyer work side-by-side to develop and perfect new products through a totally integrated working procedure which does not stop until the product is in the customer's hands.

From the customer's point of view there is no doubt that a knowledgeable outsider in the value team can make considerable impact, if only because he is able to ask those simple but important questions which focus thinking on the crucial issues: 'Why do we have it this way?' 'What is really wrong with this alternative?' All too often these are the questions which insiders are too inhibited to ask, or which they may not even see as being relevant because they have got used to one material, one process, one method. It takes a big man to ask a question which may produce an answer indicating that he has been doing the job wrongly for years! The supplier's sales engineer is in a position to look at the problem free from the restraints of company habits and traditions.

Benefits of Supplier/Buyer Co-operation

I do not need to spell out in detail the advantages to the supplying company of taking part in his customer's value analysis programme. By operating this programme the customer is demonstrating his intention to break with tradition, to innovate, to improve. A like-minded supplier, working with the value analysis team on the same side of the table, becomes familiar with his customer's thinking, the objectives he is pursuing, his plans for products. There are opportunities in plenty to present your own new products, to discuss and evaluate new product ideas, to ensure that maximum use is made of your present products.

We must accept, too, that with the ever-widening recognition of value analysis as an essential business tool, more companies with the power to do so are going to insist that their suppliers operate methodical value analysis programmes – as the U.S. Defence Procurement Bureau already does and as British Governmental purchasing offices are beginning to do. This trend is also discernable in the behaviour of individual buyers, who are more and more using the value analysis approach in their buying procedures. As the buying function becomes more efficient, more closely controlled, better organised, we have to make sure that our representatives are equipped to deal with these trends by equipping them to speak the language of value when negotiating with their opposite numbers on the buying side.

Surprisingly, some suppliers see the introduction of value analysis by a customer as a threat, assuming that it will lead to reduced margins, increased competition, perhaps a total loss of business. So they react defensively. As in all areas of business management, a negative attitude will produce negative results. If you react in this way the situation will indeed become a threat and you may well find that your customer has value analysed you off his supplier list! How much better to see this situation as the opportunity it really is and to react positively in the way I have suggested.

Here is an example of supplier/buyer co-operation, which on the face of it was detrimental to the seller's short-term business, but which had the promise of long-term benefits. It is a statement by the buyer of the A. O. Smith Corporation (largest American independent manufacturers of motor-car frame assemblies) quoted in *Sales Management*, 21st April, 1961, p. 130:

'A certain gauge metal was being used in our water heating plant and apparently was doing the job quite satisfactorily. Before we got around to evaluating the function of this metal, the vice-president of sales for a particular vendor suggested that we might be using a heavier gauge metal than we needed. Note that this man's company was (and still is, I might add) supplying us with the metal in question. We investigated and we found that we could indeed get along with a lighter gauge metal and re-ordered accordingly. Of course, his company lost a certain amount of dollar volume on that transaction, but his position as a reliable, interested supplier was greatly strengthened. This is the kind of supplier co-operation we want and are receiving under our value analysis program'.

Dealing with the Smaller Companies

Some supplier companies are already operating technical service departments at a highly sophisticated level with the ultimate aim of ensuring customer satisfaction by helping their customers to solve problems of product application. This involves techniques of functional analysis and creative problem-solving which are basic to the value analysis process, and it is a logical step from the provision of technical service and advice to official involvement in a customer's organised and systematic value analysis programme.

Many of your customers, especially the smaller ones, will not be using value analysis. Here are opportunities to move in and help them launch a value analysis operation with benefits for them – and you. If you help your customer to run his business better your standing with him will be higher, your relationship closer and you will have achieved significant differentiation from your competitors – which is what every marketing executive would like to do with his products and his company.

Value Analysis Training for Sales Engineers

What are the snags? How do we set about using value analysis in selling? First of all your sales engineers have to be qualified if they are to work as members of a customer's value analysis team and are to make a convincing contribution to the team's achievements. They must be able to offer an understanding of his process and his business that transcends your product. They must be able to think and talk in a value analysis way. So they must be trained. How long to train them? That depends on the men and the market you are selling in. A minimum of 20 hours is normally required for experienced sales engineers and in this time you can cover basic techniques (including creative problem solving), terminology and some project work. The Tack company, well-known for their sales training courses, claim to do a worthwhile job of value engineering training in two days. Projects of a 'do-it' type are valuable, although time-consuming, and successful case histories help to stimulate a positive approach to the subject. The technique content should be based on the steps of the standard value analysis job plan:

1. Define *objectives*
2. Gather *information*
3. Generate *alternative* possible *solutions*
4. *Evaluate* these *alternatives* and choose the most *promising*
5. *Plan* intensive investigation of chosen solutions
6. *Execute* the plan
7. *Summarise* the findings for decision.

An instructor who knows your market and products as well as value techniques can build the course round specific product applications and problems, and these will keep the trainees' interest and attention at a high level. A good sales training manager can usually set up a suitable course after he has had a grounding in value technique.

Competent Thinkers and Better Communicators

The cost in time and money of training sales people in value analysis methods will certainly not be wasted. Experience has shown that these techniques do more than equip a sales engineer to help customers with specific problems: they enable him to handle better his everyday work of contacting customers, taking orders and keeping his own headquarters in touch with market changes and developments. He becomes a more competent thinker, a better communicator, a more valuable company man generally.

It is in the areas of communication and information that the worth of value analysis as a basis for industrial selling is demonstrated most impressively. To hold a selling conversation at all it is essential that common ground should be established between buyer and seller. The sales engineer who can talk intelligently about his prospect's business and products, who is clearly trying to understand the buyer's point of view and who offers constructive thoughts about the buyer's problems will find a ready audience, for the buyer will have a clear and agreeable reason for joining in the conversation: he will see 'what is in it for him'.

Identification of Customer Need

As regards information, every sales engineer should be required to feed back details of customer needs and problems as well as market information generally, so that product improvements and ideas can be generated. The head of product planning of Rank Xerox said recently 'The company's own resources and experience are the best sources of information. Salesmen's reports are very good. . . .' Analysis of product function and identification of customer need is, of course, fundamental to the salesman's job. He has to work through this process in order to set up a presentation of his own products through which he hopes to demonstrate how well they will perform the functions and satisfy the needs. Unless he does this competently he will not get the order. Value analysis will heighten his awareness of the importance of function and need, and improve his ability to identify them. His approach to information collection will become more controlled, more objective. How many representatives, when making reports, question the validity of the information they obtain, especially when it appeals to them? How many include information they do not like, however relevant? Value analysis teaches them objectivity, an essential attitude when conducting investigations of any kind.

Value engineering/analysis is a total cost philosophy, i.e. it includes product reliability and quality, supplier stability, service, delivery and dependability. So the value analysis trained representative will see the total picture and through him the rest of the company will be made aware of the importance of these factors and of customer's staff working with the seller's representative, will become more aware of his company's capabilities.

If the Sales executive reading this article is still not convinced of the value of value analysis training for his men, let me remind him of the attributes we look for if a man is to be successful as a salesman. They can be conveniently summarised:

Attitude – must be positive
Knowledge of product and customer – at a high level
Skill in presentation, analysis, etc. – reasonably expert
Motivation – more than adequate.

A positive attitude is essential for value analysis and part of the training is designed to overcome negative thinking. Fortunately sales engineers are less likely than most to be inhibited by such blocks to creative thinking as the standard reactions 'It won't work', 'We've tried it before'.

Value analysis training will increase knowledge about products and customers and increase the ability to recognise and use new knowledge.

Motivation, the feeling of doing a worth-while job, is likely to be improved when a sales engineer obtains orders by helping customers to solve their problems.

As to the actual selling process (which even in the sophisticated area of high-level, technical selling can be represented by the time-honoured formula A I D D A: attention, interest, desire, decision, action) the value analysis approach again makes a worthwhile contribution. To be able to offer a potential customer help with his problems, working from a convincing basis of experience and practical know-how is a good starting point for the sales presentation. Attention and interest are assured, desire, decision and action develop quite naturally out of the value analysis discussions. Product knowledge builds up steadily and product applications are equated with consumer needs – again quite naturally – readily satisfying the old, but still relevant cliché, 'Nobody ever buys anything for what it is, but only for what it does – for them'.

How far you go in the use of value analysis as a sales tool depends on your products, your people, your marketing philosophy. Whilst value analysis training itself can do nothing but good, your people will only become successfully involved in your customers' value programmes if they are capable of clear, analytical thought, and creative imagination. Not all sales engineers have the inherent qualities that are necessary and some companies provide a value analysis service through a separate force of service engineers. This can work reasonably well – but watch out for the problems developed when two men are in close touch with one customer, and the weaknesses created when responsibilities are divided.

Finally we must recognise that value analysis help is costly to provide. It has to be kept in balance: orders received must eventually justify the additional cost. But subject to proper control, value analysis in selling can repay many times the investment involved. Improved and more secure relationships with customers, more skilful and better motivated sales people, and a strengthening of your reputation in the trade (customers do talk – at trade association meetings, conferences and the like) are all rewards for the effort of organising a carefully thought-out training programme in an area which at first sight, may not have an obvious appeal.

* * * *

In this article we have been concerned with the use of value analysis as an external tool to sharpen the edges of both marketing strategy and selling tactics. The use of value analysis internally by the supplier to engineer into his products and services the maximum customer-oriented value is another subject, but not one to be neglected. Certainly an alert marketing team will insist that value analysis is used to build into the company's products values which give them scope for developing strategies superior to those of the competition and leading to increased market shares and higher profits.

Reprint No. 1:1:5

Design — Creativity — Product Development

The Product Development Process illustrated with reference to Domestic Appliance Development

by A. R. C. Morphy*

Describing an ideal product development pattern with special reference to the 'Classic' electric iron, the author outlines seven objectives before the development work begins.

In the Research Phase practical methods for obtaining an optimum design solution are set forth, and the results of their application to the 'Classic' iron are described.

Value Engineering – in the author's experience – best comes in at the stage where a firm definition of the proposed product design has been arrived at. Attempts to bring it in earlier have not proved satisfactory. Mr Morphy sounds this cautionary note – 'A badly conceived design cannot be retrieved by good work in the later stages.'

Introduction

The essential part that cost considerations must play in appliance design is best seen in relation to the product development process as a whole – a process that has been deserving of a critical re-examination in recent years.

Historically the majority of new appliance designs have failed commercially (excluding straightforward replacements of 'bread-and-butter' lines), and those that have succeeded cannot be held up as examples of 'good' design. The latter cases arise, of course, because success does not depend purely on product design. Factors such as Brand reputation and marketing methods often play a dominant role. Discounting such factors the success/failure ratio has been sufficiently depressing to lead to a good deal of rethinking, particularly regarding objectives and methods of evaluation and operation.

In addition, where the appearance of a product plays such an important part in its acceptance, assessments tend to be subjective and therefore difficult to control. A concept of the development process is described in this article by reference to the Morphy-Richards 'Classic' iron.

The Corporate Product Development Process

Figure 1 shows an idealised version of this process. Traditionally the research stages would be omitted and a start made half-way through, at the Analysis-Synthesis stage, using a background of experience and making use of the 'crystal ball'. This truncated procedure still has to be used where time is short (which is perhaps more frequently than one would wish), to meet the needs of a changing industrial and economic situation.

Mr Morphy is Development Manager of the Portable Appliance Division of British Domestic Appliances Ltd., Orpington, Kent, England. The substance of this article was presented by the author at the Value Engineering Association's Conference at Stratford, England, in October, 1967, and is reproduced with grateful acknowledgement.

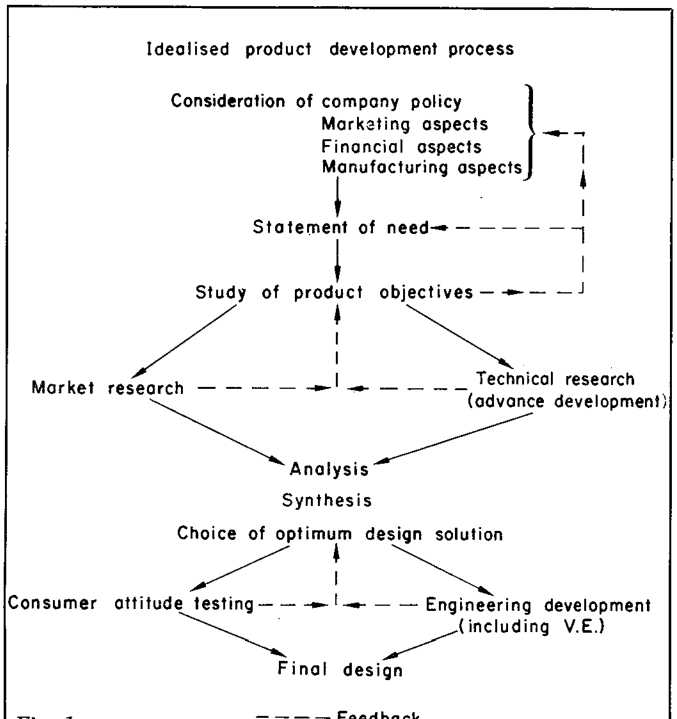


Fig. 1

The cyclic nature of parts of the process should be noted. This arises because preliminary decisions have to be taken at certain stages before all the facts are known. After a subsequent stage, when the necessary information has been obtained, a recapitulation is made, and the original decisions are either confirmed and amplified, or changed – in which case the programme may well have to be revised.

The process as a whole is essentially a multi-disciplinary affair, far from being a pure 'engineering design' process.

Objectives

Before starting the active development of a particular project, a proper study of objectives is clearly of central importance. For a typical appliance the objectives may well be as set out below – shown, perhaps significantly, in the order with which they strike the potential customer.

1. To succeed at 'point-of-sale'. Both trade customers (wholesalers, retailers) and the eventual user must be impressed by the product, often in an apparently superficial manner and without demonstration. The conditions under which the product will be sold will vary and may affect the approach to the design. Properly devised market research is generally necessary to help define price and specification (or product features) and to give pointers on appearance (particular care being necessary in the last case). Naturally it is to be hoped that technical developments have come up with certain unique features to give a lead over competition, but this is frequently not the case with 'bread-and-butter' products.

2. To satisfy in use. This means, of course, that the product must function satisfactorily from an ergonomic point of view and that it must be reliable in use. Reliability will also affect the trade in terms of service returns.

3. To meet various Approvals requirements, notably to obtain certification by the British Electrical Approvals Board, and to comply with C.E.E. requirements.

4. To maintain the corporate image (House Style). The product range may include products of widely differing appearance but an attempt should be made to give them a common style. This may be quite indefinable and may rest, for example on the use of a common Industrial Designer. The product packaging is an important item in many cases.

5. To make optimum use of Company resources. This involves the use of common parts, processes and plant where feasible. Decisions in this area, as with make-or-buy decisions, can be difficult to resolve.

6. To make a satisfactory operating profit from sales of the product. Because of the competitive nature of the appliance market, retail selling price targets are often almost impossibly low. Hence the need for obsessional cost consciousness throughout the development process.

7. To achieve objectives 1 to 5 within a certain budget in terms of resources and time.

A study of these objectives will tend to throw up areas where insufficient information is available to make certain key decisions.

This leads to the 'Research' activity phase

(Lumped together under this heading are those activities which are designed to obtain this missing information and to provide the necessary background against which the major design decisions can be taken.) The research activities fall primarily into two main categories – Market Research and what may be termed Advance Development.

Market Research must be used in the first place to define the markets to be entered and to study them, particularly in relation to the existing competition. In addition to the straightforward facts and figures in terms of sales trends it is very important from a design point of view to have information on consumer attitudes towards various design solutions.

Well established product types (i.e. those with high market penetration) tend to have developed stereo-typed images in the public mind which must be taken into account. It is the characteristics of these 'stereo-types' that we are exploring in the main by market research. Much variation will be found from market to market depending on local conditions and on decisions taken in the past by dominant manufacturers in the particular markets concerned. An example of this variation is illustrated by reference to the 'Classic' iron.

In certain European countries 'open' handle irons hold a very strong position whereas in others they achieve negligible sales compared with the conventional 'closed' handle iron, and

The following two tabulations are purely illustrative and are in no way intended to be exhaustive.

A. **Orthodox solution only**

		Partial Solution			
	Element or Parameter	A	B	C	D
1	Soleplate	Cast Iron	Aluminium diecasting		etc.
2	Heating Element	Sandwich	Tubular Cast-in	Embedded	
3	Thermostat	Slow make-&-break	Snap action		
4	Control actuation	Cam	Screw	Lever	
5	Cowl	M.S. pressing	Aluminium pressing		
6	Handle	Phenolic moulding	Melamine moulding		
7	Connections	Wire	Tape		
8	Mains lead	B.S.S.			
9	etc.				

B. Unorthodox solution permissible

	Element or Parameter	Partial Solution A	B	C	D
1	Heat transfer means	Metal soleplate	non-metal		etc.
2	Heat generating means	Mains fed resistance	Thermal storage	Rechargeable cell + resistance	
3	Control means	Bimetal + switch	Semi-conductor		
4	Enclosure	Metal pressing	Part of soleplate	Part of handle	
5	Handle material	Thermoset	Thermo-plastic	Ceramic	
6	Handle orientation	Horizontal above enclosure	Inclined	Vertical	
7	etc.				

consumer attitudes reflect this. One single design of iron could not satisfactorily meet both demands; we chose as the most economic solution to design in effect two irons with all parts common except the main handle mouldings, thus obtaining maximum market coverage with minimum cost.

Certain features of a product involve extra cost and it is particularly important to have information on trade and consumer attitudes to these, e.g. pilot light.

Obviously market research cannot in itself define a constructive, forward looking design solution since it only measures the existing state of the market – although so-called motivational research can help to give insight into the whys and wherefores behind certain overtly stated opinions. This may point to the possibility of new design solutions which still meet the consumers' basic need.

The category I have designated Advance Development includes a study of systems, materials and ergonomics (or the study of the man/machine system). Here we look for improved technical solutions, for the use of less costly alternative materials and systems, for solutions which suit the user more exactly.

An important piece of groundwork in this area is a systematic review of the state-of-the-art, in other words, the competition. In the case of the iron one will of course be looking for cheaper and better insulating materials, possibly ones that will permit an entirely new and less costly element design. There will be a scrutiny of systems for controlling soleplate temperature, including the fashionable solid state controls (still in this case too expensive). There will be a study of the user actually ironing (remarkable thought!) using techniques analogous to work-study and experimental psychology.

Process development has an important part to play. Because we are dealing in high volume production relatively large sums can be invested in tools and processes in return for low costs per unit. By the same token the investment necessary to develop the process to achieve lower unit cost is often quickly recoverable.

In Advance Development we are generally studying the function of the product type and the alternative means of achieving the function.

Analysis-Synthesis

As a result of the research activity there will now be a considerable body of information which requires processing. In general terms this is done by evaluating solutions to parts of the system against one another and in relation to the objectives. Many ways of trying to systematise this process have been advocated and the method actually used is very much influenced by the type of industry involved.

To describe the process at its most straightforward form: The product is broken down into 'elements' or parameters; the actual choice of which depends to a certain extent on the objectives, but they are what the product must 'be' or 'have' or 'do'. These elements are listed along one axis of a chart. Possible solutions to each element are entered in columns to complete the chart, a careful note of the boundary conditions being made, together with a cost estimate for each element where possible.

After sifting, elimination and regrouping the most economical complete design solution can be seen to emerge and can be compared with others. Care must be taken to see that the picture is not distorted by arbitrary demarcation between elements and it may prove necessary to consider the elements broken down in several different ways.

Choice of Optimum Design Solution

Each element of the alternative solutions must be assessed in respect of:

- function and reliability
- marketing requirements (including appearance where appropriate)
- manufacturing considerations
- cost
- approvals requirements
- service requirements
- compatibility with other elements of the design.

In general one or more of these aspects will conflict with another; the essence of the design process lies in the resolution of this conflict.

Some examples in the design of the 'Classic' iron follow:

1. The need for an open handle and a closed handle iron from a marketing point of view has already been mentioned. The solution to the problem is highly satisfactory since the quantities involve more than one set of multi-impression handle moulding tools. Making at least one set of each type therefore involves negligible additional tool and part cost, leaving simply the one (admittedly bulky) extra item of inventory from a stock and handling point of view. Although the solution appears neat, the resolution was tricky in that both versions had to be thoroughly satisfactory from an appearance point of view. In the early appearance design studies one version was always adversely affected by the achieving of a satisfactory solution in the other. In achieving the end result we were fortunate in enjoying the services of one of the foremost industrial design consultants in the consumer durables field.

2. In achieving the looked for appearance and function we found that we could not avoid using a cowl with a sharply profiled nose which does not lend itself to the most simple and economic automatic polishing set-up. This is a case where the ideal manufacturing solution was quite deliberately set aside.

3. The soleplate has a mirror finish which involves greater cost than a matt or brushed finish, both in terms of the work done to the casting and the reject rate for visual defects. In terms of ironing performance the difference between the two finishes is negligible, but market research had shown the need for the mirror finish at point of sale. It was finally adopted after careful balancing of the alternatives.

4. The iron includes a sandwich-type micaceous element which is familiar to the trade and easily replaceable by them. It is known to be more costly than the main alternative, which is a tubular sheathed element cast into the soleplate. The decision was taken on the basis that the favourable attitude towards easy and cheap element replacement more than offsets the extra price that has to be charged for the iron to recover the extra cost.

5. The thermostat is apparently more complicated than some alternative designs. Now that greater emphasis is being placed on the accuracy of thermostat settings of irons we have disposed the components of the thermostat to give much greater consistency in the thermostat characteristic between one iron and another. This greatly simplifies the setting procedure and cuts down rework on irons with 'rogue' thermostats. The cost involved in this rework is not easy to identify, but is by no means negligible. The thermostat is also resettable without dismantling the iron, a feature with production and service benefits which outweigh the slight extra cost involved.

Testing of Crucial Areas

Having selected the preferred complete design solution in principle there will generally follow the need to test in greater depth certain of its aspects. This may include a check on consumer attitudes to the proposed appearance design and it will certainly be necessary to check function and reliability implications, probably on some sort of hardware.

For example, in the case of the 'Classic' iron the soleplate was to be a pressure die-casting with a relatively thin wall, the element being clamped in position by a pressed steel clamp plate. Clearly it was necessary to check the effects of differential expansion, both in terms of soleplate distortion and abrasion of the element through the relative movement of parts. This involved making a number of models and running them for lengthy periods.

Since this activity is likely to lie on the critical path of the development programme, its significance will readily be appreciated. This illustrates the very important effect that time considerations must play in determining the design solution. If a result is required in a given time – and the time or resources are not available to check a particular feature, then that feature must be dropped in favour of one that is of proven reliability, or the risk involved must be recognised and accepted. When the complete design solution has been checked out in its various aspects we are then in a position to define it quite firmly. This definition generally takes the form of an appearance model, a functional model, a detailed mechanical and electrical specification (including layouts) and a cost estimate.

Value Engineering

Since there is now a firm definition of the proposed product design it is feasible for a Value Engineering exercise to be carried out. Attempts to run a V.E. exercise at an earlier stage have not generally proved satisfactory, since there is insufficient data available for adequate guidance of the team. At the end of the period prescribed for the exercise the design is redefined to incorporate agreed findings and is now ready for detailed design and development.

Detail Design and Development

During this phase detail drawings are produced based on the layouts and information previously arrived at, prototypes are made from these drawings and are put through a complete range of functional and life tests as well as being checked for Approvals compliance (B.E.A.B. and C.E.E.). There is continued liaison in detail with Production Engineering, Quality Control, and Service and with suppliers in conjunction with the Purchasing department. The packaging design is completed at this stage.

The culmination of this activity is a complete set of production drawings, specifications, etc., quotations from suppliers for bought-out components and materials, and a methods schedule from Production Engineering. A final cost estimate is produced from this information enabling management to consider the full financial implications of the project.

Tooling and Production

Given the go ahead to make the necessary investment, the normal sequence of tooling, sampling, trials and production follows.

The latter stages in the product development process have been mentioned very briefly, not because they are unimportant, indeed thoroughness and professionalism are vital here if the design concept is to be brought to a satisfactory conclusion. It cannot be denied, however, that any amount of first class work in the later stages will not make a poorly conceived design successful.

Summary

I have tried to emphasise the importance of defining all the objectives to be met, that the selling function is as important as the using and manufacturing functions and that each requires a proper study using the appropriate disciplines.

Time should be allowed for research and information gathering before attempting to start the actual design process. The additional information gained as a result allows us to be more precise about our objectives and give us a range of potential solutions from which to build up our product design.

There are means of formalising the process of building up to the optimum design solution; more important is the understanding of the need to break the system into a meaningful number of discrete parts and to evaluate these separately and jointly against the objectives.

In general it will be found that certain objectives conflict when it comes to putting them into practice – it is the exception where no conflict occurs. The essence of the design process lies in the resolution of the conflict and this almost invariably means that the ideal solution must be sacrificed in one direction or another. The important thing is to understand this and to be clear about what one is sacrificing and why.

Certain aspects of a proposed design will probably require checking out. If the time or resources are not available to carry out the check and the risks in failing to do so are untenable, then they will have to be dropped in favour of safer, if less attractive, solutions.

Value Engineering is best carried out when the proposed design can be defined fully, just prior to the phase where final production drawings are in process. A badly conceived design cannot be retrieved by good work in the later stages.

Reprint No. 1:1:6

Applications — Design

Value Engineering in Rolls-Royce Aero Engine Design

by L. W. Crum, D.F.C., C.Eng., A.F.R.Ae.S.*

The author has interestingly noted a reference to Value in the current engineering sense was made in his organisation as far back as 1915. Design Cost Control then evolved through the Weight Control Group resulting in the use of weight/cost relationship as the basis of a cost-estimating and cost control system.

Investigations of the progress of Value Engineering in the United States convinced the company that the functional approach to cost reduction was very similar to their own, and – in 1964 with the Spey engine – Management decided to form teams to investigate engine build and component tolerances. As a result of this investigation Value Engineering was proved to be a well-organised approach to cost reduction and a worthwhile level of savings was achieved.

Since then, improved cost management disciplines (of which Value Engineering is one) have enabled the number of parts trend to be reversed with consequent cost savings. Mr Crum goes on to describe Departmental Value Engineering Organisation in his company, and concludes with the information that Value Engineering training is now provided for all staff who are in a position to influence costs.

