TECHNOLOGICAL INNOVATION : A STUDY OF THE ADOPTION AND DIFFUSION OF TECHNOLOGY IN THE POTTERY KILN INDUSTRY

BY

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ABSTRACT

This Thesis is about behaviour, a special type of behaviour, the adoption and diffusion of new ideas and practices - "innovations"- in particular technological innovations. Successive Governments and the Media frequently point to historical cases where British inventive skills have failed to make subsequent commercial impact in the country of origin. What determines a successful invention and what affects the behaviour of organisations involved with its development and commercialisation? Answers to both these questions are sought through reference to research into the diffusion of innovations, both at a conceptual and operational level.

In response to criticisms levelled at numerous studies(highlighted in the text), this Thesis holistically considers both the results and process research orientations on the grounds that the consideration of consequences or causes of behaviour in isolation tends to present only a part - picture of innovatory behaviour. Evidence is later presented in the fieldwork to suggest that the causes of innovation decisions in turn can arise from the consequences of previous innovation decisions; the two research perspectives remain inextricably linked.

Section 1 introduces the reader to the current tendency, though gradual, for the merging of research methodologies used in diffusion studies. Evidence is provided to suggest that the failure on the part of the researcher to consider work other than that from his own particular academic discipline has weakened the development of a grand theory of diffusion and, in doing so, reduced the explanatory

value of isolated empirical studies.

The subsequent Section reviews the literature for contributions made by past researchers to the understanding of adoption and diffusion behaviour processes. A framework originally presented by Katz, an eminent sociologist, is used, namely:-

An Innovation
Which is Communicated
Through certain Channels
Over Time
Among the Members of a Social System

Each element, in turn, is critically evaluated in this Section. A case is made for a middle-course methodological approach between that of the grand theorist on the one hand and the raw empiricist on the other. A wide range of cross-disciplinary sources are cited in this examination, intended to provide a base for examining industrial innovation in Section 3.

Section 3 extends the literature search into industrial systems, with particular emphasis upon those factors considered influential in the adoption and diffusion of technological innovation. Investigation is made into the definition of "industrial innovation" and how discernable types of innovation can affect the level of responsiveness to adoption in the industry. Factors seen to impinge upon adoption decisions and the subsequent diffusion process arise from both internal and external-to-the-organisation sources. Economic and non-economic variables are considered. Again sources not traditionally presented in diffusion studies are used.

Section 4 (Volume II) is concerned with applying theoretical diffusion concepts to an on-going industrial situation to examine both causes and consequences of industrial innovatory behaviour. Two complementary field studies were conducted in the Pottery Kiln Industry - to suppliers, customers and kiln-builders themselves- from which a number of system-perceived major technological innovations were identified and used in the subsequent investigation. A nomination approach was used as it was considered that what firms themselves considered to be technological innovations - watersheds in technological progress - would assist in the explanation of subsequent adoption and diffusion decisions. A number of innovations were identified, spanning a time period 1800 - 1975. The innovations were then used to probe both causes and consequences of their adoption and diffusion; in-firm and environmental influences were identified.

In the final Section, summary and conclusions are presented by relating the thoughts and findings of the literature review to the facts established through the empirical studies. Points are raised as to discrepancies and to remaining gaps in knowledge.

The comprehensive Bibliography, citing over 450 references, emphasises the multi-disciplinary approach advocated by the critics of early research studies.

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INTRODUCTION

The choice of topic area stems in part from the author's own practical experiences with Bristol Siddeley (later Rolls Royce Bristol Engine Division) a company at the forefront of technological innovation, but equally there are wider implications deriving from research into industrial diffusion processes. Criticism is frequently levelled at industry in the United Kingdom for being inventive but failing to reap the rewards from commercial exploitation. The theme of this Thesis is to identify and explain both the causes and consequences of technological decision making at intra and inter-firm levels.

A 'middle range analysis' approach as advocated by Merton is favoured on the grounds that this approach seeks to identify and explain the epistemological links between theory and operation rather than the untestable concept development of the grand theorist or the field studies of the raw empiricist unrelated to theory foundation; middle range analysis is seen as a research process where the theoretical basis is specific enough to be empirically testable and where the data derived can test theoretical hypotheses.

The overall objective, to critically evaluate concepts applied to explaining the adoption and diffusion of industrial technological innovation is pursued over two volumes; the former critically examines literature sources, whilst the latter reports literature and field studies centred around one particular industry concerned with the development and manufacture of kilns for the pottery industry. The concentration of the industry in one particular geographical location - the Potteries, Stoke-on-Trent - lent itself to study, given the operational constraints of the author as a part-time researcher; however, it also allowed the researcher to identify and embrace wide ranging causes and consequences of innovatory behaviour infrequently featured in other research studies.

The reader will find, as the text progresses, questions posed, the answers to which fall outside the scope of this particular Thesis. It is hoped that these questions and others raised by the reader himself will provide momentum for further research into an area seen as crucial for the future of the United Kingdom.

SECTION 1 : MERGING DIFFUSION RESEARCH TRADITIONS

Whilst considerable work has been carried out in the area of communications in general, and diffusion research in particular, there appear to have been few attempts at establishing a formalised research tradition; that is, where a series of studies on a similar topic are seen to be influenced by preceding investigations. Rogers, in his latest work, concludes "there has been a definite lack of diffusion of diffusion research"(1.1). One effect of this academic partitioning into diffusion research traditions has been an inadequate flow of research findings among diffusion researchers. The result has often been unnecessary duplication, unwanted replication and the considerable difficulty of comparability of research findings.

From the mid-1960's there appears to have been a gradual breakdown occurring in the formerly impermeable boundaries between the diffusion research traditions, even though the traditions continued to exist as distinct communities of scholars (1.2).

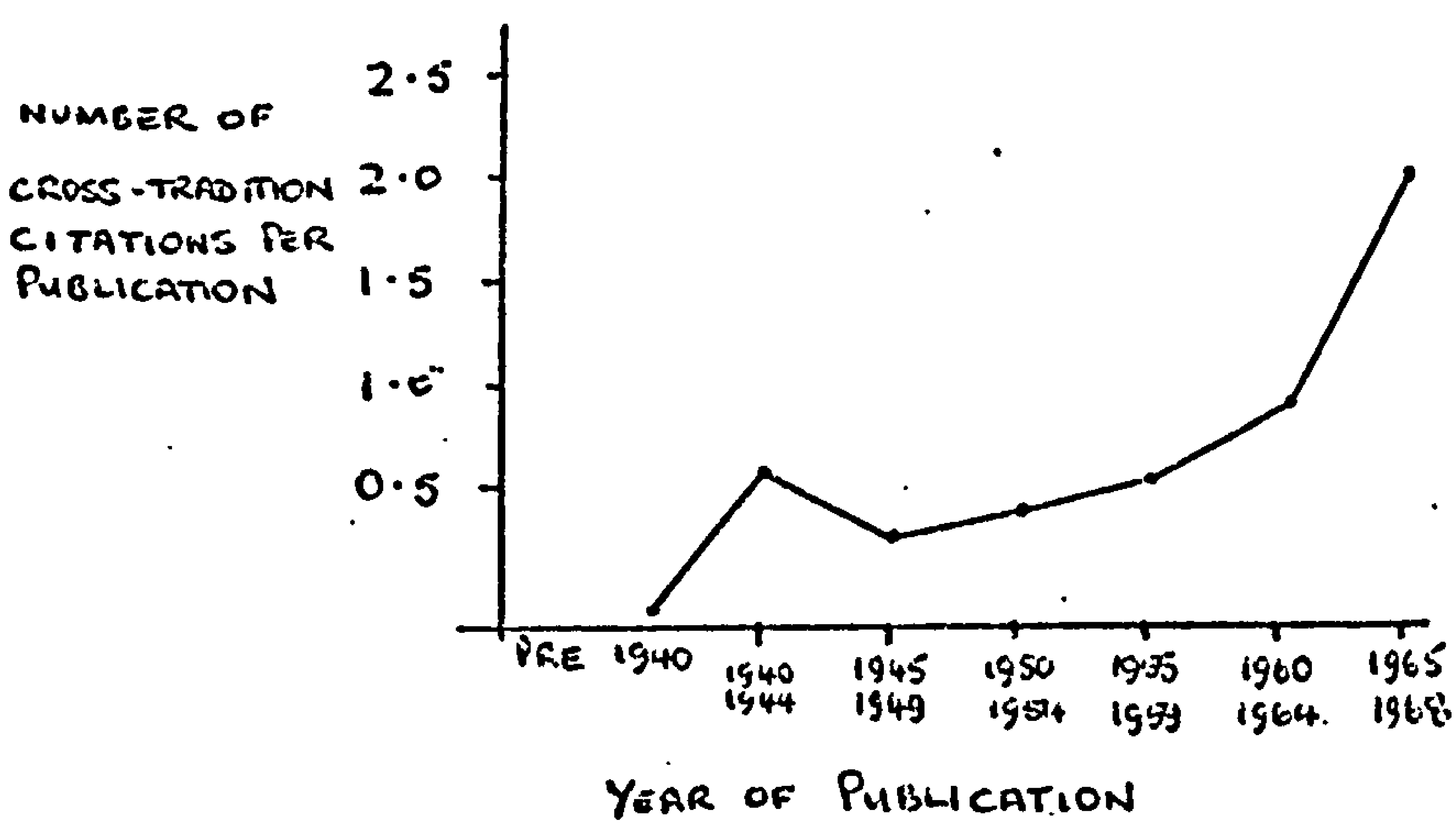


Table 1.1

Source: Diffusion Documents Center. Michigan State Univ. July 1968 (1.3)

Table 1.1 traces the intellectual ancestry of each of the seven major diffusion research traditions (1.4); the primary criterion for the delineation of these traditions has been the disciplinary affiliation of the researcher, modified somewhat by the nature of the innovation studied.

It is not the intention of this thesis to review the historical development of the major research traditions; cross-tradition citation will be used to highlight possible methodological links with the diffusion/adoption process in marketing in general, and industrial marketing in particular as the text progresses.

As early as 1903 Tarde was suggesting several ideas which later became refined and tested by researchers (1.5), yet, by 1972, less than 5% of all studies have been carried out in the area of marketing and/or economics (1.6).

Again, it was during the 1960's that interest in the interface between marketing and diffusion research seems to have developed in strength; primarily it seems through marketing managers (and others) witnessing the appearance of large number of new consumer products, and the resultant demise of a very high percentage of such 'innovations' (1.7).

Upon examination, it seems possible to identify two rather different research approaches to the study of diffusion processes in marketing; those that emphasise "results" (ie consequences of action/behaviour) and those that emphasise the "diffusion process" (ie causes of action/behaviour). While this is not an absolute dichotomy, an emphasis upon one or other approach is usually quite distinctive in a given piece of research (1.8).

Results-oriented research tends to take an econometric approach, examining relationships between variables describing the firm, such as "size" (eg number/size of assets, number of employees, sales

Table 1.2. Comparison of the Major Diffusion Research Traditions

Source : Diffusion Documents Centre. Michigan State Univ. July 1968.

Diffusion Research Tradition	Number of Empirical Publications Available	Typical Innovations Studied	Method of Data Gathering and Analysis	Main Unit of Analysis	Major Types of Findings
1. Anthropology	69	Technological ideas (steel axe, the horse, water-boiling)	Participant and non-participant observation and the case study approach	Tribal or peasant villages	Consequences of innovations; relative success of change
2. Early Sociology	10	City manager government, postage stamps, ham radios	Data from secondary sources and statistical analysis	Communities or individuals	S-shaped adopter distribution; characteristics of adopter categories
3. Rural Sociology	480	Agricultural ideas (weed sprays, hybrid seed, fertilisers) and Health ideas (vaccinations, latrines)	Survey interviews and statistical analysis	Individual farmers in rural communities	S-shaped adopter distribution; characteristics of adopter categories; perceived attributes of innovations and their rate of adoption; communication channels by states in the innovation-decision process; characteristics of opinion leaders.
4. Education	71	Kindergartens, driver training, modern maths, programmed instruction	Mailed questionnaire, survey interviews, and statistical analysis	School systems or teachers	S-shaped adopter distribution; characteristics of adopter categories

Table 1.2 (continued)

5. Medical Sociology	76	Medical drugs, vaccindations, family planning methods	Survey interviews and statistical analysis	Individuals	Opinion leadership in diffusion; characteristics of adopter categories; communication channels by stages in the innovation-decision process
6. Communication	87	News events, agricultural innovations	Survey interviews and statistical analysis	Individuals	Communication channels by stages in the innovation-decision process; characteristics of early and late knowers, of adopter categories, and of opinion leaders
7. Marketing	64	New products (a coffee brand, touch-tone telephone, clothing fashions	Survey interviews and statistical	Individual consumers	Characteristics of adopter categories; opinion leadership in diffusion
8. Other traditions	227	-	-	-	-
Includes general sociology, agricultural economics, psychology, general economics, industrial engineering and several others.					
TOTAL:	1084				

volume etc); "technical orientation" (size of research budget, number of scientific personnel employed etc), "growth rate", and variables describing the results of (usually successful) innovation. The implicit assumption of results-oriented research is that a firm's speed of adoption is related to the profitability of the innovation for that firm — ie those firms that can profit most, adopt first. "Profit" is usually seen only in the light of financial rewards. Variables chosen for analysis are related to the ability of the firm to absorb the risk involved in the innovation, and to profit from it. This approach generally conceives innovation as one in a series of steps which links science to use, rather on the lines of the following series (1.9):

— scientific knowledge
— invention
— development
— innovation
— diffusion or imitation

Most economists have focussed on one or other of the following questions:

1. What mathematical curve best fits the pattern of diffusion of an innovation?

2. What are the factors predisposing a firm to be an early or the first adopter? (or conversely, what are the characteristics of the innovation which facilitate its adoption?)

3. Does evidence support the hypothesis that the firm's behaviour is consistent with profit motivation (1.10) This form of research does not introduce the consideration of how the actions of the firm in a system might be influenced by (or, in turn, influence) other members of the industry (system) — or, by firms outside the industry (system) and vice versa.

One might suggest that results-oriented studies are <u>not</u> really studies of diffusion at all, but studies of adoption-decisions by individual firms. There is no explicit recognition that the industry constitutes a (social) system through which 'influence/information' flows, either from one to another or, indirectly, through "change agents" who inform firms (individuals) of adoption decisions (1.11). Process-oriented research tends to focus upon the relationships and influence-processes among firms in the market (ie within a system) (1.12).

In part this approach seeks to identify the characteristics of those firms that are consistently among the first to adopt new products, on the assumption that they are the "opinion leaders", whose actions are highly influential upon other firms. Such studies start with an assumption that the influencers/deciders/buyers/users in a firm (or "the firm") are watched by, and are influencial upon influencers/deciders/buyers/users in other firms, and vice versa. Process oriented research emphasises the social-influence aspects of diffusion and tends to overlook economic criteria such as 'profitability' as determinants of the rate of diffusion.

A similarly recent diffusion research tradition is 'communication'; which has arisen largely in the past twenty years in response to a need for applied social science research on human (and the 'body corporate') communication problems. However, a review of research literatue on word-of-mouth communication and opinion leadership reveals scant attention to industrial and institutional markets. For example, Webster concludes from his study..."opinion leaders, if they exist at all, seem to be rare in industrial markets" (1.13). In an earlier article, he suggests perhaps the reason is that researchers haven't really bothered to look! (1.14).....

"Patterns of influence within a given buying organisation and among the various companies in an industry make industrial markets complex targets for marketing effort..... it is therefore....that marketing literature has few studies of influence processes in industrial markets".

However, Hayward in his study of the flour milling industry, did consider that he had identified 'opinion leaders' to the point of establishing...."all of the eight (leader-millers) both visited other mills and were visited in their own plants by other millers" (1.15). Whilst, suggesting the existence of personal networks, he did not proceed to analysing the nature of this influence, and concluded with ...."the research shows that much work needs to be done with regard to sources of information, and on the role of opinion leaders" (1.15).

It is appropriate at this stage to examine the role played by more 'impersonal' sources of communication in the industrial marketing situation. Once again the inherent weakness of past research into "advertising effectiveness" seems to be the lack of cross-citation of research methodology and of research findings (1.16).... one is drawn to the recent research of McAleer, who suggests that industrial advertisers do not understand what influences their markets (1.17); that is, what function advertising plays in influencing the industrial adoption process. Like Webster, he concludes his study with.... "the question of whether or not the results are generalisable to other industrial buying situations is not presently answerable. It is hoped that research will give impetus to the study of other industrial markets" (1.17).

An essential step in the development of any field of study is the successful utilisation of a rigorous thinking methodology in the theorising and applied research of that field. As has been already noted, there has been considerable efforts made during the past thirty years towards the advancement of knowledge about "diffusion" and "adoption processes". One might suggest, however, that although important and impressive steps towards a unified methodology have been recorded, the actual accomplishment in the research has not been consistent with the size of effort. The researcher requires a thinking methodology to evaluate the material he tries to build upon and, equally important, he needs a thinking methodology to guide his own theoretical and applied research to ensure the greatest value for his efforts. Yet it is only recently that there has been any significant widespread acknowledgement of the need for a much more careful scrutiny of the procedures or thinking methodologies used by marketing and behavioural scientists in their knowledge building and use of that knowledge (1.18).

The multidisciplinary background of diffusion research has probably been the main contributory factor accounting for the failure of a metatheoretical approach to formalising clarity in methodology.

For progress to be made in a field of inquiry or for a given problem area, a series of activities need be performed - Figure 1.1.

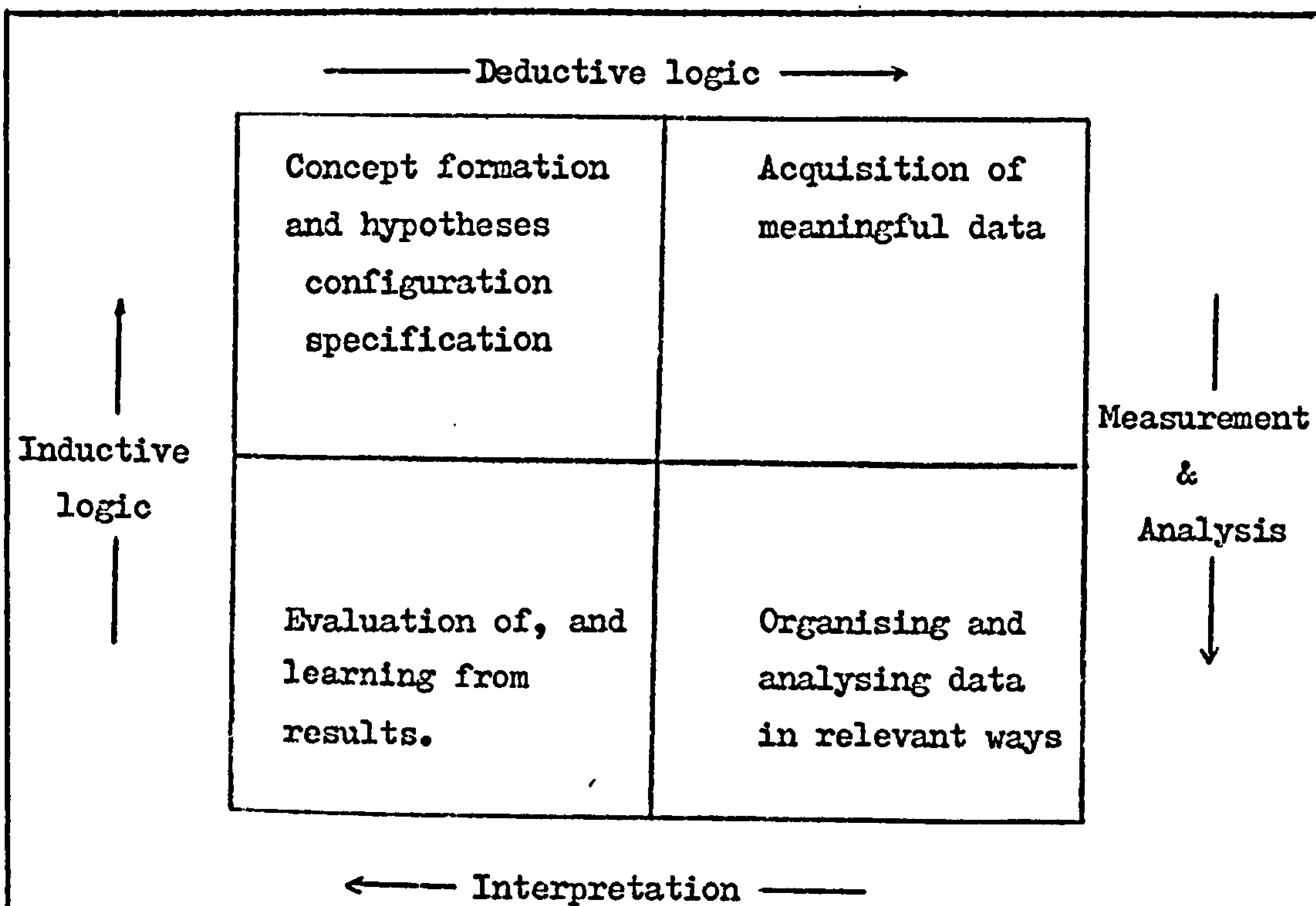


Figure 1.1. Basic Research Activities

The process of theorising involves both the construction of theories through concept development and hypothesis specification and, through a process of deduction, the application of theories in such a way that meaningful data can be acquired (1.19). Much inexactitude in diffusion research stems from the misuse (or, perhaps misunderstanding) of the "concepts" employed (1.20). Concepts are of fundamental importance in science. "Scientific knowledge is entirely conceptual; it consists of systems of concepts interrelated in different ways" (1.21). Thus concepts are those items which refer to the subject matter of science. Whereas concept formation is basic to theory formation, good theory is also necessary for good concept formation (1.22).

Theory application also involves careful measurement, both in the sense of experimental design and choice of quantitative tools. Table 1.2 illustrates the various methods that have been used to gather data; what is immediately noticeable is that of the 1084 studies quoted, 227 (or 21%) of these have no identifiable experimental designs!

Given proper measurement, data interpretation follows. This involves the evaluation and learning from the results of the test. Failure of cross-citation has seriously weakened this fundamental step in theory building.

The research process then proceeds through inductive logic from the empirical plane to the theoretical plane. The inductive logic process involves the integration of the final evaluations of the test into the existing theoretical state.

Again, until recently, there has been little concrete effort to complete the fourth stage of this research process. Researchers seem to have gravitated away from a grand theory approach; what is missing in the intellectual exercises of the grand theorists is a consistent system of interrelated propositions abcut 'diffusion behaviour', and how it changes, at a level of generalisation that facilitates testing....."the major shortcoming of grand theory is neither unintelligibility nor lack of content, but its grand level." (1.23).

In contrast to this approach is the work of the 'raw empiricist', who, in the main, has been guilty of dealing only at the empirical level, giving little attention to the generalisation of his results beyond the particular respondents or social system under study. As Rogers points out "empirical investigation without theoretical basis becomes inevitably bogged down in irrelevant data while ignoring potentially fruitful objectives" (1.24)
The move has been towards what has been termed "middle range analysis" (1.25); which, in essence relates to a research process, whose theoretical basis must be specific enough to be empirically testable, and where the data derived must test theoretical hypotheses. Briefly, a theoretical hypothesis is tested by means of an empirical hypothesis (or hypotheses) defined as the postulated relationship between two operational measures of concepts. An 'operation' is the empirical referent of a concept; whereas concepts exist only at the theoretical level, operations exist only at the empirical level. The degree to which an operation is a valid measure of a concept is referred to as an "epistemic relationship". Figure 1.2 illustrates a possible theoretical and empirical hypothesis relationship....

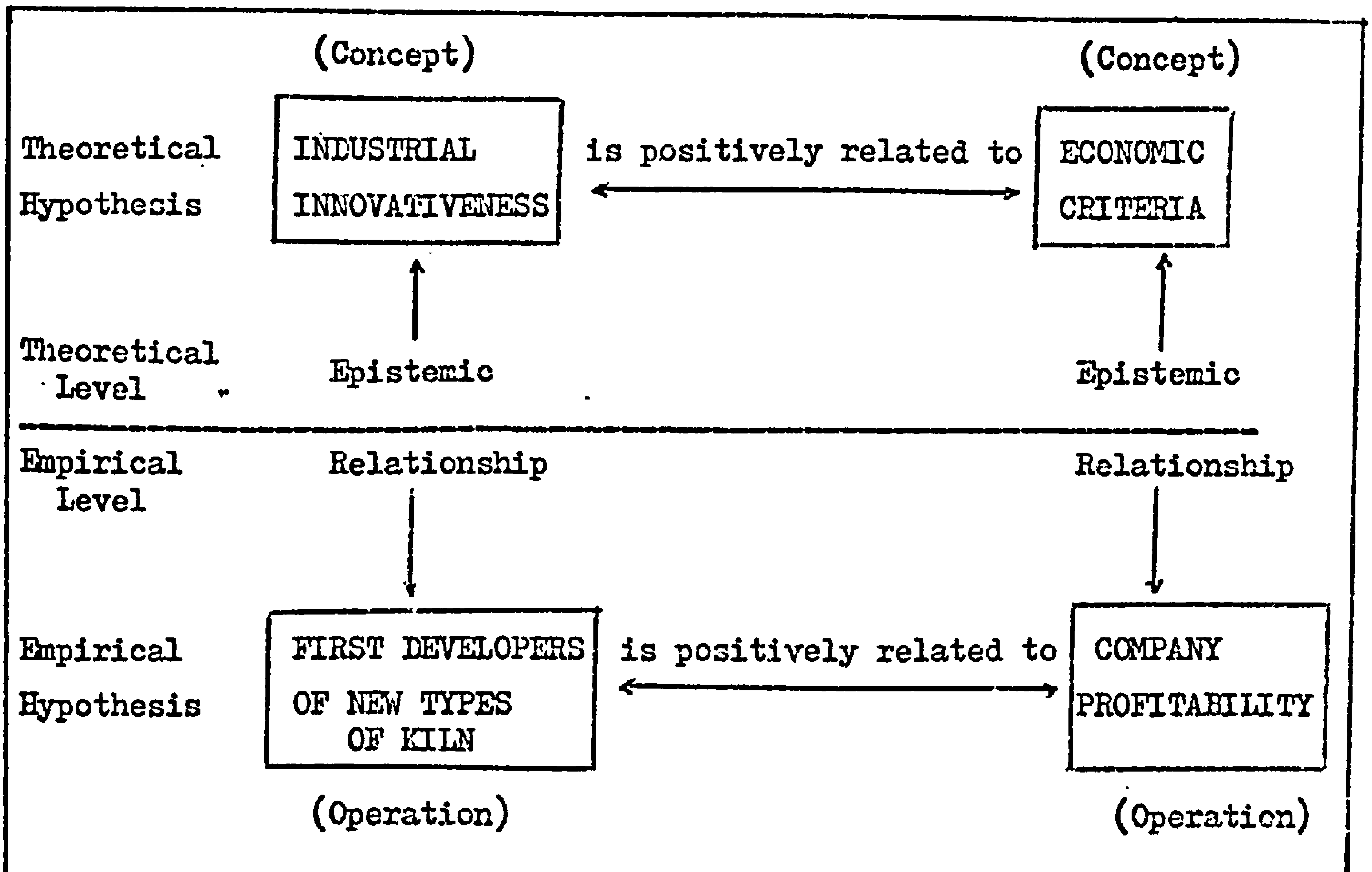


Figure 1.2: Diagram of a Middle Range Analysis of Industrial Innovativeness and Economic Criteria.

The problem which emerges for the industrial diffusion researcher (and possibly for all diffusion researchers) has been the lack of clarity of concepts. For example, misunderstandings as to what one might consider to be "industrial innovativeness" or "economic criteria" not only weaken theory building per se, but also preclude definite empirical testing because of the vagueness of the epistemological relationship between concept and operation (1.26). What has been witnessed is a circular effect of illdefined concepts leading to poor empirical work which has failed to redefine and improve the concepts! (1.27)

Conclusion:

The status of diffusion research today appears impressive. During the 1960's, the results of diffusion research have been incorporated into basic textbooks - in social psychology (Secord & Backman 1964); communication (Katz 1964, Richardson 1969; advertising (Warneryd and Nowak 1967); marketing (Zaltman 1964, Baker 1974) and consumer behaviour (Engel et al 1966, Chisnall 1973). (1.28). Both practitioners (eg change agents) and theoreticians have come to regard the diffusion of innovations as a useful field of social science knowledge. Larsen describes diffusion research as "perhaps the most viable area in current communic ations research ... is the study of the diffusion of new ideas, products, and practices. Diffusion studies are extensions of traditional research on mass media 'campaigns' that proceed from a more sophisticated frame of reference than does this earlier work (1.29)

Yet this study turns to an article by C.W. King for a conclusion to this Chapter ..... "the application of diffusion theory in industrial product acceptance is an unexplored field (1.30). The growth of diffusion research has not been reflected in industrial diffusion studies; information remains inconclusive to the extent to which innovation-generating information is sought; its nature; how it is collected, diseeminated and implemented and why it should be so; and the extent, if any, of inter-firm imitation..... The remaining Sections of This Thesis are intended, in some way, to correct the imbalance which still exists, as diffusion research traditions continue to merge towards one unified theory.

SECTION NOTES:

1.1 Rogers E & Shoemaker F: "Communication of Innovations" Collier. MacMillan 1971 p.45.

1.2 One can only speculate about the specific techniques that were instrumental in causing greater interdisciplinary awareness of the diffusion field. Among the more important are probably the availability of courses in diffusion at various (US) universities, the appearance of general multi-disciplinary textbooks on the subject (eg Rogers E: "Diffusion of Innovations" 1962), and the activities of such scholars as Katz E (Univ. of Chicago), Schramm W. (Stamford Univ), Deutschmann P (Michigan State Univ.), all of whom promoted a more cosmopolite view of diffusion research to their colleagues, both in their writings. And more recently (in the UK) 11th Marketing Theory Seminar: "Innovation in Marketing" (Univ. of Strathclyde) May 1973.

1.3 The index of cross-tradition citations per publication is computed on the basis of the research traditions represented in the footnotes and bibliography of each empirical diffusion publication. Even though there is evidence of greater cross-tradition citing, especially in more recent years, the typical diffusion report cited only about two other traditions (from the seven main traditions) in the mid-1960's.

1.4 Source: Rogers E & Shoemaker F: Op. Cit ps. 50-51.

1.5 Tarde G: "The Laws of Imitation" : Hott, Reinhart, Winston 1903.

1.6 Refer Table 1.2 p.3

1.7 eg Martin E: "New Products, New Profits" American Managmt. Assoc. 1964 p.9.
: suggested only one idea out of every 540 results in a successful new product eg Conner JT : "Progress Reshapes Competition"
: only 8% of approx. 6000 new consumer items introduced each year have a life expectancy of even one year.
- no doubt this type of business research increased the awareness of product planners etc in the problems of new product (innovation) development etc.

1.8 Fisher LV : "The Diffusion of Innovation : A Synthesis of Research Traditions" a paper presented to the 11th Marketing Theory Seminar : Univ. Strathclyde May 1973 suggests three originating sources:

1. Economists
2. Behavioural Scientists
3. A gp. of writers - "management theorists" - who tend to show little close commitment to any one of the primary disciplines. eg Carter & Williams; March & Simon.

1.9 This synopsis is consistent with Mansfield (1968); Jewkes et al (1958) & Schumpeter (1950)

1.10 The whole question of approach and methodologies used is reviewed in Section 2. p.16

1.11 The best known examples of results-oriented research are Mansfield's studies of the rates of diffusion of innovations in the iron-and-steel, bituminous coalmining, petroleum refining, railroads, and brewing.
eg Mansfield E : "Innovation & Technical Change in the Railroad Industry" - Transportation Economics. National Bureau of Economic Research N.Y. 1965 p.169-197.

1.12 Such a question as "How does innovation become known within a firm and how is it accepted?" seems to have fallen to the behavioural scientist (usually the process-oriented researcher) for study, although in general, they have not tackled it directly, but more through consideration of organisational change and development. This thesis returns to the question of organisational/system structure on p.108

1.13 Webster Jnr. FE : "Informal Communication in Industrial Markets: J. Mkt. Res .Vol. VII (May 1970) p.186-189.

1.14 Webster Jnr. FE : "On the Applicability of Communication Theory to Industrial Markets" : j. Mkt. Res. Vol V (Nov 1968) p.426-428.

1.15 Hayward G : "Diffusion of Innovation in the Flour Milling Industry" . European J. Marketing Vol. 6. No.3 1972 p.195-202.

1.16 This is often due to objectives of the study being defined primarily in operational - management - terms, with no intended epistemological links with theory-building.

1.17 McAleer G : "Do Industrial Advertisers Understand What Influences their Markets"?
J. Marketing Vol 38 Jan 1974 p.15-23.

1.18 Various authors focusing on one or another aspect of metatheory - "the science of science" - have directly or indirectly suggested that it would be desirable to introduce metatheory to marketing.
eg Nicosia F : "Consumer Decision Processes. Marketing and Advertising Implications". Prentice-Hall 1966 p. 18.
Howard J & Sheth J. : "Theory of Buyer Behaviour" Wiley 1969 p.2
Pinson C, Angelmar R & Roberts E : "An Evaluation of the General Theory of Marketing" . J. Marketing Vol 36 July 1972.
Zaltman G, Angelmar R & Pinson C : "Metatheory in Consumer Behaviour Research". Proceedings of the 2nd Annual Conference of the Association for Consumer Research. Illinois 1971.
N.6
Broadly defined, metatheory is "the investigation, analysis and the description of:

1. the technology of building theory
2. the theory itself, and
3. the utilisation of theory — metatheory

is not concerned with the context of scientific activity, but rather with the conceptual procedures of science"
- Zattman et al : "Metatheory and Consumer Research". Holt. Rinehart. Winston. 1973 p.4.

1.19 One should note the importance of intersubjective testability as the criteria of definiteness and precision. The data should be collected in such a way as to constitute an empirical test that clearly allows for the possibility of the hypothesis being shown false and not simply unsupported.

1.20 An examination of 'conceptual terms' follows in Chapter 2.

1.21 Bunge M : "Scientific Research I. The Search for System" Berlin 1967. p.46.

1.22 Kaplan refers to this as the "paradox of conceptualisation" - Kaplan A : "The Conduct of Inquiry. Methodology for Behavioural Science". Intertext 1964 p.53.

1.23 Etzioni & Etzioni Op.Cit p.7

1.24 Rogers & Shoemaker : Op Cit p.88.

1.25 This idea is accredited to Merton K : Social Theory and Social Structure. Free Press 1957 p. 9, who asked for "theories of the middle range" : that is, postulated relationships which are testable but that deal with only a rather limited, particular type of behaviour. These middle range theories may eventually be consolidated into more abstract general conceptual schemes.

1.26 This point is further developed in Section 2 : eg the various interpretations of "innovativeness" are examined.

1.27 N.6: Using middle range analysis, there can be the problem of the rather arbitary specification of concepts as 'dependent' and 'independent' — a dependent variable is the dimension that is used to predict/explain through its relationship with the independent variable.
eg: In Figure 1.2 'industrial innovativeness' is the dependent variable and 'economic critera' the independent, but the reverse may also hold (eg in highly competitive market structures).
The labelling of variables does not imply that they are necessarily consequences and antecedents in a time-order sequence. Often such categorisation is made on the basis of the purpose of the research worker and may not necessarily correspond to the expected time-order in which the variables occur in the real world.

1.28 For complete list of books, periodicals and papers used refer Bibliography p.(XLii)

1.29 Larsen O : "Social Effects of Mass Communication" in Faris R (ed) : "Handbook of Modern Sociology" Rand McNally 1964 p.359

1.30 King C.W.: "Adoption and Diffusion Research in Marketing. An Overview" in Haas RM : "Science, Technology and Marketing". Proceedings of the Fall Conference of the American Marketing Association 1966 p.665 - 684... It would be accurate to say that there has been, since King's article, an upsurge in interest though far less in the area accepted as "industrial marketing"
More recent published works include:
Baker M.J. : "Marketing New Industrial Products." 1974
Hayward G : "Diffusion of Innovation in the Flour Milling Industry"(1972)
National Science Foundation (U.S.A.) Successful Industrial Innovations (1969)
However, as will be reviewed, many of these more recent studies still have methodological/epistemological problems.

SECTION 2 : EXPLORING THE DIFFUSION AND ADOPTION PROCESS

2-1 AN INTRODUCTION

"Diffusion research is emerging as a single, integrated body of concepts and generalisations, even though the investigations are conducted by researchers in several scientific disciplines" (2.1). In this Section the reader is presented with an outline of these 'concepts and generalisations'; the implications of which being that a unification of theory is still a considerable distance away (2.2)

2-2 SOCIAL CHANGE

A theme which is developed throughout this thesis is that communication is essential for social change (2.3). The process of social change has been suggested as three sequential steps (2.4):-

1. Invention - new ideas, created or developed
2. Diffusion - new ideas are communicated to social system members
3. Consequences - the changes which occur within a system as a result of adoption, rejection of the invention.

This model can be extended to encompass a stage which occurs after invention and before diffusion, and also to include possible consequences of the social change. Figure 2-1 illustrates

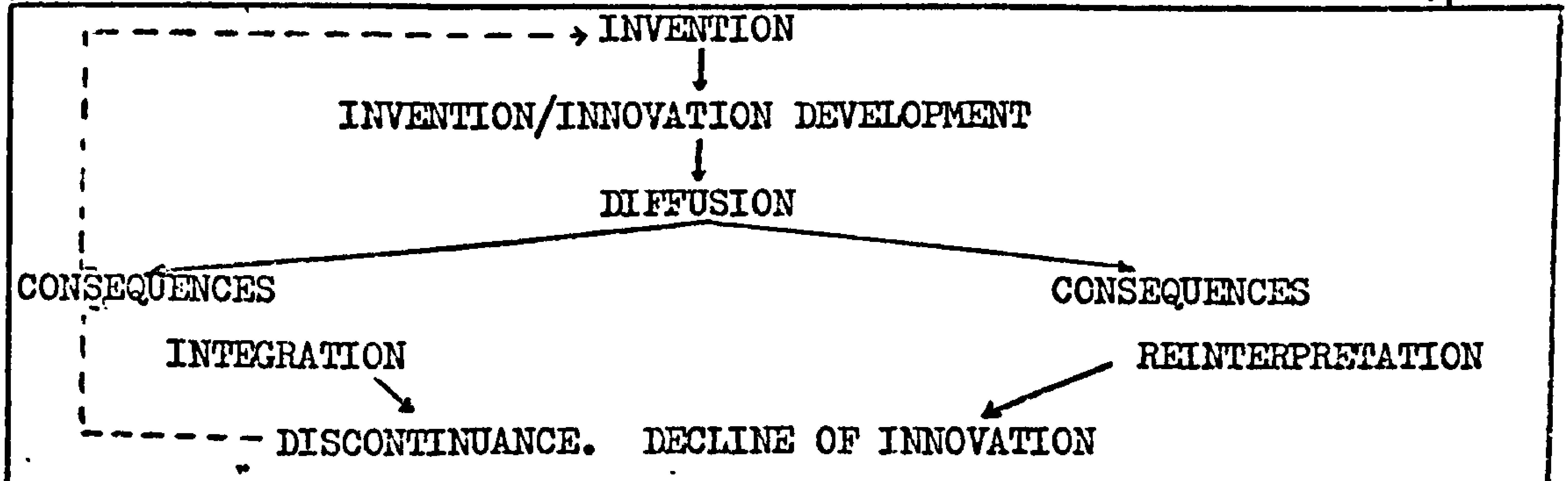


Figure 2.1 SOCIAL CHANGE. DIFFUSION OF INNOVATION

Briefly, the stages outlined in Figure 2.1 not already discussed are:-

4 Invention/Innovation Development - putting the idea into a form, where necessary, that meets the needs of the intended members of the system, especially where the invention arises from outside the particular system; ie it has to be adapted to the particular system's needs.

5 Consequences: Integration - process by which the new idea/ innovation is incorporated into the continuing operations and way of life of system members.

6 Consequences: Reinterpretation - which occurs when the receivers use an innovation for different purposes from which it was initially designed or indeed diffused to them. This is less likely in industrial systems due to the specialised, non-divisible nature of the innovation.

7 Discontinuance. Decline of Innovation - viewing the process of social change as 'dynamic' then new ideas will eventually supplant the old.

2-3 DEFINING SOCIAL CHANGE

Social change has been defined as "the process by which alteration occurs in the structure and function of a social system" (2.5). Social function (status and role) and social structure are closely linked and reciprocally affect each other; in the process of social change, as one is altered, so is the other. Viewing social change from its source of change, Rogers & Shoemaker proposed four categories (2.6). Figure 2.2 illustrates

RECOGNITION OF NEED FOR CHANGE \ ORIGIN OF NEW IDEA	WITHIN SOCIAL SYSTEM	OUTSIDE SOCIAL SYSTEM
INTERNAL	immanent change	Selective contact change
EXTERNAL TO THE SYSTEM	induced immanent change	directed contact change

Figure 2.2: PARADIGM OF TYPES OF SOCIAL CHANGE

Rogers is none too explicit whether new idea precipitates or follows the recognition of the need for change, but certainly empirical studies suggest that immanent change is probably effected with the least conflict within the system; legitimisation of a new idea which has evolved from the system, a product of prevailing system norms, seems more likely than when change is introduced from outside the system.

A second perspective is provided by studying the nature of the 'unit' that adopts or rejects the new idea/innovation; that is, by observing the level at which change occurs. One can take a micro-analytical approach, viewing change at the individual unit level and studying resultant changes in behaviour from adoption or rejection of innovations; the alternative is the macroanalytical approach, viewing change at the system level (2.7). Nevertheless, change at these two levels is closely interrelated.

2-4 COMMUNICATION AND SOCIAL CHANGE

All studies of social change must ultimately centre some attention upon the communication networks operating within the system. All explanations of human behaviour stem, in part, from an examination of how individuals acquire and modify ideas through communication with others. The learning process, the diffusion process and the change process all basically involve the communication of new ideas (2.8).

Diffusion research is usually focused upon overt behaviour change (ie adoption/rejection of new processes/ideas) rather than just changes in knowledge or attitudes per se. One accepts that overt behaviour change (eg production of a new industrial product) will necessitate some form of change in the present state of knowledge and (possibly) attitudes both before and after innovation implementation. This emphasis upon behaviour change is seen as important because several writers argue that knowledge change and attitude-shift do not always lead directly and immediately to overt behaviour change (2.9).

2-5 DIFFUSION RESEARCH AND SOCIAL CHANGE

'Diffusion' can be defined as the social process by which an innovation spreads through a social system over time. For the purposes of this thesis, five elements have been defined as parts of this process (2.10)

Viz

(a) An innovation

(b) which is communicated

(c) through certain Channels

(d) over Time

(e) among the members of a Social System.

The remainder of this Section is devoted to an examination of these parts of the process....

2-6 AN INNOVATION

The studying of past research indicates a glaring failure of these researchers and theory-builders to standardise research nomenclature; an ommission which often precludes direct comparison of findings between studies. Whilst there can be a danger in spending an inordinate amount of time on 'niceties of definition', the term "innovation" is so widely and loosely used that some exploration of its varied interpretations is unavoidable.

Mansfield defined "innovation" as "an invention applied for the first time" (2.11). This tends to take a somewhat narrow view, because it would be impossible to consider its diffusion through a system if the innovation disappeared as soon as it was first tried!

Rogers emphasised that "innovation" was a function of the individual's perception of the newness of the proposed innovation rather than the elapsed time since it first originated.

Innovation is "an idea, practice or object perceived as new by an individual" (2.12). An innovation might be known by an individual (or 'firm') for some time, but until a favourable or unfavourable percept is formed, he has neither gone through a process of adopting or rejecting it. The "newness" aspect of an innovation may be expressed in terms of knowledge, of attitudes, or regarding an overt decision to use it. It should be noted that there is more to knowledge about an innovation than simply awareness of its existence; of importance for effective decision-making (to try, to adopt or reject) is the degree of knowledge about how properly to use the innovation. This point is highlighted in Carter and Williams' study of the development of the pottery tunnel kiln; they found that "there was a forty year time lag between the first sucess of this 'revolutionary' method of firing, and the time when its use became fairly general in industry" (2.13).

Knight refers to applications new to the organisation and to the environment (2.14).

This point is developed by Engel who suggests different types of innovation will have varying degrees of impact upon the members of a social system (ie Knight's environment). He proposed three 'ideal types':-

(a) <u>A Continuous Innovation</u> - this type possesses the least disruptive influence upon system behaviour; for example, a modification of an existing product.

(b) <u>A Dynamically Continuous Innovation</u> - this type generally has a more disruptive influence, but does not alter established patterns of behaviour; for example, a more varied modification of an existing product.

(c) <u>A Discontinuous Innovation</u> - this involves both the creation of a new concept and new patterns of behaviour (2.15).

Whilst Engel's work provides an interesting perspective of innovatory effects upon a system, one cannot ignore the effects the system will have upon innovatory behaviour and the likelihood of the occurrence of Engel's "ideal types".

When looking at the nature of a particular system it seems two "ideal types" are postulated - a 'traditional system' and a 'modern system' (2.16) - if one then combines these two perspectives six possible alternatives (again ideal types) are derived - Figure 2.3 illustrates.

