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THE IMPLICATIONS OF COST BEHAVIOUR FOR PROFIT PLANNING AND CONTROL

by

MICHAEL GEORGE MOULDER

Submitted for Consideration of the Award of Doctor of Philosophy.

UNIVERSITY OF ASTON IN BIRMINGHAM,
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SUMMARY

MICHAEL GEORGE MOULDER PhD UNIV OF ASTON JULY 1977

:THE IMPLICATIONS OF COST BEHAVIOUR FOR PROFIT PLANNING AND CONTROL

The work described in the following pages was carried out at various sites in the Rod Division of the Delta Metal Company.

Extensive variation in the level of activity in the industry during the years 1974 to 1975 had led to certain inadequacies being observed in the traditional cost control procedure. In an attempt to remedy this situation, it was suggested that a method be found of constructing a system to improve the flexibility of cost control procedures.

The work involved an assimilation of the industrial and financial environment via pilot studies which would later prove invaluable to home in on the really interesting and important areas. Weaknesses in the current systems which came to light made the methodology of data collection and the improvement of cost control and profit planning procedures easier to adopt.

Because of the requirements of the project to investigate the implications of cost behaviour for profit planning and control, the next stage of the research work was to utilise the on-site experience to examine at a detailed level the nature of cost behaviour. The analysis of factory costs then showed that certain costs, which were the most significant, exhibited a stable relationship with respect to some known variable, usually a specific measure of output. These costs were then formulated in a cost model, to establish accurate standards in a complex industrial setting in order to provide a meaningful comparison against which to judge actual performance.

The necessity of a cost model was reinforced by the fact that the cost behaviour found to exist was, in the main, a step function, and <u>this complex cost behaviour</u>, the traditional cost and profit planning procedures could not possibly incorporate.

Already implemented from this work is the establishment of the post of information officer to co-ordinate data collection and information provision.

Key words : MODEL, COSTS, METAL.

DEDICATION

To my parents, sister and friends. Of all our gifts in life may honesty and sincerity be counted high.

ACKNOWLEDGEMENT

I would like to thank first of all my three supervisors-

Ian Watson,	Joe Smith,	Michael Hussey,
Technical Director,	Senior Lecturer,	I.H.D. Tutor,
Rod Division.	University of Aston.	University of Aston.

for all their patient supervision, constructive criticism and countless hours of work on my behalf. I am deeply indebted to them.

I would also like to thank the various sites and establishments of the Delta Group, in particular Group Training for their help and forebearance, to those factories in the U.K. and abroad who made my stays rewarding and I.H.D. Office personnel.

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M. G. MOULDER

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CHAPTER ONE

It is a foolish thing to make a long prologue, and to be short in the story itself.

2 Maccabees ii 32

The first chapter sets the scene of the research and the Group of Companies of the sponsoring firm.

"Begin at the beginning," the King said gravely, "and when you get to the end stop."

CHAPTER ONE

1.1 The author is employed by the Delta Metal Company Limited, under the Interdisciplinary Higher Degrees Scheme at the University of Aston in order to undertake research leading to the presentation of a thesis for consideration of the award of Doctor of Philosophy. The area of research is broadly concerned with the building of a cost model to predict adequately and aid in the control of cost, with particular emphasis on labour and energy costs, to be able to maintain a high degree of accuracy of prediction, irrespective of product mix, and to be able to analyse the effect of alternative production methods, technical improvements and activity levels on cost behaviour. In addition, the model must be specific enough to take account of the physical and financial environment within which it is formulated, yet be flexible enough to be applicable to the sponsoring divisions other factories and industry at large.

1.2 The Delta Metal Company Limited is now a Group company engaged in the manufacture, distribution and sales of five principal products: building products, electrical equipment, engineering products, non-ferrous metals and overseas division (manufacturing items overseas). Delta Metal then has eight divisions encompassing its principal products, as follows:-

(i) Building Products

Manufacture domestic water fittings, radiator and gate valves, compression and capillary fittings.

(ii) Electrical Equipment

(a)	Cables Division	- Electric cables, copper wire, special cables
(b)	Electrical Division	- Switch, motor gear, printed circuit capacitors.

(iii) Engineering Components

(a)	Astonia Division	- Non-ferrous and ferrous turned parts. Hardware products.
(b)	Components Division	- Forging and diecasting Gas and marine fittings. Industrial valves. Dies and moulds.

(iv) Non-Ferrous Metals

(a)	E.R.M. Division	- Cast rolled extruded and drawn non-ferrous metals. Heat exchangers.
(b)	Rod Division	- Brass rods, section, wire, copper tube, non-ferrous castings.

(v) Overseas

Mainly similar to the United Kingdom.

One can see that on a product basis alone Delta is a widely based Group company.

Having looked at the product base, it may well be a good idea to examine the size of the Group from a financial and personnel basis and documents relevant to this are appended. Also appended is an overview of the organisation and the relative size of each division. The charts are basically self-explanatory and designed to give an idea of the sort of company Delta is, its scale of operations and where the research fits in. Nevertheless, it should be pointed out that Delta is, by policy, a very decentralised company and only 125, out of the 33,075 group employees, do not belong to a division. Finally summarised statistics showing the size of Delta as an international company are included.

The research concerns itself with Rod Division so that it is this smaller area of the Group's activities to which we now turn our attention.

Rod Division is a division consisting of companies involved in the semi-manufacture of non-ferrous metals, and is really a group of three related businesses. However, it makes it easier to visualise the position of the researcher in terms of DEMCo. Limited (Delta Extruded Metal Company Limited) rather than Rod Division itself. The chart appended clarifies the position of the researcher and indicates the two factories within the Extruded Brass Business with which he is most concerned.

It should be noted that the factories controlled by DEMCo. are manufacturing units. DEMCo. is responsible for the commercial aspects such as raw material purchase and order processing. Hence the emphasis at a factory level is on cost effectiveness and reliability of service and quality. As was previously mentioned, because of the variety of products made, it makes little sense to talk of Delta's products or competitors. However, if we consider simi-finished products, that is extruded non-ferrous rod and section, which is in the province of DEMCo. and Rod Division, we can be a little more specific.

For general comparison selected information from Government sources (Business Monitor) is provided to give an indication of the industry size and value of semi-finished products. If we were to couple this information with the fact that Delta accounts for just under 50% of rod production and nearly 40% of the section market (% figures based on British Non-Ferrous Metals Federation data covering most firms in the industry) one can say that Delta Rod Division leads its competitors, Imperial Metal Industries and McKechnie Bros. by a considerable margin in terms of market share.

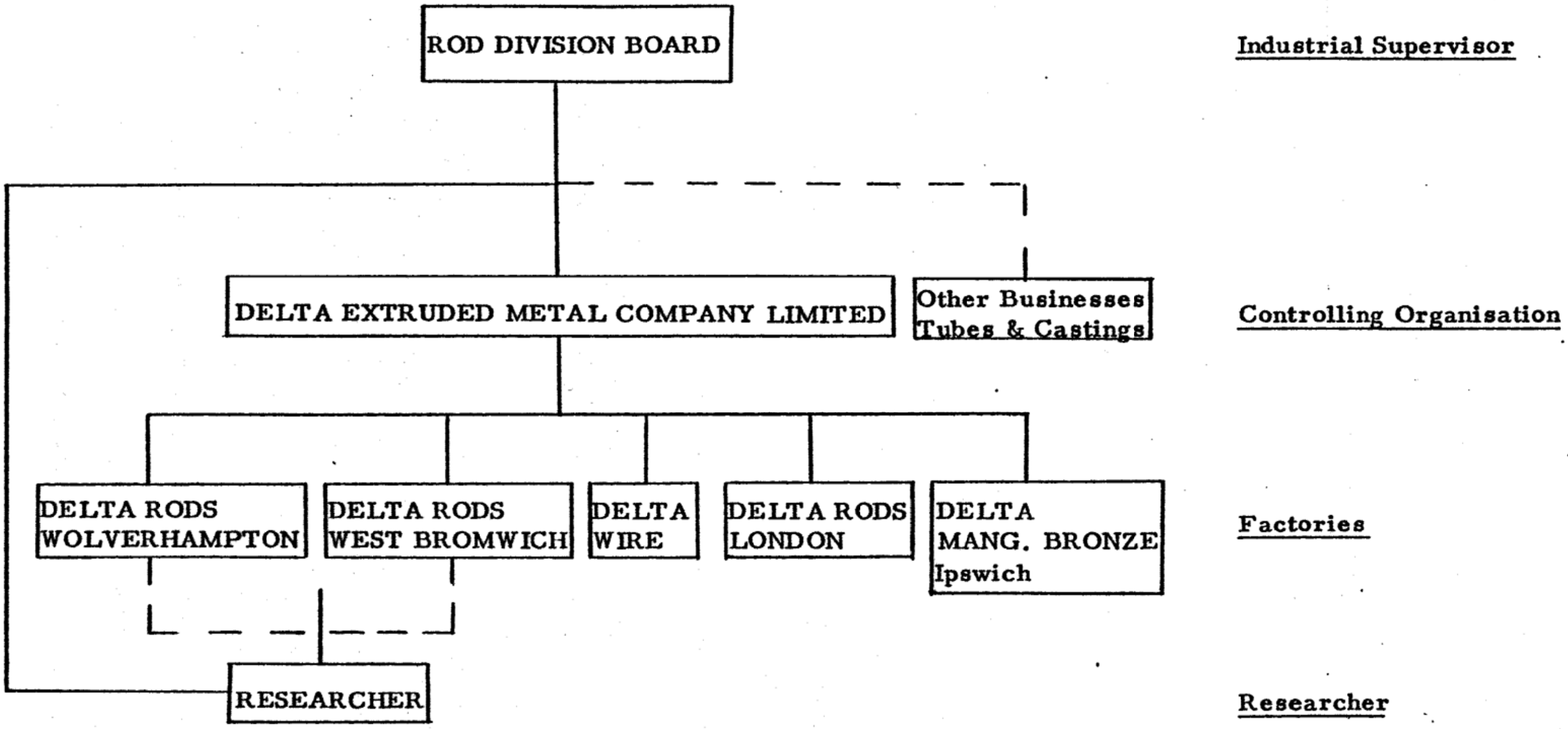
ROD DIVISION BOARD
Industrial Supervisor
DELTA EXTRUDED METAL COMPANY LIMITED
Other Businesses Tubes & Castings
Controlling Organisation
DELTA RODS WOLVERHAMPTON
DELTA RODS WEST BROMWICH
DELTA WIRE
DELTA RODS LONDON
DELTA MANG. BRONZE Ipswich
Factories
RESEARCHER
Researcher

FIGURE 1

1.3 Having now seen broadly where the two factories in question, West Bromwich and Wolverhampton, fit into the Delta scene, it is now opportune to consider them in a little more detail. Clearly they are both extrusion factories as they are members of the DEMCo. Group.

Wolverhampton is a factory employing of the order of 260 personnel that consists of three basic production areas: a foundry which smelts brass scrap into billets of a small number of alloy types (about the size of large fireside logs) of two sizes. The large size billets are then hot extruded in a press into solid rod of various shapes and sizes, most of which are then drawn, straightened, cut to size, as necessary for customer requirements. The small size billets are used in a smaller press where they are hot extruded into hollow brass rod and finished in a like manner to the solid brass rod. A complication emerges in that this smaller press is also used extensively to produce copper shell from <u>externally</u> procured copper billets. For this, Wolverhampton perform no more than a turnround function for a copper tube factory (Delta Tubes) which is in Rod Division but not in DEMCo., and which finds it more convenient to pay Wolverhampton to perform the first stage of the copper tube process - that of extruding the copper billet into shell rather than perform this operation itself. As a broad generalisation, Wolverhampton produces output from scrap metal, without resorting to the use of outside sub-contracting to perform specific operations.

West Bromwich in size and output is a larger factory. Again its foundry produces two sizes of billets. Large sized billets are used to produce brass rod (standard types on one extrusion complex, more difficult types on the other) the billets of which tend on average to be of a larger size than one would find at Wolverhampton. Smaller size billets are used to produce Section (one section press being used to produce standard section, another press being used for non-standard). In this case, again the range of section produced is much broader than one would find in a corresponding rod extrusion process because of the fact that many more variations are possible with section than with rod mill.

1.4 If one turns ones attention away from an overview of the basic industrial environment, towards the financial information which corresponds to the production system, then the knowledge of cost behaviour was less adequate than one would like, as is quite common in a practical situation. It was felt that an improvement in knowledge of cost behaviour, in particular the most important controllable elements thereof, would be useful. At a broad level such knowledge of costs incurred in terms of output will aid us to switch production levels at each factory and rationalise types of production (i.e. what is produced where) knowing that the majority of the information we are using is accurate and quantitatively based. In addition our control of costs (those which can be related to output) can be improved by our increased knowledge.

At the beginning of the research period, because of the time constraint which always operates in a factory environment, our knowledge of these costs which should show a stable relationship to output (labour, energy, etc.) or which impinge on costs directly (e.g. yield) was insufficiently thorough-going: it was felt therefore that a cost model was required. Since it would concentrate its attention mainly on those costs which can be controlled by reference to output, it would be a step forward in answering the points mentioned overleaf and in addition would be a framework and reference point for the introduction of such a system in any other factory in a similar or different area of activity.

CHAPTER ONE APPENDIX

ABSTRACTS OF INFORMATION SHOWING THE NON-FERROUS METAL INDUSTRY IN TERMS OF SELECTED STATISTICS AND DELTA'S POSITION WITHIN IT

PRODUCTION

No. of Enterprises		1974	1975	1976 (1st Quarter)
		(£m)	(£m)	(£m)
	COPPER:			
39	Semi-manufactured	365	251	70
	BRASS:			
47	Semi-manufactured	234	161	46

These figures illustrate the cyclical trend of the metal industry: SOURCE - Central Statistical Office - Business Monitor.

EMPLOYMENT IN THE COPPER, BRASS AND COPPER ALLOY INDUSTRY

	(Thousands)
June 1972	47.4
June 1973	49.4
June 1974	48.0
2nd Qtr. 1975	45.0
1st Qtr. 1976	42.7

The reduction in employment seems to lag behind the production cycle and to be less intense in its reduction.

SOURCE - Department of Employment.

Because Delta is a firm engaged in many different areas of activity, one has to be careful about comparing it to "comparable" firms. However, if one considers companies having at least part of their interests in the same area as Rod Division, although having many others, then in Germany VDM and in the U.K. McKechnie Bros., and I.M.I. seem to fall best into this category.

DELTA - ITS PLACE OUTSIDE THE U.S.A. IN TERMS OF SIZE

No. of firm ranked outside U.S.A. in terms of size	Name	Sales $	Assets $	Profit (000$)	Equity	Employees
93	Metallgesellschaft (VDM is a subsidiary Co.)	2, 250, 380	1, 216, 493	9, 497	199, 891	26, 626
281	Delta Metal Co.	754, 021	561, 464	4, 376	188, 996	33, 200

SOURCE - Fortune (August 1976)

DELTA - ITS PLACE IN THE U.K. IN TERMS OF GROWTH

Growth No.		Market Value (£m)	Net Capital Employed *	Taxable Profits *	Sales *	Gross Cash Flow *	% Change Share Value *	Growth Rating
130	McKechnie Bros.	22.9	+ 238	+ 117	-	+ 47	+ 27	+ 100
144	I.M.I.	115.7	+ 191	+ 160	+ 383	+ 200	+ 24	+ 87
169	Delta	89.5	+ 122	+ 32	- 125	+ 46	- 2	+ 65

* Are percentage changes 1966 - 1975

As one would expect, all three companies have similar growths, capital employed, etc.

SOURCE - Management Today (June 1976)

DELTA'S ORGANISATIONAL STRUCTURE AND PHILOSOPHY IN BRIEF

The chart showing the organisation and products of Delta is taken from the prize-winning Delta Annual Report. It emphasises the decentralised philosophy, but which has considerable authority at divisional board level, and also the wide spectrum of products produced.

DELTA'S FINANCIAL PERFORMANCE IN BRIEF

An excellent summary of the relative financial performance of the Group is given in the table "Group Financial Information".

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CHAPTER TWO

'Preach not because you have to say something, but because you have something to say.'

R. Whately, Archbishop of Dublin
1787 - 1863

This chapter enlarges on two factories in the Delta Group, and in Rod Division itself which require, for the forthcoming chapters, a more detailed analysis. In the first part one factory is examined and compared to a similar factory (by means of section numbers) this second factory itself being examined in the second part. In this second part of the chapter, the opportunity is taken to look at the important technical considerations which need to be considered in order to place the research work in context. The third and final part of the chapter examines some of the financial ideas and practices at Group and factory level which are of interest to us.

'The statements were interesting but tough.'

(Ch. 17) Huckleberry Finn - Mark Twain
(C.L. Clemens)
1835 - 1910

CHAPTER TWO

2.1(WB) DELTA RODS (WEST BROMWICH) LIMITED - AN INTRODUCTION TO THE PRODUCTION SYSTEM

2.1.1 History

Despite the fact that Alexander Dick, the founder of Delta, extruded brass for the first time in 1894, the history of Delta Rods (West Bromwich) is more recent. In 1954 Copper and Alloys Limited joined the Delta Group at a time when the Group capital employed was about £5m. Today the West Bromwich factory is one of the main manufacturers of stamping rod and profiles at a time when the Delta Group capital exceeds £94m. Delta Rods (West Bromwich) has a total work force of approximately 430, 125 of which are staff.

2.1.2 The Foundry

There are three methods of casting billets from molten brass. A first method is a static mould where brass is poured and then cooled. A second method is a scc (semi continuous casting) unit where a 'log' is cast into a bath of water. A third method is a continuous casting unit where the log is cast, cooled by water jets, then cut into billet size (normally 32"/36" long x 9" or 20" x 6") as required. Thus the continuous caster can achieve lower cost per Kg. of billet produced, than the static caster, with its limited range, or the scc with its wasteful intermediate log stage. The casting unit is designed for long runs of one or related alloys. Dr ιy raw material, be it solid or swarf, is weighed and placed in the furnace charger. It is then transferred to one of the 4, 4 ton melting furnaces, which will also contain previously melted brass to ease the melting procedure. A 5 ton transfer furnace which moves on rails, then collects the molten brass and transfers it to a 6 ton holding furnace. From here the molten metal passes through a mould and is cooled by water sprays. Flying saws cut the hot solid metal into billet size (9" x 36", say), it is stacked into various groups, which are mostly of stamping rod type. In fact the types of brass produced at Delta Rods (West Bromwich) are diverse, stamping, turning, etc. are all produced. Manganese bronze is no longer produced here at West Bromwich, but is now brought in from Ipswich, the former static furnaces and operatives having been declared redundant.

One problem the furnace can have is in the production of 6" billets for section. If lengths of 10" are required this can be difficult to achieve. As the metal is cast at 12" per minute this implies that the hit rate for the saw is 72 per hour, too high for the necessary degree of accuracy. Therefore one cut of 10" is made and one of 20" to reduce the cut per minute rate to 48 per hour which is much more acceptable technically for the saw.

As at Delta Rods (Wolverhampton) an X-ray spectrograph is installed to check on the composition of the molten brass. Arsenic, antimony, and to a lesser extent, bismuth are three impurities that can cause problems as they all could cause weakening of the metal even in small percentages.

There are two forms of metal input to the furnaces. It is, therefore, of paramount importance that the percentages of these impurities are known. Even a 0.5% tin impurity can cause the final output to be unsaleable.

Raw materials are either solid, in which case they are cropped and baled prior to weighing, or swarf, in which case they are dried, deoiled and the ferrous content removed.

2.1.3 <u>The Metal Recovery Plant</u>

At West Bromwich the arisings, dross, clinker, etc. from the furnaces at Wolverhampton, Delta Wire, as well as West Bromwich itself, are processed to remove the brass content. This is achieved by ball mills which crush the lumps of dross. The lighter oxides are filtered by centrifugal force and sold to firms who extract the zinc. The heavier remains are purified to remove oil, iron, etc. and is then melted in an Ellington 2 ton furnace and cast into ingots. These ingots, however, are of insufficient purity for input to the furnaces. Thus the ingots are sold currently to casters, achieving a much greater contribution even allowing for the extra costs of processing, than could be achieved by selling the dross as it stands.

2.1.4 Hangar 1 - Rod Mill

Hangar 1 houses the Rod Mill, consisting of two 3,000 ton presses 'Alice' and 'Alcop' plus ancillary equipment.

A cast billet is preheated by natural gas to 680 - 750°C. It is then transferred to the press which consists basically of a hydraulic cylinder operating a ram, a steel container and a die block. The billet is placed in the container and the ram forces the metal through the die orifice, the die being locked in position at the front of the container. The resulting extrusion assumes the shape of the die.

Extrusion proceeds until most of the billet has been extruded when the forward movement of the ram stops, the unextruded portion of the billet known as the discard is then separated from the extrusion by sawing. The extruded length is pulled clear of the die and allowed to cool before being cut into lengths suitable for further processing. Unlike Wolverhampton, (2.2.7) West Bromwich rod, which is almost all stamping, is not quenched but extruded onto a long table or in coil form, and allowed to air cool. Both presses are pre-war and tend not to deal with rod less than ½" diameter as this is the province of Delta Wire. Whereas Wolverhampton can undertake rod of 3/8" to 2", West Bromwich can undertake rod from ½" to 6".

Thus production at Wolverhampton (2.2.7) and West Bromwich are parallel for rod between ½" and 2". The two run out tables for the presses were installed 5 - 6 years ago. An integrated Schumag machine which straightens, draws, cuts and finishes rod up to 3/4" is available for coil. This parallels the Schumag press at Wolverhampton (2.2.8). The capacity of the presses is about 10 tonsper hour per press. It is a straight through extrusion, therefore, capable of large throughput. A maximum capacity of 1,000 tons per week could be achievable, although in practice 722 tons achieved in late 1973 is the best to date. The current market decline has, of course, prevented the attempt to increase production.

Despite the division of the factory into Hangar 1 (Rod Mill) and Hangar 2 (Section Mill), some section, particularly large which cannot be handled on the lighter section presses is extruded on the rod presses. Unlike Wolverhampton (2.2.6) both presses use a 'false nose' extruder head which needs daily replacing instead of backing pads. Both methods are necessary because of the sudden heat when the extruder head touches the red hot billet.

2.1.5 Hangar 2 - Section Mill

The Section Mill has two presses, both of just over 1,000 tons and utilising 6" billets. The Ena press has a manual run off table, whereas the Nan has a mechanical run off table.

After the extrusion of a section, the section is pickled, tagged, drawn, straightened and cut to size. It is obvious that the tolerances for section (window frames, etc.) will be much tighter than for rod. Whilst for many applications, sections are extruded to the correct size and shape and need only a light stretch for straightening before despatch to customers, others require a difficult tolerance (+ .002") and a high degree of profile accuracy. To achieve these requirements material is cold drawn in straight lengths.

Where sections need more lengthy straightening, they are hot stretched. Generally, the Ena press deals with the section requiring drawing and difficult treatment to meet customer requirements. There are three draw benches, each-one strand as well as a straightener and stretch which can be used hot or cold. A roll straightener for regular bar, and a Siefer to correct the angle of the section is provided. A similar technique corrects channel shaped sections. Nevertheless, because of the great variety of section, three skilled manual straighteners, at the time the author was present, are employed on the labour intensive task of straightening section to the correct specification. Two final inspectors also ensure that the section is within specification. Whilst the section is inspected after extrusion, the stretcher, for example, can pull the section out of specification. The Nan press, being more automated, tends to deal with more straightforward sections. A series of walking beams transports the section to be finished.

Some customers request that their section be cut into small lengths, say 1" - 2" long, rather than being supplied to them in long lengths. Naturally an extra charge is levied for this. However, this process can lower the yield figure because defects such as cutting back and sawing loss, which might have gone unnoticed particularly as the section is to be heated, may make the cut section only suitable for scrap, thus lowering overall yields.

All works movement within the factory is undertaken by overhead crane.

2.1.6 Toolroom

At West Bromwich the making of dies for rod extrusion does not cause any more problems than one might expect. Section dies are far more difficult to manufacture in the toolroom, in point of fact, whilst some section dies are made by traditional lathe methods, some of the more complex dies can only be made by spark erosion. The older type of spark erosion machine erodes all the cobalt/stellite die until the required shape is achieved. A new swissmark agiecut machine has, however, revolutionised this process. A papertape, punched with the profile of the die from a previous cutting, or as required, is fed into the reader. The Agiecut then cuts the appropriate former file from a blank block by cutting this with a thin gauge copper wire (Fig. 3) This former is then used as template to produce the die inner.

A chart follows which shows the general production stages of rod and section from initial metal receipt.

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2.2(WO) THE PRODUCTION SYSTEM AT DELTA RODS (WOLVERHAMPTON) LIMITED

In 2.1(WB) a brief description of one of the factories under consideration was given in respect of the essential elements of production. The aim now is to take a second factory engaged in a similar activity, but to expand on the production processes and problems in a little more detail since this will aid our understanding of the environment within which the model was formulated.

2.2.1 General

The basic process consists of heating scrap brass metal to molten temperature and forming it into large billets or log shaped circular sections of brass about 9" diameter and 2' in length. In a separate stage of the process these billets are then heated up to red heat and forced, by means of a hydraulic ram and die, into the required shape of rod or section, usually about 1" in diameter. A variant on this process is to use a hollow rod press to produce rod, etc. with a hollow centre extruded in it.

The rough rod is then 'drawn' through a narrow die to improve its appearance and metallurgical qualities, straightened, cut to size, polished and delivered to its customer as a semi-finished product. In the hands of the customer the rod is often cut into small ingots in order to be pressed or machined to make cogs, tap parts, etc.

2.2.2 First Stage Metal Preparation

Swarf and scrap copper and brass are stored in a metal bay, either from internal factory scrap or from external sources. The scrap is dried and checked, etc. before it becomes the 'heats' as input to the metal melting furnaces.

2.2.3 Furnaces (Theory)

There are two groups of furnaces which both semi-continuously cast molten metal into billets. This means that the speed of flow of molten metal is synchronised with the cooling of the metal by water spray with the result that the lower end of the log as it passes through the mould has an outer skin which is not liquid, but whose inner core is still molten. Naturally, too fast a flow would result in the log being molten, too slow a flow would lead to the log sticking in the mould. A log of about 24' is formed per flow, hence the name semi-continuous casting.

2.2.4 Furnaces Practice

At Wolverhampton two sets of furnaces exist.

The first and by far the most important furnace group consists of melting furnaces of 1½ tons each which feed a holding furnace of 5 tons from which the casting process takes place at a temperature of about 980°C. For this group of furnaces mostly large billets of 9½" diameter are produced.

A smaller semi continuous unit operates to produce predominantly (in practice) $5\frac{1}{2}$" diameter billets. It has a throughput capacity probably only 10% of the large unit, although the two units can both produce both $5\frac{1}{2}$" and 9" billets if required to give the system maximum flexibility.

2.2.5 Alloy Type

Formerly many types of alloys were produced as variants on the 'stamping' alloys (used for hot working) and turning alloys used for lathe work. Today, however, these alloy types have been rationalised so that the foundry produces mainly T12 as a turning alloy and S1, S2 as stamping alloys in the ratio of about 4:1 respectively.

2.2.6 Extrusion (Theory)

The principle of extrusion has already been mentioned, but one or two points of amplification remain necessary. A billet is squeezed between two backing dies and is forced by a hydraulic ram into a rod shape. Yet not all of the billet is extruded, since beyond a certain percentage of part of the billet, were it to be extruded, would simply produce "back end defect" rod. This means that the skin of the billet is intruded into the rod itself, weakening it beyond the standards allowed.

2.2.7 Practice

An extrusion can take place in two forms: by coil or by rod. The choice taken depends upon relative costs and the length of the run out table. Generally, small size rod is extruded in coil, whereas larger sizes (over .866" for round, .718" for hexagon) tend to be lengths.

In the hollow rod extrusion press, both copper and brass billets can be used to produce copper shell and hollow rod respectively. Thus one is required to estimate the proportion of electricity used by metal type.

2.2.8 Finishing

The rod (either hollow or solid) is then finished. It is pickled in acid to clean it, drawn, reeled or straightened and cut. Small coil tends to be drawn, straightened and cut in one operation by a Schumag machine, which operates without the need for 'tagging' (chamfering the end of the rod to allow a machine to pull it through a draw die). Thus, at the end of the process, a clean straight bar of brass rod of good finish and tolerance levels, (both of measurement and metallurgical quality) is achieved.

Note that stamping rod, which may account for 25% of total rod output, is generally pickled and then cut to size since it is designed to be reheated.

2.2 Metallurgical Problems (Yield Loss and Metal Faults)

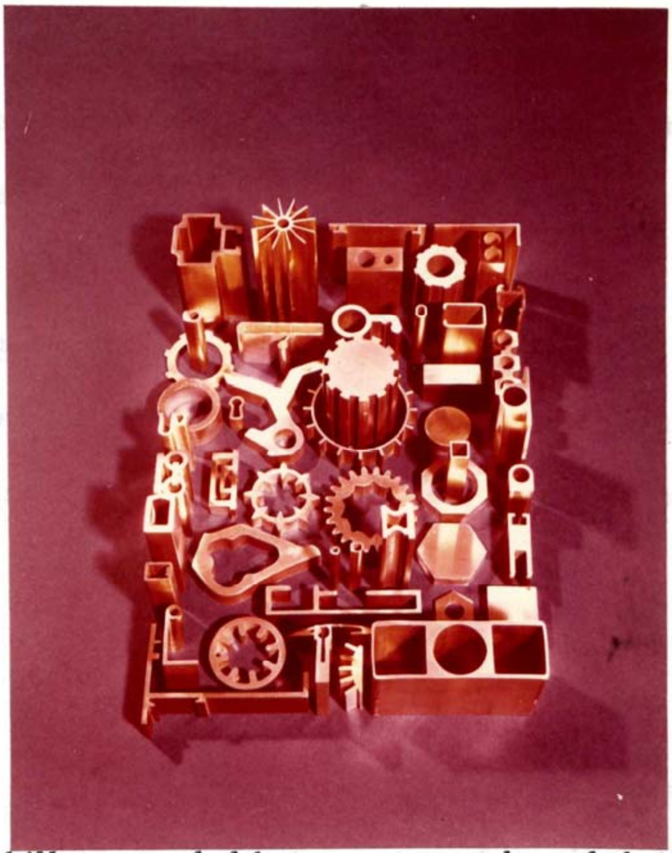
The method of extrusion has already been mentioned, but perhaps a point of clarification needs to be made here regarding the importance of yield. Yield is defined as the ratio of good output from total input and is important in the non-ferrous metal industry because of the high price of metal, the production costs incurred, and as an index of the efficiency of a process.

As part of the interdisciplinary approach of analysis, one can consider the sources of yield loss in each of the foundry, extrusion stage and finish work.

In the foundry possible sources of yield loss are: the incorrect formulation of an alloy (i.e. not within the required specification), the metal losses through oxidisation of the metal into the atmosphere (about 5% loss), the losses caused by having to cut the 24' logs into billet lengths: losses caused by faulty casting (e.g. billet not cast straight).

In the extrusion press (see pictures below) we have

FIG 2



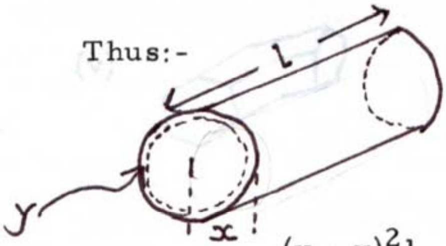
section products

FIGURE 3

the billet extruded between two pads and the scavenger pad removing the unextruded billet portion. The unextruded % tends to be relatively constant at 2% of the billet (except section length where the yield may be more variable) Thus a short billet has a lower yield for this reason than a longer billet.

When the billet is extruded, part of the outside surface area is not extruded through the die since the extrusion press face has a diameter slightly smaller than the billet face.

Thus:-



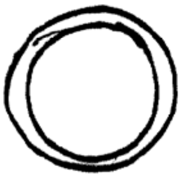
If x is the radius of the billet and y is left unextruded then:

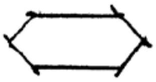
$$\% \text{ Yield} = \frac{(x - y)^2 l}{x^2 l} = \frac{(x - y)^2}{x^2}$$

These then, together with non-normal faults, such as faulty billets, represent possible causes of yield loss at the extrusion stage.

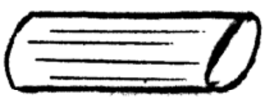
Rough Rod Stage

If we now look at the extruded rod stage, most of the causes of yield loss stem from faulty extrusions.

(i)  Eccentricity

(ii)  Metal 'hair' at corner of section.

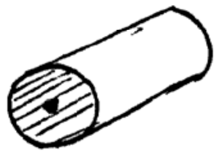
(iii)  Xmastree extrusion caused by incorrect lead content.

(iv)  Extrusion lines. Billet over-softened by too high an extrusion temperature.

(v)  Extrusion not straight. Caused by poor die positioning or control. Can be caused by muffler being too high or the run out speed not being designed or

(vi)  synchronised correctly to take the weight of the newly extruded rod.

(vii)  On section extrusion, fragile side extruded as underside crushing section against run out table.

(viii)  Porosity/oxidisation caused by extrusion skin intruding into the metal.

(Pictures with commentaries of typical metal faults are shown overleaf)

N.B. The extruded rod is cut back until the coil or rod no longer contains evidence of oxidisation or porosity on the last length or footage of coil to be extruded.

At the finishing stage metal is lost by cutting to size, and tagging.

Yield Loss Summary (Rod)

Foundry

Cause	Expected % *
Atmosphere oxidisation of metal	6.2
Incorrect alloy produced	1.0
Billet cutting losses	6.0
	13.2

Extrusion

Cause	Expected %*
Unextruded billet portion	10.0
Skull	2.0
	12.0

Rough Rod Stage

Cause	Expected %*
Sawing loss Extruded rod faults (i - viii) Cutting back oxidised rod	7.0

Finishing Stage

Cause	Expected %*
Cutting to size, tagging	10.0

*N.B. % = per stage loss

Section follows a similar pattern to rod except that the typical yield loss is likely to be very much higher. We note that Wolverhampton does not produce section, but a discussion here is logical since the stages are roughly similar to rod production.

Foundry Stage

Cause	Expected %
As rod	13.2

Billet Extrusion Stage

Cause	Expected %
A Bridge Die requires the angle to be not more than 30° for the correct production of e.g. window frame sections. For other section dies % will tend to be smaller.	25.0% - 45.0%
Rough Rod Stage	
Because Section is more complex in structure, more faults can develop, e.g. corners not at ∟ Same basic pattern as rod.	25.0%
Finishing Stage	
Tends to be higher than rod equivalent - % = per stage	15.0%

2.2.10 Copper Yield

As Wolverhampton is only a turn round function for Delta Tubes, and performs only the extrusion stage from copper billet to copper shell, yield losses tend to be low. Some of the copper is oxidized to cupric oxide

$$2\,Cu + O_2 \xrightarrow{heat} 2\,CuO$$

This is a possible source of metal loss as is the unextruded portion of the billet and the fact that the beginning and end of the extruded rod will be bent. About a 93% yield should be recorded.

2.2.11 Wages

At this juncture it may also be useful to review one or two general factors which apply at Wolverhampton as well as comparable factories in the Delta DEMCo. Group. Wages differ between factories in the group but the principal basis on which remuneration is based is similar. A basic wage is paid plus the addition of a bonus based on some relevant output criteria. Quite obviously, when a machine fails to operate due to a fault, or an operative has to wait for the metal to arrive from a previous stage, then this system will mean that he will be penalised for operation difficulties outside his control. Thus, for downtime, the operative is paid a fall back bonus (based on some average rate). Thus, although the basic wage may appear to be 72% of the total wage, in effect the fall back bonus is much more akin to a basic wage than a true bonus. In the foundry where groups of four plus the chargehand operate, then the bonus is a group bonus. In other areas it is mainly individual.

2.2.12 Production Control

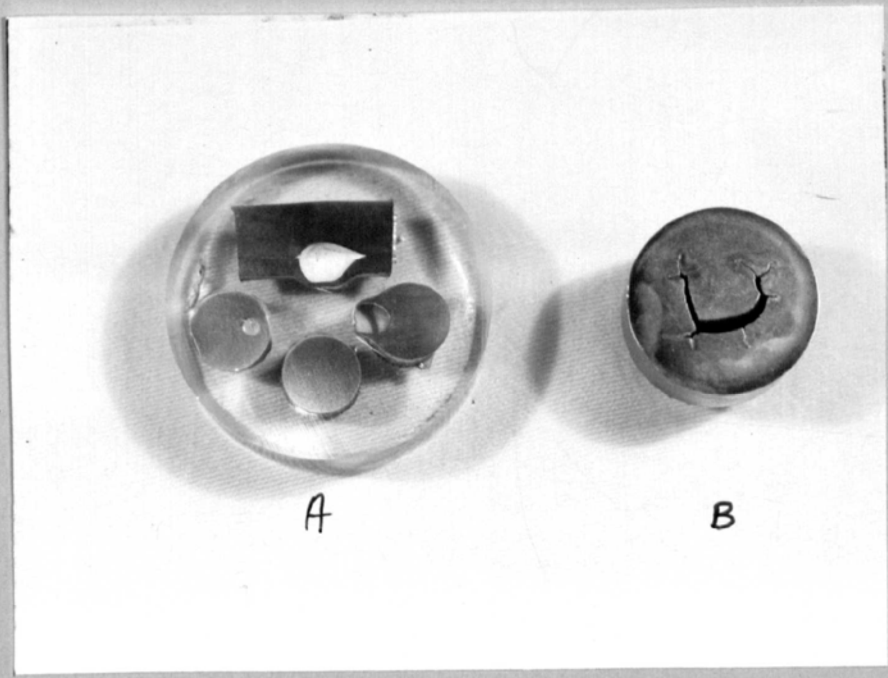
The aim of the physical production control system is to reduce the turnover time from metal input to delivery, as well as reducing stock levels at all stages to a minimal level, yet retaining the continuity of the flow of production. Because many orders are standard in terms of their alloy and size requirements they are made as stock items without a specific order being made for them. Other items that are non-standard are only made against a specific order.

Thus, to take an analogy, a stock item is like a floating debenture which crystalises on some fixed asset, whereas a make item is the mortgage debenture which is always issued against one specific asset.

In practice, as far as Wolverhampton is concerned, of the 1,250 tonnes average made per month, about 2:1 would be stock items.

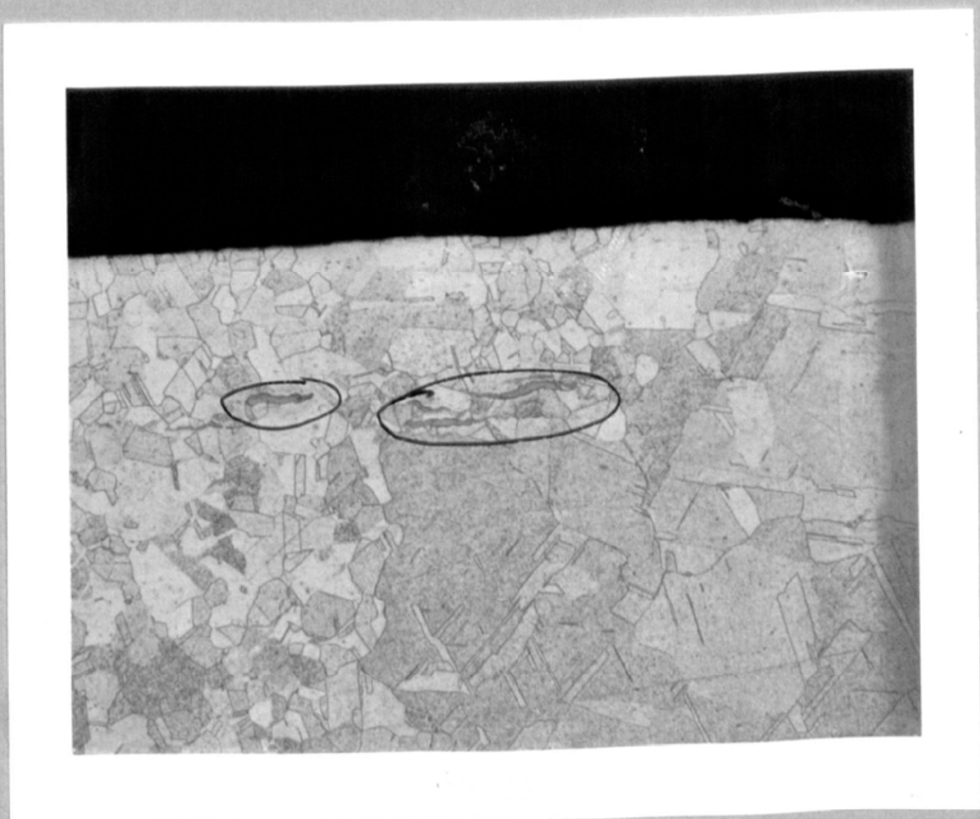
2.2.13 Production Flow

The next four charts illustrate as a summary some of the major centres within the factory. Chart 1 shows the principle stages of foundry work engaged in billet casting, from metal input to billet cutting. Chart 2 then considers the process of extruding the larger size billet into solid rod. Chart 3 follows through the like process for hollow rod from extrusion to despatch. Chart 4 examines how the solid rough rod is processed via its various rod types in more detail than is shown in Chart 2.

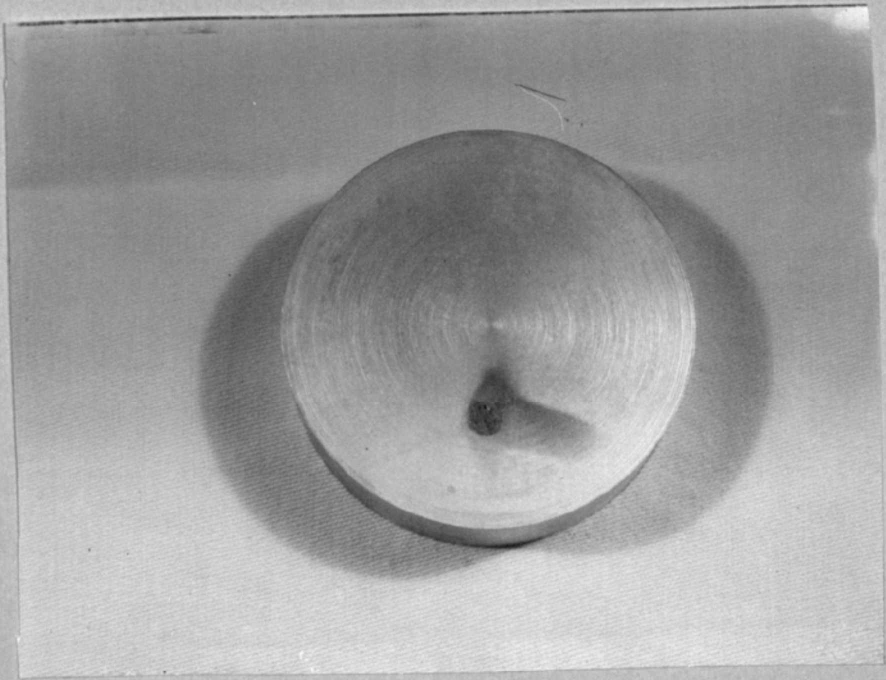


A: The use of a device to lengthen die service life has resulted in a graphite inclusion.