Introduction

The need to consider cost during design is accepted as efficient design engineering practice, and has been intrinsic in all Rolls-Royce Design since the Company was formed by Rolls and Royce in March 1906 to produce motor cars of very high quality.

Although Royce had never been in an aeroplane his gifted mechanical instinct for what was right was as sure in the air as on the ground.

With the outbreak of war in 1914 he quickly turned his skill to the design of an engine for an Admiralty aircraft. The engine – subsequently named the Eagle – was on test six months after the first drawings were started and it is in the communications between West Wittering, where Sir Henry Royce then lived under the constant strain of a serious abdominal illness, and the factory at Derby that probably the first reference to Value in the current engineering sense was made.

In a letter to the General Managing Director on the 20th January, 1915 Sir Henry referred to a letter from the Admiralty concerning the requirements for the starter motor. He says that the Admiralty would be wrong to consider only the horsepower of the motor – buying could not be narrowed down to so small a limit. Furthermore, the value of the engine would certainly rise with its lightness so that roughly a formula might be considered in which Value was equivalent to

$$\frac{\text{Horse Power x Life without attention}}{\text{Weight}}$$

This simple expression sums up the Rolls-Royce approach over the succeeding forty years or so to the design, development and manufacture of aero engines for a predominantly home military market. This is not to suggest that cost was not a consideration. Of course it was, but it was subordinated in priority to the achievement of the primary goals of performance and reliability. It would be presumptious to question such a philosophy which led to the most famous aero engine produced in war-time – the Merlin and, since the war, the highly successful Dart.

However, in the mid nineteen fifties it became apparent that the level of military aero-engine business might well seriously reduce and to be able to compete successfully for a substantial share of the growing commercial market would require a greater degree of cost control than had previously prevailed.

Design Cost Control

Of the various steps taken to ensure that this happened one of the most important was the decision to involve Engineering in the responsibility for engine pricing.

At that time this function was performed by the Commercial Department from cost estimates provided by the Production Department.

Engineering's reaction to the edict was that if considerations of cost were to be given then it was necessary to have a cost estimating service which could promptly evaluate the probable production costs of new projects and the comparative costs of alternative designs.

The task of performing this service was allocated to the Weight Control Group whose methods bore a close affinity to those considered necessary for successful cost estimating and cost control.

In due course a cost estimating system was devised mainly based on a detailed analysis of existing component costs using weight as the linking parameter.

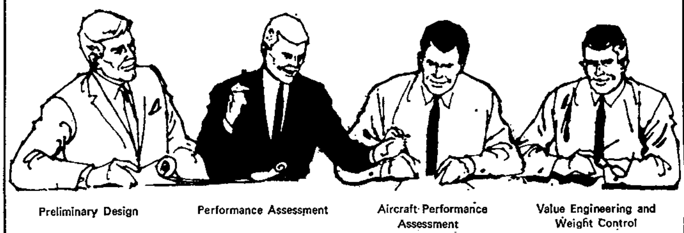
Over the next few years this system was increasingly used to exercise a degree of cost control over many new designs but chiefly, and most effectively on designs at the preliminary design phase.

Mr Crum is Chief Value Engineer at the Aero Engine Division of Rolls-Royce Ltd., Derby, England. He takes a very active interest in V.E. seminars and other methods of exchanging ideas on value engineering matters.

The following illustrations show the way in which this control was achieved.

Phase 1 – Initial Feasibility Evaluation

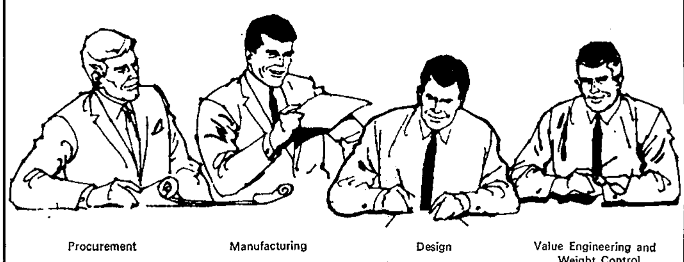
All new designs produced by the preliminary design team were evaluated for their probable production cost and weight. With this data and the relevant performance data, the suitability of a new project for its particular market could be assessed. This evaluation was carried out by the Aircraft Performance Group from the estimates provided by the specialists shown.
So began a continuous process of considering all aspects until the most acceptable proposal emerged.



Initial Feasibility Evaluation Phase

Phase 2 – Preliminary Design

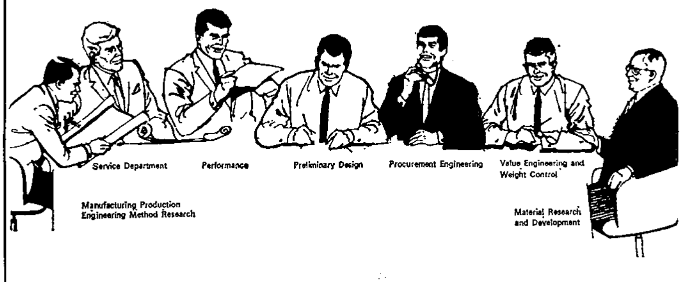
As the preliminary design became firmer the Manufacturing, Procurement, Service and other specialists were brought in to examine in detail each component and assembly to make sure that costs were kept to the minimum consistent with the requirement of function and reliability.



Preliminary Design Phase

Phases 3 and 4 – Main Design and Development

After a preliminary design was sold it became a committed project and was passed to Main Design for detailed design of each component and assembly.
During this and the subsequent development phase the design was monitored by the Design Cost and Weight Control Group to compare the cost and weight with the targets set during the preliminary design phase.
A continuous liaison was maintained between the Groups shown and where excesses were found they were promptly attacked in order to achieve the target figures.



Main Design and Development Phase

Value Engineering

But although the design cost control system was obviously making itself felt it became increasingly obvious that a method for revealing and reducing high costs was also essential. More and more the question being asked was not what does a part cost, but why does it cost the amount it does. Thus many of the investigations become functional cost orientated.

During the same period – 1957 to 1963, the new technique of Value Engineering was having a noticeable impact in the U.S.A., and investigations made by the personnel of Design Cost Control provided the necessary evidence to convince them that the Value Engineering functional approach to cost reduction was very similar to theirs. In fact from the subsequent trials which were carried out it became obvious that this approach enabled many hidden unnecessary costs to be revealed which would otherwise remain undetected.

The opportunity to apply Value Engineering on an extensive scale came at the end of 1964 when Management decided to attack the production cost of the Civil Spey. Agreement was given to form eight teams – six on the major section of the engine, one on Engine Build and one to investigate component tolerances. An exhibition, showing each component of the engine with its own labour and material cost was laid on for the direct benefit of each team. There was not time to go into the niceties of Value Engineering unfortunately, and only three hours of indoctrination into the main techniques was given. Each team was given a maximum of three months in which to Value Engineer the components in that section of the engine to which it was allocated. The team Managers were drawn from senior levels in Engineering, Manufacturing and Service, and team members from Design Development, Production, Quality Laboratory, Cost Engineering, Purchase Service and Design Cost Control.

The result of this investigation was that not only was Value Engineering proved to be a well organised approach to cost reduction, but in the Spey Series a worthwhile level of savings was still possible despite the fact that the series had been produced in a more enlightened cost conscious environment than any previous engine type since the advent of the gas turbine.

Many of the proposed savings have already been implemented and where also applicable incorporated into current new design such as the Trent and RB 207 and RB211.

During the remainder of 1965 two further major Value Engineering programmes were completed successfully. The second concerned one particular type of component - compressor blades, and the third the Military Spey for the Phantom Aircraft. Before proceeding to describe the Value Engineering organisation which presently exists and is still being developed, it is interesting to look at the achievements of Design Cost Control up to this time.

Number of parts trend (Figure 1)

Until the late fifties the number of parts per engine, which is an easy first approximation of the relative cost, seemed to increase as a function of time, and accordingly, as a function of the effort applied to improving other parameters such as cruise specific fuel consumption and specific weight. These improvements caused increased complexity bringing not only higher first costs but often more difficult maintenance and higher learner and tooling costs.

The trend, prevalent during that period has now been dramatically reversed by advances in technology in all fields and by improved cost management disciplines of which Value Engineering is one of the most significant.

Total Number of Parts (Figure 2)

The illustration shows the reduction in numbers of parts compared to the Conway of the Civil Spey, the RB 207 and the Trent, whilst still achieving very substantial improvements in both S.F.C. and specific weight.

Cost and Cruise Specific Consumption (Figure 3)

This figure illustrates an attempt to isolate the increased cost associated with improvements in S.F.C. by scaling all the engines to a common power (20,000lb thrust at sea level 125k 90°F) using a relationship of manufacturing cost with engine scale based on available experience.

A line has been projected through the points representing three earlier standard engines to indicate to what extent cost has been allowed to increase to obtain improvements in S.F.C.

The two points below the line representing currently offered engines show a very marked improvement as a result of being designed in a Value Engineering environment.

The wide variation exhibited by these engines is evidence of the compromise that must be used in Engineering. The small engine (Trent) was designed for a small range aircraft and cost was considered extremely important as compared to cruise S.F.C. The large engine (RB 207 Airbus) was designed for a high productivity short range aircraft where cost and S.F.C. have a more balanced significance. The cruise S.F.C. for this engine is reduced by 25 per cent for a modest cost penalty.

As a result of the successful Value Engineering programmes and of Design Cost Control, the latter Group was reformed in late 1965 to become a Value Engineering Department.

Departmental Value Engineering Organisation

A Senior Engineer has been appointed as Project Value Engineer to each new project to be responsible for Value Engineering the project through the design and development stages.

He is assisted on a full time basis by one of the senior cost estimating engineers and in the team part-time by specialists from production, procurement, service, staff design and staff engineering.

The efforts of the Project Value Engineer are closely associated

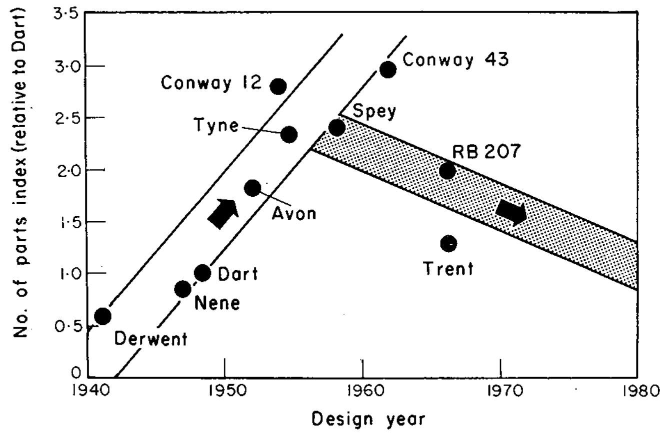


Fig. 1

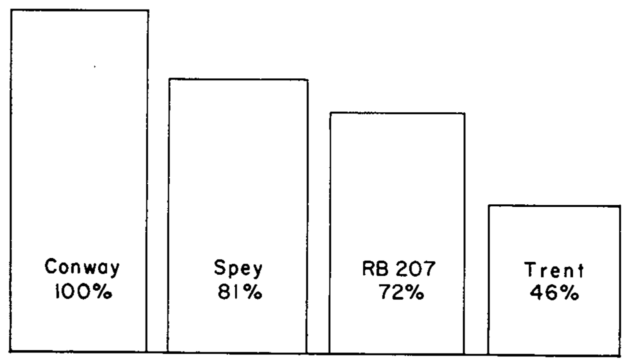


Fig. 2

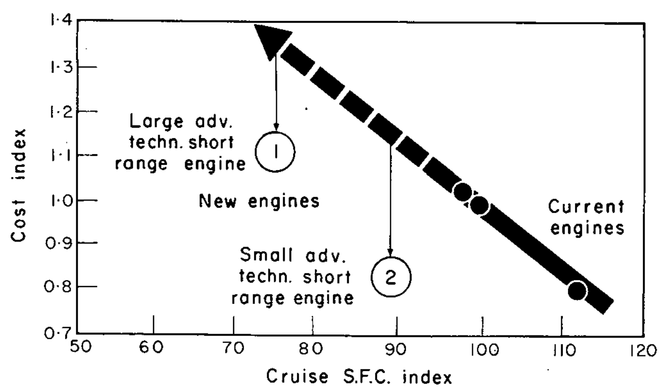


Fig. 3

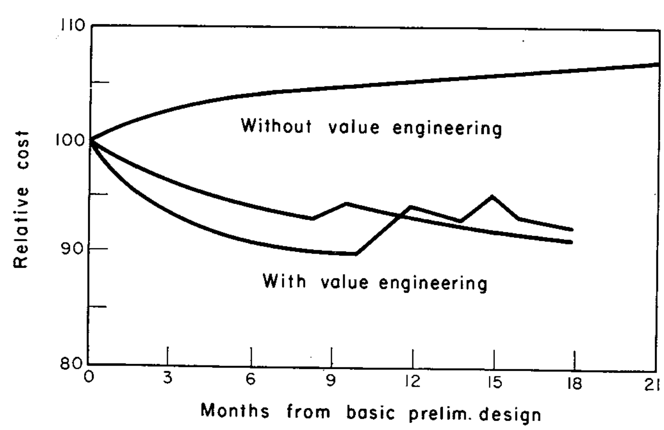


Fig. 4

with the Division's cost control effort to achieve the cost targets set by Management.

The cost estimating function of the Value Engineering Department monitors the progress being made towards achieving these targets and reports excesses as quickly as possible to the particular Chief Engineer concerned so that remedial action can be taken.

In addition, Value Engineering training is being given to all relevant personnel, not only those in Engineering, in order that cost considerations can be invoked concurrently with their normal tasks.

This training is in the form of workshop type seminars, data sheets and a Value Engineering information service.

Special mention should be made of the effort of the Production Engineering Organisation which has formed a group of liaison engineers to engage with designers in evolving low cost designs. These liaison engineers also serve on the Project Value Engineering Teams.

Recently, Value Engineering was introduced into one of the new Product Centres by the appointment of a Value Engineer responsible to the Manager. He is assisted by a Value Engineering Team consisting of representatives from the main functions of the Product Centre and the Design Organisation.

Significant too is the Value Engineering activity in the Purchasing Department which for many years has practised target pricing using Value Analysis type of investigations.

Cost Trend during Design (Figure 4)

The effect of this new organisation is shown in this figure which compares the situation on current projects with that which existed when the Spey was designed.

Summary

Summarising, the following procedures and disciplines are now operated to ensure that the best value is obtained in the Division's products:

1. A realistic cost target is set by Management.
2. Means are provided to achieve the target.
3. Means are provided to monitor the progress towards achieving the target.

Items 1 and 3 are provided by the cost prediction and cost estimating teams, including that in the Value Engineering Department.

Item 2 is Value Engineering provided in the form of training for all personnel who are in a position to influence costs and by full time specialists in Engineering, in the Purchase Department, and more recently in one of the new product centres.

* * *

Acknowledgements

The author thanks the Directors of Rolls-Royce Ltd. for permission to publish this lecture and his colleagues in the Value Engineering Group of Rolls-Royce Aero Division who have assisted in the preparation of the information.

Miscellany

A Classic Treatment of Methodology

Mr Gage, in his recent book *Value Analysis* which is reviewed elsewhere in this issue, refers in his Selected Reading list to the International Labour Office's publication *Introduction to Work Study*. He calls it a 'classic treatment of the specialism nearest to Value Analysis' and it is thought that readers (especially those who were brought up on Work Study) will be interested to learn of its impending *seventeenth* reprint.

First issued in 1957, *Introduction to Work Study* described (to quote from the Preface of the current edition) 'as simply as possible the basic techniques of work study'.

In view of the considerable potential which Value Analysis holds for cost-savings perhaps the I.L.O. will consider performing the same service for Value Analysis as it has done for Work Study and provide a similar simple basic treatment.

The new seventeenth edition of *Introduction to Work Study* to be published early in 1968 is to be reviewed in these columns and it will certainly repay the time spent on its study by value engineers whose backgrounds have not included Work Study in any detail.

A Checklist for Specifiers

The National Council for Quality and Reliability instigated the compilation – through a committee of the British Standards Institution – of a *Guide to the Preparation of Specifications* (PD 6112, price 5s.).

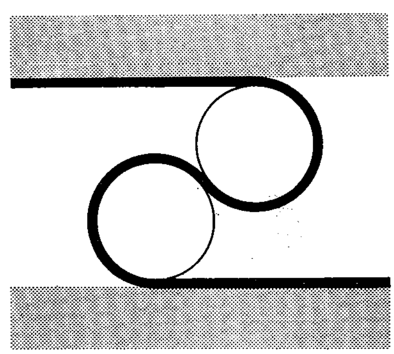
Naturally, the contents of a specification will vary according to the purpose for which it is being written and the types of materials and processes which are involved. The *Guide*, however, has been drawn up as embracingly as possible and its headings will serve to remind specifiers of anything they may have overlooked.

The *Guide* will also be of assistance to designers, value engineers and others concerned that specifications are complete and that nothing is overlooked in their initial briefs.

Two useful appendices list B.S. Glossaries and British Standards and serve to draw the specification writer's attention to the existence of any appropriate British Standards.

Simple as a Wheel – the Rolamite

Invented by Mr Donald Wilkes of the Sandia Corporation, New Mexico, a Rolamite consists of three parts: a track of two parallel surfaces, a band under tension which is bent into the shape of an 'S' in reverse and attached to the top and bottom of the track, and two rollers or cylinders.



When the rollers are put into place, one on either side of the band, they can be caused to move by any push or pull on the band. This movement can be started by changes in speed or in temperature, and a Rolamite can be used to trip switches and to shut valves.

The action of the Rolamite is relatively frictionless for the rollers do not rub against each other as ball bearings do nor do they slide about. They are only in contact with one surface of the band and this contact becomes smoother as time goes on so with wear the Rolamite produces even less friction than at the beginning of its operation. This eliminates the need for lubrication and makes Rolamites look attractive as bearings for machines.

Whether Rolamites can do very heavy jobs such as serving as shock absorbers for motor cars is doubtful, and it has been queried whether the light materials used will stand up to constant wear over the long periods of time that would be needed to make the device reliable.

Reprint No. 1:1:7

Purchasing — Specialist Suppliers — Value Standards — Inventory Control

Purchasing's Contribution to Value Analysis

by Dennis C. Simpson, B.A., M.I.P.S.*

Purchasing's part in Value Analysis is described with special reference to the value of gaining the co-operation of the specialist supplier, and the help which may be obtained from the construction of comparative cost and technical data.
Several useful methods of increasing the awareness of potential suppliers of the problems and requirements of the buyer are outlined.
The need for keeping stocks under constant review so as to enable the quick implementation of the savings generated from Value Analysis is also pointed out.
Successful Value Analysis is almost invariably the outcome of teamwork. Purchasing, as part of the Value Analysis team, has two main roles to play. Firstly, Purchasing is ideally placed to collect and initially to screen new developments in materials and processes which could have potential application to the products of their company. Secondly, Purchasing's knowledge of material costs helps to establish a commercial environment for the ideas-generating designers and engineers.
It is essential that Purchasing does much ground-work prior to the Value Analysis workshop sessions. This is not to say that they do not – or should not be encouraged – to brainstorm with the rest of the team members on analysis days. Purchasing's maximum contribution, however, is made when they have done their homework thoroughly and found out all they can from the specialist supplier.

Co-operating with the Specialist Supplier

In an age of very rapid technological change no single firm can ever hope or – more to the point – is ever likely to find it economic to keep abreast of all the design and development work within even its own industry group let alone that of others. It is nevertheless the case that spectacular cost savings have been made as the result of applying to one's own products the technology of another quite unrelated industry. The task of appraisal is immense yet no firm can hope to go unchallenged in the market place unless it keeps up to date with what is happening around it.

There is a limit, of course, to the extent to which any company will be prepared to commit labour and facilities to value analyse its range of products. It is open, however, to any company to speed up its action by involving its sources of supply. Constructive suggestions on ways of extracting cost may be solicited at the enquiry stage. For example, a number of firms have chosen to display a range of the items which they purchase as a way of encouraging the interest and ingenuity of suppliers. Other firms have set up workshop sessions to which suppliers' representatives are invited to learn about Value Analysis techniques and to take part in the analysis of a product in a practical way. They are then encouraged to go away and practise it for themselves on the basis of a shared savings incentive plan.

Suppliers' Awareness of End-use

It is important, too, that a supplier is made aware of how the part which he is making fits into the buyer's end product. It is unfortunate to have to record that on too few occasions will you find an assembly drawing on a buyer's desk when he is discussing the supply of a component with an outside firm.

Mr Simpson is Purchasing Controller with The Rank Organisation, 11, Belgrave Road, London, S.W.1.

If a supplier is allowed to manufacture his parts in isolation as customers we are failing to get maximum benefit from his special know-how and from the range of assets which he has available.

Developing a Network of Specialist Sources

It will be to the specialist firms that a company turns for advice on much of what is new. The buyer cannot wait on the off-chance that suppliers will come to him; he has to find ways of being in at the birth of innovation.

Purchasing, therefore, must develop a network of specialist sources of supply relevant to the range of material and facilities requirements, and maintain a relationship with them which encourages early contact.

Innovation breeds obsolescence which in turn bites into profit margins. The Purchasing man therefore wants to know about what is new and has application to his products as early as possible, preferably with specification parameters and samples. One way for a buyer to ensure that he gets only what he wants is to prepare and make available to suppliers a profile of his company's manufacturing interests and to up-date it as the need arises.

Meaningful Cost and Technical Comparisons

Purchasing should also try to make the data which they receive from their specialist sources meaningful in a comparative cost way in order to speed up the evaluation processes of the Value Analysis team. One way of presenting this data is in the form of Cost Guides.

The Cost Guide seeks to express elements of choice in terms of cost relationships. If, for example, an acceptable quality of White Bank Paper (11lb) costs 100 units, and we discover that an 18lb White Bond costs 180 units then we have quantified a quality relationship between these two materials.

Technical parameters might be similarly expressed. For example, if a carbon film resistor rated at 5 per cent has a cost base of 100 and a 1 per cent device costs 130, the designer knows just how much more he has to pay should he decide on the tighter selection tolerance.

Quality standards dictated by the needs of the end product, by design caution or by engineering conservatism can – to varying degrees – be expressed in such fundamental cost terms. They then help to guide the Value Analysis team in assessing potential cost savings if they were to pursue a particular line of investigation. The team is thus able more readily to determine the likely financial results of its efforts in one direction as opposed to another.

Such Cost Guides, if they are to be really useful and also economically produced, need to be confined to the requirements of one's own organisation. They become if you like a 'Which', tailored to suit the particular requirements of the company.

Increased Profitability with Minimum Delay

Having developed a product information service and found a way of presenting it comparatively the Purchasing department is also in a position to speed up the implementation of the savings generated by the Value Analysis team.

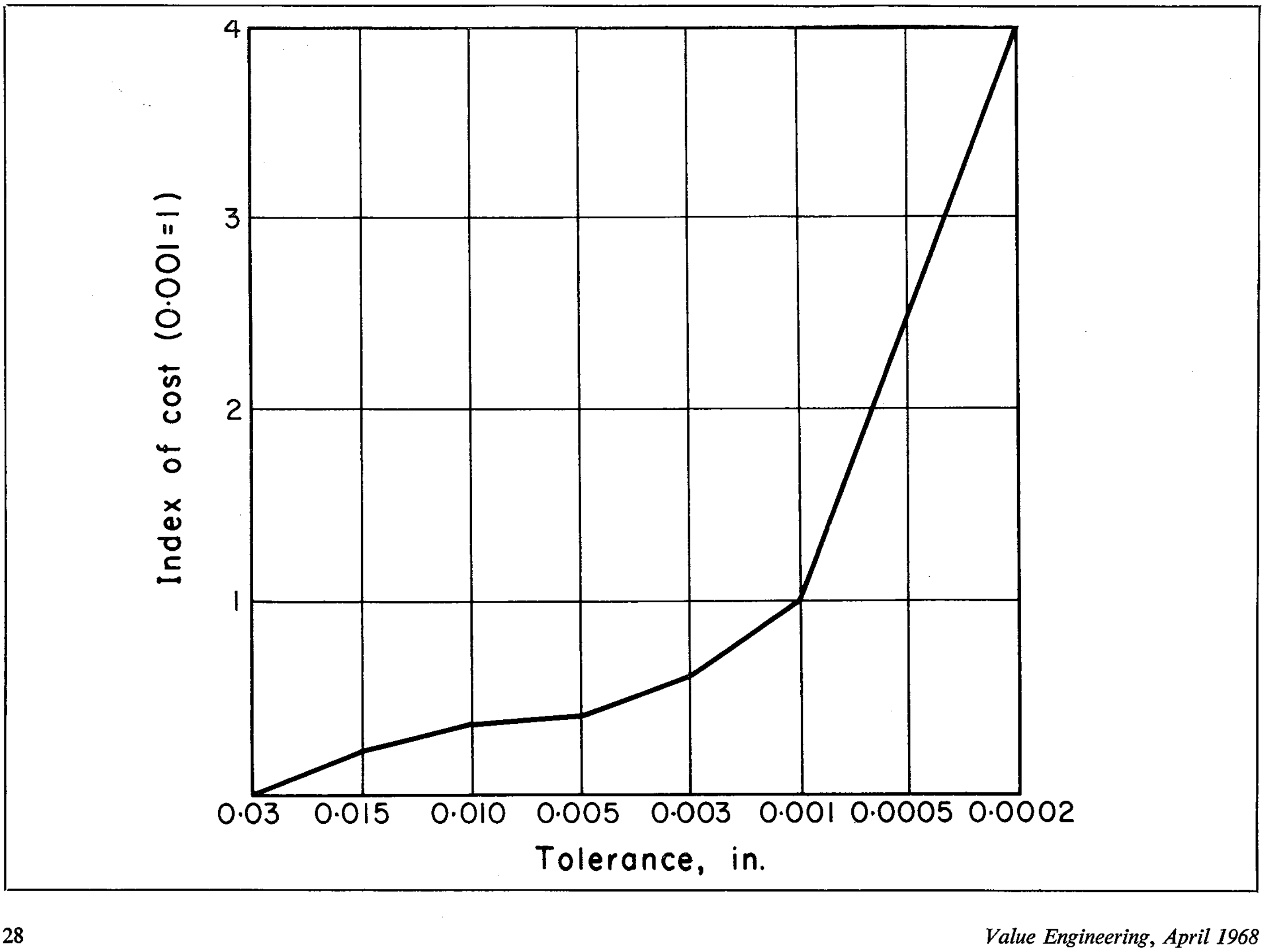
The most important last step of any profit improvement process is that which turns potential into actual. The more quickly a Value Analysis decision can be implemented the more quickly profitability can be improved. Purchasing can make certain that stocks and order commitment do not prevent the speedy introduction of any design changes proposed.