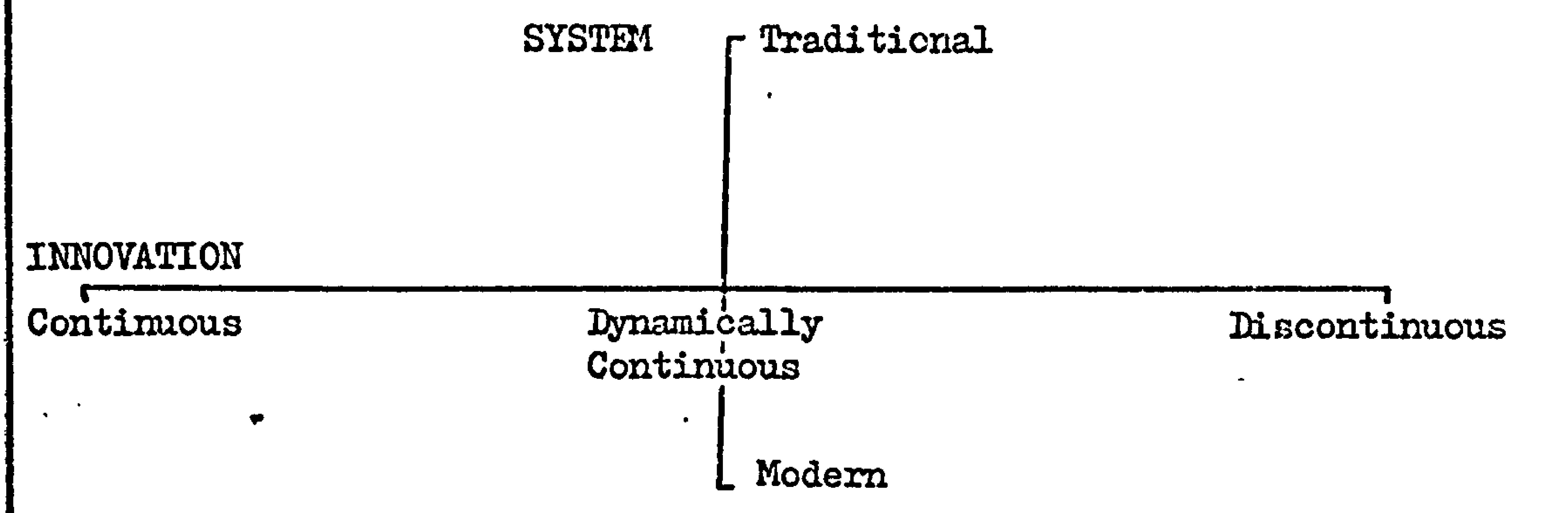


Figure 2.3 INNOVATION AND SYSTEM INTERFACE
SIX IDEAL TYPES.

From the figure these are:-

1. Modern - Continuous
2. Modern - Dynamically Continuous
3. Modern - Discontinuous
4. Traditional - Continuous
5. Traditional - Dynamically Continuous
6. Traditional - Discontinuous

The implications from this model suggest that the innovations which would meet the greatest 'system-resistance' (and thereby requiring the greatest incongruent attitude change and overt behaviour change) would be the Traditional-Discontinuous; more so than a similar innovation introduced into a modern system, which, by definition is more "geared to change" (2.17). Also, the easiest form of innovation for a system to assimilate - the Continuous type - is still likely to meet greater resistance in a Traditional system. In turn, one should note that the climate of a traditional system is such that the appearance (from within the system) of the more advanced innovation-types is less likely anyway.

Fisher (2.18) offers a wider definition of "innovation". He visualises it as a function of three variables, so deriving a relative rather than absolute concept:

(a) the newness of the innovational object or idea

(b) the newness of its fit to a specific applicational context

(c) and the relative lack of knowledge of the adopting organisation (system unit).

He also does not introduce innovation - to - system influences.

2.6.1. CHARACTERISTICS OF INNOVATIONS

The speed at which an innovation will diffuse is seen to be a function of five variables.

(a) Relative Advantage - which is the degree to which an innovation is perceived as better than the idea it supercedes. This relative advantage is sometimes measured in economic terms (predominantly the approach taken by economists to argue as a cause of innovation), social prestige, convenience or 'satisfaction'. What is needed in research methodology is the consideration of the system-unit's perception of this relative advantage rather than as sometimes is the case the researchers own perception which may not be congruent with the former.

(b) Compatibility - which is the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of the receivers. An innovation that is seen as not compatible with the existing pattern of behaviour (viz. the Discontinuous Innovation) of the social system will, if adopted at all, take longer to diffuse through the system. The adoption and diffusion of an incompatible innovation may require the prior adoption (and diffusion) of a new value system, especially in traditional social systems.

(c) Complexity - which is the degree to which an innovation is perceived as difficult to understand and use (2.19).

(d) Trialability - which is the degree to which an innovation may be experimented with on a limited basis (2.20).

(e) Observability - which is the degree to which the results of an innovation are 'visible' to others; the easier it is for an individual to see the results of an innovation, the more likely he is to adopt. For industrial systems observability will tend to be the perceived relative advantage (and expressed in economic terms - profitability). A firm's successful implementation of a new idea can both actively and passively force its competitors to likewise imitate, but little research has been carried out with regard to the influence of less 'tangible' criteria influencing the decision to imitate (2.21).

2.6.2. CAUSES AND CONSEQUENCES OF INNOVATION

So far types of innovation and the speed at which they diffuse have been the main consideration, but attention now turns to probing why a system unit or indeed a system should be 'innovatory' and what are the consequences of such innovatory behaviour.
The consequences of innovatory behaviour at the system unit level should, in theory, be congruent with the projected reasons why the unit chose (where 'choice' is the appropriate word) to adopt or reject the innovation, yet in practice this is not always so.
This possible incongruency between purpose for innovation and consequent outcomes becomes in part a function of the complexity of the adoption process of the system unit - the problems of organisational/industrial systems regarding goal-setting is outlined in Section 3 (2.22). In terms of giving due attention to the consequences of innovatory behaviour Rogers comments "in spite of the importance of consequences, they have received very little study by diffusion researchers...(who) often assume that adoption of a given innovation will produce only beneficial results for its adopters" (2.23).
Rogers has classified three types of consequences:-

(a) Functional or Disfunctional - depending upon whether the effects of an innovation in a social system are 'desirable' or 'undesirable'. Figure 2.4 illustrates

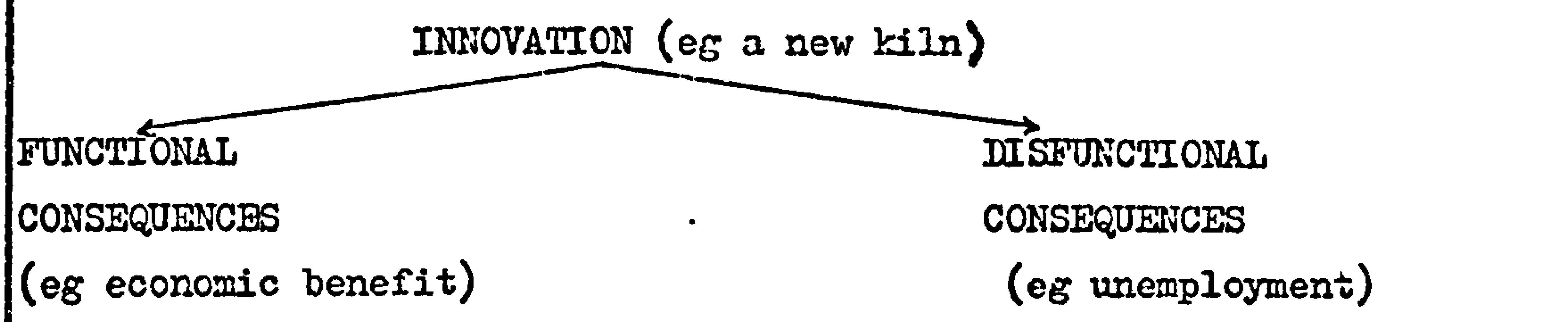


Figure 2.4 <u>FUNCTIONAL AND DISFUNCTIONAL CONSEQUENCES OF INNOVATION</u>

(b) <u>Direct or Indirect</u> - depending upon whether the changes in a social system occur in immediate response to an innovation or as a result of the direct consequences of that innovation. Figure 2.5 illustrates

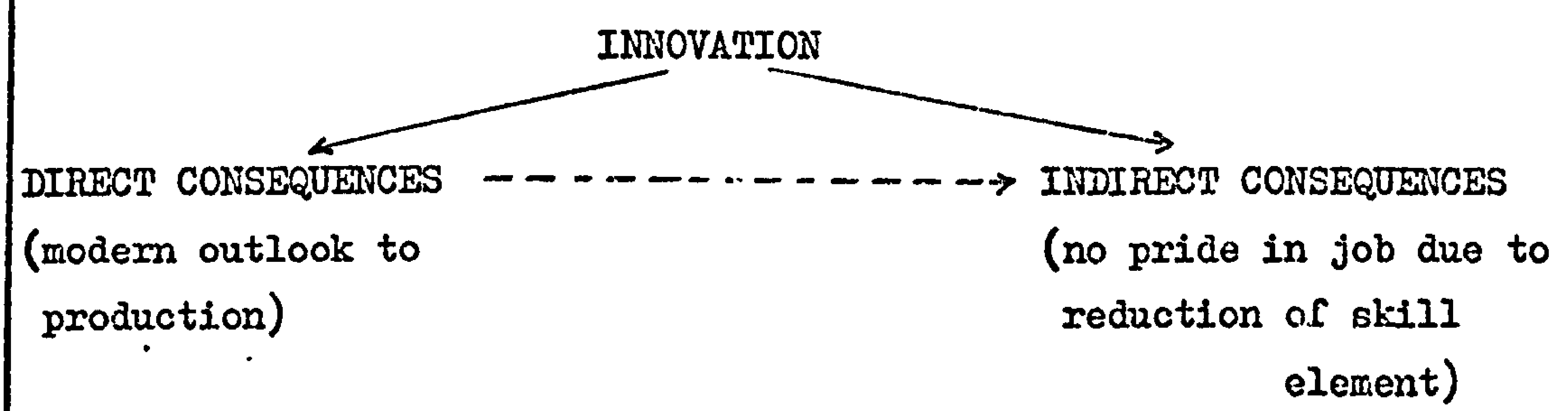


Figure 2.5 <u>DIRECT AND INDIRECT CONSEQUENCES OF INNOVATION</u>

(c) <u>Manifest or Latent</u> - depending upon whether the changes are recognised and intended (manifest) by the members of the social system or not. For example, in figure 2.5 above, modernisation would not have been intended to produce apathy amongst the workforce (2.24).

To present this discussion Rogers has focused upon the intended and unintended consequences of innovatory behaviour, but what of the causes of such behaviour?
Rogers proposed his paradigm of types of social change which sought to identify the origins of such innovatory behaviour (2.25) but this work did not fully indicate 'why' this behaviour so occurred, what con-

straints there were upon it, and the product of any self-risk analysis. Rao and others carried out a study to examine the motivational pattern of known innovators (2.26). They suggested motivation to be the 'impeller of action at a specific point in time', basing their work upon the achievement motive concept as proposed by McClelland (2.27) - the achievement motive... is revealed in man's effort to reach a high level of excellence despite adversity, constitutes one of the important motives identified by the researchers carried out by experts in the field (2.28). Their findings, though somewhat restricted by their methodology and research design, do suggest a hierarchy of motives present in the innovator where economic and self-actualisation motives are seen as important determinants in innovatory behaviour.

The problem of identifying the causes of innovatory behaviour is complicated by the various theoretical positions taken by the major behavioural schools of thought. The theoretical position taken has depended upon two explanatory variables...

(a) the Timing and

(b) the Position/Locus of the Causal Event relatives to the observed behaviour. Figure 2.6 illustrates

LOCUS OF CAUSAL EVENT	TIMING OF CAUSAL EVENT	
	PRIOR TO BEHAVIOUR	FOLLOWING BEHAVIOUR
EXTERNAL TO ORGANISM (SYSTEM UNIT)	S - R Theory	Social Psychologies
INTERNAL	Psychoanalytic & Quasi-Freudian	Gestalt Theories

Figure 2.6 AN OUTLINE OF THE MAJOR BEHAVIOURAL SCHOOLS OF THOUGHT

In essence, the Cause of behaviour is viewed as:-

preceding the event ("deterministic behaviour")

or following the event ("goal seeking")

AND

as a reaction to the environment

or as the result of some internal state of the organism.

A study of published research information on diffusion research illustrates that identification of causes of innovatory behaviour has been a much neglected area. The writer has found no work which has, in any detailed manner, sought to relate behaviour during adoption and consequent diffusion with the general outline illustrated in figure 2.6; for example, the treatment of the innovator as "venturesome (2.29) provides a somewhat shallow psychographical picture of the reasons why an individual (or firm) should be prepared to undertake innovatory behaviour at possibly great personal and social risk (2.30).

2-7 WHICH IS COMMUNICATED

A principle of human communication is that the transfer of new ideas (and communication generally) between source and receiver occur more frequently when they are alike, that is "homophilious" (2.31). By "homophily" is meant the degree to which pairs of individuals who interact, are similar in certain attributes - for example, beliefs, values, education, social status (2.32). Homans noted "the more nearly equal in social rank a number of men are, the more frequently they will interact with one another" (2.33)

With regard to industrial systems the presence and identification of homophily is more complex. There are two types of communication networks operating at both inter and infra form - namely the formal and the informal communication networks. One often finds the presence of homophily more between individuals with similar (functional) interests between firms than between individuals within the same firm (2.34).

Rogers states "when source and receiver are identical no diffusion can occur. Therefore the very nature of diffusion demands that at least some degree of heterophily be present between source and receiver" (2.35. Research along similar lines does indicate that receivers often seek sources that are slightly more technically competent. In terms of theory, the applicability of this approach hinges upon "some degree of heterophily" and "slightly more technically competent". Figure 2.7 illustrates a proposal that communication of an innovation will tend to become more difficult (too technical) and so non-existent as the relative levels of comparative technical competence approach an heterophilic state (that is, the receiver is unable to comprehend what is being communicated neither at a formal nor informal level) and where a high level of system-heterophily is present (2.36).

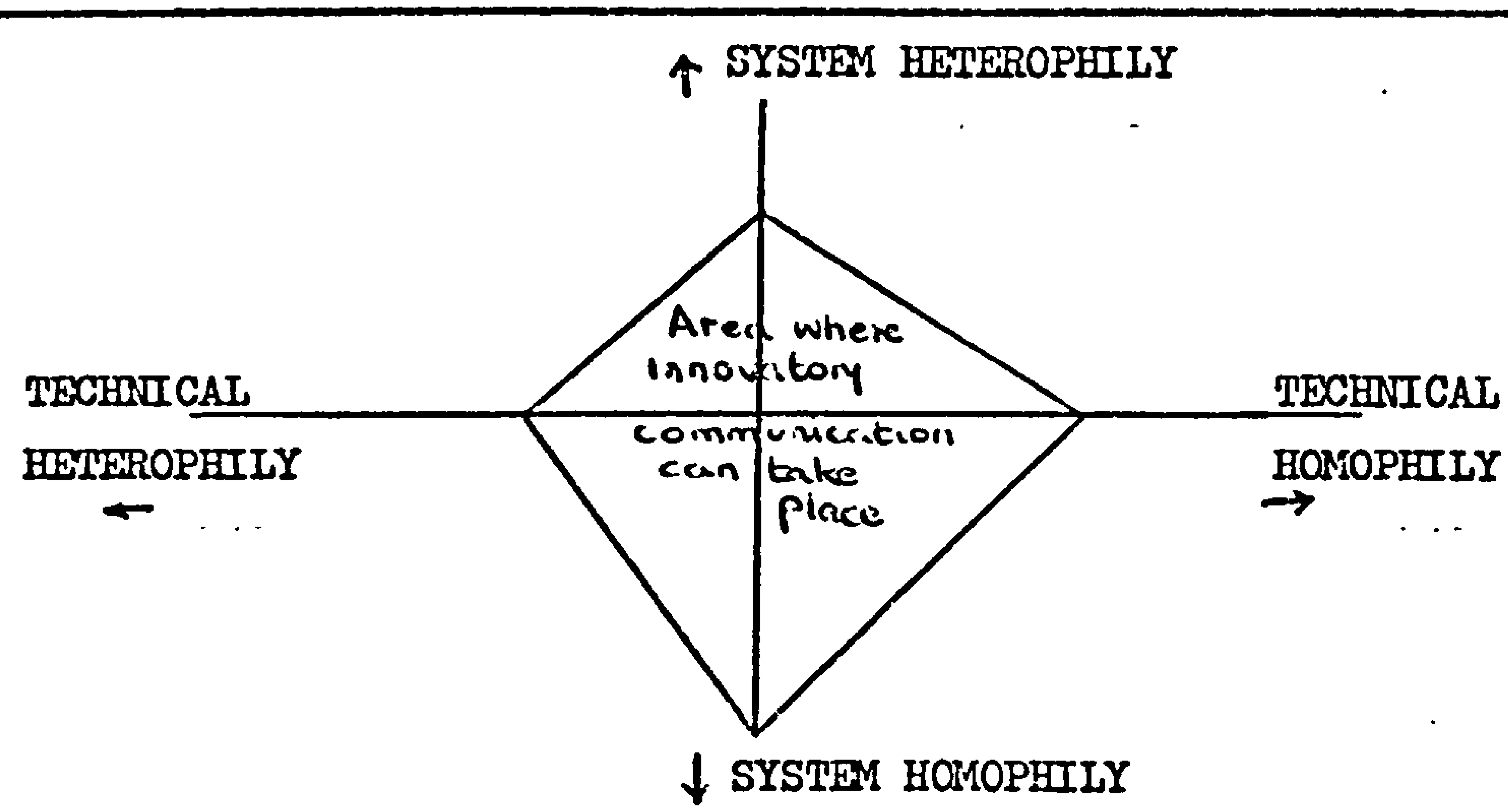


Figure 2.7 TECHNICAL-SYSTEM; HOMOPHILY - HETEROPHILY AND INNOVATION COMMUNICATION

In seeking explanations of 'what is communicated' in industrial systems (albeit in all systems) there is a need for more than the identification of homophily, it is necessary to understand the type and the nature of the communication and the source and receiver of such communications.

Even in a small, cohesive system where (technical) knowledge might be 'equally distributed' (perhaps emitting from a central source outside the system - eg a Government Agency) there still remains the problem of ascertaining the nature of 'what-is-communicated'. An explanation can be proposed by understanding the process how messages are received and interpreted. Figure 2.8 illustrates

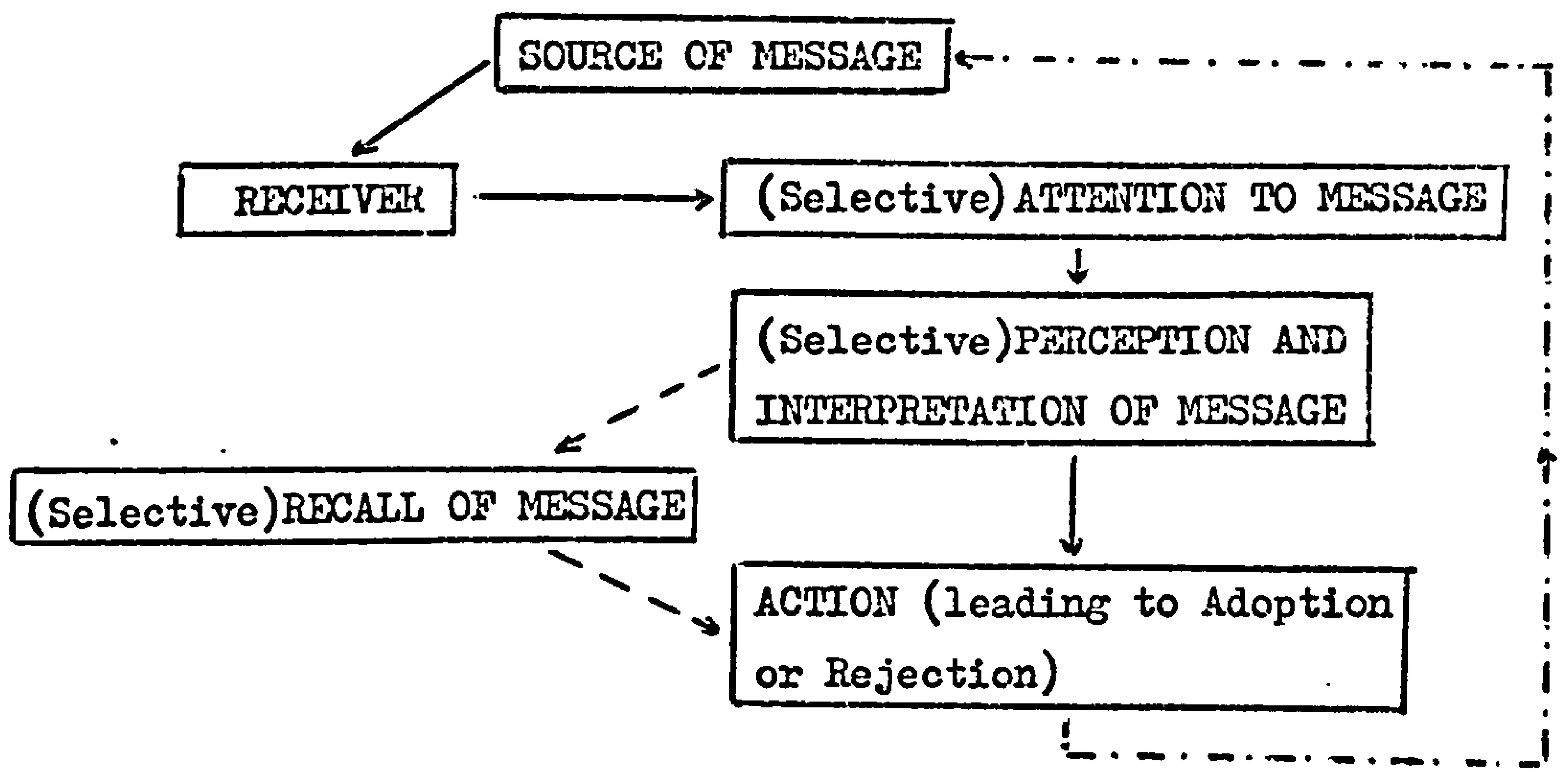


Figure 2.8 THE PROCESS OF 'WHAT IS COMMUNICATED' BETWEEN SOURCE AND RECEIVER

The message must initially attract the attention of the (potential) receiver, the appeals from the source must, in some way, be 'compatible' with the lifestyle of receiver. The receiver then interprets what is being communicated in the light of his own environment and past experiences (ie 'apperception') - for example, the 'relative advantage discussed on p.23 as a motivator for innovation is highly subjective in interpretation. It is what the receiver 'sees' is being said rather than what the source is saying, which is influential on innovatory behaviour.

Studies have demonstrated that 'what-is-being communicated' (in terms of how it is received and used by the receiver) varies as the receiver moves through the Adoption Process - generally the more impersonal the source the less the likelihood of it influencing decision-making in the later stages of the Adoption Process (2.37).

2-8 THROUGH CERTAIN CHANNELS

It has been suggested in the previous section that 'what-is-communicated' will be influenced by the channels used to transmit information. Figure 2.9 illustrates

ELEMENTS IN S.M.C.R.E. MODEL	SOURCE →	MESSAGE →	CHANNEL →	RECEIVER →	EFFECTS
CORRESPONDING ELEMENTS IN DIFFUSION OF INNOVATIONS	Inventors Scientists Change Agents Opinion leaders	Innovation & the perceived attributes such as relative advantage	Communication channels: mass media word-of-mouth	Member of a social system	Adoption/ Rejection consequences both intended & unintended & resultant behavioural change

Figure 2.9 THE S.M.C.R.E. COMMUNICATION MODEL AND CORRESPONDING ELEMENTS IN THE PROCESS OF OF DIFFUSION OF INNOVATION

The diffusion process is about 'interaction' - where one person communicates an idea which is new to a receiver and so on. At its most elementary the diffusion process is seen to consist of:- (Figure 2.10 illustrates).

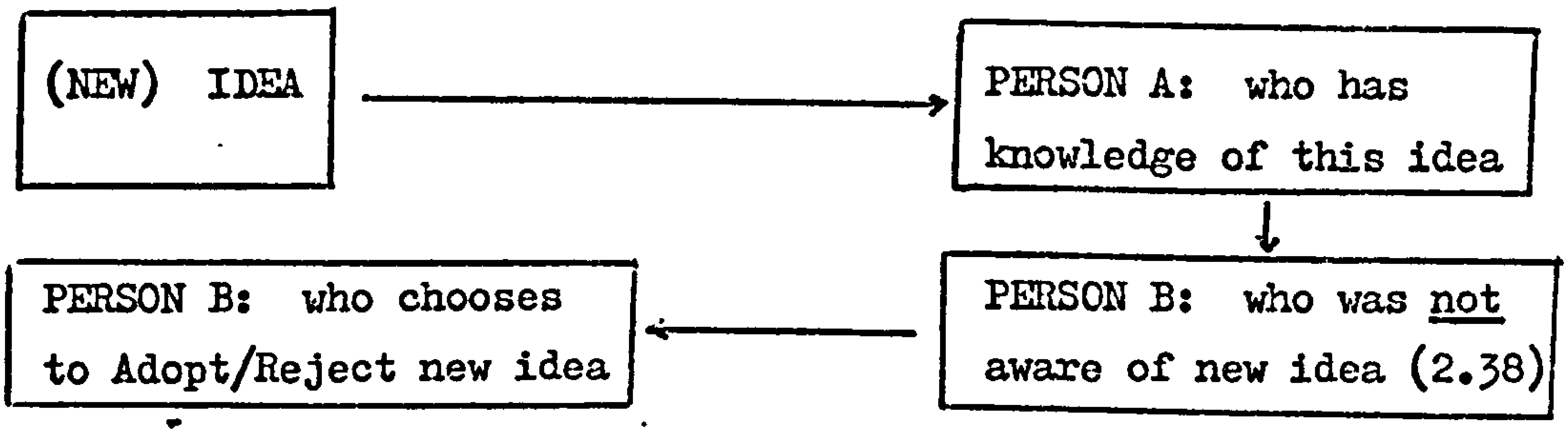


Figure 2.10 AN ELEMENTARY DIFFUSION MODEL

Those parts of the model signified by —> are the channels used to convey the message. The nature of the relationship between A and B determines the conditions under which A will or will not inform B about the new idea, and further, it influences the effect that the telling has upon B. The nature of the channel between A and B is also important in determining B's decision to adopt/reject the new idea. To a certain extent, choice of channel remains with A, but this is less so where observability (by B) of new ideas exists (for example, in industrial systems new plant/equipment cannot be concealed for long).

The channel used (and message content) tends to become more structured in more structured social systems (eg in industrial systems) though even in such systems it is too easy to underestimate the influence of informal channels; a point which will be examined at a later point. In such structured systems it becomes necessary to distinguish between the inter-firm communication network which might be highly formalised whilst an intra-firm communication network might exist predominantly only at an informal, unstructured level.

It is felt that this structuring into formalised networks is, in part, due to the nature of the innovation-decisions made in these systems. These decisions being:

(a) Optional Decisions - where the decision to innovate is optional to the individual (person or firm). These decisions will always exist in terms of an individual firm's decision to adopt or reject.

(b) Collective Decisions - where decisions to innovate become dependent upon group census. Such decisions could arise at both inter and intra firm system level; the intra-firm where group research and shared development is needed.

(c) Authority Decisions - these decisions are 'forced' upon the individual (person or firm) by 'someone' in a superordinate power position, these decisions are usually to adopt rather than reject (except perhaps where union pressure is against new innovations). Again, such decisions could result at inter and intra firm (perhaps competition pressure) level.

(d) Eco-Authoritarian Decisions - with regard more specifically to industrial/organisational systems, the pressure may be from the system itself to accept (2.39). This pressure might arise from outside the system (2.40).

(e) Contingent Decisions - these are essentially a sequential combination of two or more of the above types, namely, where there is a choice to adopt/reject which can be made only after a prior innovation-decision.

Authority decisions tend to impinge more upon the individual's freedom to innovate due to the control that can often be exerted by the authority structure of the system, usually in the form of recognisable hierarchical structures. Figure 2.11 illustrates

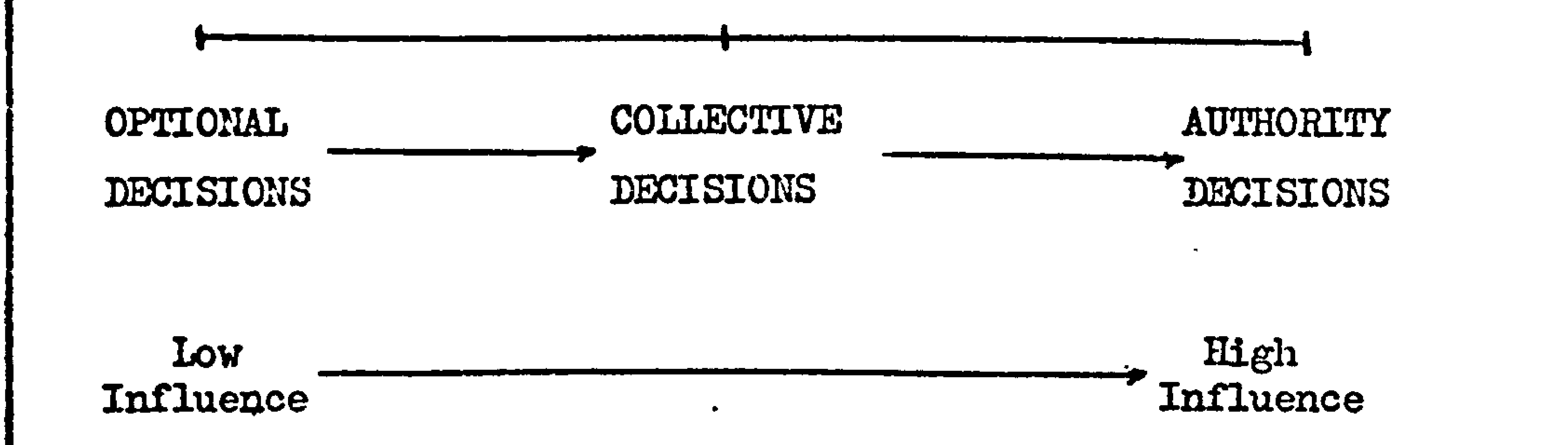


Figure 2.11 INFLUENCE OF THE ORGANISATIONAL/INDUSTRY SYSTEM UPON INDIVIDUAL INNOVATION DECISIONS

The power and legitimacy of the 'authority' will be decided by its nature - for example, Governmental pressure upon firms to innovate through investment grants (Optional), through the formation of Research Associations (Collective), or to change from solid-fuel to alternative methods of kiln-firing (by legislation - Eco-Authoritarian). Similarly the ability of the adopter unit to interpret and present its "own answer" to the decision influence-making source will tend to decrease along the same continuum.

Returning to Figure 2.10 (featured on p.31), for even the most basic of organisational communication networks this model needs modification. There tends to be two kinds of units involved in Authority-Innovation Decisions - the adoption unit and the decision making unit (ie the higher authority). Figure 2.12 illustrates

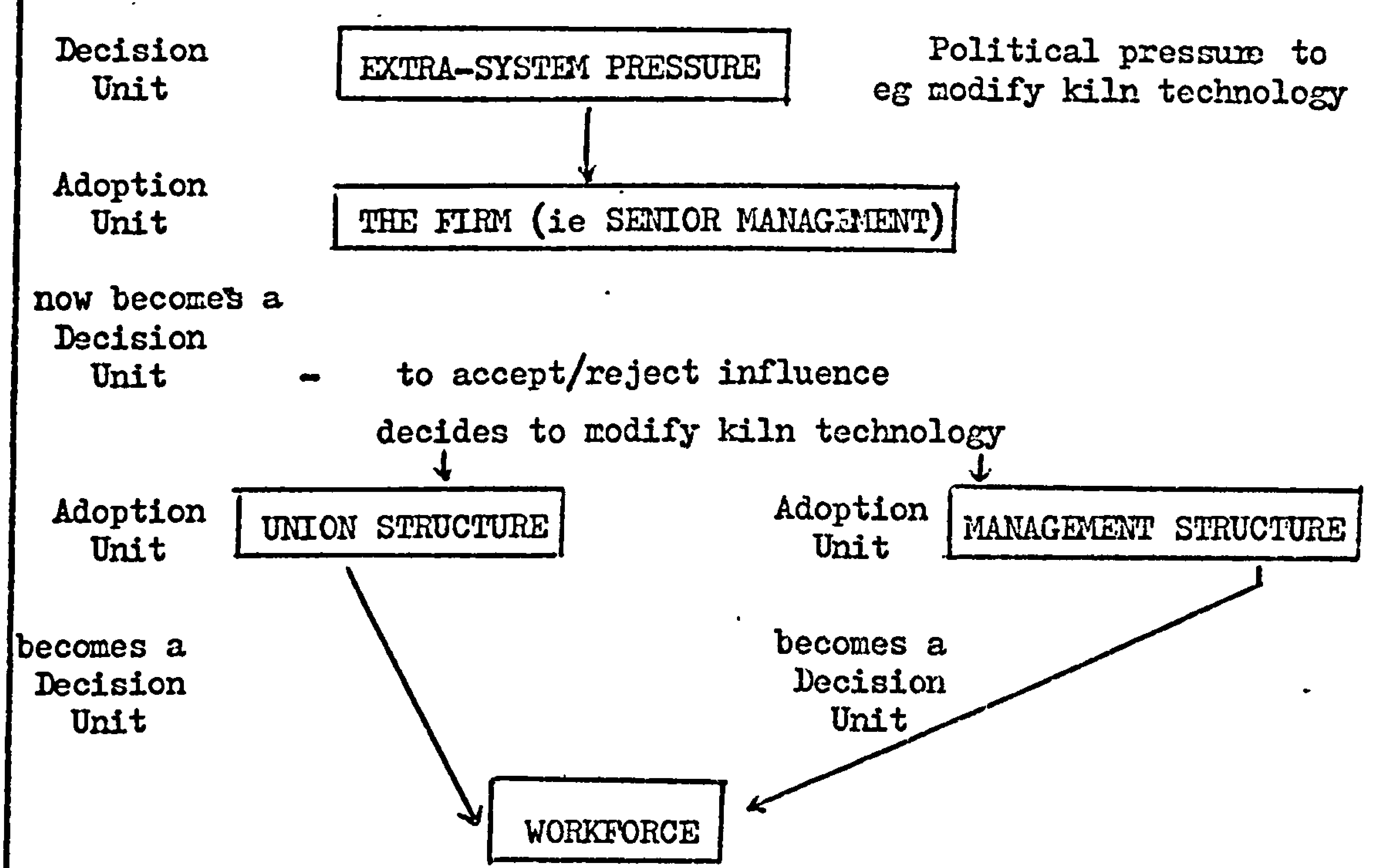


Figure 2.12 <u>ELEMENTARY ORGANISATION DIFFUSION MODEL</u> (based on Fig.2.10)

This model is constructed to provide for only one extra-system pressure; complications of competitor, customer, supplier or even 'within-firm' pressures can be added. Nevertheless, this elementary model does highlight the more involved channels of communications in industrial systems; the multiplicity of networks also suggests a problem in ascertaining 'what-is-communicated' through them. The reader will note that figure 2.12 makes no provision for the existence of informal channels, yet their recognition is often paramount in understanding how diffusion and adoption <u>actually</u> occurred - for example, the congruency of message from unions, fellow-workers and the management to the workforce. There might occur a situation where the workforce have a collective decision to innovate (mediated through the power of their Union whereas the management (eg foremen) have the innovation more or less forced upon them. Figure 2.13 illustrates

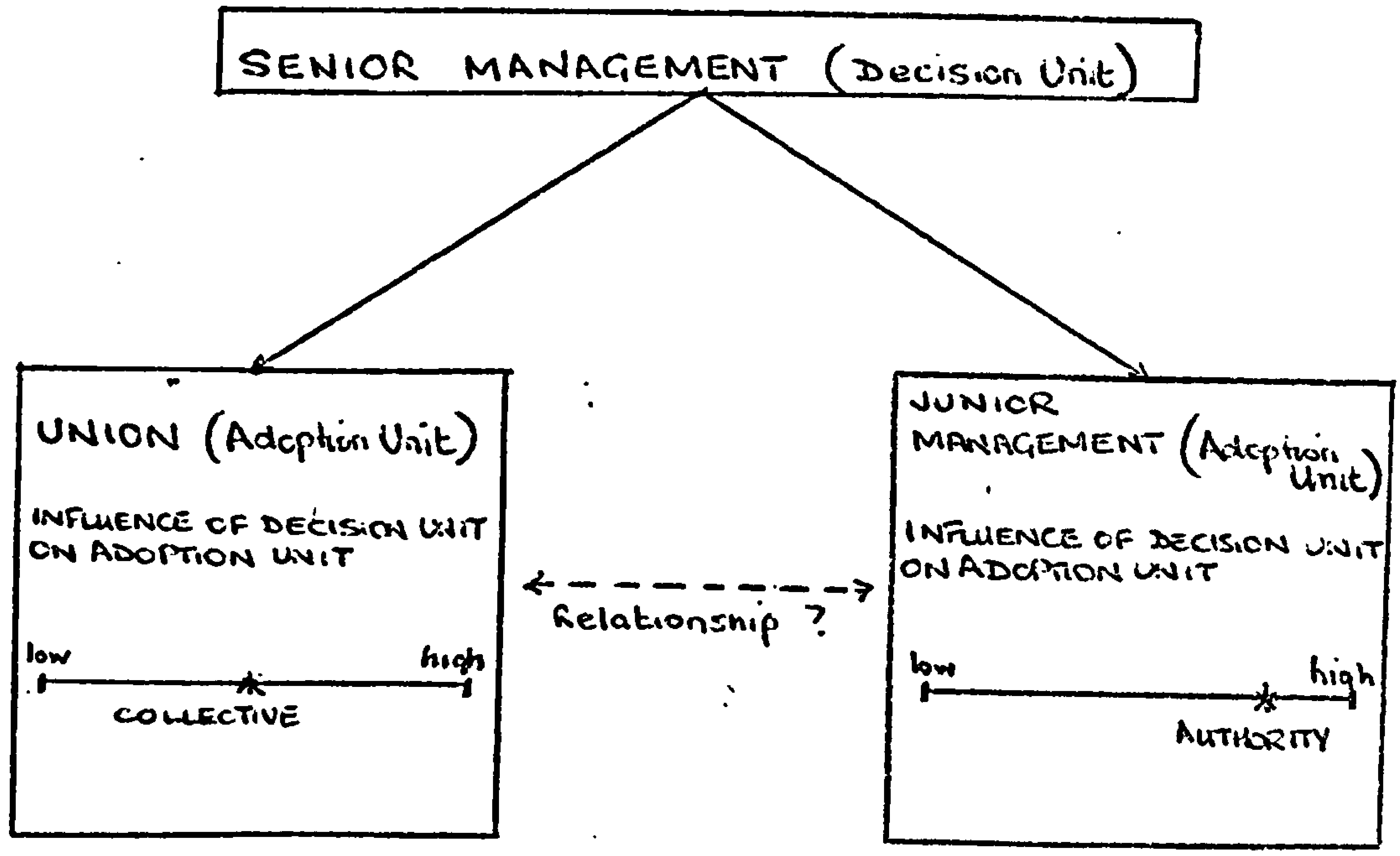


Figure 2.13 MODEL TO ILLUSTRATE POSSIBLE INCONGRUENCY OF DECISION UNIT INFLUENCE ON ADOPTION UNITS (2.41)

2.8.1. OPINION LEADERS AND COMMUNICATION

The present state of knowledge regarding communications is seen to date from the publication of a study entitled "The People's Choice" (2.42). Briefly the findings suggested:

(a) that personal contact tended to be more frequent and more effective (influential?) than mass media.

(b) re the flow of personal information, opinion leaders were more interested in the election, and opinion leaders were evenly distributed throughout each class of society and occupational type.

(c) opinion leaders were more exposed to mass media persuasion (2.43)

Fundamental though its findings were, a methodological problem was incurred - it illustrated the limitations of using random sampling of units in communication research. Each respondent only spoke for himself. Identification of leaders relied upon self-designation. There were no cross-checks made of designated opinion-leaders and followers.

The second major step forward was the 'Rovere Study' (2.44) which studied both advisors and advisees. Attention was given to three fundamental points:

(a) classification of opinion leaders

(b) study of communication patterns

(c) interaction among opinion leaders.

There followed the Elvira and Decatur Studies (2.45)

Focus moved from opinion leaders alone to the more general consideration of the relative importance of personal influence on the person naming the influencor. It was, therefore, possible to attempt validation of the self-designation technique. Certain generalisations arose from these studies:

(a) opinion leaders were influenced by other opinion leaders

(b) opinion leadership was <u>not</u> a trait. In fact he is 'granted' his status by the group at particular times in particular circumstances

(c) although it was possible to talk about various influences by various individuals, it was not possible to talk about aggregate influence unless account was taken of both the content of the decision, and the time when the decision was made.

The realisation that 'time' was a crucial element led to a rethink in research design; a rethink which became manifest in Coleman's "Drug Study" (2.46). Coleman used the total population (namely doctors within a certain area) of the social system under examination; his aims being to:

(a) establish a network of interpersonal relationships

(b) to study a specific item gaining acceptance/rejection in a social system

(c) to study diffusion over time.

When compared with the earlier studies, one can see that it sought to be more objective for two stated reasons - the realisation that the decision-maker himself, is not the only source of information and, as the rate of different influences were assessed not only on the basis of the decision-maker's reconstructinn, but also on the basis of objective correlations (between leader and follower) it was possible to draw inferences about the flow of communications.

Coleman's study introduced a new perspective of diffusion and communications research. It defined the social system before the research was carried out. It became possible for him to investigate the relevance of various points of the sociometric structure to the transmission of influence. The development of this research design has indicated the need to define the parameters of the system to be examined for three reasons:

(a) the system constitutes a set of boundaries within which items diffuse; by defining these boundaries comparative analysis of inter and extra system influences can be examined.

(b) it aids the description of major channels of person-to-person communication.

(c) it affects the distribution and differentiation of status and roles; and the characteristic patterns of interaction among occupants of varying positions.

The author notes the lack of comparative research of the same idea diffusing through different systems within the marketing area. Of considerable interest would be cross-cultural comparatives.

From the empirical work quoted evolved the idea of a 'two-step flow' in communication networks - from the mass-media to opinion leader and then opinion leader to his followers (2.47). This was a move away from what has been termed the 'Hypodermic Needle model of communication. Figure 2.14 illustrates

HYPODERMIC NEEDLE MODEL	TWO-STEP FLOW MODEL
MASS MEDIA	MASS MEDIA
↓	↓
	OPINION LEADERSHIP (SOCIAL RELATIONSHIPS)
	↓
DIRECT AUDIENCE EFFECTS	INDIRECT AUDIENCE EFFECTS

Figure 2.14 THE HYPODERMIC NEEDLE AND TWO STEP FLOW MODELS OF COMMUNICATION

Note: The Hypodermic Needle model assumed that the mass media were powerful in their effects, while the Two Step Flow model recognised interpersonal influence from opinion leaders as an important intervening mechanism between the media message and its effects.

Opinion leadership is regarded as the degree to which an individual is able to informally influence other individuals' attitudes and/or overt behaviour in a desired way with relative frequency.
The implications are a leader-follower relationship between two or more people rather than an abstract attribute or trait of an individual leader. The existence of leader-follower relationships in the diffusion process tend to assume pro-change opinion leadership yet, as Klapper pointed out, practically no research attention has been paid to the role of anti-change leaders in discouraging diffusion (2.48). Although stated sixteen years ago, the same comment could be made today. Research suggests that opinion leaders operating in modern systems tend to be pro-change and those in traditional systems to be much less so (2.49), - however, one must modify such a generalisation with regard to the influence of any particular

innovation in any particular system.

It would seem true to say that communications research during the past thirty years has profited greatly from use of the two-step flow model; with degrees of modification, it is probably the most popular framework, explicitly or implicitly, utilised in diffusion research. However, more recent works have suggested various shortcomings, especially when one seeks to consider the model in a 'time dimension'.

Six such limitations have been identified:

1. The two step flow was proposed during a period when the conception of a passive audience was widely accepted in communications research. The activity of opinion leaders was thought to provide the main thrust in initiating the communication flow. Later research suggests that opinion leaders often play both active and passive roles in the relaying of information (2.50).

2. The view that the process is 'two-step' is a limiting factor. The communication process may be one-step on some occasions, two-stepped, or a multi-stage process on other occasions. By focusing only on the two-step aspects of the process, research intended to reflect reality is severely limited (2.51).

3. The two step flow model implies a reliance by the opinion leader upon mass media channels for informational input. However, the specific channels utilised tend to be a function of such considerations as nature of message, origin and credibility of origin of message, spatial location of the opinion leader in the system (2.52).

4. The original 1940 study did not take into consideration the different channel behaviour by receivers on the basis of their time of learning about a new idea. The opinion leaders may simply be the earlier knowers of new ideas, and their dependence upon mass media channels may be a function of their early-knowing, rather than their

opinion leadership per se. Earlier knowers must necessarily depend upon mass media channels because at the time of awareness of new ideas, few of their peers in the system are yet knowledgeable of the new idea (2.53).

5. Different communication channels function at different stages of the receivers innovation/adoption decision process (2.54). Mass media channels are primarily regarded as knowledge creators/ awareness creators, whereas interpersonal channels are more important at persuading (2.55). Such channel differences at the awareness versus persuasion stages (in adoption/rejection) exist for both opinion leaders and followers.

6. An audience dichotomy of opinion leaders and followers is implied by the two step flow model, yet many 'non-leaders' are not followers of the leaders, at least not in any direct sense (2.56).