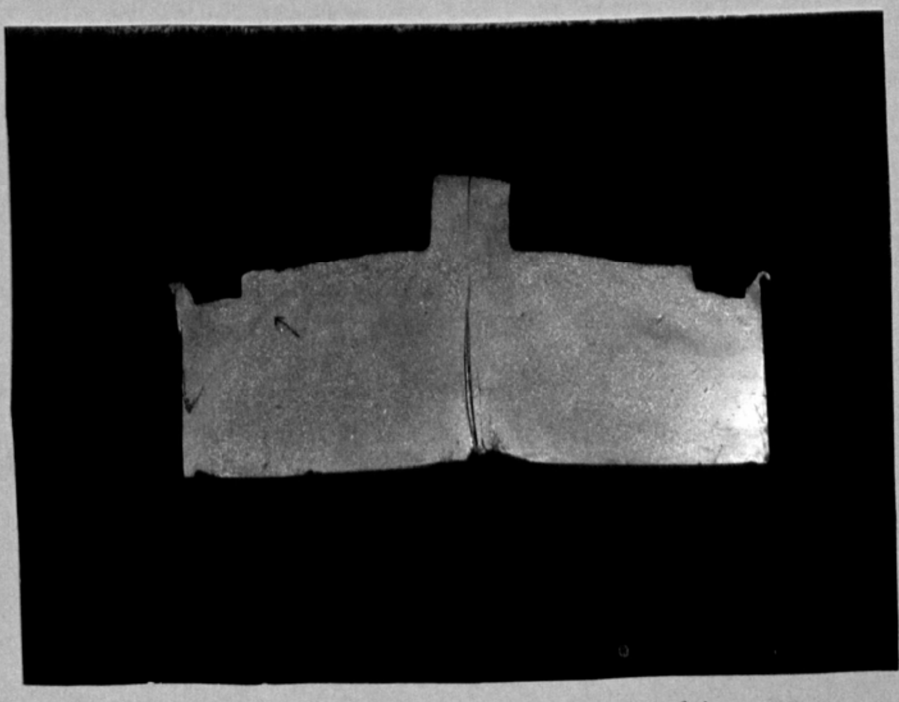
B: Severe back end extrusion defect.



X150. Skin pipe shown (circled) in metal grain of copper tube.



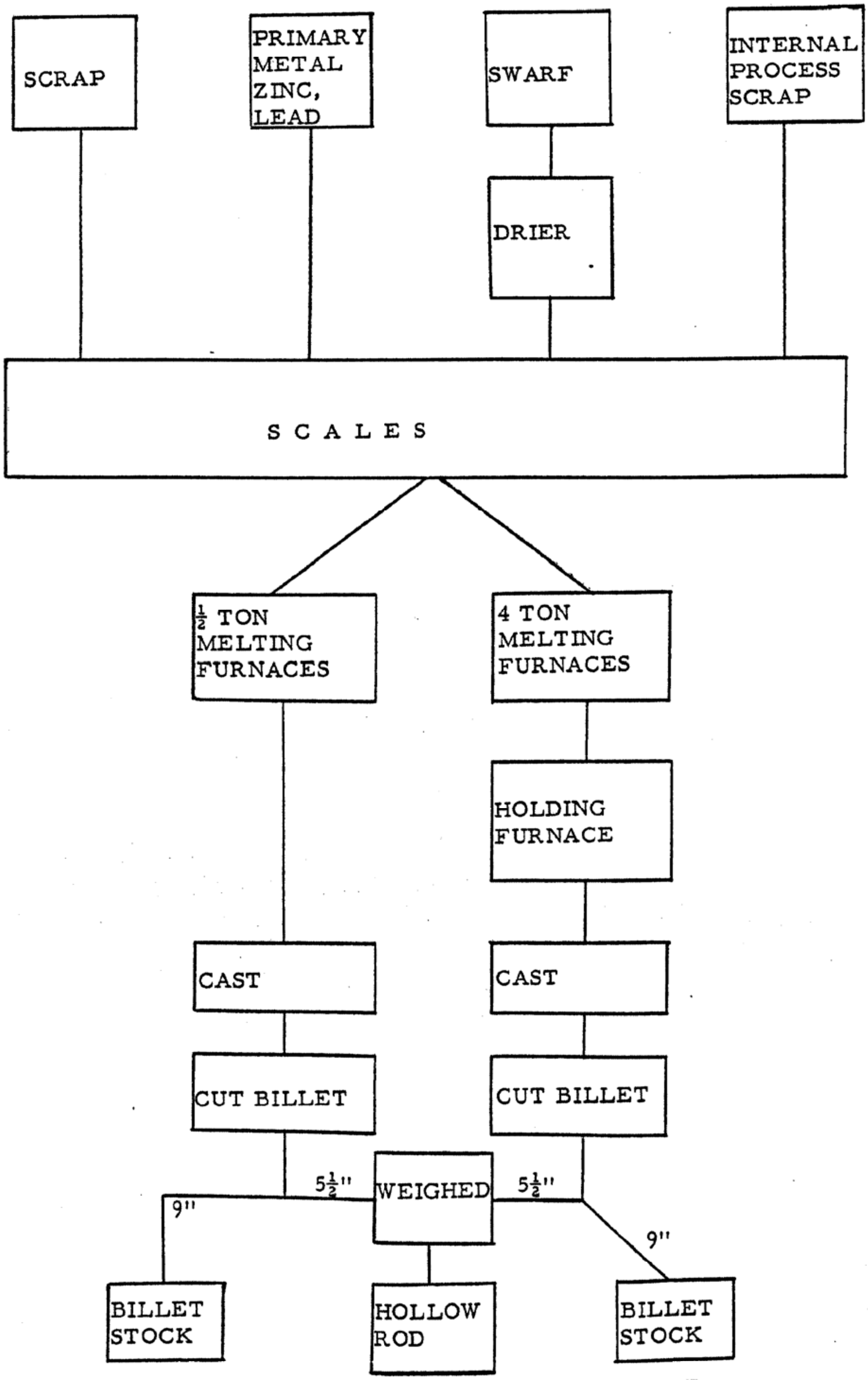
A slag inclusion defect in a billet.



"Get end" or discard arrowed has a skin pipe of a different alloy included. In addition a metal fault in the centre of discard is visible. B shows the ends of skull remaining.

CHART 1

THE PHYSICAL PROCESS OF CASTING



EXTRUSION OF SOLID ROD

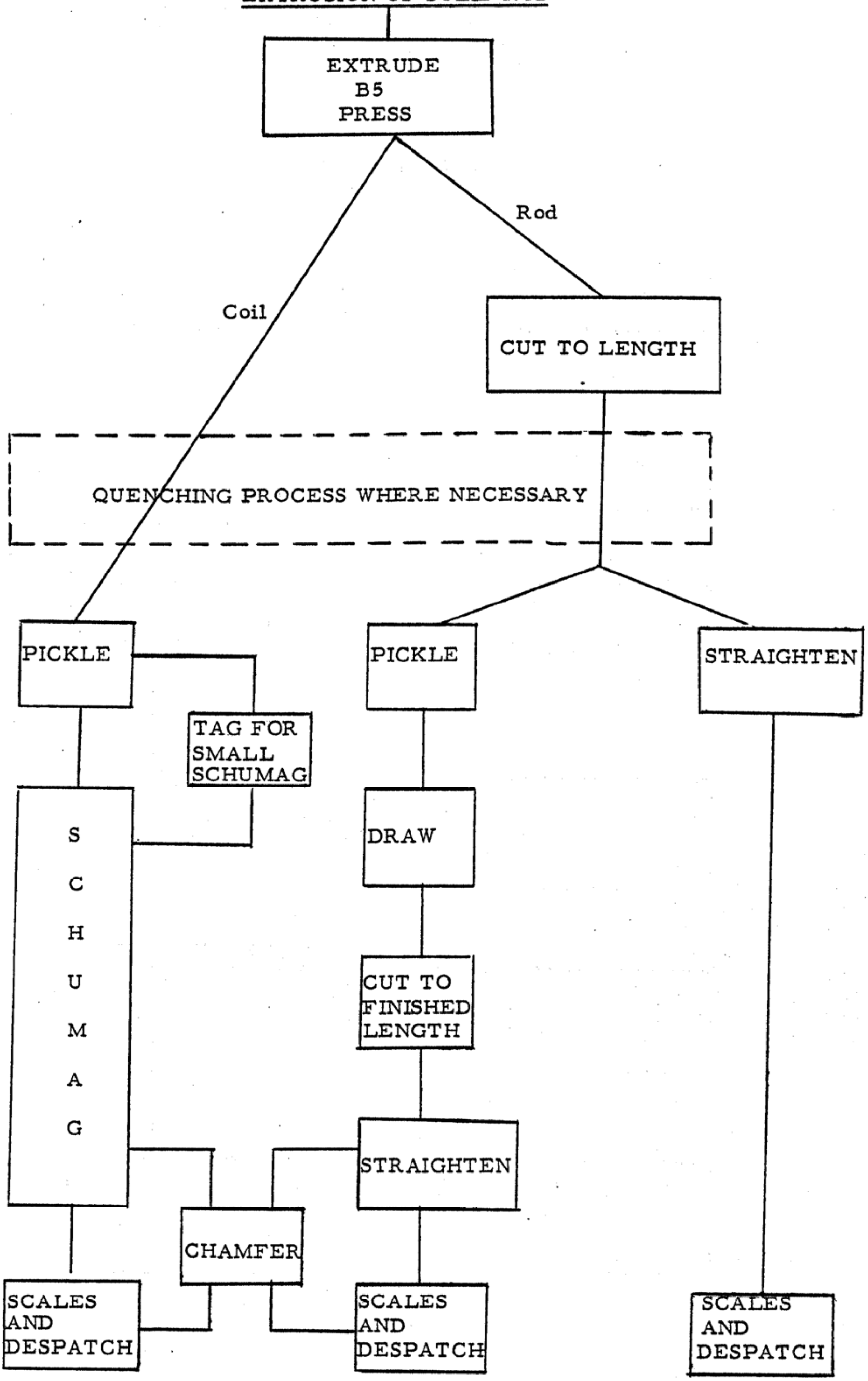


CHART 3

HOLLOW ROD PHYSICAL PROCESS

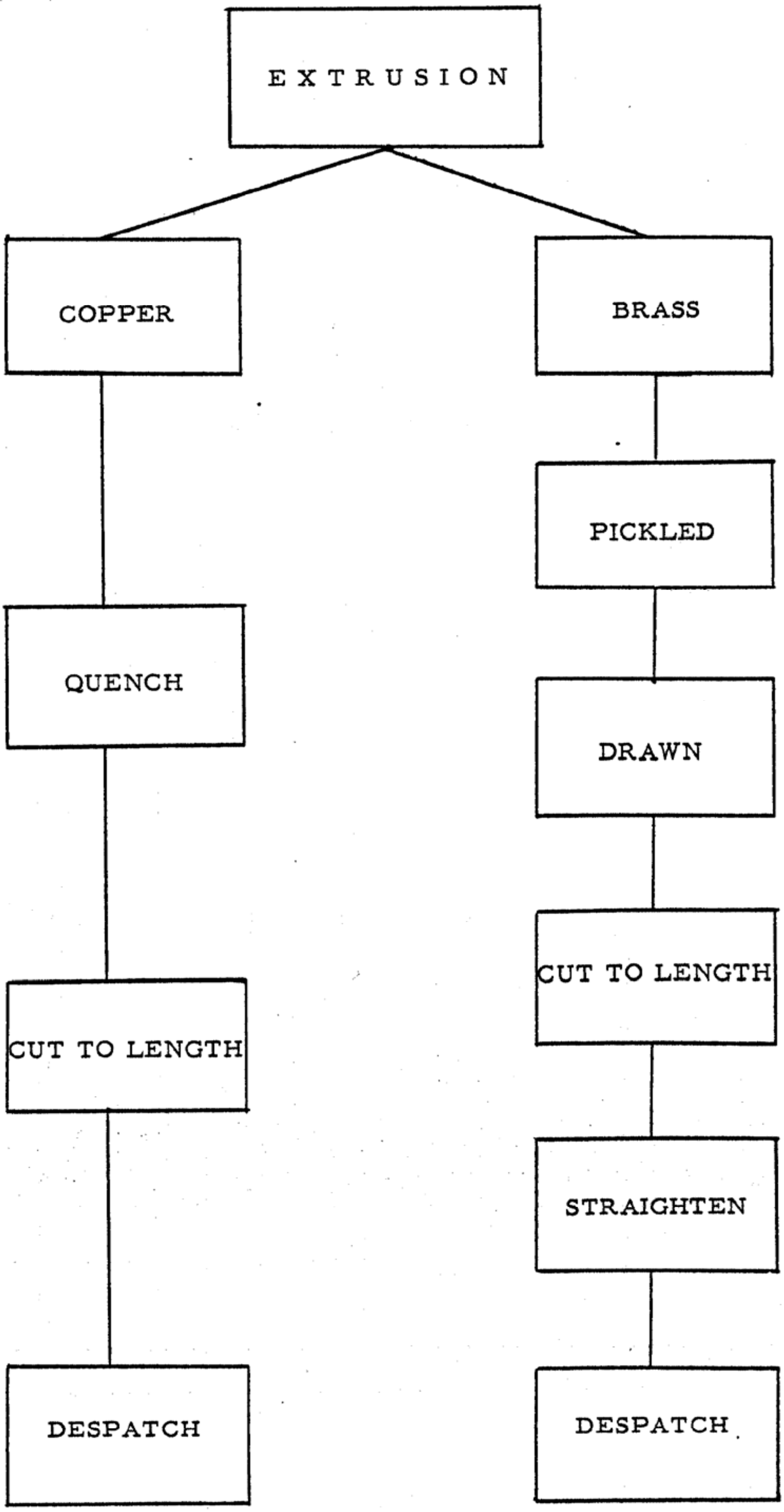
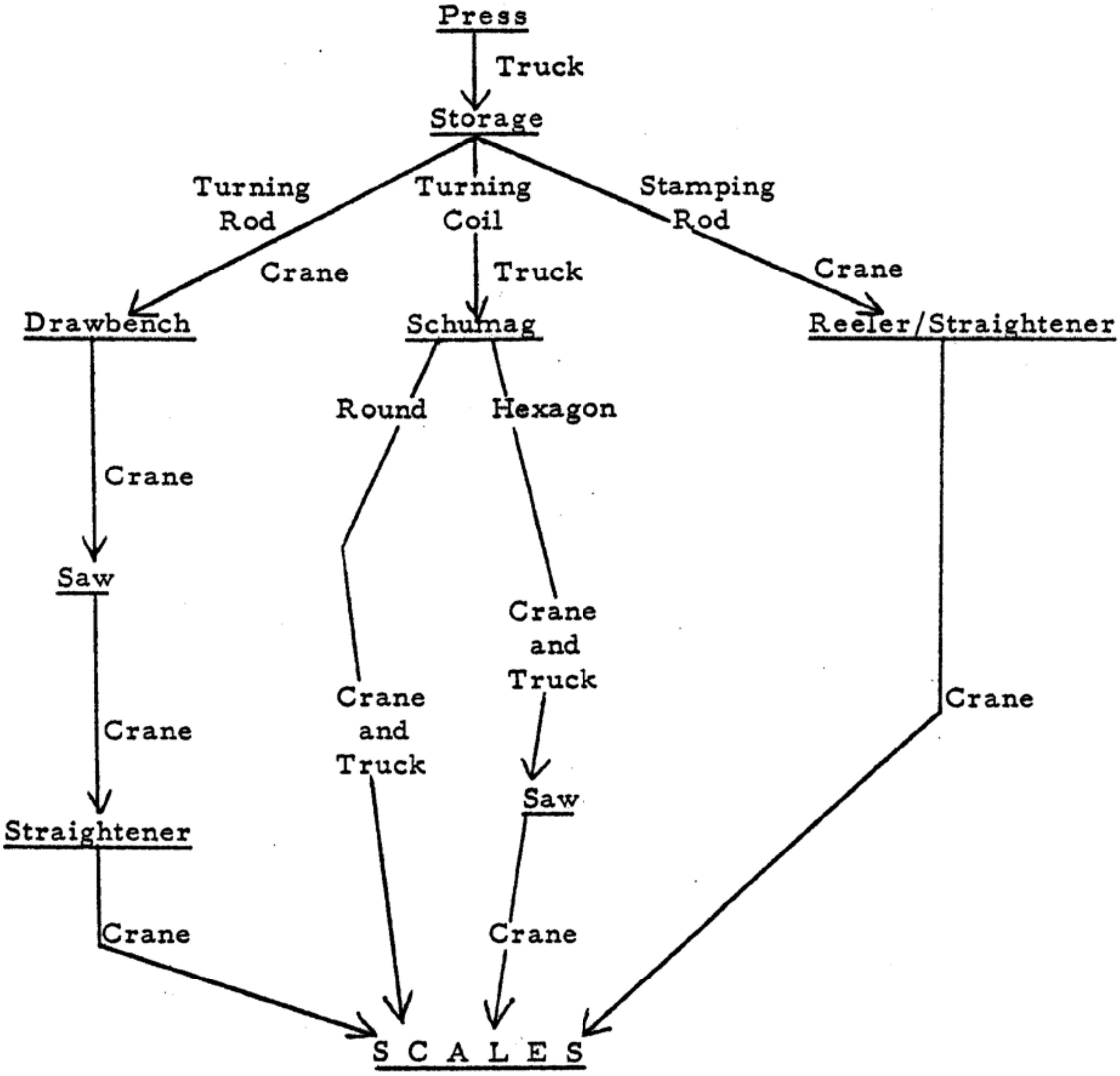


CHART 4

THE PRODUCTION FLOW OF THE FINISHING AREA FOR SOLID ROD (DETAILED)



SUMMARY OF MOVEMENTS

	Stamping	Turning Rod	Turning Coil Round	Turning Coil Hexagon
Crane	2	4	1	2
Truck	1	1	3	3
TOTAL	3	5	4	5

2.3 DELTA'S GROUP PHILOSOPHY

In terms of production expertise Delta, as the preceding chapters have indicated, have at their disposal complex production techniques involving large scale capital expenditure. Yet, if one considers Delta, not just as a group of scattered factories, but as a group with Group objectives, resources, etc. then in this aspect Delta as a Group is of comparatively recent origin.

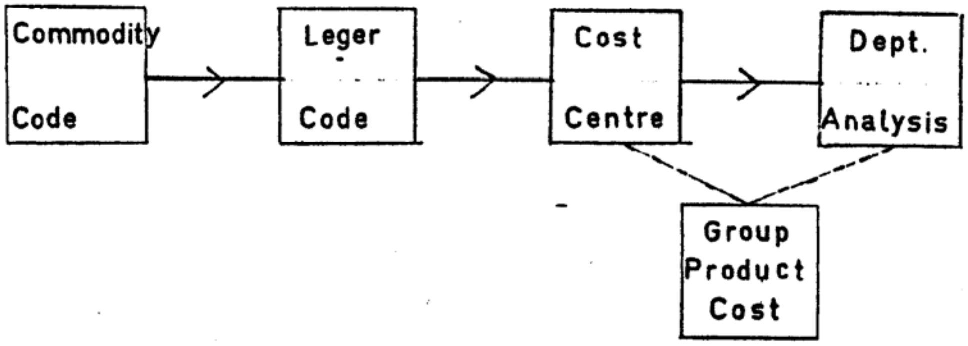
Being part of a group, large expenditures of finance, or wide ranging decisions are taken at, or need approval of, the Group. Nevertheless, because of the decentralised philosophy of the Group, many important decisions are taken at division, and further at factory level which indicates that a good control system is necessary at both these levels. We shall only be looking at the financial control system where it impinges on a discussion of the model. It should be remembered that cost control is only one part of the wider picture of financial control embracing metal stock control, metal price control, control of work in process, the control of co-ordinating stocks and production deadlines between interlinked factories, etc.

At the level of the division, a divisional budget is set consolidating target levels of sales, production, stock levels, etc., into a mutually consistent set of targets. Thus a budget is more than a series of aims of sales, production, etc. It is a co-ordinated plan of mutually consistent objectives. Thus the broad aims of the factories within the Group are laid down. Each factory must then set up its yearly budget which will act as its cost control standard against which to assess how the actual production levels, etc. match the production objectives, and how far the actual costs incurred are in accordance with the planned costs, given the actual level of activity.

The mechanics of the budgetary system are very similar to those of many other factories. Despite the relative inexperience of Delta as a Group, (for its experience in budgetary procedures is comparatively short - 8 years ago there was no systematic budgetary method in many Delta factories), Delta has done more to promote Budgetary Control as providing information for cost control than have many of her counterparts in ferrous activities, the latter of whom have retained <u>budgeting</u> in its unflexed form as a ipso facto executive arm of corporate planning, with budgeting (as opposed to budgetary control) being little more than an operational one year corporate plan. It is ironical that a firm whose cost information and cost knowledge is better than many firms, whilst still having areas of uncertainty, should show interest in improving its knowledge - whilst other firms should appear to be content to remain in ignorance of their cost structure and how effectively they are using their resources.

A classification of costs is at three levels. Each expenditure is classified to a commodity code. Certain groups of commodity codes correspond to ledger code headings so that costs are assembled into ledger codes which are then allocated, or much more often apportioned into cost centres which is the primary cost control level representing the amount of money expended by these centres of production. At the current time, the computer system of splitting ledger codes into cost centres only allows a primitive, totally variable, or fixed division, which must be a linear function of output. All costs, whether variable, fixed or policy costs, are apportioned or allocated onto a cost centre so that all the main costs of production are absorbed onto the production departments. The indirect costs of production (maintenance, etc.) are assembled together into indirect production centres and thence to maintenance departments (before being absorbed onto the production departments). At a higher level all cost centres, within one department, are aggregated to give global departmental comparisons of budget and actual costs for each department. Budgeted product costs are derived from the cost centre level or department level and accumulated. It bears reiteration that the budgetary control system is somewhat traditional in concept*, and is very similar to that

*(for example the system described in Batty(54))



which one might find in many factories both here and abroad.

A further issue is that Delta is still undergoing a good deal of rationalisation, as part of Group Policy. By transforming a fragmented, loosely-aligned group of traditional small to medium size factories with traditional production and financial control methods, into a cohesive, well-structured and logically integrated group of enterprises, one will use to the fullest the various, financial and technical advantages and facilities that being a member of a large group company affords.

In Rod Division, one problem was that the more complex technical processes and degree of integration of factory output had rendered inadequate a global factory view of labour costs being dependent on some output index. In practice, cost control tended to rest on an actual versus budget comparison. Therefore a criticism of current cost control methods is really a criticism of the budget.

Because of the work involved in examining cost behaviour, in the past cost categories had had to be considered as exhibiting a certain cost behaviour without scientific validation, therefore those who received the information felt sceptical about the accuracy of the standard/actual comparisons that they received, and upon which their production performance was, in part, judged. In addition, it was widely agreed that the more technically complex production and rationalisation procedures had rendered fixed/variable categories less useful. Money costs might tend to show some variable behaviour in a step function configuration.

Naturally, as the budgetary system had to take account of all costs, a great deal of effort was expended in allocating and apportioning all costs to cost centres - the cost centre being the primary level of cost comparison and thence control. In view of this time, less time was available to make a more thorough-going analysis of specific, crucial costs - labour, energy, maintenance and tool supplies, and yield in particular.

In addition, the fact that all estimates were in money terms led to inflation clouding the picture which the interpreter of the cost information had.

In brief, the behaviour of costs, because of the time deadline, tended to be assumed rather than investigated. Less time than would have been necessary was available to study in more detail labour, energy, cost, etc. which made up a large part of the variable element of costs. Our knowledge of the behaviour of these key costs in 'usage' terms (KWH, labour hours, etc.) was at a disappointing level. Our knowledge of labour costs tended to be at an aggregative money level, whereas for control analysis and prediction purposes an accurate knowledge of direct hours worked, indirect hours worked, overtime levels, etc. was clearly a prerequisite. Likewise, energy costs required a more thorough-going cost centre by cost centre analysis on usage and money basis so that one could utilise the relationships that were shown to exist between each centres 'output' and the energy it used. Clearly, certain cost categories could not be controlled by examining activity levels alone, but yet their behaviour could be predicted and hence control procedures established. An example was the control of space heating costs. The budget method of estimating the proportion of semi-variable costs to be absorbed by a production cost centre producing two products was always a subject of disquiet, as any fixed ratio must be, since it cannot but assume that the ratio of cost absorption remains fixed for all product mix combinations.

Other costs such as insurance and pension employer contributions were clearly semi-variable, but were difficult to treat effectively using a budget system. KVA was an example of a cost which really required a sub-model to predict how production charges would affect it.

Finally, under any budgetary system, the treatment of inflation must always be suspect since one must inflate budget estimates to match future presumed cost increases which may or may not be realised.

Thus the foregoing comments criticise the use of a budgetary system without additional information for the control of costs. It is not intended to criticise the considerable efficiency and enthusiasm which is generated in order to get through the massive work load necessary to formulate a budget. Rather it is a caveat that the excessive reliance on a budget to control costs at any level, and to predict likely cost behaviour at activity levels usually divergent from the planned, is likely to be a dangerous exercise. The questions previously posed appear to suggest that a method needs to be established to provide answers to questions concerning cost behaviour, for only when such a method is established can one consider the analysis and implications of cost behaviour for profit planning and control. A suitable candidate as an alternative method to fulfil these criteria would appear to be some sort of cost model.

e.g. to answer p 79 where step function cost behaviour is found.

CHAPTER THREE

'But the age of chivalry is gone, that of sophisters, economists and calculators has succeeded and the glory of Europe is extinguished forever.'

Edmund Burke 1729 - 1797 -
Observation on a publication, The Present State of the Nation

The first part of this chapter explains the basic principles of model building. The second part, by a question and answer style, attempts to allay the misgivings that might be felt about modelling generally and about cost modelling in particular.

'Write that down," said the king to the jury and the jury eagerly wrote down all 3 dates on their slates and then added them up, reducing the answer to shillings and pence.

Alice in Wonderland - Lewis Carrol

CHAPTER THREE

3.1 A CONSIDERATION OF A MODEL

3.1.1 Introduction

Having decided that a cost model is the way to examine cost behaviour for profit planning and control purposes, there is now a requirement to define and explain modelling in this context.

3.1.2 Definition

Any model might be defined as an abstraction from reality which seeks to shed light on real world phenomena which are either too complex, or unrepeatable to permit direct study. Thus a model might be formulated as an aid to our understanding of a problem because an investigation of real world phenomena is complex and/or difficult to analyse in terms of cause and effect. For example, it is sometimes helpful to synthesise certain key aspects of phenomena, in general terms, to see if any broad conclusions can be drawn. Thus any cost model is an abstraction from reality no matter what sort of model is developed. Rivett (1) sub-divides models into various typologies - iconic, probabilistic, deterministic, simulative. Iconic models tend to be used as a physical representation of the phenomena in question, for example wind-tunnel models.

Probabilistic models t end to be associated often with simulation techniques, with marketing models, etc. where the actual array of equations would be too numerous and the interconnections too complex to follow through. Thus a simulation of demand may simply be $D_t = \alpha e^{h_0 t}$ where α is a constant and ho is the initial level of demand. It is not suggested that Demand is solely related to time, but that the simulation of effects on demand by changing the time factor may prove helpful in the explanation of the model as a whole. One can visualise the introduction of a probabilistic (stochastic) feature of the model by re-forming it as $D_t = \lambda D_{t-1} + (1 - \lambda) D_{t-2}$ where λ is some probability factor.

3.1.3 Consideration of the Type of Model Most Suitable for a Cost Model Formulation

The reasoned choice of model type can best be described in negative terms by ruling out those that are unsuitable. An iconic model would seem to be more suitable for, say, effects of wind on various models of suspension bridges where a physical model can be drawn. Simulation models can be very useful where the underlying structure, causing certain phenomena to occur is either uncertain or too complex to consider in detail. Supposing that consumption (i) is one of a large number of elements to be considered in a marketing problem. Then (i) $C_t = \alpha + \beta C_{t-1}$ may be an accurate simulation of C in time t, but it in no way explains why C_t is a specific value, nor what effects taxation would have on such a value. It gives results, often probabilistic in terms of method, without going through the actual variables involved which affect the result one is interested in. Thus as Kotler cites, it is very useful for marketing where to attempt to record all the elements involved in a decision to buy a certain brand of chocolate would be an immense task, to decipher their interrelation absolutely impossible. But in cost model terms, when considering a change in a cost variable, one wants relationships established in a <u>deterministic</u> model, of the form:

$\underset{(nx1)}{\underline{y}} = \underset{(nxm)}{A}\,\underset{(mx1)}{x}$ where $\underline{x}$ would be an (nxl) vector of exogenous variables such as billets produced, rod produced, etc., upon which the endogenous variables $\underline{y}$ depend. $\underline{A}$ being an (nxm) matrix is a matrix of cost equations formulating in what manner the $\underline{y}$ are related to the $\underline{x}$ variables.

The reasons that this sort of deterministic framework should be used for a cost model are that:

First - where relationships are known on a relatively sure basis between variables, a deterministic rather than a probabilistic equation system should be set up. It is perfectly possible to incorporate probabilistic equations as a sub-system (for example in the treatment of maintenance costs) inside a system mainly deterministic in nature. Simulation techniques could be employed on cost areas of relatively minor significance which are complex to formulate in terms of equations, but, as will be shown in the next section, the power of the model is reduced by doing so. Indeed, one needs to consider the aims of a model in determining the best sort of model to be used.

Second - a number of suitable packages exist which could process the accounting data into output for the model. Whilst simulative model packages exist, their design makes them less suitable for the processing of data which is in the form of a matrix of equations.

Third - the small number of previous attempts at cost modelling (22) and (28) both used a deterministic model, and this view is shared by some of those whose opinions have been sought on this matter.

3.1.4 Aims and Objectives

Thus far it seems that, for a cost model, a deterministic model is appropriate, as this is most appropriate for the aims and objectives which this model formulation is meant to fulfil.

In my opinion, there are three aims of a cost model formulation:

(i) Control

to act as an aid to improve control procedures

(ii) Prediction

to predict the change in costs, etc., caused by changes in output, for example.

(iii) Analysis (This is linked to (ii) but is a separate issue nonetheless)

to analyse the salient features of more complex cost changes to see the results of such changes both on other costs and on output variables. A cost reduction exercise might be a very good example of this. This view is backed up by the fact that the literature, such as it is on cost modelling, supports this view, for example the cost equation system of Singh and Law (22)

In sum it can be seen that to analyse cost changes via a simulation model would be rather ineffective, since there would be no way of knowing what variables in the "black box" had shifted in order to achieve the actual result. Whilst prediction via simulation might indeed outperform deterministic models (for example, predicting Y_t from $Y_t = \alpha + \beta Y_{t-1}$ has a higher coefficient of determination than using a reduced form ((of a structural model)): $Y_t = \alpha + \beta I_t + G_t$), one must have an equation system which gives reasons as to what causes Y to vary, and not just how much.

3.1.5 It seems therefore that a deterministic model of structural equations which adequately describe the system in order to predict values of key variables, act as an aid for management control, and to analyse effects of change in variables appears a logical choice. In addition, if one was to consider more than one factory, a compatible model should be able to compare equivalent functional areas, and compare like costs, to perform the three aims of control, prediction & analysis, both on each factory and functional area and to compare results, and to consider the factories as a contiguous whole. By way of an example: if an area of a factory devoted to the extrusion of brass rod and copper shell were to be devoted only to copper shell on a permanent basis, and the brass hollow rod transferred to an area of another factory producing section rod, how would the cost configurations alter, and what would their level be?

3.1.6 Having considered the sort of model one requires and the aims it sets out to achieve, what area of cost is one trying to examine?

One suggestion could be that every cost aspect should be considered - labour, administration, water consumption, irrespective of their relative importance.

An alternative view suggests that one should examine only key areas of cost which are important and capable of an improved method of analysis.

It may be that neither of these two viewpoints is correct. The first is easier to reject for it taints too much of book-keeping completeness, instead of accountancy as an aid for management decision-making.

The second view is intuitively very interesting, but I would nevertheless reject it on the following grounds: it would be useful if a model could be reconciled with existing methods of control accountancy so that the difference in assumptions can be ascertained and perhaps both can be improved. Also a model only aiming to explain certain elements is likely to be viewed with suspicion as being only a partial explanation, and runs the risk of ignoring costs which might be irrelevant for many purposes but could be important for investment decisions. To quote the example in Section 5.3.1.e normally one might not pay great attention to toolroom costs, but this particular example might involve a considerable long term shift in toolroom costs and levels at the respective factories, and indeed in respective production control costs.

It seems to me that a third option is both open and appropriate in these circumstances. That is to consider all aspects of costs but to devote much more attention to important areas than to those which are less important. For example a doubtful assumption on natural gas costs for die heating might be acceptable, whereas a similar assumption for foundry labour (a more important cost) might be totally unacceptable.

In particular one might want to place much more emphasis on those costs which are large and exhibit variability with respect to output.

3.1.7 Having decided on the approach to cost analysis to be employed, a pertinent question to be posed is at what level is the model to operate. It should be able to aid decision-making at a factory level by providing aggregate information on the factory asa unit, perhaps for comparisons between similar factories in the group (or for BNFMF or ICFC purposes), or for consideration of future acquisitions/disposals.

At a lower level a model should be capable of sub-division into distinct functional areas. At this level, apart from being an area that a general manager might want to examine in detail after a study of cost details for the factory as a whole, the cost model should be of use for control, prediction and analysis purposes in each function area.

Thus one might consider a factory producing semi-finished products in terms of functional areas, e.g:

(i) a smelting area where scrap is converted to a suitable form for extrusion (large and small billets).

(ii) the major extrusion area where large billets are extruded into solid rod in a rough form.

(iii) a minor extrusion area where small billets are extruded into hollow rod in a rough form. In addition this area will also extrude externally purchased copper billets into copper shell.

(iv) a finishing area which converts the rough solid rod to a finished form.

(v) a finishing area which converts rough hollow rod to a finished form.

(vi) a maintenance functional area which is responsible for maintaining plant and equipment.

(vii) ancillary service areas whose relation to output is less clearly defined.

One therefore needs to consider what sort of information would be a useful aid for the effective management of each area, and for the factory as a whole.

It may well be that in an industrial context, certain cost may, because of their significance and/or cost behaviour, require more detailed attention in comparison to other cost aspects. In the metal industry, for example, labour and energy costs by virtue of size, warrant particular attention. Thus if one considers a cost model in a metal industry context it would need to:

a) set actual energy consumption (whatever energy source(s) is relevant to the area under consideration) against the model prediction based on the 'actual' output achieved in that area. It needs to be able to predict in energy and money units (deflating the values within the model) for relevant comparison. Obviously, in the case of electricity it needs to separate and treat in a different manner the KWH and KVA charges (Dixie (41) gives a short note on electricity charges). The model should compute useful ratios (e.g. KWH used per ton billets cut) where these are helpful.

b) On labour hours, attention may need to be drawn as to the downtime (production hours lost) occurring, the actual production hours worked, and efficiency ratios computed as to total hours worked per ton, actual productive hours worked per ton, predicted hours worked per ton, predicted non-productive hours against actual non-productive hours, etc.

Clearly these ratios need to be computed on an area basis and also on a centre basis (a large furnace for example) so that the centre where labour (in-)efficiency has occurred can be readily identified. Note that it can often be the case that apparent efficiency in one area is inefficient from the point of view of the factory as a whole. An increased output of billets (e.g. containing slag) which ultimately need to be scrapped simply means that the value added on a given tonnage of scrap is higher than it need be.

c) Other cost categories where it might be appropriate for control to operate via prediction.

d) Plant maintenance. This is an area where a different approach could yield most interesting results. A survey has been conducted by the DTI in conjunction with the Terotechnology centre as to the various approaches to maintenance cost control one can take.

The traditional approach is to consider plant maintenance costs as a service to the production units, the costs being shared amongst them in some predetermined ratio.*

A different approach, put forward by the Terotechnology Centre and the DTI is to consider maintenance as part of production process and to classify it under three headings: The aim to adjust plant availability until a minimum of (1 + 2 + 3) is achieved:

1. direct costs incurred (corrective element)

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* e.g. using maintenance department hourly cost rates on the basis of work done.

2. direct costs incurred (preventive element)

XX Calculated as in (1), p60

3. indirect costs incurred ("loss of contribution to profits and overheads due to downtime, scrap, etc., where these can be attributed to inadequate maintenance")[XX].

The survey suggested that indirect costs could be * about 50% of total costs. Existing methods of control (usually budgetary in origin) whilst used in * 74% of firms, were of value in only 38% of firms. All too often budgets were based on last year's figures plus 10% to allow for the inevitable cuts. There is no doubt in my mind that more work on this aspect would be very interesting and could well yield substantial savings on maintenance costs (in total) or in diverting maintenance resources to functional areas in a different proportion to that currently employed. There is no reason to suppose that the total maintenace cost (including indirect cost) should be the same for all functional areas. The difficulty of the analysis is undoubtedly in estimating indirect maintenance costs. "The evaluation of lost production in money terms is not a straightforward calculation." (*Economics of Downtime - C. R. Young, see DTI/Terotechnology Report on 'Life Cycle and maintenance costing)

Nonetheless, if we consider a case where the value of production lost is irrevocable as in the newspaper industry, then (1) downtime cost = production lost x contribution* if the value of production is recoverable, in other words we can meet today's sales by tomorrow's production, then the downtime cost incurred is simply an extra cost of labour, fuel, etc. used. *Note that for a firm using only conversion values, one needs to look at value added lost as the equivalent of the contribution foregone.

@ It may be seen that the indirect cost of production lost is often less than might be at first thought. In passing statistics in newspapers purporting "£20m. of production lost" are misleading. The value of what is lost depends on the feasibility of increasing future production to fulfil our current orders. Thus "more plants are over-maintained by enthusiastic engineers than the converse", if (1) is always the calculation made. This approach, at least, puts maintenance in the context of production. At any rate, since only 50% of firms keep records of downtime due to maintenance and only 1/283 quantified its downtime in any systematic way, this area is a novel one.

3.1.8 Having examined briefly some of the control areas in which the model should be a useful aid, one next wants to consider the predictive qualities of a model. In this case, one is not concerned with comparing actual

@ See Glossary

with "estimated" but in trying to visualise the likely costs and functional area "outputs" and inputs that will be incurred given certain specified product targets, e.g. 900 tonnes of turning rod per month. In other words, one is using the model to evaluate likely downtime, electricity consumption from the finished product (rod, etc.) point of view. The analysis which the model should be able to cope with is really an extension of prediction. In the latter one considers the production areas operating roughly as now, in the former one looks at how changes in production patterns might affect cost configuration. For example, if the production mix of large and small billets on the two furnaces were radically altered what would be the likely effect on electricity, labour and downtime hours?

3.1.9 It is envisaged that this model will be capable of performing a very important function which is generally ignored in cost modelling. It really concerns the static nature of models.

This cost model will monitor the cost assumptions which form the basis of the predictions or control statistics. It will compare the assumptions made to the actual behaviour of costs (for example) over a period of the last 10 months, say. The reason for this is that in my experience costs often show permanent changes which need to be included in the cost model. Thus the model will retain its flexibility and will not suffer from an objection of model building that it is unresponsive to change, to anything like the extent of a typical model. For example, models on investment analysis do seem to be very vulnerable to even minor changes in the tax allowance system which can cause the conclusions to have a large margin of error which they otherwise would not have.

3.1.10 The major aspects of the cost model have now been considered and it is therefore opportune to enquire what is novel about the procedure outlined.

In the first place, cost modelling, unlike its marketing sister, is a relatively uncharted sea.* Those models that have been developed (usually for appraisal methods) have tended to be somewhat simplistic and to contain errors of principle (for example assuming that depreciation is tax-allowable - it is of course tax allowances that are allowed against tax. The two are seldom the same unless the firm merges the two. With FYA* at 100% on plant and machinery it is difficult to see this being the case).

Second models in general tend to be limited in the

*First Year allowance against tax.

* The industry under consideration pp1-46 makes the application via work study and industrial engineering of standards setting difficult

problems on which they can aid. This model attempts to be both a control and a prediction/ analysis model thus being of use for a wide range of purposes.

Third, the model will form the basis for a cost model at a second factory in the Delta Group, thus providing a compatible base for relevant performance comparisons.

Fourth, the treatment of plant maintenance costs represents an exciting new departure* when compared to a traditional treatment. This could well serve as a pilot method for what could be a future standard method of dealing with plant maintenance costs.

Fifth, the model will raise its own assumptions so that it will adapt itself to technical changes. Thus it will produce useful information about the scale of changes in cost behaviour for example, that appear to have occurred.

3.1.11 What this model will not do is investigate the detailed effects of cost differences within turning rod groups for example, but will treat turning rod as a product group. If it is felt that the finishing rod functional area is of sufficient size to merit such a more detailed treatment this could be done at a later stage.

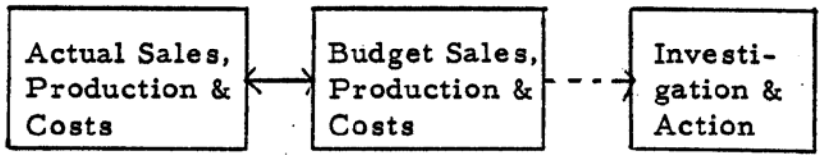
* p59 compared to (54)

3.2 A COST MODEL - MANAGEMENT CONTROL ASPECTS

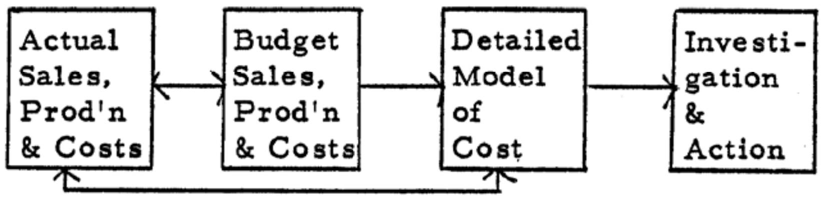
3.2.1 General

The control of cost, particularly when price or market restrictions are in force, remains an important aspect in retaining and improving on a firms efficiency performance.

3.2.2 In practice one method often evolved or chosen to provide information for cost control is a budgetary procedure which sets targets and estimates woven into a mutually consistent and complementary plan with which to assess cost efficiency and pinpoint areas of concern. A budgetary procedure can be very useful for the purposes of an initial examination of whether production, sales, costs, etc. are roughly in line with the plan, and indicating the source of future (and present!) difficulties and matters requiring managerial attention. At this level the budgetary procedure can perform an invaluable function in alerting management to take financial or other action to bring an abnormal situation into normality. Unfortunately, one must realise that the budget is a <u>first</u> and not <u>the</u> sole information for management control.



It seems to the author than an extra step is useful between a question raised in the mind of a manager because of budgetary information and action based on such information. In fact, a second stage of more detailed information should be available to a manager to suggest in less general terms where abnormalities exist and their likely causes.



3.2.3 <u>Why is this extra step necessary</u>?

a) Budgets are bound to be susceptible to error where actual output (by a fall in demand, etc.) differs significantly from that planned. Their effectiveness as a control procedure relies on the level (actual) being not too different from that planned.

b) Because a budget, particularly under a full cost system needs to take account of all costs will necessarily be less than the more detailed model which mainly focuses attention on labour, energy, and to a lesser extent, production materials (dies etc.) and maintenance. In addition, great stress is laid on the analysis of the division between variable (not necessarily proportional), fixed costs and policy costs.

c) Because so many cost codes are involved in a budget, efforts to separate fixed, policy and variable cost elements tend to be, of necessity, rather difficult to quantify.

d) Because the control information (variance, etc. is in money terms, this can, because of inflation or faulty estimates, etc., mask the real situation.

e) The treatment of inflation using budgetary control is difficult in practice. Often it is necessary to forecast future wage or electricity price increases which is an onerous task at best.

f) Much of the enormous amount of time involved in setting up a budget is taken up by deriving apportionment principles for fixed or policy costs which are, of themselves, of small importance.

g) The cost model, the author would like to reiterate, is not intended to replace the budget, but rather to supplement it. All too often the

N.B. These points refer to the situation found in the 2 factories under consideration.

budget is criticised because it is used for purposes for which it was never intended (e.g. using one month's electricity variance figure in isolation, instead of by budget/actual comparison for, say, three consecutive months). A brief example follows which illustrates how these features can be put into practice in a given industrial situation.