Using the material control card as a reference point, Purchasing must be constantly reviewing stock/ordering policies established for any materials with significant usage values once they are programmed to come under the Value Analysis microscope, and be ready to apply as much brake as necessary and possible to material intake and order commitment.

The emphasis all the time with Value Analysis (as with all other cost reduction processes) is increased profitability with the minimum delay. If Purchasing does its 'prep' conscientiously; if it develops and presents its specialist contacts intelligently; and if it does a good job in reviewing commitment and stock status then the goal of Value Analysis (increased profitability with the minimum of delay) stands that much more chance of being realised.

Over-specification and building cost into a product

An article on 'Value Engineering' from the pen of Mr Arthur Garratt who is Technical Director of Value Engineering Ltd. draws attention to the cost of tolerancing. 'Very often,' Mr Garratt says, 'the designer just does not know how much cost he is building into the article which he is designing. A typical case is the question of tolerances. Most designers assess a tolerance and then make it slightly tighter *to make sure of it.* They even specify fairly tight limits for components that mate with air! Economically, tight tolerances can be the difference between profit and loss, but the designer just does not know what the figure of ± 0.001 costs.' He goes on to say that the following figure '*should hang over every designer's drawing board.*'



Reprint No. 1:1:8

Value Assurance — Basic concepts — Quality — Standardisation

Economic Production and its Disciplines

by Anthony Tocco, M.E.*

The task of assuring the integrity of today's products is challenging the minds of Product Assurance specialists throughout the world. The increasing complexity of commercial and non-commercial products and systems has acted as a forcing function towards the development of new approaches to the management of resources. A number of new disciplines have been created to provide management with the tools required to meet the challenge of domestic and international competition. This article deals with four methodologies and their inter-relationship. These are Quality, Reliability, Standardisation and Value Engineering.

Introduction

As a matter of survival in an environment of fierce competition, the modern businessman is continually challenged to produce better products at lower costs. The escalating standard of living of workers the world over, coupled with the demand for higher and higher compensation, has had a salutary effect on the economic health of many countries. However, for the individual businessman it has served to intensify the challenge of **economic production,** with profit to the producer. Further, the complexity of commercial and military products and systems has made it imperative that he search for new ways to 'manage' his material, monetary, and human resources so that the delivered item will meet high performance requirements reliably – and competitively.

Quite naturally, to fill this lacuna a number of specific disciplines have emerged whose characteristics deal with the attainment of quality, reliability, and economy. They exist under a variety of names. Collectively they may fall under such designations as: Product Assurance, Product Integrity, or Systems Effectiveness. Specific disciplines which are variously grouped under these major designations as a rule include: Reliability, Quality, Value Engineering, Standardisation, Maintainability, Human Factors, and Safety Engineering. Four major disciplines are discussed in this paper – Quality, Reliability, Standardisation, and Value Engineering.

Quality Control

The importance of quality control of manufactured products has increased steadily with the growth of modern technology. The rapid industrialisation of agricultural nations and a growing awareness on the part of the consumer of quality considerations in the products he buys, show that product quality has always played a major part in the outcome of industrial competition as well as in consumer attitudes. In today's fierce competitive environment a deserved reputation for quality and the economic advantage of such a reputation can only be attained by the calculated application of a formalised programme to achieve optimum product quality. To begin with, a truly dependable and comprehensive programme of quality control or quality assurance demands much more than an examination of the finished product. Final inspection *per se* is of little significance for a large number of modern products. For example, many of the components of an electric motor cannot be seen, much less measured or gauged, without complete disassembly. Whether the motor will run at all will be determined by applying electrical current to it. Its durability can be tested only by operating it under load and ascertaining and determining how long it takes to burn out under required environmental conditions.

In order to be effective, quality assurance requires the establishment of production standards which encompass the product's specification and design, raw materials, manufacturing processes, as well as packaging, labelling, etc. These standards must be augmented by procedures for objectively verifying that the producer has conformed to established requirements. Finally, a quality programme must follow the product into the customer's hands and assess its quality in actual use for operations.

Due to the complexity of many modern products, more and more manufacturers have become consumers in a sense of products of other manufacturers or specialty suppliers. Consequently, there is a critical increase in the need for applying high standards of quality control to many industries simultaneously in order to have assurance that the final assembly will perform reliably.

It is easy to understand the interdependency of quality and reliability programmes when one considers the overall reliability of an assembly of independent components is the product of the reliabilities. Unless each component is nearly perfect there can be little confidence that the assembled product will be even moderately reliable. Assurance of overall reliability, therefore, is predicted on the establishment of a centralised quality control programme which extends into every factory which contributes

Mr Anthony R. Tocco is Director of Value Assurance at TRW Systems, Redondo Beach, California, U.S.A. He is a Past National President of the Society of American Value Engineers and has contributed a great deal to the literature on Value Engineering.

a component part to the final product. Effective quality control can play a major role in reducing waste of material, human, and capital resources. It can minimise the production of defective items which result in unnecessary cost and effort which must be devoted to inspection of the finished product. On the other hand, excessive quality and reliability represents waste of another kind. Therefore, the goal of quality control must be to achieve the optimum quality for the function to be performed. Some parts require precision machining to very close tolerances, others do not. Some parts need to be highly polished, or plated to meet aesthetic requirements, while others do not, etc. A well-conceived and planned quality programme must achieve a proper balance between satisfactory quality and the cost of attaining it. In this instance, quality control finds a companion piece in the discipline of value engineering, which will be discussed later.

Organisation for Quality Assurance. Experience has shown that an effective quality programme must be the function of top level management, must be centralised and not subservient to the production or distribution functions. At this point it would be well to consider the principal elements of a comprehensive quality programme. Fundamentally, the quality function has the responsibility for development and implementation of quality methods and procedures to assure the attainment of prescribed levels of quality. This involves a number of specific tasks. To keep this paper within reasonable bounds, these tasks will be discussed only to the degree pertinent to the subject of the overall paper.

Specification. A standard or specification represents an insurance policy for the consumer or customer. It delineates those controls that must be maintained by a manufacturer as a condition for approval of his product. Collectively these controls represent the manufacturer's quality system. Defined, a quality system is a managed series of planned work operations, examinations, measurements, tests, and evaluations applied to design, manufacture, and marketing to assure that products delivered are of satisfactory quality in terms of processing, conformance to established requirements, and performance in service. John J. Riordan, Director of Quality and Reliability Assurance, DOD, stated in a recent article: 'the first line of defense against inferior products is a system of specifications by which producers and vendors are informed clearly and explicitly of their contractual obligations for product quality. The second line of defense is the establishment by the consumer of a capability to assure that producers perform to their contractual obligations. This capability must incorporate up-to-date techniques that permit flexibility in concentrating consumer quality assurance effort where it is most needed.'

Workmanship. Workmanship standards and other acceptance standards are based on engineering requirements, and represent a form of specification. These uniform standards establish the requirements for a quality level consistent with customer or the company's quality objectives.

Discrepancy Data. To promote reliability defect prevention and cost effectiveness, the quality function maintains a programme for general discrepancy data. These data guide operating management in determining the priority and urgency of corrective action. Computer processing is employed when dictated by the volume of data to be handled.

Measuring Equipment. Quality personnel must exercise the necessary controls over acceptance measuring equipment and procedures to assure adequate evaluation of product conformity to engineering specifications.

Failure Analysis. The role of quality in this instance involves the participation in reviews of failure analysis and the disposition and control of nonconforming materials.

Supplier Quality Rating. Quality establishes and maintains an effective supplier quality rating and the preferred source list of suppliers who have demonstrated effective quality control to assure procurement of materials, components, parts, assemblies, sub-assemblies, and sub-systems with the required levels.

Store Room Surveillance. This function involves maintaining laboratory store room surveillance and conducting periodic audits to assure that materials, parts, assemblies, etc., are being maintained and controlled in accordance with the established requirements.

Record Keeping. Appropriate records are maintained to provide objective evidence of quality and configuration status of contract items. Such records are available for customer review.

Design Change Control. In the area of design change control, sometimes called configuration management, the quality function supports the control system through verification of change status, identification of parts, and by final comparison of design descriptive records with the required change status, as established by engineering.

Training. The quality organisation must develop and conduct training programmes as required to develop necessary job skills and understanding.

Pricing Data. This activity involves maintaining pricing data for proposal pricing relating to new contracts involving quality tasks.

Monitoring Product Quality. Quality audits represent a management tool used to assess the effectiveness of operating systems which directly or indirectly affect quality. They also assess the degree of compliance of the performer to these standards of performance and procedures. In defence contracts the requirement is specifically expressed in contractual quality specifications such as MIL 9858A and related specifications.

The requirement can also be found in requirements for consumer products ranging from household appliances to automobiles as specified by the procuring agency or organisation. To assure objectivity, audits are generally performed by teams of quality assurance personnel who are independent of line responsibility of the functions being examined. Normally, the director or manager of quality assurance is responsible for creating the organisation to administer the programme.

Predicted on the findings, corrective action requests are then issued to responsible organisations as appropriate and followed up to assure that adequate measures have been taken. Reports are issued both for management information and to serve as a basis for scheduled quality reports to the customer. Some companies encourage the participation of supervisors of areas being audited (as observers) during the surveys.

The control of quality for material purchased from specialty suppliers or sub-contractors also requires periodic assessment. The frequency and comprehensiveness of audits of suppliers' manufacturing operations is based in part on the suppliers' acceptance or performance record with the buying activity. With respect to outside suppliers, this function is conducted as a collaborative effort between the quality and purchasing organisations.

Assessment. The assessment of quality is conducted unannounced to assure maximum effectiveness. Fundamentally, the assessment or audit team will determine if control procedures are adequate to satisfy company functional manual requirements, that they are understood and being followed by the operating personnel, and that the necessary documents are available on the job. Follow-up visits to deficient areas are then scheduled to verify that corrective action has been taken.

Quality Costs. An important element of the total product assurance job is that of assessing the costs of quality or costs related to quality. In this connection many companies maintain and use quality cost data as a management element of their quality programme. These data serve the purpose of identifying the cost of both prevention and correction of items representing nonconformance; for example, the labour and material involved in spoilage caused by defective work, correction of defects for quality control time or effort. Professor W. G. Ireson of Stanford University, a leading researcher and authority on the subject, has this to say about the cost of quality. 'Basically, the cost of quality can be divided into two parts – (1) those costs which we deliberately incur in our attempt to produce the desired quality level, and (2) those costs which we incur as a result of not having produced perfect or desired quality. It is reasonable then to expect that as we increase the first class of cost (and approach perfect quality) the second class of cost will decrease. Or conversely, reduction of effort to create quality will result in increased failure and defect cost.'

As the industrial community becomes more competitive, this aspect of quality control and quality assurance becomes increasingly important in overall planning and management. A review of Professor Ireson's studies on the subject for those who have a specific interest is highly recommended.

How the discipline of Value Engineering and Value Assurance relate to the business of control of quality cost will be discussed. Of specific concern to the value engineer would be the assessment of cost–benefit ratio resulting from the various elements of a quality programme. An important document, **Quality Cost Analysis Implementation Handbook,** is currently available from the United States Government Printing Office.

Quality Programmes and the Computer. Regardless of what facet of technology one is concerned with, it all involves listings of one type or another which need to be generated and analysed. In many industries this mass of data is of such proportions that it no longer can be manually processed. At this point computer processing becomes an absolute necessity in view of time and cost considerations.

The Processing of Data. Large amounts of stored data are essential to a quality programme and the retrievability of that data is equally important if the proof of quality is to be established. The adaptation of modern-day, high-speed, computers to the needs of quality has made it possible for the quality control manager to truly 'manage' the quality process. His decisions can be based upon a review of historical data, presented in a synthesised and integrated form, and retrieved in minimum time, as opposed to past practice of basing many of these critical judgements on intuition or subjective analysis. As an example, from the time that materials, parts, and equipment are received at the receiving point they are subjected to inspection, testing, analysis, and evaluation. Inspection data, acceptance tests, and life testing are among the items which contribute to an endless flow of data. All of this data then requires processing for storage and retrieval. This is where the computer is useful for real time computer processing, particularly in the area of quality control. If the time required to report information is considerably greater than the time it takes for information to change, then the stored data may be totally inadequate for operational use. In other words, if files are to be useful from an operational point of view, the information must be reported at a rate commensurate with that at which the information changes. Getting back to the economic aspects, if the information is reported at a more frequent rate than that at which it changes, the costs are inordinate and represent a negative factor.

Reliability Assurance and Reliability Engineering

Next to be reviewed is the reliability function and its role in the total process of designing and producing products which will meet performance specifications at minimum overall costs. The role of quality is to insure that the inherent designed reliability is not degraded during fabrication, assembly, and test and that specified reliability requirements are met. The prime role of Reliability Assurance is to insure that the required reliability levels are inherent in the basic design. The accomplishment of this objective involves the application of reliability disciplines during the systems engineering and product design phases of the product. In many organisations the term Reliability Assurance identifies the activity or personnel who essentially design the reliability system or develop the techniques and methods of the discipline. On the other hand, when we speak of reliability engineering we are describing the activity or personnel actually involved in the application of the methods and techniques as the product goes through the various stages of specification, design, manufacturing, and test. **The reliability of a system is defined as the probability that it will successfully complete its intended mission under given environmental conditions for a specified period of time.** Methods and techniques concerned with reliability include:

Numerical Reliability – mean-time-between-failure techniques (MTBF). Reliability Apportionment – the equitable assignment of a reliability value to each functional element of a total system based on the required performance of that system.

With respect to specific parts, unnecessary specification of high reliability can have an adverse impact on both cost and schedule. Therefore, the reliability engineer must lean toward standard parts wherever possible, which have inherent high reliability. Standardisation in product design is extremely important and should always be kept in view. The mathematical tools for estimating numerical reliability, such as Weilbull and Poisson distributions, as well as exponential and binomial characteristics of distributions are described in various documents listed in the Bibliography.

Design Reviews. Another important element of the reliability system is the design review. Essentially, the design review is a technique for assessing the integrity of the design at strategic points during the design cycle, or as the design goes through its various stages. On complex systems, three or four formal design reviews are scheduled to assure conformance to the various design parameters. These parameters or design objectives include not only performance criteria, but also considerations regarding reliability, producibility, maintainability, and economic factors, among others. Preparation for the design review is in itself a form of discipline for the responsible engineer in that it imposes on him the requirement for checking on each aspect of the design, and in essence, developing a design inventory for review by a design review board or committee. To assist him in this process, a design checklist is commonly used. A representative sample is provided with this paper.

Interrelationship of Reliability and Quality. It is generally recognised that reliability characteristics which are specified are achievable only if they are reflected in the design of the product. Quality, on the other hand, depends principally on the production processes. It is commonly stated that quality cannot be inspected into a product, it must be built into it. This being the case, the best protection the consumer can have against unreliability (assuming sound design) is assurance from the producer that certain controls are exerted during manufacturing. Accordingly, a formal reliability assurance programme in the case of DOD contracts includes an economical and effective system of production control and assessment in accordance with MIL-Q-9858 A* to assure that reliability achieved in design is maintained during production. The specification establishes the basic quality control activities within which detailed consideration is given to a number of activities ranging from the testing of raw materials to machine controls and including packaging and labelling controls. Assurance that the manufacturing environment is favourable to quality include drawing control, adequate records, materials control and organisation.

Reliability of Commercial Products. Although much of the published material on the subject of reliability deals with the aerospace industry, the demand for high reliability exists in many consumer products. The automotive industry, for example, is placing more and more emphasis on the reliability of its products. This stems in part from public concern over equipment failures which often result in serious accidents and the loss of human lives. It might be well to review at this point a typical reliability programme in that industry where high reliability criteria have resulted in many changes in design, testing, and specification. These are some of the basic elements normally found in reliability programmes in the automotive industry:

***Note:** On the international level consultation on NATO quality matters is effected through the 'NATO Group of Experts on Inspection and Quality Control.' This Group has prepared a NATO specification similar to MIL-Q-9858 A – 'Quality Programme Requirements,'.

1. Definition of specific reliability requirements for each vehicle system (automobile) and its sub-systems.

2. Design effort leading to the required reliability levels for parts, sub-assemblies, and finally for the total system.

3. Sufficient testing to verify the integrity of the design and manufacturing processes.

4. Specification of part requirements in precise and understandable terms for both in-house manufacturing activities and for outside suppliers.

5. Collection and analysis of user complaints for quick reaction to problems and to serve as a guide for future designs and processes.

In both the aerospace and automotive industry, it is recognised that the prime responsibility for reliability rests with the design engineer, and that he must have at least a working knowledge of reliability concepts if he is to consider them throughout the design, development, and testing process. In the automotive industry the product design engineers receive expert assistance as required from reliability engineers who are generally located in the product engineering area. Product Engineering (also called Producibility) is the organisation responsible for translating preliminary design into production design. In turn, the reliability engineers look to the Reliability Assurance staff organisation for policy support. This staff group, analogous to the Quality Assurance groups we described earlier, is responsible for development of uniform procedures for implementation throughout the company. Although the automotive industry does not normally operate under the constraints of Government specifications such as those which apply to the aerospace industry, it is interesting to note that many of the methods and techniques employed are nevertheless similar.

The reliability programme normally begins with the establishment of reliability specifications in customer terms. These specifications are developed in concert with various engineering and production and marketing functions. The specifications, therefore, reflect marketing considerations as well as past performance, cost, and technological considerations. Reliability requirements are expressed in terms of the maximum allowable repair rates at specified miles of customer operation for each sub-system of the automobile. To provide guidance for design engineers, the sub-system reliability requirement is apportioned among the parts which make up that sub-system.

Laboratory testing is another important element of the reliability programme. The objective of laboratory testing is to verify that reliability requirements have actually been satisfied, and where necessary, to identify what modifications will be required to meet the specifications. Although most of this testing is done in the laboratory, a considerable amount is actually accomplished on the proving ground or in the field. Laboratory testing has the advantage of being more economical, in that parts wear can be accelerated beyond normal rates. However, proving ground tests are necessary to verify system reliability under actual operating conditions.

One of the most important aspects of an automotive reliability programme is the development of life testing plans to monitor the reliability of production parts. The challenge is to define specific reliability requirements in terms which will be clearly understood by manufacturing and quality control personnel using them. The Ford Motor Company, for example, has over 2,500 major domestic supplier companies which furnish close to 100,000 different types of automotive production parts at an annual cost of over two billion dollars. Since it would be unrealistic to expect that this large family of subcontractors and specialty suppliers would all be equipped with reliability engineers knowledgeable in the wide distribution and the general subject of mathematical modelling, reliability requirements must be expressed in simple terms.

Reliability Proof Positive. The ultimate proof of automotive reliability effort is determined by how well the production model cars perform in the hands of the customer. In this connection it is essential to obtain accurate information relating to the user's experience with the cars in order that problems which have arisen may be corrected. Attesting to the fact that no reliability programme is foolproof is the fact that on occasion an automotive manufacturer may have to recall an entire production series for correction of a defect which was not discovered prior to delivery to the public. Normally, production vehicle reliability data comes from two principal sources – engineering test and customer reports (designated in the industry as 'feedback').

In the case of Ford Motor Company, this engineering test data is obtained by sending a group of the first production cars to the proving grounds to be operated seven days a week, 24 hours a day until the required test mileage is accumulated. These vehicles are tested an average of 25,000 miles each, ranging from a minimum of 5,000 miles to a maximum of 75,000 miles. This represents customer operation of several times these mileages, because of the accelerated durability test procedures mentioned earlier.

Another important production car test is the cost durability programme. As cars are introduced to the public each year, competitive manufacturer's cars are purchased from dealers and shipped to the proving grounds along with Ford vehicles, and are put through the durability route for 50,000 miles each. Precise records are kept on operating costs, such as fuel, oil, tyres, and brakes.

The unscheduled maintenance cost and repairs test programme provides an early comparison of Ford products with those of their competition. Results are carefully analysed and company management is kept fully informed.

After vehicles are in the field, reliability data comes back from customers by several different routes, such as the owner's manual questionnaire, customer letters, and market research studies. An additional source of information is the warranty cost and repair history. This is a tabulation of warranty repair rates and costs, based upon claims submitted by automotive dealers and prepared in the controller's office. This source of field problem information represents essentially a complete sampling of product performance. Since this paper deals with the relationship of computers to various management and engineering disciplines, it should be mentioned that most major automobile manufacturers in the United States have installed computerised systems for recording and classifying warranty data, thereby greatly simplifying its analysis for engineering uses. The information which is stored includes body style, assembly plant, mileage, time in service, defect code, part number, vehicle serial number, vendor code and engine type.

The warranty data analysis programme provides answers to many important questions such as:

1. Do the springs on the convertible have a higher failure rate than on the sedan model?

2. Did the failure rate on a particular part change significantly for different months of production?

3. Does the failure rate on wheel bearings vary significantly between cars equipped with automatic transmission and those equipped with standard transmission?

The mileage analysis warranty is defined as a 'written guarantee of the integrity of a product and of the maker's responsibility for the repair of defective parts.' The warranty data is programmed on a computer and analysis made of each component part in the car. The computer programme also groups components into their appropriate sub-systems and computes the total sub-system failure rates. Warranty expense is also included in this analysis and is often used in assessing any corrective action. Implementation of such a data storage, retrieval and analysis system would be virtually impossible today without the aid of a computer programme.

Trends in Reliability and Quality. Increased emphasis on the supplier's responsibility for quality and reliability is bringing about a technical up-grading of the methods and techniques of both disciplines. Standardisation will play an increasingly important role in areas of design practices, manufacturing, and processing procedures. Although the establishment of standards is not normally a reliability or quality responsibility, these organisations will be held responsible for reviewing these standards for adequacy in meeting contract requirements. Additionally, they will be responsible for monitoring and insuring that the standardisation criteria are being complied with.

Computerised Reliability Data Processing. A good example of the data management problem and how it is being handled can be found in TRW in connection with its Space Systems Programmes. The problem was one of developing a central data file for experience retention and retrieval of failure analysis information and corrective actions taken. Information of this kind is a necessity if each succeeding generation of equipments or systems is to reflect the 'lessons learned' on earlier systems or models. Such an historical file or data bank provides valuable information for engineering and manufacturing, as well as for quality assurance, reliability assurance, and value assurance. To meet this need a computerised data file system has been developed which provides us with a uniform and regulated system of information transmission analysis and corrective action dealing with equipment failure. This data file records the efficiencies in design, manufacturing, and testing as they are recorded via the failure reporting system. The system is coded to provide uniform failure information on operating equipment to aid in the determination of failure rates, as well as providing the capability of monitor failure analysis and corrective action for product improvement.

Standards

Consumers the world over are becoming increasingly concerned about the need for better standards which identify quality levels. The consumer needs standards to help him select the level of performance and quality which will meet his requirements. Grading and labelling standards which make this possible can make a significant contribution to a country's foreign trade. The lack of uniform standards of performance, quality, and safety not only affects the sale of complex products such as automobiles and aircraft, but also applies to the thousands of consumer products which are purchased by housewives in the corner drug store, grocery store, and local department store.

The emphasis on standardisation in the United States has brought about its emergence as a natural companion piece to the disciplines of quality, reliability, and value engineering. In this relationship the standards engineer not only maintains and encourages the use of approved standards, but also has the responsibility for discarding out-moded or obsolete standards and introducing new standards which will meet the requirement for higher reliability and quality levels as well as improved value.

Types of Standards. There are two broad classes of industrial standards – technical and managerial. Technical standards define the product and its components in terms of size, shape, colour, composition, quality, and performance characteristics. They also apply to manufacturing processes, materials, and product specifications, including nomenclature. Managerial standards are concerned with organisation practices, worker performance, accounting systems, and other activities not directly concerned with production or processes of manufacture. For the purpose of this paper, technical standards are more directly concerned with the subject under discussion.

Standards are not only important to the consumer, but also to the producer of the product and the businessman who must sell it. The advantages of standardisation practices include:

1. Creating customer confidence as to acceptable quality, performance and safety.
2. Economic production resulting in lower cost to the consumer and higher profits to the producer.
3. Improving and facilitating service through repair, replacement, and interchangeability of parts.
4. Facilitating procurement through adequate specifications and reference to established standards.
5. Acceptance of a standard item can result in a wider field of application for the product or process.

A recent report by the Purchasing Agents Association of Northern California makes this statement: 'Every company, no matter how small, can use to advantage an organized standardisation program. Many current business problems, business pressures, disputes and misunderstandings between buyer and seller, the severity of emergencies in stores and purchasing departments can be traced to the lack of an effective program of material and standardisation.'

Standardisation/Specification Interrelationship. The need for specifications has existed ever since man first began to transform the natural resources around him into manufactured products. The inventive processes which created the first wheel had to be transformed into some kind of a specification or standard in order to assure that the second wheel met the performance criteria envisioned by its creator. In the case of many arts and crafts of past generations these specifications or standards were passed on from father to son and were seldom if ever reduced to the written word. Modern man found this informal arrangement totally unacceptable and therefore has been forced to create formalised systems of specification and standardisation upon which criteria for product acceptability can be established. Specification is the critical element in product standardisation; without it the producer in today's economy cannot survive – the enlightened consumer had made it a condition of purchase.

The relationship of specifications to quality, reliability, and value can be readily seen when one considers that specifications clearly define a requirement and a method of measurement to determine the degree of compliance. By specifying these requirements and providing criteria for design, production, and performance the specification system provides contractual control over acceptance and rejection. Further, it provides the consumer with the control necessary to determine procurement responsibility. In the case of aerospace products, specifications also provide the customer or using agency with a complete and well-defined system of documents which specify the exact configuration of the system (or hardware) and the established performance for that system. For the designer, specifications provide descriptions of company requirements for manufacturing, testing, material, and parts which offer him a realistic basis for prediction of results as well as reproduction of results. Prediction of results in the end product is possible only with adequate knowledge of materials, components, processes, and company facilities. To be widely available and useful this knowledge or information must be presented in the form of well-organised specifications and standards.