2.8.2 MEASURING OPINION LEADERSHIP

Three main methods for measuring and identifying opinion leadership have been utilised in communications research: Figure 2.15 illustrates. These being

(a) Self designatory techniques

(b) Informants ratings

(c) Sociometric techniques to trace all networks.

The most commonly used method in past research has been the self-designatory, using probability and/or non-probability data collection. Operationally the limitations include

(a) the need for a confirmatory exercise to validate and test reliability

(b) the problems of interviewer bias (where applicable), especially control of respondents self-perception (without validation). It has been suggested (Rogers) that if the individual designates himself as a leader then he is one (that is, it modifies his behaviour), however, his influence <u>in</u> a system as a leader, if his perception is not perceived by the other system units as legitimate, will be zero - perhaps even acting as a reference point for dissociation

(c) it may be that interpersonal communications (and influence) takes place without either respondent and/or leader overtly aware; imitation without an overt awareness that it has a source

(d) the discriminatory power of a self-designation type of method will vary from system to system and with a system from time to time

(e) the problems of questionnaire construction; usually the wording of a self-designation questionnaire distinguishes only between influential and non-influential, whilst there can be marked differences between the follower and the non-influenced (both of which would be designated as non-influential)

(f) Finally, in systems where system-units are themselves comprised of sub-system units (eg an organisation) there remains the problem of 'who to ask?'

Comments on the other two methods of identifying opinion leaders are illustrated in Figure 2.15 (p.42).

Assuming identification of the opinion leader, how in fact do they differ from those it is purported they lead? Research disclaims the idea of the innate 'leadership trait'; the following generalisations summarise a plethora of empirical studies designed to answer the question (2.57).

Opinion leaders demonstrate:

(a) a high degree of exposure to mass media

(b) greater social participation - ie system accessibility

(c) higher social status due to nomination by group

(d) they are more innovative than their followers.

MEASUREMENT METHOD	DESCRIPTION	QUESTIONS ASKED	ADVANTAGES	LIMITATIONS
1. SELF DESIGNATION	Ask each respondent a series of questions to determine the degree to which he perceives himself to be an opinion leader.	"Are you a leader in this social system?"	Measures the individual's perceptions of his opinion leadership, which will influence his behaviour	Dependent upon the accuracy with which respondents can identify & report their self images - or maybe their idealised self-image.
2. INFORMANT'S RATING	Subjectively selected key informants in a social system are asked to designate opinion leaders	"Who are the leaders in the social system?"	Overcomes limitations to Method 1. Cheaper & easier to perform than Method 3.	Each informant must be thoroughly familiar with the system.
3. SOCIOMETRIC TECHNIQUE	Ask system members to whom do they go for advice and information about new ideas.	"Who is your leader?"	Sociometric questions are easy to administer and are adaptable to different types of settings & uses. Have a high validity.	Analysis of sociometric data is often complex. Requires a large no. of respondents to locate a small no. of opinion leaders. Cannot be used unless total, or near total units of system are considered.

Figure 2.15. <u>COMPARISON OF METHODS USED IN OPINION LEADERSHIP IDENTIFICATION</u>

based upon Rogers & Shoemaker Op.cit. p.216.

It is of interest that past research examining the characteristics of innovators and early adopters has often generated a very similar profile to that presupposed of opinion leaders. This very substantial similarity between the empirical characteristics of opinion leaders and innovator/early adopters must lead to the question as to when can we assume opinion leaders to be innovators (and vice versa)? One researcher, Baumgarten refers to this overlap as the "innovative communicator" (2.58). Generally, research remains inconclusive as to the universality of the presence of the innovative communicator. It may be that, in specific cases, the innovator becomes the opinion leader, or the opinion leader, to preserve credibility in the group (where 'advancement' is the norm) innovates, yet this need not always be so. The power (and legitimacy to influence) of the opinion leader has its source in the group's approval to do so; a leader is judged by his competence to lead, so that where innovators are regarded with scepticism, it is hardly likely to find the opinion leader innovating. It is necessary to consider the nature of the system and of the system units and of the innovation before accepting Baumgarten's findings. Homans (2.59) suggests that leaders obtain their position of influence by rendering valuable and rare service to their system (obviously 'valuable and rare service' is open to system interpretation). Leader conformity to norms is a valuable service to the system in that the leader thus provides a living model of the norms for his followers. An individual of high status (ie leadership) will conform to the most valued norms of his group as a minimum condition of maintaining his status. How then can opinion leaders most conform to system norms, and also lead the adoption of new ideas? The answer stems from the prevailing system norms - as Arndt suggests "when the system's norms favour change, opinion leaders are more innovative, but when the norms are traditional, opinion leaders are not especially innovative" (2.60).

Returning to Lazassfeld & Merton's concepts of homophily and heterophily in communications (2.61) one can construct a model to illustrate the communication relationships between opinion leaders and followers. Figure 2.16 illustrates

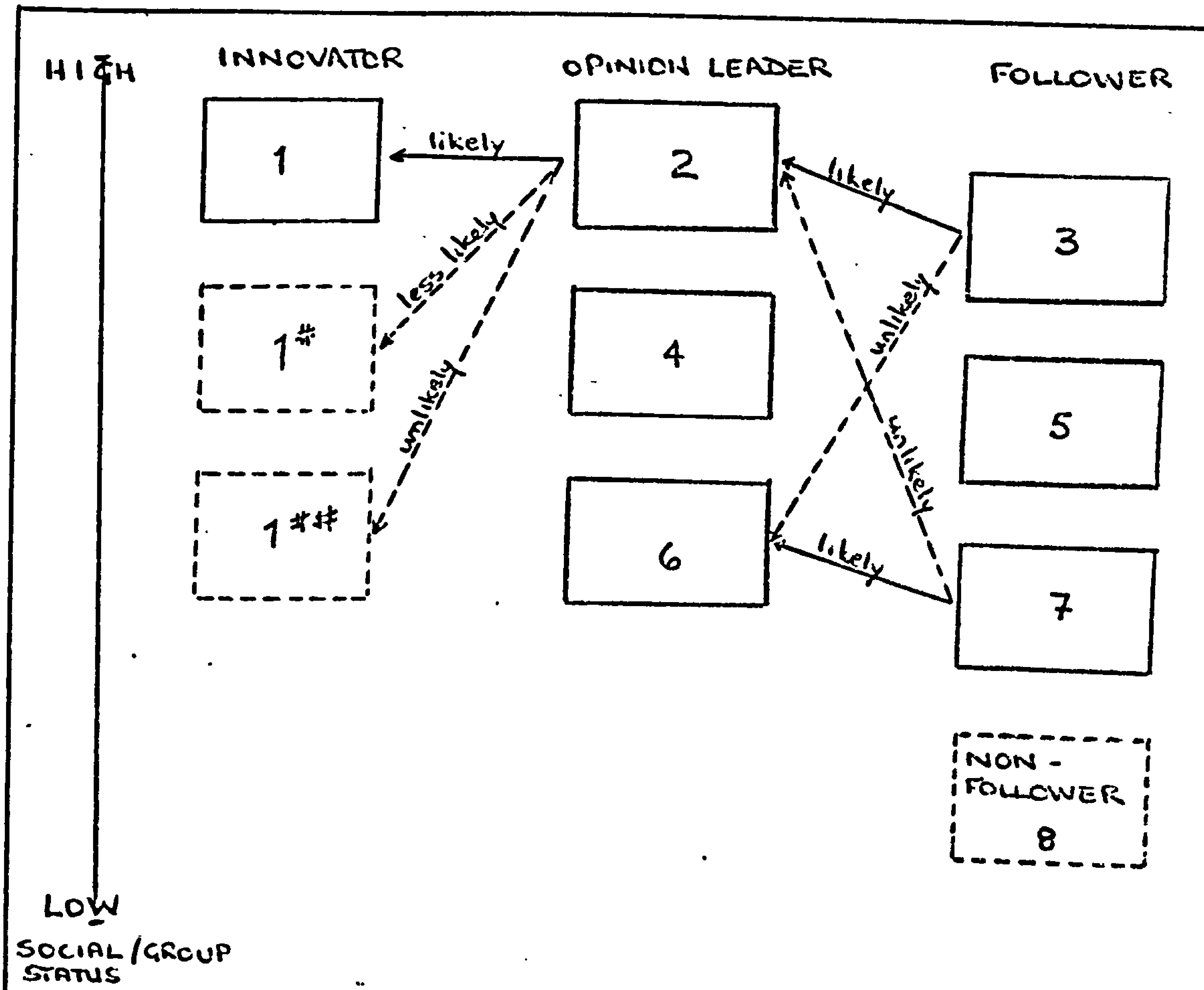


Figure 2.16 A COMMUNICATIONS MODEL TO ILLUSTRATE RELATIONSHIPS BETWEEN INNOVATORS, OPINION LEADERS & FOLLOWERS

The model suggests that most interaction between innovators, opinion leaders and their followers occurs between homophilous dyads, but that often opinion leaders are of slightly higher social status and/ or more technically competent than their followers. The innovator, depending upon the system, remains difficult to classify in terms of social status - the innovator may,indeed, not belong to the same system as the opinion leader (expressed in membership terms) - the opinion leader may seek his 'sources of new ideas' from outside his system, interpret these ideas and so filter them into his own system (eg industry) (2.62). One might propose that 'Follower 3' might be the opinion leader for 'Opinion Leader 4' and so on; this would lead to the formulation of the widely held diffusion of innovation categorisation (2.63).

There is a need to include in a discussion of opinion leadership the role of the 'change agent' in the communication of new ideas. A Change Agent has been defined as "a professional who influences innovation-decisions in a direction deemed desirable by a change agency" (2.64). In most cases he is seen as seeking to secure the adoption of new ideas, but he may also attempt to slow down diffusion and prevent the adoption of certain innovations. The role is one of a communication link between two or more social systems - this need not always be so if a system has its own, separate innovation generating force (eg industrial research associations). Figure 2.17 illustrates two possibilities.

In general research on the role of change agents in the diffusion process has been restricted primarily to sociological and anthropological studies of the introduction of new agricultural/medical/health/educational methods into traditional societies, and little has been carried out in examining the possible effects of change agencies/change agents in industrial systems; yet marketing, as an area of study dictates attention to customer requirements, and change agencies through the usage of change agents, seek to provide these requirements (eg consultants, research bodies, supplier firms etc).

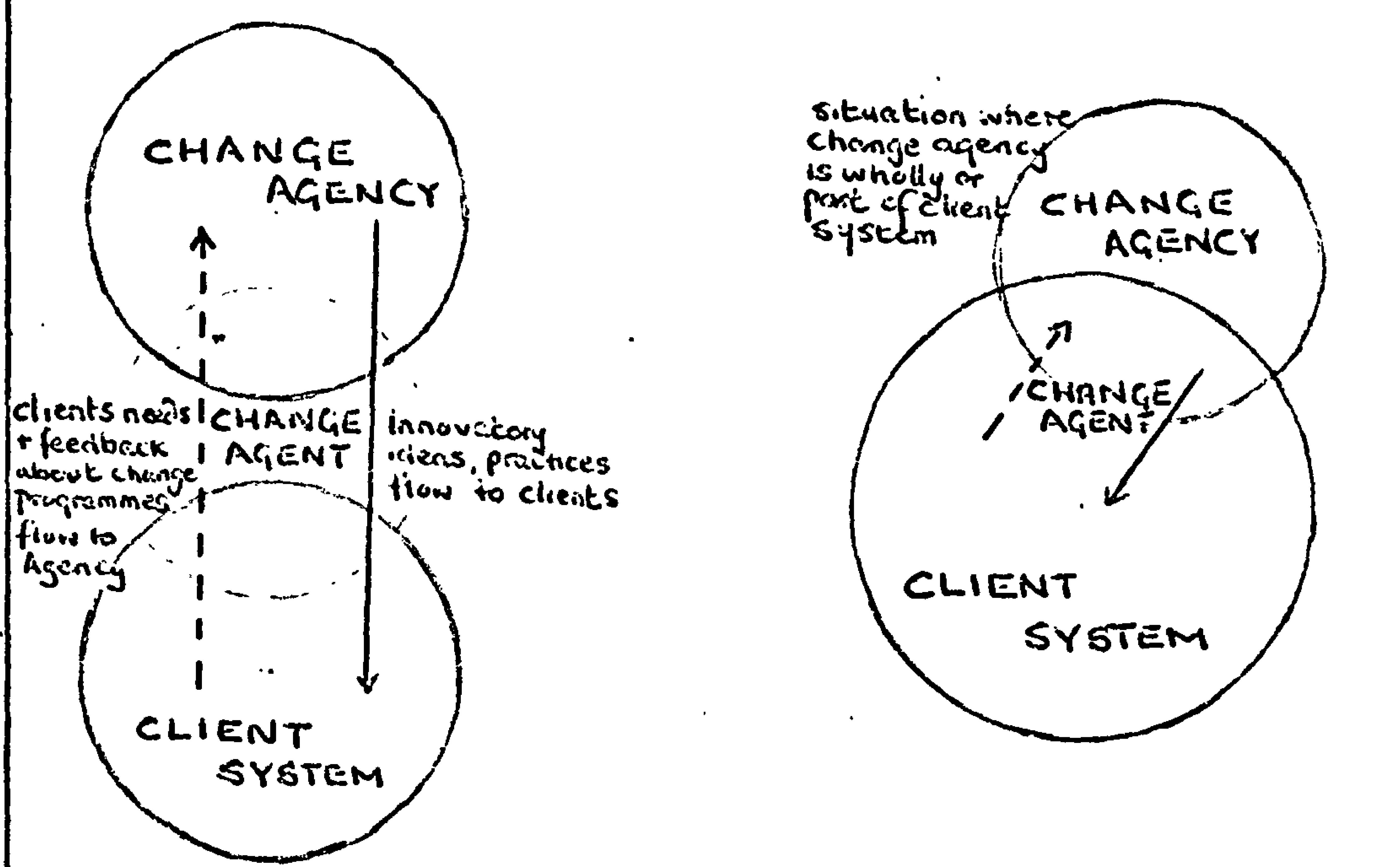


Figure 2.17 <u>CHANGE AGENTS PROVIDE LINKAGES BETWEEN CHANGE AGENCIES AND CLIENT SYSTEMS</u>

Some research has been carried out to guage the relationship between change agent effort and the diffusion of innovations: Figure 2.18 illustrates this relationship based upon research data from two studies (2.64): stage 1 suggests that initially the change agent's efforts do not result in a proportional number of adoptions (2.65); in stages 2 & 3 as opinion leaders (and later followers) adopt one sees a climb in the rate of adoption under the system's own impetus and the efforts of the change agent is seen to retire from the process (2.66).

Effectiveness of change agents (and their agencies, although client perceptions may differ between the two) will depend upon client/system credibility - the perceived credibility by those whom the change agent is trying to influence.

It may well be that the change agent and opinion leader are synonomous, in which case change is most likely. However, where they

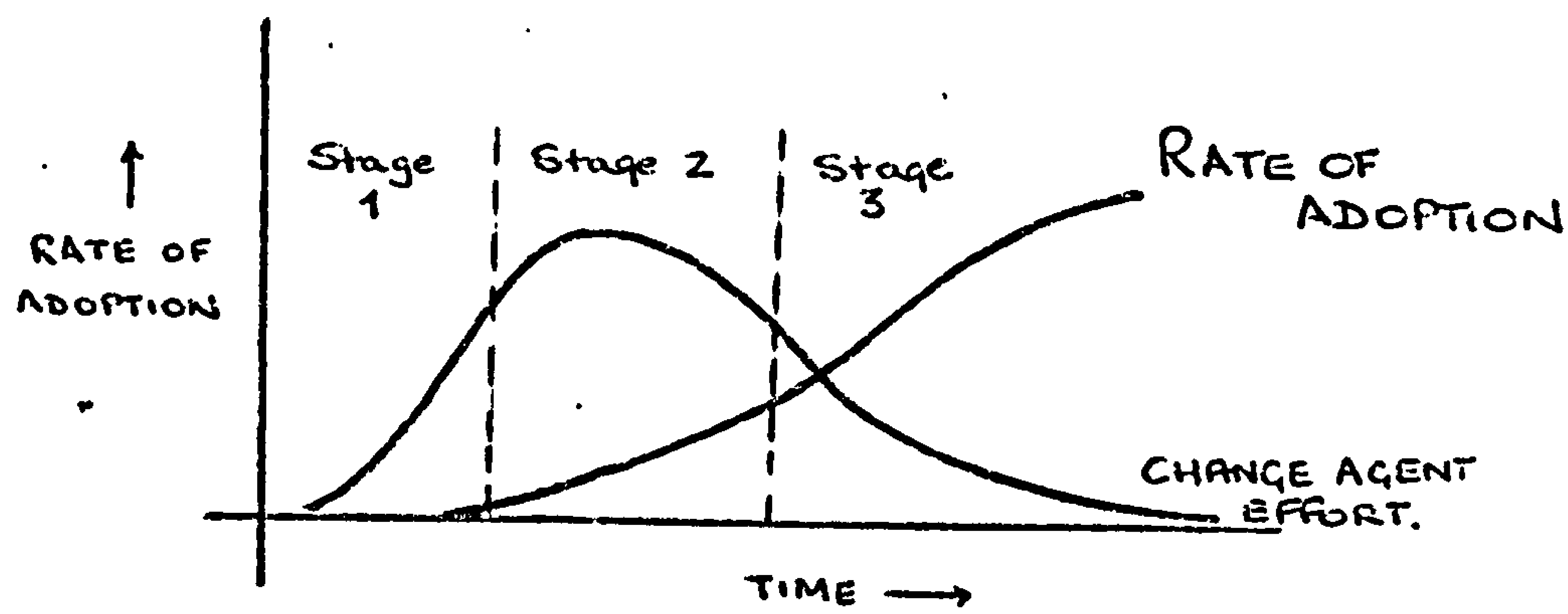


Figure 2.18 EXTENT OF CHANGE AGENT EFFORTS AND THE RATE OF ADOPTION OF AN INNOVATION

are not so, then conflict in affecting change is possible; a within-system change agent will probably command a higher level of credibility.

In conclusion, one finds that most channel studies have been based upon the recall ability of respondents; the methodology used is much in need of refinement. Katz and others have been highly critical of past research on channels .... "If there is any single thing wrong with contemporary studies of diffusion...(it) is that there is too much emphasis on channels. The typical design for research ... has been based, almost exclusively, on the assumption that people can be asked to recall the channels of information and influence that went into the making of their decisions to adopt an innovation" (2.67). Considering the channel alone is insufficient to explain behaviour of importer and receiver in the innovation decision process - examination of message, system, innovator and innovation itself are fundamental to further understanding of this process.

2-9 OVER TIME

"Time is the key to diffusion research" so expounded Katz (2.68). The time dimension is involved in:

(a) the innovation decision process by which an individual passes from first knowledge of the innovation through its adoption or rejection

and

(b) the innovativeness of the individual - that is, the relative earliness/lateness with which an individual adopts an innovation when compared with other members of his social system and the innovations rate of adoption in that social system - usually measured as the number of members of the system that adopt the innovation in a given time period.

Yet there seems to have been varied consideration of the time variable in diffusion research designs (primarily it would seem due to the methods of data collection used). Studies have relied upon recall, past records and/or 'influence' to record the time of adoption and rejection. It is only some past research designs (eg the Drug Study) which have attempted to study the moments in time of adoption.

2.9.1. THE INNOVATION DECISION PROCESS (THE ADOPTION PROCESS)

The first dimension, outlined above, is most often referred to as the Innovation-Decision Process (or the Adoption Process) - the mental processes through which an individual passes from first hearing of a new idea to final adoption/rejection of that idea. In terms of previous research designs there has been established some measure of agreement as to the stages in this adoption process

VIZ:

Ryan & Gross — Awareness, Conviction of Usefulness, Trial,
Acceptance, Complete Adoption.

Wilkening — Awareness, Obtaining Information, Conviction and Trial, Adoption.

Beal, Copp & Rogers — Awareness, Interest, Evaluation, Trial Adoption.

Holmberg — Availability of Innovation to the Individual, Awareness, Interest, Trial, Evaluation, Adoption, Integration of innovation into individual's routine.

Taking the most common elements to each researcher they are:

Awareness — the individual is exposed to the innovation but lacks complete information about it and he is not yet motivated to seek further information. Researchers saw the primary function of this stage as to initiate the sequence of later stages that led to the eventual adoption or rejection of an innovation. Some researchers have conceptualised this stage as a random or non-purpose occurrence; that is, the individual becomes aware of the innovation quite by accident, he cannot seek out an innovation which he does not know exists. Reynolds (2.69) suggests this 'innovation oriented' beginning to the adoption process is only one possible beginning; he suggests that the adoption process may be conceptualised as having a 'problem-oriented' beginning — "I felt that I needed to change my credit operations. I later heard about the bank charge account plan and recognised that it would be a way to change my credit operation" (2.70). Hassinger argues still further, that awareness must be initiated by the individual and is not a passive act — he must have a problem or a need that the innovation is perceived as being able to solve.

Interest — the individual has become interested in the new idea and seeks additional information about it. It is implicitly assumed that he 'favours' the innovation in a general way, but he has not yet judged its utility in terms of his own situation. He now embarks on seeking information about this innovation. His own personality and values, interacting with the norms of his social system may affect 'where' he seeks this information, as well as how he then 'interprets' this information about the innovation.

Evaluation — he now mentally applies the innovation to his present and anticipated future situation, and then decides whether to try it or not. Innovation carries a subjective risk to the individual (in terms of social prestige, profitability for the firm) and this stage tends to focus upon the individual using reference points upon which to evaluate its worth to him (eg friends, competitive firms). Where the individual can identify others using this innovation (he being somewhat after the 'innovators' in the diffusion process) the risk element is considerably less than with the innovator/early adopter who can recourse to far fewer reference points.

Trial — this stage involves use of the innovation on a small scale, in order to determine its utility in his own situation. The main function of this stage is to demonstrate the new idea and to determine its usefulness for possible complete adoption. In many instances this trial stage is not possible; eg the adoption of a new industrial process may have to be on an "all-or-nothing". However it is possible to introduce computer simulation of a situation which can aid this 'trial' stage.

Adoption — the individual now decides to continue the full use of the innovation. Adoption implies continued use into the future. Research has tended to end here without probing scales of continued adoption and the reasons for discontinuance, possible readoption or replacement adoption.

In all of these studies the dynamics of the adoption process are implicit; sequential steps are assumed, with no defined time period per sequence. Similarly, implicit (or at times not implied at all!) is the provision for a 'non-adoption process. Figure 2.19 illustrates

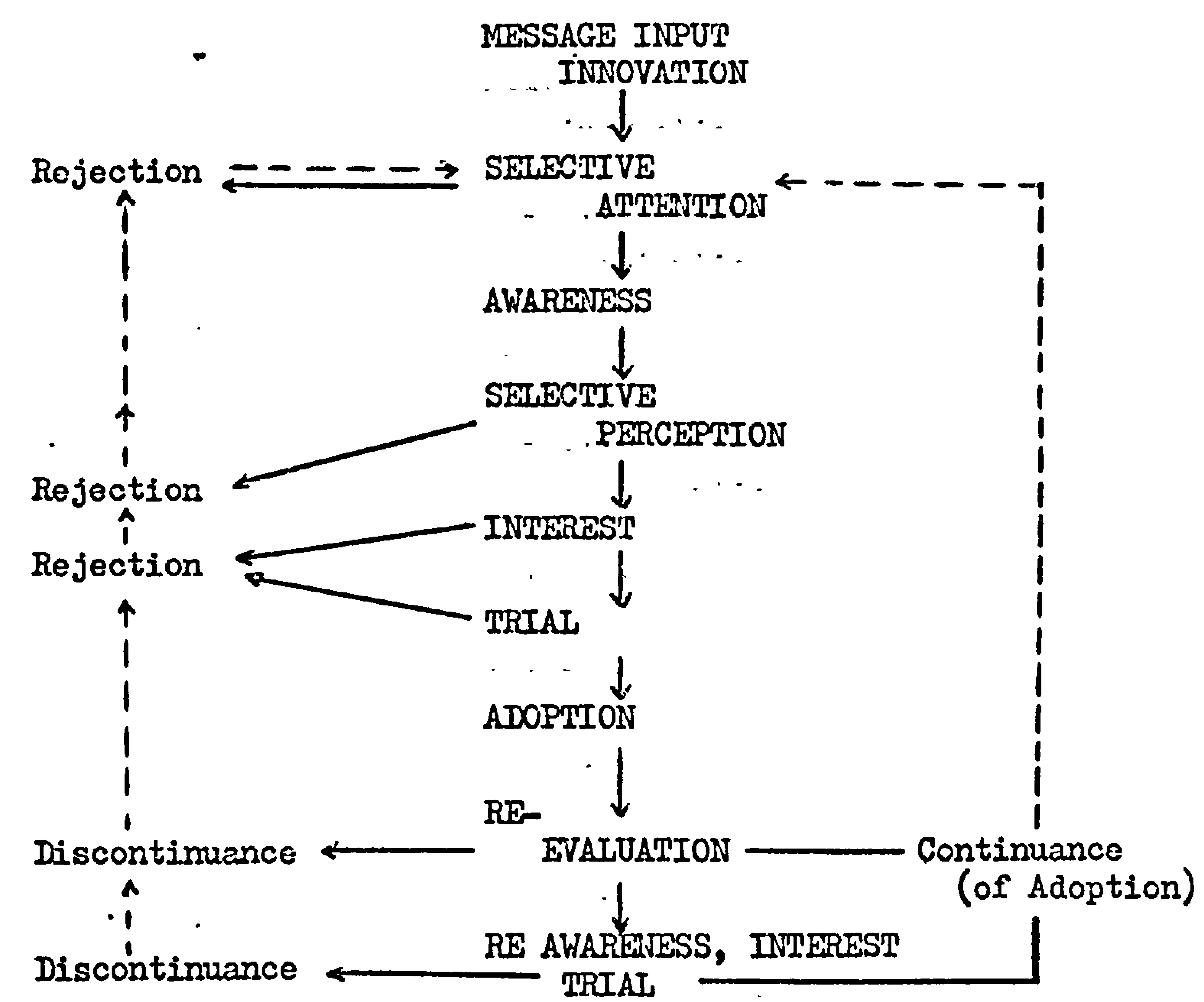


Figure 2.19 EXAMINATION OF THE NON-ADOPTION PROCESS

One research study suggested that it had established empirical proof that adoption stages existed as realities - as conscious processes of the individual (as reported by the individual) (2.71). An inherent weakness in this study is the reliability of the recall data - especially seeking recall of mental processes during the evaluation stage (2.72). This problem is minimised where the evaluation and trial stages are more of a 'mechanical process'; for example, using financial analysis techniques to guage feasibility of new capital, though subjectivity of interpretation of data will still remain.

In 1971 Rogers (and Shoemaker) moved from his original five stage adoption process "because our present model of the innovation-decision process makes provision for rejection as well as adoption decisions, and allows for post-decision communication behaviour, which usually reinforces the original decision, but may lead to its reversal. The present model is conceptually linked to the notions of decision making, the learning process and dissonance reduction" (2.73).

His reappraisal was as follows: Figure 2.20 illustrates:

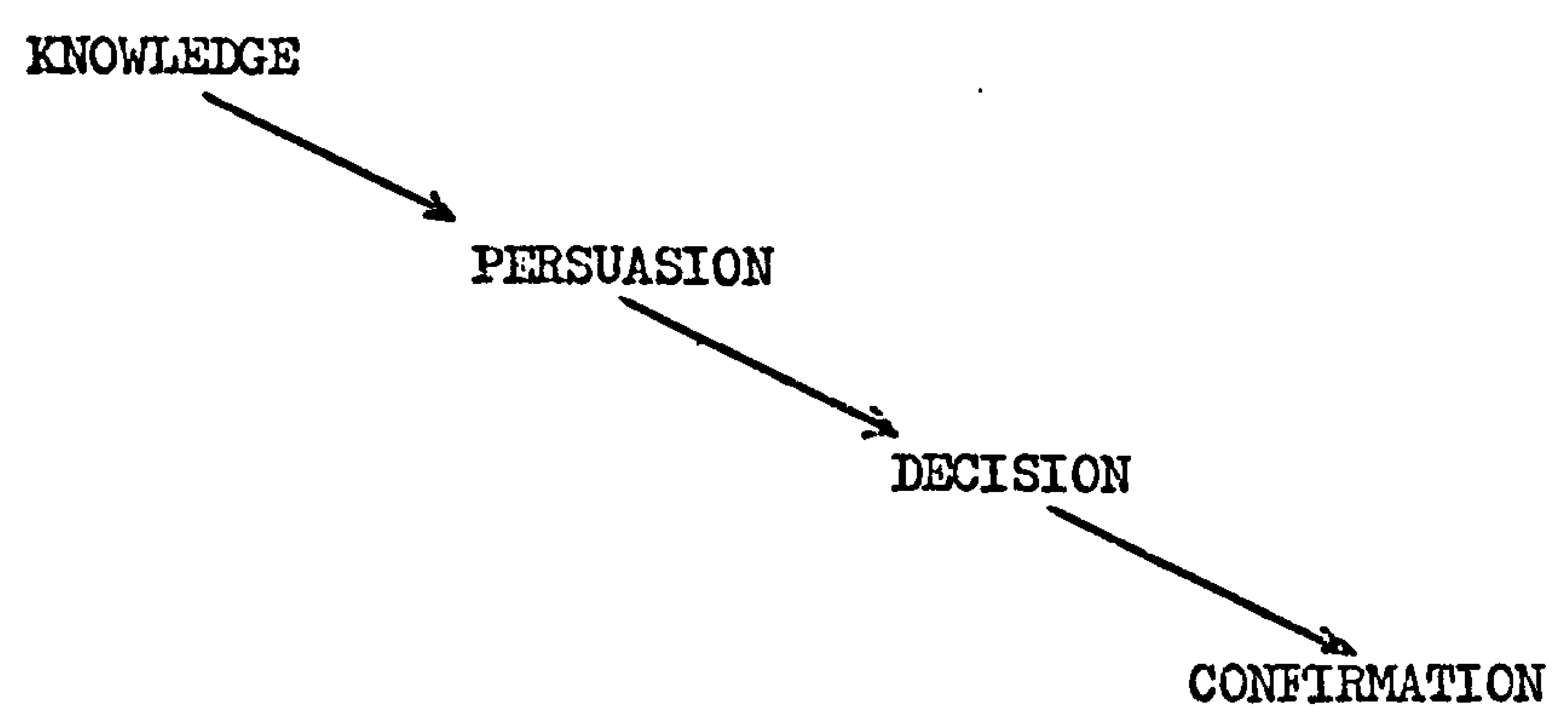


Figure 2.20 THE ADOPTION PROCESS (Rogers & Shoemaker post 1971)

The stages being described as follows:-

Knowledge — where the individual is exposed to the existence of the innovation and gains some understanding of how it functions

Persuasion — the formation of a favourable or unfavourable attitude towards the innovation

Decision — this stage occurs when the individual engages in activity which lead to a choice to adopt or reject the innovation

Confirmation — occurs when the individual seeks reinforcement for the innovation-decision he has made, but he may reverse his previous decision if exposed to conflicting messages about the innovation.

Of more apparent application to industrial systems is the 'collective innovation decision making process' (defined as involving more than one person (suggested by the research of Beal and John (2.74)). Figure 2.21 illustrates. This model evolved from research into

STIMULATION ↓	of interest in the need for the new idea by stimulators - can be from within or outside the system
INITIATION ↓	of the new idea in the social system - by "iniators"
LEGITIMATION ↓	of the idea - by powerholders or "legitimisers"
DECISION ↓	to act - by members of the social system
ACTION I ↓	or execution of the new idea
ACTION II	to continue/discontinue usage of new idea.

Figure 2.21 <u>PARADIGM OF THE COLLECTIVE INNOVATION DECISION MAKING PROCESS</u> (based on Beal & John study)

community decision making, but has been widely supported (eg by Rogers Beal & Bohlen) as being applicable to most other types of collective decision making situations - viz. bureaucracies, industrial organisations, etc.

For operational reasons, the length of the innovation decision period is usually measured from first knowledge until the decision to adopt or reject, although in a strict sense it should perhaps be measured to the time of confirmation. However, the problem remains that the confirmation function may continue over an indefinite time period. For example, the Iowa Study (2.75) can be depicted as follows (Figure 2.22 illustrates):-

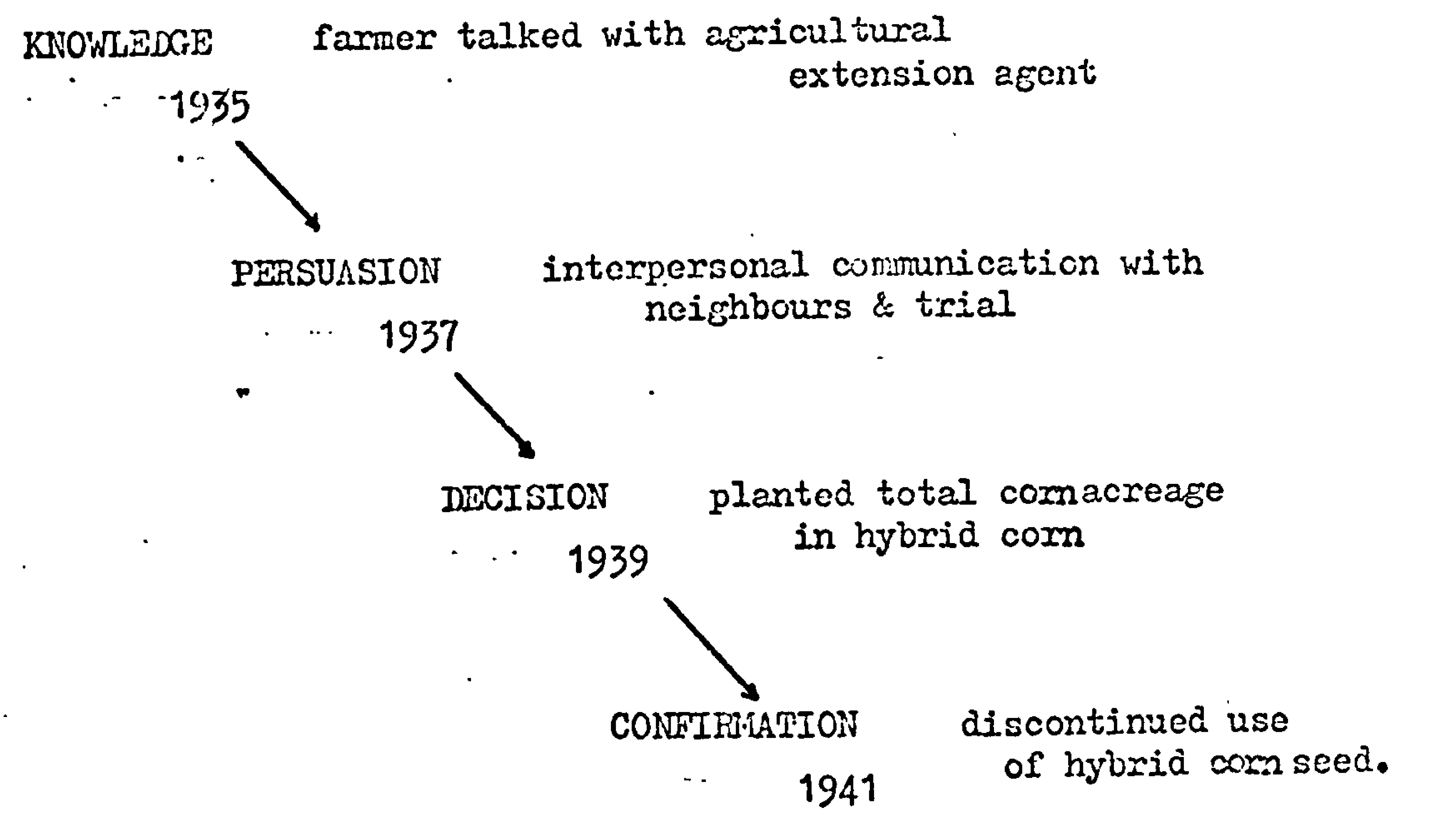


Figure 2.22 <u>TIME SCALE OF IOWA STUDY</u>

In industrial systems (as in particularly all systems with modern norms) as one innovation becomes standard practice, so it becomes prone to being superceded by a 'new' innovation. Figure 2.23 illustrates this process.

TIME PERIOD →

	t	t+1	t+2	t+3	t+4	t+5	t+6
FIRM A PRODUCT A	STIMULATION	INITIATION	LEGITIMATION	DECISION	ACTION I	--------→	ACTION II --
FIRM A PRODUCT D			STIMULATION	INITIATION LEGITIMATION	DECISION	--------→	ACTION I →
FIRM B PRODUCT B		STIMULATION	INITIATION	LEGITIMATION	DECISION	ACTION I	-------→
FIRM C PRODUCT C			STIMULATION	INITIATION LEGITIMATION	DECISION	----→	ACTION I →

Figure 2.23 <u>INNOVATION SUPERCEDES INNOVATION</u>

The model outlined above shows three producers each engaged in their own innovation decision process.

Firm A is first into the market in time period (t+4) although recognition of a market need was made in (t+1). The time lag between 'stimulation' and 'Action I' (and indeed Action II) will vary considerably from system to system.

Firm B, aware of development at Firm A achieves arrival at the market in (t+5), whereas Firm C, although assisted by the knowledge of its competitors' strategies, is not able to achieve a comparable product until (t+6).

Meanwhile, the innovator (Firm A), learning from its own behaviour, and from the competition, is 'stimulated' in (t+2) to consider possible improvements to the earlier product (ie Product A); the decision to act is taken in (t+4) and the new model (Product D) is introduced in (t+6) and supercedes Product A which is phased out.

Whilst this model depicts a common enough occurrence of product planning in both consumer and industrial markets, it does pose a fundamental problem to the diffusion researcher. By introducing 'time' into the diffusion process, the problem returns as to the establishment of what constitutes an "innovation", and at what point in time did it begin? From the model - is product B the same as Product A; is it a modification; or even an innovation in its own right? The problem is in defining identifiable watersheds in the development of innovations (2.76)

2.9.2 CLASSIFICATION OF ADOPTERS (THE DIFFUSION PROCESS)

The second dimension of time is in its use as a 'classificator of innovativeness' - for example, in figure 2.23 firm A innovated before firm B and so on. This form of classification in diffusion research is called 'adopter categorisation'. Adopter categories are the classifications of members of a social system on the basis of their relative propensities to innovate. The most commonly used being:- innovator, early adopter, early majority, late majority and laggards (2.77).

Rogers proposed five ideal-type adopter categories, although he accepted that there were no pronounced 'breaks' in the innovativeness continuum among each of the five categories ...

(a) Innovator (venturesome) — observers have noted that venturesomeness can be almost an obsession with innovators; their eagerness being to constantly develop and try out new ideas. This interest leads them out of a local circle of peers and into more cosmopolite social relationships.

Being an innovator is seen to require prerequisites - the control of (substantial) financial resources to absorb the loss of an unprofitable innovation; the ability to absorb, understand and apply possible complex technical knowledge; and, the willingness to accept social risk and prestige. As such, the innovator is a risk taker.

(b) Early Adopters (respect) — early adopters are a more integrated part of the local social system than are innovators. It has been suggested that it is these adopters who demonstrate the greatest degree of opinion leadership in most social systems; with potential adopters looking to them for advice and information about the innovation. Because early adopters are not too far ahead of the 'average' individual in innovativeness, they serve as a role-model for many other members of a social system; the continuance of such a role depends upon the maintenance of such a 'credible source' within the system.

(c) Early Majority (deliberate) — the early majority adopt new ideas just before the average member of a social system. The early majority's unique position between the very early and the relatively late to adopt, makes them an important link in the process of legitimising innovations... "they follow with deliberate willingness in adopting innovations, but seldom lead" (Rogers).

(d) Late Majority (skeptical) — the late majority adopt new ideas just after the average member of a social system. Adoption may be both an economic necessity and the answer to increasing social pressures. The weight of public (system) opinion must definitely favour the innovation before the late majority are convinced; it is the pressure of other system members which is seen as motivating this group to adoption.

(e) Laggards (tradition) — laggards are the last to adopt an innovation; they hold a perception of 'what-was' rather than 'what-is' or 'what-might-be'. Some researchers have tended to include in this group Non-Adopters, because they show similar behavioural traits regards adoption.

The inadequacies of a meaningful research tradition are no more apparent than in the failure to achieve a standardisation of nomenclature for these adopter categories (2.78). Are Rogers' "innovators" synonomous with "pioneers" (Ross 1958), "progressists" (Chaparro 1955), "parochials" (Carter & Williams 1957) or "opinion leaders" (Katz & Lazersfeld 1940)? It seems accepted that segmenting adopters can provide a conceptual convenience, whilst viewing adoption along a time continuum. However, what does seem to exist, is the problem of circular reasoning. The general practice is to categorise given groups of adopters because of their position on the time-adoption continuum. Once groups have been so classified, a search is made for common characteristics of individuals belonging to that group. Once these common denominators have been established, other individuals possessing these characteristics are labelled as belonging to a particular adopter group. One might suggest an answer might be not a statement that given individuals possess given characteristics, but an understanding 'why' they possess these characteristics.

Robertson suggests that the boundaries should be placed where there is a "distinct change in the characteristics of the individuals so categorised" (2.79).

Petersen proposed a method whereby categories could be formed on the basis of time of adoption alone. He suggests that any categorisation technique should mirror the categories which actually exist in the empirical distribution and should not force this data into a preconceived number of categories, or into a preconceived distribution form. The aim of his technique is to form categories by maximising the between-group differences and minimising the within-group differences. However, Petersen himself highlights the problem of his approach - the optimal number of categories "does not consider either the theoretical aspects nor the reliability of the categories derived" (2.80).

Midgley (2.81) suggests that within each category of adopters three distinct types (regarding possible future communications) can be identified:

(a) Favourables — those who have tried the idea and who will communicate favourable experiences of it should the situation arise

(b) Rejectors — those who have tried the idea, found it deficient and will communicate unfavourable experiences of it should the situation arise

(c) Passives — those who have tried the idea, may or may not have rejected it, but who do not communicate their experiences of it.

As an innovation is introduced to a system it is the early adopting 'favourables' who are responsible for the spread of the idea (at least in terms of interpersonal communication) - Coleman calls this the 'contagion effect' (2.82). The 'passives', having adopted, will retard this 'spreading' of the idea, but not in terms of actually giving of unfavourable communications regarding the new idea. It is the 'rejectors' who, using the same channels as the 'favourables' - Whyte's 'web-of-word-of-mouth' (2.83) can seriously retard future adoption where their opinion is viewed as legitimate by those to whom they communicate. Two methods of categorisation have been used by diffusion researchers:

1. Categorisation by 'objective' placement (by experts): where expert judgement is utilised, based upon past experience, to rank individuals, firms etc in terms of innovativeness. This method is often a valuable aid to the second method used, primarily as a validatory tool.

2. Categorisation by Time of Adoption: the resultant diffusion curve will always demonstrate 'normality' because this form of categorisation uses a rigid form of ranking, namely (2.84):

the first 2½% of adopters are Innovators

next 13½% are Early Adopters etc.

Figure 2.23 illustrates:

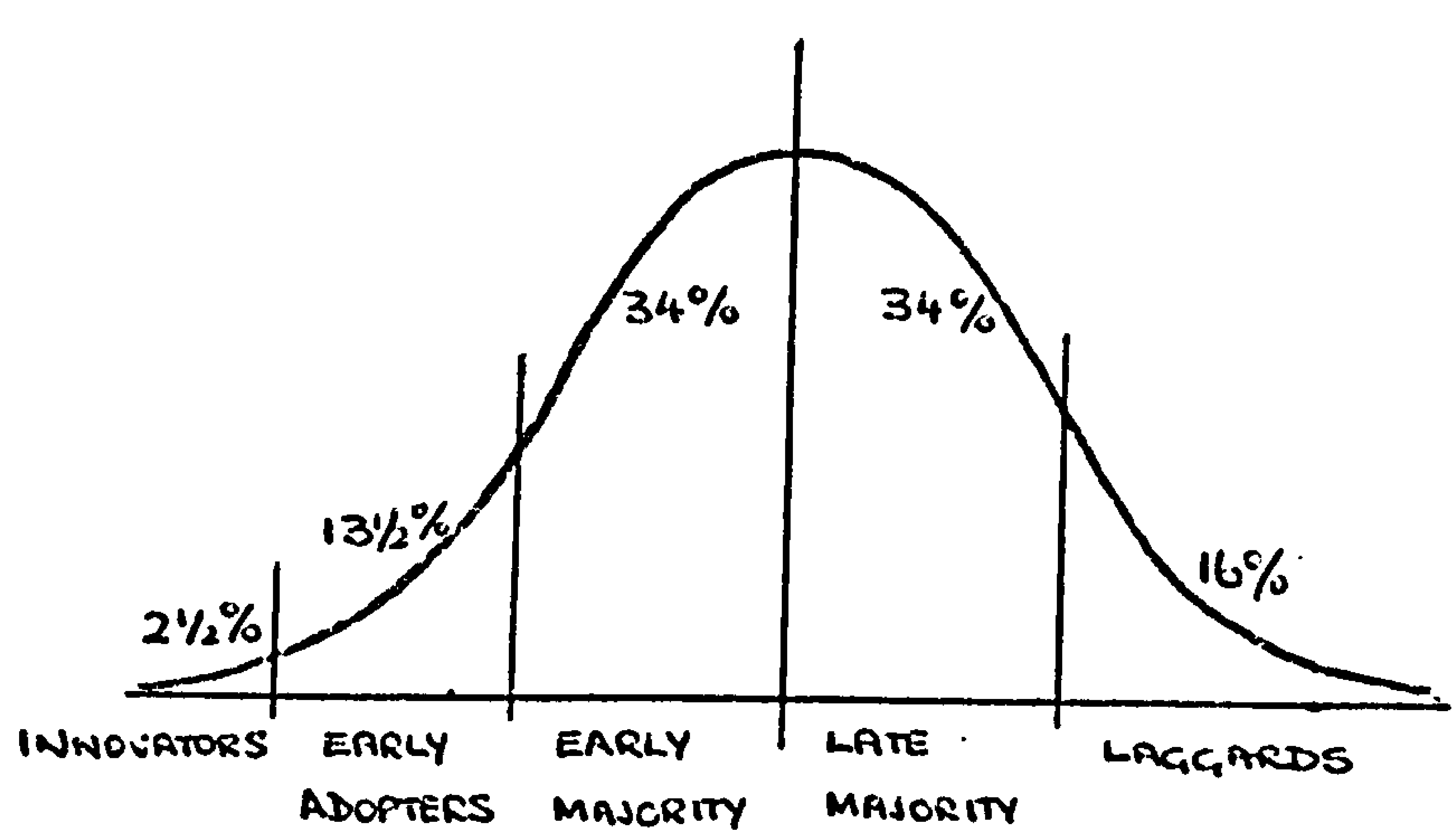


Figure 2.23 ADOPTER CATEGORISATION ON THE BASIS OF INNOVATIVENESS

The model as proposed by Rogers assumes that the rate of adoption of a new product exhibits a normal distribution with respect to time. The adoption distribution is described as:-

$$dQ = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-(t-\mu)^2}{2\sigma^2}\right] dt$$

where

dQ : the number of new adopters averaged over a period dt at time t.