3.2.4 What are the main features of the Cost Model?

a) This cost model directs the majority of its attention to the analysis of labour and energy costs. These are sub-divided until a proven steady relationship between "usage" and "activity" is established. For example, KWH v the billets extruded on a press.

b) The model does not assume that variable costs are linear, but is designed to permit the use of 'step functions', etc.

c) Because of the equation methods used, holiday pay and NIGP should readily be associated with respect to cost areas (e.g. an extrusion press).

d) The relevant control statistics should be computed both in usage units (hours worked, overtime hours, KWH used, etc.) and in money terms.

e) A model should be able to deal with heating and jointly incurred costs. Two areas causing common difficulty are space heating costs, KVA charge and the apportionment of variable joint process costs by product mix (for example where copper and brass billets are both extruded, or where the labour cost of a large stamping machine must be apportioned between many products). A model should be able to out perform any other control/estimation method totally convincingly.

f) A model ought not to have to make the assumption that absorption rates in, for example, a two product joint-process cost centre are independent of the product mix.

g) The accuracy of a model when tried on dummy data should be good overall, and retain a reasonably good degree of accuracy when costs are disaggregated down to smaller "areas of interest" because of the nature of the costs selected for detailed examination.

h) "Derived data" such as yield estimates, labour efficiency per production time, breakdown time as a percentage of total time, labour efficiency per total time, etc. are designed to be pointed out.

In general, the aim of a model is to assemble the sorts of data and control which prove, in practice, necessary, into one complete system.

i) The treatment of inflation should be consistent in that both model and actual estimates are deflated with reference to a given base date by using internally derived inflation indices for electricity, etc. As a 'bonus', indices of, for example, KWH charges, labour rates, etc. are printed out which could prove a most important area of information in the future. By combining this with the "efficiency" of any machine where more than one heating source is possible, one can, time period by time period, analyse relative price with efficiency comparisons of alternative fuel sources.

j) The whole model should have an accent on management information. The design is not to produce an enormous wad of paper, but by selective data and management ratios, to point out information that is clear, concise and in a form suitable for its recipient. It is designed to reduce the amount of 'ad hoc' tasks which an accountant is so often called upon to do (either by immediate boss or higher) because the information is <u>available</u> in the model and can be easily accessed.

k) Ambitiously, a model should attempt to be self critical. As well as its "standard" estimates it quickly assesses estimates based on say the last six months data to consider whether the "standard estimates" are reasonable. A model should be designed so as to facilitate easily changes in, for example, wage rates. It should not be caught out by, say, a new method of arranging <u>lathing</u> machines, or a new billet heating method.

No model should aim to increase the already heavy workload endured by industrial personnel, certainly not when the model is in its operational phase, since at that point in time one of its advantages is that it reduces the need for ad hoc reporting. Where comments like that of Ariel to Prospero "is there yet more work?" are heard, it should only be because what is asked is novel and therefore at <u>first</u> not always obvious to envisage: This model will aid the work necessary for the budget, will greatly curtail the work needed for 'ad hoc' reporting (e.g. projections cost reduction indices of energy or labour costs, downtime, etc.) by consolidating much of the work into one systematic method.

The system is designed to reduce the image of the industrial accountant as a "negative" adviser - interpreting complex printouts to advise technical management of their shortcomings stereotypes the accountant as a criticiser - often with the suspicion that he has designed the 'standard', interpreted it and commented on it purely to criticize for criticisms sake. This method presents the line manager with a short printout so that he can analyse and take action from the document, the standards of which he has had an important part in planning. The layout is exceptionally clear with key ratios clearly marked. @

3.2.5 Costs of the System

a) The implementation of the system might be enhanced by the writing of a suitable software programme. Although the system could be undertaken manually, it would require manhours which might not be available. The computer software is simplicity itself for anyone with a reasonable training in programming. It is simply a data base,

@P225ff

a series of mainly linear or step equations, and then output procedures to type out and/or compute derived results. Because the system is so flexible, once the model has been set up for one factory relatively few adjustments are necessary to render it suitable for another.

b) The model does demand a reasonable knowledge of the cost behaviour of a factory both in usage and money units. For example, a system is bound to be impaired if the KVA and KWH charges are treated as one single statistic. But no knowledge is demanded which would not be known or about which industrial personnel themselves would not be interested in finding out. Even if all the information is never as we would like, implementing the cost model will improve our understanding of the causation of costs and how we can improve them, either by cost control or by cost reduction. All the time the model runs by its iterative estimation techniques, our information improves so that not only can we criticise but we can positively improve the quality of information upon which decisions are based.

This model represents a cheap, reasonably easy and exciting prospect in Delta, and in general in any industry concerned to produce efficiently.

3.3 THE PRACTICE OF A COST MODEL

A model is an abstraction from reality: it is an attempt to indicate, by means of positing fundamental, stable relationships, likely answers to questions which would be difficult, if not impossible to achieve by observing the complex, real world situation direct.

On a less abstract level, one can look at a cost model and justify its being used in terms of the scope and accuracy of the replies it is capable of giving to the questions which are asked.

In a factory environment, so many variables are capable of causing important variations to the costs which we are attempting to control or to predict or to analyse, subsequent to technical changes being considered.

A model is able to cope with this large number of variables without imposing a peripatetic assumption on them for reasons of simplicity.

For example, if, for control purposes, we refer only to a table comparing last years cost per unit output to this, one sees only what has happened in general terms, not the causation nor the specific area. One expects a model to provide some standard measures against which to assess the actual performance. Thus traditional accounting techniques of control such as budgeting control are in themselves a form of model. Therefore, the discussion is best couched not in terms of either a model or no model being formulated (unless you believe that a complex factory can be controlled by glancing at monthly production figures). Instead one must examine the pay off between increasing the complexity of the model and hence its costs of formulation and implemenation and the increased number of questions which can be posed and the increased accuracy and depth and scope of answers which can be put forward.

Perhaps, then, one can consider some of the questions which only a reasonably comprehensive model could hope to answer. @

Q.A. What effect would a technological improvement in Yield of x percent on an extrusion press (say the use of extrusion method) have on:-

(i) Energy consumption: (example given)

(ii) Labour hours per tonne billets extruded

(iii) Labour payments per tonne billets extruded

(iv) Labour payments per tonne billets extruded including associated labour costs (pension insurance and holiday contributions).

In this case we must consider the press as a cost centre with billets used and rough rod as inputs and outputs respectively. Yield is a double-edged variable as it can affect costs relating to input variables as well as costs relating to output variables.

@These questions were raised during the investigation.

With the improvement, only $\frac{100}{y + x\%}$ of billets are needed to produce a given level of output (rough rod) where y is the current yield and x the improvement. The summarised results are shown in terms of capacity levels 50% through to 100%, Yield can be seen to be incorporated as a cost element itself rather than a separate statistic.

Q.B A decision is being considered as to the most efficient way to organise labour to increase foundry output, for simplicity the large furnace, from its present level to a 20% increase. The question under consideration is whether it would be more effective to operate another shift or to employ overtime.

Only an accurate model can answer such questions as this, since it demands a step function labour cost v. foundry output graph.

Q.C The factory consists of a number of sub units producing saleable products such as billets, rough brass rod, etc.

It is proposed to consider increasing considerably the sale of billets as an intra group sale based on a variable cost plus basis. What light does the model shed on the likely labour and energy costs to be incurred?

Q.D The firm has recently become more aware of a desire by the Government to tax firms indirectly via increasing the NIGP contributions. How would various increases on these contributions affect the wage bill in each of the factory areas? If a "German" type system were adopted, what would the likely affects be?

Q.E One unit of the factory is involved in a joint product process. The absorption rates to the two products of the process cost are felt to be inaccurate. What help would the model be in examining the "technical" absorption rates used and in suggesting how product mix alterations might affect the absorption rate we should use?

Q.F One of the problems of providing standards against which to ascertain the efficiency of current performance is just how often to adjust our standards: adjusted too often and we fail to see our progress in the medium time horizon, and tend to let yesterday's errors become today's standards: adjusted only at long intervals (and this in practice is the side on which we seem to err) and the standards become out of date and a hindrance in a changing production system: How can a model help reconcile this apparent paradox?

Q.G Space heating costs can in some factories be a large proportion of energy costs, yet little progress seems to have been made in assessing our efficiency in this respect. Does this mean that the model cannot help us in this aspect?

Q.H So far the model seems to be useful in operational terms, e.g. in examining our control and in looking at likely cost results from alternative strategies. Does this mean the model will not be useful for, say, capital investment decisions?

Q.J Cynics would say that this so called model is no more than a glorified budget. Would you agree?

Q.K The model seems to do no more than be a collection of multiple regressions assembled in order. Do you agree?

Q.L The model seems to be useful in looking at one factory. Can it be useful in making a comparison across factories, perhaps even internationally?

Q.M The model does not seem to have dealt at all effectively with maintenance or disposable tools, etc. Do you agree?

Q.N How effective is the model in providing management information (i.e. rough but relevant) to deal with strategic decisions, for example the minimum level of price necessary to cover variable manufacturing costs of a typical brass rod.

Q.P The snag with these so called quantitative methods of analysis is that all they end up doing is providing masses of computer paper, which does not aid the solution of management problems but only cures wobbly tables. Do you not agree?

Q.Q If we were to agree that the model seems to have performed quite well in the factory(ies) under consideration, does this not mean that it is inflexible in dealing with other factory situations?

Q.R Just how wide can differences in output be before the model ceases to be accurate? In practice, surely, it will have the same inadequacies as a budget in terms of inaccuracy of prediction outside of the budget = actual output activity level.? *

Q.S In Q.Q we asked about how well the model performed with respect to a factory in a different environment: it seems to me difficult to see just how a model of this complexity could be used, for example, in a small Brazilian extrusion mill having only four full-time managerial staff.

Q.T It seems to me that all this information could just be done via "ad hoc" reporting like we used to do in the olden days.

* Because of step-function cost behaviour

Q. A What effect would a technological improvement in YIELD of x% on an extrusion press (say the use of indirection extrusion instead of the current direct extrusion method)

(i) energy consumption: (example given)
(ii) labour hours per tonne billets extruded
(iii) labour payments per tonne billets extruded
(iv) labour payments per tonne billets extruded, including associated labour costs.

WORKING EQUATIONS

ORIGINAL

Electricity Press Usage = 5 + 0.0562 (1700) - 0.04(90) — Billets Used / Yield — At Activity Level

96.9 MWH = .9 x 1700
= 1530 TNS ROUGH ROD — 80%

TAKE 1530 as 80%

NEW

$$= 5 + 0.0562 \left(\frac{100}{90+3} \times 1530\right) - 0.04(93)$$

90.7 MWH produces 1530 tons rough rod — 80%

This data shows the detail to which the model can descend. It shows us how the minor of two energy sources to one cost centre is affected by a small change to a variable (yield) seldom considered as a mathematical variable. Note that this would be a small part of the work required to indicate the effect of a yield change on this press. We would consider the other energy source and the value added of the foundry saved by the 3% yield increase. Note that even this deliberately chosen small amount comes to a saving of £422 per year. A usual factory method of examining total finished output cannot explain the savings of yield increases.

FINAL DEMONSTRATION

YIELD INCREASE OF 3%. WHAT EFFECT IS THERE ON ELEC. CON.

			OUTPUT 50%	80%	100% OUTPUT
Elec. Cons.	MWH	OLD	61.00	96.9	120.8
Elec. Cons.	MWH	NEW	59.05	90.7	116.9
Elec. Cons. *	£	OLD	671	1066	1329
Elec. Cons. *	£	NEW	650	1030	1286
DIFFERENCE	MWH		1.95	3.2	3.9
DIFFERENCE	£		21.00	35.2	42.9

* The change will not be enough to affect the KVA charge pattern significantly (model). We will say £11 per MWH elec. cost.

Q. B A decision is being considered as to the most efficient way to organise labour to increase foundry output, for simplicity the large furnace, from its present level to a 20% increase. The question under consideration is whether it would be more effective to operate another shift or to employ overtime.

We are to produce 700 tonnes of billets. Do we use 7 men on one shift, making up output by overtime, or do we employ another shift, using it for only 17/20 of its capacity.

MEN	Method A: One Shift			Shift All	Overtime	Holiday Pay (Model	NIGP @ 10.25%	TOTAL COST
7	Direct hours paid) Indirect Hours paid)	£1413	ADD	204 (17/20)	248	70	198	2133
12	Direct hours paid) Indirect hours paid) (incl. £187 for non-productive time)	£1600	ADD	204	-	120	200	2160
		(1)		(2)	(3)	(4)	(5)	

This exercise illustrates the importance of accurate labour cost per ton figures (1). Knowing the effects of shift and overtime (2) and (3). Remembering holiday pay and NIGP (5).

The figure give similar costs for both methods. What is interesting is to consider whether the 5 workers would have had to have been paid holiday pay in any case. Also, I have included £187 for unproductive time (the shift is occupied 17/20 of its time). As important as the figures are the fact that this method brings home just how we need to approach the problem. Step function labour cost v. output plus the various wage additions logically built up. Only a comprehensive model could achieve this.

Q. B (Continued)

MORE DETAILED CALCULATION OF PREVIOUS PAGE

PROBLEM

We are to produce 700 tons on the large furnace. (We at present employ 17 men to produce up to 2, 400 tonnes B/C.) Should we use overtime or reduce shift of men (5) and pay the remainder for a full month production?

	METHOD	Hours Required	No. of Men	Rate	Hours Paid	Shift All. *2	Overtime *3	Model Holiday Pay	NIGP at 10.25%	TOTAL
A	Direct Hours	1070	7	.90	963					
	Indirect Hours	600		.75	450					
		1670			£1413	204	248	70	198	2133
B	Direct Hours	1070	5 + 7	.90	963					
	Indirect Hours	600		.75	450					
	plus full wk. time*	250		.75	187					
		1920			£1600	240	-	120	200	2160

* total hours for 2 shifts need to be 12 x 40 x 4 = 1920 hours

*2 Same shift allowance, but under A only

$\frac{1670}{1920}$ of shifts are needed

i.e. 17/20 x 240

*3 (7 x 40 x 4) - 1670 = 550

Q. C The factory consists of a number of sub units producing saleable products such as billets, rough brass rod, etc.

It is proposed to consider increasing considerably the sale of billets as an intra group sale based on variable cost plus basis. What light does the model shed on the likely labour and energy costs to be incurred?

MODEL COST ESTIMATES

	PRODUCE NOW	FUTURE	
Billets at: 2,100 ton Large Furnace / Billets at: 200 ton Small Furnace		3,000 ton Large Furnace / 200 ton Small Furnace	
	8076	10792	Labour Total
	686	1089	NIGP
	541	597	Holiday Pay
Future 4% below variable prediction	9303	12478	Labour Total
	8998	11445	Electricity
	463	594	Gas
	525	525	Water
Future 10% below total variable prediction	9986	12564	Total Energy
	(1)	(1)	Maintenance
	(2)	(2)	Production Supplies
	(3)	(3)	KVA Charge

Q. C (Continued)

(1) To estimate the change in maintenance costs is really to ask how the maintenance policy is to be adapted - hence the estimation of the extra maintenance effort required. Prediction via quality of output change has shown no reliable relationship. We must confine our attention to areas where an analysis of cost v. output has shown a meaningful relationship.

(2) Again, a not very significant expense, but the best estimation is to ask how many e.g. more bags of vermiculite, etc. are likely to be required for the extra 900 ton output. Because of the holding at cost centre level of disposable supplies, no statistical prediction will throw much light on usage.

(3) Given as a sub-model, one cannot give a prediction without all the necessary data being available.

Q. D The firm has recently become more aware of a desire by the Government to tax firms indirectly via increasing the NIGP contributions. How would various increases on these contributions affect the wage bill in each of the factory areas? If a "German" type system were adopted, what would the likely affects be?

Using the [illegible] facility of the model to sub-divide labour costs, the chart below gives the likely effects:

No. Empl.	x (NIGP %)	8.5%	10.5%	40.0%	70.0%	Hol. Pay (22 days)
44	Foundry	686	847	3228	5649	541
16	Main Extrusion Wrks.	267	330	1256	2199	188
30	Finishing Work	373	461	1755	3071	352
17	Hollow Rod Press	325	401	1529	2676	212
10	Hollow Rod Finishing	140	173	659	1153	117
33	Maintenance	784	968	3689	6456	436
13	Toolroom	219	271	1031	1804	172
6	Build Main Lab.	85	105	400	700	79
12	Other	176	217	828	1450	140
15	Warehouse	207	256	974	1705	165
(60	Staff)	*	*	*	*	NIL
256	Total Workforce	£3262	£4029	£15349	£26863	2, 402

* Staff really a policy cost, cost is x% x salary total. Remember that staff holiday pay is included in salary. Add in private pension fund contribution.

Thus:		
	Total Wages	38, 371
	plus 10.5% NIGP	4, 029
	plus holiday	2, 402
		£44, 802

gives the current situation.

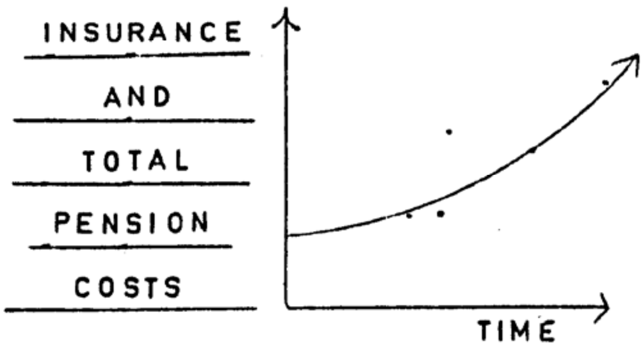
To compare to Germany:

Total Wages	38, 371
plus 54.8% NIGP	20, 151
plus $\frac{32}{22}$ x holiday*	2, 878
	£61, 400

* 32 German holidays (effectively about 54.8% + 7.5% = 62.3%).

Q.D. (Continued)

In case the reader feels that figures of 20%, etc. for NIGP contributions are illusory, the sketch graph is interesting. It is a favourite form of indirect labour tax (a sort of backdoor SET).



Because the firm under consideration is not itself a profit centre, and sales are in quantity terms, it does not possess a profit and loss accountant (public) as an independent firm would:

Suppose, however, that profits were to be $^3/_2$ of the value of labour value added, say

	£66,000	per month, taxable profit
Corporation Tax @ 50%	33,000	
	£33,000	net of tax

what reduction of Corporation Tax is necessary to equate a rise in NIGP of 29.5%.

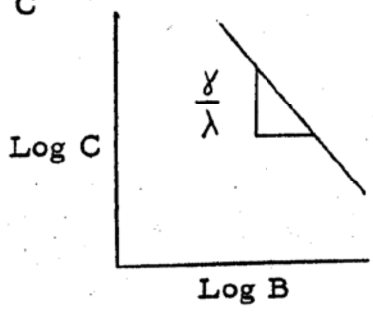
NIGP costs have risen from £4,029 to £15,349, a rise of £11,320. Thus, the C.T. bill needs to be £33,000 less £11,320, an effective Corporation Tax figure of about 32.8%. Thus C.T. must fall by 17.2% to compensate for the NIGP increase.

Note that the change in emphasis from Corporation Tax to NIGP affects labour intensive factories (e.g. Delta Rods (West Bromwich) Limited) more than Delta Rods (London) and Delta Rods (Wolverhampton). Thus, changes in the NIGP rate will encourage output switching policies to capital intensive products.

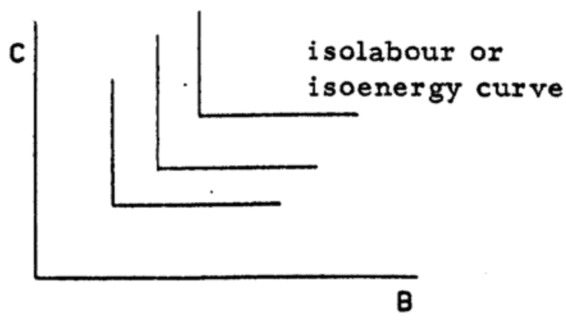
Q. E One unit of the factory is involved in a joint product process. The absorption rates to the two products of the process cost are felt to be inaccurate. What help would the model be in examining the "technical" absorption rates used and of suggesting how product mix alterations might affect the absorption rate we should use?

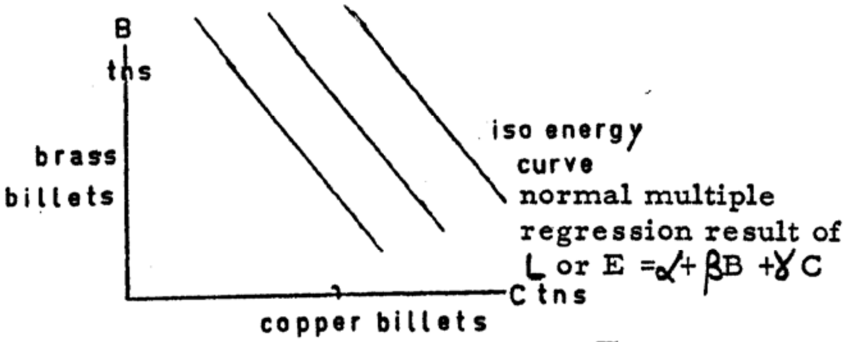
The model is able to continually examine how accurately our absorption rates fit the actual circumstances. Traditional accounting practice defines α to be the absorption rate for one output of a joint process and $(1 - \alpha)$ the other without considering any fixed element - all too often these estimates are based on out-of-date debatable "scientific estimates". The model reviews how the relative absorption rates are moving - whether they need to be re-examined or not, etc. The method used is multiple regression of T_1 periods with a comparison of a more recent shorter T_2 period. Note that we examine which format is most suitable for regression before not after we obtain our estimates, e.g.

α or $E = \alpha B^{\gamma} C^{\lambda}$



C & B are e.g. 2 types of output from joint process.





Practical Example

Traditional techniques gave the apportionment of energy costs between copper and brass billets in the ratio 1.53:1 for heating and extrusion in a joint process.

	TRADITIONAL (1.53:1)			NEW RESULTS (0.94:1)	
Energy Usage (MWH)		Cu.	Brass	Cu.	Brass
	300	247	53	220	80
Tonnage (Billets) Used		600	200	600	200
MWH/Tonne					

Results as per October 1974

COMMENT

One can see that my regression result gave vastly different absorption rates from that traditionally used. The traditional method is based on looking at the specific heat capacity of copper 380 $JKg^{-1}K^{-1}$ with the temperature rise.

Just for the sake of argument:

(N.B. By traditional is meant those in use at that time)

Q. E (Continued)

Extrusion Temp.		S.H.C.			Absorption Rate
930	x	380	=	353400	60.5%
630	x	365	=	229950	39.5%
				583350	100.0%

In fact, if one were just to take the ΔT, this would give ratios of about 60:40 (1.52:1.00). More correctly, by using ^oK.

Using ^oK					Absorption Rate
1203	x	380	=	457140	58.0%
903	x	365	=	329595	42.0%
				786735	100.0%

If we recall that a watt is a joule per second, this tells us that we must consider the time for which the billet is heated. As brass billets are less in tonnage and more complex in extrusion, we expect a result perverse to the scientific one. Therefore, various types of regression were tried related to various configurations of Brass v. Copper all of which were better in terms of R^2, but not significantly better than the 95% R^2 values obtained from the multiple regression (simple method). Whilst disappointing in that we cannot positively say which production isoquant (B v C) is most appropriate the high R^2 value one can say:

"the ratio of 1.53:1 of Cu. to Brass billet tonnage heating requirement has been a long established MYTH in the non-ferrous metal industry." The quote is a B.N.F. energy audit of Wolverhampton factory the words in capitals is my own.

Q. F One of the problems of providing standards against which to ascertain the efficiency of current performance is just how often to adjust our standards: adjusted too often and we fail to see our progress in the medium time horizon, and tend to let yesterday's errors become today's standards: adjusted only at long intervals (and this in practice is the side on which we seem to err) and the standards become out of date and a hindrance in a changing production system. How can a model help reconcile this apparent paradox?

This is indeed a real problem. All too often in practice we tend to let, for example, absorption rates slip until they are badly out-of-date. On the other hand, too frequent changes make it difficult to compare. This is a problem not just in cost accountancy, but in current v. historical cost accounting (c f F M Paper ICMA Part V - May 1976).

What the model can do is to isolate influences which are outside the factory system and therefore ought not to be included when considering factory control, for example inflation. The model deals accurately, thoroughly and consistently with this problem. The paradox is: how far should we allow a deviation between "The Standard" and the "New Standard" to continue before we alter the Standard? This is a management decision, but the model displays the forecasts for both "Standard" and "New Standard" to make this decision an easier and objective one. In any case, this model (in contrast to budgets) can be re-run using older standards, for example, to show how a fall in yield over 8 years, say, has gradually increased the energy requirement per tonne of output.

Q. G Space heating costs can in some factories be a large proportion of energy costs, yet little progress seems to have been made in assessing our efficiency in this respect. Does this mean that the model cannot help us in this aspect?

A recent DT1/Dept. Energy/Industry survey showed that space heating costs can be the most important energy cost of all. Yet our progress in controlling the cost can often only be couched in derisory terms, consisting of exhortations to shut doors, lag pipes, etc. Yet the paradox remains that winter office temperatures are 70°F. in summer only 60°F. What is required is an objective method of predicting what our heating effort should be for the available temperature. A proven relationship between heating cost per week and ambient temperature was established: therefore, we have an objective measure of the heating effort we <u>should</u> need. This method remains valid even if we partially use re-cycled heat or more than one heating source.

Q. H So far the model seems to be useful in operational terms, e.g. in examining our control and in looking at likely cost results from alternative strategies. Does this mean the model will not be useful for, say, capital investment decisions?

The model would be useful in the area. Let us take one specific example relating to space heating:

We are considering installing a device which will utilise waste heat from the presses and convert this to a hot water space heating system. The problem is that we have no systematic measurement of the likely saving in fuel cost. The model provides such a basis.

Month	°C.	galls./working week fuel oil used	Cost @ 35p/gall. £	% Distribution of cost by model
Jan.	2.9	16390	5736.50	28.0
Feb.	3.2	14860	5201.00	26.0
Mar.	5.4	5187	1815.50	9.0
Apr.	8.2	2369	829.00	4.0
May	11.1	1308	458.0	2.0
June	14.2	889	311.00	1.5
July	15.8	732	256.00	1.0
Aug.	15.4	761	266.00	1.0
Sept.	13.6	932	326.00	1.5
Oct.	10.3	1508	528.00	2.5
Nov.	6.3	4089	1431.00	7.0
Dec.	4.1	8809	3083.00	15.0
TOTALS		57834 galls.	£20241.00	100.0%

Q. H. (Continued)

Thus our model provides objective information about likely fuel savings if all space heating is from re-cycled waste heat.

Suppose the cost of 2 heat exchangers is £105,000 and the Group DCF rate chosen is 15%, then:

$$\sum_{i=1}^{10} \frac{\text{Savings - Cost}}{(1 + r)^{i}} = 116823 - 105,000$$
$$= £11,823$$

The IRR is probably about 17%. Naturally, we can look at inflating the cost figures and altering the DCF figure about which far too much has already been written. The purpose here is simply to suggest that the model provides good data in a difficult area.

Clearly one needs to consider the labour saving against the extra labour incurred in controlling the waste heat flow. This is best done by examining the likely labour hours (savings if any) and new requirements on the shop floor.

The reader may say that this analysis only applies where all the space heating requirements are provided by waste heat. I would point out a similar analysis would show how the methods outlined above would be used.

Q. J Cynics would say that this so called model is no more than a glorified budget. Would you agree?

In order to answer this question one needs to consider the purpose of a model, and the assumptions on which it is based. Any aim, oral or in writing, for production, finance, etc. has to be based on some assumptions. It may range in complexity from a few unverified observations to the complexity of an econometric model of the United Kingdom.

Therefore, whether the model is the same as a budget hinges on whether it can achieve more in terms of scope, accuracy, etc., and this has been examined in Section 3.2

Q. K The model seems to do no more than be a collection of multiple regressions assembled in order. Do you agree?

It is of great importance to distinguish between a technique, and a methodology or an approach to problem solving.

Certain variables of the model showed stable relationships between certain usages and activity levels. These were useful to explore via multiple regression. We looked at likely cost configurations before resorting to every conceivable cost shape (in other words, we thought about the practical shape likely to be shown before quantitative analysis).

Where regression is attempted without a cost structure, then one relevant variable may be ignored in the morass of mathematical symbols. Where regression is used to regress everything against everything (a sort of regression à la kitchen sink) one variable, perhaps metal yield, a key variable which did not vary during the experimental period will be ignored. Yet it is a crucial part of the cost structure because:

(a) a low yield reduces the throughput of billets, increasing waiting time.

(b) low yield means more billets input per tonne output.

Thus, one builds from practical experience and knowledge, a logical mathematical structure the <u>form</u> of which may be helped by statistical and regression analysis.

Q. L The model seems to be useful in looking at one factory. Can it be useful in making a comparison across factories, perhaps even internationally?

Yes it can be because the model helps to make the data base uniform across factory structures and focussing our attention on key variables without these being hidden by "Central Management Costs", etc. It can, therefore, be used for aiding such decisions as product relocation (e.g. stamping rod 1" - 2" from West Bromwich to Wolverhampton), multiple correlated activity level changes, changes in intra product "sales", for example billets produced in West Bromwich being used in the Wolverhampton press.
The model is also very useful indeed for comparing strategic variables and cost and usage configurations between England and, say, Germany, as is given in Chapter Six.

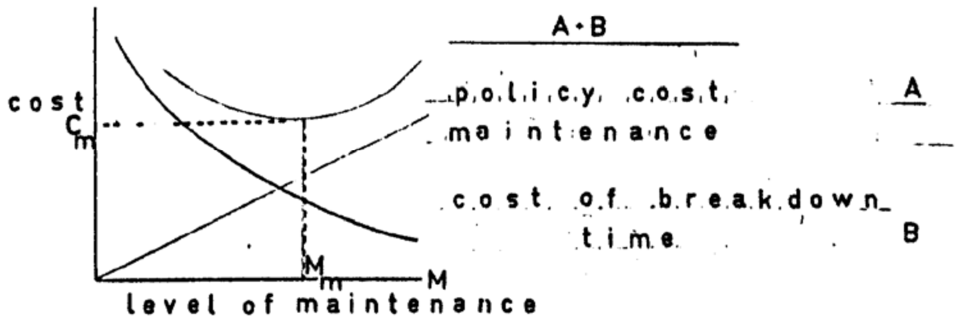
Q. M The model does not seem to have dealt at all effectively with maintenance or disposable tools, etc. Do you agree?

Yes this is indeed a very good question. For what purpose do we formulate a model? Because we believe that a knowledge of the behaviour of certain key variables with respect to activity will help us to control our expenditure, predict usages, etc. under alternative conditions and an alyse alternative production strategies.

We have to ask ourselves therefore whether such a treatment of maintenance adds to our managerial control.

In fact, many man-hours were spent analysing maintenance costs against activity levels and relationships were found. Unfortunately two, at least, were inverse relationships because maintenance work could only be effected when activity levels are low. Thus we have to consider the time period when the activity incurred the cost, really outside the scope of a model.

It is better to say that much of maintenance is a policy cost and that an optimal input of maintenance is best calculated methodologically by examining the increased costs of downtime versus maintenance saving by lower levels of maintenance until some curve minimum is reached, i.e. $\frac{(A + B)}{M} = Mm, \ Cm$



Q. M (Continued)

This research above is the subject of several Ph.Ds(Loughborough e.g.) is best left out of an activity based cost model.

Far more likely to be successful is to estimate at a factory level how much maintenance effort is required as policy, how much is unplanned, for use in product costing and inter factory analysis, without using an activity based approach which may, because of above give misleading results.

Maintenance is just within the ambit of an activity cost model as such. For production supplies many many hours were spent analysing production supplies against activity levels, but as P. Bubb (Phd. Aston '73) found, the difficulty remains of resolving the usage of the expense item against the relevant activity period because of stock holding at cost centre level. If you divert the effort of a cost model to this problem then you are using hammer style resources to crack a medium nut-sized problem. Instead, estimate physically and logically how many dusters, brooms, or loose tools, etc. you ought to need and if you find you are feeding half the West Midlands with spanners, mops and buckets then go to the shop floor, find out why and take appropriate action.

Q. N How effective is the model in providing management information (i.e. rough but relevant) to deal with strategic decisions, for example; the minimum level of price necessary to cover variable manufacturing costs of a typical brass rod?

A great deal of thought has gone into giving the model flexibility: as for product costs, although perhaps a little more emphasis has gone into cost centre control rather than throughput analysis, nevertheless, using value added at each cost centre stage and linking these together enables us to use cost centre variable costs to form product costs. In any case, example (c) shows the cost formation of a given quantity of billets which one can consider as a product in themselves.

@ Value added, See Glossary

Q. P The snag with these so called quantitative methods of analysis is that all they end up doing is providng masses of computer paper, which aid not the solution of management problems but of curing wobbly tables. Do you agree?

Yes, I sympathise with this view. However, one must judge each case on its merits. In the body of Chapter 5 one should be able to see the accent on information which was impressed on me as being important during my industrial research period. Data from the model is therefore contrasted with actual results in a form which is relevant to the recipient rather than a series of pale bracketed figures which may or may not be relevant. I would point out that the Management Information System at one factory has been radically altered by my work (and an Information Officer responsible for information retrieval appointed) following my recommendations. The same practical line of approach has been followed to present data as relevant information.

Q. Q If we were to agree that the model seems to have performed quite well in the factory(ies) under consideration, does this not mean that it is inflexible in dealing with other factory situations?

The model is certainly meant to be flexible within and among factories that the preceding questions A to H show just a glimpse of the wide spread of questions and statements the model can give (in addition to control information shown in Chapter 5). When looking at other factories, what needs to be altered?

(see over)

Q. Q (Continued)

Level 1

Cost Centre Control	Variable Fixed Cost Consideration	Inflation	M.I.S. System	Standards Set	Module System	Usage to Money Conversion	Step Function from Linear First Analysis	Reappraisal of Standards Set

Level 2

ENERGY	LABOUR	MAINTENANCE	DISPOSABLE MATERIALS USED

Level 3

KWH USAGE	KVA	GAS	WATER	FUEL OIL	HOURS USAGE	MONEY WAGE	OVERTIME SHIFT	NIGP	HOLIDAY PAY	METAL VALUE

Level 4

EQUATION TREATMENT OF EXPLAINED VARIABLES

Q. Q (Continued)

At Level 1 (methodology) I would have thought that the problem of converting actual costs, etc. to standard money values was as great a problem in a U.K. factory (or Brazilian for that matter) whatever the product. Again, any marketing exercise which relies on product contribution demands a good method of splitting fixed and variable costs - this model does that. The emphasis on information presentation is examined particularly in Chapter 5. The setting of the standards show what can only be described as a considerable degree of ingenuity. Our technical knowledge of likely influential variables backed up by a thorough appraisal of likely statistical configurations where appropriate has yielded a model of considerable complexity (about 160 equations) yet of a logical and easy to follow mathematical structure. Batty* has argued that "the use of historical data should never be permitted, instead the use of technical estimates will enable standards to be set". What he appears to be in too much of a hurry to mention is from whom and how these estimates are to be obtained. What I have done is to initially use regression methods, etc. to follow up suggested cost patterns and then, as the model becomes operational, so the two standards (one from older observation, one from very recent) can be compared so that the management decision over standards can be made.

The module system increases the model's flexibility. If it were true of budgetary control procedures, factory targets are first set, and the costs then apportioned to appropriate cost centres, the work

*(54)

Q. Q (Continued)

would need to be repeated de novo where another factory is considered. However, since this model is modular a second factory producing, e.g. strip coil will still have a foundry so that this module remains more or less unaltered. Thus the model is very flexible.

We also notice that the model derives estimates in usage terms before converting these to money values (naturally on a modular basis). Thus temporary monetary irregularities do not affect the model which derived labour £ costs from activity indirectly.

The indirect method of using labour hours as an instrumental variable is a useful tool to have at one's disposal.

At Level 2 one would be hard put to find a factory where labour was not an important cost so that the methodology of labour treatment is vindicated. Energy now and in the future, for many industries, is a second most important cost, and these two often form the bulk of "avoidable costs"

At Level 3 factories usually have some heating method and the method used as control is a valid one. Of course, at this level one expects changes of emphasis - if heating is via superheated steam then looking at cost of steam heating cannot be done in terms of single usage variable (c.f. gallons of oil used) but is an algorithm of pressure and degree of superheatedness along the relevant pipe length.

Nevertheless, the principle of splitting up electricity into its KVA

Q. Q (Continued)

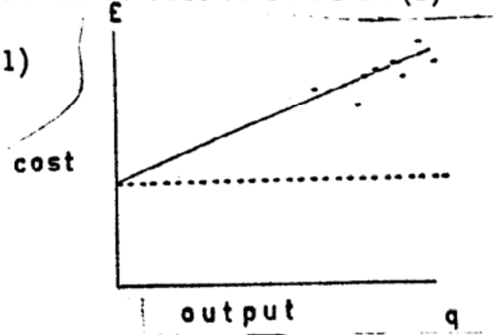
and KWH segments remain valid. as does on the labour side the encompassing of NIGP and holiday pay as an integral part of the labour cost.

As the 4th level of equations, the actual format will need to be amended accordingly to the context, but the design of the model to be in formula form with the numerical data and parametric values in a store file adds to its flexibility.

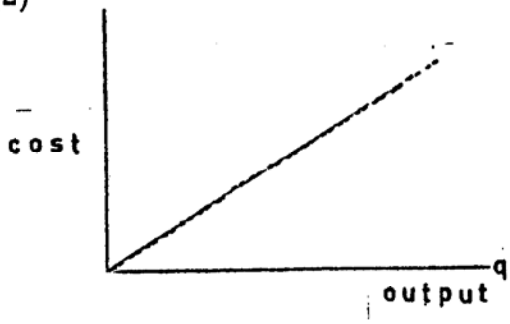
Q. R Just how wide can differences in output be before the model ceases to be accurate? In practice, surely, it will have the same inadequacies as a budget in terms of inaccuracy of prediction outside of the budget = actual output activity level.

The model is indeed designed to be accurate over wide ranges of activity levels. Because the assumptions of cost behaviour implicit in a budget tend at best to be as in (1)

(1)

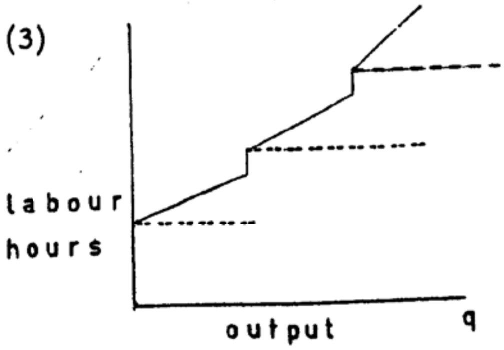


or in practice often as in (2)



it is not likely to perform accurately outside narrow limits. Because the model is formulated on diverse configurations and uses very [illegible] accurate methods, it performs well over a vast range of activity levels, e.g. in (3) Labour Hours are split by shift:

(3)



Q. S In Q.Q. we asked how well the model performed in a factory in a different environment: it seems to me difficult to see just how a model of this complexity could be used, for example, in a small Brazilian extrusion mill having only four full-time managerial staff.

What we have to remember is that the factory method will also be less complex. Although it would be true that the answers we can give will be less accurate, because less detailed knowledge and information will be available to us, the control procedure we could adopt, in terms of the information we could give, would still be better than the alternative available. In this sort of situation the model would focus on inflation, and the converting of cost information to a common money base, the form of cost behaviour, which variables showed consistent behaviour patterns, and the presentation of information. This might not be stunningly complex or dramatically accurate, but we could marshall our information so that the basic information that the small staff needed would be available to them.

Q. T It seems to me that all this information could just be done via "ad hoc" reporting like we used to do in the olden days.

Yes, but in the old days firms were smaller managerial decision making less complex, the data available was rudimentary , and the information which one could reasonably expect to receive is relatively small-scale.

The 1970's demand rather more in the work we expect of a manager, and in the information he needs to perform his function effectively.

CHAPTER FOUR

'It is a capital mistake to theorise before one has data.'

Sir A. C. Doyle, 1859 - 1930

(Scandal in Bohemia)

This chapter examines the role of data in a cost model, with examples drawn from on site work and experience.

' There are lies, damned lies, and statistics.'

Mark Twain

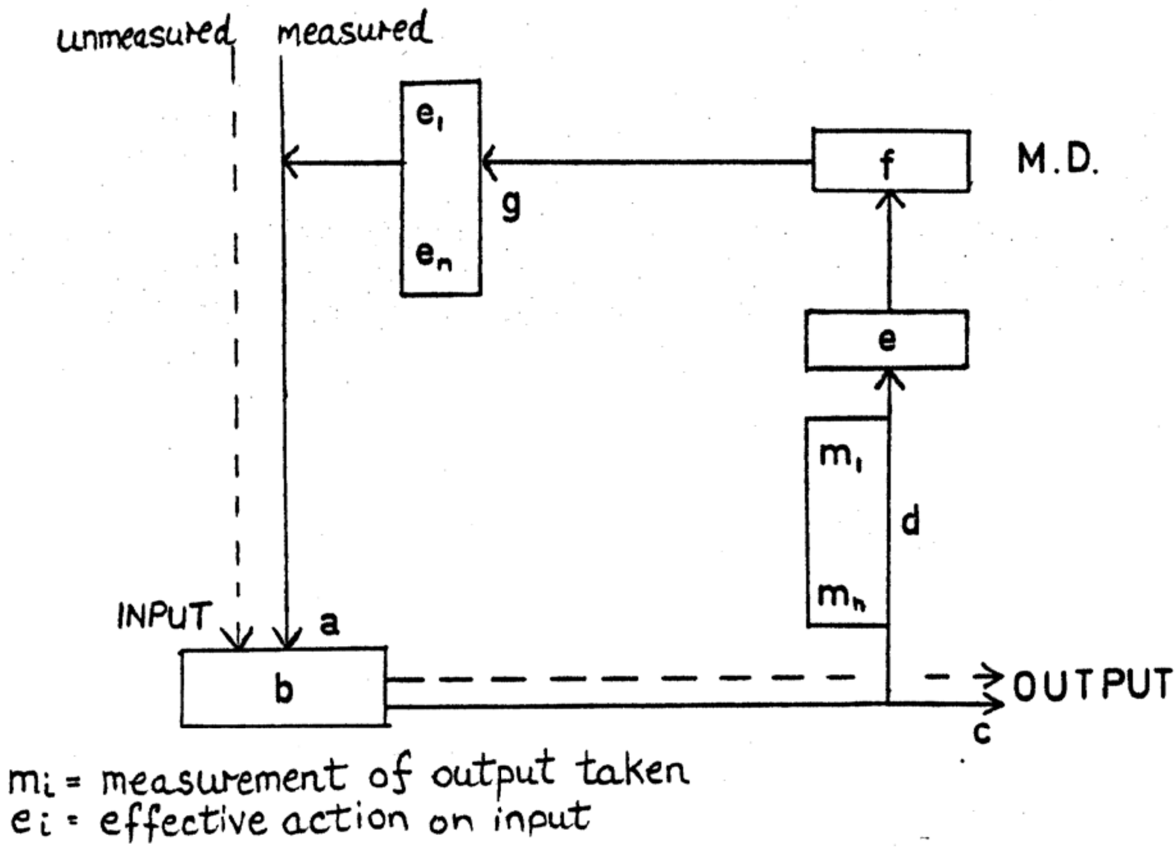
CHAPTER FOUR

DATA COLLECTION

No model can provide information that is of a quality better than the data used, upon which the model is based. But the "goodness" of the data itself depends upon several considerations which need amplification.