Finally, specifications normally provide the basis for contract negotiation. The specification defines what the seller has agreed to supply to the buyer, and as a legal document is given authority in the resulting contract. If a product is complex and consists of many parts, materials, and processes, there may exist an equal number of specifications that are used for purposes of design, manufacture, and procurement. However, the product itself may be purchased with only one top specification. Changes required to specifications during the performance of the contract are normally introducted via a formal change control system. In the aerospace industry this activity is known as Configuration Management.

Systems Specifications. Complex systems such as those found in the aerospace industry – aeroplanes, spacecraft, and communication systems – dictate the requirement for an overall system specification which will establish the functional and performance requirements to be attained. Additionally, the system specification provides criteria for the design, development, test, and production of the complete system. The system specification defines the system parameters upon which subsequent analyses are based. The evaluation of subsystems, test philosophy, reliability, human factors, cost effectiveness, etc., are developed from the requirements specified in the system specification. Subordinate to the system specification are subsystem, equipment, interface, environmental, test, material, parts and processes specifications. Also included are detail specifications covering finish and packaging requirements. For example, the finish specification normally establishes the minimum requirements for the finishing, marking, colour, and corrosion control of the product. It may describe cleaning method, surface treatments, pre-treatment, and coatings. The packaging specification may establish the method and detail requirements for packaging, handling, preservation, storage or shipment of the product.

Value Engineering

Genesis and Development. Value engineering, sometimes referred to as value analysis, emerged during the last two decades as an effective cost reduction discipline in Government and industry. Its growth pattern has been predicated on a number of completing factors. Government procurement during World War II and the years following was conducted in a contracting environment which placed great emphasis on superior product performance and rapid delivery – with minimum control over cost performance or cost consequences. The contractor was generally paid a fixed fee over and above the costs he incurred in meeting the requirements of his contract. Under this arrangement it might be stated that profits were predicated more on waste of manpower and materials than on frugality or cost effectiveness. Ultimately, the cost spiral reached such proportions that officials in the DOD were forced to address themselves to the task of arresting this trend and to explore the possibility of a totally new contractual concept which would provide economic incentives for superior cost performance and reduction. Value engineering, by this time a proven methodology within commercial industry, was adopted and incorporated as an integral part of the new contractual arrangements. For the commercial producer following the war years the techniques of value engineering offered an effective answer to the cost/price squeeze, and later, as an economic discipline helped them complete successfully in both local and international market places.

The genesis of value engineering can be traced back to the year 1947 when the General Electric Company launched an intensive effort to reduce the cost of consumer products. Household appliances in their product line were subjected to functional analysis for the purpose of establishing their **essential functions** and proceeding to the attainment of these functions at the lowest overall cost. The dramatic results of this initial pioneering effort are now a matter of history. Today value engineering programmes in one form or another exist in the majority of companies within the defence industry and in all branches of the DOD. In the consumer products industry, Value Engineering has fulminated from its point of origin and now is applied in the manufacture of almost every product available to the public. The DOD has established a value engineering savings objective of $500m annually. Accomplishments to date give promise that this goal will be substantially surpassed. Within industry, management has come to expect a return on investment of at least ten dollars for every dollar spent in value engineering activity. In order to understand how such ambitious objectives can be obtained, it is necessary to examine the methodology in some detail.

Definition. In simplest terms, value engineering involves the systematic application of techniques which serve to identify the required function; and to provide the function at the lowest overall cost. This approach differs from pre-existing cost reduction activities in that it is **function** oriented and involves the analysis of the function of a product as differentiated from the search for lower cost methods and processes to produce the same item or product. The accomplishment of value engineering involves the utilisation of many proven cost reduction techniques. However, the organisation of these techniques in a manner which permits systematic application represents to a degree the 'newness' of the methodology. Neither value engineering nor any of the other disciplines discussed in this paper are ends in themselves. All are directed towards some broader objective, such as the design, development, and operation of products or services within the limits of pre-established economic constraints. In one way or another they are all interdependent. Failure to recognise this relationship can lead to the isolation of essentially similar functions and thus inhibit the expeditious and economic realisation of the ultimate objective.

Methodology

The systematic arrangement of known techniques plus a number of new techniques constitute what is called Value Engineering Job Plan. The six basic elements of the Plan are:

1. Item selection
2. Information phase and determination of function
3. Development of alternatives
4. Cost analysis of alternatives
5. Testing and verification
6. Proposal submittal and follow-up.

The following is a brief description of each element and how it is employed in the performance of a value engineering study.

Item Selection. In selecting an item for value engineering study, certain criteria are applied. The first concerns production quantity. The more units involved the greater the yield in terms of savings due to value engineering changes. Second, the earlier the change is effected in the production cycle, the lower the implementation costs. (Implementation costs include not only production line modifications, tooling, and procedures, but costs as they affect spare parts, manuals, field maintenance, etc.)

Some organisations have developed standards of value which indicate areas where low value exists. In such cases, a previously established (standard) cost for a given function is compared with the actual cost of that particular function, in a product currently in design or manufacture.

For example, value standards have been developed for such functions as generating electric current, interrupting current flow, power transmission, etc. Accordingly, items whose costs are not in accordance with established standards are natural candidates for value engineering study.

Priority or selection then is based largely upon consideration of the following:

1. Production quantity (current and future)
2. Present status with respect to design and/or production
3. Present item value.

Information Phase and Determination of Function. In this element or phase, the objectives are to collect all pertinent information available about the project, or item under study (for example, specifications, design criteria, costs, quantity, manufacturing methods, and other relevant facts) and to determine the item's **required** function.

To accomplish these objectives a number of basic questions must be answered:

1. What is the item?
2. What is the function?
3. Is it required?
4. What is its present cost?
5. What else will perform the function?
6. What will **it** cost?

The design is reviewed with the cognizant design engineer from the standpoint of determining the item's engineering 'history' – what approaches were taken, what failed, and what succeeded. Manufacturing and purchasing personnel are consulted on the same basis. Finally a complete assessment of the information obtained leads to the determination of required or essential function(s).

In this phase of the study, a number of 'Tests for Value' are applied. The following examples are typical:

1. Does its use contribute value?
2. Is its cost proportional to its usefulness?
3. Does it need all 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?

Development of Alternatives. The development of alternatives represents the speculative or creative phase of the Job Plan. Having defined the required function, the next step is to examine the methods used to provide this function and to explore alternate approaches. Creative problem-solving techniques are employed extensively in the determination of alternatives. Thus, in logical sequence, speculation follows the accumulation of all relevant information and the analysis of function. Again the emphasis is on **function,** a ground rule which allows complete freedom of thought – as opposed to conventional cost reduction efforts which are basically directed towards producing essentially the the same item at lower cost.

Cost Analysis of Alternatives. Having developed a number of promising alternative approaches to the attainment of essential function, the value engineer then begins to make cost comparisons, The lowest cost method is tentatively selected subject to verification that it will provide required function and lead to net reduction in overall cost without degradation of other essential design parameters (for example, reliability, safety, maintainability).

Testing and Verification. The economically promising alternative approaches are next subjected to intensive technical evaluation to assure feasibility. In some cases, technical adequacy is easily demonstrated; in others, proof of feasibility demands considerable effort, often involving hardware testing and verification of results.

Proposal Submittal and Follow-Up. Finally, a value engineering proposal is generated which presents all data necessary for final evaluation by the cognizant engineering authority. A typical proposal would include design sketches, material or labour cost estimates, tooling requirements, and all other cost consequences associated with the change. The object, of course, is to answer in this document all questions which might be raised by the individual who ultimately must accept or reject the proposal. The fact that executive decisions are often made on the basis of minimum personal risk represents one of the major roadblocks to cost reduction changes.

Since the original value techniques were developed primarily for application to high production consumer products such as refrigerators and cooking appliances, the technology was not ideally suited to the aerospace environment wherein system acquisition is characterised by low production quantities, rapid state-of-the-art changes, high complexity and high reliability. To meet the needs of this more 'sophisticated' environment, value engineering has undergone a metamorphosis by which established techniques have combined with new developments which focus on early stages of specification, design, and production process.

Specification Analysis. In specification analysis, value engineering techniques are applied to identify and eliminate areas of 'over-specification.' The mechanism used to accomplish this objective is a value-oriented specification review, wherein the value engineering principles are applied. Checklists are employed which emphasise the cost consequences of each specification requirement.

Design Review. Periodic design reviews offer the value engineer an opportunity to influence the design before it is turned over to production. As in the case of specification reviews, the application of value engineering techniques assures an optimum trade-off between all design parameters in the interest of reducing overall cost.

Value Engineering Task Forces. Recognising that cost avoidance techniques are seldom completely effective, a 'second look' can often produce significant savings. For this purpose, value engineering task forces are organised to implement the Value Engineering Job Plan on specific low value items. Each element of cost is challenged from a function/worth viewpoint, and alternative approaches are developed in each case where value is considered low. Following the Job Plan a proposal is generated which presents a value engineered design for engineering evaluation. Participants in the task force normally include members from engineering, manfacturing, and purchasing, and a value engineering specialist.

Target Cost. For value engineering programme purposes, a cost target is defined as an attainable economic goal for the variable portion of the production cost of a specific end item at specified points in the acquisition programme. In most companies, cost targets are generated by a collaborative effort on the part of engineering, cost estimating, and value engineering. Cost targets are based upon cost models which express cumulatively a significant portion of the total cost of a system or subsystem. Cost models can, of course, be expressed in either algebraic of graphic terms. Cost targets are generated by assigning dollar values to each element of a cost model.

It is noteworthy that a value programme has as an objective the stimulation of **cost consciousness** in all individuals who contribute to product cost. A cost target programme provides a goal for the designer and a continuous assessment of cost performance against that goal.

Organisation

Organisation for value engineering generally involves both line and staff functions. The staff role is primarily one of planning, co-ordination, assuring compliance with company policy, customer interface, etc. The line activity is mainly concerned with the actual 'doing' of value engineering. As a staff function, value engineering is often an element of Product Assurance (which may include Reliability, Quality Control, Specifications, and Standards). As a line function the value engineering focal point is normally located within the engineering and manufacturing organisations.

Purchasing Aspects

Value specialists in purchasing have an important role in a company's overall value engineering effort. Here, the value analyst has the prime responsibility for value in procured material and services. Specifically, he serves as a consultant to buyers and as a prime mover in motivating outside suppliers to apply value engineering techniques to equipment or services under contract.

The Value Engineer

Basically, there are two types of personnel involved in a value engineering programme: personnel having prime responsibility for the design of a product, and personnel providing the focal point for cost reduction and cost avoidance as a full-time endeavour. One of the essential elements of a good value engineering programme is the establishment of a comparatively small group of individuals whose **prime** responsibility involves value engineering actions which assure management that cost considerations are systematically factored in the decision-making process. This is the role of the professional value engineer. In order to quality for this role in the engineering organisation, the individual should possess certain qualifications. For example. formal education in a field of engineering is a requisite as well as a background of experience in manufacturing and cost analysis. In addition, a formal value engineering course (involving 40 to 80 classroom hours) plus a certain amount of on-the-job training is necessary to complete the background of education and experience essential to practice value engineering as a professional endeavour.

Within other organisations, such as manufacturing and material, the qualifications are in accordance with general qualifications for employment in those areas. In the area of procurement, for example, it is more important that the individual be well founded in the principles of good purchasing practices than it is for him to possess an engineering degree. Nevertheless, to perform as a **value specialist** in the areas of manufacturing and material, the individual should receive formal training in value engineering and on-the-job training.

Professional Activity

The Society of American Value Engineers was organised in

1959. The Society provides value engineers with a focal point for professional activity, paralleling that of most technical societies. Fundamentally, the Society is dedicated to the advancement of the theory and practice of value engineering and the promotion of ethical professional standards. The Society carries out its objectives through the media of conferences, seminars, newsletters, and various technical committees established at both the chapter and national level. Membership is not limited to American citizens however, and its roster includes members from many countries.

Conclusion

The dynamics of commerce in the 20th Century have created the need for revolutionary concepts in the design, manufacture, and merchandising of consumer products. Some of these concepts have evolved in the form of disciplines or methodologies which serve as management tools which can help produce better products at lower cost and higher profit. This paper has addressed itself to an overview of some of these disciplines and has attempted to demonstrate their effectiveness when judiciously applied. However, a paper or lecture can only serve to illuminate the essence of the subject, it cannot shed light on all facets, or provide a universal formula for all problems. In practice each discipline must be tailored to meet the needs of its intended application; specific applications dictate specific formulations. It is fair to state that they must all be present in proper proportion if economic production is to be attained. They represent to industrial management what new pharmaceuticals represent to the field of medicine. To ignore their existence is to limit progress – wisely used, they can make the difference between success and failure of a business enterprise.

Bibliography

Quality Control

DOD Directive 4155. 11, *Improved Management for Quality and Reliability Assurance of Materiel*, 17th June, 1965.

DOD Handbook H 50, *Evaluation of a Contractor's Quality Program*, 23rd April, 1965.

DOD Handbook 4155. 12-H, *A Guide to Zero Defects*, Office of Assistant Secretary of Defense (Installations and Logistics), Washington, D.C., 1st November, 1965.

DOD Instruction 4155. 6, *Department of Defense Quality Assurance Concept and Policy*, 15th June, 1964.

MIL-Q-9858A, *Quality Program Requirements*, Headquarters, U.S. Air Force, 16th December, 1963.

Riordan, John J., *Protecting the Consumer Against Inferior Quality* (DOD Quality Assurance Policy), Office of the Assistant Secretary of Defense (Installations and Logistics), Washington, D.C. 20301.

Reliability Assurance and Reliability Engineering

Aroian, L. A., *Exact Truncated Sequential Tests for the Exponential Distribution*, Ninth National Symposium on Reliability and Quality Control, Institute of Electrical and Electronic Engineers, 1963.

Feller, W., *Probability Theory and Its Application*, Wiley and Sons, New York, New York.

Sandler, Gerald H., *System Reliability Engineering*, Prentice-Hall, Englewood Cliff, New Jersey, 1963.

MIL Handbook 217, *Reliability Stress and Failure Rate Data*, Department of Defense, Washington, D.C.

MIL-R-275442A, *Reliability Program for Systems, Subsystems, and Equipment*, U.S. Air Force.

MIL-STD-785, *Reliability Program Plan*, Department of Defense, Washinton, D.C.

NASA NPC 250-1, *Reliability Program Provisions for Space Systems Contractors*, U.S. Government Printing Office, Washington, D.C. 20402.

Reliability, General Specification, WS-3250, Bureau of Naval Weapons, 24th October, 1962.

Standards

DOD Directive 4120. 3, *Defense Standardization Program*, 23rd April, 1965.

Standardization and Purchasing prepared by the Purchasing Agent's Association of Northern California, Inc., 21st May, 1966.

Value Engineering

Cost Reduction Digest, Industry Reports, Inc., Washington, D.C.

DOD Handbook H-111, *Value Engineering*, U.S. Government Printing Office, Washington, D.C., 29th March, 1963.

MIL-V-38352, *Value Engineering Program Requirements*, U.S. Air Force, 13th May, 1964.

Thompson, William M., *Producibility Workshops – A Unique Approach to Value Training*, prepared for the Seventh Annual Meeting of the Society of American Value Engineers, April 1967.

Tocco, Anthony R., *Value Engineering*, prepared for Encyclopedia of Management, Reinhold Publishing Corporation, 1963.

Tocco, Anthony R., *Value Engineering and Systems Effectiveness*, prepared for 19th Annual Convention of American Society for Quality Control, May 1965.

Systems Effectiveness Workshop (*Redondo Conference*) *Report*, TRW Systems, March 1965.

Value Engineering Organization and Operation Report, published by the Electronic Industries Association, Engineering Department, 11 West 42nd Street, New York 36, New York, June 1965.

The Constraint of Habit

Mr. J. S. Weber in his article in *Value Engineering Volume 2* tells a story about the new bride who was cooking a ham dinner for some of her friends. To play safe she obtained her mother's recipe. The ham was cooked accordingly and the guests who came commented on the delicious meal. The next day the bride telephoned her mother, thanked her for the recipe and said, 'I would like to ask you a question. In the recipe it said to cut off the end of the ham and throw it away. Why?' The mother thought a little while and said, 'I will have to ask your grandmother, I don't know'.

The grandmother's answer was, she always cut the end off the ham and threw it away because she never had a pan large enough to cook the whole ham in it.

Here you have a habit repeated for two generations.

Reprint No. 1:1:9

Value Assurance Checklist for Product Design

A checklist is not a panacea for design problems, it can serve as an aid to engineering activity concerned with product design. It can identify factors to be considered before work begins, highlight specific tasks to be accomplished, and help to evaluate the design in terms of the user's needs.

This checklist accompanies Mr Anthony R. Tocco's article entitled 'Economic Production and Its Disciplines' which commences on page 29 of this issue.

The prime requirement of a design checklist is that it be aimed directly at the job at hand.

This checklist was developed around three major activities:

I. Specification Review and Predesign Analysis II. The Design Process III. Evaluation of the Cost Effectiveness of the Completed Design.

It helps to:

1. *Identify design parameters and system specification requirements.*
2. *Highlight items which must be considered to insure sufficient design input data.*
3. *Identify (but not contain) required data – including contractual specifications, interface documents, design criteria, etc.*
4. *Remind product design personnel of all factors to be considered during design. Contain sufficient detail to assist in establishing design approaches, making design decisions, delineating interface requirements, etc.*
5. *Verify the adequacy of design data (drawings, specifications, etc.) for such downstream activities as manufacturing, purchasing, quality assurance, etc. Provide guidelines to judge whether the design data will meet the needs of the users.*
6. *Assist the designer in completing and optimising hardware design.*
7. *Insure that an optimised design will meet requirements for adequate performance and producibility at the least cost.*

Specification Review

1. *Have the customer's requirements been subjected to a systematic review to determine whether they exceed actual needs?*
2. *Have Value Engineering Change Proposals been initiated for those requirements which appear to go beyond the systems' needs?*
3. *Do the specifications include excessive cost-producing requirements relative to high temperature, shock, vibration, or other environments?*
4. *Has the cost effect of over-design been called to the customer's attention?*
5. *Is redundancy essential, and have its cost consequences been considered?*

Design Criteria

1. *What is the required performance function?*
2. *What are the required tolerances on the performance function?*
3. *Are special materials and processes needed to meet functional requirements?*

4. *What is the operating life (fatigue, wear)?*

5. *What is the storage life?*

6. *Is there a rigidity or stiffness requirement?*

7. *What degree of reliability and confidence level are required?*

8. *What degree of interchangeability is required?*

9. *How much clearance is required?*

10. *How will the unit be handled or transported?*

11. *What is the allowable weight?*

12. *What are the centre of gravity location tolerances?*

13. *What are the alignment tolerances?*

14. *What are the balancing requirements?*

15. *Is a fail-safe feature required?*

16. *What are the applied loads?*
    - *(a) Static*
    - *(b) Vibration*
    - *(c) Acceleration*
    - *(d) Aerodynamic*
    - *(e) Acoustic*
    - *(f) Thermal*
    - *(g) Shock*

17. *Are the different kinds of loads additive?*

18. *What is the correct safety factor?*

19. *What are the environmental atmospheric conditions (temperature, pressure, humidity)?*

20. *What are physical conditions (corrosive atmosphere, micrometeorites, presence of oil, grease, dirt, dust)?*

21. *What are the radiation conditions (sunlight, electromagnetic, high energy particles)?*

22. *How is the part or assembly to be fabricated?*
    - *(a) Will tooling be necessary?*
    - *(b) Can fabrication, tooling or inspection be simplified?*
    - *(c) Can fabrication time be minimised?*

23. *Will the fabrication process permit reliable inspection?*

24. *How will the part be inspected for quality?*
    - *(a) Magnetic*
    - *(b) X-ray*
    - *(c) Ultrasonic*
    - *(d) Dye penetrant*
    - *(e) Destructive tests of identical and/or representative parts*

Post-Design Evaluation

1. *Was the design challenged by the value engineering technique of* evaluating the function?
    - *(a) What is the function? Is it required?*
    - *(b) How much does the present design cost?*
    - *(c) What else will perform the same function?*
    - *(d) How much will the alternative(s) cost?*

2. *Were dimensions of component parts which affect their assembly properly related to a common base point?*

3. *Were unnecessary additional drawings introduced?*

4. *Has weight been kept to a minimum?*

5. *Will the unit still function when maximum strains have occurred? (Strains include all dimensional changes due to temperature, stress, etc.)*

6. *Can the unit be properly tested?*

7. *Was the design of individual components challenged with respect to economy, and suitability of manufacture? For example, shall a part be machined, cast, forged, or welded? Were trade-off studies conducted before the drawing was released?*

8. *Were the designers of individual components aware of the quantities to be required on the development programme? Was this factor considered in design decisions?*

9. *Were recent state-of-the-art improvements or new components and processes reviewed for possible applications, to eliminate or minimise unnecessary or high-cost items?*

10. *Is there clearance for tools, wrenches, bucking bars, rivet guns, milling cutters and arbors?*

11. *Has the correct fastener type and size been used for material and thickness specified?*

12. *Is a reliable fabrication process used?*

13. *Does the design represent optimum mechanical simplicity, commensurate with functional requirements?*

14. *Can any part be eliminated or combined with another part to reduce the total number of parts and cost?*

15. *Has relative workability and machinability of materials been considered?*

16. *Can the design be modified to use common tooling for right and left hand or similar parts?*

17. *Are drawings for similar fabricated parts to other fabricated parts cross-referenced so available tooling can be used?*

18. *Are casting bosses of adequate size, considering the large tolerances in the casting dimensions?*

19. *Is impregnation of castings called out when it would aid processing?*

20. *Have all experienced engineering and manufacturing specialists been consulted for castings, forgings, weldments, heat treatment, and other specialties?*

21. *Are all specified manual welding operations absolutely necessary?*

22. *Are holes too close to edges or shoulders to cause difficulty in die fixture design or maintenance?*

23. *Do hole sizes correspond to standard drill sizes?*

24. *Have castings been designed to simplify coring to balance foundry savings against machining costs? Consideration should be given to making two simple castings instead of one complex casting.*

25. *Will repair costs be minimised by not threading large castings? (Rather, design threads for bolting into secondary parts.)*

26. *Has deep-hole drilling been minimised? Cost comparison of drilled hole depth, expressed as a ratio of length or diameter?*

Ratio $\frac{L}{D}$	***Approximate Relative Cost***
1	*100%*
2	*190%*
3	*300%*
4	*430%*
6	*730%*
8	*1160%*
10	*1700%*

27. *Are all machined surfaces necessary?*

28. *Can a less expensive finish be used to accomplish the same function?*

Cost Comparison of Various Surface Finishes

Types of Surface Finish	***Surface Roughness in Micro inches***	***Approximate Relative Cost***
Cast and Unmachined	*500*	*100%*
Rough Machining	*250*	*250%*
Ordinary Machining	*125*	*500%*
Fine Machining or Rough Ground	*63*	*1100%*
Ordinary Grinding	*32*	*1800%*
Fine Grinding or Honing	*16*	*3500%*
Honing or Lapping	*8*	*600%*

29. *Has all electrochemical finish been specified on a partial assembly where purging at joints will occur?*

30. *Have state-of-the-art adhesive bonding techniques been considered for applications requiring riveting, bolting, and their associated fabrication operations?*

31. *Are all parts designed for assembly at the earliest possible time considering assembly costs increase as system build-up progresses?*

32. *Have the various assembly processes required by design been evaluated as the optimum methods to meet design requirements at the lowest cost, consistent with the required performance and reliability levels?*

Parts Selection and Evaluation

33. *Were appropriate standards consulted for selection of standard electrical components?*

34. *Could a redesign omit a nonstandard part or replace it with a standard part?*

35. *What parts are nonstandard; have these been approved?*

36. *Have environmental tests been started on nonstandard parts?*

37. *Have potted circuits been subjected to environmental testing?*

38. *What are the parts having the highest failure rates?*

Standardisation

39. *Has the design been co-ordinated with similar designs, circuits, parts or components to get optimum benefit from standardisation and part experience?*

40. *Are the standard circuits, standard components, and standard hardware the lowest cost standards which will supply the minimum required characteristics?*

41. *Can the use of each nonstandard part or circuit be adequately justified?*

42. *Can any new nonstandard part be replaced by a nonstandard part which has already been approved?*

43. *Do control drawings leave any question that a vendor standard part is being specified when such is intended?*

44. *Has standardisation been carried too far so the cost of excess function is greater than the gains resulting from high quantity?*

45. *Was the field of commercially available packaged units, sub-assemblies, and circuits thoroughly reviewed to be sure there were no standard vendor items that would do the job?*

Design Criteria – Material

46. *Were standard, off-the-shelf items used wherever reliable items were available?*

47. *Was the Project Material Manager given all available information covering functional and specification requirements to maximise his effectiveness?*

48. *Were material specification call-outs on drawings reviewed for redundant and unnecessary requirements?*

49. *When specifying special parts, were vendors consulted for alternatives or modifications that would hold down costs?*

50. *Were standard alloys, grades, and sizes of stock specified whenever possible?*

51. *Were suggestions invited from prospective suppliers regarding possible value improvement from relaxing specification limitations?*

Electronic Design

52. *Were standard preferred circuits' reviewed to see how many could be used beneficially?*

53. *Was the field of commercially available packaged circuits, power supplies, etc. reviewed against requirements?*

54. *Could circuitry be eliminated by having one component or circuit do the job of two or more?*

55. *When specifying special component parts, were potential vendors consulted for alternatives or modifications to hold costs down?*

56. *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?*

57. *Can any electrical tolerance be liberalised to allow specification of lower cost parts?*

Detail Considerations

58. Are the bend radii correct for the material used?

59. Are bend reliefs adequate?

60. Is proper edge distance used?

61. Are rivet diameters too large for material thickness?

62. Do all screw type fasteners have locking means?

63. Have bolt torques been specified where needed?

64. Does the material require the inserts to be used in tapped holes?

65. Are tolerances and clearances closer than necessary?

66. Have stress concentrations been avoided?
(a) Sharp radii
(b) Changes in section

67. Will the part warp due to welding, heat treatment, machining?

68. Are the extrusions readily available?

69. Are the special hardware items readily available?

70. Has good welding practice been used?
(a) Have welds of thick to thin sections been avoided?
(b) Is material gauge above minimum for fusion welding?
(c) Are welds used in shear?