σ : standard deviation of time

μ : time at which 50% potential adoption is achieved.

t : time period.

Whilst this model can be fully specified when the parameters are known, in practice these parameters can only be calculated <u>after</u> the adoption/diffusion process has taken place; that is, the usage of this model is limited to the application of historical data rather than as a predictor of future innovative behaviour (2.85).

The most commonly noted empirical regularity with respect to diffusion over time is that of a graph "describing the course of an item's diffusion, expressed as a cumulative level of adoption at succeeding points in time, approximates an S-form" (2.86). The function used most often to generate such graphs is the logistic (2.87); the use of the logistic curve implies a contagion-type diffusion, under the assumption of homogeneous mixing within a definable, finite population, and, an adoption rate which is directly proportional to the percentages of adopters and non-adopters (2.88). The popularity of this approach seems to stem from the fact that the parameters can be readily estimated (by least squares methods), applied to a minimal amount of data, and that these parameters can be treated as dependent variables for further analysis (2.89).

Widespread acceptance of the S-curve (2.90) by researchers seems based upon:

(a) the writings of sociologists which seem to indicate that the adoption of new ideas is S-shaped in distribution (Tarde).

(b) that learning curves tend to approach normality (Rogers)

(c) that there exists an 'interaction effect', whereby a person who has already adopted influences a non-adopter, approaches normality (Coleman).

However, not all researchers have been so ready to accept the universality of the S-curve (2.91). Sample data by Mansfield, and later Hagerstrand, indicated that the researcher must frequently use "not a little imagination" to find an S-shape among the sample points (2.92).

A major criticism of use of adopter categorisation is that little attempt is made to explain the nature of these categories; placement is by consequence of behaviour (and it cannot be used where system boundaries are undefined) (2.93). A point of distinction needs to be made between 'discontinuances' and 'rejections'. Some attempts have been made to distinguish between those who never adopt and those who, having adopted, are observed to later discontinue this behaviour. The former units have been termed "rejectors" (sometimes "non-adopters", even "laggards", which tends to present a value judgement that the consequences of innovation are 'good' for the individual and the system - this is certainly not always so!) the latter are known as "discontinuances". A failing of much diffusion research has been the lack of investigation of reasons for discontinuance, acceptance and rejection, and the resultant effects upon future system behaviour (2.94). Coughenour has suggested an approach which can present a clearer picture of the diffusion process (2.95), using an "innovation use tree". His approach is to map out the diffusion process; a model has been constructed based upon Rogers five ideal-types to demonstrate its usage. Figure 2.24 illustrates:

FIGURE 2.24 USE OF COUGHENOUR'S INNOVATION-USE TREE TO ILLUSTRATE DIFFUSION PROCESS

This approach presents a more conclusive picture of a diffusion network, taking into account those units that adopt, reject and discontinue, having adopted. The Rogers model can identify who has adopted but it does not cater for usage of the innovation at any particular point in time as it fails to account for discontinuances. Figure 2.25 illustrates possible variance when contrasting Rogers' and Coughenour's models; this variance could have been more pronounced if in the Coughenour example, Rogers normalised ideal-types had not been used.

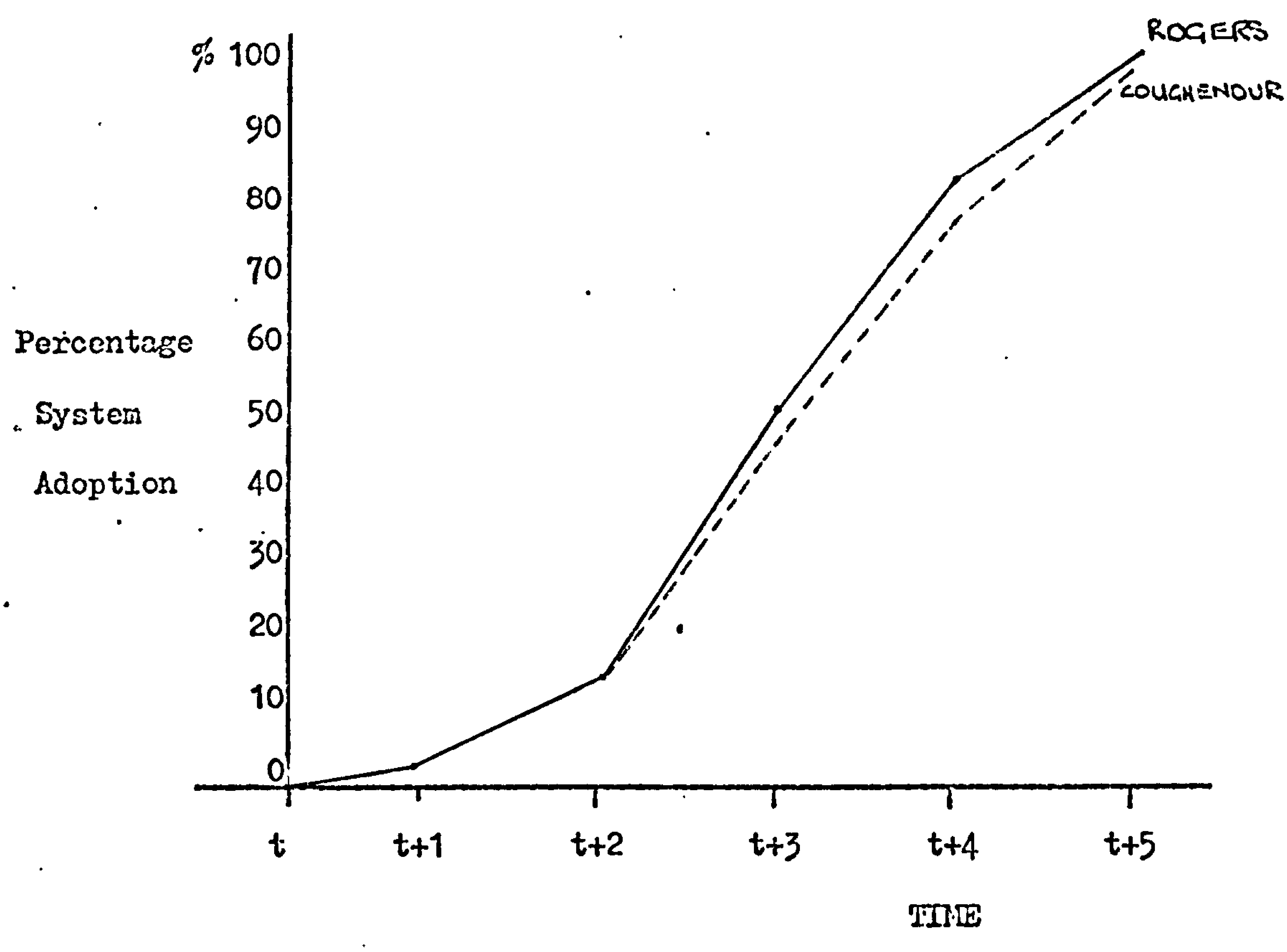


Figure 2.25 COMPARISON OR CUMULATIVE ADOPTERS': COUGHENOUR AND ROGERS

By using Coughenour's method one is able to highlight innovation usage at any particular time period; where discontinuances have taken place by earlier adopters before the innovation has diffused through the entire system. Also it takes account of a 'non-adoption' element rather than acceptance of Rogers 'laggards' which assumes eventual 100%

system acceptance of an innovation. In point of fact non adoption could be any percentage; for example where a new idea supercedes an idea which has not itself totally diffused through the system. Midgley suggests a change in research direction. That in order to define precisely what the concept of innovativeness means, as opposed to what is measured, it is necessary to replace the approach of examining the number of adopters over time with an examination of the distribution of individuals with (what he calls) "innovativeness scores" (2.96). He is replacing time as an element in the diffusion process with "the distribution of a trait amongst members of society...one which can be thought of as essentially similar to any other, such as intelligence or extroversion". The implications of his approach are to suggest that innovativeness is an inate expression of a person's psychological or sociological characteristics (2.97). He is able to move away from 'time' as a yardstick of measurement towards analysis based upon levels of interpersonal communication because his concern seems to be one of prescriptive, identification of innovators (2.98) for use in market research. As such he uses only two adopter categories - Innovators and Later Adopters. Figure 2.26 illustrates

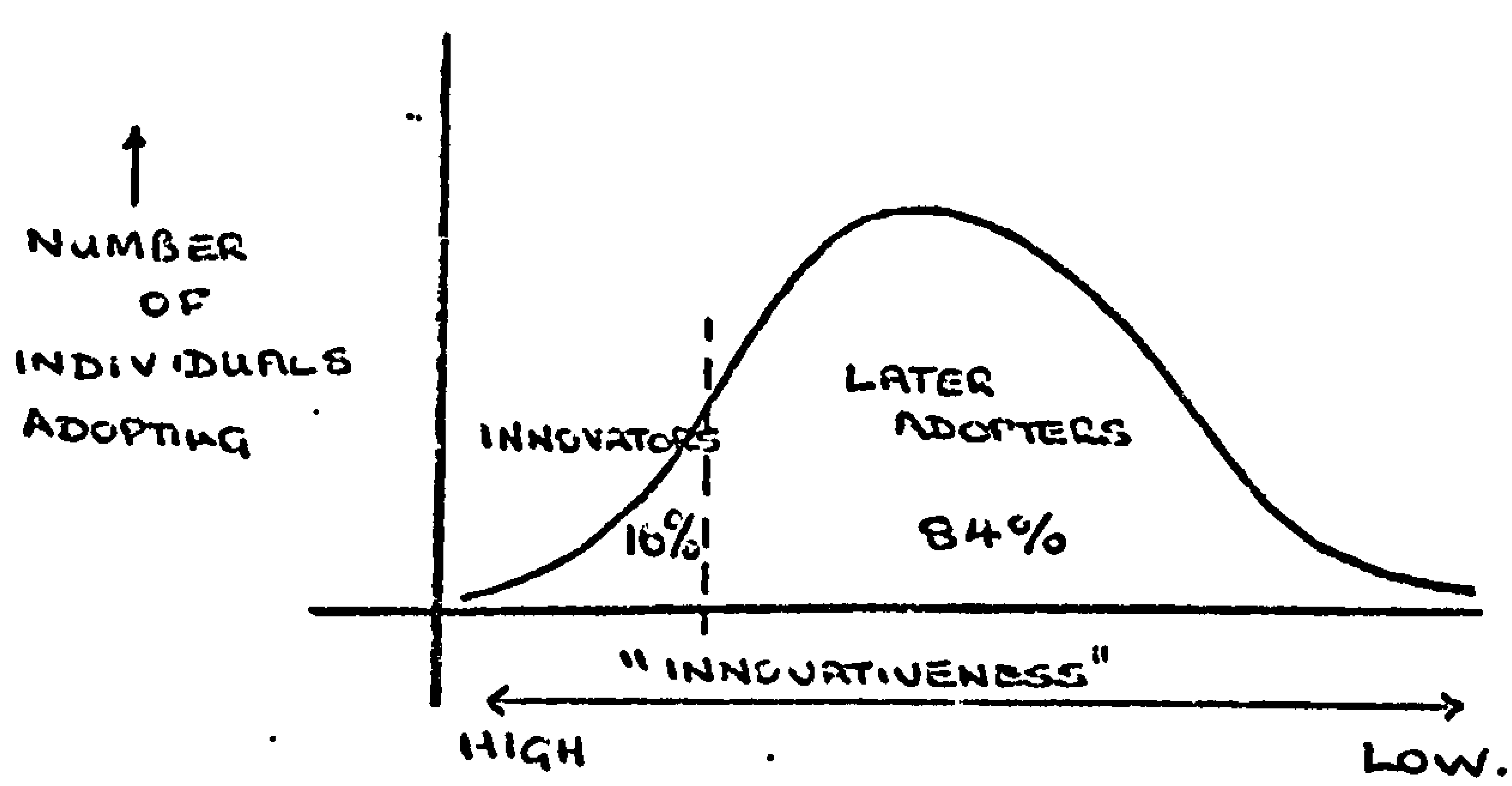


Figure 2.26 ADOPTER CATEGORIES BASED UPON INNOVATIVENESS SCORES - Midgley.

His work on the identification of an "innovativeness trait" seems, as yet, inconclusive and restricted to only one or two product groups (eg fashion). By choosing to ignore time in the diffusion process, one can loose dynamism - the very criticism made by Midgley about earlier researchers.

2-10 AMONG THE MEMBERS OF A SOCIAL SYSTEM

Katz fifth (and final) element of the diffusion process is the System itself, through which the innovation is observed to diffuse. A 'system' has been defined as "an organised or complex whole; an assemblage or combination of things or parts forming a complex or unitary value" (2.99); that is, "a collectivity of units which are functionally differentiated and engaged in joint problem-solving with respect to a common goal" (2.100).

The social system constitutes a set of boundaries within which innovations diffuse. The structure of these boundaries can have an important effect upon rates of diffusion; it can impede or facilitate the rate of diffusion and adoption of new ideas through what are called "system effects" (2.101).

As Katz points out "it is unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located as it is to study blood circulations without adequate knowledge of veins and arteries" (2.102).

Size of system expressed in terms of spatial separation of system units, can be seen to have an effect upon the speed of communications of innovations. An empirical regularity in diffusion of innovation has been the occurrence of adoption in a spatial sequence...."the main spatial similarity is, briefly, that the probability of a new adoption is highest in the vicinity of an earlier one and decreases with increasing distance. Later events seem to be dependent upon earlier ones according to a principle for which the term "neighborhood effect' would be apt" (2.103); a point of view supported by Griliches' study of the diffusion of hybrid corn in the USA (2.104). These observations suggest that where interpersonal communication underlies diffusion, the neighbourhood effect operates within a population group that is homogeneous with respect to a given set of characteristics, but between such groups to a lesser degree.

A development of this thesis has been the study of "central place" as adding a critical element to the diffusion situation. It is proposed that, in addition to the neighbourhood effect, there is a "hierarchy effect; that is, for certain types of innovation, more important places tend to adopt earlier than less important places in spite of their relative locations...."in addition to the influence from the centre on the neighbouring districts we find short circuits to the more important places at a greater distance" (2.105). This suggests that system unit size is related to the direction, rate and path of diffusion, and can result in short circuits that reduce the neighbourhood effect.

It has been suggested that the presence of "homophily" assists communication of new ideas (2.106). This homophilic state between system units contributes both to the cause and consequence of "norm standardisation". Norms are seen as established behaviour patterns for the members of a given social system (2.107). They define a range of tolerable behaviour and serve as a guide or a standard for members of a social system. In addition to influencing the original adoption or rejection of an innovation, norms also influence the manner in which an innovation will be integrated into the existing pattern of system behaviour.

Research has focused upon identifying 'differences' in the adoption/ diffusion processes as affected by the presence of traditional or modern norms (2.108): these two normative states are seen as 'ideal types' - conceptualisations based upon observations of reality and designed to facilitate comparison. These ideal types do not necessarily exist empirically, but may be constructed by abstracting to a logical extreme the characteristics of the behaviour under analysis. They are not 'ideal' in the sense that they describe 'what ought to be', but rather in the sense that they logically accentuate some dimension of analysis. What is important to the diffusion researcher is the suggestion that firms (individuals) with modern norms (or perhaps adhering to modern norms) view change favourably, predisposing them to adopt new ideas more rapidly than firms (individuals) in traditional systems.

It has been suggested that "traditional systems" can be characterised by:

(a) demonstrating a lack of favourable orientation to change

(b) a less developed, or simpler, level of technology

(c) a relatively low level of literacy, education and understanding of scientific method

(d) a social enforcement of the status quo in the social system, facilitated by affective personal relationships, such as friendliness and hospitality, which are highly valued as ends in themselves

(e) little communication by members of the social system with outsiders

(f) lack of ability to empathise, or to see oneself in others' roles, particularly the roles of outsiders to the system.

In contrast, a modern social system is typified by:-

(a) a generally positive attitude towards change

(b) a well developed technology with a complex division of labour

(c) a high value is placed upon education and science

(d) 'rational' and businesslike social relationships, rather than emotions and affectivity

(e) cosmopolite perspectives, in that members of the system often interact with outsiders, facilitating the entrance of new ideas into the social system

(f) empathic ability on the part of the system's members, who are able to see themselves in roles quite different from their own - that is, they are visionary (2.109).

Rogers suggested three criteria for establishing the normative structure of a system for diffusion research purposes:

(a) identify the 'average' innovativeness of the system's members

(b) establish their attitudes towards innovations

(c) use (what he calls) key informants ratings to cross-check the findings of (a) and (b); these being those who 'know' the system (2.110).

Rogers' proposal is applicable only to historical data; with inference that the 'average' innovator in the system will exhibit similar tendencies in the future.

As with any attempt at extrapolation, the 'goodness of fit' will depend upon the present state of the environment continuing into the future. Whilst the 'traditional-modern' continuum (that is, a reference to the state of the system's norms) seems important in predicting individual diffusion behaviour, of equal importance is the commitment of the individual to these norms (2.111), and also where the individual has the ability to influence and redefine these norms (eg the opinion leader) .... as Rogers concludes "thus an individual's integration into a social system, as well as the nature of the system's norms, need to be studied in order to fully explain his adoption behaviour" (2.112).

2-11 A SUMMARY

The purpose of Section 2 has been to provide a detailed picture of the contents of the entire thesis, outlining the main concepts and methodology used in diffusion research. It has introduced to the reader the importance of communication in the process of spreading of new ideas and that this diffusion affects social change.

The structure follows in the footsteps of two of the more emminent researchers in this area (2.113) in identifying five elements in the diffusion of innovations

----the nature of the innovation itself

----how it is communicated from adopters to potential adopters

----the channels used in this communication

----the time taken for this process

----the effects that the system, through which the innovation is diffusing, has upon the rate of adoption (and hence diffusion).

This thesis now turns to a closer examination of diffusion in industrial systems.

SECTION NOTES:

2.1 Rogers E & Shoemaker F: Communications of Innovations P.47.

2.2 Appendix 1 contains a list of these 'generalisations' as prepared by Rao J., which is seen as providing a skeleton summary of major conclusions of present day knowledge re the subject area.

2.3 One might consider exceptions - where social change is caused by a natural event, eg a volcanic eruption changed Pompeii.

2.4 Rogers E & Shoemaker F. Op. Cit p.7.

2.5 Rogers E & Shoemaker F. Op. Cit p.7.

2.6 Rogers E & Shoemaker F. Op. Cit p.8.
immanent change is a 'within-system' phenomenon
contact change is a 'between-system' phenomenon.

2.7 What is the nature of the system unit? In studies of individual adoption behaviour (eg doctors adopting new drugs) the system unit is identifiable in its most practical indivisible state; however, the system unit in industrial systems is generally regarded as 'the firm' (eg Mansfield's studies) yet the firm is a system in its own right, comprising of series of subsystem units, many of which can hinder/assist the firm's adoption process. This point is examined in Section 3, p. 168

2.8 Although communication and social change are not synonomous, communication is an important element throughout the social change process. Diffusion research - concerned with messages that are new ideas - is part of communications research.

2.9 The reader is referred to the extensive work of Fishbein and others on attitude and behaviour change. Indeed the existence of the concept of the 'Adoption Process' caters for this transition from knowledge change to behaviour change: p. 48

2.10 Katz E: "Traditions of Research on the Diffusion of Innovation" American Sociological Review 1963. His work has scarcely been questioned regarding his seven-parts of the process, although later writers (eg Rogers) have given less weight to his last five points...

(a) the Acceptance
(b) over Time
(c) of some specific Item, Idea or Practice
(d) by the Individual/Group or other Adopting Units
(e) linked by specific Channels of Communication
(f) to a Social Structure
(g) to a given system of Values or Culture.

2.11 Mansfield E: "The Economics of Technological Change" (1968)

2.12 Rogers E & Shoemaker F: Op. Cit p.19.

2.13 Carter & Williams: "Industry and Technical Progress - Factors Governing the Speed of Application of Science" (1957) p. 206.

2.14 Knight K: "A Descriptive Model of the Intra-Firm Innovation Process" Journal of Business Vol. 40. No. 4 (1967)

2.15 Engel, Kollat & Blackwell: "Consumer Behaviour" p.107.
Holt R.W. 1976.

2.16 The reader is referred to p. 65 where the nature of system norms and perspectives are examined in depth.

2.17 Traditional v. modern systems p. 66

2.18 Fisher L: "Diffusion of Innovation. A Synthesis of Research Traditions". A paper given at the 11th Marketing Theory Seminar. Univ. Strathclyde May 1973.

2.19 Often is the case in overseas marketing that adoption and consequent diffusion can be affected by 'de-inventing' a product/innovation, whereby the reduced complexity (in relation to the state of consumer knowledge) brings the product more into line with existing standards of (purchasing) behaviour.
Weller D.G.: "Overseas Marketing & Selling" (1971) p.118.

2.20 The question of trialability provides a considerable block on industrial diffusion due to the indivisibility (and complexity) of capital and skilled labour.

2.21 Levitt T: "Innovative Imitation" Harvard Business Review Sept-Oct (1966) p.63-70.
Note that the observability of success in the industrial system (ie the relative advantage) may be a considerable time after the innovatory firm has actually adopted the innovation. If time lags do exist (eg due to high level of technical R & D knowledge necessary, particular patents etc) then the diffusion of such ideas can take a considerable time from the adoption by the innovator until that by the laggards - as demonstrated by the aforementioned Carter & Williams study of pottery kiln adoption.

2.22 p. 168 PP

2.23 Rogers E. & Shoemaker F: Op. Cit p.319.
They do suggest three reasons why this neglect:
1. change agencies, often the sponsors of research, over-emphasise adoption per se, tacitly assuming the consequences of innovation decisions will be positive
2. inadequacy of traditional survey methods to investigate 'innovation' consequences
3. consequences are difficult to measure; clients of change are often not fully aware of all the consequences of their adoption/rejection of a given innovation.

2.24 Note that regarding the industrial adoption process, the sub system units will probably adopt varying percepts of the desirability of an innovation: for example, a managerial perspective might be new kiln —— economic benefit (functional) —— reduction in manpower (functional), which would certainly be at variance with a workforce/union perspective.

2.25 Section 2 p. 18

2.26 Rao G, Singh K & Pal K: "A Study of the Motivation Pattern of Farmers towards the Adoption of High-Yielding Varieties of Wheat" Behavioural Science & Community Development Vol 5 No 1 (1971) p.64-71.

2.27 McClelland D. & Atkinson: "The Achievement Motives" (1953)

2.28 Rao et al: Op. Cit p.64.

2.29 An outline of all Rogers' adopter category-types can be found on p. 56 See also Appendix 1. Generalisations of Diffusion Research.

2.30 The nature of industrial innovatory behaviour is reviewed in Section 3.

2.31 The existence of homophilic behaviour was noted as early as the beginning of the C 20th - "social relations, I repeat, are much closer between individuals who resemble each other in occupation and education" Tarde Op. Cit (1903) p. 64

2.32 "Homophily" - this concept, and its opposite "Heterophily", were first called to scientific attention by Lazarsfeld & Merton (1964). Heterophily, the mirror opposite of homophily,is defined as the degree to which pairs of individuals who interact, are different in certain attributes. The term homophily derives from the Greek 'homoios' meaning alike or equal, thus homophily literally means affiliation or communication with a similar-like person.

2.33 Numerous small group laboratory studies of group dynamics have demonstrated heterophily can lead to message distortion eg Asche, Sherif & Sherif & Lewin.

2.34 The problems and complexity of communication networks in industrial systems is reviewed in Section 3, p. 135

2.35 Rogers E. & Shoemaker F: Op. Cit p.15

2.36 Prevailing levels of techinical competence are part of an industrial system's 'norms' of behaviour - the implications are examined in Section 3 p. 87 ff

2.37 eg. Ryan J & Murray J: "Spreading the Word". Management (Eire) Dec (1975) p.11-14

2.38 It is generally held that an idea has not diffused until the receiver has made an overt decision to Adopt or Reject the idea: the stages between Awareness and Action are referred to as the Adoption Process: p. 48 ff

2.39 System-influences and "system-effects" p. 65

2.40 The Clean Air Acts 1956 had a profound effect upon kiln technology Section 4 p. 379

2.41 This introduces the qudstion of system conflict: it is likely that even with resolution (perhaps compromise) based upon relative power positions, the passage of innovation diffusion will be slower than had congruency between adoption units prevailed.

2.42 Lazarsfeld P. et al: "The People's Choice" NY (1944) - a study of the 1940 U.S. Presidential Elections.

2.43 'Opinion Leaders' - "what we shall call opinion leadership, if we may call it leadership at all, is leadership at its simplest: it is casually exercised, sometimes unwittingly and unbeknown... it is almost invisible, certainly inconspicuous, form of leadership at the person-to-person level of ordinary intimate, informal, everyday contact" Katz E. & Lazarsfeld P. p.138 Decatur Study: refer note (2.45).

2.44 Merton: "Patterns of Influence. A Study of Interpersonal Influence and Communication Behaviour in a Local Community" in Lazarsfeld and Stanton (eds) "Communication Research 1948-49" (1949)

2.45 Katz & Lazarsfeld: "Personal Influence. The Part played by People in the Flow of Mass Coummnication" (1955) - the Decatur Study
Berelson et at: "Voting" (1954) - the Elvira Study.

2.46 Coleman et al: "Medical Innovation" A Diffusion Study" (1966)

2.47 The term "opinion leader" has occurred in research in many differing guises.
viz fashion leaders, gatekeepers, influencors, information leaders, key communicators, sparkplugs, style setters, tastemakers even innovators - the question of "are innovators opinion leaders?" is examined on p. 43

2.48 Klapper JT: "The Effects of Mass Communication" (1960) p.84

2.49 Terms "modern", "traditional systems" p.66
"by their close conformity to the system's norms, the opinion leaders serve as an apt model for the innovation behaviour of their followers"
Rogers & Shoemaker Op. Cit p.35.

2.50 Sicnski A: "A Two Step Flow of Communication: Verification of an Hypothesis in Poland". Polish Sociology Bulletin Vol 1 (1963) p.33-40.
and
Wright C & Cantor M: "The Opinion Seeker and Avoider: Steps beyond the Opinion Leader Concept"
Pacific Sociology Review Vol 10 (1967) p.33 ff.

2.51 Menzel & Katz E: "Social Relations and Innovation in the Medical Profession. The Epidemiology of a New Drug"
Public Opinion Quarterly Vol 19 (1955) p.337-352.
"We have found it necessary to propose amendments to the two step flow of communications, by considering the possibility of a multi-step rather than two-step flow".

2.52 Rogers E & Svenning: "Modernisation among Peasants. The Impact of Communication" (1969)

2.53 Industrial system opinion leadership traits. p. 185 ff

2.54 For explanation of 'adoption process' stages p. 56 The original two-step flow model did not recognise the role of different communication channels at these various stages says: Van den Ban A: "A Revision of the Two Step Flow of Communications Hypothesis". Gazette Vol 10 (1964) p.237-250.

2.55 Troldahl: "A Field Test of a Modified Two Step Flow of Communication Model" Public Opinion Quarterly Vol 30 (1967) p.609-623 proposes, on the basis of dissonance theory, that followers who are exposed to mass media messages that are inconsistent with their predispositions, will initate interpersonal communication with opinion leaders to reduce their dissonance.
Work based on Festinger L. "Theory of Cognitive Dissonance" (1957)

2.56 Rogers & Shoemaker: Op Cit p. 208: suggest "In order to identify the followers from the non-followers among the category of non-leaders, researchers should use leader-follower sociometric dyads as units of

2.56 (contd): analysis rather than individuals, as has generally been the case in past enquiry of opinion leadership and diffusion research. Not all non-leaders are followers of opinion leaders - that is, the non-adopters in a sense have not followed similar adoption behaviour to their peers.

2.57 Generally, research has followed two-variable relationships, dealing with the dependent variable 'opinion leadership' and some other variable as independent (eg gregariousness). Multivariate analysis to explain variance in opinion leadership has tended to be rather desultory
eg Rogers & Butridge: "Muck Vegetable Growers. Diffusion of Innovation among Specialised Farmers" (1961)
and
Rogers & Svenning : "Modernisation among Peasants. The Impact of Communication" (1969)

2.58 Baumgarten S: "The Innovative Communicator in the Diffusion Process". Journal of Marketing Research Vol 12 (Feb 1975) p.12-18.

2.59 Homans G. : "Social Behaviour. Its elementary forms" (1961) p.339.

2.60 Arndt: "A Test of the Two Step Flow in Diffusion of a New Product". Journalism Quarterly Vol 45 (1968) p.457-465: opinion leaders can either favour (and so lead) or oppose (and so retard) change, so influencing their followers accordingly
for explanation of "system norms" p.65
and industrial leadership traits. Section 3 p. 220

2.61 p. 27

2.62 In such a case the opinion leader is likely to be perceived by his followers as innovator for that system.
Eg. Carter & Williams identified the technically progressive firm as being "receptive to outside ideas".

2.63

Model	Traditional Classification
INNOVATOR 1	INNOVATOR
OPINION LEADER (following innovator 1) 2	EARLY ADOPTER
Follower/Opinion Leader 3	EARLY MAJORITY
Follower/Opinion Leader 4	
Follower/Opinion Leader 5	LATE MAJORITY
Follower/Opinion Leader 6	
Follower 7	LAGGARD
Non-Follower 8	NON-ADOPTER

For discussion of traditional classification p. 56

2.64 Rogers & Shoemaker Op. Cit p.227.
Also change agent refers to the helper, the person or group who is attempting to effect change" Bennis "The Planning of Change Readings in the Applied Behavioural Sciences" (1962) p.5.
Also "the change agent must be exogenous to the system" Lippitt (1958) — this definition tends to be too restrictive for use in industrial systems, where a change agency may exist within a system, being separate from member firms.

2.64 Stone J: "How County Agricultural Agents Teach"
Michegan Agricultural Extension Service (1052)
and
Petrini F: "Experiment with Different Time Disposition of a Given Extension Programme"
Uppsala Agricultural College. Sweden (1967).

2.65 One would expect the time scale of stage 1 to be dependent upon the congruency between the change proposed and the prevailing system norms and system environment.

2.66 It is in the later stages of the model that the similarity of the role of change agents in industrial systems most differ from Stone and Petrini's research. In industrial systems the change agency will strive to assist/direct/persuade diffusion (eg through continued sales effort) rather than relying purely upon system momentum.
The reader will notice a marked similarity between this research and a marketing concept - The Product Life Cycle; this similarity and its relevance to industrial diffusion theory is examined p.215

2.67 Katz E et al: "Traditions of Research on the Diffusion of Innovation". American Sociological Review Vol 28 (1963) p.237 ff.

2.68 Katz: ibid p.238.

2.69 Reynolds F: "Problem Orientation". Rural Sociology Vol 36 (1971) p.215-218.

2.70 Ibid p.216.

2.71 Rogers, Beal & Bohlen: "The Importance of Personal Influence in the Adoption of Technological Changes"
Social Forces Vol 36 (1957) p.329-335
also Lazer W & Bell W: "The Communication Process and Innovation"
Journal Adv. Research (Sept 1966) p.2-7.

2.72 Copp (1958), Byland (1964) support this study, whereas Mason (1962) suggested that the researcher should consider, empirically, only two stages - Awareness and Adoption - due to problems of establishing the presence and recall of mental processes.

2.73 Rogers & Shoemaker Op. Cit p.25.
It is noticeable that general texts on marketing, published as late as 1975/76 still rely heavily upon Rogers' original model!

2.74 Beal G & John M: "Role Performance of Change Agents": a paper presented to the Rural Sociological Society of San Francisco (1967).

2.75 Ryan J & Gross N: "The Diffusion of Hybrid Seed Corn in Two Iowa Communities" Rural Sociology Vol 8 (1943) p.15-24.

2.76 The reader is referred to p20 for a discussion of 'what is an innovation'.

2.77 Rogers E & Shoemaker F: Op. Cit p.27.

2.78 Section 1 "Merging Research Traditions"

2.79 Robertson : "Innovative Behaviour and Communication" (1971) p.87

2.80 Petersen R.A.: "A Note on Optimal Adopter Category Determination" Journal Marketing Research Vol 10 (Aug 1973) p.325-329 quote from p.327.

2.81 Midgley D.F. : "Innovation & New Product Planning" (1977) p.116.

2.82 footnote 2.85: discussion of S-shaped diffusion curve.

2.83 Whyle W : "The Web of Word-of-Mouth". Fortune (Nov 1954) p.140.

2.84 Rogers E & Shoemaker F : Op. Cit p.182 states:-
"the innovativeness dimension, as measured by the time at which an individual adopts an innovation is continuous. However, this variable may be partitioned into 5 adopter categories by laying off standard deviatinns from the average time of adoption."

2.85 Note: the cumulative number of new adoptions is given by

$$Q_T = \frac{1}{\sigma\sqrt{2\mu}} \int_{t=0}^{T} \exp\left[\frac{-\frac{1}{2}(t-\mu)^2}{2\sigma^2}\right] dt$$

where QT = cumulative no. of adopters at time T.
Application of this model approaches an S-shaped curve. Source:
Lancaster & White: "Industrial Diffusion, Adoption and Communication" European Journal of Marketing Vol 10 No 5 (1976)

2.86 Jones GE : "The Adoption and Diffusion of Agricultural Practices" World Agricultural Economics & Rural Sociology Abstracts Vol 9 (1966) p.11.

2.87 Casetti E : "Why Do Diffusion Processes Conform to Logistic Trends?" Geographical Analysis Vol 1 (1969) p.101-105.

2.88 Coleman JS : "Introduction to Mathematical Sociology" (1964) p.42

2,89 Casetti E & Semple RK: "Concerning the Testing of Spatial Diffusion Hypotheses". Geographical Analysis Vol 1 (1969) p.254-259.

2.90 Tarde G : "The Laws of Imitation" (1903)
eg Rogers E : "Diffusion of Innovations" (1962)
& Coleman, Katz & Mensel : "Social Processes in Physicians Adoption of a New Drug" (1968)
: their model takes the form :-

$$dQ/dt = rQ_t(\bar{Q} - Q_T) + p(\bar{Q} - Q_T)$$ where

r = the effect of each adopter upon each unreached potential adopter
p = the rate of self-motivated adoption.
This model assumes that the rate of adoption is a constant proportion of the product of adopters and potential adopters, suggesting adoption is caused by the exposure of potential adopters to those who have already adopted the product.

2.91 eg Astor :"The Adoption Process. S or J curve"Rural Sociology Vol 32 p.220-222.

2.92 Mansfield E : "Technical Change & the Rate of Imitation" Econometrica Vol 29 (1961) p.741-766.
Hagerstrand T : "Innovation Diffusion as a Spatial Process" (1967)

2.93 An inherent problem in measuring diffusion is to decide 'when' an idea/product has stopped diffusing - it is perhaps easier in a commercial area where sales can be measured, although even here, future purchases can be the result of behaviour modified by knowledge learned during present purchasing behaviour. Can we assume a point in time when every unit in the system has undergone/exercised a choice process to adopt/reject?

2.94 Research is sketchy in the area of investigating the perception of members towards fellow system-members, self-images and system images (re adopting categories). Rogers has suggested that "innovators" and "laggards" see themselves as deviants from prevailing system norms of behaviour - but this is piecemeal in nature and does not adequately link behaviour between either individual units or between adopter categories.
Section 2-10 p.65 examines 'system effects' on individual behaviour.

2.95 Coughenour CM : "The Problem of Reliability of Adoption Data in Survey Research". Rural Sociology Vol 30 (1965) p.184-203.

2.96 Midgley DF : Op. Cit p.47. : his approach is based upon figure 2.23 (p54) where deviations from the 'average adopter' $\bar{X}$ are calculated ie innovators two standard deviations etc.
Midgley states "although a normal distribution is shown, this is not necessary to the argument, which would hold for any empirical distribution" (p.47)

2.97 Midgley defines "innovativeness" as - "the degree to which an individual is willing to adopt without receiving favourable interpersonal information on the innovation's performance from his social contacts" Op. Cit p. 49 ie the amount of such favourable information that an individual requires before accepting the risk of adoption.

2.98 The objectives of his book reflect this "the author is able to suggest certain systematic procedures by which an organisation can radically improve both its short and long run chances of launching successful new products,"
from backcover Midgley "Innovation and New Product Marketing".

2.99 Kast & Rosenzweig : "The Modern View. A Systems Approach" in Beishon & Peters (eds) : "Systems Behaviour" Open Univ. Press 1972 p.14.

2.100 Rogers & Shoemaker; Op. Cit p.28.

2.101 : also known as "compositional effects" (Davis et al 1961), "contextual effects" (Blau 1957/60), "structural effects" (Campbell & Alexander 1965 also Tannenbaum & Bachman 1964). None of these studies examined system effects upon diffusion of innovations.

2.102 Katz: "The Social Itinery of Technical Change. Two Studies on the Diffusion of Innovation" in
Schramm (ed) : "Studies of Innovation and of Communication to the Public" 1961.

2.103 Hagerstrand T : "Quantitative Techniques for Analysis of the Spread of Information and Technology" in Anderson CA & Bowman M (eds) "Education and Economic Development" (1965) p.261.

2.104 Griliches Z : "Hybrid Corn. An Exploration in the Economies of Technological Change". Econometrica Vol 25 (1957) p.501-522.

2.105 Hagerstrand T : "The Propagation of Innovation Waves". Lund Studies in Gerography No B-4 (1952) p.8.

2.106 p.44

2.107 One can identify two main schools of thought amongst sociologists as to the meaning of "norm".
1. The Neo-Positivists : "norm".- the standard behaviour represented by such measures of central tendency in a distribution as a mean, median or mode.
2. Social Achonists : "norm" - a 'group expectation' of a certain type of behaviour.
This argument between 'what is' and 'what ought to be' has subsided with a tendency towards a more operational definition of norm that may reflect either a standard or an expectation for behaviour, or both.

2.108 Research including:

Toennies	gemeinschaft	v	gesellschaft
Weber	rational	v	traditional
Merton	cosmopolitan	v	local
Becker	secular	v	sacred
Parsons & Shils Redfield Weber. Wolf Lesner	modern	v	traditional
Burns & Stalker Lawrence & Lorsch	organic	v	mechanistic

2.109 Rogers E : "Diffusion of Innovation" p. 94.
Carter & Williams. "The Characteristics of Technically Progressive Firms". Journal Industrial Economics (Vol 7 1960) p.87-104 : while being more concerned with the speed of application of scientific knowledge, nevertheless did suggest that it was possible to identify the characteristics which distinguish the progressive from the unprogressive firm. Section 3. p.100 ff

2.110 Methods used to identify the normative structure and innovativeness propensity. Section 3. p.153

2.111 often referred to as 'group cohesiveness'.

2.112 Rogers & Shoemaker Op. Cit. p.34.

2.113 Rogers E and Katz E : p. 19

SECTION 3 : AN INDUSTRIAL PERSPECTIVE

3.1 INTRODUCTION

Thus far the major variables influencing adoption and diffusion processes as highlighted by researchers have been introduced in Section 2, attention now turns to those elements specifically influencing industrial innovation-adoption and diffusion processes.

Probably more than in any other field of research, the researcher finds the subject of his enquiry open to a wide variety of influences, from a wide variety of systems (sources) - if the subject of enquiry is the firm, then influence may arise from within its own boundaries (the organisational structure), from its competition, its customers or suppliers, or from what shall be considered the business environment (eg political, legal controls etc).

To explore the industrial adoption and diffusion process, three main elements bear consideration:-

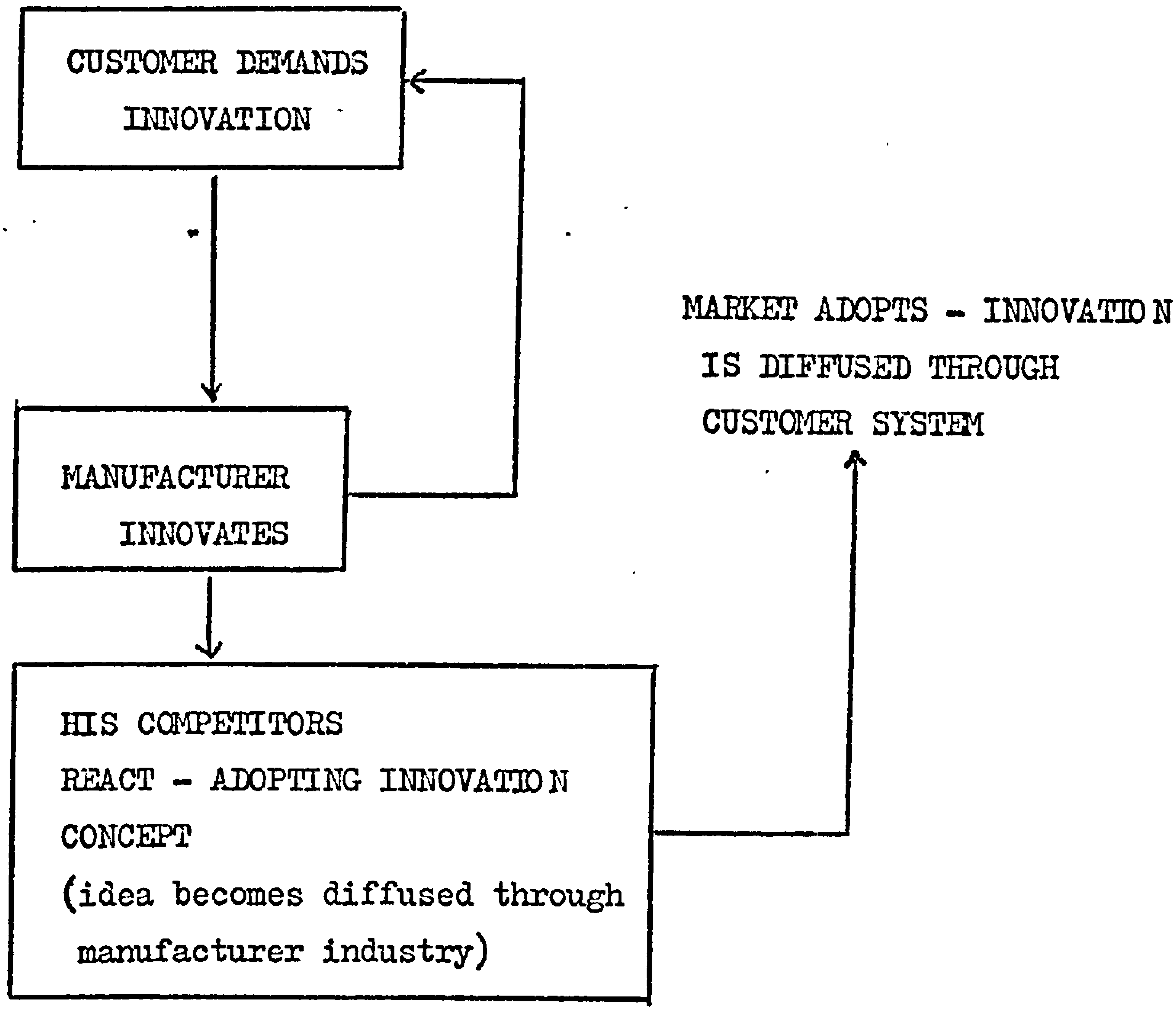
(i) customers in the market place

(ii) manufacturers - suppliers to these customers

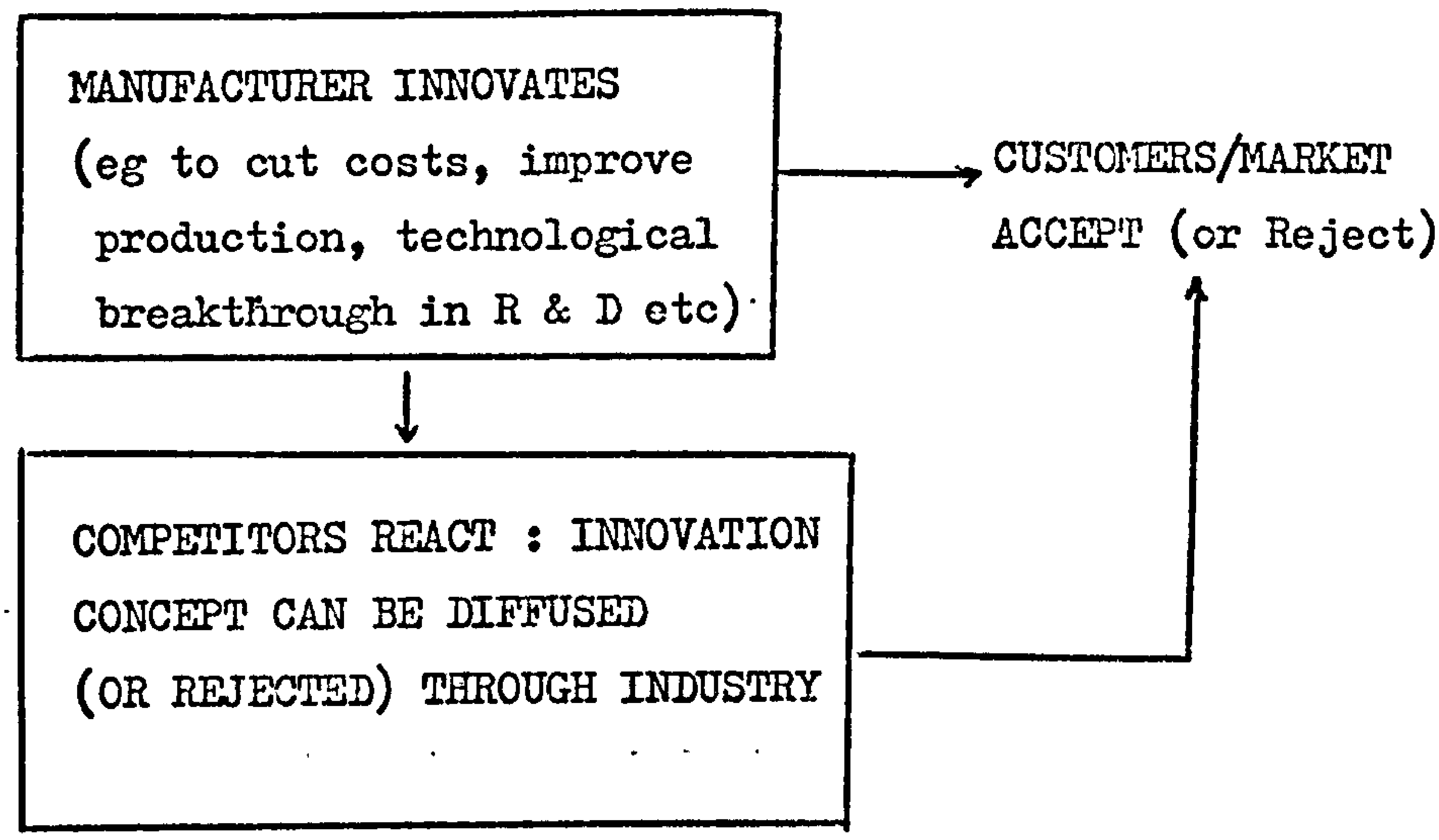
(iii) suppliers to manufacturers - component and equipment suppliers.