4.1 What Function is the Data to Serve?

A rather neglected but none the less important area in the development of any system of monitoring, control or analysis by scientific method is the quality and type of information that flows to the decision maker. Where the controller is in a situation usually to see the situation he is controlling then errors are due to visual errors, for example misjudging by eye the tonnage of work in process



But when the controller is himself isolated from the physical process and thus has to use a model as part of the control process then the errors in transmitting the signal are multiplied because of:-

	ERROR TYPE	CONTEXT EXAMPLE
(a)	The data may be defective at the input stage	metal weighed into the factory
(b)	The model may be incorrectly formulated	labour costs assumed to be 100% linearly variable
(c)	The output data is defective	Output weighed is incorrectly stated
(d)	The method of measurement chosen is defective	failure to separate the KWH and KVA aspects of electricity cost
(e)	The controller misinterprets the information presented to him	
(f)	The managing directors act wrongly on the information presented.	
(g)	The action requested by the M.D. is wrongly executed.	

Looking at it in terms of probability, one can state that a controller physically in charge of an activity has a probability P of committing an error. Instead now of a (P) probability of incorrect action, we have only a probability of

$$\prod_i (1 - P_i)$$

of correct implementation from the data input. It is therefore of limited use concentrating on information output (e.g. the information which crude equations would yield in a cost model) without considering the model in terms of its industrial situation, its input requirements, the appropriate output format for management action. All too often the emphasis appears to be placed on mind-boggling, statistical formulation and probability density functions, without apparently giving any serious thought to the data requirements that such a model would entail. Nor is it made clear how such techniques could be simplified to fit into a practical context. In fact, many such academic equation models appear designed to be impossible of practical implementation, for example, certain manpower planning models (Bartholemew). This academic technique is easier to undertake since it is the consideration of practicability that takes a lions share of practitioners time, and is the ultimate test of its worth. To take an analogy, one can examine certain aspects of a sound reproduction system which appear to have a parallel in an information system.

The aims of both systems are:

1) To remove the "noise".
2) To increase the signal strength reaching the decision maker or listener.
3) In an information system, in addition, not to remove what appears to be "noise" which might represent permanent and useful information which should be considered by the decision maker.

If one returns to a reproduction system, then in a hi-fi system all the units need to be balanced in terms of capacity and technical specification to achieve an optimum performance to cost ratio for a system. Within this system certain elements exist to reduce the "noise" problem. Dolby system on a cassette deck aims to greatly reduce the noise inherent in the tape deck mechanism. It cannot, however, improve the signal it receives from the receiver or record player. Having a poor signal generator will not be corrected by a Dolby unit however good the signal/noise ratio of the Dolby within the cassette deck: the signal is too weak to allow the cassette deck to operate effectively. Likewise a poor amplifier and speakers will not permit adequate reproduction of the correctly produced sound signal.

In music reproduction when one element is weaker it is possible to use a series of filters (for example DNL on a cassette deck and high and low filters on the amplifier) which eliminate the frequency ranges within which the noise occurs. It is at this point that the analogy needs modification: in sound reproduction our aim is to receive a perfect music signal. In an industrial environment, an information system needs to provide a strong signal in terms of information to management, on which management may then act. Thus the information equivalents of the filters might be the seasonal adjusting of data - which may be fine until the following is reported to the managing director:-

"Although our adjusted information indicates adequate cash sources, the current situation is that no cash is available. Our creditors have called in a receiver under the relevant section of the Companies Act. I have assured them that come six months time we will have adequate cash to meet all our debts but they refuse to wait. I enclose my resignation." Controller

The analogy between a hi-fi system and an information system is thus a very helpful one - they are both concerned with information generation and reception. The difference is that in a hi-fi system the stronger the signal the better; in an information system, the signal needs to be strong but not immutable.

4.2 Having thus given a brief analogy of one of the many functions which the model in Chapter 5 is expected to perform, it is clear that data collection is for a purpose and not an end in itself. We require data as input to a cost model for three purposes:-

(i) Control - to compare actual usage against actual output, e.g. in ratio terms - to compare actual usage against standard.

(ii) to predict usage levels for various activity levels.

(iii) to predict changes in usage patterns and analyse cost effects, and hence profit planning effects, where output levels are altered or there are alterations in production method.

One can now see that "adequate data" and "accurate data" are phrases which have no absolute meaning.

4.3 Adequacy of Data

In the first place "adequate data" may even imply that there are some areas in the study under consideration where data does not exist at all. For example, where a factory consists of many products, and one section of a factory is devoted to one product, cost or usage data may not be available because of its unimportance. More normally data problems occur because what is adequate for one purpose is not adequate for another. The types of inadequacy frequently encountered might be itemised as follows:-

TITLE		ITEM
Dimensions Error	(1)	the data is measured in the wrong units to be useful.
Aggregative Error	(2)	the data is too global for the purpose considered.
Integration Error	(3)	the data is adequately split but does not reconcile itself with sister data say at preceding and following production.

TITLE		ITEM
Measurement Error	(4)	the data is not recorded, not measured or is incorrectly measured.
Time Error	(5)	the data does not relate to an appropriate time period.
Insufficiency of Observations	(6)	there are insufficient numbers of observations to perform an analysis.
Static Variable Fallacy	(7)	a crucial variable has not altered during the observation period, and is therefore assumed constant.
"Apples and Pears" Error	(8)	data has been added together that should have been kept apart.
Inconsistent Accuracy	(9)	two conjugate data groups are not to the same level of accuracy.
Inaccuracy	(10)	the data is inaccurate or too old .
Triviality	(11)	the data breakdown does not match its importance.
Purpose of Collecting Error	(12)	Data is collected on a functional area not appropriate to the model.

These 12 points probably appear very academic 'bones of a skeleton' but in fact, itemising the types of errors in data gives a comment such as "The data is no good", which essentially is a negative comment, a positive value by considering data problems in a form where one can usefully examine the weaknesses of the data, how they can be improved and/or how the model can be made to accommodate for these weaknesses. In fact, these points can best be illustrated or clarified by industrial examples using some practical illustrations from various industries on these 12 points which will clarify what we mean by data problems.

(1) <u>Dimensions Error</u>

Very often the units chosen for the data are unwise (often because the data is meant to be used for stewardship purposes of which ours is just one). For example, assessing the cost behaviour of electricity in money terms, quite apart from inflation, is not likely to yield useful information on cost behaviour, since money is not itself an absolute measure of the efficiency of a centre, etc. If one is to derive meaningful cost centre relationships then appropriate usage data needs to be available as a relevant measure of cost behaviour.

Thus for cost behaviour patterns to be established one must use the relevant usage variable (in this case KWH).

Suppose information were to be in ratio form, e.g. 2.8 KWH per Billet extruded w/e 28/10/75, then one has to consider not just the numerator but the denominator of our ratio. What do we mean by output? If one is considering a process involving a number of separate production stages, then output may have a different meaning, depending on the stage of production under consideration. For example, the swarf drying at the foundry stage suggests metal input to the melting process would be relevant output measuresagainst which to assess the cost behaviour of swarf drying, rather than tonnes of rod produced. If one were to consider another example perhaps the heating and extrusion of billets as it is the billet input into the heating process which occasions the heating cost, then billet input is the relevant quantity measure to consider rather than output "out of the door".

(2) <u>Aggregative Error</u>

Data that is insufficiently dissaggregated is a very common feature. For example, it may well be the case that for two furnaces producing billets of different size, one aggregate electricity consumption figure is available, so that any attempt at profit planning by rationalising what billets are produced by what furnace will be done without the help of cost analysis on a cost centre basis.

(3) Integration Error

The third type of data problem very commonly arises with respect to labour hours worked on a cost centre comprised of, say, five lathes. Because the input output data for each machine is often compiled for bonus purposes only, there may well be a tendency to exaggeration of the output. So much so that if we go to the shop floor and add good output from machine 5 to scrap and wastage we arrive at more than the actual total input of machine 5.

(4) Measurement Error

Very often the statistics required are not in existence, or exist, but are not comprehensively recorded in a form suitable for our use. From my own experience records of usage of oil for space heating per department did not exist since the heating system was a contiguous whole. The fact that there are 50 meters and 15 cost centres does not mean that each cost centre is directly metered. It may well be that meter readings require apportionment to cost centres.

This may in fact be adequate but one must be aware of the limitations.

In one factory, production was allowed to build up at the end of a process before being weighed into warehouse at irregular intervals, yet the "weighing in" value was taken as being the production figure which it clearly was not.

In almost all factories the control of space heating is improved by looking at the graph of fuel usage against ambient temperature on a weekly basis, yet it is rare for the latter to be done.

(5) Time Error

This problem is again a very common one, not just in industry but in any organisation where the actual usage against output variable is not clear cut. The problem of measuring die usage and small tools, or even labour costs, can often be difficult because of relating the time period in which the expense was raised against the time period which occasioned the expense(Batty). Dies and other consumable items may be held at cost centre level and reordered at irregular intervals, and it is by no means obvious how the time periods can be matched to form a meaningful cost behaviour relationship.

(6) Insufficiency of Observations

Very often it is industrial practice not to keep data for more than 2 years. Very often, for example, with a change of Company Secretary, cost classification may alter to make the observations incompatible. If one moves from a fixed to a flexible budget, and from a flexible to a "step function" cost model, the number of observations increases with the increase in complexity. Not only this, but small numbers of observations tend to be grouped around a budgeted level, which weakens the accuracy of estimation for levels outside this range.

(7) Static Variable Fallacy

This is quite a common occurrence although quite often can pass unnoticed. In a non-ferrous metal company the yield at each production stage can be regarded as of very great importance, but a fixed or even variable budget is likely to assume a predetermined yield value at each stage, and therefore cannot accurately alter the standard against which to assess actual performance, should, e.g., a technological improvement in indirect extrusion, result in a permanent improvement in extrusion yield. This problem is more acute if, say, yield has been held constant by good management control over a reasonable time period.

(8) "Apples and Pears" Error

British Rail used to compute passenger ton miles and freight ton miles, both useful figures. They then combined them into one useless figure. Clearly, there is no given relationship between a ton of passengers and a ton of freight so that these figures should be treated as joint output from one transport process.

At another level, labour costs are difficult to disaggregate into variable and fixed portions, yet the fact remains that items such as employer contributions to insurance schemes and National Insurance and Graduated Pension(NIGP) vary in sympathy with labour cost behaviour. Where labour cost behaviour is inadequately described then NIGP may well in practice be considered a fixed cost, despite the fact that this is logically inadmissible. In Germany the higher cost of what might be termed "hidden labour costs" has necessitated a more detailed treatment.

Another example is the treatment of electricity charges. These consist basically of a variable fuel adjustment charge, a variable charge per KWH and a LOAD system (KVA) based on monthly maximum usage for winter months, plus a yearly maximum LOAD. It is often the case, however, that these charges are aggregated before being apportioned onto cost centre. No matter how good or well chosen the output data is, no meaningful cost behaviour pattern is likely to emerge, because whilst KVA charges do depend on output, they do not vary directly with cost centre output charge. Another example comes from a factory in the * [illegible] Tilling group where a bonus payment was based on a previous month's output. Therefore, an attempt to predict cost behaviour on the basis of total labour expenditure is doomed to fail (and it did).

A final complex example which connects with (1) is the use of energy auditing (which is no more than an economic labour theory of value

* Bramdean 1976

... in a new form). Like fashion, energy auditing has followed agricultural economics, the computer, transportation planning, inflation accounting as the mode and is therefore prone to misuse. It has many valuable aspects, e.g. to focus attention on the fact that for nuclear power to be viable all the direct and indirect costs of obtaining the power in terms of Uranium Ore separation, etc. must be less than the value of power produced, i.e. two buckets of energy used for one bucket of power obtained is not viable. Where energy auditing focuses attention on control, then this is a valuable exercise for a firm. To take a hypothetical example, energy is capable of providing power and one can derive units of power in terms of work done per unit time (either KJS^{-1} or Watt) for each fuel. Thus using standard conversion ratios to convert gas consumption from x(00)Cu.ft. of gas into therms at Standard Temperature and Pressure and from therms to KWH and likewise for oil, etc. one could derive KWH usage of each fuel, perhaps as follows:-

100 KWH of electricity used

200 KWH of gas used

80 KWH of space heating used

Production 100 tonnes = 3.8 KWH per tonne

Unfortunately, the value of the exercise is greatly diminished because the implied assumptions are first, that fuel sources are interchangeable, second, that relative differences in the cost of supplying the power are ignored, and third, because for some costs, looking at energy consumption per unit output may not be helpful for providing information for management control. Space heating costs are better viewed against a standard set by examining spacing heating costs v. ambient temperature relationships, than space heating costs against output, since the latter has no obviously stable relationship. One is reverting to the temptation to add "apples and pears", and be they British Rail or energy flavoured, the result will only be a fruit sundae.

(9) Inconsistent Accuracy

We said before that much useful management information is in ratio form, say, £3.00 per hour direct labour cost. Very often the quality of the output data is very good, whereas that of the cost information is not, or vice versa. At any rate a ratio will only be as good as its weakest link.

(10) Inaccuracy

How many of us in industry have not come across the quill pen absorption rate or absorption rates based on working papers long since lost? This problem can often arise on the labour and energy absorption rate for a joint product cost. A technical estimate for , say, billet heating costs for two metal types of billet will be established by looking at specific heat capacities, density, temperature rises, etc. per Kg. This can then be tested for the normal input tonnages of billets per month. Unfortunately, even if these estimates of x KWH per tonne Cu., y KWH per tonne Brass are accurate, there is no reason why this absorption rate should remain constant for all product mixes. In fact, it may well be the case that the absorption rate needs to be flexed to take account of product mix.

(11) Triviality

Very often the detail of the data does not match its strategic importance and often where information is lacking for some cost, for example labour analysis, this weakness is "compensated" for by a detailed breakdown of, say, administrative expenses ad nauseam.

(12) Purpose of Collection Error

Sometimes data may be collected, not on internally homogeneous cost centres, but on responsibility areas, giving information on all those cost centres under the control of one manager, etc. This is a valuable exercise but further information needs to be given as we pass from information based on responsibility areas to information for control purposes.

Having covered 12 aspects of data adequacy as discussion points, one can then take a broader view as to what is relatively accurate data and what is not. For information may be accurate yet inadequate, for example, where accurate information based on responsibility areas cannot be sub-divided on information per cost centre. Information may be hopelessly inaccurate yet adequate - for example, if it is a small cost expenditure. Yet Accuracy of data has the idea that one has agreed the purposes for which the data is collected:

4.4 Accuracy of Data

In this light what can therefore be said about data accuracy?

The data may well be inaccurate because the costs of obtaining more accurate data might be more costly than possible benefits. For example, at one factory "foolproof" billet counting systems were twice introduced as an independent check on output, but were twice bypassed or broken. In this case one has the choice of an expensive "foolproof" system or to try to use 2 independent systems to try to obtain cross-checks for billets produced; by looking at metal input less estimated losses and comparing with a change in physical stock plus those billets taken out of the foundry. In this case 2 estimation methods are used instead of one accurate method.

Sometimes the accuracy of the data varies between parts of the factories. For example, in another factory, accurate data existed with which to examine the performance of the foundry, but the data was less accurate on section and mill performances, so that an annual factory report tended to concentrate on the foundry.

In another area, one can see data collection made where the benefits in terms of control and profit planning are not obvious. For example, maintenance cost suffers because of (5) Time Error, in that high levels of activity tend to result in lower levels of maintenance because time permits only "emergency" maintenance to be undertaken. Thus any statistical attempt to estimate maintenance cost against cost centre activity rates has first to remove the policy cost element of maintenance costs, and then to match the cost occurrence with cost incurrence time-wise.

4.5 The Benefits of Categorising and Examining Data Weaknesses

It can be argued that all that has been done is to bemoan the weaknesses of data and to categorise them. In fact, time has been taken on data problems because it has been felt that too many writings seem to concentrate on results rather than a clear progression from data collection to solution. If we only use symbols, then we demonstrate only half the problem. Output efficiency = $\frac{y}{x}$ is a renegade from 'A' level maths, for y (output) and x (input) have no meaning as information per se. On the other hand output efficiency = 105% of standard, is useful information. Whilst model formulation is as vital as data consideration, the accent seems to have shifted firmly towards the former. By considering data as we consider the format of the model, we can, by classifying data requirements, assessing data strengths and weakness, improve the data base, alter our model formulation in view of data difficulties, accept the weaknesses, perhaps in practice a bit of all of them.

4.6 A Consideration of Improvements in Data Accuracy in Terms of the 12 Discussion Points

If we now go through the 12 data weaknesses we can see how different weaknesses require different solutions.

(1) Dimensions Error

Where data is measured in inappropriate units then standard estimates will be of questionable quality. It is essential to examine cost behaviour using 2 variables which do behave in a steady relationship. The fuel example clearly implies that usage (KWH) etc. should be used to assess the shape of cost behaviour, as the separation of tariffs is not easily reconcilable to activity level variation. If KWH are transcribed to money terms then these estimates must be deflated to achieve a common measure of cost.

The case of labour is more obtuse.

If we use the same approach then labour hours against activity level will yield a stable relationship. When we convert to money terms we have a combination of basic rate + bonus rate + shift allowance + overtime + NIGP + holiday pay each of which needs separate consideration. This is the approach that the model takes, i.e. to model each element separately. But in some factories it may well be that the bonus rate itself affects the behaviour of the labour cost. If this were so then a money labour cost incorporating bonus rate might be the correct measure to use for cost behaviour. Again it all depends on the factory in question. Where rate of output is basically machine dependent then a labour hour measure will fare better for cost behaviour than a money measure. If assembly work is involved then the second alternative may prove better. All feasible combinations which accord with practical judgement should be tried <u>before</u> 'the' measure of cost behaviour is adopted.

(2) <u>Aggregative Error</u>

Where data is too aggregative there are at least three feasible solutions. Is it possible to obtain separate electricity usage estimates for each furnace? In one case it was from May 1975 onward. Suppose that we have a group of machines (lathes say) where we wish to examine cost behaviour. Were we to try to disaggregate labour down time to measure cost behaviour directly via, say, an operator dialling code for each type of breakdown which occurred, we might well encounter hostility. Therefore, where our individual output measures are reasonably accurate it may be better to estimate the individual cost behaviour via multiple regression rather than risk worsening labour relations for the sake of cost collection.

A third alternative is not to split the data at all. For example, a space heating system serving 2 centres (foundry and extrusion works) may have activity 65:35 ratios placed on respective cost centre usage. If one considers that the responsibility for space heating is a single one and the heating unit,in reality one entity, then it seems pointless to try to split a cost where control would be better exercised on a total factory basis. Where actual versus standard oil consumption differ then is the time for managerial investigation into which centres have caused the discrepancy.

(3) Integration Error

Very often at disaggregated levels sub-cost centre output statistics are suspect because they may be computed for one purpose only - that of bonus estimation. In fact, vigilant foremen might make these figures accurate enough for analysis - this is something best done by being on the shop floor and asking and enquiring from both foreman, operatives, and those who use the information. In fact, no data enquiry should be undertaken without extensive listening and learning at the shop floor level.

Therefore it may be that cost behaviour may have to be done on an amalgamated cost centre basis if accurate data is not available - again how accurate it needs to be should be the subject of your own spot checks and your accountancy judgement. Will weaker information, but at a pinpoint level, aid management control (and cost projection and profit planning) more than accurate but less pinpointed information?

This depends on you, the manager and the factory, and is really a question of professional judgement. Two contrasting examples illustrate the difficulty. At one factory, obtaining control information on two furnaces individually required little organisation. At another factory one important cost centre activity level was measured in numbers of billets used, thus not taking account of different sizes and thence weights. One department of the same factory produced a variety of dissimilar sections. To have a more meaningful control system, the weight of billets used and a separation of section output into groups having like characteristics in terms of difficulty of extrusion, would clearly be most advantageous. The industrial accountant should realise that he is not alone in being dissatisfied with the standard of data and hence in our example the departmental manager of section will be dissatisfied because his efficiency is not monitored. Note that I said dissatisfied because although poor performance will go unchecked he will rarely gain accolades for a good performance.

Here a data weakness is a problem upon which the accountant looking at cost behaviour cannot improve. It may be no more than a symptom of a weak department - in this case the department of production control responsible for data collection. Improvement in data standards may, in this case, involve a good deal of departmental reorganisation; perhaps a new production control structure with new personnel. In this case, the accountant must see to it that these dissatisfactions are noted and that improvements do not leave the data base as naked as before.

It may well rest on managerial motivation. Managers reliant on quantitative techniques may feel such a large-scale change worth making, others may judge that the smaller changes will have to suffice. At the end of the day those who use the information accept such a judgement even if not in accordance with our views, which is what happened in one factory example.

(4) Measurement Error, and

(5) Time Dimension Error

Measurement error and time dimension error can be considered in the same light. The point at issue is that usage data does not easily relate to the time period of activity level which occasioned it. Several methods can be used to improve this situation, for example, by establishing dies used directly at a cost centre, ascertaining whether such dies are for current production use or a policy decision to increase stock. In my experience this has proved difficult to implement and data exists only on gross die materials used.

A second semi solution which might aid management control, though less helpful for projection and analysis, is to see whether any other cost measures move in sympathy. For die costs much of the work involved is in labour hours in the toolroom, repairing and opening out die inners. Since we know the toolroom hours worked, the die types and the amount of indirect labour, a regression method should give absorption rates which are useful for managerial control. I call this method the "intermediate variable" control method.

Any more complex method than this is going to mean treating the die and other disposable materials as a separate profit centre system, charging each production department for work done.

(7) Static Variable Fallacy

There are two sorts of academic diseases from which the practitioner may suffer in attempting to improve control, profit planning, and cost projections. Both of these arise from a failure to have a good grasp of the factory production methods, the people involved, their views and desires, what are key areas, and what are relevant variables for consideration? For example, where, in one factory, yield has been held constant for 2 years by good managerial control, an outsider examining, say, electricity usage against billets used may find a straightforward relationship, with yield not significant in terms of a 't' value. This means that historically yield has not proved to be significant, not that it is not a factor to be considered. Ignoring such a variable as yield will reduce the value of the information provided. The reason is because one can say little about profit planning where a new extrusion method is envisaged if this involves a new standard yield figure; since the model envisages an unalterable standard yield.

The converse is to attempt the "kitchen sink" regression method. In this y is made a function of everything from metal input to sun-spots. Quite apart from the fact that this reduces the degrees of freedom, it indicates that the practitioner does not know his own factory. The rule is, therefore - what behaves with what, what else affects behaviour, how best can I implement a control method?

It should be borne in mind that a relationship showing high irregularities may be just as valuable as that giving text book $R^2 = 95\%$ results. Ignoring critical variables or using kitchen sink methods to achieve good R^2 results are to be deplored.

(8) "Apples and Pears" Error

This represents a principal of treating like with like and unlike with unlike. The case of KVA and KWH has already been cited, that of splitting labour cost into bonus, basic, overtime components is another example where separate treatment may yield good returns for effort spent. In practice it may not be possible to split up a usage figure, for example where space heating is provided via steam heating, then the difficulty of accounting for superheat losses often preclude a breakdown of cost into a lower cost centre level. In this case, control must be exercised at a factory level.

(10) Inconsistent Accuracy

One reason why data is old is the difficulty of revising absorption rates. The case of absorbing joint process costs onto two products has already been cited and here, as a practitioner, I believe that data is not collected because without a statistical method the absorption rate calculation is time consuming. In other words, the collection of data for such a situation might well be easily improved were people to be impressed by absorption rate improvement.

(11) Triviality

In practice, as already stated, too much trivial compensation in breaking down unimportant costs is given as a sop to inadequate information on key variables. We must establish data collecting effort in accordance with its importance in each production area, and not as recipients of a financial paper chase. For those who insist on every idea being conveyed using mathematical terminology planned data requirements + practical awareness = effective control procedures + higher factory operating profit!

4.7 At the end of Section 4.6 the reader can now realise that we have come some way from a bald presentation of symbols (cf Management Accountancy 1976 - 'the use of Cost Models') towards understanding and either solving or accepting the practical difficulties we are likely to face.

Let us now assume that we have achieved a data system of reasonable adequacy (remembering that we formulate the model with data constraints in mind and not against them); now is the time to critically examine some of the techniques that can be used to transform data into information in a form useful for a cost model.

4.8 <u>Regression Methods and their Relation to Data</u>

Providing that the practitioner has a practical awareness the use of statistical techniques can sometimes, but <u>NOT</u> always, be of value.

For example, in absorbing a joint process cost the use of $y = \alpha X + \beta Z$ where y is total electricity (KWV) usage by the cost centre and x and Z are, say, tonnes of billet of copper and brass respectively, may yield good absorption rates which can be readily checked every month. The traditional method of using

*1 SH capacity + ΔT etc. is much more time consuming. Yet a danger exists in the form of the equation being misspecified.

As previously explained, the 2 chief dangers are that either a key variable which has remained constant is not included, e.g. yield, or that a kitchen sink philosophy is adopted (a sort of Micawberism of some good R^2 turning up).

A good practitioner will realise what variables energy, labour, etc. should relate to, but therein lies a second problem to trap the unwary and that is the form of the regression.

In one Ph.D.*2 a linear regression of labour cost versus output gave poor regression results.

Therefore, a quadratic was attempted. Whilst any function y = f(x) can be approximated to a polynomia in terms of practicality, $y = \beta_0 + \sum_{i=1}^{n} \beta_i X_i$

*1 Specific Heat *2 line 10 P.98

where β's are parameters, and n is the order of the polynomial is useless. What should be done is to say - Given the factory situation, what form of cost behaviour do I expect to occur - step function (labour analysis), logarithmic (some catalyst reactions), reverse cubic (space heating), linear (motor power compression), etc? Simply to argue that $y = a_1 + a_2x + a_3x^2 \ldots$ gives $R^2 = .95$ (where R^2 is the coefficientof determination and explains the amount of variation in y due to the explanatory model) is useless if we do not know why the quadratic term is of practical significance. If we do not know then we cannot say how alterations in production techniques, etc. will improve control. In any case, such curves often explode once activity levels above the norm are reached and are thus likewise useless for prediction purposes.

A good sound knowledge of how cost behaviour is expected to manifest itself, translated into a straightforward series of uncomplicated equations taking account of the strengths and weaknesses of the data base will rarely cause the kind of derisive results that 'scientific over-enthusiasm' tends to give.

Another example of how simplci ty is best is again from an example of trying to derive labour costs (LC_t in time period t) in equation form against lagged output. If a prior output lies in store in a production centre for an average of one month before being called "output" then $LC_t = B_0 + B_1(0_{t-1})$ is justifiable. But simply to try $LC_t = B_0 + B_1(0_{t-i})i = 1$ to as many numbers as is needed to obtain an R^2 value is not. This is a flagrant misuse of a statistical technique to achieve a number.

Again instrumental variables can be used to test the Absolute Income Hypothesis by using investment as an instrumental variable for income, to avoid simultaneous equation bias. Some authors appear to think this means that if x is correlated to y, y can be used to predict any value of x. In one example cost was estimated against lagged bank rate, according to the highest t - i figure without explaining why such a relationship should hold. On this sort of analysis if labour cost $C_{t=t}$ is related to the number of swans in Merseyside t = t - 5 then our control, profit planning and analysis depends on the hardiness of Merseyside swans. If you feel that is useful then use such a procedure. For my part the use of practically verified relationships is of more value.

Clearly, an analysis of cost behaviour should involve not just quantitative aids, but the opinions of on-site personnel as to what is most likely to be a useful course of action.

Nevertheless, the author has found that there are problems in trying to gain the maximum benefit in terms of hours spent. Thus maintenance cost was found to have a significant correlation to cost centre activity levels but of negative sign, the reason being that not all maintenance is carried out in the same time period as the cost is incurred. If you want to control maintenance cost you first must state whether you think control via activity level is appropriate for all maintenance costs or just the non-planned non-policy aspect. Probably the only formal mechanism for control of maintenance cost is to ask - if maintenance effort is reduced by x% what will be the gains in terms of direct savings, but what is the <u>value</u> of output forgone because of maintenance breakdown. This is the "total view" of maintenance and whilst interesting, is difficult enough to be a Ph.D topic on its own. In our case the policy decision was taken to enable maintenance to be undertaken as quickly as possible, thus a sophisticated sub-model would simply 'control' a policy cost, a waste of time for all concerned.

Yield is an example of a difficult area. Much time was taken in trying to ascertain whether yield was dependent on activity level, time, etc. but no meaningful results emerged, perhaps because yield was very stable over the time period under consideration.

Yet in another factory it may well be that:

$$\text{Yield} = B_o + B_1 \text{ (Output)} \quad (1)$$

$$\text{Elec. KWH} = B_2 + B_3 \text{ (Output)} \quad (2)$$

So that looking at activity level may help to give a better indication of yield standard against which to assess the adequacy of actual yield performance.

Finally on the question of analysis we have to consider what the trade off in a model is between sophistication and simplicity. For example, (Chap. 5) Stage 5 and 6 results do not predict as accurately as Stage 1 and 2 against actual consumption. Does this mean that we should only use Stage 1. The answer is NO! For one month, whose cost expenditure may or may not have been normal, Stage 1 estimates are accurate. What we have to bear in mind is that these estimates are far more advanced than a fixed budget would be in firms. The estimates for Stage 5 were done completely honestly without juggling data estimates for shop window purposes.

In economics where C_t is consumption in time t, $C_t = B_4 + B_5 C_{t-1}$ outperforms any income hypothesis in terms of goodness of fit, but it is not a <u>control</u> equation. It says nothing of what we would expect if Taxation were to be doubled.

Thus the more complex model in economics is capable of answering control questions (i.e. how are we controlling the money supply) analysis (which will yield more revenue, VAT + 5%, or cigarettes + 5p), prediction (how will the Balance of Trade be affected were output to reach 1973 levels + 4.5%), which a quasi-simulation model stating that consumption depends on consumption can never hope to answer.

The tabular summary at the end of this chapter illustrates this point quite neatly.

Therefore the weakness in Stage 5 and 6 rests with the fact that the author has estimated step functions which, whilst capable of answering the 20 questions in Chapter 3, may lose a little in overall accuracy.

But the accuracy of the estimates in relation to that of a fixed or conventional budget will normally be good enough for management to rely on the predictions as being accurate for control purposes.

At very best we can use the simple format models of Stage 1 for prediction, the more sophisticated model format of Stage 5 and 6 for analysis and both together for control.

4.9 Conclusion - An Improvement in Approach if not in Knowledge

Little is going to be said here about how information should be presented as this is covered in Chapters 3, 5. Suffice it to say that we require useful basic data plus predictions and standards presented, tailor made for the benefit of the recipient, not in a massive wad of confusing cost centres but in clearly laid out brief expositions, as in the worked example in Chapter 5 (or Appendix to it).

What we have to do is to look at our factory, look at what is important (e.g. if metal value is centrally dealt with then a conversion cost model is more appropriate for factory control), look at the data to decide in general terms where weaknesses are, sketch the model, then try to match data, improved where practicable, with as reasonably accurate and relevant a model as possible.

4.10 COMPARISON OF MODELS OF DIFFERENT FORMS USING AN ECONOMIC MODEL AS COMPARISON

	MODEL (A)	MODEL (B)
FORMAT	$C = f(C_{t-1})$	Complex simultaneous equation system featuring taxation, savings, Income Investment, consumption, interest rate, etc. as variables within the equation system.
AIM OF THE MODEL		
Prediction -		
e.g. What will C be in 5 years time -	Simple and good estimate of C_{t+5}	Complex and not so good estimates of C_{t+5}
Analysis -		
e.g. By how much % must VAT be raised to yield an equivalent of a rise of x% on standard rate income tax.	No idea - VAT is not in the model.	Should be able to give at least a range of values, depending on the complexity of the model.
Using Macro-Model as Guide to Firms Plans, say Marketing -		
e.g. How roughly will our product fare if aggregate consumption doubles.	Rough idea, better if consumption disaggregated to population groups, e.g. $Ct_{65+} = f(C_{t-1})_{65+}$ where 65+ refers to the age group under consideration.	The complexity of the solution will swamp the essentially rudimentary marketing knowledge available.

CHAPTER FIVE

"Is to endeavour to find out what you don't know by what you do, that's what I call 'guessing' what's over the other side of the hill."

Duke of Wellington, 1769 - 1852

Croker Papers

Vol. 3 111 P.276

This chapter examines in detail the formulation of a cost model in one particular industry. It attempts to indicate the techniques of general applicability, the problems likely to be encountered, and the area which should be most appropriate for a cost modeller to examine.

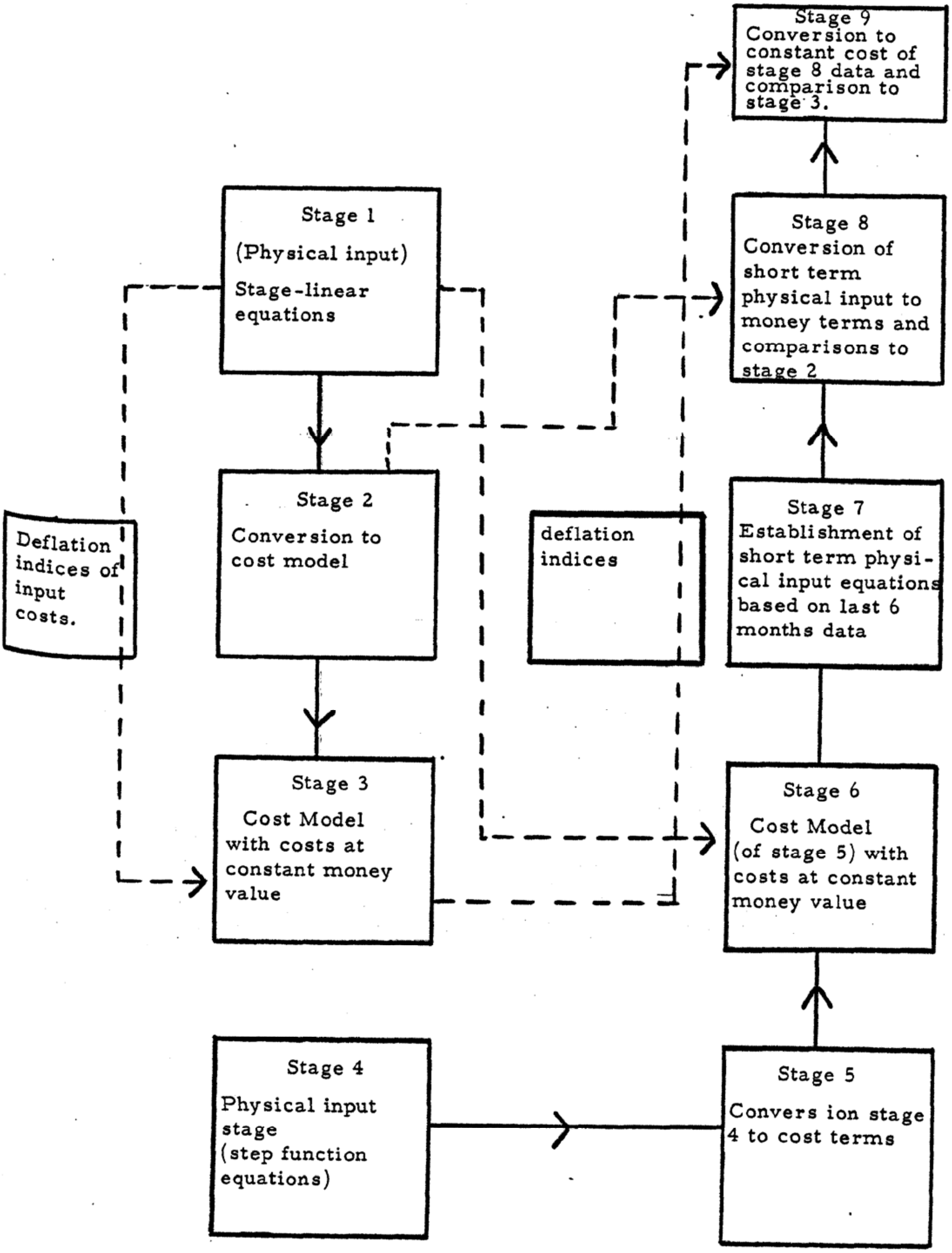
'Detection is, or should be, an exact science and should be treated in the same cold and unemotional manner. You have attempted to tinge it with romanticism, which produces much the same effect as if you worked a love story or elopment into the 5th proposition of Euclid.

Sign of 4. Sir A. C. Doyle

Diagrammatic Summary of the Operation of the Model

The tabulation and chart give an introduction to the methodology of the model prior to implementation.

Stage	Input	Conversion	Output
1	Physical production of cost centre yields	Linear equation	Energy and labour usage on cost centre basis
2	Wage rates, energy charges per unit used etc.	Matrix multiplication	Above on money basis
3	Indices of input prices	As Stage 2	As above on constant money value basis
4	As Stage 1	Step function equation system	Energy and labour usage on cost centre basis
5	As Stage 2	Matrix multiplication	As Stage 4 but on money basis
6	As Stage 3	Matrix multiplication	As Stage 5 but on a constant money value basis
7	Short period of observation (most recent) of production, yield, etc. on cost centre basis	Linear equations	Energy and labour usage on cost centre basis for shorter observation period
8	As Stage 2	Matrix multiplication	Short observation period estimates of labour, energy costs, etc. in money terms. Output comparison to Stage 2
9	As Stage 3	Matrix multiplication	As Stage 8 but at constant money value base.


Stage 9
Conversion to constant cost of stage 8 data and comparison to stage 3.
Stage 1
(Physical input)
Stage-linear equations
Stage 8
Conversion of short term physical input to money terms and comparisons to stage 2
Stage 2
Conversion to cost model
Deflation indices of input costs.
deflation indices
Stage 7
Establishment of short term physical input equations based on last 6 months data
Stage 3
Cost Model with costs at constant money value
Stage 6
Cost Model (of stage 5) with costs at constant money value
Stage 4
Physical input stage (step function equations)
Stage 5
Convers ion stage 4 to cost terms

KEY TO MODEL

STAGE	AIM
1	Predict accurately usage figures in KWH, Lab. Hrs., etc., form for all feasible activity levels. Presentation of selected estimates for control.
2	Conversion of Stage 1 estimates via separate disaggregated money conversions to money form. Presentation of summary predicted information for comparison with actual expenditure incurred.
3	Using disaggregated deflation indices, internally generated to deflate Stage 2 estimates for better comparison time wise to similarly deflated actual estimates.
4	Introduction of more accurate step functions to improve prediction capability as well as greatly increasing viability of the model to deal with any activity level. Model can now deal with analysis problems and control as well as prediction. All estimates in KWH, etc. form for use in lieu of Stage 1 estimates. Presentation of information as per Stage 1.
5	Conversion of Stage 4 estimates to money equivalents as per Stage 2 with like output.
6	Estimation of standards using last x months data in order to consider whether time has rendered

STAGE	AIM
6 (Cont)	Stage 1 estimates unreliable for required objectives. Comparison based on KWH, etc. units.
7	Appraisal of on-going accuracy of model with respect to time as per Stage 6, this time using money estimates.
8	As per Stage 6 but examining x months data as a step function against the step function estimates of Stage 4.
9	The comparison of Stage 8 performed on money denominated costs.

CHAPTER FIVE

5.1 BASIC PRINCIPLES OF THE COST MODEL

Having collected, verified and examined the cost data of the factory under consideration, the cost behaviour of controllable costs, with particular emphasis on labour and energy these being significant and relevant was established and utilised with the aid of technical estimation where appropriate in the formulation of a cost model.

The model is in modular form with each of 9 stages representing an increased stage in complexity and each formulated with a different aim in mind.

Stage 1 of the model takes the appropriate equations linking an output at each cost centre with an input usage (that is, for example, labour in lab. hours or energy in KWH, 00 Cu. ft. of gas, galls. of oil, etc.) to determine via a linear equation an accurate standard against which actual usage can be viewed.

The estimates are then collated to a departmental level and then to a summary document for the factory as a whole for each item in turn.

The accent at this stage is very much on presenting accurate standards, linearly flexed, in a format designed for the recipient, so that the maximum relevant information is presented on only a few sheets of computer print.

This information can be used for flexible budget formulation, to project cost utilisation at different activity levels and to assess the usage effects of production engineering changes or decisions concerning the complete transfer of one product from one factory to another. Also as the estimates have a good explanatory power, for usual levels of activity, departmental managers are presented with physical standard and actual comparisons, complete with output data, yield statistics, etc. in a format which renders their task of usage control very much easier.

Apart from the novelty of succeeding in building up accurate estimates of usage from cost centre to factory level, two areas of interest are the success of being able to vary the absorption rate of a joint product process according to the product mix, since it was found by research that a single absorption figure gave fallacious results for other than budgeted product mixes. This greatly aided control since the standard usage estimates are not inaccurate at abnormal activity levels.

In the control of space heating costs in particular considerable success has been achieved by deriving ab initio a suitable control system. By comparing temperature with relevant cost centre heating usage a stable non-linear relationship has been established. One of many management report documents written and formulated illustrates how this control and usage estimation technique can be used even if space heating is derived partly from waste furnace heat. Stage 2 of the model considers how best to convert physical usage into money terms. In the case of energy, clear distinctions between, say, KVA and KWH charges are made whichare considered separately. Labour cost is considered not as a single entity but at each cost stage as consisting of several components - basic rate, bonus, overtime, shift allowance, etc., all of which differ in their behaviour. Thus the actual mechanics of the Stage 2 model are complex but the output is not and is designed to meet specific objectives. The accuracy of the standards in money terms against which actual consumption is viewed are of an accuracy considerably better than that which could be achieved by a conventional flexed budget, or, of course, a fixed budget. It is able to assess how variable specific costs are in money terms at a cost centre or aggregate level and thence is of paramount importance in the calculation of contribution rates and in the value of work in process, at various stages of completion. It presents departmental and overall management with a selected output of information with which very specific malfunctions can be pinpointed before shop floor action is taken.

The information of this stage is of great use for capital appraisal decisions, since the cost at any level of activity and product mix can be readily determined.

Inter-company pricing and costing policy is also aided since inter-company transfers on a "marginal cost only" basis or "marginal cost plus" can accurately be made without resorting to doubtful apportionment methods and nominal variable rates for key costs.

This stage presents accurately in money terms information of great importance for the analysis of the efficiency of a factory, considerations as to the viability of alterations at cost centre or factory level, for the control of costs, and for the accurate prediction of costs outside current budgeted activity levels. Yet the actual output is modest in size and is designed for direct transmission to management without an accountant having to allocate time to interpret the financial data. Further time is saved in the "ad hoc" reporting which seems to be more and more time consuming in industry.

The model proceeds by stages to deflate the data, of great necessity in current times, and to present indices of labour and energy costs as useful information and by improving the cost behaviour analysis via the introduction of step functions, log functions, etc. to maximise the capability and scope of the model in its ability to answer wide varieties of financial questions.