71. Has concentricity, parallelism, perpendicularity, etc., been considered?

Interchangeability

72. Does the design permit the proper degree of interchangeability?
(a) Do the tolerances cause interchangeability problems? (Will the most open fit improperly preload the part?)
(b) Are the attachments consistent with interchangeability requirements?

73. In redesigning, has a retrofit problem been created?

Serviceability

74. When a part or assembly is installed, will it be accessible?
(a) For service?
(b) For replacement?

75. Can replacement parts be installed with a minimum of handwork?

76. Has the use of special tools and fasteners been kept to a minimum?

77. Is there tool clearance (hand tools, torque wrenches, etc.)?

78. Will the part or assembly withstand handling?

General Questions

1. Does the design give the customer what he requires and no more?

2. 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?

3. Have unnecessarily-high-cost items been included as a result of their availability when the breadboard or model was constructed?

4. Has consideration been given to eliminating unnecessary requirements through Value Engineering Change Proposals?

5. If fabricated and assembled to the drawings and specifications, will the system go together and work?

6. Can the exact configuration of the system be identified by the drawings and specifications?

7. Does the documentation meet customer requirements?

The Value Engineering Functional Approach Techniques

by Frederick S. Sherwin, B.S.M.E.*

It is the functional concept which distinguishes Value Engineering from many approaches to cost reduction. It does not concentrate in depth in any one area (Design, Production or Purchasing) to the exclusion of others. It starts with the definition of the customer's needs and then proceeds through an organised and systematic programme to create the optimum design. Value is relative and is established by comparison. An optimisation of cost/value ratios is the aim. The author cites numerous examples of successfully applied value engineering pointing out that while these illustrations were all connected with improvement of existing designs the functional evaluation techniques are equally applicable to creative engineering design work.

V.E. embodies in its methodology numerous techniques which guide qualified people in seeking out and reducing vast amounts of unnecessary costs associated with both product manufacturing and business operating expenses. The depth and breadth of all these technique areas make it difficult for many people, looking at V.E. for the first time, to grasp the concepts and realise the magnitude of their potential for dynamic achievement in the cost prevention and reduction (cost effectiveness) areas.

The Need for Combined Action

The main theme of Value Engineering is the functional approach, and it is this functional concept which distinguishes V.E. from many approaches to cost reduction which concentrate in more depth into various elements which contribute to product cost. V.E. reaches into all these elements sufficiently to extract the best information needed to solve the functional problem. V.E. does not generally advance the state of the art in any of these areas. For instance, a manufacturing engineer may become expert in many areas such as mechanisation, automation, machine tools, processes, or methods; developing and accumulating depth knowledge on machining, welding or tooling. An Industrial Engineer may concentrate in developing better methods, assembly techniques, labour standards, plant layout, material handling and factory management, leading to reducing costs and improving efficiency in all these areas. The Buyer develops skill in finding the most proficient, lowest cost source; the cost estimator has techniques and knowledge which permit him to translate specifications and engineering drawings into manufacturing cost; and the technical engineering specialist will have depth knowledge of his branch of science or specialty area.

All of these people utilise their depth knowledge to improve the product value by the application of the best of this knowledge to solve each specific problem. However, working independently without close communication or co-operation, without knowledge of the affect of their decision on other areas, and without an integrated effort or a specific value (cost) objective much unnecessary cost may be left in the product. Figure 1 illustrates this point by showing that two and one-half times the cost reduction achievement was made by a combined effort of manufacturing, purchasing and engineering personnel contrasted to individual action by these groups.

Customer's Need Considered

This is one of the reasons that the Value Engineering approach is more effective. It does not concentrate in depth in one area to the exclusion of others. It does start with the definition of the customer's or user's functional requirement, and proceeds through an organised and systematic programme to create the optimum design which permits the application of the best material, process and manufacturing source. The proper combination of design, material, process and source will provide the functional need for the least total cost to the user considering the quantity of goods to be produced and the essential performance criteria such as reliability, maintainability, etc. Figure 2 indicates the complexity of the problem of finding the proper combination of these factors which affect product value.

The Value Problem

Assuming that for any functional requirement there may be three suitable designs, 3 materials for each design, 3 processes to shape the materials into the desired design configuration and 3 manufacturing sources for each process, then 81 different combinations exist. Increasing the 3's to 6's would result in 1,296 different combinations. Moreover, any *one* product performing an overall user desired function may consist of numerous sub-functions, each of which fit this same picture. Thus, the total problem of finding the best Value Product is extremely complex. Anyone attempting to traverse this maze without an organised plan and the knowledge of essential techniques will not only have a difficult time, but also will have many areas of unnecessary costs in the end product. Any individual working within one of the factor areas (Design, Manufacturing, or Purchasing) without integrating the most appropriate information from the other areas will also develop a product which costs more than it should to perform the required function.

Mr. Sherwin is the Value Engineering Co-ordinator of The Plessey Company Ltd., Vicarage Lane, Ilford, Essex, England, and a Past President of the Society of American Value Engineers.

Fig. 1

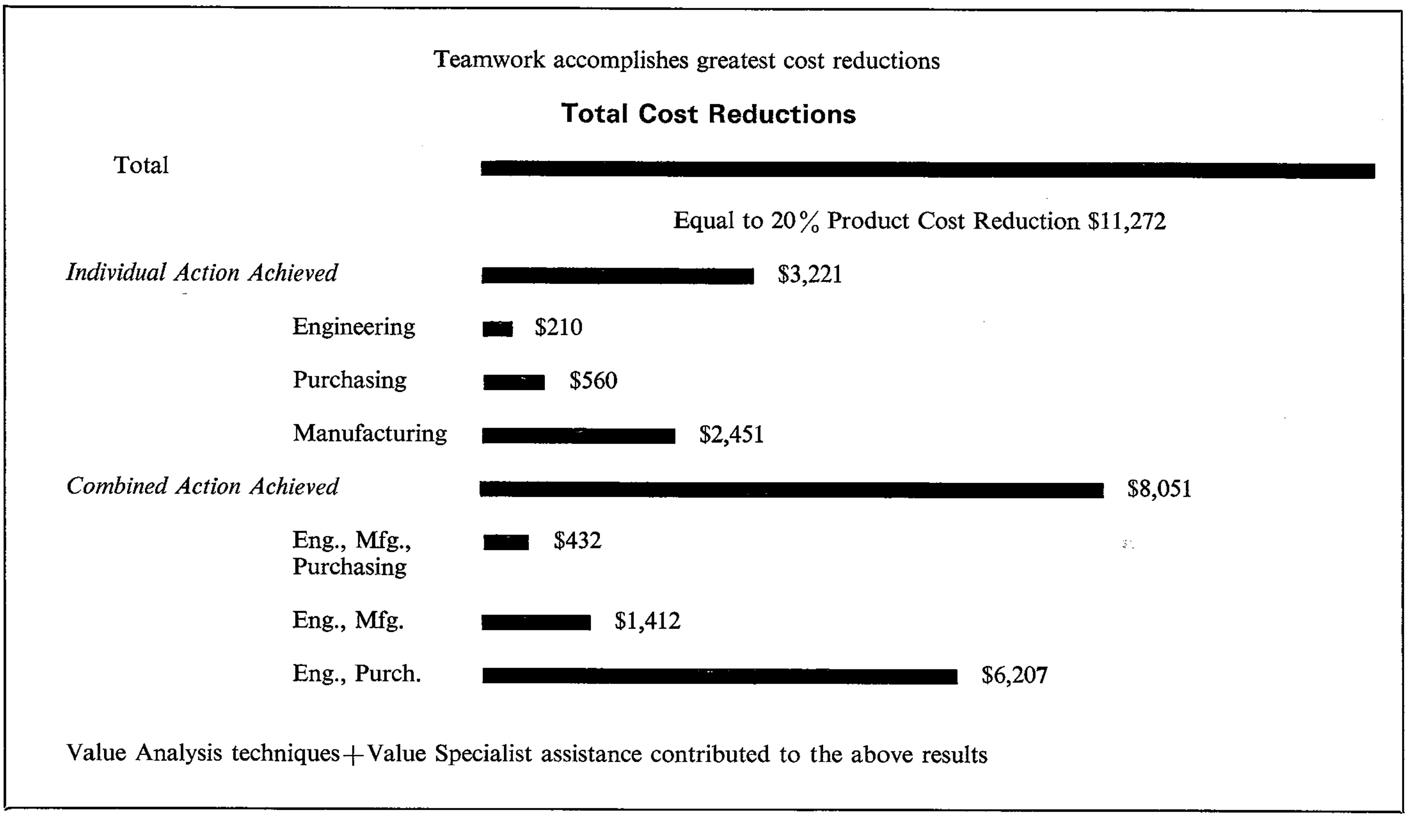
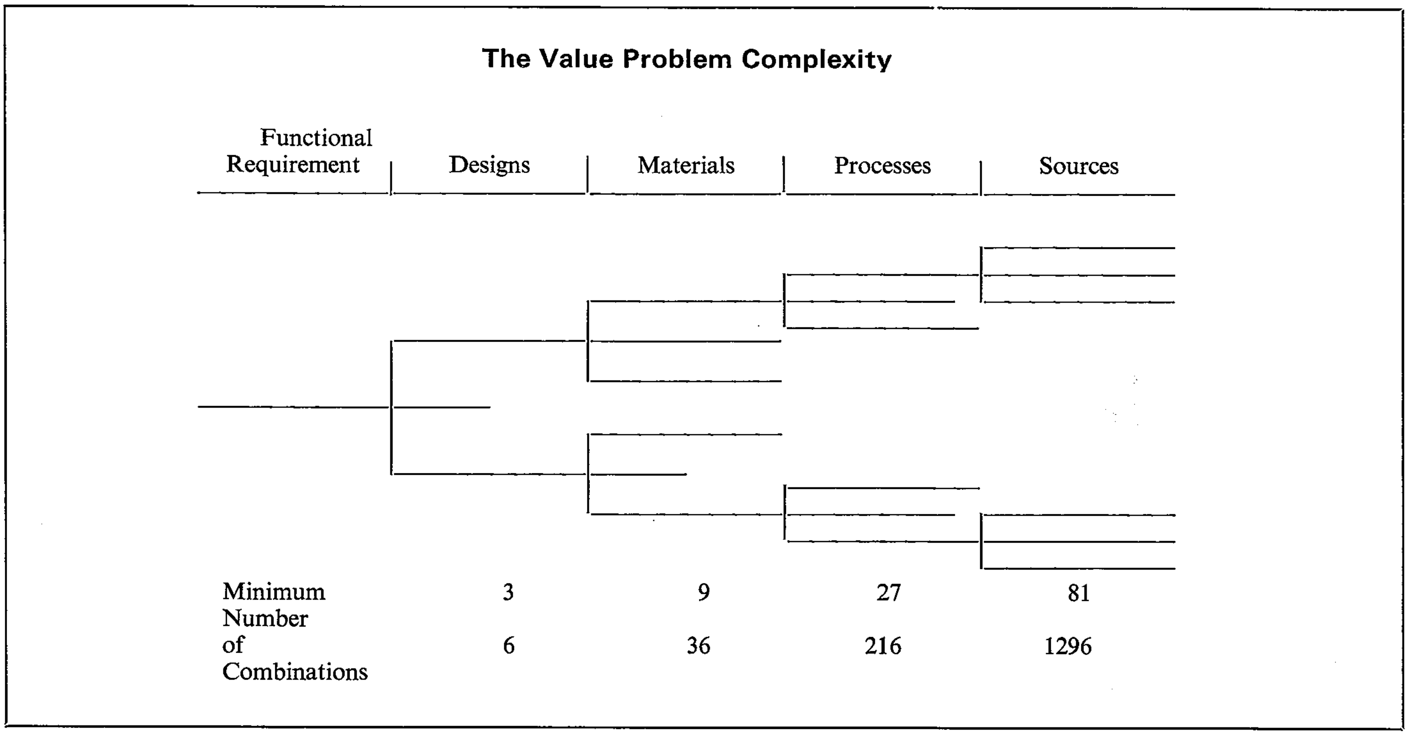


Fig. 2



Function - The Beginning

Where then should one begin the process which develops a good value product? To answer this let's look at the relationship of many of the Value Engineering techniques. As mentioned earlier the Functional Approach is the theme of Value Engineering and is the underlying foundation for the application of the many key and supporting techniques. Figure 3 shows these relationships and the general order of usage. The functional approach steps are in the left-hand column and constitute the basic philosophy for implementation of the Job Plan and Techniques. The concept of the Functional Approach forces the search for better value to begin with the user's needs and the basic design requirements; then establishes creative and cost objectives to motivate the Value Engineer or Value Team to seek out those ingredients which blend into the best value product.

The Functional Approach

1. Define Functions
2. Evaluate Functions
3. Develop Alternatives.

It is the motivational phases of the Functional Approach which are embodied in the Definition and Evaluation of Function that will now be discussed. These two phases are essential to a Value Engineering Study. Without effort in these areas a Value Analysis would not have taken place, and without this analysis any work which followed would be misdirected or fall into the category of cost reduction rather than Value Engineering.

Why A Functional Approach?

Why is it necessary and what does it accomplish? It is necessary if the best value (lowest cost) is to be achieved in the least time and because it helps people to accomplish greater results (to remove the maximum amount of unnecessary costs) by:

1. Forcing a different way of thinking or approaching a problem
2. Clarifying the specific problem and
3. Forcing functional orientation rather than hardware orientation.

This approach:

4. Brings a strong realisation that things cost *too much*.
5. Identifies specific areas of unnecessary costs and
6. Aids in setting cost targets or objectives.

Benefits of the Functional Approach

The functional approach is *not* directed at 'how to make the part for less', but 'how to achieve the essential function for less.' Hardware oriented cost reduction could dangerously impair performance or reliability. Functional oriented Value Improvement properly implemented should never reduce quality and often improves reliability. One example of this was a Value Engineered Voltage Regulator which was reduced 56 per cent in cost and demonstrated improved reliability as a result of 25 per cent fewer components and improved cooling. Regulation was also improved.

Another benefit from using the V.E. Functional and Organised approach is that it greatly hastens the time required to make Value Improvements. While many changes developed by a V.E. study will look no different from other cost reduction on product improvement work, the time and manpower required to develop the change is an important factor. A V.E. study should bring about more significant changes for less time and effort than an unorganised effort in which V.E. techniques are not used. A jet aircraft has many of the same basic parts as a propeller aircraft but it has a few new parts and they are put together into a different system to get the plane from one place to another much faster. The functional approach of V.E. is a new ingredient which is part of the complete system which gets results faster.

Six Basic Questions

The engineer seeking better value must seek the answers to many questions. Some questions are fundamental to carrying out the functional approach.

Fig. 3

Value Engineering Techniques Relationships

Functional Approach	Job Plan	Key Techniques	Supporting Techniques	V.E. Questions	Work Sheet
1. Define Functions	Information Phase	Get all the facts Determine costs Define the function Put $ on specs. & reqs.	Get info. from the best sources Work on specifics Use good human relations Overcome roadblocks Divide product into functional areas	What is it? What does it do? What does it cost?	1 2
	Creation Phase	Blast and Create	Creative thinking Deferred judgement Use teamwork	What else will do job?	3
2. Evaluate Functions	Evaluation Phase	Evaluate by comparison Evaluate basic function Put $ on each idea Refine ideas	Use good business judgement Analyse Costs Evaluate ideas Evaluate functional areas	What is the value of the function?	4 5
3. Develop Alternatives	Investigation Phase	Consult vendors Use co. & industrial specialists Use co. & industrial standards Use specialty products, processes & matls. Determine costs	Overcome roadblocks Develop ideas Apply new info. Don't be a hermit (others listed above)	What else will do job? What will that cost?	6 7 8
	Recommendation Phase	Motivate positive action	Use good human relations Spend company's money as you would your own Develop & sell or implement your solution (others listed above)		9 10

Fig. 4

Six Basic Questions
1. *What is the part?*
2. *What does it cost?*
3. *What does it do?*
4. *What is the function worth?*
5. *What else will do the job?*
6. *What will that cost?*

Questions 1, 2 and 3 are essential to the definition of the hardware, cost and function. Question 4 relates to the evaluation of the worth of the function, and questions 5 and 6 to the creation and development of alternate solutions.

Work and Sell Functions

It is important to spend some time discussing the definition of functions because this technique is vital to a value study.

Fig. 5

Defining Function

Functions can be divided

Basic
2nd Degree

Essential
Non-Essential

There are two kinds of functions which occur in most products – those which make the product 'work' (perform its intended job) and those which make it 'sell' (cause people to buy one product rather than another). Both types are important in a competitive market. 'Sell' functions may absorb a large element of cost, such as the American Automobile. Appearance, convenience, and style are some of the areas of sell functions. Those elements of a product or system which contribute directly to the prime functional purpose of the device are said to be contributing to work function. For instance, the fuel in a cigarette lighter which has a basic function of providing heat.

Functional Areas

Mechanical, electrical, protection, and appearance identifies at least four functional areas into which products can be divided. Others such as thermal or chemical may exist in some products. Any product or assembly being subjected to Value Analysis should be divided into various functional areas at all levels from system to assembly, to sub-assemblies, to parts. This functional tree analysis is very useful in finding areas of non-contributing costs allocated to non-essential secondary functions.

Basic and Second Degree Functions

In defining function it is important to segregate into 'basic' and 'second degree'. Basic functions are defined as the primary, specific purposes the device was intended to perform, i.e., the main reason for its existence. Second degree (secondary) functions are those which do not contribute directly to the basic function. Sell functions would be secondary to basic work functions. Second degree functions may be essential or non-essential. That is, they could be required to make the design concept work. For instance, the glass bulb of an incandescent lamp does not directly contribute to producing the light, but does prevent rapid oxidation of the filament by excluding air.

Two Word Definition

Functions can usually and should be defined in two words – these words are *verbs* and *nouns*, which give a concise, clear, description of the basic or secondary functions. The choice of the proper words to define functions is often critical to the proper comprehension of the function, and many times a significant factor in motivating a better value design. Figure 6 indicates some of the more common verbs and nouns used to define functions. One thing to note is that some nouns are measurable and some non-measurable. For instance, the function of a leg could be defined as supporting a table, whereas 'weight' would be measurable and would include weight placed on the table. A chassis could be said to 'hold parts' while 'weight' is more exactly measurable. The use of measurable nouns is essential to the accurate quantitative definition of function and to the evaluation of functional worth (Establishment of Value).

Fig. 6

Verbs & Nouns

Work Functions

Verb	Noun – measurable
Support	Weight
Transmit	Torque
Hold	Load
Enclose	Oxidation
Collect	Light
Conduct	Heat
Insulate	Flow
Protect	Radiation
Prevent	Current
Amplify	Voltage
Rectify	
Change	Noun non-measurable
Interrupt	
Shield	part, device, component,
Modulate	article, table
Control	
Attract	Damage
Emit	Circuit
Repel	Repair
Filter	
Impede	
Induce	

Sell Functions

Verb	Noun
Increase	Beauty
Improve	Appearance
Create	Convenience
Establish	Style
	Prestige
	Features
	Form
	Symmetry
	Effect
	Looks

Evaluating Functions - Four Kinds of Value

Man has been struggling for centuries with the problem of measuring value and it is not intended here to get into a philosophical dissertation on that subject. From a Value Engineering aspect, however, it is significant to note that there are several different kinds of value – according to one writer, at least four kinds – they are use, cost, exchange and esteem. Using a monetary measure, Use Value is determined by the availability, market, form and physical capability of a basic material to perform a desired function. It is the measure of the worth of the strength of steel, the conductivity of copper and the insulation of ceramic. Use Value is the most highly objective, influenced less by personal effort and feelings. On the other end of the scale, Esteem Value is measured by personal desire and is highly subjective. Cost Value is a measure of the labour and material required to convert raw material into usable finished form and Exchange Value is a measure of what one is willing to give to obtain a product or function. Cost Value could be matched to manufacturing cost, Exchange Value to selling price. Cost Value is very seldom known and Exchange Value is not necessarily related to Cost Value.

Asking a group the value of something is very often likely to elicit a large number of different answers because people are thinking of different kinds of value – moreover, many people will consider the cost of the consequence of failure. Now what can be done to provide a more uniform measure of value, and an approach which will motivate action to minimise costs.

Value Defined

To the Value Engineer, 'Value is the lowest cost to reliably achieve function'. It is also useful to consider that only basic functions have and are assigned values when making an analysis at one functional level within a system or product. An essential secondary function at the next lower level could be considered basic if the functional study was to be concentrated at that level. For example, a radio would have a basic function of 'produce sound' while the cabinet would have a secondary function of 'enclose components.' If a cabinet was to be studied separately as a functional area its basic function would be 'enclose components'.

Evaluation Concepts

Other concepts of the evaluation phase are:

1. The technique can be applied to either work or sell function.
2. Value is relative and is established by comparison.
3. Value is not directly related to the cost of hardware nor the consequence of failure.

The cost of any piece of hardware may be many times greater than its functional value. The ratio of this cost/value is an important yardstick in determining the amount of unnecessary cost or whether a product is good value. The consequence of failure may have a bearing on the quality level of a part, and this in turn may have some influence on cost, but this is not necessarily so and usually not in a proportional ratio.

Evaluation by Comparison

In evaluating by comparison, the analyst can use several approaches, any one of which may be effective in motivating more extensive value engineering. Mass produced common household or commercial items, or Standard catalogue items are often good products to use as a basis for comparing the cost of alternate ways (other devices) which perform the function. Another more exacting technical and mathematical approach is to consider the amount and cost of different basic material forms required to achieve the essential function.

Comparison Techniques

The 'common part' method could be illustrated by the evaluation of the 'enclose component' function of an electronic or TV cabinet by comparing with a metal waste paper basket. The Standard part method by the evaluation of 'hold cover' function by catalogue 'door holders'. The 'basic material' concept was used to evaluate the function of the plate of an electron tube, 'collect electrons' and it was found that \$.001 worth of metal would perform the function of a plate costing \$.050. This led to a redesign of high secondary cost areas resulting in a 50 per cent reduction.

Figures 7 and 8 demonstrate how the definition and evaluation of function techniques would be applied to two simple devices. In the case of the pencil, a common wooden pencil was used as a basis for comparison. The Basic Material concept would have used the cost of the lead. In the case of the lamp bulb the cost of the amount of filament contributing to producing light was used. Notice how this approach highlights areas of high secondary costs. Good value design aims to minimise costs associated with second degree functions.

Fig. 7

Case Study

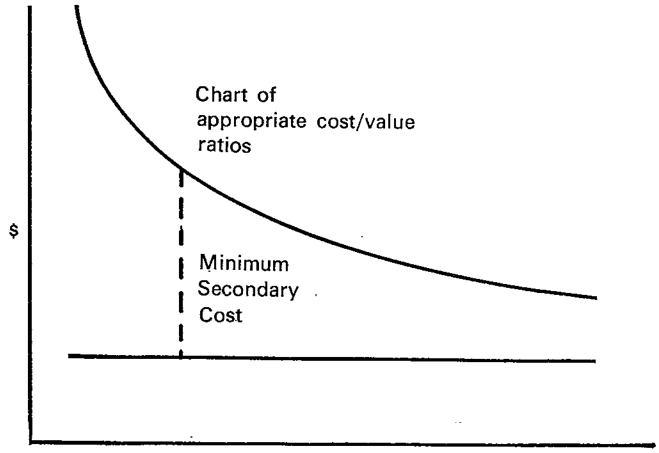
Part Name: Mechanical Pencil
Basic Function: Make Mark

Component Parts or Elements	Functions: Verb	Functions: Noun	Degree: Basic	Degree: Secondary	Value	Cost
1. Case	hold support	lead mechanism		√ √		50¢
2. Lead	make	mark	√		5¢	1/2¢
3. Eraser	erase	mark		√		5¢
4. Clip	hold	pencil		√		2¢
5. Paint	improve	appearance		√		1/2¢
6. Lead Holder	hold	lead		√		10¢
7. Lead Moving Mechanism	move	lead		√		20¢
8. Misc. & Assy.						10¢
				Total	5¢	98¢

Optimise Cost/Value Ratios

Using the Basic Material concept for establishing the value level for basic functions the quantity factor is largely removed so that a horizontal value line is established. Actual cost will follow an exponential (Hyperbolic type) curve downward toward the value level at higher quantities. The difference between the two lines represents those costs associated with second degree functions (both essential and non-essential). A good value product will have a minimum cost value ratio and the cost curve will more nearly approach the value level. With research, appropriate cost/value levels can be established for different products, and used as a guide for directing Value Engineering work into the most productive channels.

Fig. 9



Concept Variations

The above discussion on the Functional approach of Value Engineering highlights some of the concepts and techniques, which are primary and fundamental to good value work in the areas of defining and evaluating functions. There are many variations on these techniques. Often different words are used to describe the approach, but one should look beneath semantics into what is actually being done. If, in fact, functions are being properly defined and evaluated and then appropriate techniques are being applied to develop lower cost alternates, substantial results will be achieved – and after all it is results that count. The V.E. functional approach dynamically motivates people to generate results.

It should be pointed out that all these techniques are applicable to creative engineering design work. If cost and time are important to a programme – if simple, functional, reliable and maintainable designs are desired, it is fundamental that design engineers couple performance and technical skills with value skills to find the best combination of design, material, process and source. In today's competitive market for both military and commercial products, no concern should overlook steps to improve the value skills of their key decision makers, and to integrate these skills into a co-ordinated and organised programme to minimise all costs associated with both manufacturing costs and other business operating costs. These techniques provide the methodology for improving the cost prevention and reduction skills of all business people whose decisions affect cost, whether it is in product design or other areas such as procedures, methods organisation and manpower. A small investment to learn and develop proficiencies in the V.E. Functional approach will pay substantial dividends.

Fig. 8

Case Study

Part Name: Lamp Bulb: Basic Function: Provide Light

Component Parts or Elements	Functions: Verb	Functions: Noun	Degree: Basic	Degree: Secondary	Value	Cost
1. Flare	support	components		√		
	insulates	components		√		2¢
	excludes	air		√		
2. Exhaust Tube	transmit	air		√		1¢
3. Lead Wires	conducts	current		√		
	holds	filament		√		1¢
4. Filament	provides	light	√		3¢	5¢
5. Bulb	excludes	air		√		3¢
6. Base	supports	lamp		√		8¢
	conducts	current				
7. Wires	supports	leadwires		√		
	supports	filament				1¢
8. Gas	prevents	oxidation		√		1¢
9. Assembly				√		8¢
				Total	3¢	8¢

Reprint No. 1:1:11

Basic concepts — Creativity

The Importance of Search Techniques in Solving Problems of Value

by J. Harry Martin*

This article reflects on the philosophical aspects of the search for truth and knowledge as they relate to value, and suggest a similarity in problem-solving methodology between Descartes in the 17th century and Miles in the 20th century.