Four models, the results of the interaction of these elements can be presented to illustrate the complexity of the industrial innovation process:-

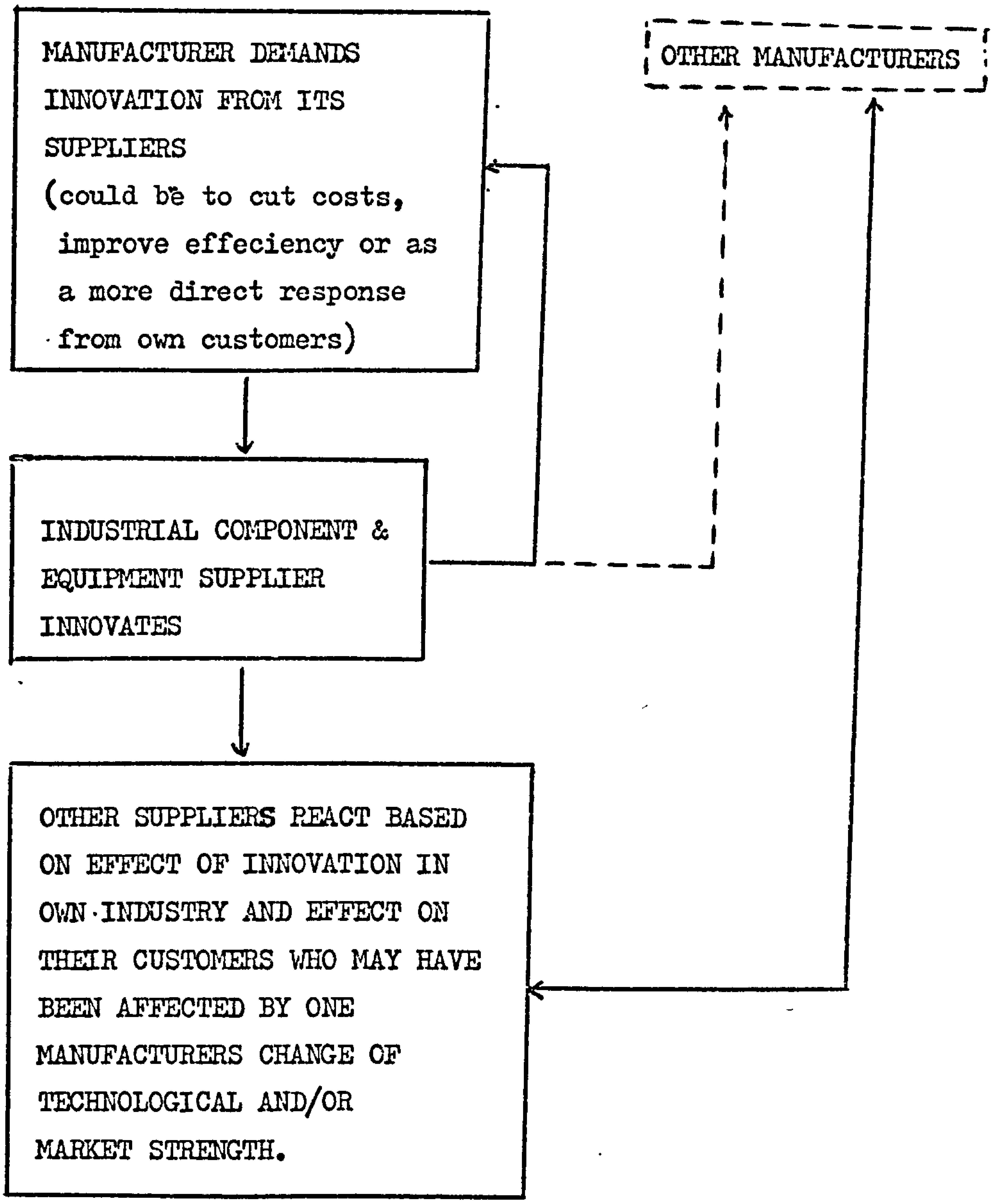
1. <u>Customer pull innovation</u>



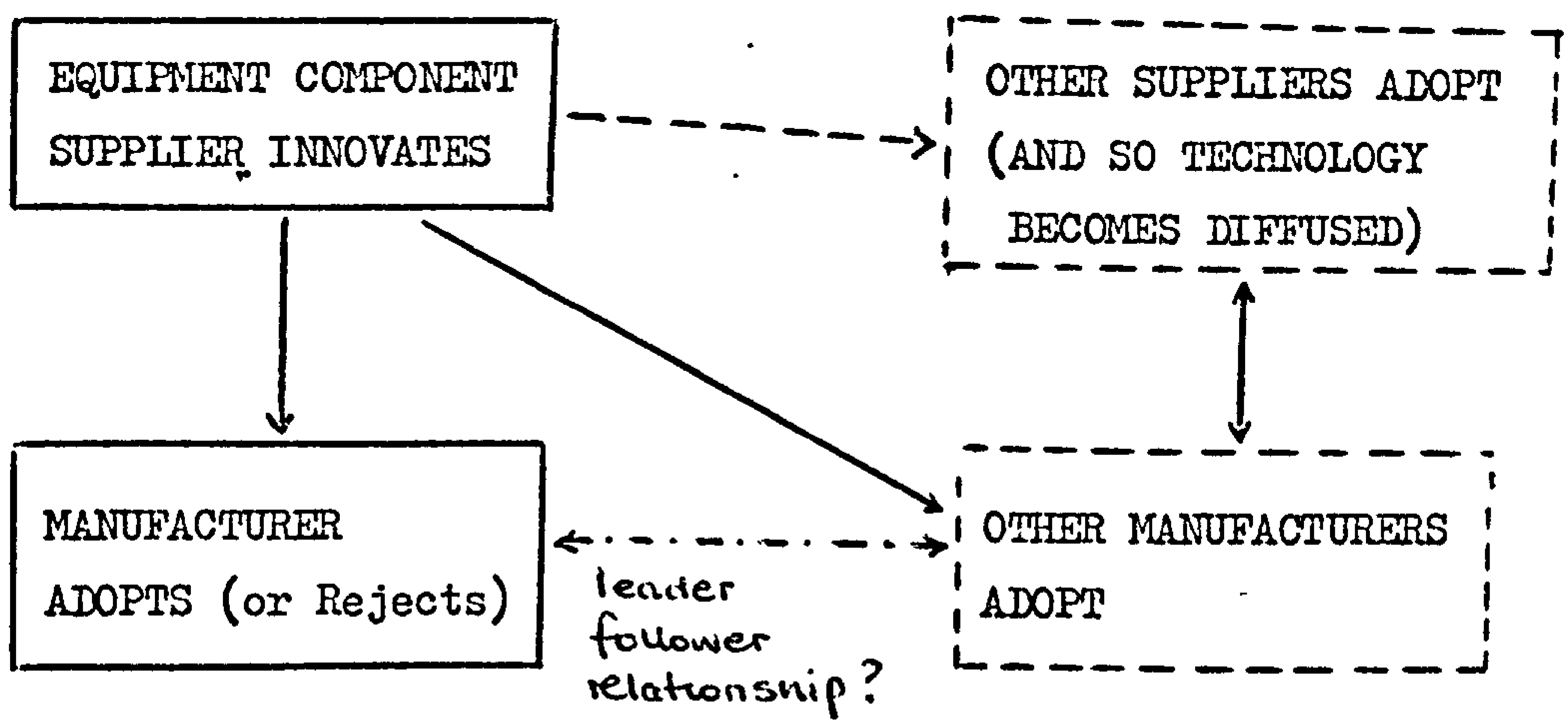
2. Manufacturer push innovation



3. <u>Manufacturer pull</u>



4. <u>Industrial component and equipment supplier push</u>



Each model is used to depict a particular 'source of innovation' pressure; it may occur in the marketplace for consumer goods and pull through technological innovation from any number of interlocking systems (ie supplier → manufacturer/supplier → manufacturer → customer) supplying that marketplace or, alternatively, it may be as a result of scientific research which eventually percolates through these self-same interrelated systems until manifesting itself (and not necessarily in its original form) in the consumer market place (3.1). The rate at which a technological innovation will be accepted and diffused is governed by a variety of system-environmental pressures:

1. Market structures
2. Rate of customer acceptance
3. Rate of technological change
4. Economic, legal and political policies of government.

1. <u>Market Structures</u>

Parker (3.2), using traditional economic market structure typology, suggests that in 'perfect competition' there is no incentive for an individual firm to consider the generation of new products or processes before any of its competitors. This lack of motivation to undertake risk is seen to exist similarly with the 'monopolist'; however, it is suggested that innovation may be undertaken to sustain the monopoly position through creating 'technological barriers' for potential competitors. Parker suggests that in 'monopolistic competition' the preponderance of smaller firms will act to reduce the size of capital needed to undertake R & D. He concludes that it is only likely in an 'oligopolistic structure' that companies will be large enough to afford large scale R & D and so generate innovations. Care must be taken not to overgeneralise that only large firms are therefore innovatory; field evidence suggests that size does not alone correlate with propensity to innovate, nor innovatory success (3.3).

Parker, in common with the more pragmatic economists, does not develop his examination of structures further, to the point where the nature of the structure itself is examined.
Amongst others, Burns and Stalker have suggested that various structures will demonstrate various propensities to innovate (3.4).

2. <u>Rate of customer acceptance</u>

Whether the source of innovation can be identified as 'push' or 'pull', the rate at which the customer demands, or is prepared to accept innovation, will determine the rate of innovatory behaviour of a particular firm, or a particular industry. In part this is determined by the structure of the industry and partly by the rate of technological change....

3. <u>Rate of technological change</u>

Technology tends to feed upon technology; rates of technolcgical change are interdependent upon changes in often previously unrelated industrial fields. As Rothberg writes "improvements in product and process technology are often introduced to a wide variety of product-markets simultaneously" (3.5). He gives the example of L.S.I. (large scale integrated circuits), which quickly become adopted in areas as diverse as computers, television sets, cash registers and automatic sensing devices. Bright, from his study, concluded ... "the most important application of a new technology is not always that which was visualised first; and, as a corollary, technological innovations frequently gain their first foothold for purposes that were originally not thought of or are deemed to be quite secondary" (3.6).
Within industrial systems, a common technological base sets limits to the intensity of inter-firm competition within a given product market. It is when this commonality is broken, either from within the industry (viz manufacturer push- model 2), or from outside (viz models 1, 3 or 4),

then the survival of the disadvantaged firms can be threatened; as was N.C.R. with its traditional cash register designs at the advent of the L.S.I (3.8).

4. Economic, legal and political policies of government

The researcher needs to remain aware of the effects ('system interference') caused by central and local government policies, when examining the industrial innovation process .... "to an increasing degree, new government standards and regulations are expressed in performance terms that stimulate rather than retard the development of new products and processes .... clean air and water standards, for example, have led to major advances in pollution measurement and control" (3.9).
However, the researcher often needs when defining the nature of 'system interference' to distinguish between the effects upon the firm, upon the industry or upon society as a whole... "the Welfare State is a protection against failure and exploitation but a national recovery can take place only if innovators, and men of enterprise and hard work, can prosper" (3.10). Whilst government standards may pull through innovation, fiscal and monetary policies, planning decisions and so on may well act contrary to the advancing of technology (3.11).
In addition to the need for a receptive environment for innovation, studies suggest that a similar receptivity must exist within the firm. Two principle elements are needed:

1. The motivation to innovate : the propensity to endure 'risk'

and

2. The ability to innovate : motivation needs to be coupled to the ability to undertake the necessary actinn to innovate. This ability is generally governed by factors internal to the firm (eg structure and organisational flexibility, good internal communications, ability of the labour force, capital strength etc), but this ability has to be viewed in

the light of environmental pressures outlined earlier.

Central to the process of industrial innovation, adoption and diffusion thereof, is 'communication'. That is:-

(i) communications within the firm; both vertically and horizontally,

(ii) between firm and its suppliers,

(iii) firm and its customers,

(iv) and between firm, its sources of technology and the business environment.

Central to the theme of this thesis is the process by which innovation is adopted, communicated and diffused in industrial systems.

The remaining text of Section 3 involves a critical evaluation of published literature regarding industrial innovation processes and Section 4 reflects field studies undertaken in the Pottery Kiln Industry to trace the introduction of some recent technological innovations.

3.2. PRESSURES TO INNOVATE

The commitment of modern industrial societies to change is almost total (3.12). The pressures of industrial/technological invention lie at the core of this process. Deane sees "... increase in the flow of inventions or of ideas for change suitable for incorporation into the productive process" as a major precondition for a successful industrial revolution (3.13). Gabor argues that the stage has been reached where "innovation has become compulsive" (3.14) yet it was not, according to one researcher (3.15) until the early 1960's that the problem of technological innovation began to assume an importance for more than a few traditionally science-based companies. He notes how R & D expenditure has grown in the U.K. (expressed as a percentage of GNP)

1900	0.05% GNP
1938	0.25%
1973	3 %

In parallel, study of this process - of technological innovation, adoption and diffusion has been scarce relative to that in other fields of diffusion research. Cook mentions seven hundred and eight publications under fourteen headings, but only five are attributed to the industrial field (3.16)

INVENTION AND INNOVATION

An extensive literature has been developed which seeks to provide meaningful definitions of these terms (3.17). Although there is some dispute at the margins of these definitions (3.18) there seems to be a general consensus about the sequence and about certain key characteristics of each.

The basic proposition that the process of invention "requires a notion of a sequence of acts of insight which leads to a cumulative synthesis of many items that were originally independent" (3.19) is echoed in a number of studies (3.20). This pattern is recognised by Kuhn in his concept of a scientific paradigm (3.21); by Scherer, who considers it to be the first stage in the process of technological innovation... "(invention) is the act of insight by which a new and promising technical possibility is recognised and worked out, at least mentally and perhaps also physically, in its essential, most rudimentary form" (3.22); and by Mueller when he says "Invention is concerned with creativity and discovery,and generally implies fabrication, mental or otherwise. It is not necessarily useful- that is, if something new is bought into being it is an invention in one non-legal sense of the word. In order to be legally patentable, however, an invention 'must represent true innovation and add to the sum of useful knowledge' according to the U.S. Supreme Court" (3.23).

A number of perspectives have been proposed to account for the invention process. The 'transcendentalist approach' predominates economic literature; it attributes invention to 'the inspiration of genius' (3.24) This perspective is typified by Redlich's observation ... "While at all times there live creative men ... no prediction is possible as to 'where' they will appear in any particular moment or how they will act. The creative entrepreneur being a deviant, he and his work are unpredictable" (3.25).

On the other hand, many behavioural scientists lay greater emphasis upon invention (and innovation) as representing the accumulation of many individual items over a relatively long period of time ..." no invention springs full-blown out of nothing: it must have antecedents" (3.26). Gilfillan writes ... "there is no indication that any individual's genius has been necessary to any invention that has had any importance. To the historian and social scientist the progress of invention appears impersonal" (3.27).

A general picture emerges that technology feeds on technology, and in the process provides a major source of inventions. The importance of basic science to industry is not denied. It is emphasised, however, that knowledge created by a study of fundamentals filters into industry, often in indirect ways (3.28)... "Technology tends to create its own problems and solutions" (3.29).

Robertson puts forward a combination of both views, rejecting the validity of either view standing alone (3.30); he suggests that invention need not necessarily be an accidental affair, yet it would also be wrong to overlook the discontinuities inherent in the process of invention.

What is important to note is that the act of invention may not necessarily be important for the examination of the adoption and diffusion of a particular innovation in a particular industrial system, because the pure technology has been transferred across system boundaries. However, the reaction to source of invention might well be an important element in gaining system-acceptance (3.31).

Theories of innovation in business stem mainly from the work of economist Joseph Schumpeter, who viewed innovation as distinctly different from invention which, he held, occurred in isolation of innovation and which could or could not be coupled with innovation (3.32). He considered the process of innovation to be an essential component in profit, capital, credit, interest and the business cycle. Innovation was seen to be the element relating the static equilibriums of earlier economic theory as they change through time. Ruttan identifies Schumpeter's definition as follows..."We will now define innovation more rigorously by means of the production function. This function describes the way in which quantity of products varies if quantity of factors vary. If, instead of quantities of factors, we vary the form of the function, we have an innovation. We will simply define innovation as the setting up of a new production function. This covers the case of a new commodity as well as those of a new form of organisation, or a merger, or the opening up of new markets" (3.33).

The research tradition concerned with technological change has also investigated changes or shifts in the production function (3.34); Ruttan concludes "technological change may for practical purposes be regarded the same as innovation" (3.35).

Whilst Schumpeter (and fellow economists) tended to view innovation as a 'discontinuous event' (3.36), behavioural scientists have presented the view of innovation being a 'process'. Anthropologist H.G. Barnett alluded to innovation as the basis of cultural change, and defined innovation as "any thought, behaviour, or thing that is new because it is qualitatively different from existing forms" (3.37) - this is a considerably broader definition than Schumpeter's 'setting up a new production function'! Marquis suggests that "when an enterprise produces a good or service, or uses a method or input that is new to it, it makes a technological change. The first enterprise to make a given technological change is an innovator. Its action is innovation" (3.38). He considers innovation to be the unit of technological change, whilst an invention, if present, to be part of the process of innovation. Rogers, a sociologist, has broadened the definition still further, when he referred to an innovation as "an idea perceived as new by the individual" (3.39). Other notable definitions include:-

...."A series of technical, industrial and commercial steps (3.40)

...."A change in, or an addition to, the physical entities that comprise its product line ... from a market perspective, however, the term refers to a new or revised set of customer perceptions concerning a particular benefit cluster" (3.41)

...."An innovation is the adoption of change which is new to an organisation and to the relevant environment" (3.42)

Levitt suggests innovation should be viewed in at least two ways (3.43):

(i) newness in the sense that something has never been done before, and

(ii) newness in that it has not been done before by the industry or by the company now doing it.

Whilst he adheres to the definition that innovation occurs only when something is entirely new, having never been done before, he does suggest that innovation may also exist when something which may have been done elsewhere is, for the first time, done in a given industry (3.44). This latter perspective illustrates the difference between 'invention' and 'innovation'; it allows the transference of technological achievement from one industrial system to another to be considered in the latter system as innovatory.

Baker questions whether it is the 'thing' (the invention?) innovated or the commercial exploitation of it that is the innovation (3.45). A question he seems to leave unresolved. When considering industrial innovation it is probably an unnecessary splitting-of-hairs because acceptance of the 'thing' will be viewed in the light of commercial possibilities (although writers do differ on the weight given to economic versus non-economic criteria (3.46)).

Twiss feels it is necessary to draw a distinction between 'technical innovation' and 'research and development', in that technical innovation implies a company-wide approach to the profitable application of technology, rather than a description of the activities of one (or a number) of departments responsible for research and development (3.47).

It has been suggested that it is possible to develop a conceptual framework for classifying innovations; one such approach is that used by Engel. He suggests a continuum illustrating innovations in terms of their possible disruption to the day-to-day process in the firm (and implicitly the industry). Figure 3.1 illustrates (3.48).

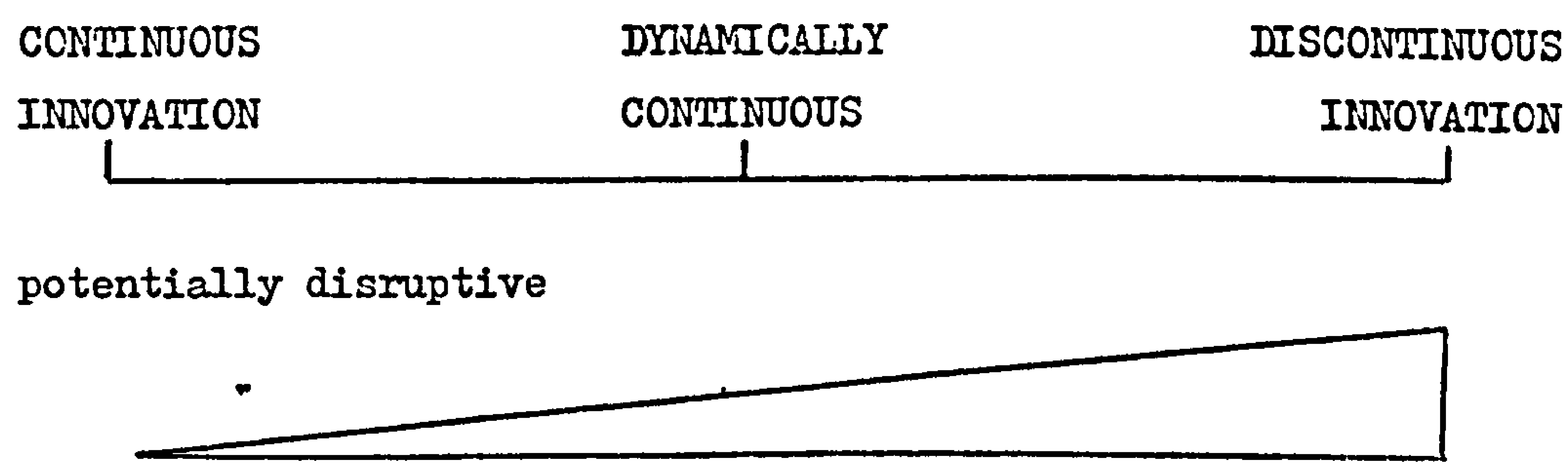


Figure 3.1

In turn, Langrish has suggested a five point scale based on the response to innovation as published in scientific and technical literature; a scale which ranges from the radical innovation marked by the publication of new textbooks, to the passing of only small incremental improvements, which attract no more than some references in the technical press (3.49). One can question this approach on the basis of its academic adherence to the written word. It is conceivable that some innovations may not be initially honoured at the appropriate literary level and therefore be underrated (3.50).

However, Langrish's scale has been adapted by recent researchers, recognising that industry does not perceive all innovations being of equal importance or consequence.

Rothwell, for example, used a 4 point scale in his study of innovation in the textile machinery industry (3.51), namely

Class 1 : Radical breakthrough
2 : Major innovation
3 : Incremental innovation
4 : Improvement

Taking a different perspective, Booz and his colleagues, proposed a matrix approach for classifying new products (and innovations) using two key dimensions (3.52):-

(i) levels of technology

(ii) target markets (Figure 3.2)

TECHNOLOGY / MARKET	INCREASING No technical change	TECHNICAL REQUIREMENTS Improving present technology	Introducing a new level of technology
Present market	PRESENT BUSINESS	REFORMULATION	REPLACEMENT
Expanding present market	RE-MERCHANDIS-ING	IMPROVED PRODUCT	PRODUCT LINE EXTENSION
Moving into a new market	NEW USE	MARKET EXTENSION	DIVERSIFICATION

Figure 3.2.

Whilst, in itself, this matrix has many limitations as a conceptual tool - it fails to identify the process of implimentation of a particular policy or to suggest the possible intended or unintended consequences of doing so - nevertheless it can be used to enhance Engel's continuum in a way suggested as follows:- (Figure 3.3)

In practice it is difficult to take such a dichotomous view of these two activities ... "Invention and innovation are to be distinguished, but they are not separate. They are often inextricably inter-linked because they stand mutually in a mixed cause-effect relationship: each is part cause, part effect of the other" (3.53). Robertson subscribes to this point of view .. "there is a significant difference between the generation of the idea and its introduction into practice" ...; he

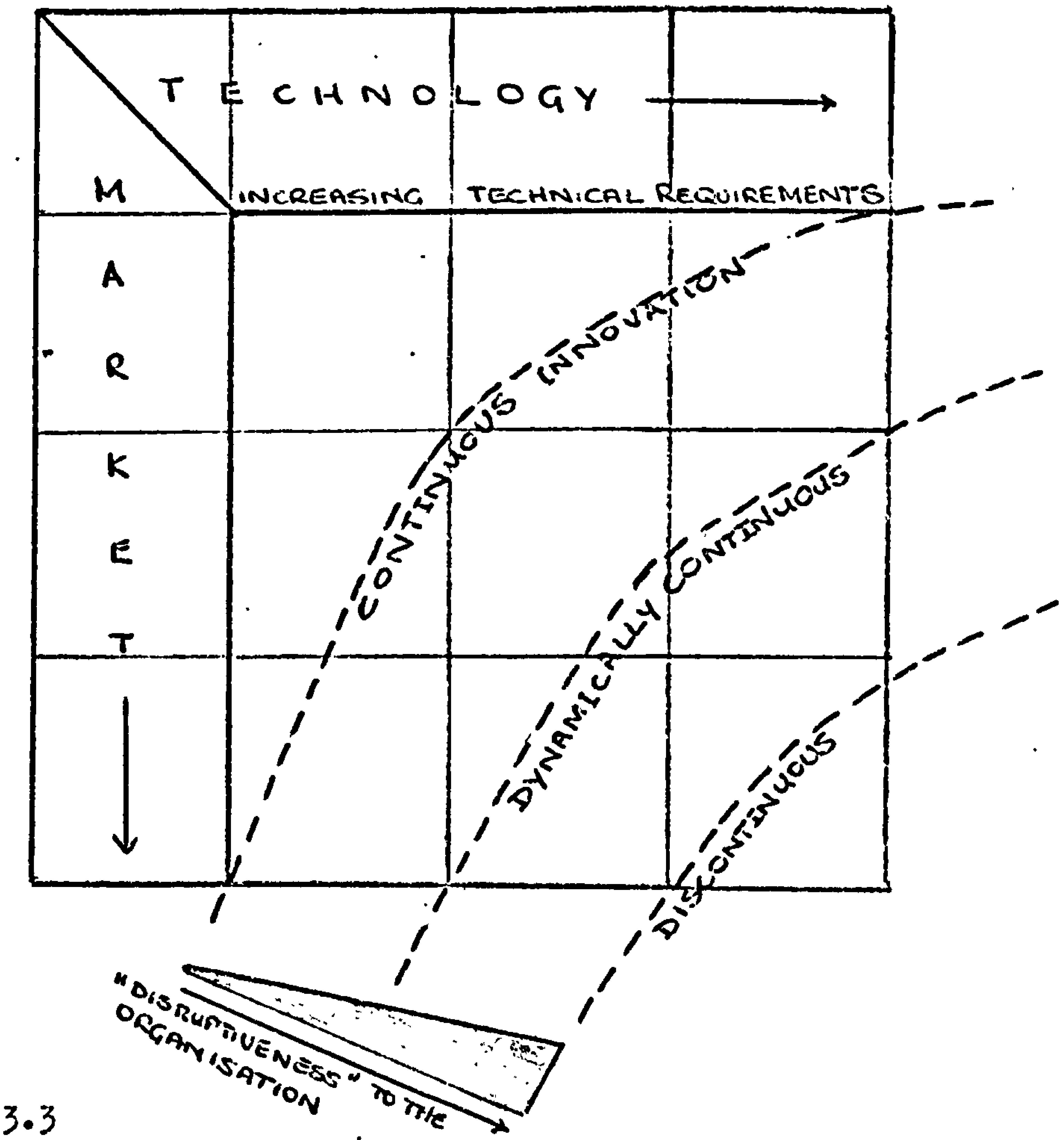


Figure 3.3

suggests that the available evidence indicates that innovators often are not the creators (inventors) (3.54).

What does seem in agreement amongst researchers is that invention and innovation cannot be divorced from creativity. The successful innovation is offered to the market as something new, for which the customer, being prepared to risk deviance from existing practices, is prepared to pay, albeit some more slowly than others. The quality of the invention and innovation results from the 'originality' of the creative minds of one or a few individuals ... as Twiss concludes "without creativity there can be no invention and no innovation" (3.55).

3.3. INNOVATION : DEMAND PULL OR TECHNOLOGY PUSH?

For some twenty years now economists have argued about the basic source of successful technological innovation in terms of 'technology push' or its opposite, 'demand pull' (3.56). In theory, for the researcher, the problem of initial source becomes one of emphasis - an idea may originate from the market place yet become so refined as to lose its definition once in the hands of the technologist, and similarly an idea initially born in the laboratory is much modified via product/market research findings before it emerges in the market place. However, as will be discussed, the initial source can help to explain receptivity to communication vertically and horizontally in the firm, and evidence will be presented from research studies to suggest that the probability of market success can be explained, in part, by reference to the idea source.

In Britain the rush to recapitalise after the second world war led to an unrivalled expansion of capital projects and R & D expenditure. The restored profitability of British manufacturers during the Macmillan era of 'you've never had it so good' paved the way for Wilson's 'white heat of technology'; the funds and the political backing were present for technology push. Woudhuysen feels that the attention given to America's very evident economic superiority over Europe reinforced this (3.57). Certainly investment by US companies in their European operations did much to create fears of a transatlantic 'technology gap' especially in the more technologically advanced product categories (eg computers and aviation).

Heavy commitment to R & D was accentuated by state-financed R & D spending on defence technologies, for which costs were virtually immaterial and purchasers guaranteed, 'demand pull' did not figure highly in business thinking. As Woudhuysen observes "public or private, civilian or military, the 'propulsive' powers of R & D were lauded to an unprecedented degree, allowing expenditure to climb rapidly in most developed countries during the sixties" (3.58).

If one is to highlight one main reason for the dampening of enthusiasm for 'technology push' it would be the growing recognition by firms to be aware of their accountability to market forces (to undertake a market orientation). Evidence now suggests that attention to market needs ('demand pull') reduces the uncertainties inherent in undertaking scientific development without planned and anticipated outlets for these discoveries (3.59).

Demand pull innovation is seen to receive impetus from outside the R & D area. Requests tend to fall into two technical categories:-

(i) those that represent incremental advances over the present state-of-the-art

or

(ii) those that are technologically exacting or essentially impossible, either because they are beyond the current state-of-the-art or to achieve the technical excellence would cost unforecastable expenditure.

Demand pull, by comparison with technology push, tends to be comparatively easy to bring to fruition because:-

(i) demands tend to be the former type, which are frequently small, to which the company has at its disposal technical excellence; the advance in many cases is no more than an elaboration or refinement of an already mature technical field..

(ii) generally there will be less resistance within the organisation (eg expenditures will be smaller; the improvements may be comprehendable to a wide variety of organisational decision-makers and market research may be available to 'prove' the demand) and from the customer.

However there may be resistance from the R & D area. Emphasis upon demand-induced innovation tends to be regarded as incompatible with the inherent nature of scientific personnel.... "highly competent scientists have a strongly developed sense of autonomy" (3.60).

Technology push are results from inventions and discoveries made in the R & D area as a result of ideas generated from within, regardless of whether or not any user-need has yet been expressed. Steele feels that it is "out of supply-pushed type of innovation are most likely to appear the major achievements, the large discontinuities in technology" (3.61).

Operating management, usually out of technical ignorance, tend to view technology push innovation as high risk, with possibly no immediate return on investment (3.62). Steele observes "major inventions of the supply-pushed type are relatively infrequent and have a relatively high failure rate" (3.63). How much of this that can be attributed to lack of commitment by operational management is not clear; it is a point not pursued by Steele or many other researchers who have examined push versus pull innovation.

It was suggested earlier that research evidence would be presented, which strongly suggests that the source of pressure to innovate in the industrial system may indicate the probability of success in the market place. A number of studies are now presented to substantiate this claim:-

Schmookler and others (3.64) lean heavily towards demand-induced innovation as the path to commercial success.... "demand induces the inventions that satisfy it" (3.65). His studies of patents in the USA led him to believe that "inventive activity tends to rise and fall with the sales of the products they improve (3.66).

In a study of the origins of 25 important product and process innovations at Du Pont, 15 were attributable to outside sources (3.67).

Langrish and others found only one-third of important ideas arose internally (from R & D), and of the factors that hinder market acceptance, over 20% was attributable to 'no market or need' (3.68).

.... 45% of failures could be linked with inadequate market analysis and weaknesses in marketing effort (3.69).

Failure to identify 'user need' was highlighted by the Way Report on the Machine Tool Industry (3.70); criticism was levelled at companies for lack of emphasis on marketing, and the use of marketing research and technological forecasting.

Stage I of the Project SAPPHO examined 29 pairs of similar projects (in each pair, one project a success, the other a failure) from two industries - chemical process industry and scientific instruments. The research concluded that the clear cut differences between success and failure within pairs could be best summarised as:-

(i) successful innovators were seen to have a much better understanding of user needs and

(ii) successful innovators pay more attention to marketing (3.71).

Reekie et al examined 53 projects which had been abandoned during development. Reasons given included:

(i) In 30 out of 51 cases reported the reason given for abandonment was due to too small a market or too high a level of competition

(ii) In 14 out of 44 cases, a lack of marketing capacity or expertise was given (3.72).

"Spotting technical opportunities plays a suprisingly minor role in sparking innovations as shown by three-quarters of innovations stemming from recognising a market potential or a need in a production process"

(3.73). Marquis presents the following findings from his study (Table 3.1 below):-

INNOVATION INITIATED BY	No OF CASES	%age	
Technical feasibility	120	21	
Market demand	257	45	USER NEEDS
Production need	169	30	
Administrative change	21	4	
	567	100	

TABLE 3.1 SOURCE OF INNOVATION - MARQUIS.

Mansfield found that about 60% of the projects studied that did not achieve their technical objectives were terminated before completion because of poor commercial prospects, and over 45% of projects seen as attempts at relatively large advances in the state of the art were terminated before completion because of poor commercial prospects rather than technical difficulties (3.74).

Levitt, in examining sources of ideas for new products suggests 'imitation' as a "much more prevalent road to business growth and profits" (3.75); in stressing what is essentially a demand-pull approach he gives examples such as IBM which entered computers as an imitator, and Texas Instruments' entry into the transistor market as an imitator.

Baker found of nearly 300 ideas arising in a divisional laboratory of a large US corporation:-

> 212 ideas were stimulated by a user-need (a 'need-event') whilst 60 could be attributed to technology push.

Of the eventual successes (an amount not disclosed) he noted 85% were from ideas stimulated by user-need considerations (3.76).

Project SAPPHO Phase II involved the study of a further fortythree pairs of projects in the same chemical processes and scientific instruments industries (3.77). The findings presented below in table 3.2 represent combined data for both industries; success variables for which the probability of chance occurrence was estimated to be less than 0.1%....

RANKING	SUCCESS VARIABLE
1	Successful firms understand user needs better
2	Successful innovations have fewer aftersales problems
3	Successful firms employ larger sales efforts
4	Successful innovations have fewer 'bugs' in production
5	Successful firms have better communications in specialised areas
6	Successful firms pay more attention to educating user
7	Successful innovations need less adaptation by users
8	Successful innovations need fewer unexpected adjustments in production
9	In successful firms there is less opposition to the innovation on commercial grounds

TABLE 3.2. PROJECT SAPPHO PHASE II: FINDINGS COMBINED FOR BOTH INDUSTRIES

Whilst only the top 9 variables are presented, indication is given to the emphasis placed upon market/customer forces in determining successful diffusion of an innovation.

Project SAPPHO Phase II found the emergence of inter industry differences in variables attributed to successful innovatory firms. In the tables 3.3. (for chemical processes) and 3.4 (for scientific instruments) only the top 5 ranked variables are given, but differences in emphasis are apparent...

RANKING	SUCCESS VARIABLE
1	Successful firms understand user needs better
2	Successful innovations have fewer after-sales problems
3	The executive in charge of success has more responsibility
4	Successful firms have better commuications in the specialised areas
5	Successful firms drop processes as a result of innovation

TABLE 3.3 PROJECT SAPPHO PHASE II : CHEMICAL PROCESSES INDUSTRY

RANKING	SUCCESS VARIABLE
1	Successful firms understand user needs better
2	Successful innovations have fewer bugs in production
3	Successful firms employ greater sales efforts
4	Successful innovations have fewer after-sales problems
5	Successful firms have better external communications

TABLE 3.4 PROJECT SAPPHO PHASE II : SCIENTIFIC INSTRUMENTS INDUSTRY

Whilst both industries indicated successful innovation was reflected in understanding user needs better, differences are apparent in terms of the role of an individual (a Product Champion) in the adoption process and also the speed at which firms discard old technologies ..... Rothwell attributed these inter-industry differences to environmental and structural factors. He concludes his study .... "SAPPHO results strongly support the belief that successful firms pay more attention to marketing than do failures" (3.78).

Other studies which have found root failures of new products to lay mostly with projects started by R & D iniative include Peplow (3.79), Nicholson (3.80) and a Materials Advisory Board (USA) study (3.81).

In contrast, a US study by Seiler clearly demonstrates that the majority of ideas for new R & D projects came from members of the research staff (3.82); table 3.5 illustrates:-

IDEA SOURCE	SOURCE OF IDEA, BY INDUSTRY (%)					
	CHEMICAL + PHARMACEUTICAL	ELECTRONICS	PLASTICS PETROLEUM RUBBER	FOODS + FEEDS	METALLURGICAL MANUFACTURING	ALL INDUSTRIES (Average)
RESEARCH STAFF	70	54	60.2	66.9	48.6	60
MARKETING. SALES STAFF	10.9	9.3	18.4	22.2	22.5	17.3
CUSTOMERS	1.7	10.4	4.4	0.9	10.9	4.1
GOVERNMENT	0.6	12.8	0.7	0.3	5.8	3.9
OTHER MANAGEMENT	7.4	5.4	13.8	8.0	10.2	9.2
OTHERS	9.4	8.1	2.5	1.7	2.0	5.5

TABLE 3.5 SOURCE, SEILER

On average 60% of ideas from R & D

17% from Marketing and Sales

and 4% from customers directly.

Similarly, another report indicated that between one quarter and one-third of successful new ideas originate with R & D, but that their importance may be greater than this proportion suggests since these ideas tend to be the radical, major innovations (3.83).

The key to explaining the apparent divergence in findings lies in making a clear distinction between

(1) THE ORIGIN OF THE INNOVATORY IDEA

and

(2) THE SUBSEQUENT ADAPTATION AND SOLUTION OF THAT IDEA

A simple matrix can be constructed to illustrate:-

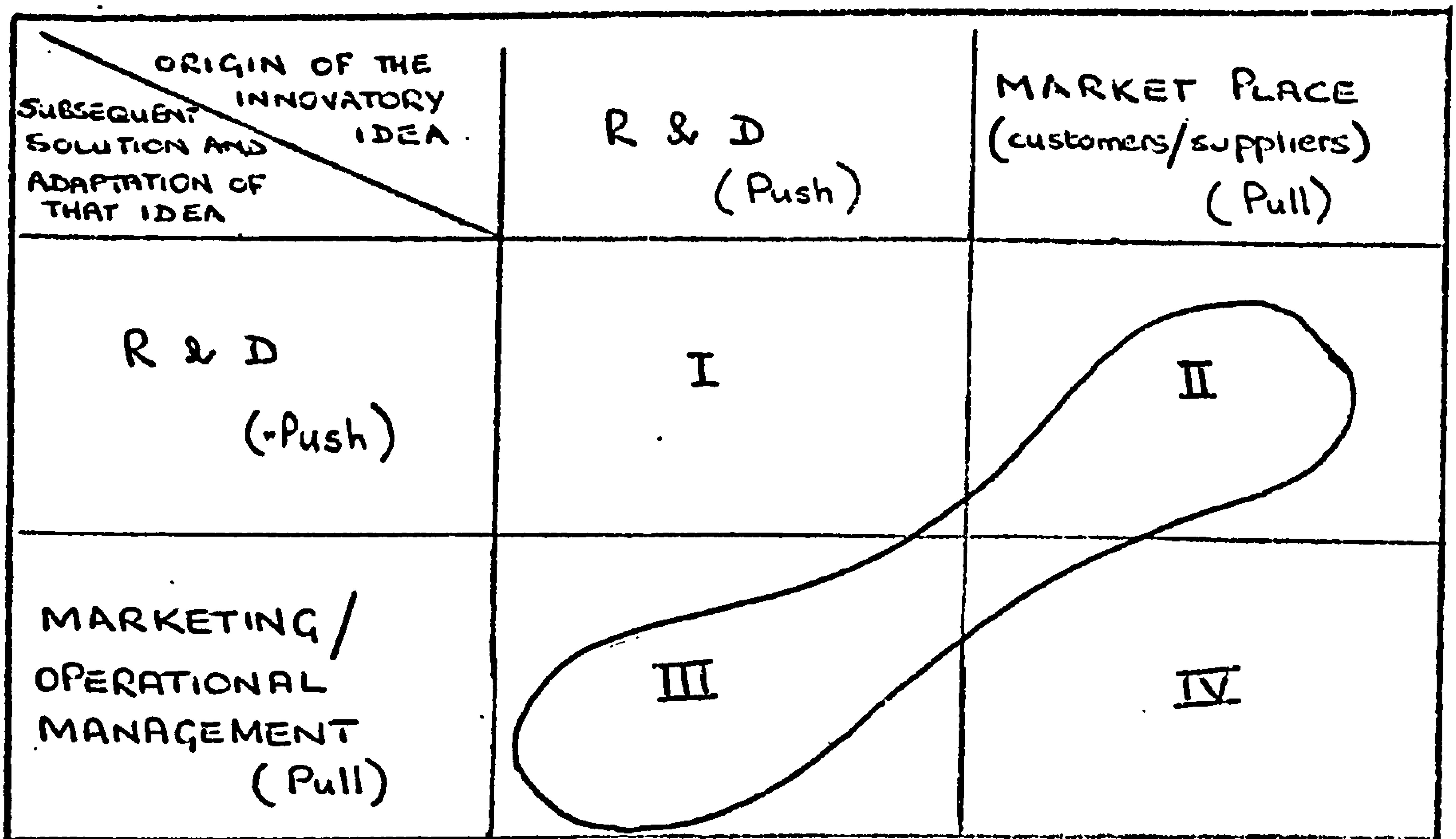


FIGURE 3.4 : MATRIX TO ILLUSTRATE ORIGIN AND SUBSEQUENT ADAPTATION OF INNOVATION

TYPE I :'Push-Push' Innovation

Can be seen to be the traditionally accepted Technology Push type of innovation, with the origin of the idea coming from the research area, being transformed into a product concept also by the R & D function. It is this type of innovation that whilst likely to be the most radical is also likely to carry the greatest commercial risk of failure.

TYPE IV : 'Pull-Pull' Innovation

Can be considered to be traditionally accepted Demand Pull Innovation; the origin of the idea in the market place, being identified by the marketing area and passed on to the R & D function for 'development to detailed specification'. In this situation the R & D function is seen to be closely defined and passive in innovation development.

Of the two remaining types...

TYPE II : 'Pull-Push' Innovation

Whilst the emphasis is towards Demand Pull, either directly from the customer or via market research findings, the adaptation of the users needs remains the providence of the R & D area. Hence a degree of iniative is retained by both marketing and R & D.

TYPE III : 'Push-Pull' Innovation

With this final type the emphasis is towards Technology Push, but the innovatory idea is seen to pass over to the marketing/operational management function to test commercial viability. The outcome is dependent upon the relative 'strengths' of these two functions as to whether the iniative for finalised adaptation remains with marketing or R & D.