5.2 THE IMPLEMENTATION OF A COST MODEL

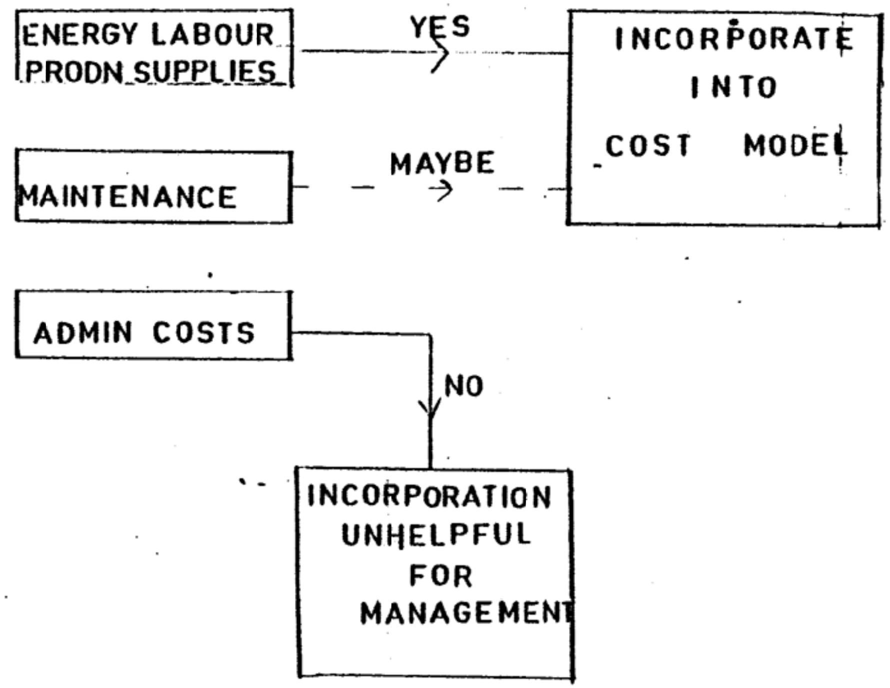
Having previously established that a cost model, (despite its theoretical preconception) has a role to play in a modern industrial setting, by virtue of the information it is able to provide to facilitate easier managerial control, it is now opportune to examine in more detail some of the general principles involved in transforming our theoretical ideas into ideas in practice.

5.2.1 The Selection of Costs

A factory incurs a large number of different types of costs by the nature of its production process. One crucial question is which (or all) of these costs should we attempt to examine? The answer lies in considering what we set out to achieve. By examining certain costs, one finds that some show a reasonable relationship to output. One aims to provide management with information regarding how high a specific cost is, given the output achieved,in comparison to we believe it should have been, based on estimation. In point of fact, the most fruitful effort is likely to be made by directing attention to those costs which show some regular pattern when viewed against output: It is these activity related costs which deserve the attention of cost conscious management attention.

5.2.2 Which Costs Are These Likely To Be?

Certain costs should show a regular pattern with respect to output because of the nature of the production process. For example, gas used to heat aluminium ingots prior to their being stamped should bear some relation to output achieved. Likewise, some labour costs should be related to output where the operation is such that the labour involved is directly related to a product. For example, the labour cost directly incurred in heating billets should bear some relationship to the tonnage heated. Production supplies should also be related to the output of the area concerned, since they are incurred in order to further production. Maintenance costs are difficult to treat since they are in part incurred because of increased production, in part because of policy decisions made. Therefore, we must separate out the various elements of maintenance cost into those which possess some regular relationship to output and those which are policy costs.


ENERGY LABOUR PRODN SUPPLIES
YES
INCORPORATE INTO COST MODEL
MAINTENANCE
MAYBE
ADMIN COSTS
NO
INCORPORATION UNHELPFUL FOR MANAGEMENT

Thus, so far, we have established simply the type of cost most likely to be of interest to us in an activity based model, and the first priority is to examine costs in relation to their likely behaviour as output levels change.

To reiterate, usually some or all parts of energy, labour, production supplies, material content, pickling, etc. would show some sort of relationship to output levels.

The methodology used is that some costs, such as administration costs, can best be kept in check perhaps by the manager examining how effectively they perform their functions, etc. For others, such as labour, a comparison between actual cost and predicted costs (as per model) will indicate to management whether the actual operation of the plant is roughly reasonable or whether some aspect needs to be rectified by him either directly or indirectly.

5.2.3 Definition of 'Cost' and 'Output'

We have talked rather glibly about 'cost' and 'output' as though these are obvious quantities. In practice, this is not so because our view of output tends to depend upon the extent to which we sub-divide the factory into cost areas.

Dealing with output first, how we look at it depends upon the disaggregation in the factory under consideration. Where a factory is a "through" process, and most labour and energy are involved directly in the direct production process, and the production cycle time is short, it may be that a good relationship exists between labour costs and finished output.

Yet in other factories this may not be possible. If we consider a factory as consisting of a foundry, where metal is melted, formed into logs and then cut into billets which are stockpiled, then extruded into rod and stockpiled, then drawn, reeled and put into store, then it seems probable that each area of the factory will have to be considered separately. In other words, we break down our factory into centres each of which is likely to have an output to which the production costs of that centre can relate. This may not be the system currently in use in factories which may not sub-divide the factory output at all, or may use responsibility areas which are not homogeneous for production costs.

Equally well, the term "output" does not indicate how we are to measure it. This depends very much on the situation under consideration. Where we examine a foundry producing a homogeneous product (metal billet) we can take the tonnage of billets produced as measuring outputs against which to examine cost behaviour. Where, say, 30 different types of section were being produced in another part of the factory each of which has different difficulties of production then a tonnage of output has little meaning. A German factory in this situation devised an index method to take account of yield variation to derive an index tonnage equivalent to x tonnes of one typical section having been produced. In an organisation where sales value correlates well with production costs it may be that sales value will represent our best estimate of "output". Clearly, for an industry which because of the vicissitudes of metal price keeps metal price variation out of the sphere of factory costs this is inappropriate. We may have to use conversion costs at each production stage as a standard against which to assess the efficiency of certain costs. In some cases it may be the case that labour hours themselves or machine hours themselves are the only relevant variable which can act as a standard for efficiency assessment.

In an ideal world we would have some magic measure of cost and output against which to assess our factories. In practice, we have no Merlin. Where a factory produces a homogeneous product on an interconnected flow line we may have a suitable output measure - the weight of ingots cast, the number of screws produced. As a factory system becomes more complex, two problems arise. Looking at total output and total cost fails to give a satisfactory relationship because the factory consists of a number of semi-automatic units each having only an indirect link to total output and total cost. In this case we need to consider cost and output at these sub-factory levels where a meaningful relationship can be established. As regards a measure of output, we pass through a continuum; ceteris paribus,

Tonnage	Index Tonne	Sales Value	Value Added	Machine Hours	Labour Hours

⟵——————————————————————⟶

we try to use an independent measure, e.g. tonnage, where part of what we aim to compare to a standard, (e.g. lab. hours expended) is not itself part of the standard. But in a factory environment it will be left to managerial judgement to assess just how effective and adequate the standard is against which to judge our performance.

One further difficulty which can emerge, even when the "output" standard is determined, is how best to consider cost categories - that is in money or usage terms (e.g. KWH, etc.) There can be no doubt that in the end it will be how actual (pound £) costs fare against any sort of yardstick (be it a manager looking at last year's comparison, or a budget or a cost model) that determine whether managerial action is called for.

Unfortunately, looking at the behaviour of energy or labour costs, for example, in money terms against a relevant output variable is likely to give misleading results. For example, electricity in £ terms against a cost centre output is not likely to yield meaningful cost behaviour information. The reason is because in money terms the electricity usage is really a composite charge of KWH plus KVA plus fuel adjustment. When looking at labour costs, the wages bill is really a composite sum of basic pay plus bonus pay, overtime rate, shift allowance, holiday pay and NIGP, none of which has the same cost characteristics. Therefore, we can say that probably viewing cost in terms of usage separately assessed (e.g. KWH and KVA assessed separately) with respect to the most appropriate measure of output at each cost centre (or any other level where appropriate) is likely to yield the most meaningful and illuminating expose of cost behaviour.

Once estimates of cost/usage in terms have been obtained, by looking at cost v. output relationships for given levels of output, it is then possible to use appropriate conversion factors to transform these cost usages into money costs. We can <u>then</u> amalgamate our money estimates to get the total cost picture. In short, to get a cost centre analysis of cost usage disaggregated against suitable output variables.

5.2.4 The Relevant Variables Upon Which Cost Usage Depends

So far the implication has been that output is the only variable upon which cost behaves or in which we are interested. This is not true. Whilst we are focussing our attention on activity related costs, it may well be that other factors need to be considered.

This point can best be considered by way of example. In the non-ferrous metal industry, metal melting costs are likely to be affected not just by quantity melted, that is the input, but the yield obtained if we view output as billets or logs cast.

In certain industries, such as foam production, the ambient temperature affects the amount of production per input unit. In the ammonia production (Haber) process the cost behaviour depends not just on quantity produced, but also on the rate of production (mol NH_3 s^{-1}) and also on the pressure.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad \Delta H = -92.37 \text{ KJ mol}^{-1}$$

The higher the pressure the more the equilibrium moves to the right, and the better the ammonia yield. The lower the temperature, the better the yield because the equation is exothermic, and the use of catalysts will also naturally affect the situation.

Thus costs of ammonia production =

f(quantity NH_3 produced, also pressure, temperature, and the rate of reaction, catalyst quantity used).

All in all, a complex situation since equipment to lower temperature and/or raise pressure themselves cause costs to be incurred.

Put simply then, output may in many cases be the main variable upon which costs depend, but one or more than one other variable may significantly affect production costs to such an extent that we ought to incorporate them into our model. Yield may in the non-ferrous industry be the one other variable to be considered in this aspect.

It is not the intention at this stage to consider specific cost problems since they are dealt with later. It might, nevertheless, be mentioned that the degree of care with which we treat specific costs is going to depend on their relative importance. For example, packaging and warehouse costs might show only a medium - strong relationship to despatches which we would nevertheless accept as satisfactory: total electricity costs might show a medium strong relationship to total output but this would be considered as very unsatisfactory, because of the relative importance of the two costs, what is in one is certainly not in the other.

5.2.5 The Use of Statistical Techniques in Financial Control

At the outset it should be stated that statistical techniques can only improve our knowledge of a situation where, by practical experience we have some albeit vague ideas as to what variables are relevant, what areas we are really interested in, and the kind of results we expect. It is pointless to pump data into a computer in the vain hope that something may turn up. All statistical techniques can do is to confirm or deny our suspicions and enable us to throw a search light on areas where we have currently a pale light. Of the many elements of statistical analysis of interest to us, one that is very commonly used is the application of regression analysis. Other statistical techniques, such as probability, etc. are used, but the mystique wrongly associated with regression suggests that further explanation may be helpful. In Chapter 4, Section 4.8 , regression methods were discussed in the light of data requirements and the role of regression and, indeed, statistical methods generally in the advancement of practical knowledge of cost behaviour and hopefully the provision of information for management control. In this chapter, whilst practical examples are given, the emphasis is not on the practical problems that regression entails in a factory situation, but more on the concept of what regression is, the types of regression available, and whether statistical analysis is likely to be of help or not. One can best begin by examining what a regression is. Regression is an algorithm designed to compute a straight line having the property of minimising the sum squared deviations from the mean observations - in this sense it is a line of best fit on the data. (Figure 1 shows this for bi variate data). In three dimensions the aim is

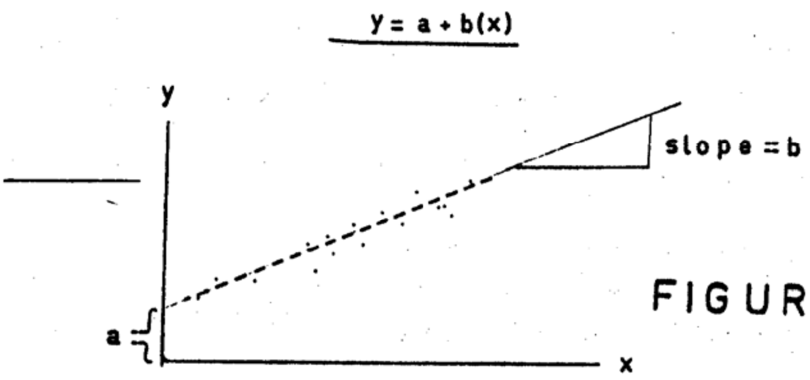


FIGURE 1

to fit a 2 dimensional plane having the same property as its linear counterpart (for an analogy it is rather like moving a sheet of glass in a fish tank containing partially submerged table tennis balls to achieve the best fit). $y = a + bx + cz$

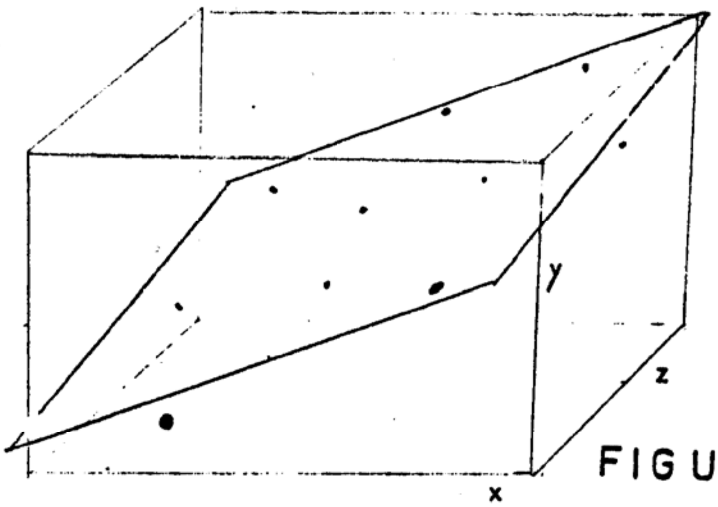


FIGURE 2

This technique can be used logarithmically, for polynomials, for rectangular hyperbole, etc. and is a useful technique.

Of the many examples of its use, three picked out as being representative and of interest to us are in the area of apportioning joint process costs onto products, providing absorption rates for a group of machine lathes, and showing a possible relationship between space heating costs and ambient temperature.

In the first case, let us visualise an extrusion press producing copper shell or brass hollow rod. If we want to examine the electricity consumption of the extruder we really want to examine how effectively the standard and actual consumptions match for each metal rather than altogether. Thus:-

$E = a + b\,Cu + c\,Br$ where E is total electricity consumption in KWH and Cu and Br are

are tonnages of copper and brass billets extruded respectively will give us the relative billet electricity consumptions per ton (b and c) and fixed element (a). This method is simple to use and thus monthly use will indicate whether any permanent shift of electricity consumption is discernible.

In the second case, one might visualise a group of 5 lathe machines producing similar products and we require to examine the absorption rates of electricity per machine where we know the individual outputs but not, of course, individual electricity consumption per machine. Here

$$E = a + b\,M_1 + c\,M_2 + d\,M_3 + e\,M_4 + f\,M_5$$

will give the absorption rates as b, f respectively. In fact, we need not use a common measure for each machine, we might use tonnage for machine 1, index tonnage machine 2, etc. Providing we are consistent for each machine we may use any measure we like. 'a' will provide us with the fixed element.

If one looks at space heating consumption against temperature, two likely graphs are figs. 3 and 4

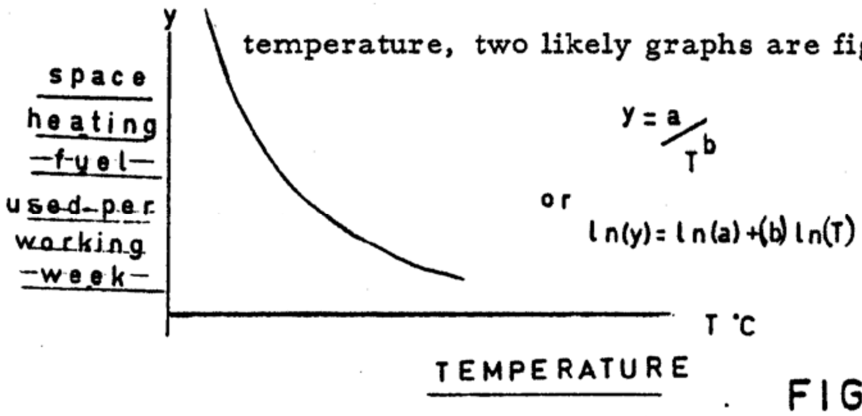


FIGURE 3

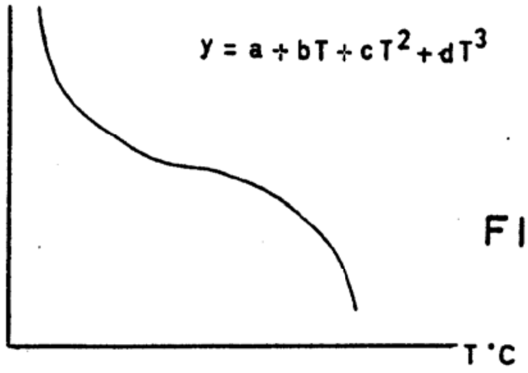


FIGURE 4

and the proposed regressions $\log y = \log a + b \log T$ and $y = a + b\,T + cT^2 + dT^3$ will indicate whether a stable relationship exists.

More generally, statistical analysis will help to decide whether a particular form of relationship is valid, and to what degree.

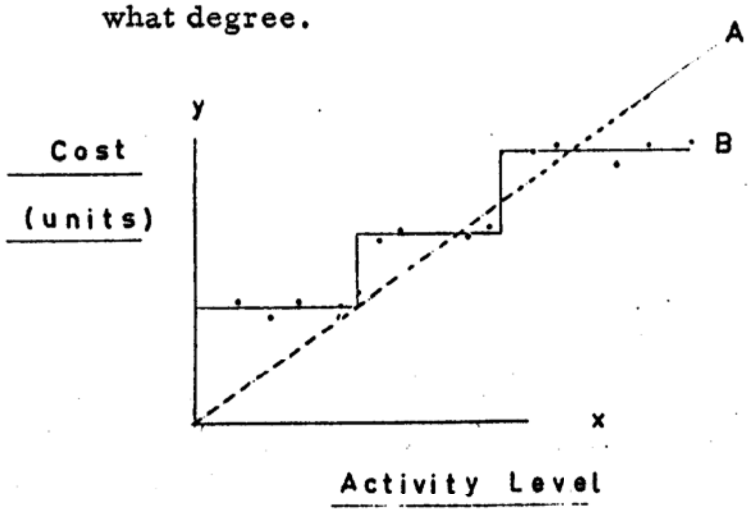


FIGURE 5

For example, a view of cost as being totally variable suggests curve (A), but statistical regression suggests curve (B) is likely to be a more consistent cost behaviour pattern. Whilst graphically this might appear obvious, when we consider more than 2 variables graph (B) will appear as a crooked step function (rather like a crooked house stairs at a fun fair) which we can only hope to approximate via statistical methods.

One final point to be made here is that a certain irony exists in statistical cost tests.

Where an assumed cost behaviour of, say, (curve (A))
Lab. Hours = 50 + 0.5 (Output) is assumed and our statistical regression produces Lab. Hours = 45 + 0.48(Output) which is virtually identical (curve(B)) we may consider

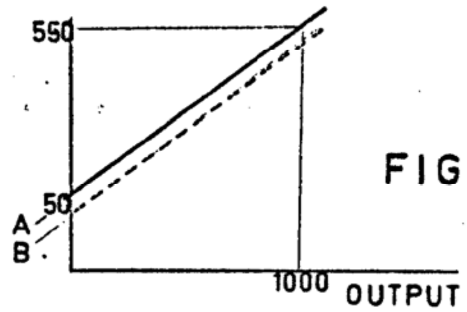


FIGURE 6

that we have done good work. Ironically, it is precisely when a statistical test fails to confirm an apriori assumption (e.g. that labour hours at cost centre are 100% variable) where we score most because we can then consider whether semi variability, step function, log function, polynomial, etc. might fare better or whether we have misunderstood our data or cost - is part of it a policy cost - is it wildly inaccurate or calculated on the wrong basis, etc. In other words, it is interesting in that our statistical analysis gives a danger signal which we should heed for it suggests that our assumptions are invalid somewhere along the line.

5.3 Some Specific Problems of Cost Categories

Thus far we have probably gone as far as we can in terms of generalisations and it is now opportune to consider some specific problems in terms of cost behaviour for:

A (1) Electricity

(2) Gas

(3) Water

(4) L.P.G.

(5) Fuel Oil

(6) Diesel Oil

(7) General Fuel Problems

B Labour Costs

C Production Supplies

D Maintenance Costs

E Distribution Costs - See Diesel Oil Treatment (A6)

F Other Activity Related Costs.

5.3

5.3.1a Electricity

There are several quite distinctive problems likely to be met in forming cost behaviour relationships.

The first problem is that electricity is in fact a composite charge. One must ensure that one has units consumed in KWH separately from those computed for KVA, and that the former are metered on a cost centre basis, the latter measured at a factory level. Thus, when these metered amounts are converted to money values, we can compare usage on a comparable cost centre basis.

One difficulty in practice is that very often the metering system does not equate to current cost centres. Thus, one may have 30 meters to 12 cost centres, yet,because a factory environment is always undergoing change, meter readings may yet have to be apportioned to derive cost centre consumption.

Apart from taking the opportunity of advising the maintenance engineer at an appropriate time (i.e. when he is modifying the electricity supply system for new machines, etc. and not when he has just finished it) to balance up the cost centre and meter systems one can see just how serious the apportionment is. If, for most cost centres 85% is directly metered and

15% apportioned then this may be satisfactory. It depends how critical the cost centre is, how satisfied you are (or can be) with the apportionment, and how costly it would be to improve it. It is once more a question of judgement, but the foregoing caveat is nonetheless valid for there have been examples of reports written on the assumption of cost centre allocated meter readings where part in fact were cost centre apportioned.

5.3.2a Gas

It can be the case that certain gas tariffs consisting of standing charge plus variable usage element can cause similar problems to those of the KVA/KWH split in electricity. However, in many factories the gas tariff may be considered as a variable usage tariff, being charged on a per 100 cu. ft. basis. *

The major difficulty which can, therefore, arise is that as with electricity the metering system does not match our cost centres. This is more likely to arise in gas consumption because of the relative lack of meters and therefore I can do no more than reiterate my above comments. In general, cost/activity relationships prove to be of less stable form than their electrical counterparts.

* Converted to therms at standard temperature and pressure.

5.3.3a Water

How effectively one deals with this as a cost depends on its relative importance. In one factory under consideration no useful relationship between water used for log cooling and activity level could be established, but as the water cost was of a small order of magnitude it was not felt worthwhile to investigate further. Again, it depends on the factory. Where water or pickling or quenching processes form a significant cost then it may well be the case that improving our control information on acid usage is worthwhile for the increased data collection, etc. cost. For example, it may be that where 3 acid baths are used for separate product groups, separate measurement of acid used may be helpful. It can well be that too many baths are used so that the concentrated acid as an oxidising agent is itself reduced in air (Hydrogen is a reducing agent). In other words, where pickling is an important cost then the intensive use of pickling baths may reduce the pickling cost per tonne metal pickled as opposed to the extensive use of a large number of baths. Again a large cost might suggest the consideration of alternative techniques avoiding pickling (annealing, dry acid, underwater extrusion) whatever might be appropriate.

All that cost information can do is to pinpoint likely problem areas.

5.3.4a L.P.G. (Liquid Propane Gas)

This cost may only be relevant to certain factories, but it will be important where used. One of the difficulties is to assess whether gas vaporisation occur before cost centre usage, a second is that as measurement in practice appears to take place at the tanks, apportionment to cost centre is likely to be dangerously inaccurate and management control information is best exercised by examining total L.P.G. consumption, leaving management to examine further where ineffective use of resources has been utilised. One should note, however, there is no technical reason why pressure/flow meters should not be installed for each cost centre, although the high level of skill, installation/capital cost of L.P.G. meters makes this practice less common than for its natural gas counterpart.

5.3.5a Fuel Oil

In general this is used for internal transport, certain metal drying processes and perhaps very important space heating. It is very unlikely that all three (or more) types of usage will be separately measured and our only estimate is likely to be fuel oil usage per month. Whether this is satisfactory or not depends on the factory. In one factory space heating usage accounted for a large % of cost, and internal transport and metal drying as relatively small usages. Providing that we can by an exercise establish that, say, internal transport costs are constant and swarf drying costs are a function of swarf dried, we can establish by subtraction how much total fuel oil is likely to have been used, which, though approximate, is by virtue of its large relative usage likely to be good enough to establish a stable relationship to, say, ambient temperature. What we cannot do is to then apportion this space heating costs onto departments because it is (a) meaningless and (b) the space heating system needs to be looked at as a cost entity itself. Simply to apportion good or bad usage figures onto departments is pure book-keeping without the kind of information for control methodology which we are attempting to establish. It may well be that where one cost centre appears to use an abnormal amount of space heating fuel then an exercise to reduce its consumption may prove worthwhile, or even separate fuel oil tanks and supply systems. All that we can do is to set a process in action of looking at space heating costs as a potentially <u>controllable</u> cost rather than an unavoidable "fixed" cost enabling us to critically appraise waste heat recycling projects with a little more certainty and having a procedure which is easily adapted to a situation where a percentage of heat supplied for space heating is in fact recycled.

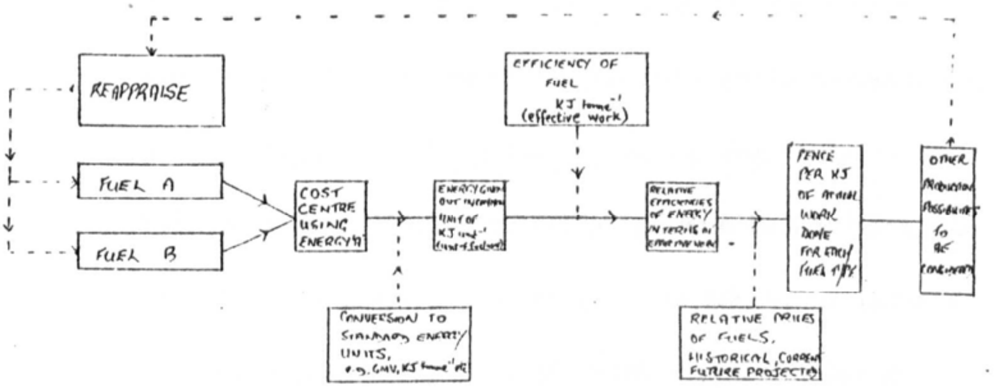
5.3.6a Diesel Oil

Because of the fact that diesel oil is used for external transport, our major problem is not that we do not know what has caused the cost but how transport costs behave with respect to transport miles, tonnage carried, etc. In one factory under consideration it was not felt worthwhile to do more than identify a reasonable relationship between diesel oil used and delivered tonnes. Our philosophy depends on the relevant importance of this cost. Where it is important we may want to consider labour maintenance and fuel usage independently and separate from other areas using as accurate a relationship between these costs and ton mileage, etc. as can be established. Indeed, where transport is of crucial importance, then as Unilever and VDM have done we may want to separate out our delivery service into a separate company (SPD and Montan respectively) offering a service both inside and outside the group. In our industry with transport costs a bare 4% of total costs this would be akin to using a sledgehammer information system to help management control a nut sized problem. We rest content here with a relationship inadequate with respect to accuracy and detail but adequate with respect to cost importance.

5.3.7a Fuel Problems in General

One problem which has been found to exist is in fact a surprise to the author and this concerns the comparability of alternative energy sources. It is a current

practice to try to add all our energy usages into a K.Joule base and thereby derive our KJ usage per tonne per £ or per something. What is not immediately obvious to me is what is the purpose of the exercise. From a government's point of view, development of alternative fuel strategies is useful but for a firm unless the fuel sources are interchangeable it is as useful as a dietician telling you that 3,250 calories per day is excessive eating and that one pint of Guiness contains 240 calories. Yet beneath the current excessive enthusiasm lies real worth. If one fuel source is used to produce energy, we want to know if we are utilising two buckets of oil to produce one bucket of oil. In other circumstances we can look at alternative fuel strategies as follows.



What tends to happen far too much in practice is that we do not do a complete analysis of alternative actual fuel efficiencies. Rather like the blades of scissors, the engineer tends to look at theoretical KJ (tonne fuel)$^{-1}$ used, and efficiencies of fuels, the accountant at prices. A more <u>incisive</u> approach would clearly be for all of us to act together to monitor the cost in pence per KJ of effective energy supplied on a regular basis.

In fact, the two biggest problems here (not surprisingly) are deriving efficiency values and, (surprisingly) the ratios of KJ theoretical energy supplied for comparative fuels. For example, is the net or gross KJ of 1 tonne of L.P.G. to be taken?

5.3

5.3.1b Labour Costs

I have already intimated that labour costs are really a complex molecular group of sub-costs which we need to separate out into costs behaving in a like manner. Probably we are going to have to look at labour costs on a cost centre basis because only at this level are labour costs likely to show a stable relationship to cost centre activity level. We, therefore, at first want to look at labour hours expended as activity alters. One would be very lucky if in all (or even any) parts of the factory accurate labour hour figures exist on a cost centre basis. Sometimes they do where, for example, cost centres are physically separated, or where a reliable work sheet/hours recording system exists (foreman or electro/mechanical hours validation) or where operators tend to stick to one machine or operation. Where we do not have this, we will have to resort to multiple regression perhaps to derive the relevant labour hour $tonne^{-1}$ for each cost centre, where we know total labour hours and cost centre outputs but not individual labour hours at cost centre level. This is a typical situation which arises with a group of operating machines where operatives switch from machine to machine fairly frequently. Occasionally we may not be able to derive any data at all for cost centre analysis and therefore we will have to expand our "centre" to the lowest level where data is available or obtainable. We expect poorer cost behaviour relationships and this will impair a managers authority since he will need to investigate a situation without having the quantitative knowledge to pinpoint the likely cause of the situation requiring attention.

A further split in labour hours that may often be required is to split labour into direct and indirect hours. By direct hours we mean those hours expended by operatives during which the operation was actual performed, by indirect we mean downtime hours (for whatever reason) plus (separately categorised where significant) those supervisory personnel directly connected with a cost centre e.g., chargehand or extrusion foreman.

The reason that we may want this split is to give an indication to a departmental or general manager that an abnormal amount of labour has been expended on a given tonnage either because the downtime was higher and the labour efficiency during actual running was satisfactory, or that downtime was normal but that labour efficiency during hours running was poor; or both.

Just how accuratdy we can obtain this split depends on the factory situation. Where labour costs relate to specific process an automatic graphical counter (e.g. on an extrusion press) or worksheets should give adequate results. Here we aim for broad management information. Thus as a manager my action in the event of downtime being high is to enquire why - is it mechanical faults, poor operating, or what? If it is efficiency at fault then why? - a new press driver, labour dissatisfaction, difficult section or rod, poor production contrd, poor foundry billets or whatever.

As a manager if I see

efficiency $\frac{70}{100}$, breakdown $\frac{95}{100}$

where 100 is some sort of norm, I am really interested in the figures as trend signals, not as 95 not 97, or 70 not 73. They could be 10% out but still give me some vital leads.

Useful though activity versus labour hours is, in terms of the foregoing, and in terms of a good stable labour hour activity behaviour pattern, it cannot but serve as a a halfway house, since labour estimates in money terms must be used to get the "feel" of how important they are in different factory areas, or to look at operational decisions such as another shift or overtime, or management decisions such as switching production patterns.

How are we then to convert our disaggregated labour hours estimates into money terms?

The labour wage is essentially made up of four elements - basic wage, bonus rate, shift allowance, overtime bonus, with the 2 additional factors of holiday pay and all types of insurance and pension contributions.

For the basic wage we expect to multiply both direct and indirect labour hours by some conversion factor c. For the bonus rate on direct labour hours we expect this to be a function of the activity reached in the cost centre, say based on the number of billets extruded, call this conversion b. Because operatives may lose out when on indirect labour hours, a fall back bonus operates to prevent their being penalised for downtime hours for which they are not responsible. The examination of how best to consider shift allowance payments in a model is a good example of the balance that needs to be struck between accuracy and simplicity. A per man shift allowance cannot be modelled for each of 240 different men. On the other hand, to label it as a fixed cost is to ignore its contribution to the step function of labour costs. If we consider operatives employed on a cost centre then they should have a similar shift allowance payment, so that Pi being the payment per man per shift on the ith cost centre may be a reasonable approximation. But we need to take account of the discontinuous cost behaviour exhibited by shift allowances and this can be done by considering discrete multiples of Pi as certain corresponding activity levels are reached. Suppose Pi* is the premium per month per man on a given cost centre when 2 shifts are in operation, then one can decelerate Pi to $\frac{1}{2}$Pi* for one shift operation, as production falls below Q1, and likewise increase Pi to 3/2 Pi*, if production exceeds Q2. Q1 and Q2 can be found by looking at a graph of labour hours versus activity level and finding the 2 step function points. These can be verified by practical estimation of how much is likely to be produced in one shift. The method is crude, but accurate enough for the relative cost of shift payments. Overtime can be considered as an excess of actual against normal working hours. Thus, if N men work in cost centre i and a 5 day week of 8 hours per day is worked, then N_h (normal hours) = N x 8 x 5 x 4 per

4 week period. Since we have already predicted the total labour hours requirement for the given activity level, say, Np then Nh - Np labour hours will require a supplement of e.g. time + half. In other words, our overtime supplement will consist of the basic rate multiplied by (100 + x)% of Nh - Np. In practice, estimation based on one factory showed that time + half gave good approximations to actual payments, except for maintenance labour. The data for overtime payments being easily obtained from wage analysis calculation sheets.

How can we deal effectively with holiday pay?

This relies on the number of people employed in each cost centre, let this be Ni.

If the number of days holiday is Di and holiday pay is paid at the basic rate then:

$$\frac{\text{Working Wks}}{4.0} \times \text{Ni} \times \text{Di} \times \text{B Rate i} \times \frac{8}{12} = \text{Holiday pay cost cost centre}$$

8/12 converts Basic Rate hours to days (x 8) and ÷ 12 converts the yearly holiday burden to monthly equivalents.

Because holiday pay is taken irregularly, no actual model comparison is possible, but comparisons of actual versus model holiday burden showed an exceptionally good fit.

The last area of labour cost to look at is the NIGP payment. In the previous pages of analysis we have sub-divided our labour into direct and indirect. Since we have already established via graphical, deduction or exercise the variability of our labour hours with respect to activity level we can sub-divide labour hours into (1) direct variable element

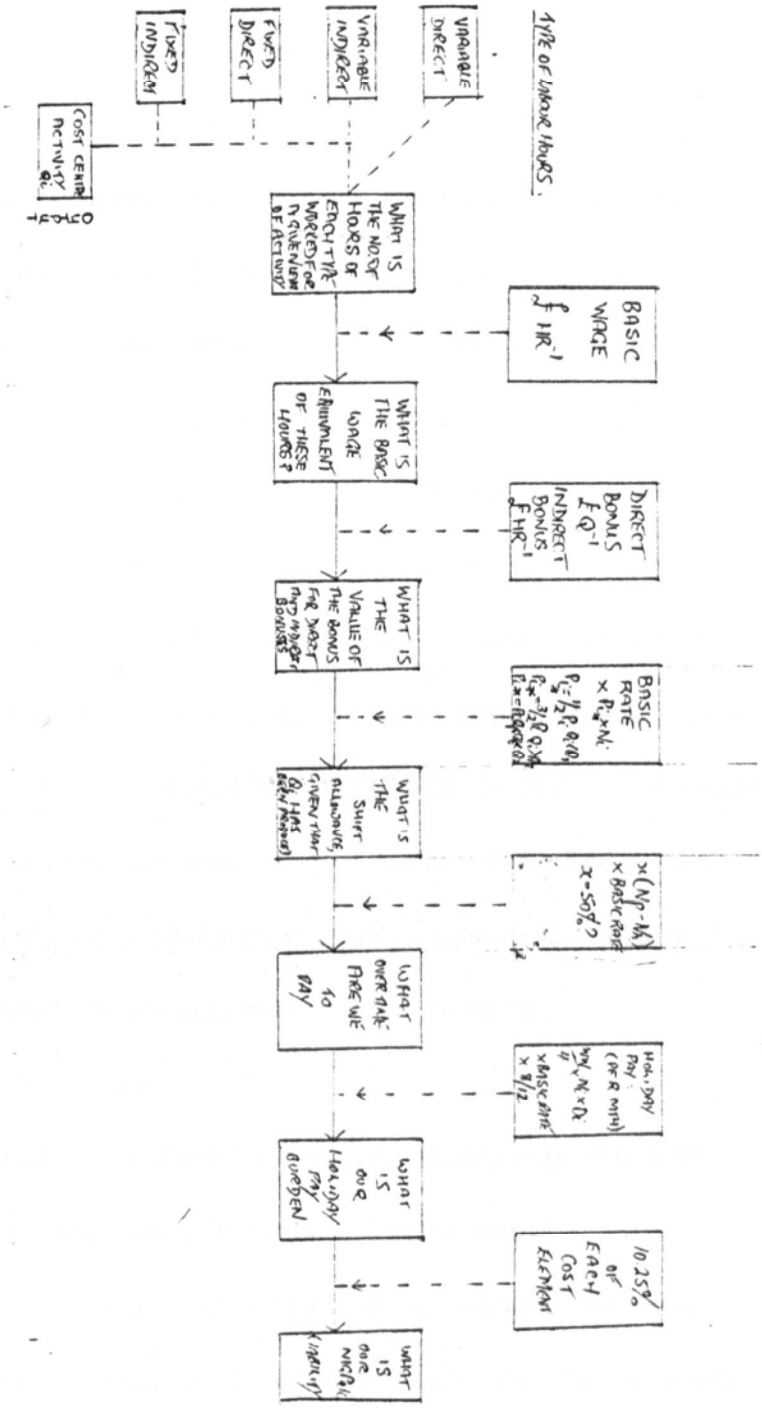
(2) indirect variable element

(3) direct fixed element

(4) indirect fixed element

and perform all our manipulations to convert labour hours to labour costs for these 4 categories. There are 2 reasons why we should want to split up our labour cost into fixed/variable as well as direct/indirect. The first is because it gives us an insight into labour cost variability at widely differing activity levels. Instead of National Insurance or Pension Contributions being taken as fixed we can, since we know our variable and fixed labour costs (direct and indirect) add the respective NIGP cost to it to get our total labour cost for each category (fixed, variable, etc.) encompassing the NIGP element which is an integral part of labour cost currently 10.25% thereof. In Germany the equivalent is 73% and this must be incorporated into labour cost analysis. We should do likewise.

The conversion of labour hours to money is by far the most complex part of the analysis. Nevertheless, it is logical, actually quite simple, valid and happens to give results very close to actual values as well as being capable of generating vital information concerning labour variability.



5.3.1c Production Supplies

The sorts of costs we are considering here are the costs of die usage, sundry materials and loose tools, in fact any item which is considered to be used up more or less immediately in the furtherance of production. If we consider die costs as typical and attempt to investigate die materials bought into the factory against activity level achieved we are unlikely to achieve any conclusion as to die cost behaviour. This is hardly surprising given that die repairing consists of opening up dies, using labour, replacing the inner, possibly the outer, so that any link activity to die materials brought in is likely to be tenuous. The weakness is likely to be that we may not know how many dies are actually used on an extrusion press - what we may know is how many are issued to each cost centre. But since some of these will be for an increase in stock, others for anticipated future die needs, the stock holding of dies at cost centre level will again mitigate against a straightforward approach.

What can we do about it?

If your toolroom effort is a significant proportion of your production cost, you may find it beneficial to provide management information by making the toolroom a profit centre.@ Ford have done this for a number

@Using the outside contractor rate as the 'price' of years, British Leyland comparatively recently, the result being that our measure of how effective our service function is, relies on the profit achieved as a signal to management.

In Germany, such a system is illegal and service functions must sell their services at cost price or be separate companies.

For many firms our service (toolroom) department is too small to allow such sophistication.

We can, as could and might be done in at least one factory, ask the respective cost centre foreman to record die usage on a monthly basis. If they were involved in this, I have no doubt as to their interest in the results.

Supposing that this is not effective or possible, what can we do about a cost which is controllable, significant yet not overwhelmingly so?

We know that a large part of the cost of dies is in the labour service required to repair them. Therefore, if we were to have available the toolroom labour hours expended on new dies, repair of dies and miscellaneous work for each die using cost centre then die repair hours versus cost centre activity may show good results. A trial estimation of total labour hours against cost centre outputs showed an encouraging 63%

fit. How would a manager use such information? Suppose in a period of high activity downtime appears high for no obvious reason, and production is being stifled, yet toolroom analysis reveals a high % of time spent on new dies, and time spent on die repairs is 20% under estimated level; This suggests that the toolroom may be starving the production centres of replacement dies in favour of new dies. This is a good example of 2 pieces of information together giving the G.M. a lead as to action.

In 2 factories under consideration, the toolroom labour analysis is better than that suggested above. Yet if we were to take the worst case analysis of only knowing new die hours, replacement die hours, and miscellaneous, we could still work out via multiple regression of

New Die Hours = $\alpha + \sum_i \beta_i \, (\text{COST CENTRE } i)$

Repair Hours = $\gamma + \sum_i \phi_i (C.C)_i$

Misc. Hours = $\lambda + \sum_i \omega_i (C.C)_i$

the cost behaviour of each part of toolroom hours and yield useful management information from it.

Naturally, labour toolroom costs are only part of our costs of production supplies but they may be large enough to say that for a cost of 50/50 importance no more effort should be expended on it.

As a point of relevance it might be considered that no one would want to give the G.M.* (or anyone else) information which could lead to more direct control or criticism. In practice, an ambitious or conscientious cost centre foreman or above is likely to encourage the sort of investigation this paper implies. If a departmental manager, etc. has no quantitative information on which the G.M. can judge him, he cannot strongly criticise him but neither can he praise him and recommend him for promotion. He will still be critical but in vague terms so his knuckles are rapped he knows not what for. My own experience is that departmental personnel prefer clear cut evaluation praise, or pinpointed criticism and would willingly and most helpfully contribute to a better understanding of their own cost centre area - particularly if it shed light on the efficiency of others' cost centres. What we are doing is laying the foundation stone at cost centre level for management by objectives - which suggests we should know what they are and should know how well we are achieving them, none of which is aided by cost centre performances shrouded in ignorance and secrecy.

* GM = General Manager

5.3.1d Maintenance Costs

Maintenance costs are an area which have caused more difficulty than almost any other because of the complex nature of the cost. How effectively it can be incorporated into a model depends on the nature of the cost itself. Suppose that like one division of ICI no planned maintenance is carried out, then a stable relationship may well exist between activity on a cost centre basis and the cost of maintenance for the centre. As the planned maintenance becomes a higher and higher percentage of total maintenance cost so any stable relationship between maintenance effort and activity level becomes progressively more and more difficult to establish.

Therefore, if one feels that maintenance costs can be improved by information leading to better control then this suggests that maintenance costing data needs to be split up into policy, unplanned and planned on a cost centre basis and we believe that activity/cost behaviour may benefit the unplanned part of maintenance costs since this may show a stable relationship to activity level.

In fact, personally, I feel that much more is likely to be gained if the industry concerned feels that variation in maintenance costs is likely to be of benefit (and this is by no means certain in the non-ferrous metal industry where a delay in production due to breakdown implies the holding of high value metal) then a full enquiry into the correct balance between direct benefits of reducing maintenance effort against the indirect costs of production loss thereby occasioned is a thorough way of deriving: maintenance cost =

direct costs (Maintenance) + indirect production cost of breakdown

$$MC = f_1(q) \qquad DC = f_2(q) \qquad IP = f_3(q)$$

$$\therefore \frac{\partial MC}{\partial q} = \frac{\partial f_2(q)}{\partial q} + \frac{\partial f_3(q)}{\partial q}$$

Where q is the amount of maintenance effort supplied to minimise total (i.e. including indirect production costs) costs.