The author stresses the need for Value Analysts – if they wish to be successful – to master search skills. Value Engineering is a search-oriented philosophy which tests products for real value.

First, the author says, it is necessary to know how to search; *second, the search must be for* facts; *and third, the searcher must beware of concentrating upon one aspect only or of dispersing his efforts too widely. He must learn to focus on the relevant and the important . The three-step problem-solving philosophy of Descartes (intuition, deduction, induction) is offered as ideally suited to problem-solving in Value Engineering, and the author puts forward six concepts for searching for truth and for making problems in value solvable and holds that these will provide a firm foundation on which value engineering work may be based.*

Value Engineering is a search-oriented philosophy

To achieve success and benefits in the philosophical, scientific, search oriented work called Value Engineering, we must learn and master search skills. We must develop techniques to help us search for truth and knowledge and then be able to apply them to solving problems in value.

Lawrence D. Miles, Manager of Value Engineering Services, General Electric Company (since retired), said that Value Engineering is a search oriented philosophy. This, I believe, is at the heart of why Value Engineering has been and always will be the greatest contributor to eliminating excess costs.

It follows that a search oriented philosophy is knowledge oriented; for what is knowledge but the search for the truth? When we can develop techniques to aid us in our search for the truth, we will have built the foundation for applying the other techniques of Value Engineering, i.e., analysis, creativity, judgement and the ability to sell ideas and change people's minds.

In any product manufacturing business involving time, men, materials, machines, money and other resources, there are intertwined relationships within all the functions of the business; these complex relationships affect the cost of all operations. It is the gaps in communications and the lack of understanding between functions that add unnecessarily to our cost structure. Further, there is not enough factual and truthful communication of information between functions so that everyone knows what *all* the requirements are on the product design. Providing the basic function often gets lost in the detailed description of procedures and protocol so that instead of a clear, precise understanding of the requirement, we frequently end up with a situation wherein the questions that the Marketing and Engineering groups, the Factory, or Purchasing or even the Customer *should* ask – are never brought forth.

The product design is then 'in repose' and never is tested for real value. At best the design is only a compromise.

Mr J. Harry Martin is the Manager of the Value Engineering and Cost Improvement Program at the Defense Electronics Division of the General Electric Company's Ordnance Department, 100 Plastics Ave., Pittsfield, Mass. 01201, U.S. His article 'Winning Management's Approval for a Value Program' published in the A.M.A's book 'Value Analysis/Value Engineering—The Implications for Managers' (pp. 42-49) contains useful advice for those contemplating or engaged in setting up a V.E. activity.

When product design is 'in repose'

What do I mean by 'repose'. The philosopher, Ralph Waldo Emerson, said that: 'God offers to every man his choice between truth and repose. He who accepts repose will accept the first creed, the first philosophy, the first political party. He gets rest, or repose, but he shuts the door to truth'.[1] This is the key to the first technique in the search for the truth.

Our habits and attitudes in business tend to lure us into the comfortable existence of repose wherein we accept the first creed; the ultra safe design that will work, but is needlessly expensive; or the procedure or process that is politically acceptable but drains resources from the business.

Because Value Engineering crosses virtually all functions of the business and searches for what is actually required and is searching for the best value, the important questions do get asked. The search for the truth is the same as the search for knowledge.

Following the path of truth instead of repose

The first basic technique then in achieving success is knowing how to search; is to condition yourself to a philosophy of truth. Follow the path of truth instead of repose.

Second, search for the facts! The questions do not get asked in time to save the businesses resources unless the facts are known. Time has an odd way of distorting and shading the facts. How do we separate fact from fable? How do we keep from chasing the will-o-the-wisp? Napoleon said, 'History is but fable that has been agreed upon'. So it is with many of our business decisions, our procedures and the designs of our products.

The basic function required by our customer too often gets obscured and distorted in the translation from the Marketing Engineer to the Design Engineer to the Manufacturing Engineer to the Purchasing people. Add a span of time to this complicated communication system and we have added shadings to the truth and when we have done this we have blunted the sharp, cold facts and built in unnecessary cost.

Emerson also said, 'No anchor, no cable, no fences, can keep a fact a fact. Time dissipates the solid angularity of facts'.[1]

This thought is offered as the second key technique in the search for the truth. *Do not* expect anything else in the search for the real facts but compromises, misunderstandings, errors in communications, honest wrong opinions, conditions that existed in the past but do not exist now. This last point may be illustrated by using these examples. Have you ever questioned why they put a slit in the back of a man's coat? So that he can ride a horse more comfortably, of course! A king once ordered the buttons on the uniform cuff to prevent the soldier from wiping his nose on his sleeve. The average man no longer travels by horseback and does not need the slit in the coat and we no longer use sleeves for handkerchiefs! Our search for truth immediately reveals that habit has replaced necessity in these cases. To get to the basic truth in the search for knowledge, go back in time to when the need was *first* defined. Why does the standard railways track spacing have to be 4ft 8½in in the United States? Because the wagon wheel tracks were that dimension. Why do most cars have the engine in front? Because the horse was always in front of the wagon.

In our search for facts and truth we have accumulated knowledge. Let us be sure that, as we go through this search routine, we ourselves do not slip into the position wherein we concentrate our attention on only one aspect of the truth lest this fact we have exposed gets distorted in meaning and importance. We are acquainted with the religious fanatic who excludes all contact with the realities of life in his religious zeal or the grammarian who cares not what is said so long as it is said grammatically. On the other hand we must beware of spreading our search so thinly over a wide area that important facts are missed. This is the third skill to be acquired.

Search techniques in business and design decisions are hardly ever used more than 25 per cent of the potential that it is possible to achieve.

Truth is not a destination but a continuing journey

Remember that a successful search is the successful search for truth, and that in Value Engineering truth and search should not be thought of as a destination but a continuing journey.

When we have conditioned ourselves to avoid being in 'repose' and to recognise and accept that facts and truth are subject to erosion and distortion; and when we have learned how to search back through time and separate fact from fancy, we can use this knowledge in making our cost problem solvable. When we have acquired the skill required to maintain the balance between too much concentration and not enough, we will have learned four of the most important skills many philosophers of the world agree are necessary in the search for truth and knowledge. The mastery of these skills and disciplines will assure success in doing Value Engineering.

To make problems solvable they must be identified; in Value Engineering work the cost of materials, labour and the operating burden required to produce a specified design are virtually always the hub of the problem.

When we can identify and locate and isolate the problem area, we have gone a long way towards solving the problem.

The problem-solving philosophy of Descartes

Let us consider the modern problem-solving philosophy of Rene Descartes, a 17th century French philosopher. Descartes suggested for the first time that the process of knowledge is understood only in the contrasting light of the *ideal* of knowledge and the *accepted* scientific doctrines of the time. In simple terms, we could relate this to the difference between the purest and most basic function required of the design and its present accepted design. Oftentimes, the cost difference in providing the basic function, when compared to the present-day accepted design, is manyfold. An example of this theory is the difference in cost between a wool coat and a mink coat. The key to the Descartes theory is to understand and evaluate the difference in the case of the wool coat and the mink coat. The basic function: to provide warmth, is the same. Descartes suggests the three step process of intuition, deduction and induction to problem solving. It is also ideally suited to problem solving in Value Engineering work.

Descartes urges that 'the investigation of any problem should not be dominated by what others have thought about, but what we ourselves can see clearly or infer with certainty'.[2] There is a definite correlation between Descartes' philosophy and L. D. Miles' teachings on Evaluation of Function. May I suggest that after reading Mr. Miles' book[3] you refer to the *Encyclopaedia Brittanica*, Vol. 7, pages 247–252?

Descartes made the point that random search for knowledge and trust in chance luck be condemned as fruitless and intellectually demoralising.

Similarity between Descartes and Miles

In his *Discourse on Methodology for Problem Solving*, Descartes suggests the three step process.

The first step Descartes calls 'intuition', wherein everything must be questioned so that we may discover some theory that is beyond doubt. At first, everything seems to succumb to the inquisition; traditional beliefs, commonly accepted ideas, the very facts of direct observation, may all turn out to be illusions and dreams. Eventually something is discovered that is a truth, a certainty beyond doubt. This is very much similar to Miles' information gathering phase and basic function evaluation.

The second step is the 'deduction' phase wherein the certainties and truths established in Step 1 are weighed, assessed, and measured. Each of these truths is built into more complex interrelated truths with each building block of complex truths as carefully built and checked as the simple truths in the intuition phase. This system is remarkably akin to Miles' speculation and analysis phase in Value Analysis and Value Engineering.

The third step is the 'induction and enumeration' phase wherein all the elementary factors of intuition and deduction are collected and enumerated and distilled into a solution to the problem. This last phase of Descartes' methodology is the same as the Programme planning and execution phases in Value Engineering.

Six Concepts for making problems in value solvable

So, in summary, let us consider the following concepts for searching for the truth and for making problems in value solvable. They will provide a firm foundation from which successful Value Engineering work can be done.

1. Be a searcher for truth, never remain in 'repose'
2. Don't expect to find the real facts without a search
3. Maintain a careful balance between narrow concentrated effort and a broad search area.
4. Start with intuition and information-gathering phase.
5. Apply deduction and speculation and analysis.
6. Solve value problems with solution or induction phase.

These concepts are as applicable to today's problems in value as they were when Descartes wrote his *Discourse on Methodology* nearly four hundred years ago.

References

1 Emerson, R. W. **Essays**
2 Descartes, Rene **Discourse on Methodology for Problem Solving**
3 Miles L. D. **Techniques of Value Analysis and Engineering**

Reprint No. 1:1:12

Basic concepts — Applications

The Technique of Value Engineering as an Aid to Profit Improvement

by J. Burnside, C.Eng., A.M.I.Mech.E., M.I.M.C.*

The article explains what value engineering is and outlines the stages in the V.E. Job Plan.
Cost prevention at the design stage by the application of value engineering techniques is dealt with by the author who stresses the group nature of the activity. Value engineering brings a new dimension into the working lives of all who are involved in it.

Maximising Product Value

Value Engineering is a technique for ensuring that no unnecessary cost is built into manufactured products, processes or services. It differs from other cost-reduction techniques in its approach to the whole question of value and function. While most conventional profit-improving methods aim at reducing the cost of manufacturing a given product *after* production has begun, V.E. aims at eliminating unnecessary cost *at the design stage*.

The method adopted is to make an exact measurement of the relationship between function and cost for every item in the product. This is done by evaluating, in money terms, the functional contribution of each of the parts to the whole, and then minimising the cost of providing essential functions. Items or parts are carefully assessed and those not performing essential functions are eliminated. This is termed 'maximising product value'.

Compiling a Functional Specification

The value engineering exercise starts by determining precisely what the customer wants. From this a complete functional specification is built up. Factors which must be considered include performance, safety, reliability, service requirements and eye-appeal. It is important that this first stage of the exercise (called the 'information stage') is carried out with the utmost care, since subsequent work entirely depends upon the accuracy of the information stage.

Brainstorming and then Evaluation

When this stage has been completed, the team takes part in group 'brainstorming', the object of which is to produce ideas that lead to cost savings but will not impair quality or performance. The value of brainstorming in a group is in the exchange and development, through discussion, of new ideas which might not have been thought of otherwise. Also, since the rules of brainstorming prohibit detailed evaluation of these ideas during this speculation stage, the ideas flow proceeds without interruption.

When speculating on alternatives, the questions which should be asked are:

What does it do?
Do we need it?
What does it cost?
What else can we use?
What will that cost?

The primary aim is to reduce the number of parts or processes contained in a product, either by combining several functions into one or by eliminating unnecessary functions. However, other means of limiting cost should also be attempted. The use of standards, proprietary parts and processes, and alternative materials and fixings, must be fully considered and manufacturing tolerances widened wherever possible. Unnecessary finishing operations must be avoided, and the use of pre-finished materials encouraged.

The Problem of the Prototype

Too often, the first prototype that works is taken as the model for production, and as a result expensive design features are perpetuated in the finished product. This procedure usually leads the manufacturer to seek other means of reducing cost after bulk production has begun, in order to achieve the calculated profit yield. Such savings must be limited by the cost of introducing modifications.

The work involved in the later stages of a V.E. project is usually delegated to departmental staffs, leaving those who are more directly involved free to tackle other projects. Evaluation of costs for new ideas is most often carried out by the Purchasing Department or the Cost Office, depending on whether the item is bought-out or made-in. Where models must be constructed to prove a new design, the task would fall on the Model or Prototype Shop or the R. & D. Department.

Selection, Reporting and Implementation

The end stages of any project are the selection of, and reporting on, those new ideas which are considered to be the most suitable for incorporating into the final design. Reports must contain detailed information on the investment required and the net savings expected.

Mr Burnside, Value Engineer with Lindustries Ltd., 100 Brompton Road, London, S.W.3, England, is also a keen advocate of the application of Value Engineering techniques in Marketing. He is a well-known lecturer on the subject of Value Engineering.

The implementation of the changes, if made, depends very much on the products being considered and the company concerned. In all cases, however, a careful procedure for implementation must be established so as to avoid new unnecessary costs. When all the changes have been implemented, the total real savings on the operation can be computed.

This cost-prevention at the design stage by value-engineering a prototype can produce great savings. Elimination of unnecessary parts and processes at the beginning of a product's life minimises design, planning and tool costs, and prevents stocks of unwanted parts being accumulated.

V.E. Introduces a New Dimension

Value Engineering is a group activity and should involve the key departments of a manufacturing organisation, namely Sales, Purchasing, Production and Design. Each of these departments has a vital contribution to make and each benefits from adopting the questioning, analytical attitude of mind so essential for successful value engineering.

By its very nature, the whole V.E. approach is highly infectious and leads to improved relations and communication between departments and the development of team spirit. Value Engineering brings a new dimension into the working lives of all who are involved in it. As for the results scored by V.E., they are always satisfactory and frequently spectacular.

Acknowledgement

The kindness of Lindustries Limited in allowing the publication of Mr Burnside's article – which first appeared in **Lindustries Review 1967** – to be reproduced in this journal is gratefully acknowledged. (Ed.)

An Example of Substantial Savings through considering a product in its entirety.

The product is a carbon brush holder as shown in Figure 1 below.

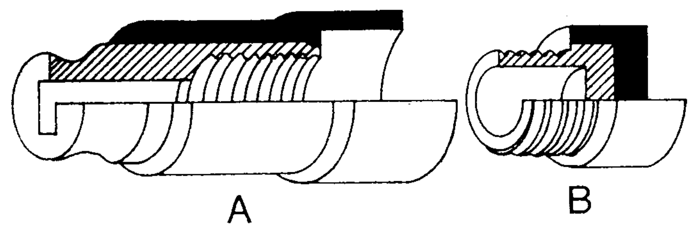


Fig. 1

A .. Brush Holder with inner portion made of brass and outer case of nylon (black).

B .. Retaining Cover with inner portion made of brass and outer case of nylon (black).

Manufacturing method –

A .. Auto turn, broach square hole, and invest with nylon.

B .. Auto turn and invest with nylon.

As a result of a new requirement for double insulation, it was decided that a high-impact plastic material should be substituted for the die-cast aluminium conventionally used for hedgetrimmer main casings. Not only did the adoption of plastics provide the required double-insulation features at less cost, but there were other savings which directly resulted. One of these related to the design of the carbon brush holders.

Traditionally, brush holders to the design shown in Figure 1 were inserted through the main casing and insulated from it by the covering of nylon. The brush retaining cover was likewise fully insulated externally and could be removed for brush replacement without disturbing the motor.

(This illustrative example of cost-savings through the application of Value Engineering principles accompanies Mr Burnside's article commencing on page 51.)

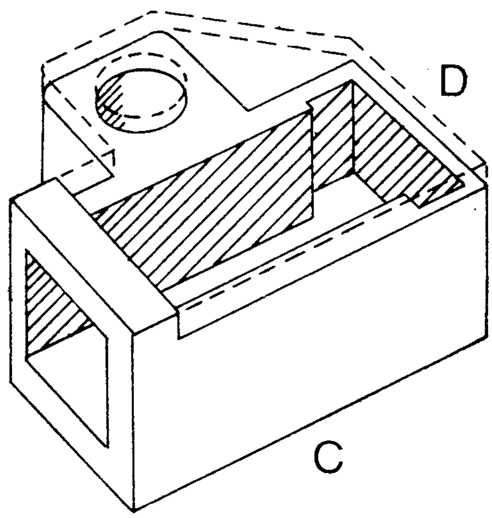


Fig. 2

C .. Brush Holder made of die-cast 'Mazak'.

D .. Cover Plate made of Mild Steel Strip.

Manufacturing method –

C .. Diecast complete.

D .. Pierce and blank on power press.

In the revised design the brush holders are located internally. Access can only be gained by exposing the motor, which for safety reasons is not considered to be a bad feature. The use of an insulating material for the casing permits the use of uninsulated brush holders, leading to a much simplified design as shown in Figure 2.

This new design has the following advantages:

(*a*) indirect savings (amounted to several shillings) through elimination of machining brush holder locations on the main housing, simplified assembly and maintenance, and substitution of a much cheaper connector.

(*b*) 65 per cent saving in cost of brush holders, yielding a direct profit improvement of approximately 1s. 6d. per machine.

Reprint No. 1:1:13

Creativity

On Catching the Fleeting Thought

by C. Hearn Buck, B.Sc., C.Eng.*

The loss of many ideas we get can be prevented through motivation and concentration. There is, however, a need for a relaxed state of mind during the problem-solving activity. Fear of criticism is a form of tension which the 'brainstorming' technique helps to overcome.
The free-play of ideation, which the technique encourages, must be followed up with selection of the ideas which are the most worthwhile to pursue.
Ideas may also be stimulated by analogy and by using checklists. Various systematic design methods also have their place. The method proposed by Graham Wallis is described.

It happens all the time. In a lunch time conversation with a colleague I looked up to see why he had stopped speaking.
'I was going to say something to you, and it's gone' he said.
'You were talking about the exercise for third year students' I reminded him hopefully.

'I know. It wasn't that. While I was speaking about the exercise, something else came into my mind that I must discuss with you. It was there for a moment, and it went. I haven't the least idea what it was about. But I know that it was important.'

This is a common enough experience. A word sits on the tip of the tongue, but it won't come out of the mouth. A face smiles at you; you know that you know the owner, but his name won't come to mind. You have a problem, and you know that there is a brilliant solution to it; the solution is in your mind, and you know it is there, but you can't get it into focus. These things happen to all of us, and we wonder how many witty repartees, how many pleasant reunions, how many inventions, are lost for ever.

No doubt some of these lost opportunities occur because of some failure in our own inner drive. Lack of the right motivation allows us to forget faces, formulae, books, names, or prevents ideas from developing just when we need them. The man who reads these lines because he has nothing better to do will speedily forget them. The man who reads in the hope of improving his powers of creative thought is already well motivated towards creativity. We need say no more about motivation except that motivation commonly leads to Concentration. The man who desires to excel in a certain field will read and study, experiment and practise, and think long and deeply about its peculiar problems. If he desires to solve a problem, he will concentrate upon the problem, and without concentration he will find a solution only by the merest fluke.

• Mr Hearn Buck is Lecturer at the University of Aston in Birmingham, Gosta Green, Birmingham, 4, England. His main interests are in the fields of Product Development, Design Management and Value Analysis.

In strange contrast to the mental states of motivation and concentration, without which effective thinking cannot take place, is the need for relaxation. I do not mean the need for rest and recreation, although these are necessities for most people. I mean the need for a relaxed state of mind during the problem solving activity. The opposite of relaxation is tension, and nothing is more productive of tension than the emotion of fear, whether it is the fear of the consequences of failure, the fear of criticism or ridicule, or perhaps even the fear of the consequences of success. Personal experience, the observed behaviour of people trying to solve problems under stress, and the written records of many thinkers, all demonstrate that the creative powers of even the best minds fade or fail when the thinker is disturbed by emotion, and particularly by the emotion of fear.

One way of dispelling the fear of criticism is to use the 'brainstorming' technique for seeking solutions to problems. In his book *Applied Imagination*, Alex F. Osborn[1] describes the underlying philosophy as 'the principle of deferred judgement'. It is possible to brainstorm alone, but it is better done in groups. The problem is presented to the group, and the members are invited to suggest possible solutions. There are some rules.

Criticism is forbidden, even self-criticism. Anyone who has an idea is bound to express it. No one may remain silent because his idea seems ridiculous, fantastic or outrageous; equally no one may withhold his contribution because it seems trifling, pedestrian, or very like an idea already mentioned. The group leader has the responsibility of ensuring that the rules are obeyed, and that every idea suggested is recorded. The brainstorming session seldom lasts for an hour. Ideas are generated very quickly, but only for a short time. When the group begins to flag, it is time to stop the exercise, and this may be after only ten minutes.

I'd like to demonstrate brainstorming, or rather to encourage my audiences to experience brainstorming, by setting them a homely and familiar problem without much warning. For example, the audience may be divided into groups of four or five men; each group elects a clerk whose job is to record the ideas suggested. Then the problem is announced; it might be to suggest ways of giving up cigarette smoking. After ten or fifteen minutes, brainstorming is stopped, and the clerks are asked to state the numbers of ideas that they have recorded. In a recent exercise, one group of four men produced twenty-four ideas in eight minutes. In another, five men produced forty-two ideas in fifteen minutes.

Naturally, you will not expect to get forty good ideas in a few minutes. Some of the ideas will be good, and these must be sorted out, and the bad ideas rejected. But not during the brainstorming session. Once this has finished, it is a good thing for everyone to rest for a while, for high speed generation of ideas is quite tiring. The sorting is done later. This is the practical expression of the principle of deferred judgement. After the period of free ideation, unfettered by practical considerations or emotional tangles, the ideas listed will be subjected to intense criticism. Every possible criterion must be applied in judgement of the ideas, such as, for example, is the idea relevant to the problem posed, would implementation of the idea be prohibited by the lack of human, material or financial resources, and would implementation of the idea be associated with or followed by unacceptable situations. Thus the long list of possible ideas is soon pruned to a short list of probable solutions. But these are still only ideas, not complete solutions, and a great deal of further work is usually entailed in producing a complete detailed solution. I will return to this point later.

So far I have suggested that the mental states appropriate to creative thinking are motivation, concentration and relaxation. The last has been illustrated by briefly describing the method of brainstorming. The group method of brainstorming also illustrates the fourth and final mental state in this list. Typically, as each idea is announced, the listeners are stimulated to produce further ideas which are variants of the first. Suppose that the group is considering a problem in engineering of the relations between two stationary members of an assembly. George says 'Bolt them together'. Frank says 'Or rivet them'. Edward says 'Why not make them in one piece'. Daniel thinks that the combined piece could be moulded in plastics and George jumps in with 'Yes, and if we do that we can simplify the rest of the assembly by moulding in location features and threaded inserts.' So the fourth state is stimulation.

In the brainstorming group, in the value analysis team, in the design team, stimulation comes from within the group. Each man's ideas promote a ferment of thoughts in the minds of his colleagues. Each man interprets or envisages the ideas in his own individual way, so that variations of the ideas come to his mind. In brainstorming, each man is bound to communicate these ideas, although they are mere variations of what has already been said. Nevertheless they are not quite the same as the originals, and so they justify their places in the long list of ideas.

But brainstorming is not the only method of generating ideas, either in a group, or singly. It is perfectly feasible to generate ideas and to criticize them in the same session. The solitary designer, mulling over his problem, commonly assesses his ideas as he works. Elsewhere[2] I have illustrated this by depicting the thoughts of a designer faced with the problem of designing an airtight end cap for a cylindrical body. Each idea in turn is seen to have drawbacks which are avoided in the next idea. So this designer optimizes his design in an alternating succession of creative and critical thoughts. His self-criticism does not inhibit him from having further creative ideas. Indeed, the criticism may stimulate him to further efforts; it may direct him to acceptable solutions by demonstrating unproductive directions of thought, and so lead him to consider his problem from a different point of view.

Exactly the same thing can happen in a group. An idea is proposed and is instantly criticised. The proposer may argue that the criticism is ill founded, or he may accept the criticism and change his idea. The critic may point a solution as he makes his criticism; so may some other member of the group. But whoever produces a solution to the sub-problem set up by the first idea has surely been stimulated by criticism. This is a useful point which is missed by orthodox brainstorming. But the basic point of brainstorming remains; creativity can be inhibited by unsympathetic emotional conditions. Destructive criticism is surely as destructive of idea generation as it is of the ideas themselves. But given the right emotional atmosphere ideas can be freely generated in an intensely critical group. For example:

George: Why not make it of plastics?

Fred: Don't talk nonsense. This cam will get too hot for plastic; unless you think we can afford to make it of PTFE.

George: No, I don't think anything of the kind, as you very well know. And there's an "S" at the end of plastics. The shape of the cam is complex and critical. So it will cost a small fortune to cut it out of metal. But in plastics we could mould it any shape we like, within reason, and get sufficient accuracy straight from the die. So why not make it in plastics?

Edward: I don't want to spoil your fun, but you are missing something. This cam does not have to be in the position shown. We could move it about two inches to the right, and the follower with it, so that the mechanical action will not be changed. But in the new position the temperature will be well within the safe range for ordinary plastics.

Fred: Of course it can, and I don't know why George couldn't have said so in the first place, instead of coming out with only half an idea.

Every designer is familiar with this kind of dialogue, in which creative ideas, critical comments and friendly insults follow in rapid succession. There is nothing inhibiting (or inhibited) about the criticisms made in such a group. Every demonstration that the latest idea is in some way inadequate only drives the group to modify the idea, or to replace it with a better one.

The secret of creating in such a group is no secret at all. The members are conscious of their responsibility as individuals to contribute what they can towards the solution of the problem, and of their responsibility as a group to solve the problem. They will know and respect each other, and their mutual respect will not be diminished by the knowledge that each member has defects and blind spots. Their relationship is likely to be enlivened by a good deal of humour, and this association of humour and creativity has been examined by Arthur Koestler.[3]

There are other means of stimulating creative thoughts than the presence of friendly colleagues. Some of these have been examined by W. J. J. Gordon.[4] He analyses the creative act into nine stages or phases of which Phase 4 is called Operational Mechanisms. A favourite mechanism is the direct analogy. This might be a biological phenomenon which has some analogies with the engineering problem under attack. Or the analogy could be between one technology and another, or between mathematics and a technology.