Clearly research findings have been hazy as to which form of innovation (as defined in the matrix above) was under investigation. For example, Seiler gives no indication as to whether the ideas he attributes to R & D were activated in response to (ie Type II or IV), or in anticipation of (ie Type I or III) market demand. Both origin of idea and which function within the firm responsible for interpreting and adapting the idea, will be presented as meaningful elements when discussing the adoption of innovation within the firm.

Some studies have approached this problem...

In the Marquis study already quoted, he found 75% of successful innovations were based on user-need considerations. He then sought to identify what he called the 'key input sources' for interpreting these user needs into product ideas; he identified two possible sources (illustrated in Table 3.5) (3.84).

(i) sources inside the firm

(ii) sources outside the firm.

INSIDE THE FIRM	NO. OF CASES	%age
Printed materials	9	2
Personal contacts	25	4
Own training and experience	230	41
Formal courses	1	0
Experiment or calcuation	40	2
	305	54
OUTSIDE THE FIRM		
Printed materials	33	6
Personal contacts	120	21
Own training and experience	39	7
Formal sources	8	2
	200	36
MULTIPLE SOURCES	62	11
	567	≏ 101

TABLE 3.5 : SOURCE MARQUIS

His conclusions were that the ideas to solve these user needs arose from within the company ... "you don't necessarily need to look outside the firm for innovative ideas. Most of the major information inputs which evoked the basic idea or led to its solution came from inside the firm" (3.85).

Although Marquis did not identify the variables at play as clearly as the matrix does, nevertheless he did illustrate the difference between origin of the need to innovate and the subsequent innovational idea to solve the need.

Rothwell in a later study (3.86) using a modification of Langrish's classification of innovations - a 4 point rather than the latter's 5 point scale (3.87) - found that for:-

Class 1 & 2 70% of these innovation types arose to meet user needs
whilst 18% - arose as a result of the innovators desire to take advantage of a new technological capability

Of the remaining 12%, these were undertaken to strengthen the firms market position vis-a-vis competition.

He noted ... "the dominant motivational mode in Class 1 and 2 innovations is, it seems, the linkage of market opportunity to technological capability, with the former aspect predominating" (3.88).

For Class 3 and 4 types of innovations he found the dominance of market factors even greater:-

40% arose in response to perception of user needs

40% were the result of customers' direct requests

and the remainder were undertaken to strengthen the market position. However it is possible that these latter figures are a little misleading. Whereas studies such as Marquis' have taken as their point of interest major innovations (ie Class 1 and 2 Rothwell) and so one would expect the involvement of a company's R & D function in that process, Rothwell has, in addition, considered the more day-to-day product improvements (ie Class 3 and 4 - 'the continuous innovation'), which may sometimes not formally reach the R & D area; customer - sales engineer - production may well produce modifications without involvement from R & D.

He found that the majority of ideas proposed for solving the problem (for Class 1 and 2 innovations) arose from within R & D, or from specialist outside sources, whereas for the less disruptive, technically radical innovations, solutions tended to originate in-house and were more evently spread within the organisation (Table 3.6)

ORIGIN OF BASIC IDEA FOR INNOVATION	Class 1 & 2	Class 3 & 4
IN-HOUSE		
R & D	6	4
MD & Board & others	2	3
Marketing & Sales	1	2
EXTERNAL	6	1
	15	10

TABLE 3.6 SOURCE ROTHWELL

Rothwell's study has pointed to two important elements to be considered when examining the in-firm adoption process:-

(i) the need to define the type of innovation under study

(ii) the need to separate the origin of the innovation idea from the subsequent innovation idea - solution

A study along similar lines, although not as well documented, is Little's investigation of 264 new industrial projects in Canada (3.89). He found that the assessement of a market need was the largest single category of 'triggering circumstance' (to develop an innovation), representing at least one of the dominant factors in 44% of the projects studied;

30% were triggered by customer request and

17% were copied/modified from competitors' products

leaving approximately 9% triggered by internal R & D.

He did make some attempt to classify the types of innovation studied: for example he found for 91 projects firms already had sufficient level of technology to proceed immediately (due to past projects with related technological aspects) but he did not directly relate type of innovation to triggering circumstance, nor triggering circumstance to source of innovation idea-solution.

3.4 INNOVATION AND ORGANISATIONAL STRUCTURE

When innovation is attempted within the confines of an organisation it is apparent that an adequate understanding of the process requires examination of the context in which it occurs. The relationship of innovation with, and its impact of consequences (both intended and unintended) upon contiguous activities and functions within the organisation are crucial to its success; and understanding the nature of these relationships becomes mandatory to understanding the nature of the innovation itself. These relationships can be investigated using a systems approach. As Scott states "the distinctive qualities of modern organisation theory are its conceptual-analytical base, its reliance on empirical research data and, above all, its synthesising, integrating nature. These qualities are framed in a philosophy which accepts the premise that the only meaningful way to study organisation is as a system" (3.90).

Early writers tended to consider organisations (and departments within such organisations) as 'closed systems': the unit of study being self-contained, dependent upon no outside-the-system influence. More recent studies tend to have an 'open-system' approach where interactions provide meaningful data for explaining the degree of propensity to innovate (3.91). Whereas the closed system is seen to have rigid, impenetrable boundaries, the open system is seen to have permeable boundaries between itself and those systems to which it comes into contact (3.92). The boundary constitutes a barrier to many types of interaction between people inside and outside any particular system, but it includes facilitating devices, both formal and informal, to allow some information flow necessary for organisational functioning (3.93).

A reference needs to be made to a distinction between the formal and informal structures in an organisation. The formal structure is seen to be planned and typified by the hierarchical 'organisation chart' illustrating both horizontal and vertical relationships between personnel. Yet, in addition, further social intereaction does occur which is not prescribed (and may not be condoned!) by the formal structure... this is referred to as the organisation's informal structure..."refers to those aspects of the system that are not formally planned but arise spontaneously out of the activities and interactions of participants" (3.94). These two structures are totally intermeshed, functioning in parallel, yet as will be suggested, not necessarily orientated towards the same (organisational) goals.

Knight gives a number of examples of how power exerted through the informal network can affect innovation (3.95). He mentions the formation of what he calls 'cohort groups' of members within departments or across departments, who hinder or assist projects. This view is supported by Cyert and March who suggest that all goal-setting is determined through inter-departmental bargaining (3.96). Such bargaining is only one step from 'political alignments' which may affect future innovatory behaviour.

Knight also suggests that the very inflexibility of the formal structure might aid the innovator, in that he may be able to move a project along ''out-of-sight' of his political opponents until it is too late for them to reverse the projects progress. However, such political manoeurverings unintended consequences may be to strengthen future cohort group reaction.

For the researcher, these formal and informal boundaries or interfaces as I shall refer to them, are not always easily definable and tend to be determined primarily by the functions and activities of the organisation.

The basic premise of early writers on organisation was that firms (the personnel) were motivated by economic criteria - if an innovation was for the 'good of the firm' then it be adopted by the personnel in the firm.

Later writers have questioned the reification of the firm in terms of identifying a unidimensional goal tied to economic criteria - profit maximisation" (3.97). What has been seen to exist is a complex plurality of goals within an organisation, and within departments - because a firm is an organisation of people. To determine a firm's propensity to innovate, the researcher must concentrate not only upon the firm's physical resources (including the resource 'labour'), but also the more emotional aspects of human behaviour. Argyris suggests that the needs of the individual, which usually manifest through informal relationships, tend to be incongruent with the maximum expression of the demands of the formal organisation (3.98).

For example, departments (and functional areas) develop their own social structures, which may be openly encouraged by the firm by delineating titles "R & D Manager", "Marketing Manager", or by friendly inter-departmental rivalry - sports/social occasions, or perhaps as the result of the particular members backgrounds, experiences - scientist, operational manager etc.

For purposes of discussion, the system considered is the firm, departments such as Marketing, R & D, etc will then constitute the various sub-systems. Kast and Rosenzweig suggest that the firm, seen as a system, will consist of two types of mechanisms' :-

(i) '<u>maintenance mechanisms</u>' - which seek to ensure that the various sub-systems are in-balance; by definition these (departments/managers) will be conservative and so likely anti-innovatory (3.99)

and

(ii) '<u>adaptive mechanisms</u>' - provide a dynamism in the firm, which changes over time "(they) develop in organisations to generate appropriate responses to external conditions" (3.100). It is suggested that it is these mechanisms which allow the firm to respond (or initiate) to changing internal and external requirements.

Industrial technological innovation takes place within a formalised structured system. The role of the formalised structure and the prevailing informal interpersonal networks is greatly affected by what is known as 'organisational climate'. Tagiuri and Litwin define organisational climate as follows:-

"a relatively enduring quality of the internal environment of an organisation that is -

(i) experienced by its members

(ii) influences their behaviour (and so tends to perpetuate the climate)

(iii) can be described in terms of the values of a particular set of characteristics (or attributes) of the organisatinn" (3.101).

By 'organisational climate' the suggestion is that the in-firm (and also extra-firm) environment is interpreted by the members of the organisation to have a certain quality to which they are sensitive and which, in turn, affects attitudes and motivation. However what is <u>actually</u> interpreted may well differ <u>between</u> participants within the system!

A number of writers have stressed the importance of organisational climate in the innovatory process. Ford maintains "organisations, like individuals, develop climates of attitudes, habits and work patterns. The sum total thrust of these creates the company's orientations and coincidentally, its character and personality" (3.102). He suggests that a firm will polarise to either a climate positively orientated towards receiving new ideas ('opportunity oriented') or to a climate actively discouraging change (which Ford calls 'problem oriented').

Kettering in his paper to the U.S. Senate implies the role of climate when he states "the greatest obstacle course in the world is trying to get a new idea into a factory" (3.103).

Fast relates structure and size of organisation to climate when he concludes "the environment of a large corporation is not conducive to creating, recognising or commercialising innovative new products" (3.104).

A point seen to be in agreement by Caves ... "the large firm with market power may be able to sustain a large scale and extensive development investment. But the small firm often seems more congenial to generating new and truly novel ideas" (3.105).

Mansfield's research of nineteen laboratories in the U.S.A. suggests that receptivity (and so effectiveness) of the R & D function is affected in part, by the organisational climate.. "there is a very high correlation between the general effectiveness of a firm's R & D establishment, the quality of its R & D management and the receptivity and orientation of top management to R & D." (3.106).

Baker suggests that the prevailing climate will affect the willingness to be innovative in that this climate will manifest itself in the organisation's structure (3.107).

Some evidence is available to suggest that the climate and structure of an organisation is related to the period of history in which it was founded.

Stinchcombe suggests that firms founded during the nineteenth century differ considerably from their twentieth century counterparts .. "extensive staff departments made up of professionals trained in colleges and universities do not appear in industries founded before the twentieth century, while practically all industries whose organisational forms were developed within this century have extensive staff departments" (3.108.) He lays stress to the fact that even though modifications are made over time organisations seem to retain a strong flavour (climate) of their original form. Certainly historical dependence upon technical competence in design and production (viz. 'product orientation') has encouraged the perpetuation of a situation whereby technical staff have performed the function of both determining customer needs and also translating those needs into products. Structures have therefore developed where technical sales have been regarded as an offshoot of design ... "technological expertise is considered by managers to be the main asset and competitive advantage which an engineering company possesses" (3.109).

Chandler's intensive study of a number of major U.S. firms (Du Pont, General Motors, Standard Oil, Sears Roebuck) does suggest that structures, reacting to changing market/environmental conditions, do change, albeit slowly. What is not fully clear from his work is the degree of climatic change that preceded and followed the structural change (3.110).

Daniel reports that in a three year period at least two thirds of the U.S. top 100 industrial companies reported major organisational realignments. He too fails to explain the reasons why and the consequences arising from the structural change (3.111).

Often the question is posed as to the relationship between size of organisation and propensity to innovate. Namely, are larger firms more innovatory? Whilst the evidence is not conclusive, a number of respected studies do suggest that the opposite may be true. Before presenting these studies it is necessary to seek clarification as to what is meant by 'size' when discussing propensity to innovate. Confusingly, writers have not always been clear as to whether they are considering:-

(i) absolute size of firm (eg number of employees, capital assets)

(ii) size of firm relative to its competitors. (eg market share, comparative production output).

(iii) absolute size of the R & D budget

(iv) size of R & D budget relative to competitor spending

(v) size of R & D budget relative to other resources commitments within the firm (eg percentage of gross turnover spent on R & D etc)

A number of studies substantiate the view that there is no strong correlation between scientific and technological productivity, or innovative capability and corporate size (3.112) ... "more than 80% of brilliant, creative invention comes from individual inventors or from inventors with their own companies" (3.113).

Roberts provides data from a number of US studies to substantiate this claim (3.114) Table 3.7)

SOURCES OF KEY US INNOVATIONS	NO. FROM MAJOR FIRMS	NO. FROM SMALL FIRMS/INVENTORS
Jewkes : general innov.	$<$ 50%	$>$ 50%
Hamberg : postwar innov.	$<$ $\frac{1}{3}$	$>$ $\frac{2}{3}$
Peck - aluminium	1	6
Hamberg - steel	4	7
Enos - petroleum	0	7

Table 3.7

Further evidence is provided by Layton and others who conclude : "the best conditions for innovation are often found in small companies, where communications between development, production and marketing are easy and a common objective, with strategies to implement it, can be understood by all concerned" (3.115). They give several examples: the world's first electronically controlled knitting machine was developed by a German firm (Franz Morat) employing only 450 people.

Also the Wankel rotary engine, hailed (in 1968) as being the most radical innovation in car engine design since the beginning of the century, was turned into a viable commercial proposition by NSU (1958). a motorcycle firm employing 6,000 people, small by the standards of the motor industry.

Apparently, in contrast, a UK study seems to suggest a strong correlation with size of firm (3.116) (Table 3.8)

SIC INDUSTRY CLASSIFICATION	PERCENTAGE LARGE FIRMS (1000 + emp)	SHARE OF MEDIUM (200 - 999)	INNOVATIONS SMALL (1 - 199)
Gas	93	7	0
Cement	100	0	0
Steel	96	4	0
Dyes	86	14	0
Aluminium	100	0	0
Paper & Board	50	30	20
Motor Vehicles	89	7	4
Food	75	17	8
Coal	100	0	0
Plastics	94	2	4
Glass	100	0	0
Textiles	79	11	10
Shipbuilding	96	2	2
M/C tools	86	3	11
Scientific instruments	60	12	28
Electronics	86	6	8
Aerospace	98	2	0
Gen. machinery	67	16	17
Textile —.—	42	35	23
Construction	55	33	12
Timber & Furniture	22	39	39
Leather & Footwear	54	20	26
Pharmaceuticals	98	2	0

TABLE 3.8 SHARE OF INNOVATIONS IN THE UK SINCE 1945 BY LARGE, MEDIUM AND SMALL ENTERPRISES

What is not clear is the relative sizes of firms quoted in the findings! For example, are there only 'large firms' (as defined above) in the aluminium, glass, cement industries? Certainly the author's own experience of the Leather and Footwear industry which has a wide span of sizes of firm is substantiated by the span of innovations illustrated in Table 3.8.

Layton and others (3.117) do accept that large companies should possess physical resources advantages for innovation over their smaller counterparts, namely

1. resources to finance large scale development (eg nuclear power).
2. resources for marketing
3. financial respectability in the City
4. possible ability to attract high calibre personnel.

They give several supportive examples:

1. Although Philips and Mullard failed in the 1950's to enter the silicon semi-conductor business (ie integrated circuits), their size and resources enabled them to regain some competitive position
2. In developing colour television, RCA spent over $100 million on its system
3. General Electric and Westinghouse were able to finance nuclear power development (in the USA) using own funds,and also were able to withstand early years of no profit.

More recent studies have upheld the claim that large size of firm is not necessarily contributory (and as shall be suggested may be counter-productive!) to successful innovation. The SAPPHO projects (3.118) suggest that 'size of firm' does not emerge as a good discriminator of a successful innovatory firm. Rather than size, what was seen as having some bearing was the size of the project team.

Even on the point of size of R & D budgets there is some contention. Professor Lord Blackett, President of the Royal Society, is quoted by Elwart (3.119) as suggesting that an R & D team needs to spend £30000 +

per year to be an effective force in a company, which, in passing should be no more than 50% of company turnover.

Yet the study by Myers and Marquis of successful commercial innovations in five industries in the USA showed that 65% of the innovations cost less than $100,000 from concept to market implementation (3.20). Table 3.9 illustrates

COST OF MAJOR INNOVATIONS	NO	%
less than $25000	187	33
$25000 - $100000	180	32
$100000 - $ 1m	132	23
$ 1m +	68	12

TABLE 3.9 SOURCE MYERS & MARQUIS 1969.

One suggestion for the apparent controversy seems certain to be lack of definition as to what is being measured, that is, clearly defining in operational terms 'size'. It is as well to note a point of interest in that the SAPPHO project does suggest that of even greater importance than size of firm and size of R & D budget, is the firm's positive commitment to innovation.

Business organisations characteristically are structured demonstrating a high degree of task specialisation (3.121). Task specialisation occurs both vertically, as represented by the organisational hierarchy, and horizontally through departmentalisation.

Parsons identifies three hierarchical managerial levels in business organisations:-

(i) technical/production level

(ii) managerial level

(iii) institutional level (3.122)

The technical system is involved with the actual task performance in the

organisation; the carrying out of innovatory decisions.
The second level, managerial (organisational (3.123)), coordinates and integrates the task performance of the technical system, whilst the third level, the institutional, is involved in relating the activities of the organisation to its environment (business, society etc).
Petit, using Parsons' typology, identified the different types of manager necessary to operate at these three levels (3.124). He suggested classification of manager-type could be made in terms of:-

the task performed

viewpoint

techniques employed

time horizon

and decision-making strategy.

Figure 3.10 illustrates:-

TYPE OF MANAGER	TASK	VIEWPOINT	TECHNIQUES USED	TIME-HORIZON	DECISION-MAKING STRATEGY
Technical	technical rationality	engineering	scientific management & O.R.	Short run	computational
Organisational	Coordination	political	mediation	Short run long run	compromise
Institu tional	deal with uncertainty, relating firm to its environment	conceptual	opportunistic surveillance and negotiation with the environment	long run	judgmental

TABLE 3.10 SOURCE PETIT.

Although Petit offers a useful tool for identifying differences between levels, his work suffers from the failure to identify possible differences within levels. Certainly studies to be presented do not suggest homogeneity of viewpoint and time horizon within the same level (3.125). Turning to size of firm and organisation flexibility (in its structure), there is a general view that as organisations increase in size, the number of administrative personnel increases more than proportionally (3.126). "As an organisation grows in size, exploiting its initial innovation, it finds it must have managers with administrative skills to ensure the organisation is efficiently and effectively run as the profit margins narrow and the product matures. For the most part innovators are poor administrators. Therefore management tends to become more and more administrative in character as it grows, relegating the innovators to relatively low positions and so frustrating them that they leave the organisation" (3.127). A view supported by Thompson who maintains "it has become commonplace among behavioural scientists that the bureaucratic form of organisation is characterised by high productive efficiency but low innovative capacity" (3.128).

A bureaucratic organisation is said to 'monocratic' (3.129).

Each person is seen to receive from and be responsible to only one other person, his superior, and so on up the hierarchical structure of the organisation; therefore there is only one point or source of legitimacy for direction of effort for each individual (that person immediately above him in the hierarchy). Therefore conflict cannot be legitimate. Yet this inability to legitimise conflict which is seen to depress creativity and innovatory ideas. "It is conflict that generates problems and uncertainties and implies pluralism in the search for solutions" (3.130). Generally speaking a bureaucratic organisation is conservative. Novel ideas are likely to appear threatening. Studies suggest that those managers having a 'bureaucratic orientation' (and therefore those most likely to survive and sustain a bureaucratic organisation) are more concerned with the internal distribution of power and status than with generating new ideas (3.131). And where change does occur it will tend to be that form least disruptive to the bureaucratic system.

The most typical form of task specialisation and bureaucratic form of management structuring is the traditional demarcation between 'line' and 'staff' managers. The Line Manager has direct command over authority and is concerned with the operational functions of the business, whilst the Staff Manager (eg the R & D Manager) is seen to perform an advisory role, concerned only with supportive activities. Etzioni does suggest that in certain types of organisational systems (eg research laboratories, universities) the roles of line and staff may be found to be reversed ... "in so far as such distinctions apply at all (the roles) are reversed. Although administrative authority is suitable for the major goal activities in private business, in professional organisations administrators are in charge of secondary activities; they administer 'means' to the major activity carried out by professionals" (3.132). What is important to note is the perception of these roles by the managerial participants, the status and consequent prestige attributable to these roles. These points are raised and discussed later in the text. The organisational structuring, by task specialisation, into definitive line and staff departments can seriously affect the generation and communication of technological innovation (3.133).

One further point bears mentioning here and that is the centralising or decentralising of the organisation. With specific regard to the centralising or decentralising of the R & D function attitudes to which structural form performs the most effectively, seems split. Bell Telephone Laboratories perform all the technical work on research and development, design and systems engineering for all the Bell operating organisations. This highly centralised approach is less favoured by other giant corporations such as Du Pont, General Electric, Westinghhouse, ICI and Dunlop who all demonstrate degrees of decentralisation, arguing that a centralised research function can become too easily detached from the 'realities' of the operating functions to which it is serving .

Some writers have sought to relate organisational structure to propensity to innovate. Essentially all identify two polarised structures:-

(i) Mechanistic/Traditional/Bureaucratic

(ii) Organic/Modern/Adaptive (3.134).

The Mechanistic structure is seen as appropriate to stable conditions and is seen to be less likely to generate or be prepared to assimilate innovation, whereas the Organic type is seen as appropriate to changing conditions, which give rise constantly to fresh problems and unforeseen requirements for action which cannot be broken down or distributed along the functional roles defined with a traditional hierarchical structure (3.135). Thompson makes two supportive comments "the innovative organisation will be characterised by structural looseness generally, with less emphasis on narrow, non-duplicating, non-overlapping definitions of duties and responsibilities" (3.136) and "an adaptive (organic) organisation may not be innovative because it does not generate many new ideas but an innovative organisation will be adaptive because it is able to implement many new ideas (3.137).

Aiken and Hage regard organic organisations as being built around the contributive nature of special knowledge, adjustment and continued redefinition of individual tasks and network structure of control. Authority and communication, importance and prestige are attached to affiliation and expertise (3.138). Whilst in reality neither of these 'ideal-types' will be so fully manifest in an organisation, it is likely that a firm will be seen to typify one of these structural forms and moreover, within the firm possibly various sub-systems (eg departments) will demonstrate particular typing-tendencies; so that communication between sub-systems is seriously impaired.

Recognition that increases in size of organisation can inhibit technological innovation has led a number of larger corporations in the US and UK to rethink the form of structure most conducive to the task. The outcome has been the implementation of a more organic structure usually referred to as Venture Team Management (even a New Ventures Department). Some writers argue for a separatist structure altogether.. "the search for innovation needs to be organised separately and outside the managerial business" (3.139). Others call for groups (teams) to take on the responsibility of innovation ... "the underlying principle is ... to place development of new product market position into an innovation group ... on a project basis. The group remains responsible for the project until its commercial feasibility has been established" (3.140).

Essentially the aim is to impose an additional horizontally linked department (or team) comprising of a variety of managerial skills from various departments who would not otherwise, within the more traditional structure, be in a position to work closely together. Venture teams' composition, by definition, are multidisciplinary; as Hill and Hlavacek found "venture team participants were from predominantly technical areas such as design engineering, application engineering, production, marketing research and finance" (3.141).

Fast (3.142) argues for venture teams based on three rationales:-

(i) it creates a centre of responsibility for new business to assure it receives sufficient attention. "A past mistake has been placing innovative activity under managers whose major responsibility is a traditional activity, and for whom the innovative venture is a minor thing" (3.143?.

(ii) it provides an organisational climate and structure appropriate for new business development. "The new venture department serves as an organic enclave within the more mechanistic parent organisation" (3.144).

(iii) it can insulate new business development from the values and norms of day-to-day business. "It is often said that the creation of a new unit is the only way to secure innovation that is not excessively bound and hampered by tradition and precedent" (3.145).

Popularity of venture teams (in various forms) began around 1965 (3.146); by 1970 twenty seven of the hundred largest US industrial corporations were practising venture management (3.147). In 1973 Vesper and Holmdahl, studying those companies among the top one hundred US companies that had won national technological awards (similar to the UK Queens Award for Technological Innovation), sixtyfive used venture management, and a further nine were planning to do so (3.148).

The venture team, being neither a traditional staff nor line function, but a hybrid of the two, exists in a form of 'structural disequilibrium', with forces pulling it towards becoming either a full-time staff research function or a full time line operating function. Fast points out that whilst the average life span of teams operating between 1960-1969 was 4½ years, those similarly operating between 1970 and 1975 the average life span was down to 1½ years; he offers no fully reasoned explanation for this fact (3.149). Nevertheless, the existence of the 'organic enclave' in a mechanistic structure must create structural stress; both from staff functions who resent the intrusion of an (elitist) group into their traditional planning domain, and from operational line managers who might resist new ventures of which they have had very little involvement in the earlier stages of both production and marketing development. It is not so much that the venture team cannot satisfy its brief (although here it might be dependent upon inputs from the mechanistic structure) which are not forthcoming, but rather the transition of its output into the firm's day-to-day business.

Whilst Hill and Hlavacek suggest "the venture team offers a practical alternative to the traditional structure of the corporation"(3.150), there still remains the need for more research before their claims can be substantiated.

As organisations grow and develop, so they take on additional functions which gravitate towards task specialisation through the establishment of line and staff departments. The organisation becomes unreceptive and structurally inflexible to those demands (including innovatory demands) which are deemed deviant from the day-to-day business. Where creativity (through conflict) is not encouraged those creative persons leave the organisation and in doing so reinforce the rigidity of the mechanistic structure they leave behind. In terms of studying the innovation process, this is the structural dilemma for larger organisations (3.151).

Attention now turns to those communication processes aiding or resisting innovation within the firm, which are facilitated by the existence of both formal and informal structures.

3.5 THE R & D : MARKETING INTERFACE

An 'interface' has been defined as "a common boundary between systems" (3.152). Chemists and chemical engineers have developed a fairly well-structured and useful body of knowledge about the transfer of materials and energy across an interface (3.153). A typical transfer situation is represented in Figure 3.5 below:-

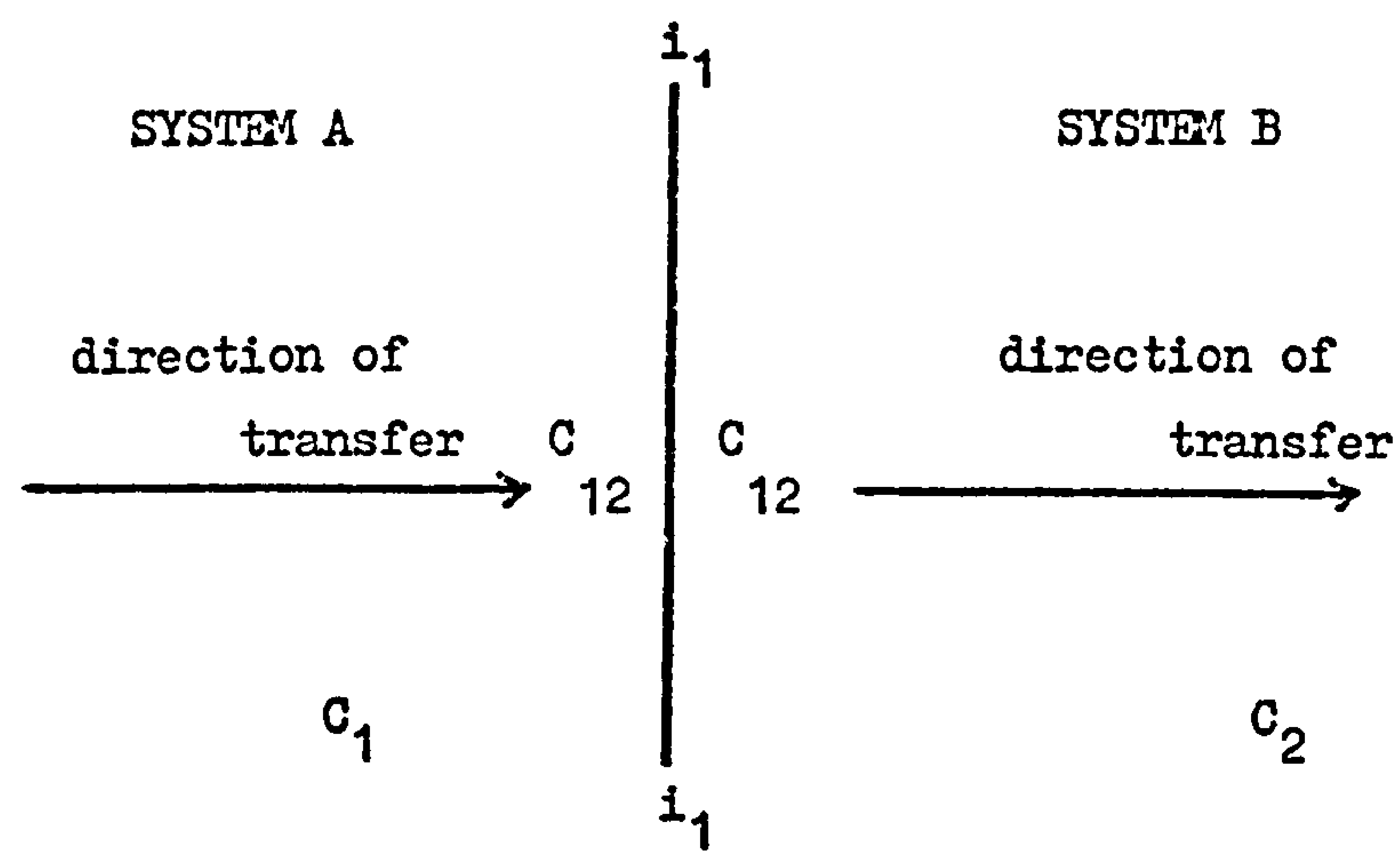


FIGURE 3.5 A GENERALISED REPRESENTATION OF MASS TRANSFER BETWEEN TWO SYSTEMS

Here, there are two systems, A and B. The boundary between them is the interface $i_1 - i_1$. Each of these systems contains elements of substance C, with the higher concentration of C, C_1, being in A, and the lower concentration, C_2, in B. The physical laws describing the transfer situation show that the direction of transfer is from the system in which C is most concentrated, A, to that in which it is less prevalent, B. Theoretically, C will continue to flow from A to B until $C_1 = C_2$; the assumption being that for this equalisation process to take place, at the interface $i_1 - i_1$ the concentration of C is the same (ie $C_{12} = C_{12}$).

Berenson has used this approach to present an industrial model using three related systems:- (Figure 3.6) (3.154).

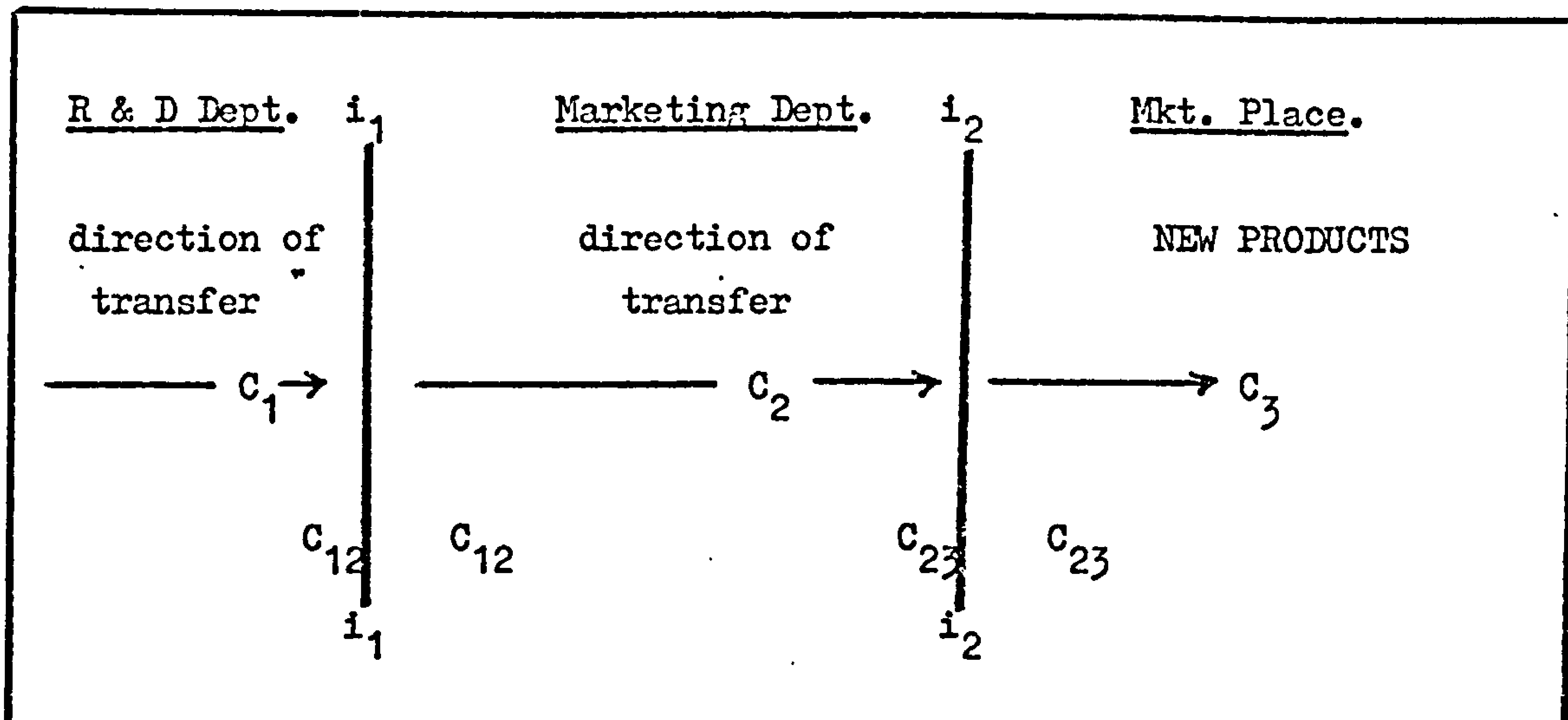


FIGURE 3.6 : A GENERALISED REPRESENTATION OF THE TRANSFER OF R & D RESULTS INTO PRODUCTS TO THE MARKET PLACE

In his model, the direction of R & D results move from the region of its highest concentration, C_1, to that of its lowest zone of concentration, C_3. In doing so, movement takes place across the Marketing Department (system), which has an "R & D results" concentration of C_2. Theoretically C (ie R & D results) will continue to flow across the interfaces $i_1 - i_1$, and $i_2 - i_2$ until $C_1 = C_2 = C_3$ (3.155). This model shows only the flow of technology across two systems, before reaching the market place; it should be recognised that a multiplicity of interfaces do exist, within a particular system (namely vertical flows) and between systems (horizontal flows - eg R & D and Production, Marketing and Accounts etc).

However, evidence is to be presented which suggests that in reality, in industrial systems, the flow across system at the interface does not always approach the theoretical state $C_1 = C_2$ (ie $C_{12} = C_{12}$).
In fact, common usage of the term 'interface' in this area implies restrictive flow of communications.

Concentrating attention upon the R & D : Marketing Interface two general reasons are suggested why there often occurs this restrictive flow of R & D ideas. One is the often spatial distance between departments, but the other is deemed to be present no matter how close the proximity of these departments. This second reason is attributed to 'different value structures' in the two systems.

It has been suggested that different value structures and business orientations exist between the technical (scientific researcher) and operational (eg marketing) manager. One attitudinal survey carried out concluded that .... "in our research amongst R & D managers, it is clear that the work itself is the prime factor of importance, but having that job in their present organisation is of least importance" (3.156). This was in sharp contrast with the attitudes of marketing managers, who identified closely with their organisation.

Moore and Renek suggest that the values of business are rejected by many technologists; they found that entrepreneurial interests sometimes came into conflict with the broader field research interests of research personnel ... even to the point where the researcher often gets the notion that he is 'prostituting' himself for commercial ends (3.157). They found large numbers of qualified research workers enter R & D departments directly from university, where their studies have been concentrated into one subject discipline for as long as seven or eight years (at Ph.D level); they were likely to relate their career goals to advancement in their own particular disciplines rather than with the attainment of corporate goals of profitability.

Barnes found .. "very briefly the findings (of his study) question the usefulness of management orientations which stress profits, productivity and practicality to the exclusion of other values. Organisational values, according to the findings of this study, may be over-stressed and self-defeating in technical groups" (3.158)

Parmenter and Garber have examined the self-percepts of creative people (3.159). American scientists in universities, industry and government services, deemed by their colleagues to be 'highly creative', were asked to rank 10 factors according to their importance in enhancing the creativity of an organisation ... the findings were (Table 3.11):-

RANKING	FACTOR
1	Freedom to work on areas of greatest interest
2	Recognition and appreciation
3	Broad contacts with stimulating colleagues
4	Encouragement to take risks
5	Tolerance of non-conformity
6	Monetary rewards
7	Opportunity to work alone rather than in a team
8	Creativity training programmes
9	Criticism by supervisors or associates
10	Regular performance appraisals

TABLE 3.11

These findings help to substantiate similar earlier work by Kaplan and by Gerstenfeld (3.160).

Steele suggests that it is these value barriers, which, polarising through the individual's maturation process, provide the most impenetrable barrier to communications across the Marketing : R & D interface. He feels these differences are manifest in three forms:-

(i) '<u>in attitudes to time scales</u>' — perspectives of time scales are seen to differ between the researcher and the operating manager. To the scientist, research cannot be hurried, put into time limits, or necessarily short cut, whilst the operating manager constantly talks in terms of 'target dates'.

(ii) '<u>action versus knowledge</u>' — due to his training and development, the scientist will not act until he 'understands' the phenomena under investigation, whilst the operating manager is frequently called to make decisions (ie take action) given a situation of 'incomplete knowledge'.

(iii) '<u>profitability versus knowledge</u>'— generally the operating manager tends to be more orientated to visible goals of the organisation (eg profitability, ROI, sales targets) whereas the scientist tends to see his work as part of the cumulative synthesis of scientific knowledge (3.161).

Quinn and Mueller, calling interfaces 'technological transfer points' state that "the key problem in research management to-day is getting research results effectively transferred into operations " (3.162). They go on to suggest that good communication flow across the interface requires the receivers (that is, the operating management) to have:-

(i) information about the technology and

(ii) enthusiasm for it.

Yet, in reality one finds the two systems talking two distinctly differing languages. Zopporth, an executive with the Xerox Corporation, points to the confusion and misunderstanding that existed between his company's technical and operating managers (3.163).

Muse and Kegerreis call it 'status patois', which they define as the tendency to talk and write in a special language which is designed to limit communications to those 'outside' a controlled professional peer group. The mystique so created then is preserved by rival systems to maintain their status positions (3.164).

Two writers have collected evidence to support their claim of R & D : Marketing interface problems ".... the findings of these reports appeared to constitute evidence of a serious failure by marketing management to involve itself in the research and development process, and by R & D management in understanding the functinns of marketing and the potential contribution that it has to make to successful innovation" (3.165).

Hanan certainly believes that this lack of involvement on the part of operating management is due to ignorance ... "R & D has traditionally been treated with great deference if not outright permissiveness on the part of operating management. Some of this 'let them alone' attitude has no doubt been the result of management's lack of intimacy with the tools and techniques of R & D and, to a certain degree, of its awe of the scientist" (3.166).

Catt feels it is the 'technocrat' who is not understood ... "technologically ignorant and hostile management" (3.167) are seen to be the blocks to innovation.

Yet Muse and Kegerreis also found from their study that "all too often there appears to be a lack of sensitivity to marketing implications on the part of the technical personnel involved" (3.168).

This discussion of the barriers to communication at the interface between Marketing and R & D suggest that Berenson's model (as presented in Figure 3.6) needs closer examination if it is to be used to explain communication in industrial systems. His model illustrates "flows of R & D results" whereas what is needed is the tracing of the flow of innovation ideas (in particular the source of the idea) to explain the possible obstacles to adoption of that idea within the firm...

What is suggested is that interface problems between Marketing and R & D are a function of the source of the idea rather than the flow of results. As Figure 3.7 illustrates, a model can be presented showing two possible (generalised) sources of innovatory ideas.

(i) ideas originating from research

and

(ii) ideas originating from the market place

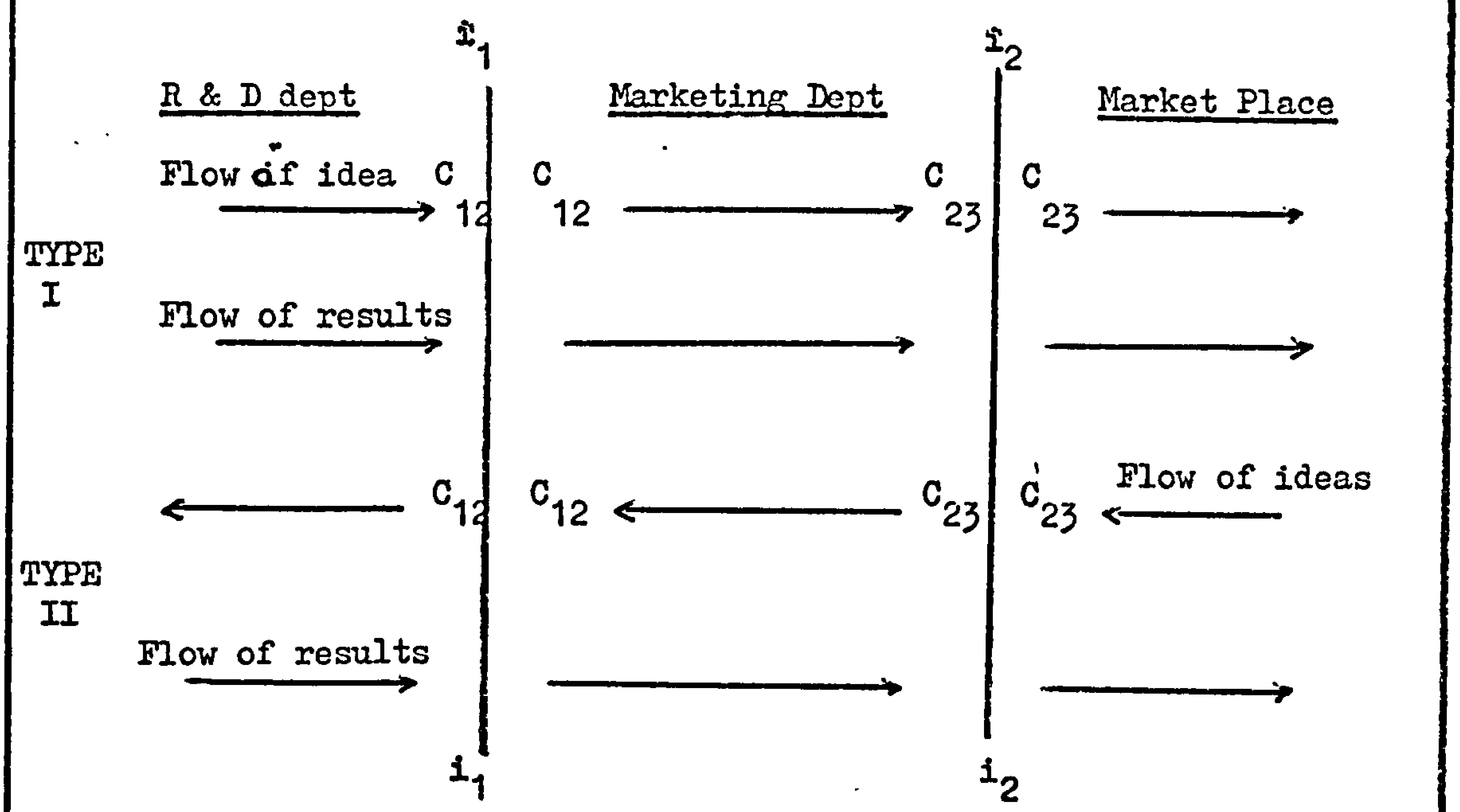


FIGURE 3.7 A GENERALISED REPRESENTATION OF THE FLOW OF INNOVATORY IDEAS & FLOW OF R & D RESULTS BETWEEN RESEARCH, MARKETING & THE MARKET PLACE

The former source - Type I in Figure 3.7 - is generally considered to be Technology Push, whilst Type II is called Market/Demand Innovation Pull. Resistance at the two interface points shown $i_1 - i_1$ and $(i_2 - i_2)$ are seen to differ when considering the two sources of innovation.