FIGURE 6

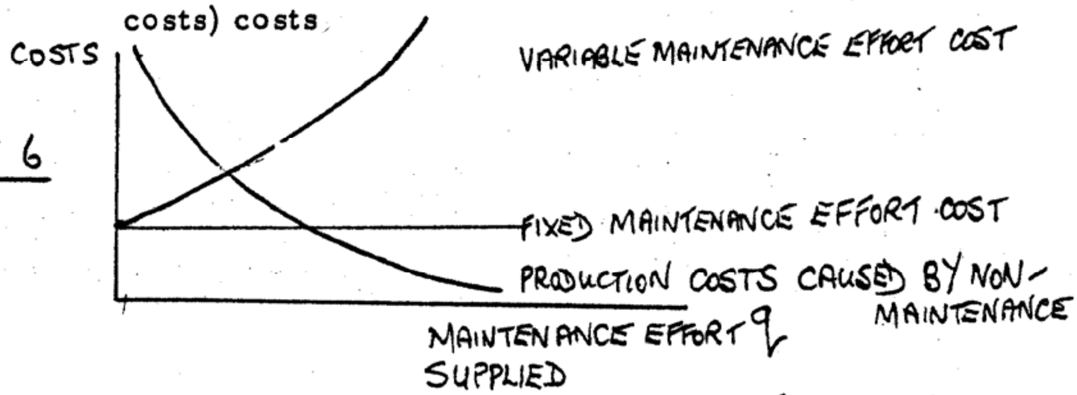
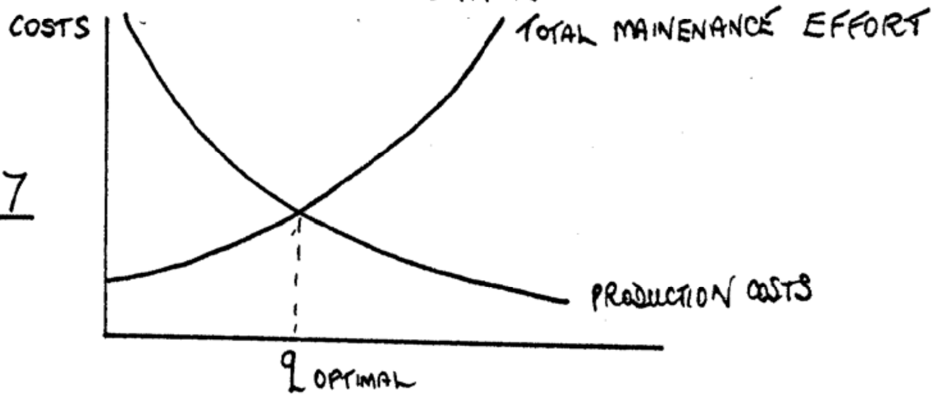


FIGURE 7



This terotechnology approach may be useful in some areas to see the value of output lost at various stages but because of the high opportunity cost of metal holding in non-ferrous metal industries then it is a policy cost to maintain quickly in order to reduce this holding cost. Thus, an activity related approach to maintenance costing as an aid to control is likely to be less beneficial per hour of effort spent in formulation then that time would be in improving our knowledge of labour cost behaviour.

5.3.1f Other Activity Related Costs

Any cost which shows a stable relationship to output may be worth considering in terms of a cost/activity level relationship. The only point to be borne in mind is that how far one examines a possible tie-up between cost and activity level depends on the ease of enquiry and the importance of the cost. It is very easy, in practice, to overpay attention to a relatively small cost leaving a larger less tractible item unexamined.

5.4 AN EXAMPLE OF A SPECIFIC COST MODEL

The next few pages discuss a particular example of the implementation of a cost model. Whilst, in fact, most of the points have been covered, it is fair to say that a well explained example does put the previous explanations into a practical context.

Since one is going to emphasise energy and labour costs rather than production supplies, maintenance and other activity-related costs, then it would seem right first to consider energy costs as a simple linear function of their relevant cost centre outputs.

5.4.1 Energy

The first task was to find out what energy was used and where. It was established that electricity and natural gas and LPG were used in "High Bay" in which the foundry and main extrusion press were situated, electricity in "Central Works" where the finishing operations on the rod were carried out, electricity again is the fuel source in the Hollow Rod Mill where hollow rods are extruded and finished. In addition, fuel oil was used to dry the incoming swarf as well as to provide space heating.

It became clear that to split the factory up into High Bay, Central Works and Hollow Rod would not yield satisfactory equations because, for example, High Bay included 2 autonomous units (2 furnaces and an extruder) and encompassed four different fuel sources. Looking at the problem of which equations to formulate in terms of each energy source in turn leads to the consideration of dealing with each furnace and extruder separately, and then considering the remainder in the foundry, extrusion mills, etc. respectively as a single user. The reasoning behind this was that with respect to electricity the furnaces solid rod extrusion press and hollow rod extrusion press accounted for a very substantial proportion of the total electricity charge, and that a less rigorous treatment of the remainder would be acceptable given its lesser importance.

The electricity consumption for each centre (furnace, etc.) was available but despite being apparently cost centre metered, some apportionment was necessary to provide KWH usage readings on a cost centre basis. However, after full investigation, it was felt that the degree of apportionment would not affect the validity of the model. For the concomitant outputs billet production figures were available and whilst these were not obtained via automatic counter (which tends to be rendered inoperative) the accuracy of the figure was judged to be good enough for our purposes. The accuracy of the figures was established mainly by cross-checking billet stock level and more important by asking departmental personnel for the views of the accuracy of the relevant figures. Thus the foundry is three electricity consumption areas - 2 furnaces and the remainder.

The main press was left as a cost centre having its own electricity usage meters and sole user of LPG gas. Its inputs and outputs of billet were clearly and accurately known because of the control which production control deployed over this press.

Electricity consumption of finishing work is relatively unimportant and the fact that data on yields and turning and stamping rod produced was known influenced the decision to use this as that on which estimated electricity consumption would depend (e.g. rather than rough rod produced).

Hollow Rod as a unit was felt to be too big and diverse for effective cost information for management control and that therefore a split between the hollow rod press and finishing work was required because of different processes. Whilst electricity consumption was no problem, rough rod production figures were unreliable. Therefore attention was concentrated on billets used, both copper and brass although hollow rod output data was available. Equally for the main finishing and hollow rod finishing centres the sub-division into machine groups was attempted. First the total electricity consumption was not big enough to justify this treatment, and second the data base for outputs of machine groups was found to be noticeably less strong than total rod output produced, because the former relies on daily worksheets produced for bonus purposes. Thus 8 electricity equations seemed to be most suitable for information for managerial control. The next question posed was what exactly did they depend on? For example, in the foundry heats to melters and billets cut gave good linear results against each furnace consumption. Nonetheless, billets cut and yield were chosen despite the fact that yield did not significantly affect electricity consumption. The reason is that yield in this factory in the foundry is so constant that no change was discernible. However, one would in the model want to answer a question such as - If a newer-type of coil improved yield by 3%, how much less efficient in terms of KWH per tonne could it be to still be viable? The statistical technique of multiple regression gave good results for the foundry equations, although a graph of electricity consumption against heats to melters was graphically examined first to get a "feel" for the likely relationship this cost centre would take. Putting in explanatory variables other than yield and billets cut failed to improve the explanation (e.g. time, seasonal effect) so that the aim of explaining as much as possible by as little as possible was achieved by equations of the form of one and two in exhibit one.* "Other" foundry consumption was comparatively negligible and was found upon investigation to consist basically of a bag filtration plant - likely to be fixed in consumption pattern, which was borne out by statistical corroboration. Electricity consumption on the extrusion press was straighforward to estimate. As with all estimation techniques there is no substitute for thinking practically about the likely shape of cost behaviour being examined. In this case as electricity provides the power only (not the heat) for the press the curve should be a very good linear fit to billets used. So in fact it proved. Again yield was included because although not significant in these estimations it would be were it to alter from its current very stable level - and one must have a model capable of dealing with such a situation.

As with many situations, the less important the cost the more trying it is with the analyser's patience and so it proved with the electricity consumed for finishing the rough rod. Since most processes are engaged in

*225 ff

turning rod production (the predominant rod product in this part of the factory) electricity consumption should show a good relationship to turning rod output, hopefully also with turning rod yield. A relationship was found which also showed a slightly improved cost behaviour pattern with respect to total output (stamping and turning) and turning rod yield. This is because stamping rod is comparatively small and showed little variation. In practice, either would do, as the relative importance of the usage is small. Electricity consumption for the hollow rod press is interesting in that the problem is that we have one process producing 2 outputs - copper shell and brass rough rod. How are we to determine relative electricity consumptions of these 2 outputs? One method is to look at the relative temperature rises needed to raise the billets to extrusion temperature, the relative specific heat capacities, etc. to form a ratio of electricity usage costs, perhaps 1.5:1, copper:brass. Alternatively, we can use multiple regression previously outlined on equation 6 so that b_6 and d_6 give us the relative electricity consumptions per tonne billet extruded. This has the advantage of speed and of flexibility. For example, at different billet usage ratios (copper brass) it may well be that electricity consumption per tonne brass, and copper are not constant. One might visualise that at low outputs of brass rod the heating cost per billet and waiting time might increase the relative electricity usage per tonne brass:copper. Using multiple regression it is in fact easy to monitor the accuracy of our joint cost absorption figures. Despite the prior assumption that hollow rod finishing electricity should show variability, none was found and the cost is left as fixed and time-dependent, hence we adjust for the number of working weeks. Were this to be an important cost, further work would have been done to examine this cost further. However it is not, and therefore it was not undertaken.

A miscellaneous equation 8 is provided as a "sink" for other costs although in this case all electricity costs are explained by the first seven equations.

For natural gas practical work established that canteen facilities were a significant user, and gas consumption for this is taken note of since canteen gas consumption is not improved by activity related cost analysis. For the rest the foundry was a predominant user, so much so that the costs of complicating the model to include other usage centres would have been more than any more precise knowledge gained given the medium importance of the cost. Therefore, natural gas was

(N.B. Structual equations and numerical values are appended. →

assumed to be used totally for the foundry launder boxes and therefore related to billets cut. The regression gave only satisfactory results which would need further work if the cost were more important. At such a consumption rate, one equation must suffice to explain natural gas consumption.

Fuel oil provided a problem in that only the total usage per month was known. However, practical exercises previously undertaken had established that internal transport was a minor and essentially fixed element of fuel oil cost. The intal drier had been assumed fixed, but statistical analysis suggested (no more than that) that a loose relationship to heats to melters existed. The problem being that only swarf is dried and this is a variable proportion of heats melted. To get the precise intal drier predicted oil usage would require further data on swarf dried, and this for a minor part of a minor part of energy costs. Therefore, equation 10 was felt to be reasonable in the practical environment. This view was justified because when intal fuel oil and internal transport oil consumption estimates were subtracted from the total a graph (on a per working week basis) of the form of figure 3 (more likely than figure 4) page[7] was shown.

Therefore equation 13 should provide a good estimate, based on practical results, for the efficiency of the

p225ff. The emphasis is on methodology rather than numbers...

space heating system as ambient temperature varies. Equation 12 gave the "heat" side of the main extrusion press examining the cost behaviour of LPG heated billets against billets used. This graph and regression gave good but less good results than its "power" sister equation (equation No. 4).

Finally, water was the last energy category over which much time could be spent to achieve little (and in fact was). Technically, as water is consumed in the foundry for log cooling water should show some trend. It did not show either fixed or variable characteristics with respect to any other likely cost centre(s). Fortunately, as it is a minor cost,equation 14 is considered satisfactory but were water charges to significantly increase further work to investigate where and on what our water is expended might prove valuable.

As regards data, a thorough discussion is given in the next section, but at this stage one should point out that data is not simply collected and then churned through a computer. Where a graph is drawn and two observations out of 15 are askew, one must investigate to see if, for example special production trials were carried out, or stock taking or other abnormal occurrences which could throw out our estimation of normal production requirement for energy, etc. This as data is historically based.

having been said one then uses as much relevant data as one can to derive the estimates, since the power of the explanation depends on the number of observations.

This however is half the battle - the real task is to take our hard-earned estimates and place them in a form giving suitable information to relevant personnel. Thus one month was taken and the model estimates worked through. Exhibit 2 shows an attempt to unify our portrayal of information. Instead of a yield report, monthly accounts, production output, cost centre computer wad, cost centre reference document, the aim is to select key data - usage, production, etc. so that as little as possible explains as much as possible. For the reader, the figure are not relevant, but the format and style of presentation is. In exhibit 2 the aim is to give usage and production and yield information on one document - to give a guide to energy as a resource and how effectively we are using it cost centre by cost centre, complete with summary documents where the detail is large to absorb in one glance.

The information presentation of cost in usage form is useful since it can often be more readily related to an output figure, e.g. x KWH/tonne, and can be a first stage for further work. However, one must bear in mind that managerial control rests on the control of £ not KWH, and therefore one must have some documents in money terms perhaps on a more summary document, on the basis that if this shows the ship is on course, no recourse is necessary to the more detailed usage based documents which can pinpoint where the trouble is.

Because of the logical basis of our usage estimates, conversion to money units is a simple process. Electricity is already subdivided into KWH (considered here) and KVA (which would warrant separate treatment) so that the variable electricity charge will be known (it is shown as KWH plus fuel adjustment charge less night rebate) all of which can reasonably accurately be considered as £x $(KWH)^{-1}$ the usage to money conversion factor. For gas the charge is published as £y $(100\ cu.ft.)^{-1}$. The rate for LPG is known in terms of £z tonne $(LPG)^{-1}$, and is fuel oil in terms of £w $(galls)^{-1}$. Thus 5 figures will convert our usage estimates onto money terms, and one document in summary terms, such as Exhibit 3, might be the most useful. Again the actual conversion factors are not useful for the reader, it is the format and presentation which is.

The next stage is equally easy. Since most firms keep a record of the price per therm KWH, etc. of the fuel Prices overtime (KWH separate from KVA for electricity) and those that do not can obtain a historical list for a specific tariff from the appropriate council or board, then one has available a document such as exhibit 4 giving the ongoing and historical costs of relevant fuels. By taking one month as base (e.g. October 1972) indices of fuel costs can be derived, exhibit 5. These are useful both as information, giving historical trends of fuel price rises, and in being able to bring the Exhibit 3 money costs to money costs on a constant value £ basis. Thus with October 1972 as base total electricity consumption (actual) will be $\frac{100}{159} \times 12369 = £7779$. A segment of such a document is shown as Exhibit 6.

When we considered the cost behaviour of energy, we implicitly assumed, in exhibit one, and in the dialogue that the behaviour would be in the form of $y = mx + c$ a semi variable cost (or totally variable or fixed by setting $c = o$ and $m = o$ respectively). However, when the cost behaviour was examined, although linear equations gave comparatively good results, many costs could be better predicted by some sort of step function as follows:

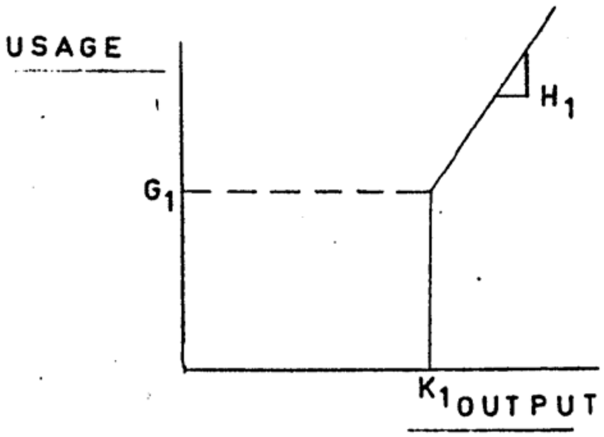


FIGURE 8

$$USAGE = G_1 \quad OUTPUT < K_1$$
$$= G_1 + H_1(OUTPUT), \; OUTPUT \geq K_1$$

Thus the 14 energy equations were reconsidered using step functions where these would significantly improve upon the closeness of the actual versus estimated cost usage for a given output level. Usually a graph of output versus usage showed one or two turning points where the slope altered, or a cost changed from fixed to semi variable. Sometimes technical knowledge of the production system leads us to believe that a cost centre would have a minimum "threshold" level of usage, for example the heating of billets which will require some amount to heat the brick muffle irrespective of billets.

Not all equations needed "the step function treatment". For example, the electricity consumption of the main press was of linear form.

More complex situations arise in joint costs situations such as the hollow rod press. Ideally, one would like to transform the figure given on page 170, figure 2, to its full step function equivalent, figure 7

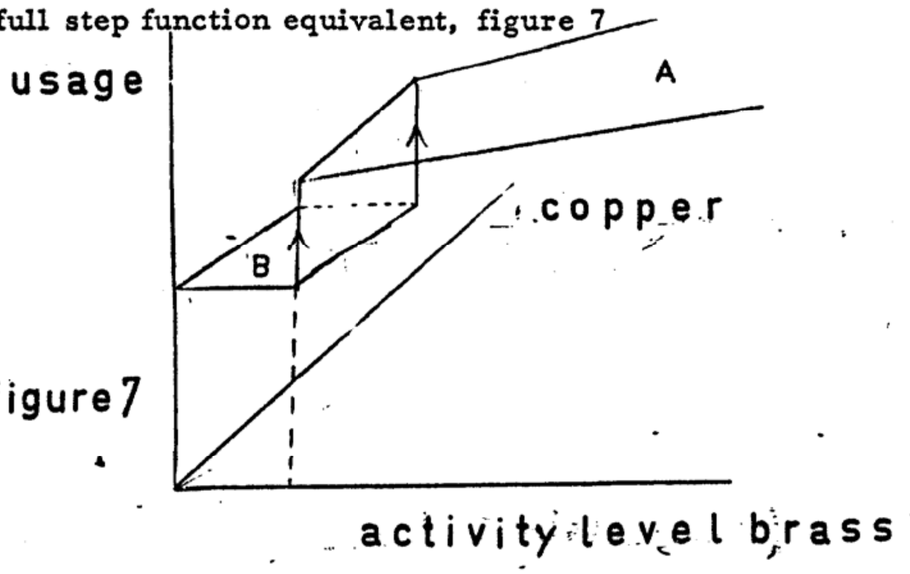


figure 7

where the step function slopes at sections A and B are different (rather like a staircase in a crazyhouse at the funfair). This requires a fair knowledge of how costs behave, for example the size of the 'step', the relative slopes, etc. Despite many attempts to find the slope of the plane (A) through examining similar monthly electricity consumptions having dissimilar product mixes, the number of observations, and technical knowledge did not allow this. Less good, therefore, but still very creditable was to take the graph 8 with the lines as marked parallel.* This still represents a good step forward in relation to a linear form (e.g. exhibit 1) since one was able to detect the fact that at low levels of activity the residuals (that is actual consumption against estimated) showed a positive divergence indicating that, whilst creditable, the linear estimation was poorer at lower activity levels, (figure 11).

* FIGURE 10

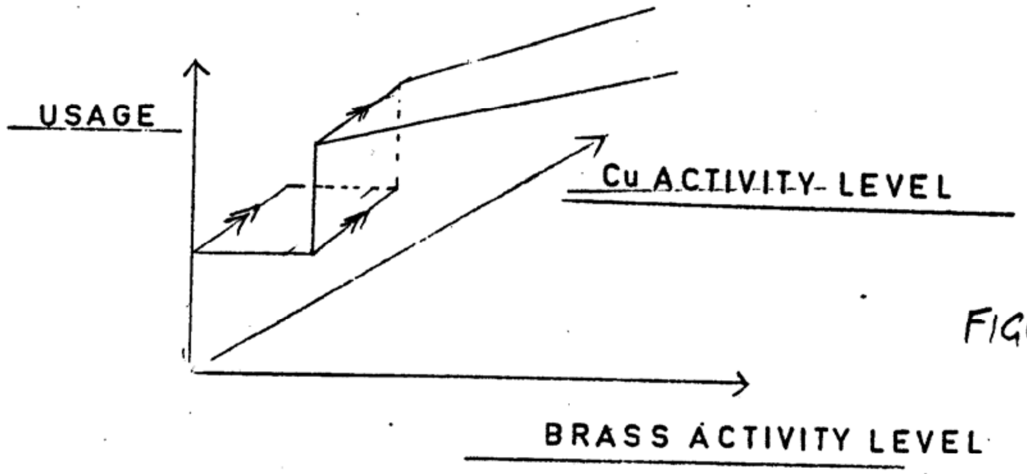


FIGURE 10

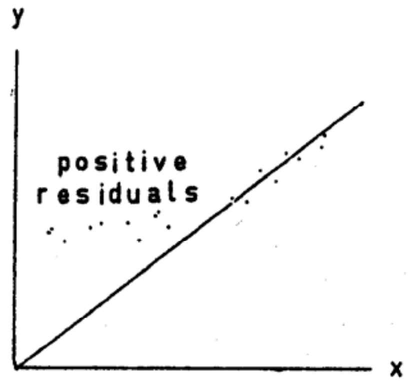


FIGURE 11

A skilled practitioner would be able (assuming he had a more flexible computer package than that available to me) to use these residuals to detect step functions even in a joint product situation by looking for abnormal residuals around key activity levels which, a priori (e.g. using on the spot information) he has reason to believe may show for example a change of shift.

Thus Exhibit 7 is the mirror image of Exhibit 1 with the sole but significant improvement of introducing step functions where appropriate. At the current time standard statistical measures of goodness of fit (e.g. R^2) do not extend to such recent innovations.

Using exactly the same fine conversion factors explained on page 208 ff. these new usage estimates can be converted to money terms, then deflated in exactly the same way as were the linear exhibit/s equation projections.

The last item that the model tackles concerns the rigidity of any estimation technique to changes in circumstances.

In this case we compare the linear model estimates we have obtained with those which would have been obtained had we only had available the last six months observations using the same technique as previously explained. Thus we are examining whether or not there has been any fundamental change in any of the cost centres and by contrasting our "best" estimates obtained with those for a very recent period (say 6 months) provide specialist information for management, as Exhibit 8 which shows how far recent cost estimation depart from the previous longer time scale sample. Using identical techniques as before, one can convert these short time period observations to money terms to compare on a money basis the "best" and "short period" estimates, Exhibit 9.

A similar procedure can be done in exactly the same way using the step functions of exhibit 7. By using the techniques as described above, one can obtain 2 estimates "best step function" and "step function on short time period" obtaining comparisons of the estimates in terms of both usage units and money units. The purposeof these comparisons is not immediately to alter our estimation method but to give management a guide to how fast, and how seriously our estimation is for recent time periods, showing a significant difference between historical estimation and recent estimations. One would visualise three general situations.

	Best Estimate	Shorter Time Estimate	Action
1	Good	Good	No significant difference. No action.
2	Good	Showing small and stable difference.	Investigate, slight imperfection in model or data, or both, e.g. variable missed from model.

	Best Estimate	Shorter Time Estimate	Action
3	Fair	Showing small but increasing difference.	Action not immediately required, but future thought on e.g. changing production situation necessary.
4	Fair	Showing high level of difference.	Action to see why estimation has diverged so much over recent time - inefficiency? New technology? New production method? What?

5.4.2 Labour

In exactly the same way as the energy model has dealt with the estimation of energy costs, labour is now the problem to be considered.

As with energy, it was first apparent via statistical analysis that labour hours on whatever cost centre basis one chose generally gave better cost behaviour relationships than its monetary counterpart.

As with energy, the current departmental basis of foundry plus main press, finishing work and hollow rod work did not give reasonable estimates of labour usage because of the heterogeneous nature of the production process carried on thereon. By further analysis and practical knowledge of the factory production system, five cost centres seemed most appropriate: the foundry, the main press, the finishing work, the hollow rod press, and hollow rod finishing, which by chance happen to be the same as those chosen for energy. (In fact, for value added@ exercises, it is better that a compromise be struck between the level of cost centre chosen for each cost considered rather than choosing non comparable centres.)

Looking at the deployment of labour in the foundry, it was clear that the large foundry and small foundry alone deserved individual treatment with other labour being a third category. There was also another very practical reason for this. The labour employed on the furnaces tends to be continually employed there with relatively small amounts of operative hours "borrowed" from other cost centres. Were one to try to examine, say, the intal drier as a cost centre for labour then where the labour hours are an amalgamation of "pool" labour as it were, one has to rely on daily work sheets. Thus the labour equations for the production cost centres follow those of energy. In addition, statistical work was undertaken to examine how maintenance labour behaved with regards to activity level. Ideally one would want maintenance (labour and materials) considered as a service function, but as a first step looking at maintenance labour in terms of representative

@See Glossary

output statistic e.g. billets seemed to give good results. The problem being that for some cost centres, when maintenance labour was multiply regressed against them, some coefficients were negative, since at periods of high activity, time only allowed emergency maintenance to be carried out. Therefore, better than the "representative" equation 10 in Exhibit 10 would be to split labour maintenance up into policy, routine and activity related labour maintenance costs. One of the problems of this technique would be in trying to match up the period in which the cost was incurred against the period in which the labour was deployed. For the toolroom labour both a 'typical' cost centre output representing the various cost centres and a multiple regression of toolroom labour against those cost centre activity levels using dies gave good results. It might therefore be possible to derive cost centre toolroom labour absorption ratios. Hence as toolroom labour is itself a fair proportion of die repair costs one has a guide as to the relative efficiency of die usage on a cost centre basis.

Thus the format of the labour usage equations mirrors closely those of energy in terms of looking at labour utilisation against cost centre activity. One complication is, however,

, that one must subdivide this labour cost into direct and indirect elements where both are significant in order to derive the likely downtime hours for a given activity level at each cost centre. Thus, direct labour hours will represent those hours spent by operatives when production on their centre was in progress. Indirect labour hours are therefore those hours of "waiting time" plus the indirect labour of the cost centre, if any. This split is one of the few requiring data from daily work sheets, however any likely inaccuracy is going to be on the cause of downtime rather than its actual value. In any case, one is going to use this information as in Exhibit 11. Here one uses the equations by saying - given the actual tonnage produced, what estimate should we have of direct and indirect labour hours? How do these compare percentage wise, to actual indirect and direct labour hours? A manager will use this information to answer a question such as - Given that we appear to have needed more labour hours to produce the actual tonnage, was this caused by (a) abnormally high downtime, or (b) that the labour efficiency during actual operating hours was poor; or both?

Nor has one yet 'wrung' all the information out of the basic equation system, Exhibit 10.

For the purposes of value added on a conversion cost basis, calculations at each production stage and to examine labour variability, it is also important to be able to separate out the variable and fixed component of labour for both direct and indirect labour, in a form comparable to the energy tabulation, Exhibit 12. For example, we may well want to look at total energy plus labour cost for a specific cost centre. The approach to the analysis of labour costs with respect to activity level is similar to that for energy. Statistical analysis of labour hours divided into direct and indirect hours showed good statistical relationships against output which were not significantly improved by considering time, seasonal factors, etc. as explanatory variables.

The next stage, therefore, is to convert the labour hours estimates into money units. Earlier, the reasoning behind the disaggregation of labour costs into hourly wage, bonus, shift allowance, overtime, holiday pay, NIGP has already been discussed. What is a problem is that the conversion of labour hours into money using 6 different aspects is complex. At first, therefore, a simplification was used to simply the manual calculation which the author had to undertake. The hourly rate and bonus were combined into one hours paid rate. This has the disadvantage that it does not take account of changes in efficiency. However, it should be noted that a fair amount of the bonus is, in fact, a 'fall back bonus' behaving similarly to an hourly wage payment. The calculation of the respective conversion rates are not as easy as the published rates for energy, but not as difficult as could have been the case. Wages analysis sheets gave (albeit with extensive work involved in making the monthly comparisons comparable on a cost centre basis from July 1974 to October 1975 when the format per month was scarcely the same) a total hours paid rate against hours worked. This by division gave a composite rate per hour cum bonus for each cost centre. This was checked on the shop floor by asking extensively about the basic rate and the bonus to ensure that the two estimates crosschecked which surprisingly they did. The shift allowance on a cost centre basis is available both from wages department and from the shop floor, as is overtime calculations.

The relative ease of obtaining conversion factors, stems from the design of the size and type of cost centre taken. In previous work both myself and previous studies of investment appraisal, for example, tried to derive labour hour estimates on a factory basis using an equation system dependent on total factory output. Even where good statistical relationships were established (as they were in my case) problems became insoluble in trying to derive satisfactory hour and bonus rates when considering such a heterogeneous production system as a factory. One is hardly likely to obtain systematic bonus rates based on finished output if part of the production payment is based on billets produced, part on billets used, etc. Thus, the planning of what cost centre to take, took account of the problems faced in converting labour hours to wages paid when non-homogeneous cost centres are taken. In one factory, a department consisted of a foundry and extrusion press. It would have been very easy (and it was a temptation) to use readily available departmental data on which to base labour hours and then payment. This was in fact tried but the fact that little direct connection existed between the foundry and main press suggested that a division into a cost centre would be necessary.

Thus the choice of type and size of cost centre took account of the data availability and difficulty so that where bonus system were based on billets used, the cost centre chosen had an activity level based on billets used. It is for this reason that the conversion of labour hours to money paid is far less of a problem that others seem to have found.

Earlier, on the previous page, it was suggested that satisfactory conversions of labour hours can be obtained by using a composite labour hour rate plus bonus figure. In some factories this may be satisfactory, in others the bonus may be important enough to merit separate calculation. An example is shown in the appendix, and the alterations required are in fact not extensive, but the example is given lest the most sceptical reader should suggest that I have side-tracked the issue.

As previously indicated, shift allowance rates are known and one can estimate both by on the shop floor questions and by corroborating graphical output in labour hours versus output, likely output levels where a further shift will be required to increase output.

For overtime, the problem is in the complexity of overtime payments where to model exactly would be out of all proportion to the importance of the overtime figures. Therefore, by saying (as explained previously) what hours were worked, against what hours were normal (i.e. 40 hour week) gives us a statistic as to how many hours are at risk of an overtime premium payment. By examining just in the past what amount per overtime hour would be needed to be to match the overtime payments made per person, one was able to settle on a reasonable figure, say Ti where i is the cost centre. The explanation of calculating holiday pay has already been given previously, except to add that a manager should be aware monthly of the holiday BURDEN which he has incurred even if the actual is not paid until, say, August. NIGP is, of course, known as being a governmental labour tax at x% of wages paid. It is believed that the inclusion of holiday pay and NIGP as a integral labour cost is useful to this model in the U.K., and outperforms, in terms of simplicity and accuracy even the German system where these hidden costs, at 73% of direct wages paid, are given serious consideration. Exhibit 13 gives the format which would be suitable for calculating the wage equivalent of a given number of hours.

Exhibit 14 is not an output document at all, but rather like a construction line in a diagram: the dotted, squared figures indicate how this connects to Exhibit 15, an output document and Exhibit 16 which further splits labour costs into variable and fixed components.

The problem of deflating the estimates of labour costs is not difficult because of the foresight shown in the apt choice of cost centre. Since historical data has been used to help validate conversion rates (c.f. shift allowance, etc.) (for no statistical data is used unless it is independently checked) then the problem is one of weight of data not how to proceed. By looking at October 1972 overtime per hour rates against the October 1974 figure, for example, an index can be derived to deflate the overtime element of labour cost on each cost centre basis. This can then be done for each cost in turn so that one will then have available the exhibits 13 to 16 this time on a say October 1972 instead of a current cost base. No exhibits are provided, since the reader has already been subjected to a total of over 30 tabular sheets, which is far more than one would wish. But it should be quite clear what results one would obtain if they were shown here.

In the same way as energy, linear graphs were good in explanatory power but by looking at the shape of the graph produced, from shop floor information and from technical knowledge, it was clear that many costs could be improved in terms of the information presented if one was to consider consider cost behaviour in step function terms. Similar techniques to those extensively discussed in the energy section were used to derive exhibit 17, these estimates can be turned into money estimates by exhibit 13 in exactly the same way as the linearly estimated labour hours, they can be deflated in the same way - the numbers are different the method is the same in principle and detail.

Finally, as with energy, one needs to look at the behaviour of labour costs over time - are they becoming more flexed? is a linear approximate still appropriate? Exhibit 18 gives the format by which management can decide - in my case labour costs during the period under examination appeared to behave similarly whatever time period considered. I have, therefore, taken the "ideal" case of no variation, although in practice one will be very interested in seeing how the 2 estimates vary over time as the model approaches middle age. The emphasis has been on labour and energy because these are two very important costs, yet one has looked at maintenance labour and via toolroom labour tried to aid our managerial information on die usage and production supplies. Nevertheless, in brief, one would like some sort of context document to set the scene of total cost against which certain costs have such an important place: In Exhibit 19 we set aside labour and energy, and even here separate out policy costs (e.g. group division H.Q. charge to factories) from factory incurred fixed costs. In the main, the policy costs model estimates will be derived from budget estimates since we have selected which costs we would like to consider.

EXHIBIT ONE – THE STRUCTURAL EQUATIONS

ENERGY — STAGE I

A. ELECTRICITY

(i) Foundry

1. Large Furnace Electricity usage $= a_1 + b_1$ (Billets cut) $+ c_1$ (Yield)

2. Small Furnace Electricity usage $= a_2 + b_2$ (Billets cut) $+ c_2$ (Yield)

3. Other $= \frac{a_3}{4.0} \times WW$

(ii) Main Extrusion Unit : Electricity consumption

4. EMEU $= a_4 + b_4$ (Billets used) $+ c_4$ (Yield MEU)

(iii) Finishing work : Main Rod

5. ELEC FW $= a_5 + b_5$ (turning & Stamping Rod Produced) $+ c_5$ (Yield turning rod)

6. ELECHREP $= a_6 + b_6$ (Hollow Rod Billets) $+ c_6$ (Yield Hollow Rod) $+ d_6$ (Copper Rod Billets) $+ e_6$ (Yield Copper Rod).

(iv) Hollow Rod Finishing

7. ELEC FHR $= \frac{a_7}{4.0} \times WW$

8. Miscele $= \frac{a_8}{4.0} \times WW$

EQUATIONS — NATURAL GAS

9. N.Gas $= a_9 + b_9$ (Billets cut Large Furnace) $+ c_9$. (Billets cut Small Furnace)

Fuel Oil

10. Intal Drier Fuel Oil $= a_{10} + b_{10}$ (Swarf Driers both Furnaces)

11. Internal Transport $= a_{11}$

12. LPG $= a_{12} + b_{12}$(Billets used) $+ C_4$ (yield)

13. Space Heating Fuel used per working week $= Pi \times \frac{a_{13}}{Ti^{b13}}$ Wk. 1., wk.2., wk.3., wk.4., wk.5.

$i = 1\text{-}5$

Pi = Proportion of days work in that week (eg. public holiday, etc.)

14. Water $= a_{14}$

C

EXHIBIT 2. COMPUTER PRINT-OUT REQUIRED :

STAGE I

ENERGY

ELECTRICITY : FOUNDRY

	TONNES
Billets cut - Large Furnace	2100
Billets cut - Small Furnace	200
	(000)KWH
Electricity usage - Large Furnace - Actual	747
Variable model 651 + fixed model 145 = Total Model	796
Favourable (Adverse) Difference	49
Yield on Large Furnace was	83%
Yield on Small Furnace was	80%
	TONNES
Billets cut - Small Furnace	200
	(000)KWH
Electricity usage Small Furnace Actual	87
Variable model 110 + fixed model 0 = Total Model	110
Favourable (Adverse) Difference	23
Yield on Small Furnace was	79%
	(000)KWH
Electricity usage (other than above)	
Actual	115
Fixed Model	120
Favourable (Adverse) Difference	5
	(000)KWH
Foundry Electricity : Summary	
Electricity Usage - Actual	949
Variable Model 761 + Fixed Model 265 = Total Model	1026
Favourable (Adverse) Difference	77

E2

Energy : Electricity

Main Extrusion Unit

Billets used (Main Extrusion Unit)		1700 tonnes
Electricity usage	Actual	90 (000)KWH
Variable Model 96 + Fixed Model 5 =	Total Model	101 (000)KWH
Favourable (Adverse) Difference		11
Yield on Main Extrusion Unit		81.3%

Finishing Work : Main Rod

Rough Rod Produced		1400 tonnes
Turning Rod Produced		600 "
Stamping Rod Produced		250 "
Electricity usage	Actual	30 (000)KWH
	Model	31 " "
Favourable (Adverse) Difference		1
Yield on Finishing Work		91.1%

Energy : Electricity

Hollow Rod Press

Hollow rod billets used		200 tonnes
Copper rod " "		600 "
Hollow rod yield		54.9%
Copper " "		83.5%
Electricity usage	Actual	308 (000)KWH
Variable Model 282 + Fixed Model 18 =	total Model	300 " "
Favourable (Adverse) Difference		8

Hollow Rod Finishing

Finished Rod		100 (000)KWH
Electricity usage	Actual	12
" "	Model (Fixed)	10

Miscellaneous Electricity Usage

	Actual	20 (000)KWH
	Model (Fixed)	20 " "

E2

e

COMPUTER PRINT-OUT

SUMMARY

Electricity Usage (000)KWH

	Model Fixed	Model Variable	Model Total	Actual	Difference
Foundry					
Large Furnace	145	651	796	747	49
Small Furnace	-	110	110	87	23
Other	120	-	120	115	5
Foundry sub-total	265	761	1026	949	77
Main Press	5	96	101	90	11
Finishing Unit					
Main work	14	17	31	30	1
Elec. HREP	18	282	300	308	(8)
Elec. FHR	10	-	10	12	(2)
Miscell.	20	-	20	21	(1)
Total Elec.	332	1156	1488	1410	78

E2

COMPUTER PRINT-OUT

NATURAL GAS CONSUMPTION (00) Cu.Ft.

	Model Fixed	Model Variable	Model Total	Actual	Difference
Foundry	1250	3550	4750	3527	1223
Other Foundry	600	-	600	1046	
Other (not canteen)	300		300		
Total	2150	3550	5650	4573	1077
Intal Fuel Oil (Galls)	600	900	1500	1720	(220)
Internal Transport	300	-	300	313	(13)
L.P.G.	6.170	31.348	37.518	34.900	2.618
Water (000) Galls.	1750	-	1750	2022	(272)

Space Heating

Fuel Used

	Model Fixed	Model Variable	Model Total	Actual	Difference
Wk. 1.	2696	-	2696	3169	(473)
Wk. 2.	2746	-	2746	3260	(514)
Wk. 3	2510	-	2510	3063	(543)
Wk. 4.	2716	-	2716	3169	(453)
Wk. 5.	-	-			

E2

COMPUTER PRINT-OUT

ENERGY SUMMARY TABLE

	Model Fixed	Model Variable	Model Total	Actual	Difference
Electricity (000) KWH	332	1156	1488	1410	78
Nat. Gas (00)cu.ft.	2150	3550	5650	4573	1223
Intal Fuel (galls)	600	900	1500	1720	(220)
Int. Transport	300	-	300	313	(13)
L.P.G. (tons)	6.170	31.348	37.518	34.900	2.618
Space Heating					
Wk.1	2696	-	2696	3169	(473)
Wk.2.	2746	-	2746	3260	(514)
Wk.3.	2510	-	2510	3053	(543)
Wk.4.	2716	-	2716	3169	(453)
Wk.5.	-	-			

Monthly Space Heating : Temperature (Model) 7.7
: Actual 7.4

Model Prediction (per w/w)	Actual	Difference caused by temperature	Leaving Unexplained
2716	3169	204	249

EXHIBIT 3

COMPUTER PRINT-OUT :

SUMMARY IN MONEY TERMS

ELECTRICITY USAGE IN MONEY TERMS (OCT 1974)

	Model Fixed	Model Total	Actual	Difference
Large Furnace	1271	6981	6551	430
Small Furnace	-	965	763	202
Other	1052	1052	1009	43.
Total Foundry	2323	8998	8323	675
Main Press	44	886	793	93
Finishing Work	128	272	263	9
HR Press	158	2631	2701	(70)
HR Finishing	87	87	105	(18)
Other (Miscele)	175	175	184	(9)
Total	2915	13049	12369	680

NATURAL GAS CONSUMPTION : £

	Model Fixed	Model Total	Actual	Difference
Foundry :				
Furnace				
Other				
	209	549	434	115
Intal Fuel Oil	120	300	344	(44)
Internal Transport	60	60	63	(3)
LPG	310	1883	1752	131
Water	525	525	607	(82)
Space Heating :				
Wk. 1	543	543	634	(91)
Wk. 2	543	543	634	(91)
Wk. 3	543	543	634	(91)
Wk. 4	543	543	634	(91)
Wk. 5	-	-	-	

EXHIBIT 4 DATA BASE REQUIREMENT FOR STAGE III

	Electricity	Gas	Fuel Oil	LPG	Water
Oct. 1972	5.5	.095	.0725	20.66	.225
Nov. 1972	5.5	.095	.0725	20.66	.225
Dec. 1972	5.5	.095	.0690	19.50	.225
Jan. 1973	5.5	.095	.0690	19.50	.225
Feb. 1973	5.5	.095	.0690	19.50	.225
Mar. 1973	5.5	.095	.0690	19.50	.225
Apr. 1973	5.5	.095	.0690	19.50	.225
May 1973	5.5	.095	.0750	21.30	.225
Jun. 1973	5.5	.095	.0750	21.30	.225
Jul. 1973	5.5	.095	.0750	21.30	.225
Aug. 1973	5.5	.095	.0750	21.30	.225
Sep. 1973	5.5	.095	.0750	21.30	.225
Oct. 1973	5.5	.095	.0875	21.30	.225
Nov. 1973	5.5	.095	.0875	24.21	.225
Dec. 1973	5.5	.095	.1335	24.21	.225
Jan. 1974	5.5	.095	.1335	32.21	.225
Feb. 1974	5.5	.095	.1335	50.21	.225
Mar. 1974	5.5	.095	.2	50.21	.225
Apr. 1974	5.5	.095	.2	50.21	.225
May 1974	5.5	.095	.2	50.21	.225
Jun. 1974	8.5	.095	.2	50.21	.225
Jul. 1974	8.5	.097	.2	50.21	.225
Aug. 1974	8.75	.097	.2	50.21	.3
Sep. 1974	8.77	.097	.2	50.21	.3
Oct. 1974	8.77	.097	.2	50.21	.3
UNITS	£ MWH^{-1}	£ 100cu ft^{-1}	£ glls^{-1}	£ tonne^{-1}	£ 1000glls^{-1}

Method of Index Calculation

(i) $\frac{\text{Month}_i \text{ (Example, Oct. 1974)}}{\text{Base month}} \times 100$

(ii) Divide unadjusted Stage II money estimates by index for Stage III money estimates of predicted cost.

EXHIBIT 5 STAGE 3 : PRINT OUT

CALCULATION OF INFLATION INDICES

BASE DATE OCTOBER 1972

	Electricity per 000KWH £	Gas per 00 cu.ft. £	Fuel Oil per gall. £	LPG per ton £	Water per 000 gall
Nov. 73	100	100	121	117	100
Dec. 73	100	100	184	117	100
Jan. 74	100	100	184	156	100
Feb. 74	100	100	184	243	100
Mar. 74	100	100	276	243	100
Apr. 74	100	100	276	243	100
May 74	100	100	276	243	100
Jun. 74	155	100	276	243	100
Jul. 74	155	102	276	243	100
Aug. 74	159	102	276	243	133
Sep. 74	159	102	276	243	133
Oct. 74	159	102	276	243	133
Prices at Base Date	5.5	.095	.0725	20.66	.225
Prices at Oct. 74	8.77	.097	.2000	50.21	.300

SUMMARY IN MONEY TERMS

DEFLATED

	Model Fixed	Model Total	Actual	Difference
Large Furnace	799	4391	4120	270
Small Furnace	-	607	480	127
Other	622	662	635	27
Total Foundry	1461	5659	5235	425
Main Press	28	557	499	58
Finishing work	81	171	165	6
HR Press	99	1655	1699	(44)
HR Finishing	55	55	66	(11)
Other : Miscele	110	110	116	(6)
	1833	8207	7779	428

✓ K

EXHIBIT 6 COMPUTER PRINT OUT

ELECTRICITY USAGE

SUMMARY IN MONEY TERMS DEFLATED

	MODEL FIXED	MODEL TOTAL	ACTUAL	DIFFERENCE
Large Furnace	799	4391	4120	270
Small Furnace	-	607	480	127
Other	662	662	635	27
Total Foundry	1461	5659	5235	425
Main Press	28	557	499	58
Finishing Work	81	171	165	6
HR Press	99	1655	1699	(44)
HR Finishing	55	55	66	(11)
Other: Misc	110	110	116	(6)
	1833	8207	7779	428

BASE DATE OCTOBER 1972

5.1

ENERGY EXHIBIT 7 STAGE IV

A : Electricity

1. Large Furnace Electricity Usage = g_1 if billets cut less than or equal to k_1

= $g_1 + h_1$ (billets cut large furnace) + j_1 (yield large furnace) otherwise.