Another method, popular in value analysis, is to stimulate by means of a checklist. Such questions as can you eliminate this part, or this operation, can you use a standard part, or a standard method, or a standard material, can you buy more cheaply, can be used to provoke the team into producing ideas. These value analysis questions can be applied to most products, but I always recommend firms to construct their own checklists, putting in the stimulating questions most applicable to their particular products.

Various systematic design methods such as PABLA[5] and FDM[6] have been developed, all of which in effect if not in intent stimulate the thinker by giving him a method of operation. For example, the product being designed may be regarded as a 'black box' having an input and an output. The input may take various forms and the designer will list as many of these as he can; and similarly with the output. Then he will list as many mechanisms as he can think of which might transform inputs to outputs; these, of course, are possible contents for the black box. Preferably the three lists (that is of input, mechanism and output) will be written side by side. The designer must then carefully examine every possible combination of input, mechanism and output that can be formed from his lists. In this way he is compelled to consider not only the familiar or favourite combinations, but also combinations that would not readily come to his mind.

Another, but less potent, method is to consider rearrangements of familiar assemblies. The most striking example that I know is the fountain pen. Who was the genius who thought of turning familiar writing materials inside out. For centuries the ink had been stored outside the pen. Now we keep it inside the pen.

It is often possible to produce novel ideas by rearrangement, inversion, or distortion of familiar ideas. The last is especially the method of the cartoonist and the comic draughtsman.

One of the earlier writers on effective thinking was Graham Wallas[7] whose book is now regrettably out of print. Wallas was not a psychologist seeking to understand the act of thought in a scientific and detached manner. He was a teacher, anxious to help his students to develop their own intellectual powers. In a fascinating chapter entitled Stages of Control he analysed creative thinking, as illustrated by many examples, and showed that it occurred in a sequence of four stages. The first he called Preparation, and it corresponds exactly with Gordon's[4] Phase 2, Making the Strange Familiar. It is the collection of relevant data, and in this stage professional competence, intelligence and the will to work hard combine to prepare the thinker for the creative thought.

Wallas called the second stage Incubation. In this stage the problem is not consciously considered. It may be pushed out of mind by the pressure of other work, or forgotten because of the attraction of some leisure activity, or maybe the thinker is asleep. During this stage there is nothing that the thinker can do to reach a creative solution beyond relaxing his mind sufficiently to permit him to sleep, or to concentrate on other activities. Mainly, the thinker must just wait.

Then comes the third stage, sometimes no more than a moment in time. Wallas called it Illumination. Often indeed it has the quality of light. Perhaps the great light that shone upon Saul as he journeyed to Damascus[8] was of this quality. Illumination describes the moment when the thinker becomes conscious of the creative idea. The magical manner in which ideas manifest themselves to the creative mind must surely explain who so many have believed in divine inspiration. We can no more disprove this hypothesis than we can prove that something happens during Incubation.

The evidence for activity during Incubation is barely circumstantial. Incubation is merely an interval of time. It is preceded by the business of Preparation, which however does not lead directly to a solution of the problem. It concludes with the moment of Illumination. The mathematician Poincaré[9] wrote that maybe the interval restored freshness to the mind, but he thought it more likely that during Incubation the mind was working unconsciously on the problem.

The idea that appears in Illumination is usually no more than an idea. It is only a tentative solution to the problem, or an outline solution, or maybe only a clue. It must be worked out, developed, analysed and examined in detail. The clue must be followed up, the outline solution developed in detail and the tentative solution must be tried. This final stage is called Verification, and like Preparation, it can be successfully completed by the willing application of intelligence and professional skill.

Wallas points out that Preparation and Verification are both conscious stages in which the thinker can largely control the operation. He goes on to search for possible means of controlling Illumination.

In its most dramatic form Illumination seems to occur instantly, like a flash. But perhaps the flash obscures the lesser light that precedes it, and certainly some sensitive souls have described an awareness of the approach of Illumination. Wallas calls this Intimation, and for one example he quotes from Shakespeare.[10]

> 'As imagination bodies forth the forms of things unknown
> the poet's pen
> Turns them to shapes and gives to airy nothings
> A local habitation and a name.'

The 'airy nothings', the 'forms of things unknown' certainly convey the impression of a vague awareness on its way to becoming something so precise as to acquire 'a local habitation and a name'. Many designers can recall the same sensation, of an idea trembling to be born, the Intimation of the solution to an engineering problem. Indeed, one is tempted to rewrite Shakespeare in engineering terms, but the effect is hardly literary.

> . . . the designer's pencil
> Turns them to shapes and gives to airy nothings
> A material specification and a part number.

Some thinkers find their Intimation in the form of a certainty that a solution is imminent; some are aware that a chain of associations is leading in a productive direction. The condition is delicate and subtle. It is not coarsely perceived, and the state can readily be destroyed. It is not possible to offer a rule for recognising Intimation, nor to construct a formula which will guarantee a moment of Illumination. But those who have experienced the pains and pleasures of creation will know enough to recognise the first faint stirrings when they recur, and will practise to develop their art by trial and error, by trial and success.

So our essay on creativity has gone full circle, starting with the familiar example of an idea gone astray, then exploring both random and systematic methods of finding ideas, and concluding with the picture of an idea almost lost, then caught, an airy nothing transformed to substantial reality.

References

1 Alex F. Osborn, *Applied Imagination*, Scribner 1953.
2 C. Hearn Buck, *Problems of Product Design and Development*, Pergamon 1963.
3 Arthur Koestler, *The Act of Creation*, Hutchinson 1964.
4 W. J. J. Gordon, *Synectics*, Harper 1961.
5 *A Guide to the Problem Analysis by Logical Approach System*, AWRE Aldermaston 1965
6 E. Matchett and A. H. Briggs in *The Design Method*, edited by S. A. Gregory, Butterworth 1966.
7 Graham Wallas, *The Art of Thought* (abridged), Watts 1949.
8 Acts of the Apostles, 9 v3.
9 H. Poincaré, *Science and Method*, trans. 1914.
10 W. Shakespeare, *Midsummer Night's Dream*, Act 5 Sc 1.

Reprint No. 1:1:14

The Value Engineer's Bookshelf

'It's not only knowing, it's knowing where to look.'

No one in industry today can ever hope to read the mass of printed matter which passes across his desk.
A Three-Star Guide system has been adopted by Value Engineering *as an indication of the relative importance of its book reviews and abstracts for the value engineer.*
Three stars (***) indicates that the material is particularly significant; two stars (**) that it is very useful; and one star (*) that – although important – the information deals with a subject on the fringe of the value engineer's interests.
For an explanation of the use of the keywords which appear in italics above each review see the system of information retrieval which has been explained on the inside front cover.
The number in parentheses ( ) refers to the publisher's name and address given on the inside of the back cover.

Basic concepts – Checklists – Value Standards – Applications – etc.

***First European Value Conference Proceedings

Leslie, H. L. C. (ed.)
Value Engineering Ltd., 1966 68 pages 42/6d. (109)

As a state-of-the-art-in-Europe report these Proceedings hold much that is of interest to practising value engineers in all parts of the world. Reporting, as these Proceedings do, on the views and news of European V.E. at about the same time as the Society of American Value Engineers publish the proceedings of their 1966 National Convention (see SAVE, Volume I, reviewed on page 59 of this journal) those who are interested in comparing the trend of developments in V.E. in Europe and America may easily do so.

Thirty-three companies and 46 conferees are listed as having taken part in this First European Value Conference.

Without pagination reference to individual Papers in these cyclostyled Proceedings is extremely difficult. This, however, is a small matter when the difficulties which faced the editor in organising and publishing the Proceedings on a part-time basis against a very tight personal work schedule are realised. Unfortunately, the Conference (which was held in London) only attracted representation from three other European countries – Italy, Belgium and Holland.

Six companies (Dunlop, Philips, Rolls Royce, A.E.I., British Aircraft Corporation and Woods of Colchester) reporting on the progress of V.E. give readers a range of size, industry and form of application from which they can study the efficacy of the technique in a variety of situations.

Other papers cover matters related to V.E. such as Quality and Reliability, V.E. Training, Information Retrieval, Creativity and the integration of V.E. within a company. It is interesting, too, to note that the relevance of other techniques (such as PABLA and Fundamental Design Method) is recognised and acknowledged.

It is pleasing to note the sincere tribute which Mr Williams (who presented the first paper) paid to the part which Mr Harry Erlicher played in the birth of V.A. According to this paper the first V.A. team in the U.K. was set up in 1957 in the Motor Cycle Fork Division of Girling's factory in South Wales and this makes the technique about ten years old on the European side of the Atlantic.

The Proceedings report cost-saving ratios which will be of interest to those who come new to the subject and wish to know the kind of performance which they may reasonably expect from V.E. effort. The Job Plan outline by Mr Engwell presents an interesting variant of this theme, and Mr Bowyer's treatment of Q & R presents this subject in an interesting light. The 'Value Disciplines' discussion by Mr Smithers points clearly to value being everybody's business, and leads to consideration of value engineering as a way of thought which should permeate an organisation rather than be simply applied by a V.E. section. Many value engineers have not realised the important part which 'knowing where to look' can play in their work and Mrs Withers draws attention to 'the relevant 4 per cent' of information and the fact that 'ignorance is not bliss but technological suicide.'

Mr Arthur Garratt's preliminary treatment of the 'Theoretical Evaluation of Function' presents an important advance in the development of V.E. method, and one if incorporated with other thinking on the subject could lead to an important break-through in the problem of building useful, practical Value Standards.

Appropriately, the editor of the Proceedings (Mr Leslie) has the final word: 'We can,' he says, 'looking toward the future, accomplish major things if we establish proper objectives. I sincerely hope that all of us gathered here will think in terms of developing Value Engineering rather than promoting the individual Value Engineer.'

B.D.W.

Creativity – Invention

*The Use of Lateral Thinking

de Bono, E.
Johnathan Cape, 1967. 157 pages. 18/– (103)

Lateral thinking is described as being a different, more creative way of using the mind to generate new ideas. According to the author this type of thinking does not call for exceptional intellect. The book begins with an illustration of the application of lateral thinking technique which results in a happy ending to a fairy tale dilemma. The illustration shows how this type of thinking can be consciously applied to break through an impasse created by the traditional, logical or vertical method of thinking.

Apart from the interest of this book for those whose daily work involves 'ideasmanship', its appearance adds to the widening recognition being given to methods of stimulating creativity.

Dr Gillespie, speaking at a recent Design Conference and using Space analogies, classified people into those who are 'ground directed', 'beam riders' and 'target identifying' people. Those people who just do what they are told and no more, who don't know (or care) where they are going, he called 'ground directed'. The 'beam riders' were those who have direction and a target but who, if the target moves, are lost. Others who have creativity and only need to be launched were the 'target identifying' people. These seek out the target for themselves and make any necessary corrections to their direction as they go along. Stimulated by the unknown, these people want to add what ought to be to what was and what is. Dr Gillespie goes on to warn that 'target identifying' people can be rendered ineffectual by poor launching or misguided interference from a superior. Superiors, he says, should realise that it requires as much creativity to manage creative people as it does to create.

As the writer modestly claims 'No textbook could be compiled to *teach* lateral thinking. . . . The idea is to show what lateral thinking is and how it works, and then to stimulate readers to develop their own potential for thinking in this manner.' This is exactly what Mr de Bono succeeded doing with a doubting reviewer. D.W.

Management Techniques – Glossary

*Glossary of Management Techniques

Barraclough, S. (ed.)
H.M.S.O., 1967. 26 pages. 2/9 (105)

Although this glossary briefly describes the techniques used in the management and cost accounting fields, written in layman's language it explains clearly many of the aids to efficient management which are available. It is intended (as the editor explains) to be used merely as an indicator as to 'whether a particular problem might be a suitable candidate for the application of a particular technique', and in this respect has an interest for Value Engineers. Together with such other term-defining works as 'Glossary of Terms in Work Study' (B.S.3138:1959), 'Terminology of Cost Accountancy' (Institute of Cost and Works Accountants), and 'Guide to Management Techniques' (B.I.M.) it provides a memory tickler for the Value Engineer who is searching for a solution to a problem.

The Glossary omits a description of marketing techniques, but includes an explanation of 'network analysis', 'operational research', 'cost-benefit analysis', 'cybernetics', 'discounted cash flow', 'management audit', and 'ergonomics'—some of the frequently referred to terms in business today.

To those concerned with Value Engineering it may be of interest to have H.M. Treasury's definition of 'Comparative Value Analysis' – 'the comparison of the cost of an object with the value obtained from it, to determine whether the value justifies the expenditure' – to ponder on. This definition and the associated description of 'Value Analysis' makes no use of the word 'function' which the reviewer (up until now) felt was essential to a proper explanation of this technique.

However, as one who has played a small part in compiling a slight work on 'Management Nomenclature', the reviewer can appreciate the editor's task. B.W.

Creativity – Invention – Checklist

*Creativity at Work

Simberg, A. L.
Industrial Education International, 1964. 188 pages. 53/- (107)

'A strong imagination', Montaigne wrote, 'begetteth opportunity.' Mr Simberg (a psychologist and the General Supervisor of Salaried Personnel for the A.C. Spark Plug Division of General Motors) sets up a practical guide as to how to attempt to develop a stronger imagination.

Everyone – so the author contends – has *some* creative ability, and he explains step-by-step procedures for developing more and better ideas. He also shows how creative employees can be recognised by Management.

As a source and stimulator of new ideas, the value engineer is vitally interested in methods for increasing creative ability. The author covers the use of creative powers, how to build an 'idea' bank, the organised approaches to creative problem-solving, and (very importantly) the appropriate techniques for supervising creative people successfully.

N.D.H. (Not Developed Here) all too often is the label given to new ideas by those who have shut their minds to progress. The company which has the slogan 'Progress is the ability to make ideas work' recognises the 'roadblocks' (other than perceptual and cultural) which confront innovators.

Five organised approaches to creative problem-solving are dealt with by the author. These are Applied Imagination (developed by Osborn), Input-Output (General Electric), Attribute Listing (Crawford), Area Thinking (Arnold), and Checklists (Osborn and Small).

Brainstorming is treated in some detail and the section 'Supervising for Ideas' gives a useful checklist with which supervisors can test the 'climate for ideas' in their departments.

There is a very useful list of references at the end of each section. T.M.

Value Standards – Cost-estimating – Time Study

**Primary Standard Data

Neale, F. J.
McGraw-Hill, 1967. 165 pages. 55/- (101)

This book explains an abbreviated form of the MTM and PMT systems. Using British units it sets out the method so that it may be mastered in 6–8 hours.

Its other great advantage – the author points out – is in the shortness of time it takes to apply. Whereas it may take 120 minutes of PMT study for one minute of work it only takes 20 minutes using Primary Standard Data (PSD) for the study of one minute of work. PSD is as quick to apply as conventional time study and six times faster than the PMT (Pre-determined Motion-Time) system.

It is claimed for the PSD system that 'a reasonably intelligent person at the end of a day's instruction can handle satisfactorily the assignment, "Measure the time required to do this work".' After two weeks' training a Work Study Officer can set (so it is said) standards as fast as with conventional time study methods. However, the real advantage of PSD is when it is used to generate synthetic costs. Using PSD – which assigns time values to the motions of GET, PUT, TURN and CRANK, etc. – the designer and value engineer can establish at the drawing board stage standard manufacturing times for each piece part and for the assembly as a whole. The author, by compiling a most comprehensive bibliography of MTM references, has made a most useful contribution to the study of work measurement systems in general, and the classification of the bibliography according to specific industrial applications points the way clearly for those who have particular uses in mind. C.B.

New Products – Design – Patents – Checklist

*Problems of Product Design and Development

Buck, C. Hearm
Pergamon, 1963. 172 pages. 12/6 (102)

The writer sets out to provide the manager with a short introduction to the problems of developing new products, and to help the young designer appreciate the significance of what he is doing. By providing useful chapter summaries for those-who-run

to read, and worthwhile references for follow-up reading he accomplishes his purposes very successfully.
For the value engineer his chapter on 'Function and Use' makes interesting reading as it draws attention to those points which he cannot afford to overlook in any new design or contemplated design change. These include the legal requirements affecting the design, the requirements of British and International Standards and ergonomic considerations.
As well as design-for-use (the ergonomic considerations) design-for-production too must be given full consideration. Standardisation, the economics of tooling, low-cost automation, and total quality are included in the designer's thoughts. Since the product is being designed for sale, handling, packaging, storage and transport must figure prominently in design discussions, and buyer-appeal, reliability and ease of servicing must also be incorporated in the original specification.
The new product, as the author comments, must be properly priced so that it will sell and there must be a market for it! To be sure of these two things, there must be arrangements for the feed-back of information upon them and for its intelligent evaluation.
All of these things will only be achieved through the correct selection of designers and the proper co-ordination of new product design. Value engineers who are anxious to secure for their employers (or clients) the maximum benefits of their ideas may find it worthwhile remembering what Mr Buck has to say about Registered Designs: 'In addition to the protection of technical improvements and inventions by means of patents it is also possible to protect the *appearance* of a new product by registering the design which, in the first instance, is for five years which may be followed by two further periods of five years.' C.W.R.

Creativity – Patents – Invention

How to find out about Patents

Newby, F.
Pergamon, 1967. 177 pages. 30/– (102)

The reviewer recently came across this footnote on a Value Engineering Results Sheet – 'This recommendation resulted in the award of U.S. Patent No. 2,715,180 issued 8/9/55 to R. A. Beers'. It indicates one aspect of the Value Engineer's practical interest in Patent matters.
The Value Engineer at times faces the possible limitation of the application of his ideas due to the existence of Patents surrounding the piece of equipment he is analysing. Again, being anxious to secure the best for his employers, he needs to be armed with enough information to ensure that he does not overlook the possibility of patenting any suitable ideas which he may bring forward. According to Dr Johnson, 'Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it.' Mr Newby's book – which is very conveniently organised for reference – will be useful to Value Engineers for it will tell them how to find out if a Patent on their ideas has already been applied for; if a Patent application on similar lines has not been carried through to completion and abandoned; and if a Patent of an idea is at present in force and is now being worked.
Reference to the book will ensure that Value Engineers do not overlook any necessary action through lack of knowledge of the requirements of the Patents Act of 1949 and various other related Acts and amendments to them.
Chapter 11 outlines the Non-official Patent Abstracts which can be a useful guide for those for whom it is sufficient to keep abreast of what is being patented in their own particular field.
A.C.W.

Value Standards – Cost-estimating – Glossary – Time Study

**Cost Estimating and Contract Pricing

McNeill, T. F. and Clark, D. S.
Elsevier, 1966. 528 pages. 150/– (104)

To help him to answer questions about costs the Value Engineer is constantly seeking useful sources of information such as the two authors – practising Value Engineers themselves – have provided in this book.
The system they outline is based on the 'Jo Bloc Technique' the application of which they have amply illustrated with 127 charts and graphs interspersed amongst the text. The 'Jo Bloc Technique' is based on a consistent measurement for the most fundamental elements of work effort. Its *absolute*-standard approach to cost estimating – with any variables fairly 'weighted' and then applied on top of the *absolute*-standard – has proved to be a very effective tool for cost-estimating. The joint author Mr McNeill is at present engaged in the further development of cost-estimating systems.
The book also contains brief, but useful, descriptions of and standards used in fabricating, machining and other processing and assembly operations. The practical application of the Learning Curve is dealt with in some detail, and the book concludes with a Glossary of Terms used in related subjects.
As well as to Value Engineers, the book is useful to those who are responsible for making engineering estimates more competitive and for controlling engineering costs.
The information in this book will provide Value Engineers with further tools to assist them in making their cost estimates more realistic. J.J.T.

Basic concepts–Creativity–DOD–Methodology–Training–Marketing – Maintenance – Pricing – Value standards – Advanced Techniques–Management Appreciation

***SAVE, Volume 1 — Society of American Value Engineers, Proceedings of the 1966 National Convention

Ross, T. A. (ed.)
Spartan Books, 1966. 315 pages. 80/– (106)

As the editor says 'many varied, divergent opinions and techniques are presented' in this book which contains conference papers which cover the whole gamut of V.E. from basic concepts through creativity, operating relationships, methodology and training to its wider applications to marketing, maintenance and competitive bid pricing strategy.
Many of the titles of the papers show an awareness of the problems facing the profession – 'Influencing Others', 'Combating Professional Obsolescence', 'Expanding Creative Potential', 'Results – Not Just Recommendations', and so on. The paper on the Ling-Temco-Vought *Let's Target Value* programme shows how ingenuity can be used to 'sell' V.E. to all those in an organisation, and the paper dealing with the application of mathematical models in V.E. shows the ever-widening use which is being made of new analytical techniques. Speakers at the conference came from Europe also, and they reported on recent developments there.
The selection and training of value engineers (and of V.E. instructors) and the position of V.E. in the corporate structure came in for attention at the conference. In this connection there was a paper on the 'Integration of V.E. into the Graduate

Business School Curriculum' describing how this was accomplished at The Amos Tuck School of Business Administration in New Hampshire (US).
It was interesting to note the extent of the various decision influences on total system cost.
As a state-of-the-art report the conference proceedings are well worth the perusal of value engineers who will find much in it – as the Round Table motto says – to 'adopt and adapt' to their own needs.
'Potted' biographies of the authors make interesting reading.
F.C.

Purchasing – Checklist

***Negotiated Purchasing

DeRose, L. J.
Materials Management Institute, 1962. 350 pages. 65/– (108)

The Executive Director of the Materials Management Institute describes the techniques which such companies as GE, RCA, IBM and Westinghouse adopt to make purchasing a *profitable operation.*
Materials – which take the biggest bite out of the income dollar – is still not being regarded for the opportunities that it presents for cost reduction. The author introduces a fresh perspective on the purchasing function by putting the dollar sign on such negotiable points as quality, quantity, delivery and *functional* value.
By providing helpful answers to the Value or Purchase Analysis questions on 'How do you measure value and how do you negotiate to get it?', Mr DeRose adds a good book to the literature on industrial purchasing. He gives six 'keys' to effective Purchasing performance – Purchasing reviews and evaluates sources; Purchasing analyses and weighs vendor capability; Purchasing takes positive action to influence the price of goods; Purchasing insists upon full value; Purchasing administers and follows-up vendor performance; and (finally) Purchasing recognises that purchase dollars are invested dollars and these must be efficiently managed for optimum return.
The checklists in Section 3 provide the Value Analyst/Engineer with useful reminders of the things which he should be considering to (1) ensure design value at lowest cost, (2) improve producibility, (3) increase the use of standard products, and (4) substitute lower cost material. The consideration of these matters will result in achieving the V.A. objective of 'equivalent or better material design, performance, or reliability at lower cost.'
The Purchasing executive will find in this book a great deal of useful information on negotiating. A.L.B.

Basic Concepts – Methodology – Management Appreciation

***Value Analysis

Gage, W. L.
McGraw-Hill, 1967. 186 pages. 55/– (101)

Value engineers working in Britain will welcome a book on their technique which, as well as presenting a great deal of American practice, contains many local references.
Written by an engineer-turned-teacher and one who has had considerable industrial experience, the book provides for those who are beginners in the subject an explanation of the basic concepts of Value Analysis in a clear and practical manner. The author does well what he sets out to do and – because of this – the book stands up extremely well to the test of *functional worth*!
The author, who claims to deal only with the basic concepts of Value Analysis, directs the attention of readers who require a fuller treatment of the subject to L. D. Miles' *Techniques of Value Analysis and Engineering* from the same publisher.
Readers interested in historical and philosophical aspects of the subject will find an interesting account of the contributions made by Erlicher, Winnie and others to the initial development of Value Analysis, and they will learn of the names of many of those associated with promoting the technique in Britain.
An organised system for handling a value assignment is illustrated by Mr Gage who also draws attention to the various creative techniques which may be applied to solve management problems as well as value engineering problems. He does not neglect the implications for Value Analysis of modern purchasing methods, critical path planning, the control of variety, marketing and sociology. On the subject of the training of value engineers and the position of the Value Engineering function in a company's organisational structure, the author's views deserve the attention of all managers who are considering setting up a value engineering activity, and his outline of a 'pathfinder team' approach for gaining acceptance for value engineering indicates a close familiarity with the problem. B.D.W.

Applications – Basic concepts – Management Appreciation – Training

***Second European Value Conference Proceedings

Bowyer, F. (ed.)
Value Engineering Ltd., 1967 104 pages 42/6 (119)

Seventy-five conferees and their eight guests from industry and government thought the subject-matter of the second annual European conference on value sufficiently important to devote four days of their time to it. The number of delegates (nearly double the previous year) is indicative of the rapidly increasing interest which is being shown in Value Engineering.
The developing concept of Value Engineering as a Universal Tool of Management (just as Logarithms are regarded as a universal tool of calculation) is touched upon by Mr Leslie. It matters little where and on what business activity the value disciplines are practised as long as they are used.
After the introductory remarks the Conference got underway on the sound advice of the Chief Value Engineer of the Rolls-Royce company urging the delegates to take an alpine view of Value Engineering. Subsequent speakers dwelt upon the implementation of V.E. Change Proposals (two papers on this), decision-making techniques, methods of motivation, monitoring V.E. proposals by Computer, and value and the consumer.
The application of Value Engineering in Sweden and to the British shipbuilding industry presented further interesting information, and reports at the Conference on the results from V.E. exercises showed them to be well in line with those put forward at similar gatherings in other parts of the world.
A paper on 'Education and Value Engineering (by Mr Boden) presents food for thought. The fundamentally important question which he posed – What should be the V.E. training of people going in for engineering? – should, in the reviewer's opinion, be provoking more attention that the half-page of reported discussion seems to indicate.
The ten conference papers and discussions are followed by 'Hightlights' out of the reflections of the six teams of delegates upon them. Top Management support, successful implementation, adequate cost information, company-wide applicability of the technique, and its place in the educational curricula were among the matters mentioned. It was said too that the Press tended to give too much attention to case histories and not enough space to the propagation of the underlying principles of Value Engineering.
The Proceedings have appended to them nineteen letters and other comments, and a list of delegates who attended the Conference. Value Engineering Limited's efforts in organising such a useful gathering on an annual basis should not go unmarked.
B.D.W.