3.6 COMMUNICATIONS, STRUCTURE & INNOVATION

The process of communication consists of four basic elements : see Figure 3.8

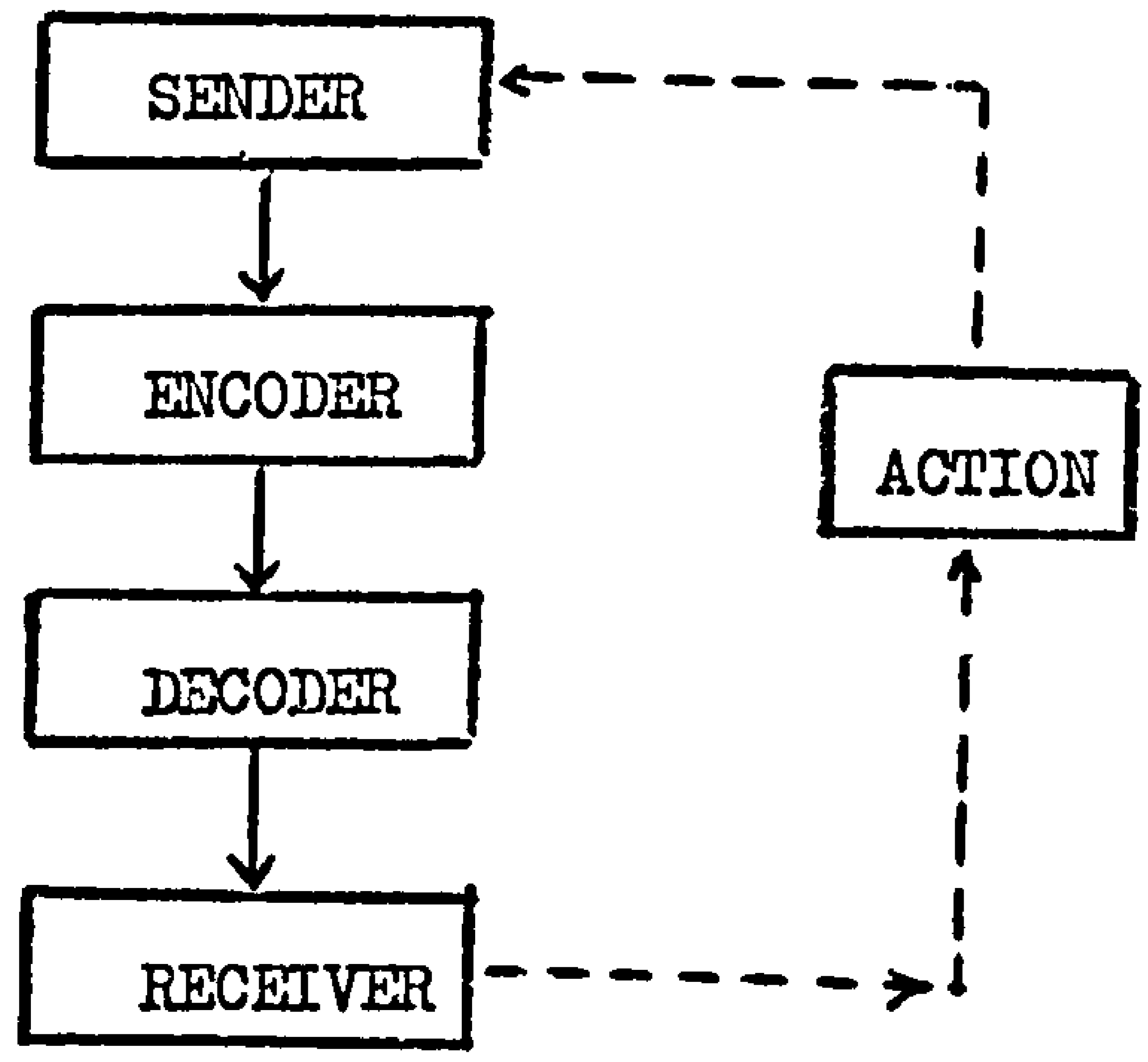


Figure 3.8 SIMPLIFIED MODEL OF COMMUNICATION PROCESS

A message from the Sender, may or may not need Encoding and Decoding before reaching the Receiver in a form understandable to the latter.
The Action that the Receiver takes (albeit simply acceptance or rejection of the message) will in turn modify the relationship and future communications that take place between Sender and Receiver.
Research findings are presented which suggest that communication problems do arise between Sender- Encoder and Decoder-Receiver in business organisations.
In terms of considering the effectiveness of a communication, the researcher needs to be aware of three interrelated elements (Figure 3.9)

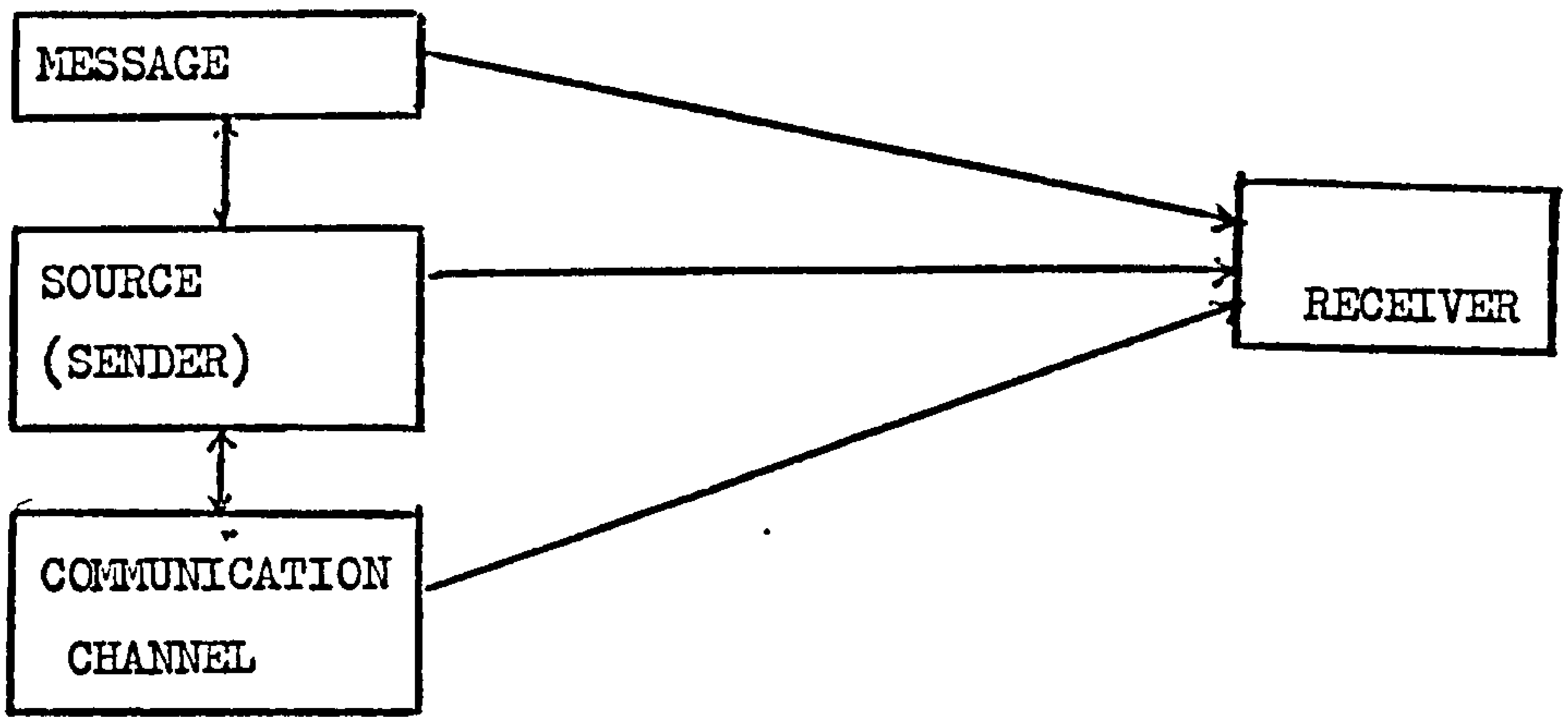


Figure 3.9 COMMUNICATION EFFECTIVENESS MODEL

For the Receiver, not only must the message be 'meaningful' to him (as outlined in Figure 3.7) but also the source of that message must be credible, as must be the communication channel used. Often departments look favourably or unfavourably towards communication from other parts of the organisation. "The appearance of the creative process, especially in the early stages, poses a problem to administrators. Up to a point, it may be hard to distinguish from totally non-productive behaviour, undisciplined disorder, aimless rambling, even total inactivity" (3.169).

Cunningham and Hammouda found in a number of engineering firms ...
"Many top managers consider that economists and statisticians are rarely found to be the best persons for managing market research operations for highly technical products because of their lack of understanding of technical matters .... they seek the information from elsewhere, and the technical departments are asked to perform some of those functions normally classed as market research activities" (3.170).

Just as credibility of the source of communication can affect its receptivity, so can the channels used to convey it. Communications will flow from Sender to Receiver via formal and informal networks (3.171). In practice many of the types of communication - technical reports, memoranda, letters, conferences, symposia, courses, seminars, visits, phone calls, temporary assignments, casual interactions, 'business chats over dinner' and so on tend to operate at both formal and informal levels. It is not the channel/method of communication used per se, but the Receiver's perception of it that affects the action taken regarding the message. Informal channels may be no more persuasive, in fact less so in bureaucratic organisations, than the more formalised, hierarchical communication networks.

There exists a number of empirical studies which indicate a positive relationship between good and efficient communication and successful industrial innovation (3.172). Booz, Allen and Hamilton found that organisational problems were cited by more than 80% of the companies they surveyed as a major cause of failure of innovation; and of these, over 60% attributed failure to a combination of :-

(i) Obscure definition of responsibilities

(ii) Failure of organic and functional liaisons and relations

(iii) Communications (3.173)

— all elements of poor organisational communication networks.

These findings, and others, do illustrate the close intermeshed relationship that exists between organisational structure, communication networks and what is communicated. In small firms the transition of innovation to eventual commercialisation is often carried out by the same person or small group of people, so that communication problems are minimised. One can identify a continuity of project enthusiasm, no (technical) language barrier, and a commitment to the project. For the larger firm, transition of ideas is certain to necessitate formalised communication between specialised functions where, as Steele points out .. "... it is true that ineffective efforts in trying to introduce innovation can create strains and severely disrupt relationships in other aspects of operating the business" (3.174).

Morton studied the implications of interaction between physical and/or spatial relationships on the one hand, and organisation relationships on the other in influencing adoption of innovation by the various functions (3.175). His work, known as 'barriers and bonds theory', suggests that both spatial relationships and organisational relationships can act as either 'barriers' that impede transmission of information, or 'bonds' that facilitate transmission and reception of information. For example, close proximity can provide easy interactions and so spread enthusiasm to all those directly involved; a facet stressed by advocates of integration of Research & Development into the day-to-day business of the firm. Morton suggests the existence of a further bond which exists between members of the same organisation vis a vis the more difficult task of cooperating between organisations. Nevertheless researchers have identified the weakness of a unidimensionality of corporate goals perspective.

Likert suggests "increases in functionalisation make effective co-ordination both more necessary and even more difficult" (3.176). His prescription for better communications was to use 'link-pins' between the various subsystems (eg departments) in the organisation (" .. to perform the intended coordination well a fundamental requirement must be met. The entire organisation must consist of a multiple, overlapping group structure with <u>every</u> work group using group decision-making processes skillfully. This requirement applies to the functional product and service departments. An organisation meeting this requirement will have an effective interaction-influence system through which the relevant communications flow readily; the required influence is exerted laterally, upward and downward, and the motivational forces needed for coordination are created" (3.177)

These 'link-pins' would be certain organisational participants who would be members of two separate groups/departments and so serve as the coordinating agent ('gatekeeper') between them. Likert does not fully examine the burden that might be placed upon both the individual (eg his loyalties and credibility in each group) and the administrative structure if such an idea was widely implemented (as he advocates) in the organisation. However, variations in Likert's cross-fertilisation idea are presently manifest in organisations, for example in the form of Management 'Venture Teams' .

Steele offers an alternative view when he suggests that communication can be improved using "two tools that are amenable to manipulation by the manager" (3.178). Namely 'money' and the establishment of what he terms 'commonality' (3.179). He suggests 'money' should be viewed as a medium of exchange and so be used as a way of negotiating common equities and mutual interests in a particular research and development project. Money becomes the common denominator by which various parties, who are potential participants in a transition of an innovation from drawing-board to the marketplace, can indicate their true interest in it "... thus, negotiating for the support of a project is a way of identifying the extent of true interest on the part of the potential parties involved" (3.180). He is careful to qualify his view, when he suggests that the idea cannot function ".. unless the opportunities for providing support are relatively unfettered by company policy regarding the flow of funds" (3.181). In reality his idea would be subject to structural inflexibilities and 'political-manoeuvering' between power groups in the organisation, so denegrating into a squabble over the actual division of funds, which, in itself, becomes a barrier to the innovation process.

Steele also suggests that information flow can be enhanced by distributing technical work and technical people in such a way that there is 'commonality of knowledge' and 'commonality of viewpoints' amongst the personnel who participate in the innovation process ... "this commonality is indispensable in establishing adequate communication" (3.182) A view shared by Seidman "attitudes and behaviour depend not only on personality but role structure, and one way in which attitudes and behaviour can be modified is by shifting an actor from one role to another" (3.183) "our studies showed that an important factor in successful innovation is the transfer of information from development to production; and here we found that there is no substitute for the movement of people, including highly qualified ones" (3.184). Although these views are similar to that of Likert in their appeal, an inherent obstacle is the nature of the innovation itself; that is, the inherent level of technology in the innovation can preclude Steele and others prescriptive measures.

There is a tendency for personnel to be less technically orientated the further the project moves away from the drawing board towards commercialisation, so that technical concepts need to be 'translated' into every day jargon. The repeated encoding and decoding can result in message distortion, misrepresentation of the facts, with subsequent barriers to information flow. Certainly a communication problem for the organisation is not to establish effective communication between 'the experts' in a particular field, because this is likely already, but rather to ensure the diffusion of information they are seeking to generate to others who are not so expert.

Whilst, in theory, commonality of interest, of values and of commitment to a project would enhance the flow of communications between departments and interested parties, in reality, except in the smaller firm where these problems are not so prevalent anyway, achieving Likert's and Steele's ideas may be more difficult. It presupposes an ability and a willingness on the part of personnel to be located at these points of potential friction; and for these 'gatekeepers' to be accepted by those subsystems for which they are acting as information-gatherers and information-disseminators; credibility of information source would be as vital as that information itself. Cunningham and Hammouda found ".. it is evident that there is a failure in communcations between people of different backgrounds whereby technically-biased managers are unable to direct the activities of economists (ie operating managers), and cannot or will not interpret the findings of economists into effective decisions"(3.185).

Ansoff and Stewart identify communication problems with their discussion of "downstream coupling" - "the extent to which the success of the company's product introduction process depends on communication and cooperation between R & D, manufacturing and marketing, which are further 'downstream' towards the customer" (3.186). They suggest the higher this coupling, the more they need for close interaction between departments.

Johnson and Jones identify three types of communication problem for the innovatory firm (3.187):-

(i) Classification Problems : the determination of the importance each innovation-proposal ought to receive

(ii) Coordination Problems : the assurance of continuity and cooperation in the evolution of the innovation from idea to commercialisation

(iii) New Knowledge : the provision of information for decisions on products with which the company has had no direct prior experience. That is, the more 'disruptive type' of innovation.

They suggest, using a matrix approach, where the source of responsibility for information flow lies.

Figure 3.10 illustrates:

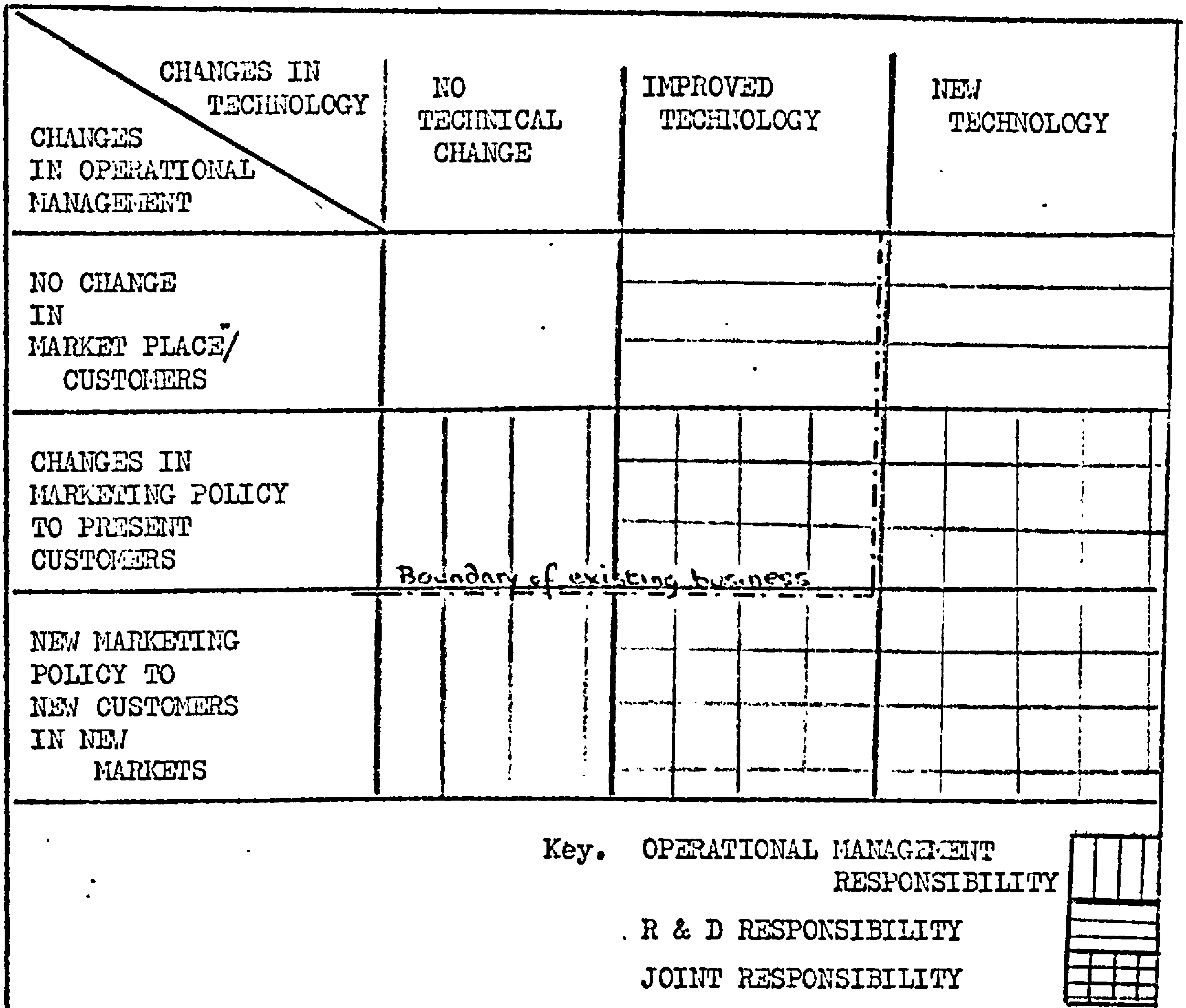


FIGURE 3.10 SOURCES OF RESPONSIBILITY FOR NEW KNOWLEDGE INPUT

Johnson and Jones sought to highlight sources of responsibility for iniating information for the innovation process, however, they do not suggest that at the very situation where changes in technology and changes in operational management procedures are most severe, and so from the matrix, joint-cooperation most necessary, how it will be actually achieved!

For many writers of 'management' and 'organisation' theory the achievement of 'effective communication' implies devising an easier path through the system for the management goal (eg product innovation). In practice the same structure and communication networks can be used by the participants to resist the management goal. What is evident is that the nature and flow of information in an organisation is facilitated by the structure, but determined by the interaction of people, who establish informal networks to assist or counteract communication through the formal channels.

General diffusion research has laid great stress upon the role of the 'opinion-leader' - 'gatekeeper' in affecting the flow of communications. Research in industrial innovation suggests that the role of the personally-committed (to the innovation) manager may be crucial for the firm seeking to innovate. These people I shall call 'Innovation Champions'.

3.7. THE 'INNOVATION CHAMPION'

Twiss maintains "innovations do not happen, they are made to happen" (3.188). But how are they made to happen? There is a growing evidence to suggest that the required catalyst for innovation is the presence of an individual who is prepared to commit his position in the organisation to further the progress of a particular project. One study found "all of the successful ones (innovations) had at least one able and dedicated leader pushing them. No project was successful without such a person behind it" (3.189). Knight sees this championing role as providing "the interface between the creative idea and the organisation ... the change agent who introduces and carries out the new idea" (3.190).

Chakrabarti, investigating the role of these committed persons in the application of spin-off NASA research, found that in sixteen out of seventeen cases where the spin-off research could be considered a commercial success, there was evidence of the presence of an innovation champion (3.191). Table 3.12 illustrates his findings:

	NO. OF MORE SUCCESSFUL INNOVATIONS	NO. OF LESS SUCCESSFUL INNOVATIONS	Σ
NO. OF CASES WHERE THE PRESENCE OF PRODUCT CHAMPIONS WAS IDENTIFIED.	16	1	17
NO. OF CASES WHERE PRODUCT CHAMPIONS COULD NOT BE IDENTIFIED	1	27	28

TABLE 3.12 SOURCE : CHAKRABARTI

Several studies have highlighted the attributes of the "innovation champion". These are presented in Table 3.13.

INNOVATION CHAMPION ATTRIBUTES / RESEARCH STUDY	PERSONAL CHARACTERISTICS	TECHNICAL KNOWLEDGE	POSITION IN COMPANY	KNOWLEDGE OF MARKET
1. CHAKRABARTI	Drive & agression Political astuteness	technical competence	seniority & knowledge of company	knowledge of market
2. ROBERTS	Business person-ity developed from favourable home-environment Well educated Aged around 35	Development oriented rather than Research oriented		
3. EILOART	democratic & consensus seek-ing	technical competence	Senior but prepared to seek views of his fellows	
4. KNIGHT	personal commitment to succeed. Willingness to accept personal risk to do so	technical competence with project	power to carry out project	
5. HILL		engineering background		
6. FREEMAN			seniority	
7. LANGRISH			seniority	
8. PROJECT SAPPHO	enthusiasm involvement	technical competence	responsibi-lity status authority	
9. HUNGARIAN SAPPHO	commitment	technical experience		
10. ROTHWELL Textile, Study Machinery			seniority but consultative	

TABLE 3.13 IDENTIFICATION OF INNOVATION CHAMPION (3.192) PROFILES BY TEN RESEARCH STUDIES

One factor which emerges from a number of studies is that the individual - the innovation champion - must be committed to the project; "an individual who is intensely interested and involved with the overall objectives and goals of the project and who plays a dominant role in many of the research-engineering interaction events through some of the stages, overcoming technical and organisational obstacles and pulling the effort through its final achievement by the sheer force of his will and energy" (3.193). This involvement need not necessarily be structured within the formal framework of the organisation.

Chakrabarti found the emergence of a 'product champion' (his terminology) to be "unsystematic and non-routine, which primarily depends upon the individual's choice and initiative" (3.194). Even where innovation is more formally structured, for example within Venture Team Management, personal commitment may still not be so forthcoming, because demonstration of this commitment is likely to involve the individual putting his personal status in the firm, and perhaps his entire career, at risk. Identifying this point Schon suggests that the innovation champion "must be a man willing to put himself on the line for an idea of doubtful success .... it is characteristic of champions of new developments that they identify with the ideas as their own, and with its promotion as a cause, to a degree that goes beyond the requirements of their job" (3.195).

Whilst a number of researchers stress this need for personal commitment, Roberts seeks to identify a clearer picture, presenting an almost 'ideal type' of the innovation champion (3.196); he is likely to be aged early-mid thirties, well-educated to at least MSc level, with a home-environment where his father, being self-employed, has provided what Roberts calls an "entrepreneurial heritage". There is no collaborating evidence to sustain Roberts' ideal type!

Research suggests that personal commitment and possibly the charisma to generate enthusiasm amongst colleagues may not be sufficient to generate and sustain the innovation process. It is believed that the innovation champion must possess the formal power to carry out the project. Freeman suggests a strong relationship between formal seniority and success of the innovation champion; "the responsible individuals in the successful attempts (at innovation) are usually more senior and have greater authority than their counterparts who fail" . . Similar conclusions were drawn by Chakrabarti, Eiloart, Knight, Langrish, Rothwell and the Project SAPPHO series.

Indications are, that the innovation-champion, to retain a level of credibility within the organisation, is likely to possess a level of technical competence equal to that incorporated in the innovation. What is not so clear is his necessity to have 'market vision'. It seems implicit in that of these studies quoted in table 3.12, the majority lay great emphasis (in particular Chakrabarti, Freeman, Langrish, Rothwell and the two SAPPHO studies) upon innovation success being due to clear identification of 'user need'. Failure to clearly identify the champion's role may have been due to the particular research designs themselves. Though research findings have been presented to highlight the importance of the innovation champion's role in the adoption process, clearly the nature and style of his leadership will be affected by the prevailing organisational structure and climate. For the innovation champion to begin to function calls for a certain degree of sympathy towards innovation by senior management. Indeed, Chakrabarti suggests the innovation champion's role is not so crucial in organisational structures demonstrating 'organic tendencies' ; where the prevailing organisational climate reduces the potential political conflict situation. Leadership is likely to be far less structured, with greater emphasis upon 'team championing'. Certainly Layton and others found the role of innovation champions to differ in successful small innovatory companies, where "there can be personal leadership by one or two people whom all the other key people know, respect and follow .... in a small concern it is possible for a technological leader to guide management and broad strategy at the same time" (3.197). Whereas, in the larger, more bureaucratic and mechanistic organisations, the need is for an innovation champion to question and drive against existing practices and procedures, so that the very structure and climate is likely to form barriers that have been highlighted in this text. As Roberts points out "of importance is the recognition that both policies and attitudes of organisation often work to defeat entrepreneurial efforts" (3.198). Similarly, structure can determine whether innovation championing is necessarily pursued by an individual, or a team well-led; Rothwell, quoting from inter-industrial differences regarding the role of innovation champions, found "the absence of individuals emerging as important in the chemical industry can be explained in terms of its large firm environment, with accompanying high degree of formal structure and bureaucracy" (3.199).

Whilst evidence has been presented to suggest the necessity of a 'catalyst' for the innovation process; and that the emergence of an innovation champion may be through the formal or informal structure of the organisation, possessing enough political power (or support of those who do have this power) to gain organisational acceptance of the project, the question posed is, at what stage in what is a collective adoption-decision process, is the presence of an innovation-champion crucial? Rogers and Shoemaker suggest that the organisation decision process consists of five sequential stages namely:

Stimulation
Initiation
Legitimation

Decision Making
Execution (3.200).

Table 3.14 illustrates:-

STAGE	DESCRIPTION OF STAGE
STIMULATION	It is the process by which someone becomes aware that a need exists for a certain innovation within the organisation
INITIATION	It is the process by which the new idea receives increased attention by members of the organisation
LEGITIMATION	It is the process by which the idea is sanctioned by members who represent the norms and values of the organisation
DECISION-MAKING	It is the actual process of decision-making for commitment of organisational resources for adopting the idea
EXECUTION	It is the actual process of implementing the decision

TABLE 3.14 ORGANISATION ADOPTION-PROCESS.
SOURCE ROGERS & SHOEMAKER

Rogers and Shoemaker suggest that the sequential progression from stage to stage is 'sparked off' by the actions of 'key individuals'. Chakrabarti, using their approach, presents the following characteristics of these key persons at each of the stages in the adoption process (3.201). "Stimulator", (Stimulation stage): may be an outsider or an insider orientated externally through his formal or informal relationships with members of the firm or other people. Stimulators are cosmopolite people who understand both the environment and the general problems of the organisation.

"Initiator" (Initiation stage): he translates the idea into a plan of action which is appropriate for the organisation. The initiator knows the organisation well enough to package the idea in a form acceptable to other organisational members.

"Legitimiser" (Legitimation stage): he is certain to be an inside person who has the social power of sanctioning an idea. An individual will act as legitimiser for different ideas depending upon:-

(i) his breadth of experience, personality and interests

(ii) the size and structure of the organisation

(iii) the type and nature of the innovation

"Decision-Maker" (Decision-making stage): he is the person who has the formal authority to commit the organisation's resources to the project

"Executor" (Execution stage): he is the person who implements the adoption decision. This execution decision generally will involve different functional groups.

But can we assume that 'key persons' are necessarily innovation champions? In the smaller organisation the innovatory champion is likely to be dominant at all the stages of the adoption process; this is less so in the larger organisation with greater structural rigidity.
Chakrabarti suggests that the innovation champion can act in multiple roles, linking the different phases in the adoption process, but what is not so clear, is to the span of his influence over the whole of the adoption process. Research evidence suggests that whilst the innovation champion is instrumental and influential in the earlier stages of the adotpion process, he is less likely to be cast in the decision-making role. Indeed he is likely to be at odds with the existing practices and procedures of the organisation, and decision-makers (given the prevailing organisational climate towards change) tend to lean towards maintaining organisational 'status quo' regarding practices and procedures; the

innovation champion has to convince the decision-maker as to the viability of the project; 'viability' usually demonstrated in physical and/or commercial terms.

For example, Project 'SAFFIL' - an innovation developed by I.C.I. (Mond Division) - was led by an innovation champion, Dr Birchall, who was given the funds by the organisation to research and develop the project. Before the project was allowed to proceed to the production stage (which would signify adoption of the innovation by the organisation) Dr Birchall had to demonstrate, using his pilot plant, the commercial viability to the I.C.I. main board. Approval was subsequently given for the establishment of production facilities and Dr Birchall was given the task of overall execution of further development, production and early commercialisation of the project. (3.202).

A second example to illustrate the role of the innovation champion in the adoption process is provided by the Pilkington 'Float Glass Process'. This innovation, now diffused to all major manufacturers of plate glass, was an entirely new concept developed by Pilkington Bros. whereby molten glass is fed continuously on the surface of a bath of molten tin, upon which it floats. The smooth surface and constant thickness of the resulting glass completely eliminates the need for a grinding operation. Development began in 1961/62 and took seven years and cost over £4 million before the first saleable glass was manufactured, but resulted in reducing production costs by 25%, and plant size by more than 33%. The initiative and drive behind the project is attributed to one man, Dr. L.A.B. Pilkington. (3.203).

Similarly, the development of glass reinforced cement is attributed to the persistence and commitment of one man, Dr. Majumdar. Research into this project began in 1966, at the Government-sponsored N.R.D.C. - Building Research Establishment under the supervision of Dr. Majumdar. In 1966 he approached Pilkington Bros. with his project, but was rejected as 'case not proved'. He then took his project, in 1967, to Cornings in the United States, who were able to produce the type of glass needed (called GZO) to assist his research; this was used to successfully produce the first batch of alkali-resistant glassfibre cement; but still the idea was rejected by the U.K. glass industry. At last, in 1968, he persuaded a glassfibre manufacturer (Turners Ltd) to produce 100 lbs. of his glass reinforced cement. Pilkington Bros. in reviewing the situation, subsequently bought all controlling rights for the new product.

In each of these examples the nature of the innovation champion's role has varied, as illustrated in Table 3.15 below:-

STAGE IN ADOPTION PROCESS / KEY PERSON / INNOVATION CHAMPION	STIMULATION	INITIATION	LEGITIMATION	DECISION MAKING	EXECUTION
	STIMULATOR	INITIATOR	LEGITIMISER	DECISION MAKER	EXECUTOR
DR. BIRCHALL ("SAFFIL" FIBRES)	*	*	*		*
DR. PILKINGTON (FLOAT GLASS PROCESS)	*	*	*		
DR. MAJUMDAR (GLASS REINFORCED CEMENT)	*				

Table 3.15 CONTRASTING ROLES OF INNOVATION CHAMPIONS IN THE ORGANISATIONAL ADOPTION PROCESS

Whereas Dr. Birchall, at I.C.I., featured predominantly in all the major stages, save only the decision to adopt, Dr. Majumdar's role tended to be restricted to a Stimulator in the strictest sense as defined by Chakrabarti's characteristics of 'key people'. With the development well advanced on the glassfibre cement project before it entered Pilkington

Bros., the earlier stages in the organisational adoption process (ie Initiation and Legitimation) were assessed by the Decision Makers themselves; the potential risk of innovation by 1968 had been considerably reduced from Dr. Majumdar's first approach to Pilkington Bros. in 1966.

Analysis of these three illustrative cases does lead the author to question the possible validity of those findings that have sought to correlate the position of innovation champion with high organisational status. By concentrating on the Decision-Making stage, to the exclusion of the other stages, the role of senior management may well have been misrepresented. For example, Chakrabarti, using his research findings illustrated in table 3.16 (below), suggested that "higher management is

	NO. OF CASES BY THE DEGREE OF SUCCESS OF THE PROJECT AS EVIDENCED BY:-			
LEVEL AT WHICH DECISION WAS MADE	COMMERCIAL MARKETING	TEST MARKETING	TECHNICAL FEASIBILITY TESTING	NO. ACTION BEYOND AWARENESS OF THE IDEA
President of Company	6	7	7	-
Divisional Head	4	-	1	5
First Line Supervisor	-	-	1	14
	10	7	9	19

TABLE 3.16 DECISION MAKING IN 45 PRODUCT DEVELOPMENT CASES - CHAKRABARTI

more involved in the successful cases than in the less successful ones" (3.204). But this is likely anyway! Given that the earlier stages of the adoption process are filtering processes, then those projects that reach the senior management decision stage will inherently contain more chance of success. For example, in the 'SAFFIL' example quoted earlier, an early research decision had to be made whether to develop one or two forms of the fibre - alumina-silicate and zirconia-silicate; an R & D decision dropped the latter, so that the Main Board decision later was made that much easier (in terms of spotting a 'successful' innovation prospect).

Similarly, the eventual conviction of Sir Alistair Pilkington (Chief Executive of Pilkington Bros. 1968) in Dr. Majumdar's project does not necessarily lead one to the conclusion that he was the 'innovation champion'. Indeed the opposite in this case is true, because the idea had been rejected two years earlier! Clearly researchers need to make the distinction, if one does exist, between the innovation champion and the 'entrepreneurial champion', who adopts the project on the basis probably of commercial viability.

3.8 MANAGERIAL REACTION TO THE RISKS OF INNOVATION

The presence of risks and the communication of these risks to others in the collective organisational decision-making process will affect the in-firm innovation adoption process. All research suggests decisions to innovate contain risks for the innovator.
Littler quoting from a number of studies suggests that failure rates can be as high as 90%, yet firms continue to innovate (3.205). De Bono calls it the 'innovation dilemma' "... the innovation dilemma lies in the fact that, in general, it makes a lot of sense for innovation to take place, but in particular it does not make much sense for any individual organisation to innovate. The risks of innovation are high in terms of disturbance, effort and cost" (3.206). But what are these risks? Mansfield found "that the technical risks involved in the bulk of industrial research and development, outside military and other government-financed areas, seems quite modest ... according to the directors of three laboratories in the sample, about 70% of the projects in their laboratories were aimed at only advances in the state of the art" (3.207). If technical risks are low, then what accounts for the high risk of innovation failure? The answer can be found in terms of rejection in the marketplace and rejection in the firm. One research study suggests that a firm needs to generate over fifty innovatory ideas to produce one commercially viable product (3.208).
Every decision to innovate in an organisation is the product of individual behaviour (generally) interacting with others; for every decision the individual is paid by the organisation to consider the possible consequences of that decision upon the performance of the organisation. However, in addition, the individual, in making the decision, will evaluate the effect upon his own personal stature and his relationships

with others inside (and outside) the organisation.

The risks of innovation may be technical or commercial, and they may threaten or support the survival of the firm, but to understand the reaction taken to these risks, the researcher must observe the behaviour of the individual, albeit acting in concert with others. To the individual, support for or against an innovation may be based upon economic criteria related to 'organisational goals' (to which he may have directly subscribed to in the first place), but his reactions will be tempered by self-interest and self-preservation within the organisation.

ECONOMIC RISKS

A number of innovation studies have viewed 'risk' solely in terms of economic criteria - the effects of innovation upon profitability. Mansfield suggests three variables which influence the firm's decision to adopt an innovation (3.209):

1. profitability of the innovation
2. level of required investment
3. industry concentration.

He explains 'risks' in terms of possible competitor reaction, and the cost of borrowing resources related to the possible returns on that investment. Certainly the risk of imitation by competitors is a consideration when taking the decision to innovate (3.210). Rarely is it possible to obtain patent protection on the basic idea, because there is almost always an abundance of prior art in the patent and technical literature. Hence protection can only be sought by filing patents that incorporate features of end-use; this, in turn, increases the problem for the manager who is forced to translate what may be loosely constructed ideas into feasible commercial projects. Webster sees the adoption decision as a 'trade-off' between perceived risk and profitability; "the higher the risk, so the higher the profitability of the innovation must be to secure an adoption decision" (3.211).

Booz et al (3.212) and Severiens (3.213) point to the increasing economic risk associated with increases in technological newness to the company's existing practices. Ansoff and Stewart (3.214) suggest economic risk is related to the distance the company is from the 'frontiers of technology'; this distance has three effects:

1. stability (of procedures, practices) - is seen as a function of distance from the frontier. The nearer the firm is to this frontier, so the pressures to innovate become greater.

2. predictability (of procedures, practices) - is low for organisations near to the frontier; they are operating in technical (and possibly commercial) areas of only partial knowledge.

3. precedent (experience) - which underpines so much management activity is sparse at the frontier due to the changing environment.

One researcher has found that the reluctance to take risks in areas of technical newness leads a firm to pursue a policy of 'cannibalisation', of existing technologies (3.215).

What becomes apparent is that it is not so much the presence of economic risks (be they technical or commercial) that affects the adoption decision, but rather how these risks are perceived by the particular organisation. Whilst economic resources are a requisite for the implementation of decisions to innovate, and economic returns a business necessity, the innovation adoption decision is not a function of economic criteria alone; as Webster concludes "... speed of adoption by a firm (as measured by expected incremental profit) and the firm's ability to tolerate the risk involved in adoption (as measured by the amount of investment required and maximum possible loss) was related to the firm's size, liquidity and managements' 'self-confidence'" (3.216).

THE INDIVIDUAL'S PERCEPTION OF INNOVATION RISKS

Schein writes "organisation planners or top managers often naively assume that simply announcing the need for change and giving orders that the change should be made will produce the desired outcome. In practice, however, resistance to change is one of the most ubiquitous organisational phenomena. Whether it be an increase in p roduction, or adaptation to a new technology, or a new method of doing the work, it is generally found that those workers and managers who are directly affected will resist the change or sabotage it if it is forced upon them" (3.217). The concept of 'perceived risk' can be used to explain this resistance; the concept has been extensively investigated since first introduced in 1960 (3.218), although the literature concentrates predominantly on the final-consumer decision making process (3.219). It is thought to have relevance in the industrial decision-making process also, in that essentially it deals with how the individual perceives the risk of a decision in the light of his own situation and experience (namely apperception). Mansfield, himself, lays credence to its use when he writes "perhaps these variables (profitability, liquidity and growth rate) are less important than other more elusive and essentially non-economic variables. The personality attributes, training and other characteristics of top and middle management may play a very important role in determining how quickly a firm introduces an innovation" (3.220). A view confirmed by Ray "... the least tangible factor is, however, likely to have the greatest impact on the application of techniques - the attitude of management" (3.221). Rothberg is more specific when he identifies the individual's perception and reaction to risks in the organisation as 'playing it safe'; " .. the tendency of people working in the new products sector to base their decisions on trying to avoid failure rather than on trying to achieve success" (3.222). He suggests that this may be the fault of the organisational climate, where the manager "worries more about not being wrong than about being right" (3.223); as he sees it "downgrading of the image of innovation and entrepreneurship succeeds in making a company's managers less likely to attempt creative problem-solving" (3.224).

Hill sees the cause of this reluctance to take risks as indicative of modern large organisations; he maintains that the propensity to innovate has been "suffocated by the increasing complexity of non-technical management hierarchies" (3.225). Hill quotes the example of the IBM Corporation which turned down the later highly profitable Xerox photo-copying system because the organisation sought to evaluate technical risk using non-technical personnel.

H.R.H. Prince Philip attributes this reluctance to take business risks (in engineering), as a result of the present society in the U.K.; he suggests that whilst "the Welfare State is a protection against failure and exploitation ... national recovery can take place only if innovators and men of enterprise and hard work can prosper" (3.226).

Most researchers have confined themselves to the parameters of the organisation. Ford suggests there are 'opportunity-orientated' and 'problem-orientated' managers; the latter are those who perceive ideas as 'risks' rather than 'opportunities'. It is less clear from his work why a manager should take one or the other of these orientations (3.227). Quinn and Mueller do suggest a number of 'motivational restrains' which temper managerial enthusiasm to innovation, namely (3.228):

1. short term management incentives
2. lack of urgency for research

- managerial attitudes tend to gravitate towards shorter-term payback projects and tend to be unaffected by the firm's prevailing business situation. That is, in 'good times', pressures are to devote all available resources to the immediate opportunities, whilst in 'bad times', retrenchment orientates the manager away from long-term projects to concentrate on day-to-day survival (3.229).

3. entrenched ideas and vested interests to maintain the 'status quo'.

4. aging of key management/operating personnel (3.230)

5. overly long lines of formal authority

6. fear of reprisals to risk taking

7. an N.I.H. (not-invented-here) complex

8. inadequate delegation of authority to carry project forward.

Slevin presents an empirically tested model of risk behaviour based on four key variables (3.231):-

1. cost of innovation

2. rewards for successful performance

3. current level of success

4. level of aspired success.

He suggests that the cost of an innovation (where high costs are synonomous with high risks) to an individual should be related to the potential rewards that will accrue if he is successful. Costs and rewards are expressable in both economic and non-economic terms (3.232). Slevin stresses that the perception of 'costs' (risks) and 'rewards' are affected by the individual's current level of success in the organisation, and the level to which he aspires to; Slevin concludes "... the interaction between perceived aspirations and current success rate is crucial in the determination of a person's likelihood to innovate" (3.233).
The empirical results for this model were obtained from a controlled in-college experiment using post-graduate business students; replication, involving managerial personnel in an on-going business situation, is needed to substantiate his findings, for one is left to assume commonality of perception of 'costs', 'rewards' by managers of varying experiences (technical, commercial, etc) performing various business

functions.

Ansoff and Stewart (3.234) in discussing the 'frontier of technology' suggest that various personnel within the organisation may perceive the risks involved quite differently:-

1. the researcher sees it as a scientific challenge

2. the developer sees it as an applied science challenge, of translating concept to production

3. the operational manager may see it as a possible threat.

Schon suggests the individual can react in four ways to the threat posed by technological innovation (3.235):-

1. Rejection of the threat: which results in total opposition to the innovation (3.236).

2. Isolation of the threat: which results in political in-fighting where committed groups (cohorts) seek to isolate and so reduce the risk threat of the innovation.

3. 'Waters it down': the more disruptive elements of the innovation are so tempered to conform with the existing practices and procedures of the firm.

4. Acceptance of the innovation: here the individual accepts the innovation as it perceived to be congruent (the risk is acceptable or controllable) with his own situation.

Baker (3.237) believes managerial attitudes are to maintain the 'status quo' in an organisation; he suggests that the greater is the commitment to the existing technology, so the greater must be the incentives to innovate. He quotes from Corey's study of the Bakelite Company (3.238). Steele stresses the importance of intuition in assessing risks; ".. a manager's intuitive feeling towards technological risk-taking will play a critical role towards aggressive use of R & D as an instrument of growth and whether, having chosen to do so, he will provide it the support it needs" (3.239). But experience plays a large part in developing the manager's intuition; can the highly structured organisation provide enough opportunity for the manager to be exposed to experiences outside the realms of his day-to-day function? As Steele notes "managers whose formative experience provided little exposure to technological risk-taking, who had no opportunity to see a technical discovery carried through to successful commercial application, are unlikely to feel comfortable when asked to approve such a course" (3.240). Similarly, the failure of research and development staff to appreciate the complexities of commercialising technological innovation can be due to a similar lack of experience and understanding.

Baker has sought to offer a comprehensive adoption model, which incorporates economic criteria and 'managerial attitudes' (3.241). He sees the process, in the form of an equation, as :-

$$A = f(EC, PC, (I - D), AR)$$

where:

A = Adoption

EC = Enabling Conditions : those elements necessary for a 'rational decision' to make use of an innovation (eg it performs a defined function)

PC = Precipitating Circumstances : encompasses all those factors which predispose the individual (or firm) to consider adoption. These are seen as the stimulii to adopt. Baker quotes both Schon and Shepard who suggest innovations are most readily accepted under 'conditions of crisis' (3.242).

I = Incentives : advantages associated with adoption of an innovation, expressed in monetary terms.

D = Disincentives : the disadvantages. Therefore (I - D) is the net economic outcome consequent upon adoption - 'the relative disadvantage'.

AR = Attitudinal Response : recogntiion that factual/objective arguments for and against an innovation will be perceived differently by personnel within the organisation.

His model presents a more embracing picture of the in-firm adoption process than, say, Mansfield's earlier predominantly economic perspective. However, criticism can be levelled against the model's apparent emphasis upon the consequences rather than causes of the adoption process. For example, his all-embracing variable 'attitudinal response' (AR) tells us little about why it should favour or disfavour, credit some and discredit other informational inputs. Similarly, 'precipitating circumstances' (PC) might be construed to be the causes, but again the generality of the variable tells us little about the process. It is likely these pre-dispositions will vary from individual to individual, with a possible self-cancelling effect. After all, consideration must always be taken as to the stimulii to reject innovation; Baker, himself, notes "... it is also true that those who would benefit most from improved practices are frequently the last to adopt them" (3.243). The importance of each of the variables, in Baker's model, to the individual - that is, the influence they will have upon his ultimate decision - is decided by his 'attitudinal response' to the variable, as well as to the innovation itself. This can be illustrated as follows (Figure 3.11). This simplified model, using Baker's variables, highlights the pressure sources upon the individual to make his organisational decision (3.244). Such pressures might originate from both 'upstream' (eg R & D need his commitment before further funds will be allocated to a project) and 'downstream' sources (eg Marketing Management are forcing the pace due to customer enquiries). The nature of the information, the source of pressure, and the channel used to convey it (eg formal or informal channels) will be perceived by the individual (and so de-coded) in the light of his own past experience regarding innovation adoption decisions and his aspirations in the organisation. It is more likely to be a 'less risky' decision in those

FIGURE 3.11 INDIVIDUAL (WITHIN AN ORGANISATION) PRESSURES TO INNOVATE: MODEL USING BAKER'S ADOPTION VARIABLES

organisations where the climate is pro-innovation, and so the individual has the experience to infuse into the decision process. Personal resistance is more likely where there is no such favourable experience; he is likely to seek the advice of others (pre-supposing he does not possess the self-conviction of an innovation champion) or to react in a less positive way towards the innovation. Rather than adopting 'with enthusiasm and total commitment', he may passively accept, delaying the rate of adoption or actively commit himself to a rejection decision if this seems the less risky decision to make.