2. Small Furnace Electricity Consumption = g_2 if billets cut less than or equal to k_2

= $g_2 + h_2$ (billets cut small furnace) + j_2 (yield small furnace) otherwise.

3. Other = $\frac{a_3}{4.0} \times WW$

Main Extrusion Unit : Electricity Consumption

4. EMEU = $g_4 + h_4$ (BILLETS USED) + j_4 (YIELD)

5. EFW = g_5 if turning and stamping $\leq$ 475

= $g_5 + h_5$ (stamping & Turning) otherwise

6. ELECHREP = g_6 if hollow rod billets less than k_3

and copper billets less than k_4

= $g_7 + h_7$ (hollow rod billets) + j_7 (hollow rod yield)

+ l_7 (copper billets) + m_7 (copper yield)

7. ELEFUR = $\frac{a_7}{4.0} \times WW$

8. MISCELE = $\frac{a_8}{4.0} \times WW$

9. NGAS = a_9 if billets cut large furnace $<$ k_5

= $a_{10} + b_{10}$ (billets cut large furnace) + c_{10} (billets cut small furnace)

otherwise

E7

10. Fuel oil $= a_{11}$ HTM $\leqslant k_6$

$= a_{11} + b_{11}$ (HTM) otherwise

11. Internal transport $= a_{12}$

12. LPG $= a_{13}$ if LPG $\leqslant k_7$

$= a_{14} + b_{12}$ (billets used) otherwise

13. Space heating $= a_{15} + \dfrac{a_{16}}{T^{b16}}$

14. Water $= a_{16}$

OUTPUT : STAGE I AND STAGE VI COMPARISON EXHIBIT 8

ORIGINAL AND REVISED MODEL ESTIMATES
(IN USAGE TERMS)

October 1974

	Actual	Model Stage I	Model Stage 6	%Diff. 2 Models
Foundry : Large furnace	747	796	885	89.9
Small "	87	110	126	87.3
Other	115	120	110	109.1
Main Press	90	101	112	90.0
Finishing Unit : Main Work	30	31	41	75.6
Elec. H. Rod Press	308	300	317	94.6
Ele. H. Rod Finishing	12	10	12	83.3
Miscele	21	20	22	90.9
N.gas : Foundry	3527	4750 }	4800 (Foundry + Foundry-other)	117.7
Foundry-other } Other }	1046	900 }		
Intal Drier	1720	1500	1600	93.8
Internal Transport	313	300	350	85.7
LPG	34.900	37.518	39.351	95.3
Water	2022	1750	1908	91.7
Space Heating (Per working week)	3169	2716	2226	122.0

STAGE VII OUTPUT

AS FØR STAGE II.

10

OUTPUT : STAGES II AND VII COMPARISON

EXHIBIT 9

(MONEY TERMS)

	Actual	Model 1 £	Model 5 £	% diff.
Large furnace	6551	6981	7761	90.0
Small "	763	965	1105	87.3
Other	1009	1052	965	109.0
Main Press	793	886	982	90.2
Finished work	263	272	359	75.7
HR Press	2701	2631	2780	94.6
HR Finish	105	87	105	82.9
Other	184	175	193	91.1
Nat. Gas	434	549	466	111.8
Intal fuel	344	300	320	93.8
Internal Transport	63	60	70	85.7
LPG	1752	1883	1975	95.3
Water	607	525	572	91.7
Space Heating	634	543	445	122.0

P

STAGE 1 : STRUCTURAL EQUATIONS EXHIBIT 10

Large furnace

1. a. DLHRSLF = a20 + b20 (LF billets cut) + c20 (Yield l.f.)
   b. IDLHRSLF = a21 + b21 (LF " ") + c21 (" ")

Small furnace

2. a. DLHRSSF = a22 + b22 (SF billets cut) + c22 (Yield s.f.)
   b. IDLHRSSF = a23 + b23 (" " ") + c23 (" ")

Other

3. DIRECTLHRSO = a24 + b24 (Heats to Melters)
   INDLHRSO = a25 + b25 (Heats to Melters)

MEU Press

4. TLHRSMEU = a26 + b26 (Billets used) + c26 (Yield MEU)
5. DLABHRSMFW = a27 + b27 (Turning & Stamping output) + c27 (Yield finished work)
6. IDLABHRSMFW = a28 + b28 (" " " ") + c28 (" " ")
7. TLABHRPRESS = a29 + b29 (copper billets used) + c29 (copper yield) + d29 (Hollow rod billets) + e29 (h/rod yield
8. TOTLABHRFIN = a30 + b30 (Hollow rod output) + c30 (hollow rod yield)
9. OTHERLAB = $a31/_{4.0}$ x WW
10. MAINTENANCE LABOUR = a32 + b32 (Billets used)
11. TOOLROOM = a33 + b33 (Billets used)
12. BLD MAIN LABOUR = $a34/_{4.0}$ x WW
13. WAREHOUSE = a35 + b35 (Sales 1350)

DOWNTIME ANALYSIS : STAGE 1 EXHIBIT 11

Large foundry furnace

Actual tonnes (billets) 2100 Estimated tonnes (budget) 2000

% Actual / Estimated = 105%

Actual direct lab.hours 2080 Estimated direct lab.hours 2610

% Actual / Estimated = 79.7% Lab.hrs.(dir.)per actual=tonne

Actual indirect lab.hrs. (downtime) 872 Estimated Ind. Lab.hrs. 1300

% Actual / Estimated = 67% Lab.hrs.(ind.) per actual=tonne

Small foundry furnace

Actual tonnes (billets) 200 Estimated tonnes (budget) 220

% Actual / Estimated = 91%

Actual direct lab.hrs. 1212 Estimated direct lab.hrs. 990

% Actual / Estimated = 122% Lab.hrs.(dir.) per actual=tonne

Actual indirect lab.hrs.(downtime) 240 Estimated ind. lab.hrs. 400

% Actual / Estimated = 60% Lab.hrs.(ind.) per actual=tonne

ETC. ON ALL SECTIONS

Main Extrusion press

Actual tonnage billets extruded 1700 Estimated (budget) 1650

% Actual / Estimated = 103%

Actual Dir. lab.hrs. 3150 Estimated total 3050

% Actual / Estimated = 103%

Actual Ind.lab.hrs.(downtime Estimated

% Actual / Estimated =

Finishing: Main works

Actual tonnage 1250 Estimated tonnage (budget) 1450

% Actual / Estimated = 86%

Dir. lab. actual 4150 Dir. lab. estimated 4495

% Actual / Estimated = 92%

Ind. lab. actual 1260 Ind. lab. estimated 1755

% Actual / Estimated = 71.8%

E 11

Hollow rod press

Actual tonnage (billets) Cu 605 Brass 205 Estimated tonnage (billets) (budget) Cu 480 Brass 150

% Actual/Estimated = Cu 126% Brass 137%

Dir. lab. actual 3330 Dir. lab. estimated 3540

% Actual/Estimated = 94%

Ind. lab. actual Indir. lab. estimated

% Actual/Estimated =

Hollow rod finishing

Actual tonnage 100 Estimated tonnage (budget) 108

% Actual/Estimated = 92%

Direct lab. actual 1292 Dir. lab. estimated 1724

% Actual/Estimated = 75%

Indir. lab. actual Indir. lab. estimated

% Actual/Estimated =

BUDGET ESTIMATES ARE FOR ILLUSTRATION ONLY

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STAGE 1 : LABOUR ANALYSIS OCTOBER 1974 OUTPUT EXHIBIT 12

FOUNDRY LABOUR

	HOURS		TONNES
Billets cut	Large furnace		2100
" "	Small furnace		200
Yield large furnace was			83%
Direct labour hours spent, large furnace		Actual	2082
" " " "	l.f. 2310 variable	Model	2610
	Favourable (Adverse) Difference		528
Indirect labour hours spent, Large furnace		Actual	872
" " " "	of which 105 var.	Model	1300
	Favourable (Adverse) difference		428
Yield small furnace			80%
Direct labour hours spent, small furnace		Actual	1212
" " " " " "	of which 800 var.	Model	990
	Favourable (Adverse) difference		(12)
Indirect labour hours spent small furnace		Actual	240
" " " " " "	of which 300 var.	Model	400
	Favourable (Adverse) difference		160
Direct labour hours spent, other foundry		Actual	2250
" " " " " "	of which 1500 var.	Model	2400
	Favourable (Adverse) difference		150
Indirect labour hours, other foundry		Actual	495
" " " " "	of which 300 var.	Model	600
	Favourable (Adverse) difference		105

FOUNDRY LABOUR HOURS

SUMMARY

Actual hours worked	7151
Model hours estimated, fixed 2010 var.6260	8300
Favourable (Adverse) difference	1149

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Main press : Hours worked, Total 1700

Billets extruded

Actual		3150
Model	Fixed 500 var. 2550	3050
Favourable (Adverse) difference		100

Main press finishing

Actual hours worked , direct		4150
Model	Fixed 370.var. 4125	4495
Favourable (Adverse) difference		245
Actual hours worked indirect		1260
Model	Fixed 630, var. 1125	1755
Favourable (Adverse) difference		495

Summary :	Total actual hours worked	5409
	Model Fixed 1000, var. 5250	6250
	Favourable (Adverse) difference	741

LABOUR ANALYSIS : FOUNDRY

HOURS : STAGE 1

Large furnace	Total Model	Analysis : Model		Total Actual
Direct L. hours	2610	300(F)	2310 (V)	2082
Indirect (inc. downtime)	1300	250(F)	1050 (V)	872
	3910	550	3360	2954
Small furnace				
Direct L. hours	990	190(F)	800 (V)	1212
Ind. (inc. downtime)	400	100(F)	300 (V)	240
	1390	290	1100	1452
Other				
Direct	2400	900(F)	1500 (V)	2250
Indirect	600	300(F)	300 (V)	495
	3000	1200	1800	2735
TOTAL	8300	2040(F)	6260 (V)	7151

E12

HOLLOW ROD PRESS
LABOUR HOURS

Actual hours worked		3330
Model	Fixed 300	
	Variable copper 1500	
	brass 1740	
	Total	3540
	Favourable (Adverse) difference	110

HOLLOW ROD FINISHING

Actual		1292
Model	Fixed 474, Variable 1250	1724
	Favourable (Adverse) difference	432

OTHER LABOUR

Actual	1292
Model	2500
Favourable (Adverse) difference	(248)

MAINTENANCE LABOUR

Actual		6692
Model	Fixed 4000, Variable 3910	7910
Favourable (Adverse) difference		918

TOOLROOM HOURS

Actual		2471
Model	Fixed 1534, Variable 945	2479
Favourable (Adverse) difference		8

BUILDING MAINTENANCE

Actual	1110
Model	1000
Favourable (Adverse) difference	(110)

WAREHOUSE

Actual		2886
Model	Fixed 1400, Variable 1350	2750
Favourable (Adverse) difference		(139)

OTHER Lab (SERVICES)Nes

Actual	2748
Model (fixed)	2300

EXHIBIT 13

STAGE 2 : FORMAT AND OUTPUT

	Rate	Direct hrs	Ind.hours	Hours paid	Shift all.	Overtime	Subtotal	Holiday pay	NIGP	Grand Total
Large furnace	11	DLHRLF	-	TOTDLF	P1 x N1	T1xTOTDLFOV		See note(a)	S1 x hrs.paid	
Small Furnace	12	DLHRSF		TOTDSF	P2 x N2	T2xTOTDSFOV				
Total dir. lab., other subtotal	13	DIRECTLHRSO		TOTDO	P3 x N3	T3xTOTDOOV				
Total Ind.lab., foundry	14		INLHRSLF + INLHSSF + INDLHRSO	TOTIF	P4 x N4	T4xTOTIF				
Total Foundry										
Total lab.M.E.U.	15	TLHRSMEU		TOTMEU	P5 x N5	T5xTOTMEUOV				
DLABHRS Main Finishing work	16	DLABHRSMFW		DMFW	P6 x N6	T6xDMFWOV				
Ind.lab.hrs. main finishing work	17		INDLABHRSMFW	IMFW	P7 x N7	T7xIMFWOV				
Subtotal Total Labour										
Hollow rod finishing	23	TOTLABHRPRESS		TLHRP	P8 x N8	T8xTLHRPOV				
Total Labour										
H.rod finishing	24	TOTLABHRFIN		TLHRF	P9 x N9	T9xTLHRFOV				
Subtotal TOTAL LABOUR										

3

E13

	Rate	Direct hrs.	Ind.hours	Hours paid	Shift all.	Overtime	Subtotal	Holiday pay	NIGP	Grand Total
Other lab. NES	18	-	Other lab.	OL	P10 x N10	T10xOLOV				
Maintenance Lab	19		Maint.Lab.	ML	P11 x N11	T11xMLOV				
Toolroom	20		Toolroom	TR	P12 x N12	T12xTROV				
Bld.M.Lab	21		Bld.Main lab.	BML	P13 x N13	T13xBMLOV				
Warehouse	22		Warehouse	W	P14 x N14	T14xWOV				
Other	25		Other	OT	P15 x N15	T15xOTOV				

Note(a) D x Ni x RATEi x $^2/_3$ x $\frac{WW}{4.0}$

D	Ni	RATEi	
Total days holiday	Number in over	Flat rate	$\frac{year}{12}$ =month x 8 = hours

x

E13

HOLIDAY PAY CALCULATION

Assumed 22 days x Ni x flat rate pay per hour x $^{8}/_{12}$

$$= \frac{22 \text{ days pay}}{12}$$

5

4

EXHIBIT 14

DUMMY DATA

	Rate £ per hour	Direct hrs.	Ind. hrs.	Hrs. paid	Shift all.	Overtime	Subtotal	Hol.pay	NIGP 8.5% of previous	Grand total	Ni
Large furnace DLHRSLF	0.9	2610		2349	20 x 17 = 340	50	2739	224	252	3215	17
Small furnace (Direct)	0.9	990		891	20 x 9 = 180	202	1273	119	118	1510	9
Total Direct Lab. other	0.75	2400		1800	20 x 18 = 360	180		154	362	4625	14
L.Furn Ind. / S.Furn.Ind.	0.75		1300 / 400	975 / 300				44			4
Foundry-other indirect lab.	0.75		550	450	inc.above						
Foundry		8300		6765	800	432					
Main press Total lab.MEU	.80	3050		2440	20 x 16 = 320	196	2956	188	267	3411	16
Finishing work Main press	0.8	4495	1755	5000	15 x 30 = 450	0	4046	352	373	4771	30
Lab. hollow rod press	0.85	3540		3009	15 x 17 = 255	348	3612	212	325	4149	17
Hollow rod finishing	0.8	1724		1379	10 x 10 = 100	50	1529	117	140	1646	10
Other NES	0.8	0		0	0	0	0	0	0	0	
Maintenance	0.9		7910	7119	15 x 33 = 495	1184	8796	436	784	10016	33

N

E14

	Rate	Direct hrs.	Ind. hrs.	Hrs. paid	Shift all.	Overtime	Subtotal	Hol.pay	NICP	Grand total	Ni
Toolroom	0.9		2479	2231	0	180	2411	172	219	2802	13
Bld. Main. lab.	0.9		1000	900	0	18	918	79	85	1082	6
Warehouse	0.75		2750	2065	5 x 15 = 75	130	2270	165	207	2642	15
Other	0.80		2300	1940	0	0	1940	140	176	2256	12

12a

OUTPUT LASHEET	Hours Paid		Shift All.		Overtime		Sub Total		NIGP		Sub Total		Actual Holiday Pay	Model Holiday Pay
	Actual £	Model £	Actual £	Model £	Actual £	Model £	Actual £	Model £	Actual £	Model £	Actual £	Model £	£	£
Large furnace Direct hours	2081	2349												
Indirect	872	975												
Total L.F.	2953	3324	331	340	141	50	3425	3714	291	315	3716	4030		224
Small furnace Direct hours	1212	891												
Indirect	240	300												
Total S.F.	1452	1191	184	180	43	202	1679	1573	143	134	1822	1706		119
Other direct	2250	1800	318	360	63	180	2631	2340	224	199	2855	2538		154
Other indirect	667	450	-	-	20	-	687	450	58	38	745	488		44
Total foundry	7322	6765	833	880	267	432	8422	8077	716	686	9138	8762		541

OUTPUT

EXHIBIT 15

NIGP is assumed not to depend on holiday pay.

EXHIBIT 15

	HOURS PAID Actual	HOURS PAID Model	SHIFT ALL. Actual	SHIFT ALL. Model	OVERTIME Actual	OVERTIME Model	SUB TOTAL	SUB TOTAL	NIGP Actual	NIGP Model	SUB TOTAL	SUB TOTAL	HOLIDAY PAY Actual	HOLIDAY PAY Model
MAIN PRESS														
	2432	2440	366	320	207	196	3005	2956	255	251	3260	3207		188
FINISHING WORKS														
	4151	5000	425	450	203	200	4779	5450	406	344	5185	5884		352
HOLLOW ROD PRESS														
	2955	3009	259	255	202	348	3416	3612	290	307	3706	3919		212
FINISHING - HOLLOW ROD														
	1155	1379	88	100	61	50	1304	1529	111	130	1415	1659		117
OTHER N.E.S.														
	0	0	0	0	0	0	0	0	0	0	0	0		0
MAINTENANCE														
	5893	7119	450	495	815	1184	7158	8798	608	748	7766	9546		436
TOOLROOM														
	2168	2231	0	0	187	180	2355	2411	200	265	2555	2615		173
BLD MAINTENANCE														
	1013	900	0	0	98	18	1111	918	94	78	1205	996		79
WAREHOUSE														
	2674	2065	78	75	139	130	2891	2270	245	192	3137	2515		165
OTHER SERVICES	1853	1940	67	0	284	0	2204	1940	187	164	2391	2105		140

OVERALL ANALYSIS DUMMY DATA : WAGE PAYMENTS (£) SPLIT ONTO VARIABLE AND FIXED

		£		£	£ Shift (F)	£ O/T (V)	Variable	Fixed
Large furnace	(V)	2079		788			2079	270
	Direct hours (F)	270	Indirect	188			788	188
		2349		975	340	50	2867	458
Small furnace	(V)	720		225			720	171
	Direct hours (F)	171	Indirect	75			225	75
		891		300	180	202	945	246
							202	180
							1147	448
Other direct	(V)	1125					1125	675
	(F)	675					180	360
		1800			360	180	1305	1035
Other Indirect	(V)	225					225	
	(F)	225						225
		450						

TOTAL FOUNDRY (Hours paid)	(V)	5162	(F)	1604
Shift all.		-		880
O/T		432		

EXHIBIT 16

dd

E16

	(V)	(F)	Shift (F)	O/T (V)	(V)	(F)
Main Press	2040	400	320	196	2040	400
					196	320
					2236	720
Finishing works (direct)	3300	296				
(indirect)	900	504				
	4200	800	450	-	4200	800
						450
					4200	1250
Hollow rod press	2754	255	259	348	2754	255
					348	259
					3102	514
TOTLABHRFIN	1600	379	100	50	1000	379
					50	100
					1050	479
Maintenance	3519	3600	495	1184	3519	3600
					1184	495
					4703	4095
Toolroom	1380	851	-	180	1380	
					180	
					1560	851
Bld. Main. Warehouse	-	900	-	18	18	900

EXHIBIT 17.

ee

STAGE 4

1. (a) DLHRS LARGE FURNACE = 1000 (HTM $\leq$ 1150) + 0.0 (Yield)

= 1000 + .35 (HTM) + 0.0 (Yield)
HTM $<$ 2000 $<$ 1150

= 1000 + .4 (HTM) + 0.0 (Yield)
HTM $<$ 2000

(b) INDHRS LARGE FURNACE = 253 + .327 (HTM) + 0.0 (Yield)
HTM $<$ 1150

= 253 + .327 (HTM) + 0.0 (Yield)
HTM $<$ 1150 $<$ 2000

= 253 + .327 (HTM) + 0.0 (Yield)
HTM $<$ 2000

2. (a) DLHRS SMALL FURNACE = 100 + 2.2 (Heats to melter) + 0.0. (yield)
HTM $<$ 50

= 100 + 2.2 (HTM) + 0.0 (yield)
HTM $<$ 50 $<$ 175

= 100 + 2.2 (HTM) + 0.0 (yield)
HTM $<$ 175

(b) INDHRS SMALL FURNACE = 150 + 0.8 (HTM) + 0.0 (yield)
HTM $<$ 50

= 150 + 0.8 (HTM) + 0.0 (yield)
HTM $<$ 50 $<$ 150

= 150 + 0.8 (HTM) + 0.0 (yield)
HTM $<$ 150

fβ E17

Foundry

3.(a) DIRECTLAB OTHER $= 900 \quad HTM \leq 1500$

$= 900 + 0.5\,(HTM) \quad HTM \geq 1500$

3.(b) INDIRECTLAB OTHER $= 300 \quad HTM < 1500$

$= 300 + 0.1\,(HTM) \quad HTM \leq 1500$

E17

4. TLHRSMEU = 1200 + 0.8 (billets used) + 0.0 (yield)   Billets used ≤ 1000

= 900 + 1.2 (billets used) + 0.0 (yield)   " " ≥ 1000 ≤ 1500

= 1300 + 0.85 (billets used) + 0.85 (billets used) + 0.0 (yield)   Billets used ≥ 1500

5. DLHRSMFW = 2000 + 0.0 (stamping & turning) + 0.0 (yield)   Stamping & turning < 600

= 370 + 3.25 (stamping and turning) + 0.0 " " " ≥ 600 ≤ 1500

= 870 + 3.50 " " + 0.0 " " " ≥ 1500

6. INDHRSMFW = 2000 + 0.0 (stamping & turning)   " " 600

= 4000 - (370 + 3.25 stamping & turning) + 0.0 (yield)   " " 600 - 900

= 4500 + 1.0 (stamping & turning) - (370 + 3.25 (s & t)   900 - 1300

= 7000 + 1.2 (s & t) - (370 + 3.25 S & t))   1300 - 1500

= 7000 + 1.2 (s & t) - (870 - 3.50 s & t)   1500 +

7. TLABHRPRESS = 300 + 2.5 (Cu billets) + 8.7 (hollow rod billets) + 0.0 yield
CuB < 200
HRb < 100

= 300 + 2.5 (Cu billets + 8.7 (hrb) + 0.0 yield
CuB > 200 < 400
HRb > 100 < 200

= 300 + 2.5 (Cu billets) + 8.7 (hrb) + 0.0 yield
CuB > 400   HRb > 200

99

E17

8. TOTLABHRFIN = 1500 + Ø.Ø (Hollow Rod Output) + 0.0 $Yield_{HR}$ HR Output 100

= 475 + 12.4 (Hollow Road) + 0.0 $Yield_{HR}$ HR Output 7100 140

= 675 + 7.4 (Hollow Rod) + 0.0 $Yield_{HR}$ HR Output 140

9. Other Labour = $\frac{2500}{400}$ x 40

10. Maintenance Labour = 4000 + 2.3 (Mam Press Billets used) + 0.0 (Foundry Billets cut)

+ 0.0 (Stamping & turning) + 0.0 (Hollow Rod Billets & Cu Billets)

+ 0.0 (Hollow Road Output)

11. Toolroom = 1534 + 0.556 (Billets cut Mam press) + 0.0 (Hollow Rod Press Cu Billets & HR Billets used)

+ 0.0 (Hollow Rod Output)

12. Bld Maintenance Labour = 1000

13. Warehouse = 1400 + 1.0(Sales)

14. Other Labour n&s = 0 + 0.0(X) + 0.0(Y)

X = 0, Y = 0

STAGE VI (HOURS) EXHIBIT 18

	Actual	Model Stage 1 Var.	Model Stage 1 Fixed	Model Stage 1 Total	Model Stage 6 Var.	Model Stage 6 Fixed	Model Stage 6 Total	Change Model 1 to 6 Var.	Change Model 1 to 6 Fixed	Change Model 1 to 6 Total
Large Furnace Direct Lab. Hours	2082	2310	300	2610	2310	300	2610	0%	0%	0%
Indirect Lab. Hours	872	1050	250	1300	1050	250	1300	0%	0%	0%
Small Furnace Direct Lab. Hours	1212	800	100	900	800	100	900	0%	0%	0%
Indirect Lab. Hours	240	300	100	400	300	100	400	0%	0%	0%
Other direct	2250	900	1500	2400	900	1500	2400	0%	0%	0%
Indirect	495	300	300	600	300	300	600	0%	0%	0%
Main press Main finishing (Dir.)	4150	4125	370	4495	4425	370	4495	0%	0%	0%
(Indir.)	1260	1125	630	1755	1125	630	1755			
Hollow rod press	3330	3240	300	3540	3240	300	3540			
Hollow rod finishing	1292	1250	474	1724	1250	474	1724			
Maintenance	6692	3910	4000	7910	3910	4000	7910			
Toolroom	2471	945	1534	2479	945	1534	2479			
Bld. Maintenance	1110		1000	1000		1000	1000			
Warehouse	2886	1350	1400	2750	1350	1400	2750			
Other services (NCS)	2748		2300	2300		2300	2300			

EXHIBIT 19

jj

OVERALL ANALYSIS

The model falls nicely into three aspects : energy, labour and overall analysis.

Because we are concerned with costs which show some sort of behaviour to output (i.e. we can examine our control prediction by using output), other are to be dealt with less thoroughly. Nonetheless an overall document will give us a good perspective on cost.

Perhaps the first useful document would be to split labour costs up on the basis of variability and fixed, rather than on a cost area basis. Stage 2 of the Energy analysis has done this for energy consumption. That for labour is analysed on the summary sheet. Less attention is paid to the other costs (depreciation etc.) which are obtained from the budget for a total picture of cost.

kk

£ 18

OCTOBER 1974 - VARIABLE FIXED ANALYSIS

	£ Model Estimate Variable	£ Model Estimate Fixed	£ Model Total	£ Actual	% Variable	Category
	12227	6311	18545	18105	66	Energy
6443		2861	9304		69	Foundry labour
20107		13457	33549		60	Rest
	26550	16318	42853		62	
	38777	22629	61398		63	Labour and Energy
			4000	3585		Electricity Max. DD
*	9833	-	9833	11517		Prodn. Supplies
	9000	-	9000	11277		Maintenance Supplies
Eqn 46	1350	1691	3041	2155		Carriage and Lorries
		16150	16150	15017		Fixed Costs
		10360	10360	- ( )		37% Admin Charges
	20183	28201	48384			(non-policy cost)
TOTAL	58960	50830	109782		54%	(Not group Charge)
	POLICY COSTS					
	600	1550	2150	-		Bld. Materials
		1600	1600	1322		Lab.
		700	700	1001		Canteen
		200	200	70		Surgery
		10000	10000	10447		Deprecent
		500	500	427		Tech. and Develop.
		17640	17640	25969 (with)		63% of Admin Charges
		700	700	581		Lorry Deprecent
	600	32890	33490		39%	
	55960	83780	143272			

APPENDIX : AN ALTERNATE CONVERSION OF LABOUR HOURS INTO MONEY TERMS (SEPARATING BONUS AND HOURLY RATE BONUS)

The division of labour hours and wages is as follows :

Direct wages		Category	Indirect wages	
Wage	Bonus	Large furnace Small furnace	Wage	"Fall-back" bonus
£W	£X	etc.	£Y	£Z

The problem is then to convert the labour hours into money terms.

The following is suggested :

Direct		Indirect	
Wage per hour	Bonus per billet cut	Wage per hour	"Fall-back" bonus per hour

Thus, for example, we know the weight of billets cut. We can use our equations to derive the direct hours that should be worked (X DHRS) and indirect (Y INDHRS)

Direct hours computation

X hours x wage rate + Z (bonus rate) x billets cut = £Direct wages

Indirect hours

Y hours x wage rate + W (fall-back) x hours = £Indirect wages

EXHIBIT ONE shows an example of how this would work.

Thus, we use actual rates per hour, and actual bonus rates to convert labour hours into £. Inflation is no problem as we can compare the actual rates and bonuses for each time period. The shift allowance is estimated as being £X for given levels of output adjusted up or down when output falls outside the limits. Again, no problem for deflating.

Little work is required to put the system shown in the appendix into practice : we need to know the wage rates in the given areas, bonus etc. A problem with indirect labour is whether or not indirect wages and the "fall-back" bonus can best be put into hour equivalents.

When, rather than if, the appendix one style of prediction is used the "rates" are easy to calculate roughly.

mm

A short worked example follows.

Suppose there are six men on a machine (a "cost centre"), 4 operatives, 1 charge-hands, then

1W	rate per hour (direct)	(bonus)	rate per hour (indirect)	
4	0.80	£.150 per billet cut	0.80	operative
1	0.95	£.250	0.95	charge-hand
rate for centre (weighted average)	0.83	0.17	0.83	

The rate we use is simply a weighted average of the labour rates.

The shift and overtime methods are as before.

A3.

WA 1 APPEND

WAGE ANALYSIS : OCTOBER 1974 OUTPUT

ACTUAL

	DIRECT WAGES			PREDICTED HOURS		INDIRECT WAGES			
Total £	£ Wage	Rate	Bonus (£.150 per billet cut)	Hrs.		Hrs.	Indirect wage	Fall-back bonus	TOTAL
2403	2088	.8	315	2610	Large furnace Direct hours				
					Indirect hours	1300	.80	.05	1105
690	630	.7	60 (£.3 per billet cut)	900	Small furnace Direct hours				
					Indirect hours	1400	.80	.05	340
1920	1920	.8	-	2400	Other direct				
					Other indirect	600	.80	.05	480
£5013	£4638		£375	5910 hrs.	Foundry	2300 hrs.			£1925

Rates (Index) October 1972 Base Year

1831	210	Large furnace 0.70 (114) direct, 75 (114) ind., .10 bonus (150)	969
543	40	Small " 0.60 (116) " .6 (133) " .10 " (150)	256
1684		Other direct 0.70 (114)	
		Other indirect 0.70 (114)	421
£4058	£250	AT CONSTANT PRICES	£1646

Shift allowance Oct. '72 £15 per person per month (within 'hormal' limits)
Oct. '74 £20 " " " "
Index 133

Overtime rate : Better to leave inflated or use direct wage rate index. Size does not justify anything more complex.

NOTE : RATES ARE FOR DEMONSTRATION ONLY.

WM

SOME EXAMPLES OF REGRESSIONS SHOWING COST BEHAVIOUR RELATIONSHIPS

As over 250 regressions in all were attempted it would be fool-hardy to reprint all the results here. Therefore, it has been decided to indicate the kind of results found by reference to five examples. These examples are typical, they are not the best in any sense, but they represent the kind of results obtained.

1. Gas Consumption for Billet Heating

LPG (tons) = 6.17 + 0.01845 (Tons Billets)

R^2 = .90

Confidence Limits: Slope 0.0144 to 0.02245

Intercept 0.7 to 11.6

2. Space Heating (Gallons of oil used v. Ambient Temperature)

log (galls. used) = log 5.05 - 1.82 log (Temp.)

R^2 = 62%

3. Direct Lab. Hours (Y) High Bay v. Heats to Melters (X) (Step Function Format)

$Y_1 = -553 + 4.13 X$ $\quad X > 2000.$ $R^2 = 0.9$, $N_1 = 17$

$Y_2 = 4825 + 0.9 X$ $\quad X < 2000.$ $R^2 = 0.68$, $N_2 = 13$

4. A complex multiple regression on energy consumption in the Hollow Mill against the billets input of copper and brass, and their yields gave:

$$E = 6.93 + \underset{(7.49)}{0.33\,Cu.} + \underset{(0.34)}{0.07\,YCu.} + \underset{(4.71)}{0.52\,Br.} - \underset{(1.79)}{1.02\,YBr.}$$

R^2 = .78

4. (Continued)

where Cu. = Copper Billets input, Br. = Brass Billets input and Y is the respective yield.

5. Electricity used in the large extrusion press against billet input.

$E = 56.18x + 5019$ $R^2 = .94$

Confidence interval: (Slope) 49.02 to 65.79
significant from 0

(Intercept) - 7823 to 18,033
not significant from 0

N.B. A full list of the computer regression results is available at I.H.D. University of Aston.

CHAPTER SIX

"Speak in French when you can't think of the English for anything."

Lewis Caroll, 1832 - 1898

(C. L. Dodgson)

This chapter indicates briefly the factors and information from a European country which a cost modeller might find helpful in his U.K. work.

CHAPTER SIX

GERMANY: A brief introduction to factors and information which might be of interest to the area of cost modelling.

6.1 Introduction

When considering the relevance (in the general financial area) of overseas investigations to U.K. firms, one can usefully sub-divide U.K. firms into three groups.

(i) Those who have direct links with Europe and overseas via subsidiary companies.

(ii) Those who have competitors based in Europe and overseas.

(iii) Those who operate in the U.K. alone.

I would say that an insight, in brief, into selected aspects of finance in, for example, Germany is a good experience not just for the first but equally for all three categories of firms.

The relevance to the first group is obvious. In practice, more problems occur in co-ordinating the activities of foreign companies so that they contribute to the group aims and objectives, than would do so with a similar U.K. subsidiary: the emphasis on a full range of, e.g., alloys in Germany, and of punctuality in delivery times can cause problems when looking at group cost objectives, to take one example.

The second group of firms, clearly, need to be aware of cost differences between their foreign competitors and themselves. A simple example is an awareness of the extent to which recent restrictions on immigrant labour in Germany and increased associated labour costs (holiday pay, etc.) is likely to affect mechanisation and the emphasis on capital intensive products in Germany.

For the third group of firms, the benefit is indirect: one becomes aware that certain aspects of industry which are taken as given are constant not in the U.K., but in certain regions only.

An appreciation of the vast differences that exist in efficiency outlook, etc. abroad make it easier to visualise, for example, that the labour control procedures that one would need in a small aluminium works in an isolated site in Scotland, where ex-mining labour was used, will differ from those in a heavily industrialised Midland area. A second example in the Delta Group is to see the effect that the region and environment play in the success and organisation of the Ipswich and (now defunct) Winsford factories, and a cost modeller must be aware of these differences if he is to aid in cost control and profit planning and not simply produce an arid mass of numbers. In sum, an experience abroad helps one to understand the U.K. better than if one has never ventured outside. The number of instances of firms who find unforeseen problems when expanding into new factory locations suggests that such a glimpse at Germany could be a very cheap form of insurance.

6.2 Cost Structure in Germany

In the previous chapters (3 and 4 in particular) comment was passed concerning which costs in a factory situation would be of concern to a cost modeller and which not.

In a non-ferrous metal firm, energy and labour were considered to be two crucial elements dominating those costs which are within the ambit of a factory to control.

In Germany the situation is not radically different, in that these two costs are again predominant. What is of interest is the fact that production supplies, dies supplies and maintenance effort would appear to be more interesting to a cost modeller than their U.K. counterpart. In the previous chapters on the U.K., whilst maintenance costs, etc. were not insignificant, the amount of time a cost modeller might spend to achieve meaningful results in terms of information, it was suggested, was prohibitive. For a U.K. company considering taking over a German firm the same effort is likely to bring more rewards. On die cost information, for example, the low die stock holding level, and information on cost centres using respective dies, and the turn round of their usage, suggests that it might well be possible to determine die costs at various activity levels.

For maintenance costing a dilemma existed for the author in attempting to identify whether the knowledge of maintenance costs arose because the firm under consideration was German or because of the large physical nature of the site and maintenance effort. In practice the probable result is a mixture of the two. The physical situation of one of the German factory sites in question (which resembled IMI site at Witton) gave rise to a systematic maintenance effort on a large scale service function basis. This being so, the relatively high costs involved, necessitated that maintenance personnel investigate in what departments and to what extent maintenance effort was necessary, and the cause of such maintenance effort. For example, was the cause of the burning out of a 75 KW motor because the motor was too low powered, or a temporary repair had been made on spec., or because the machine has been worn out by utilisation for production? The German firm seem to be well on the way to differentiating between various types of maintenance costs. Thus, as explained earlier, once separated, those costs which are occasioned by product process can be examined to investigate the possibility of a cost-activity relationship. A good deal of work in Germany would still be necessary, for example, on considering which time period caused which cost, in order for maintenance to be incorporated into a cost model.

6.3 Cost Behaviour Itself. Differences in Labour and Energy Cost Behaviour in Germany and the U.K.

Having established that in the main, the type of costs likely to be found are similar with, again, energy and labour predominant in a non-ferrous metal industry, it should not be assumed that the energy and labour behaviour one perceives is the same in the make-up and shape.

The intention here is not to explain the differences in detail, this is done in the appendix, but to draw on the information in order to highlight what would be of interest to a cost modeller where, say, part of the components were from a subsidiary overseas, or where a financial planning problem existed concerning the switching, say, of the Cavalier or Pinto from abroad to the U.K. Thus, nowadays, in the case of production being rationalised, thinking of the U.K. as an entity may be insufficient: a cost modeller may well need to be aware of the differences in cost behaviour and cost structure overseas.

As is indicated in the appendix in Germany, the "hidden" costs of labour (we would say associated) at roughly 70% of the paid labour cost alter the view of a cost modeller with respect to the treatment of holiday pay and the various types of pension and insurance contributions. Usually in the U.K. these costs are separated from labour costs and they are treated summarily as fixed costs. At the moment, the change in government attitudes to employer contributions has awakened an interest in a more systematic treatment, and there is no doubt that a cost modeller considering the U.K. in the future, or costs incurred abroad will need to adopt something like the approach taken in the thesis.

As is stated in the appendix, the charging method for electricity in Germany demands a different approach from the cost modeller to that in use under the English (not necessarily Scottish) system, since in Germany a contract is secret and individually struck between "Land" monopolist and factory or firm. This being so, the cost modeller must be aware of the cost of the factory producing its own electricity instead of having the energy supplied by the monopolist as this will be key information in striking the lowest price per KWH possible.

Very commonly in Germany the tariff is split into two aspects. Quite often a factory will consume on a stable firm basis x KWH 24 hours per day on furnace heating, billet muffle, etc. and will further incur a charge based on its less steady, unfirm factory consumption (e.g. office heating, lighting, factory usage varying with time) and a penalty tariff based on the ratio of the unfirm, firm ratio.

In Germany it is possible for a cost modeller to charge each cost centre in turn with firm, unfirm and penalty tariffs. Whilst theoretically the penalty tariff based on the total factory unfirm/firm rates may not be the sum of these cost centres charges, in practice, one finds in Germany that the difference between these figures may not be too worrying providing that there are no very abnormal usage configurations on key cost centres. If there are then it is the cost modeller's responsibility to investigate them.

The upshot is that in Germany it is possible to incorporate both the purely variable electricity charge and the penalty charge into a cost model so that product costs or departmental costs can be examined in the light of total electricity expenditure per activity level achieved.

In the U.K. a cost modeller is likely to find it almost impossible to incorporate a KVA charge into an activity related cost model. The reason is that the KVA charge is based on a factory maximum half-hour consumption and there is no reason why examining each cost centre's maximum consumption should give results reconcilable to the total factory KVA charge. Thus in the U.K. the cost modeller is going to have to concentrate on the variable KWH part of the tariff, leaving the KVA charge to a separate and complex treatment. In Germany, on the other hand, there is no real reason, time permitting, why the firm, unfirm and penalty rates could not be calculated at a cost centre level.

In the U.K. the apportionmentof a KVA charge to a cost centre base is (almost) theoretically invalid because the charge is based on a total usage at one point in time.

6.4 The Actual Cost Configuration of Labour and Energy Cost

From the presentation of typical labour and energy graphs in the appendix, a typical German factory, instanced by a non-ferrous metal example, shows a tendency to be much more like a linear variable cost than the U.K. equivalent. The U.K. curves exhibit much more of a step function approach, with a tendency to a fixed segment at low activity levels. A more detailed examination is given in the appendix.

6.5 The Information Requirement in Germany

German firms tend to be rather more market orientated than their English counterparts. Thus financial information in Germany concentrates its attention more on a basis of deciding whether an order will cover contribution, yield a profit on all costs, etc. or not, i.e. the marketing end of cost information, rather than the cost information for control - the production end of cost information. This is readily seen by reading in the appendix the nature of German competition.

Thus the cost modeller in a German environment is more likely to be called upon to assess the nature and variability of cost behaviour for profit planning via projected sales revenue rather than control.

6.6 The Effects of Production Methods on Cost Modelling

A factor at first seemingly unrelated to a cost modeller stems from the fact that a German firm will tend to offer a wider range of sizes and alloys from stock than an equivalent English firm. More simply, one would expect a German firm, because of its marketing set up, to have to provide a more extensive range of product groups than a U.K. firm. The emphasis for a German firm tends to be on accepting an order and then producing it, rather than on considering whether it should be produced at all. For the cost modeller the implication is that production stages will be more complex because of the higher number of "specials" which will tend to be produced. Also, German industry, if the non-ferrous example is typical, does not load one or more factories with high output, straighforward groups, and the rest with low output high complex groupS but allows most factories to produce most products.

For the cost modeller two difficulties emerge. Because the product stages are less distinct and production flow charts would be more complex, the cost modeller will have to make more approximations to formulate e.g. standard product flow (i.e. the balance between a model capable of being practical and accurate yet not unwieldy) or value added per stage, etc. Also the task of apportioning onto product groups the costs of joint process variable costs is likely to be difficult and the methods explained in Chapter 4 will need to be skillfully applied.

One factor will, however, make the task of the cost modeller rather easier and that is the ease with which labour is transferred from one cost centre to another, as is explained in the appendix. One reason why the U.K. cost modeller has a difficult task is that costs have to be considered on a cost centre basis before meaningful cost behaviour relationships can be discovered. For example, where two extrusion presses operate at one factory, it would not be safe to take the total labour expended on both presses (even if products were similar) because one would not be convinced of the safety of taking total labour used as a homogeneous cost over two production centres. In Germany, as is explained in the appendix, the ease with which labour is moved between cost centres makes a more aggregative cost area a possible source of deriving cost behaviour relationships. The German cost modeller may be happier to deal with costs on a more aggregative basis because the flexibility of certain costs are higher between cost centres and the actual behaviour (as explained previously and in the appendix) is more straightforward.

6.7 Certain Factors Emphasising the Need for a Cost Modeller to have a Wider Appreciation of his Environment

Despite the reluctant decision to append general discussions, four elements of Germany of relevance here need to be mentioned because they impinge significantly on to the method and emphasis and approach a cost modeller will take to provide information for profit planning and control.

Taxation

In Chapter 3, an example was given as to how the modeller might use cost information for investment appraisal purposes. As the explanation of taxation in the appendix demonstrates, a cost modeller will be called upon to give quantitative information on investment decisions, both gross and net of tax. It is therefore patently obvious that he must be aware of tax differences and their effect on financial decisions.

Stock

Both because German industry orients itself towards the "volume" objectives of a business (i.e. high volume emphasis rather than high profitability but low volume) and because of the more extensive product range vis-a-vis its English equivalent and because of the nature of the German buying decision, stock levels in a German factory at each production stage are likely to be very much higher (perhaps 2 - 2½ times from my experience) than their U.K. counterparts. Therefore, in Germany a cost modeller would need to devote more time to the correct valuation and significance of work-in-progress than his English counterpart, although in practice in Germany this emphasis is not evident - although it ought to be the case.