Reprint No. 1:1:15

Selected Abstracts of Recent Literature on Value Analysis/Engineering

Miss C. Maby — Abstracter

'Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it.' — Doctor Samuel Johnson.

These Abstracts were derived from searches in the 1967 issues of the British Technology Index (January–October) and from articles appearing in the press and business journals during 1967.
Readers wishing to consult the original texts in the periodicals may visit the National Reference Library of Science and Invention (Holborn Division) or may order in writing photostat copies of them at 9d. per page from that Library at 25 Southampton Buildings, Chancery Lane, London, WC2, England.
The Library is open from Mondays to Fridays 10 a.m. to 9 p.m., and on Saturdays from 10 a.m. to 1 p.m.

Abstracts will appear in each issue of this journal. They are serially numbered, and an Index of Abstracts will be provided with each sixth issue of the journal. All articles in Value Engineering *will have abstracts and reference to them will also be included in the Index.*
In the meantime, value engineers may care to set up their own system of information retrieval as outlined on the inside front cover.
The number in the round brackets ( ) refers to the publisher's name and address given on the inside of the back cover.

Abstracts [1] to [14]

[1]

Applications – Aircraft industry – Basic Concepts – Training – Value Standards

Ewans, J. R.

Cost Reduction and Cost Avoidance by Value Engineering
J. Royal Aeronautical Society, 71 Feb 67 pp. 93–116 il. tables refs. dis. (10)

As Manager, Economics and Project Analysis at B.A.C. (Operating) Ltd., Weybridge, the author has produced a well-rounded dissertation upon V.E. as used in his company.
He sets out a training programme and provides in a table conclusive evidence of the efficacy of the training method – a 51 per cent cost reduction on a series of components analysed in five 30-hour sessions of 5-men teams.

Mr Ewans indicates that a start has been made at Weybridge in compiling a V.E. Handbook or Cost Data for the use of value engineers and designers. The position of V.E. in the company organisation and details of V.E. in Government contracts are also given together with a useful and interesting appendix setting out the form of submitting a V.E. Proposal, the historical development of V.E. techniques, and a collection of 10 examples of V.E. changes introduced by the B.A.C.
To the article is also appended a 6-page record of the discussion on Mr Ewans' paper in which Mr Jacobs' description of the method used at Weybridge to establish priorities for V.E. investigations is likely to be of interest to those who are charged with this task.

The article is of great value to those who are not in the aircraft industry but who are vitally interested in the contribution which V.E. can make to British industry's competitiveness.

[2]

Training – Management Appreciation

Dove, M. L., Sutcliffe, J. K. and Ritchie, R. P.

Value Analysis as a Contribution to Management Development
Works Management, 20 Apl 67 pp. 11–14v il. (6)

The writers – three Value Analysts from A.E.I. Rugby – report that the effect which V.A. has had upon their personal development was the acquisition of a Management viewpoint on costs. Few graduate engineers leaving the universities they claim have any concept of costs and their relation to design and production. As under his terms of reference the Value Analyst has the time and *freedom* to investigate every element of costs he automatically becomes aware of what is costly to make and sell and he learns to estimate the value of a function. The Value Analyst also acquires a facility of working with people and in the great value of centering attention upon products and not on people's positions in an organisation.

V.A. work also assists in giving practical experience in recording, collating and presenting information in a lucid manner and it is an ideas outlet for the enthusiasm of the young engineer.
A good illustration showing PARTICIPATION – IMPACT – and PENETRATION sums up the authors' views.

V.A. they have concluded (after 2 years' practice) is not *just* an effective method of cost reduction. It provides the ideal opportunity for young engineers to expand their outlook and increase their maturity. Whilst these changes are taking place in the young engineer he is contributing to the company's profits.

[3]

Applications – Steel Industry – Value standards – Management appreciation – Checklist

Boyd, L.

Value Analysis at Bilston Iron and Steel Works
Steel Times, 193 11 Nov 66 pp. 642–650 il. (5)

Mr Boyd (now executive assistant to the General Manager of the Bilston Iron and Steel Works) presents an edited version of his project report submitted in the Diploma of Management Studies at the Wolverhampton College of Technology.
The V.A. targets set for Bilston were £10,000 in the first year working up to £30,000 p.a. in the second year. This decision was influenced by the fact that S.C.O.W. had saved £100,000 in its second year and its output was three times greater than Bilston's. In the first sixteen months 60 items were analysed and a total of £30,000 saved.
Case histories reported indicate that these savings were effected by standardisation, design change, alternative materials, dimensional changes, different method of manufacturing, and the recovery of scrap.
All was not easy and the problems encountered were of both a technical and human relations type. These kind of questions required answers:

Whose responsibility is V.A.?
How much information do you need?
Why was this not thought of before?
No, that will never work.

Useful forms and checklists fully illustrate the system used at Bilston.

[4]

Basic Concepts – Management Appreciation

Gibson, J. F. A.

Value Analysis/Engineering
J. Irish Management Institute, 14 Oct 67 pp. 13–17 il. (11)

The writer – Value Analysis Consultant to A.E.I. in England – holds that V.A. is caught rather than taught; that once begun it causes a chain reaction and it acts like a catalyst causing things to happen without executive authority.
Mr Gibson treats the basic concepts of V.A. in a refreshing way covering the consideration of functional worth, the reasons for unnecessary cost, etc. and sets down seven requirements in order that a V.A. exercise may have a chance of success.
He divides the information required into 'Hardware' and 'Paperwork'. In the 'Hardware' he includes the assembled product (if this is feasible), a set of loose identified components, samples of the raw materials, and competitors' products for comparison. The 'Paperwork' consists of drawings, specifications, production planning, suppliers, ordering quantities, prices, labour and overhead costs, material weights and scrap details. All this information is seldom available at the commencement of an exercise and it has to be collected as the analysis proceeds.
His two diagrams present the ideas of who contributes to a V.A. exercise and what benefits (both tangible and intangible) can be derived from it in a very clear manner.
As Mr Gibson says 'V.A. makes people appreciate the other fellow's job' and 'a value-engineered product is a better product'.

[5]

Maintenance – Applications – Steel industry

Davis, J. H. W.

Value Analysis
Plant Engineer, 10 Nov 66 pp. 178–183 il. dis. (4)

Mr Davis who is Manager of the Purchasing Research Dept. of The Steel Company of Wales, describes the applications of V.A. to the reduction of maintenance materials costs and to capital projects and contracts. S.C.O.W. spends £18m p.a. on maintenance material items such as machinery spares, consumable stores, rolls, oil and bricks apart from what it spends on raw materials. This total expenditure is broken down into approximately 2,000 items (called 'key parts') which each cost more than £1,000 p.a.
The author describes the type of V.E. fact finder that the company seeks who then refers the information which he has collected to an analysis committee.
He contrasts cost reduction with V.E. Cost reduction looked at a mouse trap which was costing 1s. and by altering the wires, changing the wood, etc. reduced its cost to 10d. V.E. asks *what does it do* – the *function* is to kill mice. This can be done for 2d. with rat poison. The great value to be derived from good supplier liaison is also stressed by the author who also mentions a 50/50 sharing with the supplier of any savings.
Organisational barriers soon break down before the V.A. approach because everyone is acting on a constructive way towards the solution of the problem and not defending their own interest in it.
A record of discussion follows the paper.

[6]

Applications – Rubber Industry

Smith, E. P. and Crowther, B. G.

Value Analysis in the Rubber Industry
Rubber J. 149 Sep 67 pp. 21–29 il. tables (7)

The joint authors from B.T.R. Industries Ltd. discuss why V.A. must be applied, how it can be used in the rubber industry, and give a case study of its application to the moulding of a complex compound.
They advocate that V.A. be carried out by a team of 3–5 people from different disciplines which in the rubber industry might include a rubber technologist, production engineer, product engineer and a costing man.
At the analysis of function stage the authors warn against the dangers of *over-specification.* They say 'not infrequently the standards are so unrepresentative of *real* conditions which the component must withstand that they introduce extra cost without increasing the value.' If the customer is specifying conditions which are bound to be a cause of poor value then he should be invited to be present at the value analysis session and this should serve a double purpose of releasing you from unnecessary limitations and convincing the customer how closely you have his interests at heart. The chart for a rubber company showing the Component, its cost per lb, S.G., cost per cu in, per cent NeORHC per hour, cost per cent of total material cost, and function gives a useful model for other industries.
The diagram of the V.A. process presents a clear step by step visual description of the stages.
The authors claim from this V.A. effort that a compound of equivalent properties to the original was produced with a savings of 20 per cent on material costs and an improved flex resistant compound could be produced with about 12½ per cent savings.

[7]

Applications – Training – Value standards – Agricultural implement industry

Meile, C. H. and Kenny, J. M.

Value Engineering – I.H. Makes it Work
Metal Progress, 90 Oct 66 pp. 170–182 il. (8)

These two engineers at I.H.C., Chicago, describe the build up of a strong training programme in the Company designed to make V.E. principles and techniques a 'natural way of life' with all cost-generating personnel.
The programmes conducted by the company are world-wide.

Their method is to select for analysis by the participants products which are in the design stage, for it was found that those in manufacture required a great deal of time for their implementation.
High cost areas are established by comparing cost per pound, per length or per property. Cost values are also established (e.g. by dividing the weight of a casting into its cost) and where variations occur these are further investigated.
The authors describe the organisational set up of V.E. The management of each division appoints an individual to co-ordinate the value activities within the division. One or more engineers are assigned the responsibility in the design department. Each manufacturing operation also has a V.A. group which applies value methodology to the products being produced.
These people work closely with the divisional value co-ordinator. The Corporate Engineering Research Department (which reports to the Vice-President of Engineering) includes a V.E. staff group which co-ordinates all value activities throughout the company.

[8]

Training – Management appreciation – Value standards

Dwyer, R. M.

Value Engineering Management for Engineers
Mechanical Engineering, 89 May 67 pp. 18–20 il. (2)

V.E. is a team effort which fact management appreciates more readily than designers.
According to Mr Dwyer, Asst. Project Engineer, Honeywell Aeronautical Division, Minneapolis, Minn., teaching V.E. to engineers is always a challenging experience but once they have got the message it promotes company growth.
The audience seems to divide itself into one-third who adopt the position 'Good engineers always do V.E. anyway' and the other two-thirds who say 'Yes, this is good, but my job is to make the device work.' The author defines V.E. as 'a formalised tool for returning profit for the owner through cost-problem solving'. Where the technique is being applied systematically companies are getting a minimum return on investment of at least 5:1, in contrast with 20 to 30 cents in the sales dollar.
Many users of V.E. relegate its application to the piece-part level and to the purchasing and planning departments which tackle the cost problem way downstream from its root cause. The author describes how the profit-team concept works in practice and that the cost per function dimension provides a meaningful goal for solving cost problems.

[9]

Value standards – Design – Producibility

Eccleston, D.

Value Analysis – is it a cost or an investment?
Mass Production, 43 Mar 67 pp. 35–40 il. refs. (9)

Mr Eccleston, Asst. Production Engineer at Electro-Hydraulics Ltd., briefly describes V.A., the creation of a V.A. section, the method of selecting a component to be analysed, and ways of assessing the tangible results from the work. His conclusion is that 'there can be few fields where V.A. would not pay a dividend'.
The author points to the need to consider 'TIME' costs. The price of the component being analysed will eventually be compared with the *present* price of an alternative so both costs must be on the same basis with regard to quantity, wage alterations, etc.
He classifies components into B.O.F. (Bought Out Finished), M.O. (Made Outside, e.g. castings), and M.H. (Made Here).
The author includes two significant quotations in his paper:
1. 'We seem to be overlooking the most profitable avenue of all, namely better design, which can do more than anything else to reduce cost.' (Conway, H. G. 'Design and Designer' in *The Chartered Mechanical Engineer*, June 1963.)
2. 'Even by ruling out design change and confining V.A. to such aspects as the more effective use of raw material, closer attention to minimum metal removal on forgings and castings, and extending the use of such processes as cold heading and impact extrusion on bought out components very effective savings are still possible.' (Dunn, H. G. 'V.A. Applied to Mass Production Tooling' in *Tooling*, Feb. 1966.)

[10]

Overheads – Indirect Costs – Value Control

Anon

Trimming the Overheads Burden
Financial Times 24 Nov 67 p. 15 (14)

Evidence that V.A. can substantially reduce overheads presented to the V.A. Conference at Harrogate on 23rd November, 1967 by Mr Chappel of Mead Carney and Company showed an average return of 15:1 on investment in V.A. was achieved within one year of its application.
There was at present a vital need for such economies due to the increasing proportion of overheads (as high as 50 per cent) in the cost of goods.
Four approaches for reducing overhead costs – budgetary control, O & M, inter-firm comparison, and arbitrary across-the-board cuts – have been tried and failed.
A more effective check on rising overheads is offered by Value Control, a technique based on (1) the analysis of costs on a *functional basis* rather than on a departmental basis and (2) the objective comparison of the value of a function with its total cost. Each *activity* is evaluated like a component in a product.

[11]

Design – Value standards – Target cost

Posser, F.

Frequent Design Reviews Help Product to Succeed
Product Engineering, 37 12 Sep 66 pp. 118–119 il. (3)

Reviewing products should start early in the concept stage according to Mr Posser (Value Engineer for Airborne Instruments Laboratory, Deer Park, N.Y.). Smart management at the engineering stage can usually eliminate most of the worst bumps in the product's path to market. It is essential that engineers have complete specifications and know manufacturing cost targets when they are designing a product. Designing for *least* cost is too nebulous – the designer wants to be given a cost target.
Ordinarily 20 per cent of the parts account for 70 per cent of the total cost and Mr Posser and his associates are building up a store of data on tape and microfilm which will be useful for cost analysis during the design stage. Much pertinent information exists but it has never been put in a form that is useful to design engineers.
'Ironically', Mr Posser comments, 'a successful value engineering job (at the concept stage) is only negatively visible, is marked only by the absence of belated changes and of cost overruns. . . . If you design it right the first time, you can't show exactly how much money you've saved.' The way to help a product to succeed is to have frequent design reviews.

[12]

Applications – Automobile Component Industry – Basic concepts

Milillo, J. P. and Noris, E. P.

Value Engineering
Tool and Manufacturing Engineer, 58 Apl 67 pp. 30–32 il. (1)

The article describes the classical approach to the value engineering of a Windshield Washer Pump by a Group under the Chairmanship of Mr Noris (Manager, Cost Control and V.E., Red Bank Div. of The Bendix Corporation) and Mr Milillo (Group Leader, Operation Improvement, Manufacturing Engineering, Gruman Aircraft Corporation) which resulted in a cost saving of 13.2 per cent (on $1.09) and an annual savings of $362,500. In analysing a product, it is sometimes easier to determine functional *areas* than specific functions. This is done by first dividing the product into that portion which makes it work (performance) and that part which makes it sell (attractiveness). The performance portion can be broken into mechanical, electrical, chemical, etc. Attractiveness may be subdivided into machine finish, surface coating, shape and form.

Evaluating these functions highlights those areas of cost which might be out of line.

Maximum benefit from a V.E. exercise depends on timing and 50 per cent of all V.E. effort should be directed at the design stage with cost-estimation assistance provided by way of personnel and/or value standards. Forty per cent of V.E. activity should be devoted to the production engineering stage before hard-tooling and production start up, and 10 per cent reserved for 'second look' V.E. which is sometimes distinguished by the term Value Analysis.

[13]

Basic concepts – Methodology – Applications – Management Appreciation

Garratt, A.

Value Engineering
Management Decision Autumn 67 pp. 49–55 il. tables (13)

The Technical Director of Value Engineering Ltd., in an introductory article, defines four separate functional meanings of 'value' – cost value, use value, exchange value and esteem value – and provides a simple equation for use in comparing the values of articles of varying prices.

He analyses the functions of the article and the techniques of accomplishing the functions at the lowest cost, and sets out the V.E. Job Plan defining the phases in its execution. He discusses the preparation and use of a Good/Bad Chart in performing the analysis of functional worth.

The function and scope of V.E. and the steps involved in setting up a V.E. Programme are discribed, and its possible application in other fields is outlined. The article is useful to anyone wishing to gain an overall picture of this technique of V.E.

A chart showing what tolerance costs and graph of time against return on investment mark the writer as a knowledgeable practitioner of the art of value engineering, and his inclusion of statements such as the following:

> 'Value engineering is an irreversible process, like the loss of innocence. Once a person has experienced it, he is never quite the same again.'

help his readers to retain the 'message' which he preaches so well.

[14]

Basic concepts – Methodology – Management appreciation

Garratt, A.

How to Get Value from Analysis
Management Today May 67 pp. 80–83 il. (12)

Mr Garratt, Technical Director of Value Engineering Ltd., examines the psychological and mechanical problems of implementing V.A. He quotes a fairly constant implementation (or 'leak') time of the order of eighteen months and provides a leak time analysis in which the V.A. process follows the pattern of value engineering, proto-type development and testing, production drawings, tooling, debugging and stock build up.

The writer describes two approaches for reducing the leak time – putting pressure on the people involved and the use of critical path analysis. He concludes that value engineering applied from the beginning of product development will produce greater cost savings than value analysis of an existing product.

This is an excellent contribution to value engineering and managers and those connected with design and production will find it useful reading.

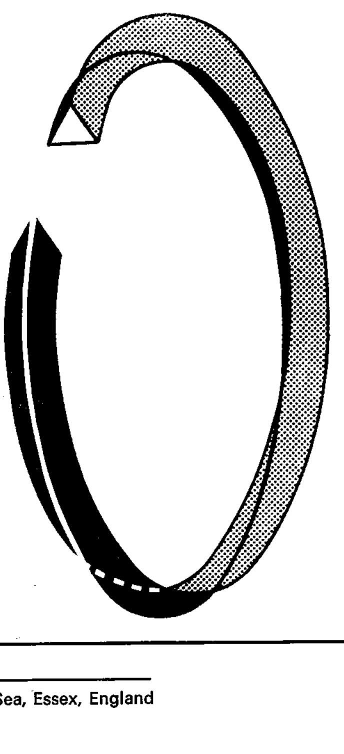
An idea for the Mobius strip

Increasing value-in-use (or the life of a product) is one of the constant pre-occupations of all good value engineers and in this connection the conversion of a driving belt into a Möbius strip is worth considering. (A Möbius strip may be made by holding a strip of paper out flat, giving it a half twist at one end, and then sticking the two ends together.) If all the available surfaces of a belt (three with a vee-belt) were used to transmit power then the wear – being distributed over a larger surface – should allow for an increase in the service life of the belt. With a vee-belt this could be 50 per cent or even higher. By converting a vee-belt into a kind of Möbius strip you thus reduce the three surfaces in contact to one.

This drawing of a vee-belt which has been twisted through 120° should not be too difficult to manufacture and when put into service every part of its three surfaces would come into contact with the driving and the driven pulleys twice for every three times of a conventional belt.

But – why stop at this? Similar principles apply to square section, or to a flat belt, or to an n-sided belt, or (in the limit) why not give a minute twist to a circular belt?

A final thought for the curious. We all know that a *flat* Möbius strip acts very strangely when it is cut longitudinally. Try cutting a triangular section Möbius vee-belt.



Vee-belt twisted through 120°

Quicks the Printers, Clacton-on-Sea, Essex, England

Reprints from Value Engineering

Value Engineering is providing a service by which reprints of *any* article or checklist can be supplied at short notice. For details of prices exclusive of postage see below.

No. of Reprints	1-2 pp	3-4 pp	5-6 pp	7-8 pp	9-10 pp
50	£4. 5. 0.	£8. 5. 0.	£12. 0. 0.	£16. 0. 0.	£19. 15. 0.
100	£5. 0. 0.	£9. 10. 0.	£13. 15. 0.	£18. 0. 0.	£22. 5. 0.
200	£6. 15. 0.	£12. 0. 0.	£16. 15. 0.	£21. 15. 0.	£26. 15. 0.
300	£8. 10. 0.	£14. 5. 0.	£20. 0. 0.	£25. 15. 0.	£31. 10. 0.
400	£10. 0. 0.	£16. 10. 0.	£23. 0. 0.	£29. 10. 0.	£36. 0. 0.
500	£11. 15. 0.	£19. 0. 0.	£26. 5. 0.	£33. 10. 0.	£40. 15. 0.
750	£16. 0. 0.	£25. 0. 0.	£33. 0. 0.	£43. 5. 0.	£52. 5. 0.
1,000	£20. 0. 0.	£31. 0. 0.	£40. 0. 0.	£53. 0. 0.	£64. 0. 0.
1,250	£24. 0. 0.	£37. 0. 0.	£47. 0. 0.	£62. 0. 0.	£75. 10. 0.
1,500	£28. 5. 0.	£43. 0. 0.	£53. 15. 0.	£72. 0. 0.	£87. 5. 0.
2,000	£36. 15. 0.	£55. 0. 0.	£68. 0. 0.	£82. 0. 0.	£110. 15. 0.
2,500	£45. 5. 0.	£67. 0. 0.	£82. 5. 0.	£101. 10. 0.	£134. 5. 0.
3,000	£53. 15. 0.	£79. 0. 0.	£96. 10. 0.	£121. 0. 0.	£157. 15. 0.
3,500	£62. 5. 0.	£91. 0. 0.	£110. 15. 0.	£140. 10. 0.	£181. 5. 0.
4,000	£70. 15. 0.	£103. 0. 0.	£125. 0. 0.	£160. 0. 0.	£204. 15. 0.
5,000	£87. 15. 0.	£127. 0. 0.	£153. 10. 0.	£199. 0. 0.	£251. 15. 0.

Prices for orders in excess of those quoted will be given on request.

Standard covers, showing only the Journal title and Publisher's name, are provided free. Any special cover requirements will be subject to quotation. Please use the cards provided below for your reprints order.

Value Engineering Reprints Service

Copies must be ordered in multiples of 50.

We require .... reprints (in standard covers) of the article entitled ....

Reprint number .... Number of pages ....

Our Official Purchase Order will follow/is not required.

Please send the reprints to: ....

Please invoice to: ....

Signed ....

Value Engineering Reprints Service

Copies must be ordered in multiples of 50.

We require .... reprints (in standard covers) of the article entitled ....

Reprint number .... Number of pages ....

Our Official Purchase Order will follow/is not required.

Please send the reprints to: ....

Please invoice to: ....

Signed ....

No postage stamp necessary if posted in Great Britain or Northern Ireland

BUSINESS REPLY SERVICE
Licence No. OF.234

Value Engineering,
Trade & Technical Publications Division,
Pergamon Press Ltd.,
Headington Hill Hall,
Oxford,
England.

Postage will be paid by licensee

Publishers' Names and Addresses

Journals

1. Tool and Manufacturing Engineer: 20501 Ford Road, Dearbon, Mich. 48128, US.
2. Mechanical Engineering: 345 E 47th St., New York, N.Y. 10017, US.
3. Product Engineering: McGraw-Hill Inc., 330 W 42nd St., New York, N.Y. 10036, US.
4. Plant Engineer: 2 Grosvenor Gdns., London, SW1, England.
5. Steel Times: 17 John Adam St., Adelphi, London, WC2, England.
6. Works Management: 34 Bloomsbury Way, London, EC4, England.
7. Rubber Journal: 109 Davis House, 69 High St., Croydon, England.
8. Metal Progress: Metals Park, Ohio, 44073, US.
9. Mass Production: 4 Ludgate Circus, London, EC4, England.
10. Journal Royal Aeronautical Society: 4 Hamilton Pl., London, W1, England.
11. Journal Irish Management Institute: 186 Orwell Rd., Dublin, 14, Eire.
12. Management Today: 5 Winsley St., London, W1, England.
13. Management Decision: 161 Fleet St., London, EC4, England.
14. The Financial Times: Bracken House, 10 Cannon St., London, EC4, England.

Books

101. McGraw-Hill Publishing Co. Ltd., Maidenhead, Berkshire, England.
102. Pergamon Press Ltd., Headington Hill Hall, Oxford, England.
103. Johnathon Cape Ltd., 30 Bedford Sq., London, WC1, England.
104. Elsevier Publishing Co. Ltd., Barking, Essex, England.
105. Her Majesty's Stationery Office, 49 High Holborn, London, WC1, England.
106. Spartan Books, c/o Macmillan and Co. Ltd., Little Essex St., London, WC2, England.
107. Industrial Education International Ltd., 17 Buckingham Gate, London, SW1, England.
108. Materials Management Institute, 221 Columbus Ave., Boston, 16, Mass., US.
109. Value Engineering Ltd., 60 Westbourne Grove, London, W2, England.

Reprint No. 1:1:16

30 WAYS IN WHICH UNNECESSARY COSTS MAY ARISE

1. Uncertainty as to customer needs.
2. Starting design before an adequate specification is compiled, with resulting wasted work.
3. Uncertainty as to resources available.
4. Uncertainty as to how to use resources efficiently.
5. Purchasing and producing in unnecessarily small quantities.
6. Over-producing and over-stocking.
7. Lack of knowledge of alternative proprietary parts.
8. Lack of knowledge of basic principles and machine elements.
9. Lack of knowledge of other technologies and the current state-of-the-art in one's own.
10. Lack of knowledge of costs of alternatives.
11. Lack of time to make the best decisions in design, purchasing, tooling, etc. and taking of decisions in areas where one's knowledge and sensitivities are not sufficiently developed.
12. Lack of knowledge in purchasing department of precise function and performance requirements of the part.
13. Excessive pride in own ideas.
14. Lack of contacts or effort to contact them.
15. Lack of techniques for objective evolution of costs.
16. Lack of communication between specialists.
17. Misunderstandings between specialists.
18. Inability to profit from past mistakes.
19. Failure to make full use of the knowledge one already has.
20. Inability to grow in capability by adding to, questioning, changing, rearranging and bringing into consciousness and clear concept one's beliefs.
21. Failure to make the maximum use for other purposes of every element of work done.
22. Lack of, or too much, standardisation.
23. Lack of historical cost data on previous jobs.
24. Allowing a temporary expedient to become permanent.
25. Lack of sufficient management pressure to investigate cost aspects.
26. Lack of adequate training of personnel involved.
27. Inability to fix realistic cost targets and periodically check achievements.
28. Satisfaction with effectiveness levels of work done and inability to group a concept of basic work content.
29. Striving for an inadequate concept of good design which omits cost and value considerations.
30. No one given specific responsibility for minimising costs.