Inflation

The comparison of interest rates in the U.K. and Germany is a very interesting one, as is shown in the appendix. For the cost modeller in the U.K. it is of extreme importance, not only to provide accurate indices to bring cost information onto a common value base, but also to provide valuable information as to the relative price changes of, say, alternative fuels over time. In Germany because the inflation rate is only about half that of the U.K. the emphasis which needs to be placed on bringing data onto a common money base is correspondingly less.

Unionism

The difference in union structure between the U.K. and Germany is very marked. Germany union organisation mirrors its respective industries, e.g. a metal union will be organised to encompass all employees engaged in metal processing. In addition its organisation and deployment of funds are more akin to the philosophy of a firm than its U.K. counterpart. Hence one might suggest that it would be easier for firms and unions in Germany to establish common ground for discussion since both have had experience and similar objectives for the deployment of financial funds. These aspects are more fully dealt with in the appendix.

6.8 Conclusions

This chapter has indicated that a cost modeller needs to have a wider appreciation of the industrial situation than simply that of the U.K., because of the increased complexity of the industrial situation. A knowledge of foreign cost structure and even union systems is helpful.

For example, the decision to produce Ford Capris abroad entails both a knowledge of cost behaviour in the respective countries (the science of modelling) and a knowledge of how union systems etc. (see appendix) are likely to affect both the emphasis of the model and the interpretation of the results.

German business ideas and the importance attached to certain aspects of business are different to that which we would find in the U.K. and this results in the alteration of the role of a cost modeller where he is considering a German based activity. Where knowledge is involved, as many products require, of foreign methods of production and cost control, where these may be one component of the final cost, a cost modeller must be aware of international considerations affecting financial decisions. For example, the aquisition of a French subsidiary company may well involve the analysis of the relative merits of rationalising production between the foreign and host factory - clearly a cost modeller must be cognisant of likely points requiring consideration in such an acquisition. The general points raised in 6.7 can be of use to a cost modeller in terms of the general environment in which he operates. For example, the way that an industry union is organised differs markedly between firms, e.g. British Leyland has to negotiate with over twice as many as its Ford counterparts and this can affect the type of cost control procedures (and more particularly profit planning decisions) which are feasible.

In the future, we are going to find that the degree of integration between E.E.C. members is likely to increase and that cost control and profit planning will need to be considered on a European basis and not on the U.K. one. The Ford Pinto and Capri are two examples which illustrate the likely trends of the future which the cost modeller must be ready to appreciate.

CHAPTER SEVEN REVIEW OF THE LITERATURE

'Education has produced a vast population able to read but unable to distinguish what is worth reading.

G. M. Trevelyan

English Social History - Chapt. 18

This Chapter surveys the relevant literature in the area, its relative merits and the subject areas where the works were of use.

CHAPTER SEVEN

7.1 Literature Review - Schema

Schema

1. What is a Model?
2. Equation system more suitable for our type of problem - what theories help us?
3. What sort of equations O.R., L.P. have been used in general, financial and cost problems, and how successful are they?
4. From 3. our success rests on what we want our model to do - why do we need a model?
5. Has anyone been of help in suggesting problems that may arise, not because of the mathematical difficulties but because it is a cost model?
6. What are the implications of these problems for application in industry?
7. Metal considerations: setting the industrial environment within which a model is to operate.
8. Miscellaneous.

LITERATURE — REVIEW

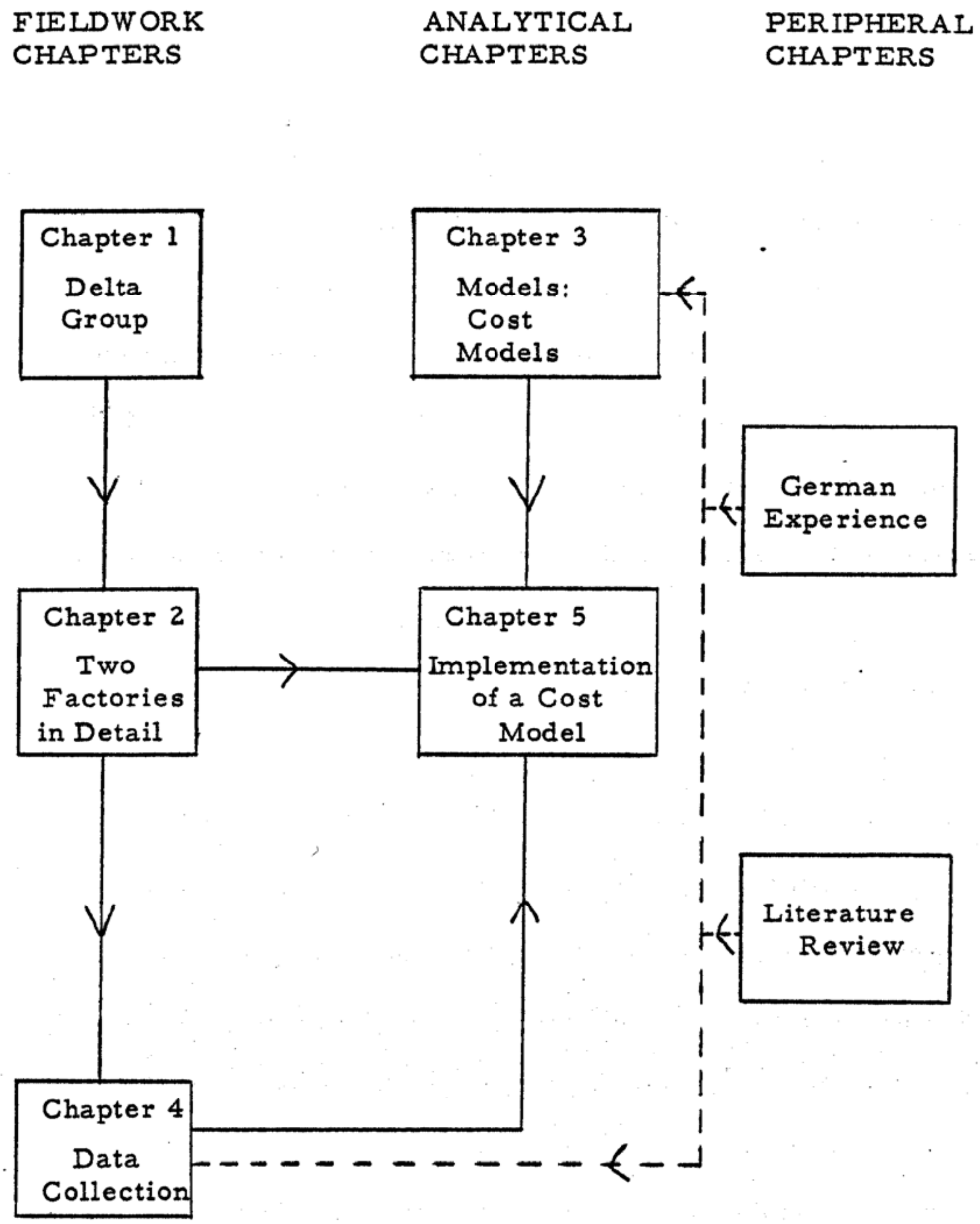
Schema	Main Area	Subsidiary Area	Name	Title of Article	Ref. No.	Country	Nature of Article	Comment
1	What is a Model	What are its basic principles	Rivett	Modelling	(1)	UK	Basic Principles of Modelling	Good basic ideas
		Does any subject area shed light on what type might be used	Ferguson C. E.	MicroEconomic Analysis	(2)	US	Goes through the basic nature of traditional cost demand functions and production functions such as CES and Cobb Douglas	Thorough but pedestrian. "U" cost curves and CES and CD production functions do not normally fit reality.
2	What does Economic Theory suggest?	If an equation system is suitable, are there any problems in applying it?	Johnston	Statistical Cost Analysis	(4)	US		
			Heathfield D. F.	Production Functions	(55)	UK	Disproved "U" shaped Cost Curves show why CES and CD functions may not work.	Shows practical reality to be a difficult area
		This suggests that we cannot use one derived equation from economic theory. We need to use many structured equations - a model	Chiang or Ball & Drake	Demand for Capital Goods	(3)	UK	Principles of "Aufban" of model building	Good piece of work
3	What progress has been made in modelling?	Are there any difficulties in equation estimation?	Johnston	Econometric Methods	(5)	US	Standard book on equation estimation	Good book
			Kushner	Estimation Bias in Measurement	(38)	USA	As title	"U" costs are irrelevant anyway
	Can OR be a useful aid for Management Control		Rivett & Russel	Managers Guide to OR	(17)	UK	An interesting discussion of the use of OR	
			Hobel and Hamma	Models in Management	(49)		As title	Good discussion
	Can OR and accountancy help in financial problems		Fox	Use of OR in Management Accountancy	(7)	USA	Market orientated	
			Mepham	Use of Models in Accountancy	(10)	USA	Dialogue on use of models	Good discussion
			Borst	About Mathematical Models	(6)	USA	How a finance model was set up (Inland Steel)	Somewhat simplistic
		Are there any guidelines in cost models		ICMA: Cost Models	(34)		Shows how cost Model can be of use	
4	What approaches have been adopted in models?	Linear programme, simulation, equation system	Ijiri	Leontief method for Cost Analysis	(39)	USA		Assumed homogeneity and linearity of costs.
			Leininger	Stochastic Process Cost Models	(11)	USA	Shows how probability can be used in cost models: (if you could find the data)	Limited value, academic and boring

Schema	Main Area	Subsidiary Area	Name	Title of Article	Ref. No.	Country	Nature of Article	Comment
	What problems arise (and what answers are there) with respect to specific areas, in setting up and implementing a model:							
		(a) Generally - identification problem	Common	The Clawson Demand Curve	(27)	UK	Problems of underidentified models	Good criticism of Clawsonian method
		- data problems	Bubb Hussey & Smith	How Accurate are our figures	(32)	UK	Shows the necessity of an accurate data base	Good practical commentary
		- information	Staats	Information needs in an era of change	(19)	USA	as left - Examines at the end how best MIS may be best utilised by accountants	End of the article of passing relevance
		- presentation	Beyer	A positive look at Management Information	(18)	USA	Links MIS to data flow	Illustrates how one can use data
			Kelvie & Sinclair	New Techniques for breakeven analysis	(12)	USA	More or less tarted-up presentation	
		(b) Financial Models:	Lahrii	An Economic Model of a Box Co.	(21)	India	O. R. example, bit academic	application?
			Anderson	Financial Modelling	(20)	Canada	Simplistic view	
		(c) Cost Models	Singh & Law	Cost Model for Sand Reclamation	(22)	UK	Good discussion of use but limited to investment appraisal rather than cost control	
			Araten & Dickman	OR Cost Model	(28)	UK	Typical OR stuff	
			Summers	Cost Estimation of Prediction of Weapons Cost	(25)	USA	Very applied customer area	Spoilt by being so specific
			Doney & Gelb	Estimating Product Costs in a Machine Shop	(14)	USA	Fairly readable expose	Not obviously generally applicable. Longwinded
			Hallbauer	How LP Regression Analysis helped cost standards	(23)	USA	Accent rather on mathematical derivation and not the rationale	Did it?
	Why do we need cost models anyway? could we not use our traditional accounting methods		Jopplin and Pattilo	Responsibility Reporting	(53))	USA	Accent on information not paperchase.	Useful
				Models use in Cost Cutting	(52))		As title: gives rationale for models such as mine	Discussions
			McRae	How Mathematical Concepts are useful	(43))		Mathematical concepts for non mathematicians	Standard stuff

Schema	Main Area	Subsidiary Area	Name	Area or Title of Article	Ref. No.	Country	Nature of Article	Comment
5 6	With specific regard to cost models, what attempts have been made to solve these problems, which could be of use to cost model builders		Crowningshield & Battista	How Ineffective Information and Poor Cost Information make cost reduction difficult	(35)	US	As title. 2 catalogue how poor cost information and responsibility areas made life difficult	Verbose, but interesting
		(a) Generally	Deniski	Criticism of Traditional Cost Variance Model	(37)	US	Examines the weaknesses of variances information for cost control	A lot of criticism not so much on improvement
			McClenon	Cost finding through Multiple Regression	(24)	Rand USA		
			Smith & Bubb	Cost Apportionment Via Multiple Regression	(33)	UK		Readable
		(b) Maintenance	Hremish	Maintenance Cost Control	(30)	USA	Good guide to the methods	A difficult area in practice.
		(c) Definition and aims	Kilvington	ICMA	(31)	UK	Shows up the difference	
		(d) Direct costing controversy	Wells	To allocate Overheads or not?	(29)	Australia	Points out that it depends on purpose one has in mind.	
			Logan	Direct Costing Controversy	(40)	USA	Shows how fixed cost apportionment can mask information for cost control.	
		(e) Planned production problems	Arcus and Pietsch	Planned Production Performance and Product Cost Controversy	(16)	USA	Rather general discussion, examples not clearly illustrative.	
		(f) Lack of standardisation of cost allocation	Manz and Skousen	(Survey of firms) Lack of Standardisation of Cost Allocation	(13)	USA	Alarming lack of agreed methods of cost allocation	Good
		Lack of account taken of Product mix variation	Anderson				"Macro" financial equation system. Not a cost or production cost estimation system.	
		(g) Problem of what you examine	Powell	Third Dimension of Management Accounting	(19)	UK	Theory only. Typical business school output.	Stick to getting the first 2 dimensions right.
	Can we afford to ignore personnel for whom the cost model is intended		Broster	Economics and the Accountancy?	(48)	UK	Good title, but not much else.	
			Bishop	The role of the A Accountant	(42)	UK	Shows the role of the modern finance man	Excellent
			Chenhall	Modelling Implications for the Accountant	(50)	Australia	- " -	Good
7			Bailey	Metallurgy	(44)	UK	Obviously necessary for the technical environment of the research.	
			Bailey	Foundry Practice	(45)	UK		
				Extrusion Techniques	(46)	UK		
				Konzepte über Extrusion	(47)	Germany		
8	Miscellany: Electricity payment and charging		Dixie	The Electricity system of charging - how it works.	(11)	UK	Readable examples	Good
			Sony Co.	Explanation of Dolby & DNL System	(36)		Readable account	

SUMMARY OF THESIS CONTENTS

THEIR INTERCONNECTION



CHAPTER EIGHT: SUMMARY

8.1 Background to the Research

In terms of general industrial activity, the years 1974 and 1975 demonstrated extremes of variation in terms of sales and output.

As far as the non-ferrous metal industry was concerned, the 1974 boom was sufficiently high for some firms to adopt its output level as 'the standard' of full capacity: future production being specified as x% of the 1974 level.

1975, in stark contrast,was the year of the recession.

As far as cost control was concerned, the net effect of two successive years of such extreme fluctuations was to reveal the weaknesses in traditional cost control and profit planning procedures. On the one hand an obvious danger lay in standard cost over-estimating actual costs at high 1974 activity levels, and, on the other hand, in the difficulty of reducing costs as the much lower 1975 activity levels became normal. It also became clear that some costs which had always been treated as fixed, just had to become variable (as at least one General Manager ruefully commented), whilst other costs which had been considered as at least partly variable appeared to be immutable. What then had gone wrong with our control procedures?

The objective assessment of the financial performance of firms using traditional control procedures had not been effective in part because the standards were hampered in their objectivity by the 'inflation' factor. Money could no longer be taken as a constant measure of worth with inflation rates of 12, 15 and 20% rife. Their accuracy had also been brought into question because the assumptions of total variability, with particular emphasis on labour and energy cost usage, appeared to be too crude an approximation to facilitate accurate cost control. This situation was exacerbated where cost behaviour was considered on a factory and not cost centre basis.

To summarise the comments made above, we can say that the sheer amount of variable changes which needed to be considered could not be assimilated into the traditional cost control procedures. It was, therefore, felt that someone outside the system, not having responsibilities for day to day operations, and in this sense disinterested in the current system should examine what was lacking and what improvement could be made.

8.2 The Approach Taken

Since, from the previous section it was clear that the budgetary control system in operation was not able to cope, a new procedure needed to be adopted which would be able to cope with the number of changing variables which needed to be considered. Several factors appeared of paramount importance in our choice:

The inflation rate, the precise knowledge of cost behaviour, the degree of disaggregation of costs under consideration, changing technical factors such as metal yield, the role of associated labour costs such as holiday pay and insurance contributions had somehow to be incorporated into the new procedure since the major failing had been that these factors could not simultaneously be considered in a traditional budget context.

The number of variables involved in such decisions, to take one illustration, is the standard labour cost of producing x tons of billets, a typical cost control question, or the likely effect in terms of labour hours of producing only large diameter billets, or what would be our labour cost were pension schemes contributions to double. Typical profit planning questions could not hope to be answered unless some system could be devised which was flexible enought to have as input these sorts of variables, and be capable of iteration. For example, one would want to see the effec' on total labour costs of different production methods in a foundry. This cannot [illegible] be done with a budget which can only with difficulty be amended to take account of changing conditions.

Therefore, the preceding paragraph has suggested that a new system should incorporate flexibility to changing circumstances as a major requirement. This suggests that some sort of cost model might be appropriate, because only a model has the facility to incorporate so many variables as inputs and be capable of iteration to take account of different circumstances.

Although two sorts of model might have been appropriate earlier work had helped us to postulate the form the model would take and the areas it would investigate. A prediction model (e.g. simulation model) might be useful in some areas such as marketing, but here we needed a structural equation model to assess the exact impact of one variable change on the others.

In sum, a model consisting of structural equations emphasising the relationships between key variables such as labour and energy and the appropriate output variables to which they related was felt to be of extreme importance.

The method of selecting appropriate equations was dependent on the type of relationship considered. Where the melting of metal in the furnaces was considered, for example, the physics of the process suggested that a relationship between heats to melters and electricity used should exist. For many of the labour relationships the knowledge of the industrial situation suggested that certain elements of labour should show a relationship to specified cost centre outputs. Occasionally a relationship was inappropriate because of a misunderstanding of the physics involved. For example, in the case of space heating it was clear that, from engineering knowledge, a relationship between space heating and ambient temperature ought to be hyperbolic in nature.

8.3 Verification and Validation of Data

It is difficult to establish whether one collects data before a model is postulated, in which case it is uncertain how one can determine precisely what data is to be collected, or whether one postulates a model first, only then to discover that the data required is unavailable. In this case, model and data development and organisation were undertaken at the same time to ensure that only relevant data was collected, and that the model remained practical.

After the relevant data had been collected and its accuracy checked as indicated earlier in the thesis, it was then used to obtain statistical relationships between relevant variables. The fact that the data obtained had been felt to be of good adequacy and accuracy indicated that there was a good possibility of finding statistically meaningful relationships between key variables, since in addition the output variable to which the key cost variables related had been correctly found and the form of the relationship correctly assessed.

To take a typical example, that of Liquid Propane Gas consumption against billets heated showed that:

LPG (tons) = 6.17 + 0.018447 (Tons Billets Heated)

$R^2 = 0.9$ where R is an indication of the goodness of fit.

95% Confidence Limits: Slope = 0.0144 to 0.02245
Intercept = 0.7 to 11.6

Because of the care which had gone into the selection of suitable equations, the high regression values in terms of R^2 usually reflected this care. Where this was not so, it was often the case that the equation had been misspecified. For example, the space heating equation was found to be hyperbolic in form which confirmed the advice given by heating engineers, and that a linear equation was unlikely to be helpful in explaining cost behaviour.

$$\text{Log (space heating galls. used)} = \text{Log } 5.05 - 1.82 \text{ Log (Temp.)}$$

$$R^2 = 0.62$$

This part of the project also enabled us to focus our attention on those cost elements whose behaviour with respect to some variable (not necessarily output) showed a stable relationship. An activity based model would be unlikely to help cost control in the area of maintenance costing for example, if this were a policy cost, since no stable cost behaviour pattern would be likely to be established.

8.4 Summary of Recommendations

The suggestions and recommendations made are of two sorts, those which are concerned with the methodology and those of specific interest to the firm.

8.4.1 Methodology

(a) Organisation of data collection

One of the first recommendations that is to be made is to rationalise the collection of data so as to maximise the impact of the data in terms of the information provided. This is essential as it emphasises the importance of viewing data collection as the usage of scarce resources. In practice, it is essential to achieve a compromise between arranging all of the data necessary for formulating a model on the one hand, and having insufficient data for a complex model because of the costs of data collection on the other. A balance needs to be struck with good benefit being obtained in terms of information made possible by logically thought out data collection systems.

(b) Concentration on Key Cost Variables

A second requirement, to focus our attention on those variables the control of which we are to influence by our work. It is ridiculous to formulate any system covering all aspects if many of the areas we examine are not amenable to the purposes we propose. In the area of cost control and profit planning certain areas such as maintenance costing though a fine area for modelling per se, must methodologically speaking be reduced in importance. This we must do as the information we derive will not have the same impact as would be the case had we concentrated our attention on costs such as labour and energy where the results of the model in terms of information for control would have had a greater impact.

(c) The Signfiicance of Non-linear Cost Behaviour

An important feature found in practice in innumerable examples is the fact that cost behaviour can no longer be considered as linear (often assumed to be totally variable or totally fixed) but often exhibits step function tendencies which need to be mirrored in our standards.

(d) Degree of Accuracy of the Model

Methodologically speaking, the precision of our estimates depends upon the element we take as our cost behaviour base unit. For example, one could take the factory as a whole as a cost centre but it is unlikely to yield cost behaviour relationships accurate enough to permit the kinds of cost control and profit planning procedures we require. Therefore, we must look at those levels of cost (e.g. a cost centre) which is a small part of the factory process where stable meaningful cost relationships can be established.

(e) Consideration of the Degree of Model Complexity

Finally, one must consider the flexibility of the model results with respect to changing circumstances. In the first place a relatively simple model formulation cannot consider the changes in variables which for simplicity have been assumed to be immutable. The more flexible a model is, the more complex it must be, and one has been conscious throughout my research of the need not to be caught out by being unable to provide a framework for an answer to questions such as: If yield alters, what will be the effect on certain variables? Yet one must not go to the extent of a model so complex that only the modeller could ever interpret it.
The balance struck is about right - basic simplicity but with logically thought out possibilities for flexibility in different circumstances.

8.4.2 The Firm

The recommendations for the firms in many cases mirror the methodological considerations made in the previous subsection. Only a few are given here since this is a summary chapter.

(f) Data Collection

Data collection must be organised in order to facilitate good information being available from extensive rather than exhaustive data sources. At one factory under consideration it was recommended that the organisation of data collection be rationalised by the appointing of an Information Officer responsible for disseminating managerial information from the various production, finance and technical services areas. At a rather more detailed level the author recommended the necessity of verifying just how far key usages relating to cost centres were actually derived via apportionment from meter readings rather than being, as is often assumed, to be 100% allocated. The research established the necessity of examining only certain costs, that is the necessity of focussing our attention on to those costs where an activity based relationship would be found and be helpful for control procedures. In this case, labour and energy costs in particular needed to be examined at a cost centre level because only at this level were cost behaviour relationships found to be stable and meaningful. In sum, it was felt that by examining in greater detail those costs which were capable of control via activity related model, in our case energy and labour, the most mileage could be gained per unit of effort and time.

For the firm, crucial points to have emerged are the step function relationships which have been established. It was felt that the use of a model, and indeed the on site work enabled us to allow for the alteration of inflation rate, metal yield, different labour efficiencies in various cost centres, to instance three crucial areas which would affect the efficiency of our cost control procedure and accuracy of our profit planning forecasts. One particular instance is the recommendation that one should treat associated labour costs such as holiday pay as an integral part of the labour burden and be able to assess this cost as partly variable pro rata with the traditional labour cost calculation.

It has been demonstrated that the use of scientific method for the investigation of, say, joint product cost absorption rates (e.g. multiple regression) could be a very time saving method of computation which had not been considered before in the factories to my knowledge and which I would recommend should be used more widely.

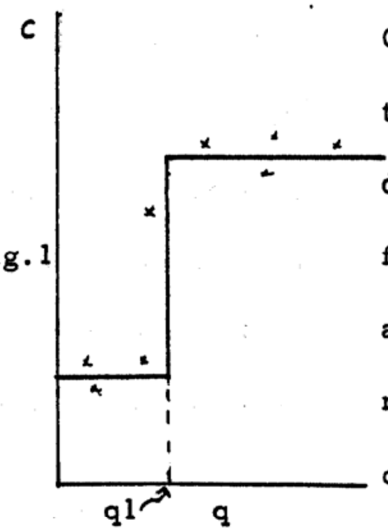
8.5 Future Work

As has been done with Section 8.4, this section can be subdivided into the mathematical area and operation aspects which need to be done.

8.5.1 Mathematical Areas

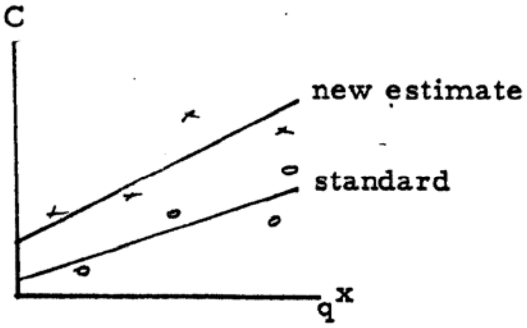
On the mathematical side, the development of certain techniques would have aided the analysis in the later stagesof the model:

Fig.1

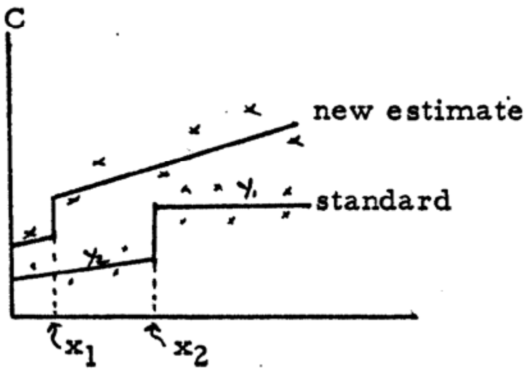


One difficulty is to estimate the value of q1 which best describes the step function, from the observations available. Because R^2 is not defined as an estimate of goodness of fit until the value of q1 is determined, an interative technique which examines the change in the value of the R^2 in both segments of the step function as the value of q1 changes would be useful. The author had to expend a good deal of time in manually assessing the likely value of q1 which would give the best "step function fit".

Slightly more complex than the problem of computing an R^2 value for one step function, is the situation of comparing our standard with those which we would estimate using only, say, the last six months data (figure on right)



where the question is one of a new linear estimate for an old, then an iterative technique aiming to find some new estimate maximising the R^2 value may suffice where the lower graph is portrayed what is the appropriate 'X' value, and what are the relative slopes?



The problem is that R^2 is not defined for a step function as opposed to its linear counterpart, until a value of X has been specified.

The author had a number of problems in terms of considering the best "new" standard and of devising a suitable index of goodness of fit. It would indeed have been useful if an algorithm could have been developed to search for a possible better cost configuration based on the short period of observations with which to compare the standard estimates we obtained more conventionally, and possibly to devise an index to suggest how good an estimate it is (the author is thinking on the lines of the 'h' statistic which is the counterpart in multiple regression, of the Durbin Watson statistic used in simple regression for the detection of serial or auto correlation, see Econometrica 1970).

These two points, however, only affect the refinement of the model since a great deal is achieved by its use in the early stages before these areas are examined.

The author has not, apart from the extensive use of statistical regression and graph plot facilities, attempted to develop the software for the model. Instead, all the equations and results have been worked through manually, because although the development of the software is very straightforward it is best left to those with the necessary expertise Indeed, it begs the question whether a model should automatically be put on a computer system, given the fact that one Delta factory recently manually processed its departmental and monthly accounts. Whilst the model is amenable to either manual or computer processing, a computer method would have the advantage of relatively cheaper reiteration of the equations to answer the typical profit planning questions of the "what if?" type. In the future, it might even be possible to develop a VDU system paralleling Delta's stock and sales computer system, but here we are moving from fact, straightforward application and future possibility, to applications which are not implementable in the near future. It is the aim of this research that our feet are always on the ground, and that our proposals for applications are readily implementable.

8.5.2 Applications

On the applications side; certain areas still cause me concern. The cost control of dies must be based on usage because it is this to which output relates on a @ res ipsa loquitur basis. Yet what data we have is based on materials used. What the statistical results of examining toolroom labour hours against cost centre outputs show (at about 60%, one of the poorest estimates) is that so much of the die cost is taken up by labour content that this might be a fruitful avenue for improved cost control.

The possible methods of controlling maintenance costs have already been examined and the use of total maintenance cost concepts might be useful although I suspect that because of the nature of our industry, the rewards of this sort of work will be less beneficial per hour spent than in other

@ let the facts speak for themselves

industries where the metal value is not so high and the delivery and quality of service not so crucial.

In more general terms, any attempt to improve information would rely upon understanding the motivation and style of managers in the factory under consideration. Very often future work would involve similar basic ground work being undertaken on the lines of the current research to set up an effective data collection and dissemination system.

I have in my mind a situation where the setting up of a suitable data system might impinge on a political situation where a department might be weaker than functionally it should be, and if this impinged on financial information (and few aspects indeed do not) it might need prior action being taken before modelling work itself could commence. For example if we knew roughly our costs, but not our output on a logical basis any ratio would be meaningless, not because of a financial weakness, but because of a system failure outside our usual areas of interest, in this case in production control.

8.6 Summary

The appointment of a person from outside the factories in question was made because this work demanded a large amount of time which factory personnel could not spare. In addition, the ability to examine the problem from afresh entailed a critical examination of the current procedures which personnel engaged in the arduous operational activities on a day to day business might find difficult. This needed to be undertaken in order to recommend proposals which were unbiased, accurate and demonstrated a wide pers'.pective having been given to the project. By this I mean the ability to grasp the essentials of the production methods organisation, envirnoment and metallurgical concepts which affect any proposals or research which are industrially orientated. The personal characteristics required to be industrially "accepted", of being able to communicate in an industrial environment all need to be fulfilled before any aims of a project can be considered. But once the acceptance process has taken place and one is part of the [illegible] personnel then a transition can be made from merely acquiring knowledge (which never should end) to putting forward criticisms, praise and recommendations.

The aim of assessing the implications of cost behaviour for profit planning and control suggest that first one must appreciate what cost behaviour is implied - what cost, by what measure is associated with what output and what is the form of relationship exhibited. This enables a standard to be set for a control procedure to be established. If we are flexible in our approach one can examine the impact of this information if circumstances alter, so that we are examining not how we have performed given what we have produced, but how we would perform if we produced more, or differently, or the inflation rate altered, or yield was improved. But these questions relating to profit planning require a knowledge of cost behaviour; if we cannot assess how well we are doing now, we cannot possibly assess how well we would do, because the former relies on standards, the latter on the alteration of standards given alternative conditions.

This thesis has sought to show how meticulous investigation and analysis can be helpful as regards the control of labour and energy costs in a given situation.

GLOSSARY OF TERMS

Billet	A large log shaped piece of metal, from which rod is extruded via the extrusion process.
Drawing	The process of 'pulling' rod through a draw die in order to improve its surface metallurgical qualities, and slightly reduce its cross sectional perimeter.
Metal Yield	The metal yield of a given process is the tonnage of good output achieved by a given process expressed as a percentage of tonnage input.
Turning Rod	Being rod designed for use in lathing processes as part of its final stages of production.
Stamping Rod	Being rod designed to be heated up and stamped into a given shape.
Contribution	Being the difference between the value of sales and the variable costs of production thereby incurred.
NIGP	National Insurance and Graduated Pension Contributions, levied by the government as a percentage of gross wages paid.

KWH	KWH is a measure of physical electricity usage.
KVA	Is the measure of load used in this context by the Electricity Board in order to assess the highest consumption of electricity by a firm at a point in time.
DCF	Discounted Cash Flow.
IRR	Being that DCF at which income and expenditure over the time period chosen are equal.
H	Being a measure of the amount of heat change in a chemical process.
Terotechnology	Being a method of viewing maintenance effort in terms of the costs of maintenance effort against the increased production capability thereby occasioned.
Betrebsrat	An internal advisory committee in a firm composed of workers and managers.
Aussichtsrat	A committee composed of shareholders and union representatives haveing an interest in the company.
Value Added	From page 25 of the Delta Reports added value is defined. Where sales are centralised, standard costs incurred can represent a 'value'. This is a different concept from added value, but is useful when considering manufacturing units. Thus here it may be helpful to think of conversion costs as if they represented value added

APPENDIX: GERMANY AND THE U.K.

This appendix gives a guide to certain aspects of Germany which serve as a useful backcloth to the short discussion in the text. It is not intended to be comprehensive, but to concentrate on those aspects which are considered of special importance.

APPENDIX: **Germany and the United Kingdom - A comparison with specific reference to the Non-ferrous Metal Industry.**

Before considering the more specific areas of cost behaviour, a short note on more general differences may be helpful. The attitude of Germany and the U.K. regarding the achievement of government objectives shows a different approach. In the U.K. a rather interventionist policy tends to be adopted in order to ensure the achievement of social aims. In Germany a rather more pragmatic position is adopted and social aims tend to be achieved by indirect influence through, rather than instead of, private enterprise. Thus associated labour costs of pension and insurance in Germany are established by agreement with industry on the required minimum levels of provision of health care and pension insurance. The use of the established industrial structure as a suitable vehicle for achieving improvements in social welfare, such as pension rights, etc. is reflected in other spheres of industrial activity.

For example, the union structure in Germany, apart from its professional and business-like attitude being based on an industry wide system, means that the metal industry has one union with which to negotiate, rather than the 17 for example which British Leyland must negotiate. It can, therefore, be said that the union structure of Germany promotes a good economic environment for wage bargaining, etc. in which the Betrebsrat and Aussichtsrat, two bodies involved in the process, play their part.

In terms of philosophy and emphasis in industry, the fear of a return to the hyper inflation of the '30s manifests itself in a strong desire to keep price (and therefore wage) increases below 8% per annum. This keenness to strike a fair but hard bargain can be seen throughout the German industrial process, whether it be wage bargaining, electricity contracting, price setting, assessing the viability of alternative suppliers, etc. What one sees, only indirectly, is the influence of the government which operates by indirect action. It would be wrong, however, to assume that this influence is costless. In terms of a labour tax, the high cost of associated labour costs can readily be seen. To conclude this preliminary survey, a qualitative chart may well bring this clearly to mind.

Source: Gesamtmetall 1976

	DM	%
Wages paid, average yearly	17,300	100
Bank Holiday pay	934	5.4
Holiday pay	2,110	12.2
Days illness	1,523	8.8
Other	173	1.0
'Personal'hidden costs	4,740	27.4
Statutory special payments		
Holiday bonus	1,055	6.1
Special payments	743	4.3
Other	312	1.8
Statutory Payments	2,110	12.2
Social Payments		
Pension	2,180	12.6
Illness	1,452	8.4
Unemployment benefit	363	2.1
Other	675	3.9
	4,670	27.0
	28,820	166%

The Nature of Cost Behaviour

Given that labour and energy appear in both countries to be two costs worthy of further consideration, how would a disaggregation of these costs differ in type and then in configuration against relevant activity level?

In the U.K. electricity needs to be divided into variable components (KWH charge and fuel adjustment) and the KVA charge which is neither fixed nor variable. In Germany the tariff can be viewed as 3 elements: steady constant usage per hour, irregular usage and penalty charge based on the ratio of the above 2. At all levels from factory to cost centre the same calculation can be made. The implication is that in Germany the private contract system, plus the manner of charging, makes it relatively easier to model information useful for management control.

For labour costs as a group, the split into relevant sub-divisions of basic rate, bonus holiday pay, insurance, shift allowance and overtime shows differences of emphasis. In the U.K. typically management will use basic or total wages as information for control. In Germany, because the hidden costs of labour are so high, the holiday and insurance liability needs to be included as a labour cost.

In terms of configuration, the 2 graphs for labour for each country (not actual examples but typical graphs to preserve confidentiality) show the differences quite clearly. As is stated, energy curves follow similar patterns to those of labour.

1. The ratio of costs in Germany decreases the importance of energy and increases the importance of labour costs with maintenance and production supplies being similar.
2. The configuration of all costs in Germany is much more linear, more variable (i.e. higher gradient) at wide ranging activity levels.
3. Whilst labour costs in hours do exhibit step functions due to fixed elements such as supervision, etc., they are far less marked than in the U.K.
4. When labour costs are converted to an aggregate money

base, the straightforward linear relationship holds far better than in the U.K., where step function relationships for labour costs in money terms are quite pronounced.

5. Because the level of inflation in Germany, both currently and in the past, is considerably less than that of the U.K. the problem of providing information on a common money base is far less problematical.

The Reasoning for These Differences

Energy costs in Germany are comparable in price terms $DMKWH^{-1}$ to those in the U.K., despite the higher general price and cost level. Since each customer negotiates his own tariff, a larger difference in $(DM)KWH^{-1}$ may well emerge, quite apart from policy decisions, such as the relative price of energy, charged for domestic and industrial use, possible differences in the organisational efficiency of the electricity supply industries and energy differences in general.

The linearity of costs in Germany, particularly of labour and thence energy where the latter behaves in a similar way to labour costs (where a process involves a specific energy and labour input), stems in large measure from the flexibility of units from which labour is utilised. Suppose that a small factory of 6 cost centres has a normal output of 100 units, where output falls to 50 units labour costs in Germany fall to near half of their original level.

They do so because overtime levels tend to be higher in Germany first, because the high indirect costs of insurance and holiday pay tend to make it relatively less expensive to increase output via overtime rather than increase the payroll. The reverse is often true in the U.K. owing to higher overtime rates and lower payroll taxes.

In Germany the flexibility of labour with respect to a cost centre is far higher. For example, a department consisting of 3 extrusion processes in different factory locations was able to use a common core of operatives, depending on output required from each press. In another example a department consisting of extrusion plus finishing and delivery/packaging was able to arrange its operatives according to the workload on the press, from production and packaging areas.

The only bar to flexibility is one of experience in the different functions, but in practice most operations have usually been performed by most operatives and in the U.K., as the comparative graph shows, labour costs tend to be higher at low activity levels.

When costs are converted from a man-hour to money base the linearity fo cost behaviour is preserved because overtime bonus rates are lower in the BRD* than the U.K., and the wage payment system is similar consisting of basic rate

* BRD = W. Germany

plus simple bonus system and an overtime increase. Because of the flexibility of labour one would suspect that overtime costs would also be linear rather than step-wise.

Implications for Cost Modelling

1. In the U.K. environment, it is usually necessary (for management information to aid control) to go down to a cost centre before a meaningful usage unit versus activity level configuration can be established. In Germany meaningful cost behaviour can often be established for labour, energy, etc. on a departmental basis because of the more straightforward behaviour pattern. Thus one would expect to develop a cost model for managerial information and control on a departmental rather than cost centre base, because a meaningful cost behaviour relationship can be established at a higher level.

2. The implications for energy control are that the German system of contracting for electricity allows us to convert energy usage into money terms without destroying the fixed variable. Because of the KVA method of charging on a maximum factory KWH level, it is impossible to convert the KVA to a meaningful cost centre statistic.

3. The hidden costs of labour in Germany of 70% of direct labour costs imply that more thought needs to be given to holiday and NIGP as integral parts of labour costs.

Our cost model does well in separating out variable and fixed labour elements, and apportioning the insurance and pension elements in the same proportion. Were we to have the German system we would need to consider the relationship between payroll and man-hours worked in more detail than the U.K. since holiday pay is a higher figure in the BRD.

4. Because the German production system tends to be more complex in terms of products and production flow, the analysis of joint process costs (e.g. as for copper and brass billet extrusion) will need to be used more extensively in Germany than in the U.K. Quite apart from this, we may well have to establish more product groups of rather heterogeneous nature and approximations in product flow than would be necessary in the U.K. in order to achieve a model of manageable size.

5. The transfer of products at an intermediate production stage due to rationalisation, implies in the German firm under consideration extra emphasis on the value added at each production stage. This is necessary because German firms price either at market value or contribution plus or value added plus so our cost knowledge must extend to each cost centre stage.

6. Less concern is necessary in Germany in considering

step function cost behaviour because "steps" tend to be smaller and costs more linear. Nevertheless, attention needs to be shifted in this case to whether the state of the cost line is becoming more fixed or shows no trend with time.

7. Whilst product costs are confidential the following table gives an indication of the likely comparison of the 2 countries in terms of variability and cost level.

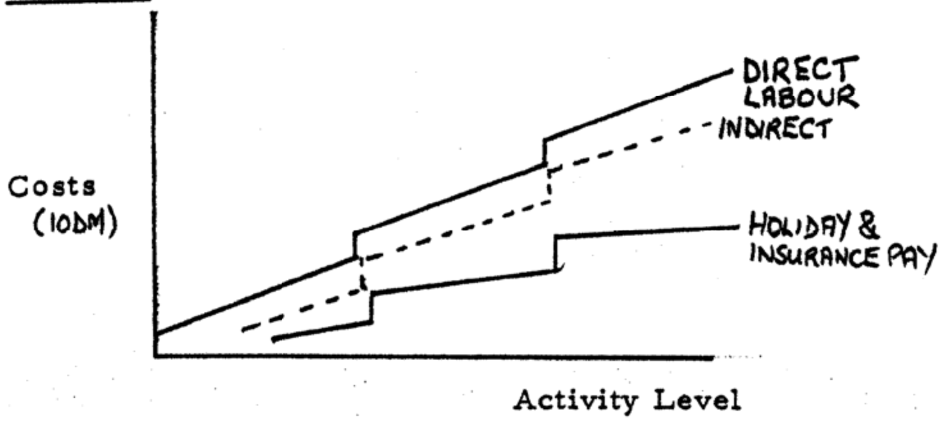
	Variability *		Index (Price)	
	UK	GERMANY	UK=100 UK	GERMANY
Fuel Oil	-	-	-	-
Electricity	75	80	100	103
Gas	-	85	100	105
LPG	85	-	100	253
Labour Cost - direct	75	90	100	173
Labour Cost - indirect	50	68	100	165
Holiday and hidden costs (NIGP)	45	65	100	285
Maintenance - toolroom	55	65	100	320
Maintenance - other	N/A	N/A	100	320
Overtime	higher variability in Germany		100	150
Production supplies	70?	70?	100	230

* Production areas only (%)

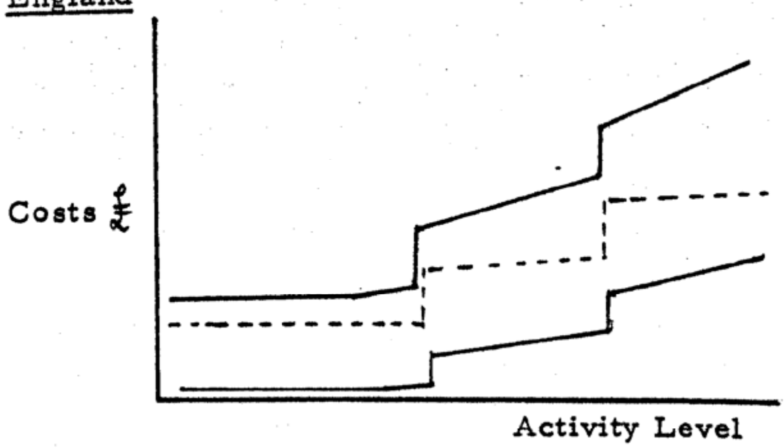
For the purposes of comparison, these figures represent orders of magnitude rather than scientific accuracy. Nevertheless, it is quite clear that it is in labour rather than energy that German costs are higher. Their variability of costs tends to be much higher for all categories considered but particularly for labour, both direct and indirect, and for the toolroom labour.

A Typical Graphical Analysis of Labour Costs

(a) Germany



(b) England



The energy curves would show a similar configuration with step function slightly less marked than in the labour analysis.

LITERATURE REVIEW (BIBLIOGRAPHY)

'0 this I have felt and this I have guessed and this I have heard men say. And this they wrote that another man wrote of a Carl in Narroway.

R. Kipling

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