Because of the 'inherent newness' of any innovation decision, it is likely that the degree of experience that the individual can bring to bear will be minimal when compared with day-to-day operations. He seeks to compensate this 'experience' defficiency by using predictive measures, forecasting. However, evidence questions the accuracy and predictability of technological forecasting. One is left to consider that the resistance to innovation is not necessarily that it is perceived to be high risk, but rather that it is the failure to be able to calculate it and so estimate the consequences of making an innovation decision.
Certainly Baker's model presupposes the ability to accurately estimate the economic value of 'incentives' (I) and 'disincentives' (D) to decide the 'relative advantage' in innovating.

FORECASTING AS AN AID TO REDUCING RISKS IN INNOVATION

Prehoda defined technological forecasting as "the description or prediction of a foreseeable technological innovation, specific scientific refinement or likely scientific discovery, that promises to serve some useful function with some indication of the most probable time of occurrence" (3.245). Forecasting, then, is an attempt to predict future consequences of present behaviour; this is sometimes seen to be the converting of uncertainty to calculable risk. But how calculable are the risks in innovation?

One approach suggests that the innovation process can be viewed as a number of identifiable (and so forecastable) steps "... in general, the economic analysis performed at successive stages of the new product development process will yield smaller and smaller levels of uncertainty" (3.246). McTavish sees this approach as "innovation thought of as a manageable process, similar to other business functions, wherein risks are controlled or reduced by means of quantified assessments of the merits of different technical projects" (3.247), but as he concludes from his own studies "in practice many firms find themselves having to make investment decisions on inadequate evidence in a general atmosphere of uncertainty, even at quite advanced points in the development cycle" (3.248). A view substantiated by Schon "... in the light of experience, the notion of innovation as an orderly, goal-directed, risk-reducing process must appear as a myth" (3.249); he concludes "a man must take leaps, not once at the beginning of the process, but many times throughout the process, always in the face of uncertainty and on the basis of inadequate information ... a company cannot escape it by careful planning, or by gathering exhaustive data" (3.250).

Although much has been written regarding 'decision-making under conditions of uncertainty' (3.251), McTavish found that firms "did not, in general, show a high level of sophistication in investment appraisal techniques" (3.252). Certainly Freeman, like McTavish, found firms more inclined to take risks on past innovation performance rather than pragmatic economic evaluation of the risks involved with a project "... as long as sales are achieved, precise cost estimates in advance are irrelevant" (3.253). Mansfield reports that where cost estimates are made, that they bore no semblance to realised costs "... about one-half or more of the laboratory directors in our sample feel that estimates of a project's manpower requirements, its development cost, its capital requirements, its research cost, its probability of technical success and its development time are good or excellent .... given our findings concerning the size of the errors in estimates of development cost, time and technical outcome, it appears that laboratory directors may be unduly optimistic" (3.254).

Commercial assessment of innovation seems no better; whilst evidence is available that suggests demand-pull innovation has a higher probability of success (3.255) - "it is worth noting that commercial risks were considerably lower where marketing inputs were injected earlier in the decision-making process" (3.256) - Cooper and Little found "highly innovative products were found to be characterised by less market assessment than 'me too' products. The tendency to become enamoured with high technology breakthroughs, together with the difficulties involved in conducting market research for true innovations were uncovered as the reasons for this phenomenon" (3.257).

McTavish found one firm that did not include marketing costs on the grounds that "a case against a comprehensive prior tally of marketing costs is that this might discourage the development from being undertaken in the first place" (3.258).

Fisher points to the subjectivity of input of the data used in innovation forecasting. He asks the question, that if uncertainty is great, what value can be placed upon the subjective estimates of the probability of its success? As he says "are (these subjective assessments) some impartial assessment of the play of forces in the environment, or are they more influenced by feeling, in the sense that he who is predisposed to innovate will produce probabilities more favouring success than will another person of a contrasting attitude ... if this is so, does it leave the manager with his elegant decision models deceiving himself about apparent norms of rationality which guide him?" (3.259). Buetow writes "risk assessment must be based on a considerable amount of subjective analysis" (3.260); and Nicholson points out how subjectivity, due to the individual's position in the organisation, can affect the forecast. He suggests that the weakness of predictive powers of technical forecasting is due to.."scientists and engineers have to date predominated in such activities" (3.261).

Recent developments of decision-making techniques, using subjective estimates (executive judgements), have sought to incorporate group decision-making as a method of reducing individual subjective-bias (3.262) nevertheless the basic dilemma remains.

One study of 70 projects in a U.S. Company found that the expected probability of technical success for over 75% of projects exceeded 0.8. When these expectations were compared with results, it transpired that only 44% were as successful (achieving the criterion 0.8) as first anticipated (3.263). Mansfield found that only a small proportion of the discrepancy was due to 'unforeseen technical difficulties', the remainder was due to various examples of subjective optimism for the projects.

McTavish concludes that because of the lack of 'useful' data, the manager resorts to intuition rather than economic reality in risk analysis methods; "managers, like other people, tend to face new problems and situations by relying on the knowledge and judgments tested by past experience, rather than on the logic of computational procedures for aggregating, discounting and comparing assumed outlays and incomes" (3.264). Bodroghy lends support to this view when he suggests that the most likely usable techniques in technological forecasting are "synoptic rather than numerical methods" (3.265); as does Jewkes

".. our conclusion is, therefore, a simple one: that the path of innovation is always thorny, that there are no short cuts to success, no infallible formula" (3.266). Yet the outcome of a decision, although based on data dubious in nature, is still likely to be crucial to a manager in terms of his position in the organisation. It is likely, therefore, that a manager will evaluate informational inflows against the 'cost' of disturbing the 'status quo'; subjectively assessing the risk consequences of the decision he makes.

3.9 THE PROCESS OF IN-FIRM INNOVATION ADOPTION

Thusfar the elements considered influential in the industrial adoption process have been examined, but what of the act of adoption, as measured over time?

The collective nature of organisational decision making necessitates a different approach to that advocated by studies orientated specifically to the individual adoption process (3.267). However, even within an organisation, the initial decision to invent, or the recognition of a perceived need, may have been the product of an individual's adoption process. Similarly, the emergence of an individual to support (or oppose) a project - an Innovation Champion - may be an individual decision. Again, consideration needs to be taken of collective decisions made by individual departments/business functions within the organisational adoption process; it is this latter reified adoption process most favoured by the literature (eg "British Leyland decided in 1971, to begin developing the Rover 3500").

One commonly quoted definition of the industrial adoption process comes from Robertson .. "the process of taking an apparently saleable notion and developing it to the point where it achieves a profitable measure of market penetration" (3.268).

But the act of adoption, certainly by an individual within an organisation, or indeed the organisation itself, does not necessarily guarantee success in the market place that is the profitable measure of market penetration. Of those new products introduced onto the market, estimates of commercial success vary widely. Booz, Allen and Hamilton's study of 366 products places the failure rate at 33% - 10% clear failures and 23% doubtful (3.269); O'Meara quotes a failure rate of 80% (3.270), whilst a study by a New York design firm places the rate as high as 89%!

(3.271). The act of adoption or rejection being primarily a management function, tends to be the screening, filtering process of those projects less likely to succeed.

Common to all adoption (and diffusion) models is the assumption that the decision takes place over time (3.272). Whereas an individual's decision to adopt may range from an instance to a period of deliberation (eg over a major purchase such as a house, car, etc), the time span for organisational decision making will tend to be more protracted, simply because of procedural structures as much as the (technical) complexity of the purchase/action under consideration.

A number of studies have been carried out to identify the time taken by the innovative organisation in launching new technology (that is from idea-to-launch). Enos presents numerous examples, as table 3.17 illustrates (3.273):

INVENTION	INTERVAL (yrs)
Distillation of hydrocarbons	24
Fluorescent lamp	79
Safety razor	9
Television	22
Steam engine (Newcomen)	6
Steam engine (Watt)	11
Jet engine	14
Turbo-jet engine	10
Nylon	11
Radar	13
Self-winding watch	6
Crease resistant fibres	14

TABLE 3.17.

Lynn has suggested that the industrial adoption process has tended to shorten, as table 3.18 (overleaf) demonstrates: (3.274)

TIME PERIOD (3.275)	AVERAGE TIME INTERVAL (Yrs)		
	EXPLORATION TO DEVELOPMENT STAGES	COMMERCIALISATION STAGE	TOTAL
Early 20th cen.(1885-1919)	30	7	37
1920 - 1944	16	8	24
1945 - 1964	9	5	14

TABLE 3.18

The most popular approach taken by writers (perhaps because it lends itself more easily to prescriptive advice) is an in-firm adoption process, incorporating a number of sequential, identifiable events. For comparative reasons a number of studies are presented in table 3.19 (overleaf).

A degree of commonality is observable in the 'stages' highlighted in table 3.19; both Booz et al and Pedraglio refer to the adoption process in terms of a 'decay curve' for ideas. Booz's study found that 58 ideas were found to be initially required to yield one successful new product ".. almost three quarters (of new product expenditure) goes to unsuccessful products; about two-thirds of which is wasted at the development stage (3.277). Pedraglio presents this 'decay curve' as illustrated (Figure 3.12) (3.278).

AUTHOR	WELLER + CLEMENTS	BOOZ et al	PARKER	PESSEMIER	TWISS	PEDRAGLIO	FOGG	ZOPFORTH	KNIGHT	JONES
SEQUENTIAL EVENTS ↓	EXPLORATION	EXPLORATION SCREENING	APPLIED RESEARCH	SEARCH PRELIMINARY ECONOMIC ANALYSIS	TECHNOLOGICAL CONCEPT	EXPLORATORY STUDIES	IDEA TECHNICAL SEARCH		CREATION OF IDEA	CREATING NEW PRODUCT CONCEPTS EVALUATION AND SELECTION
	DESIGN	PROPOSAL	SPECIFICATION PROTOTYPE	FORMAL ECONOMIC ANALYSIS	PRODUCT DESIGN	ECONOMIC STUDIES	TECHNICAL FEASIBILITY AND PROTOTYPE ↓	DESIGN	ADOPTION OF IDEA ↓	REALISATION
	DEVELOPMENT	DEVELOPMENT TESTING	PILOT PLANT TOOLING AND MANUFACTURE FACILITIES MANUFACTURE START-UP MARKETING START-UP	DEVELOPMENT AND PRODUCT TESTING	MANUFACTURE	DEVELOPMENT MARKET TEST	↓	DEVELOPMENT AND ENGINEERING MANUFACTURE	↓	REFINEMENT TEST MARKETING
	←	←	COMMERCIALISATION	COMMERCIALISATION	COMMERCIALISATION	→	→	SELLING	↓	COMMERCIAL-ISATION

TABLE 3.19 (3.276)

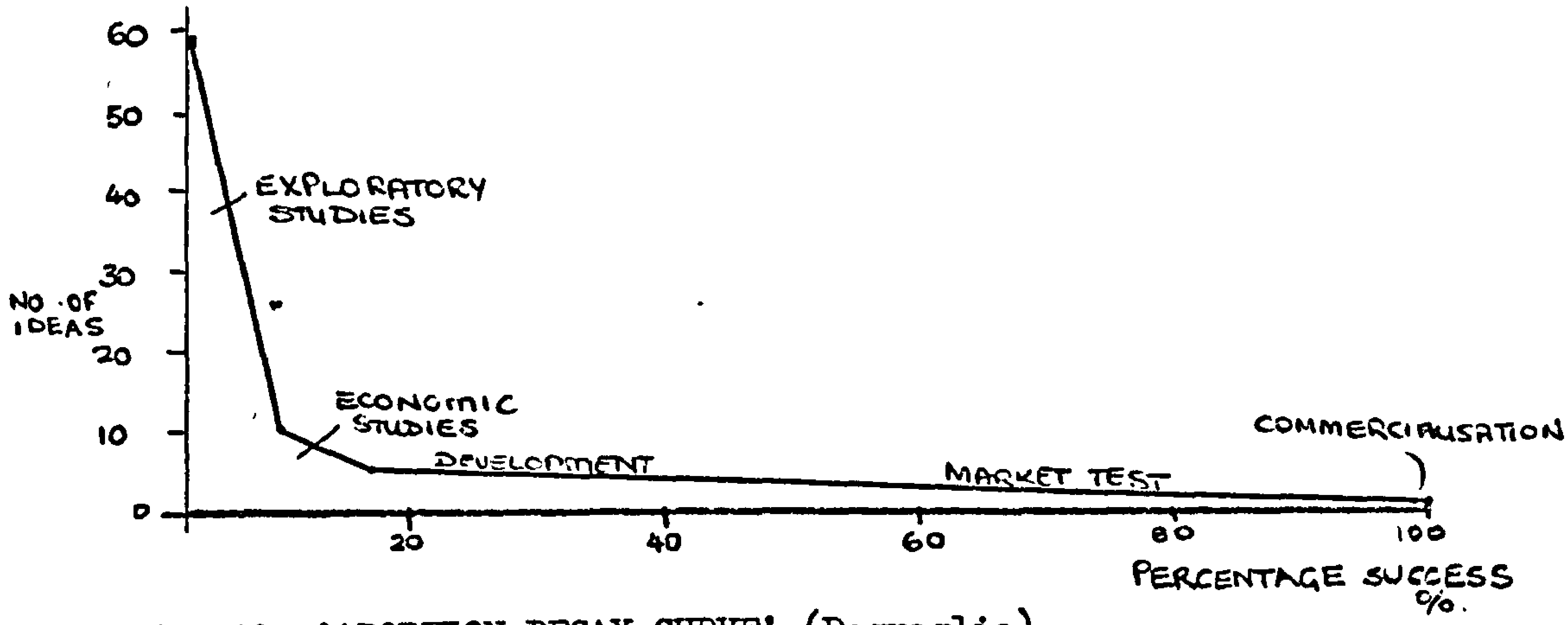


FIGURE 3.12 'ADOPTION DECAY CURVE' (Pegraglio)

In taking a similar stance, Fogg relates the number of ideas/projects needed at each stage and the 'typical time' needed to complete each adoption stage. Figure 3.13 illustrates (3.279):

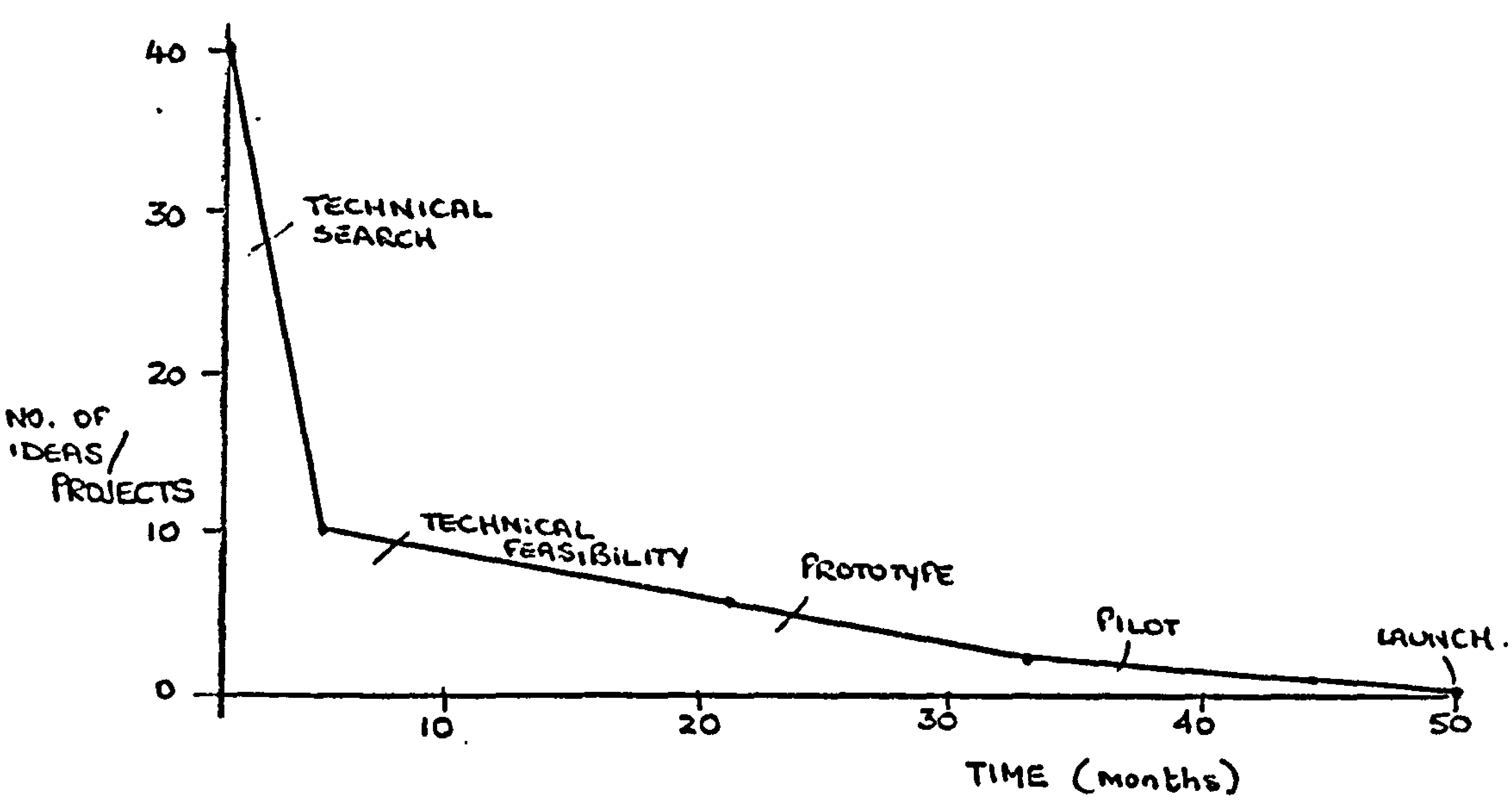


FIGURE 3.13 'ADOPTION DECAY CURVE ' (Fogg)

Fogg's typical time scale of two years from conception to launch tends to be more applicable to consumer (less-technical) products than to industrial technology, although Du Pont successfully completed an innovatory project inside four years (3.280).

Whilst there is considerable support for the 'sequential steps approach' - "every programme has uniform and identifiable patterns common to all efforts in chronologically developing ideas and concepts through various phases to an end product" (3.281) - a number of writers have raised methodological doubts....
Schon suggests the approach is "in violation of company practice and experience; innovation cannot be analysed into component parts and made subject to rational control" (3.282). McTavish maintains ".. in practice many firms find themselves having to make investment decisions on inadequate evidence in a general atmosphere of uncertainty, even at quite advanced points in the development cycle" (3.283); he suggests that due to the absence of 'adequate knowledge', management resort to decisions relatively isolated from the market, or from other departments in the firm and in a manner quite dissimilar from that suggested by Pessemeir and others.

Reekie offers a modified alternative to the traditional 'decay curve' approach (3.284). He assumes that the highest likelihood of rejection of any particular idea or project will take place when the idea is first mooted, and that as commitment is secured through the subsequent stages the probability of rejection declines; a viewpoint supported by Twiss "... a project generates its own momentum and there is an implicit assumption amongst those working on it that it will be allowed to proceed to completion unless some major new factor emerges" (3.285).
Reekie's point tends to be rather obvious, that the probability of

rejection will decrease - if screening leaves fewer to choose from at a later stage (as the decay curve indicates) then obviously chances of survival of the remaining projects has increased!

Similarly, care has to be taken in accepting Twiss' over-generalisation of the process. Again reference to the 'decay curve' shows a number of projects rejected very late in the process, contrary to Twiss' projection.

A number of examples are available from aircraft projects where rejection (albeit political rather than economic criteria alone) has come at a point where the project is at the commercialisation stage (eg Bristol Siddeley's TSR 2 Project).

Where Reekie does provide an advance on the 'decay curve' principle is through his recognition that as the project moves through the organisation, there remains the possiblity of rejection actually increasing as departmental/functional interfaces are reached - as figure 3.14 below illustrates:

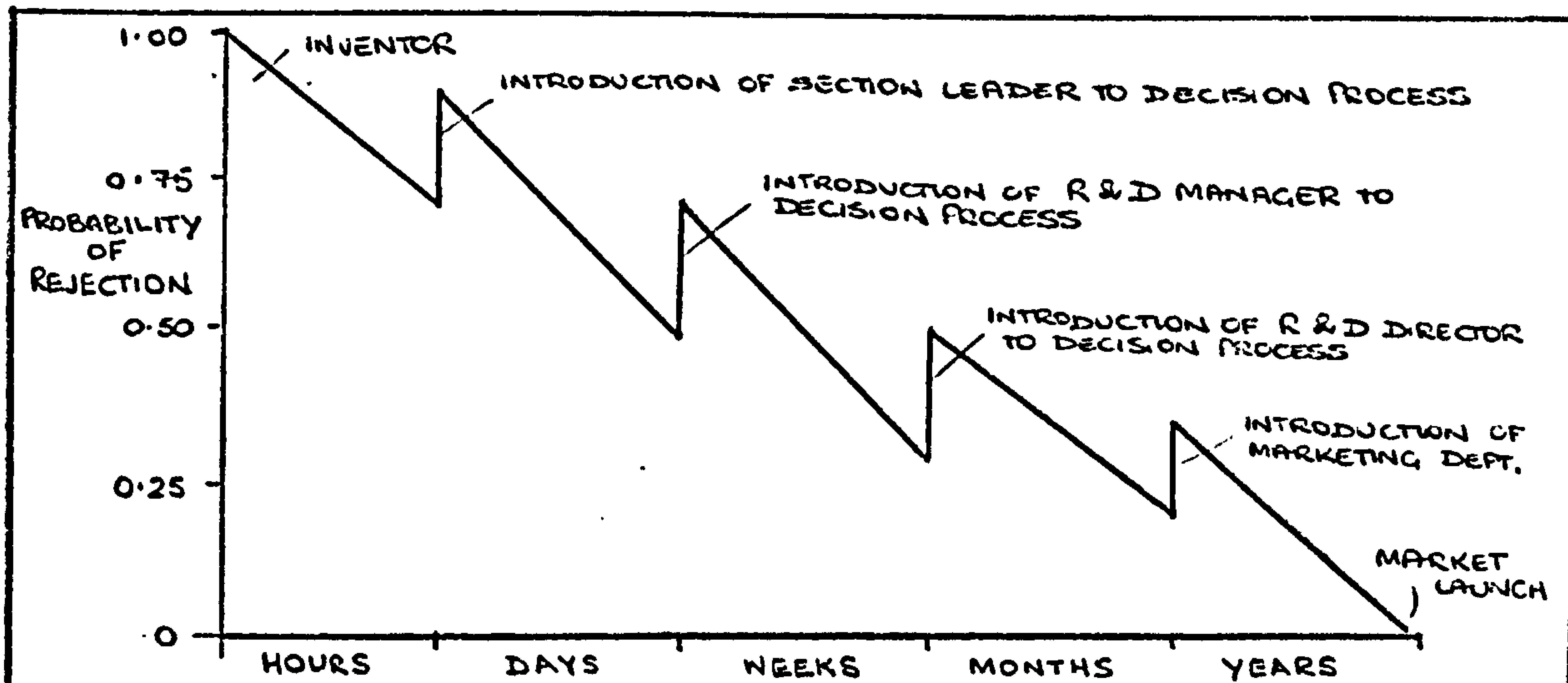


FIGURE 3.14 MODIFIED DECAY CURVE WITH INTERFACE REJECTION PROBABILITIES ILLUSTRATED

(Reekie)

However, he does still adhere to a decay curve approach in that it is assumed that the gathering momentum will preclude rejection, whereas in practice crossing a functional interface - for example between R & D and Marketing might result in total rejection (probability 100%); a point supported by Layton et al who writes ".. we found that skilful initial invention in the R & D departments has been marred in the past by an inability to achieve effective commercial exploitation, either at the production phase or in marketing" (3.286)

Taking a second consideration. For routine incremental development to the existing product range, established screening procedures can be used by the management to arrive at comparatively 'objective' evaluations regarding risk vis a vis the current range. However, deviation from current practice - non-routine innovation - introduces risk and uncertainty to existing management practices, possibly at all stages of the adoption process.

A further suggestion made by Knight, and Cyert and Marsh is that the speed of adoption is affected by environmental pressures. Cyert and Marsh suggested the propensity and speed of adoption was governed by a company's past history (technological experience) of success rather than upon its current absolute level of performance (3.287); that is, in-company personnel are more likely to be affected (re their adoption decisions) by a favourable past experience than by the current prevailing situation. It suggests that the modified decay curve, as suggested by Reekie, needs to be viewed in the light of Cyert and Marsh's work; probabilities of rejection through the decay curve will tend to increase if there has been unfavourable past experience.

Knight has developed this approach further by distinguishing two forms of innovation resulting from environmental pressures, namely:-

(i) Slack innovation.

(ii) Distress innovation.

(i) In the former situation, the decision-makers perceive the organisation to be successful and as having resources additional to those considered necessary to achieve day-to-day objectives (3.288). Spending on R & D is maintained or increased to sustain the slack situation; decisions accepted as the norm by the participants within the organisation. In such a situation probabilities of rejection of innovative ideas will decrease.

(ii) However, in the latter situation, perception of the business environment is considered to have a retarding effect upon the adoption process. Knight suggests that 'distress innovation' is more likely to occur in the less successful organisation .. "(which) is more likely to search for different types of changes than it would in a slack situation" (3.289). He suggests that internal changes (eg propensities to innovate) will occur as a consequence of the pressures arising from the 'adverse' business environment; one might suggest that all subsequent managerial appraisal of the situation will affect the attitudes and disposition of the company personnel towards innovation adoption and so perhaps become the cause of an aggrevated distress situation in the future. Namely, if a distinction is made between 'mild' and 'extreme' distress (ie the degree of perceived environmental threat), a resultant failure to a mild distress situation may likely increase the threat to the organisation's (and individual's!) position; so rather than an innovation to relieve the situation, fear of further failure results in a high propensity to take no further risks thereby possibly exacerbating the distress situation! Frequently those firms most in need of change resist the pressures to change. Mansfield suggests that it is the successful firm that makes the more radical and more frequent technological innovations than its unsuccessful counterpart (3.290).

A damning criticism of the sequential adoption model as presented by Booz and others is that it fails to explain the actual process involved in the adoption decision(s). Whilst identifying consequential steps in a process (a point questioned earlier) it does little to explain the causes of the adoption/rejection behaviour.

Rogers and Shoemaker have put forward a model to describe the 'collective decision process' - figure 3.15 illustrates:-

STIMULATION	:	awareness of need to innovate
INITIATION	:	idea receives attention
LEGITIMATION	:	idea is sanctioned
DECISION-MAKING	:	decision is taken to commit resources
EXECUTION	:	process of implementing decision

FIGURE 3.15 : COLLECTIVE DECISION PROCESS

(Rogers & Shoemaker)

This model suggests an interaction transcending traditional departmental, functional boundaries. It does not necessarily negate those research findings that suggest a number of ideas are needed to produce one marketable product, but rather supplements and gives reason to these findings...

(i) in introducing the source of the idea (STIMULATION) which may be important in determining legitimation for the idea (eg technology push or demand pull?)

(ii) research suggests that decisions to adopt or reject innovation are not necessarily made on economic grounds; legitimation of an idea will be a function of a wide variety of 'facts'. A project deviating the most from the prevailing organisational norms (as viewed relative to past experience) is most likely not to be legitimised.

(iii) decisions to commit resources, and the execution of those decisions will obviously be affected by the nature of legitimisation received for the idea. Legitimisation of a project - manifest in the bearing of risk upstream in the organisation - may well demonstrate 'good faith' downstream and so affect a favourable adoption decision. Similarly weak legitimisation upstream may, in fact, gather momentum as lack of faith is perceived by those downstream, thereby not necessarily presuming adoption because the project has successfully proceeded through earlier departments; one cannot assume that this 'organisational change-of-heart' is necessarily based on economic criteria alone.
Organisational adoption of innovation and information flow are inseparable. Risk evaluation will tend to be assessed on informational input; but such information will always be encoded by the sender and, as such, need not necessarily present a 'true and accurate picture' of the situation. This may manifest from one of a number of reasons, viz:-

(i) information distortion

(ii) information delay

(iii) information disappearance.

(i) Information can be distorted by the sender to present a more favourable or less favourable presentation of an innovation's prospects. Such distortion may be due to the sender's own perception of his position vis a vis the organisation and the environment. Possibly an Innovation Champion may optimistically view data on innovation. Adverse adoption experience will discredit the information source's credibility in future adoption decisions.

(ii) Secondly, it may be possible for a department/function to delay adoption by slowing down the information flow. Such delays may cause project abandonment or, as McTavish has indicated, adoption decisions being made with 'inadequate information'.

(iii) The extreme case tends to be where information 'disappears'. This may be due, unintentionally, to the prevailing organisational structure being unable to assimilate information not normally encompassed within the procedural structure. However, it may also be the ultimate delay weapon to be used by sectional interests to retard indefinitely a project.

THREE CASE HISTORIES OF IN-FIRM ADOPTION

I. 'THE FLUID MILK POUCH' LAUNCHED BY DU PONT OF CANADA (3.291).

The fluid milk pouch - a method for packing/delivery of milk using plastic packaging - was developed and introduced by Du Pont into Canada over a period of four years.

In 1964 Du Pont R & D learned from research papers that a packaging process for liquids had been successfully introduced in France. Because of Du Pont's heavy commitment to packaging and plastic film business in Canada, the process was viewed as an unusually attractive opportunity to penetrate the dairy packaging market.

Initial market assessment took place "... this initial investigation sought to determine the financial viability of the new venture as well as to forecast required production facilities. Conceivable launch strategies were tentatively formulated and evaluated" (3.292).

The favourable outcome was the establishment of laboratory facilities in Montreal and discussions with manufacturers of liquid packaging process systems.

Consumer research continued. In 1965 the first test of consumer acceptance was carried out in-house; acceptance levels were high with favourable reaction.

A second acceptance test was conducted by an independent research agency; this too indicated a favourable disposition towards the product-concept but that it would be necessary to carry out an educational/promotional campaign to counteract the belief that the milk might taste 'plasticy'. A third test, directed towards guaging trade acceptance indicated a similar favourable response amongst local dairies; the product-benefit of reduced distribution costs vis a vis returnable glass bottles was the most reported attribute.

Full scale development did not begin until all these test findings had been presented and discussed by the Du Pont management (the source indicates no individual championing the cause); the outcome was a decision to develop a plant to Canadian specifications, which meant an almost total redesign of the original French machinery.

Trial production began in April 1966, but development progress was slow due to two reasons:-

(i) complexity of operation of plant by personnel

(ii) the new machinery had failed to solve a number of technical problems, namely leakages.

"... line efficiency was far from satisfactory, and a true estimate of operating costs, or value-in-use, could not be obtained" (3.293).

A number of local dairies began deliveries using the new method and market acceptance was favourable; over 50% of home delivery purchases switched to the plastic pouch and remained loyal, but the technical problems remained unsolved and this caused a degree of reluctance to adopt further by the dairies. Du Pont approached the French machine manufacturers once more and gained Canadian approval to use the French machine in an unmodified form. By mid-1967 all technical problems had been satisfactorily solved.

More market research studies were conducted; they continued to demonstrate a favourable response to the product concept; a number of further diaries became involved in limited production runs.

A full market and production test followed in Quebec City in mid-1968;

success in this test market led to the decision to launch the packaging system nationally; "... today more than 40% of all the fluid milk bought by Canadian consumers is packaged in Du Pont's pouch" (3.294).

Certainly this case history highlights the interdependence of organisational functions in the adoption process. Ideas seem to have constantly floated between research and operational management.
It also seems evident that after two years of development, it was still very difficult to arrive at accurate cost-estimates of the innovation; it supports the research of McTavish referred to earlier that one cannot necessarily assume information to aid decision-making becomes more definite as one moves through the adoption process (3.295).

II. PROJECT SD 1 : THE LAUNCH OF B.L. ROVER 3500.

The Awareness Stage began in 1969 with a recognition that a replacement model was needed for the Rover 2000 series (project code-named P10); basic design dimensions were produced by June 1970.
In parallel the Triumph Division was working on a replacement for the Triumph 2000 (project PUMA).
A high degree of inter-divisional rivalry developed; each project was developed in a cloak of secrecy within the organisatinn. By February 1971 the Main Board, having concluded that both models were essentially being aimed at the same market segment, arranged a complete technical comparative assessment and decided in favour of project P10.
It is possible that in order to heal the wounds of the vanquished Triumph personnel, it was decided to rename the project RT 1 to signify the new Rover-Triumph consolidation within British Leyland. However, in reality, a number of senior personnel moved within the organisation or left. Two months later (April 1971) the project was renamed SD 1 to reflect its specialist division affiliation within British Leyland.

In addition to organisational pressures, a number of design constraints were imposed upon the project, essentially to keep costs down; it was intended that existing components were to be used 'wherever possible', for example, in March 1971, the scrapping of project P8 in favour of later-launched Jaguar XJ6 series, led to pressure on the design team (by Lord Stokes) to incorporate the already-designed project P8 facia in the SD1 project.

Because of numerous design changes "due to internal compromise" (3.296) the final exterior and interior designs were not completed and ratified by the Main Board until February 1972.

Planned launch date (October 1975) was not achieved due to a number of reasons:-

(i) problems of trim development

(ii) failure of deliveries by component suppliers

(iii) production delays (a new factory was built specifically for project SD 1).

Actual launch was achieved early 1976.

Project SD 1 has tended to be seen as a landmark for British Leyland; the adoption process led to organisational restructuring to bring together the then diverse engineering/development functions - a system which perpetuates today (1979). It is also interesting that use of formalised 'innovation champions' was made whose role ".. is to ensure that management decisions are translated into the necessary detail and are followed through" (3.297). Coordination at the highest levels of management was the resonsibility of the Director of Engineering, who chairs all progress meetings (3.298).

III. ISOMERISED CORN SYRUP (High Fructose Corn Syrup)

The production of highly sweet liquid sugar was first considered scientifically during the 1800s, but basic lack of scientific knowledge precluded further investigation. Scientific possibility was not demonstrated until 1953; from then, seven years were spent on basic research and a further seven years on technological advance, all carried out by institutions in U.S.A. and Japan; it was not until 1970 that the innovation reached the commercialisation stage.

A number of reasons have been suggested to account for this adoption time scale:-

It is considered that the corn wet-milling industry that produces the raw material from which the sugar is extracted were guilty of directing corporate R & D into existing products rather than encouraging exploration into parallel fields of science; Casey suggests ".. the lack of interdisciplinary knowledge exchange or failure to bridge the gap in the fringe area between enzymology and carbohydrate chemistry resulting in the failure to recognise the significance of the discovery of glucose isomerise (3.299). He continues "... the net result was failure by industry to identify an area of opportunity until the technology had been brought by institutional scientists to the brink of commercial feasibility" (3.300).

But not only was the rate of adoption retarded in the early stages by myopic R & D briefs, but this was further exacerbated by pessimistic marketing research forecasts. A failure to define the market potential in a number of market segments led to a series of pessimistic forecasts of product success, which retarded the commitment of resources to the project. Casey believes this pessimism was due to the then current depression of corn syrup selling price and the low profit margin; this led to a lack of confidence in this product area as a source of profit contribution - high innovation risks were seen not to be commensurate with possible high profitability (or career enrichment?). Therefore this project was seen as a 'distress innnvation' and operational management did little to increase the rate of adoption.

It was an exogeneous factor - the dramatic rise in world sugar prices in 1973/4 - that created a more favourable development environment for the pessimistic management.

Success in a number of market segments has been dramatic; market forecasts for U.S. consumption of this 'lower cost' substitute for crystal sugar may reach as high as 10 billion lbs. by 1980, replacing 30% to 40% of the industrial sugar consumption" (3.301).

3.10 THE DIFFUSION PROCESSES

AN INTRODUCTION

Industrial innovation diffusion is the aggregated study of adoption/rejection decisions made in a system measured over time. Gruber and Marquis (3.302) suggest four stages in this diffusion of technology:-

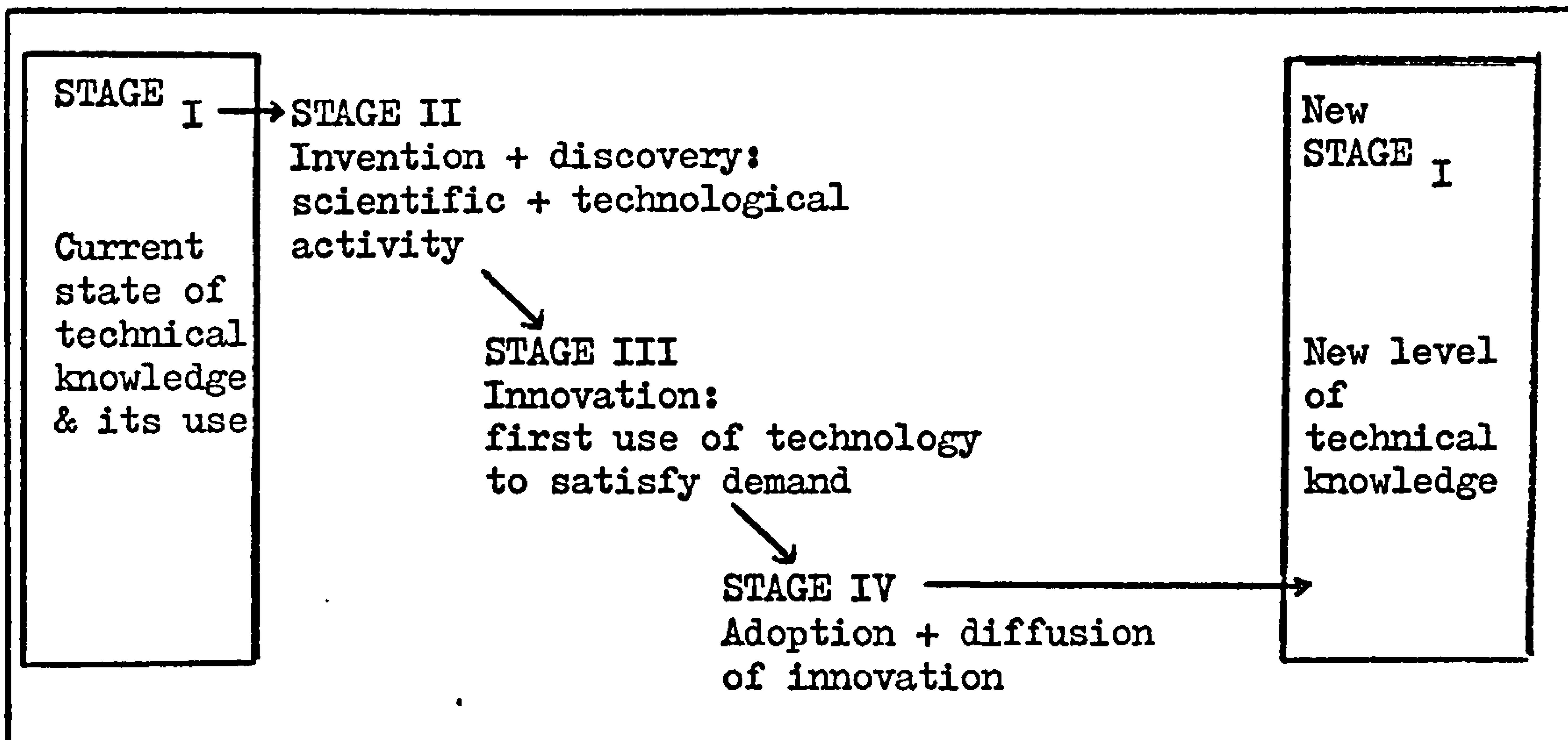


FIGURE 3.16 DIFFUSION OF TECHNOLOGY (Gruber & Marquis)

Their model illustrates the invention - innovation adoption and subsequent diffusion of technology to a higher plane of knowledge but it does not explain how or why technology is diffused; that is, the nature of this process of diffusion. Indeed a search of literature concerned with industrial diffusion highlights two deficiencies:-

(i) a failure to explain the causes rather than the consequences of diffusion

(ii) to identify what process is being examined.

Two distinct processes are frequently merged without regard for their individual distinctiveness. The researcher needs to consider:

(i) the diffusion of the technology within the innovator's own industry - namely, "technology imitation" and also

(ii) the diffusion of the technology (which may or may not be entirely that developed by the innovator) amongst the customers of that industrial system.

Figure 3.17 illustrates:-

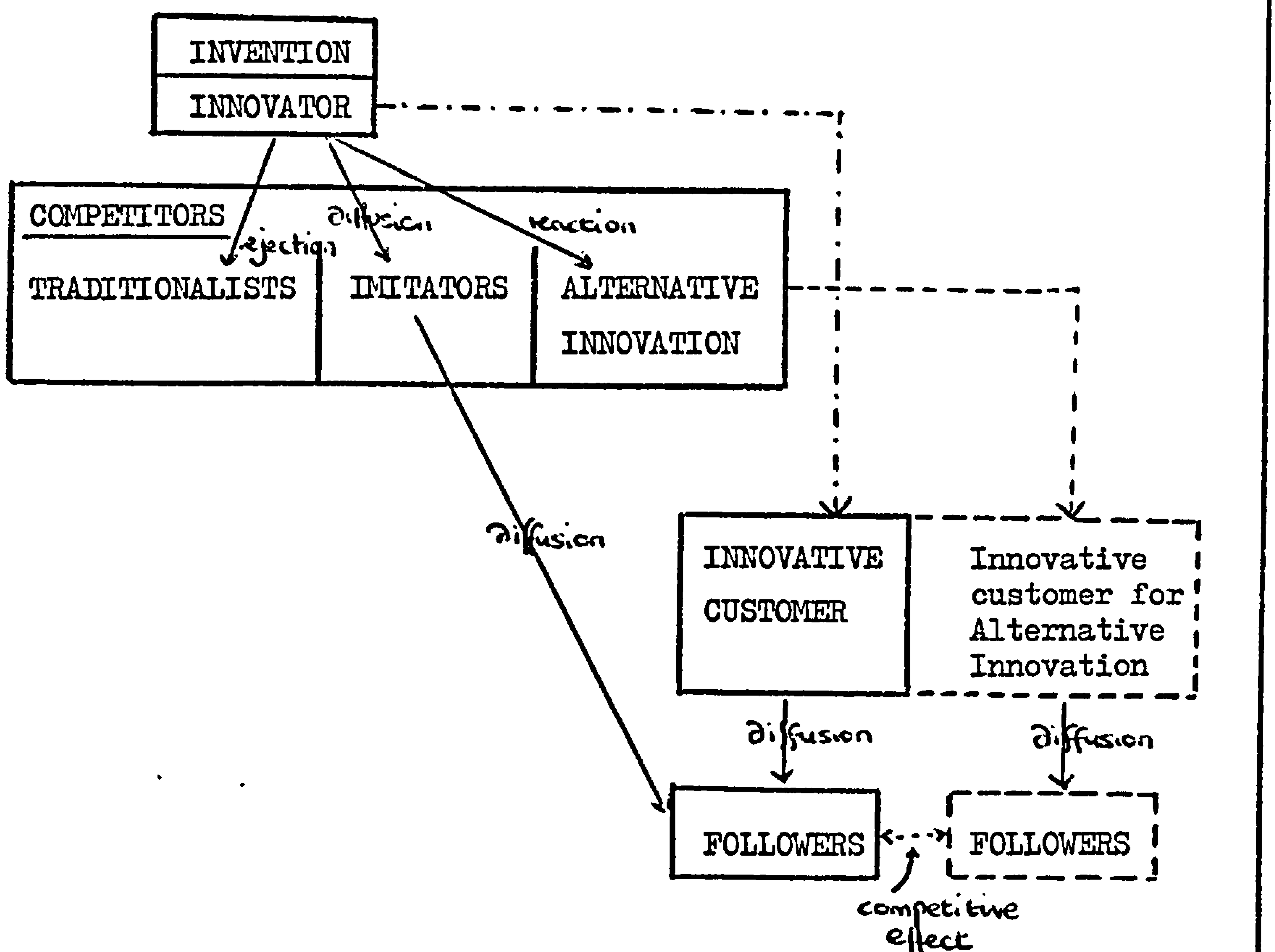


FIGURE 3.17 DIFFUSION OF TECHNOLOGY

The first of the diffusion processes - that of adoption of the technology by the innovator's competitors may be confused by the methodological problem of defining 'who are competitors' and what is to be accepted as 'imitation'? Frequently it has been found that the source of new ideas (and new competitors) arise from outside traditionally prescribed industry boundaries. For example EMI Medical Division developed a whole-body X-ray scanner in competition to the then only suppliers Phillips and Siemens; that is, before the innovation, EMI were not even in this market.

Reaction, within the industry, is likely to take one of three forms. There will be those companies that in rejecting the technological concept so reject adoption (and if this is a significant section of the industry so retard diffusion); secondly there will be those competitors who in accepting the technological concept, seek to imitate the innovators product. The competition may seek to licence the rights of development from the innovator or to circumvent patents or other barriers erected by the innovator. The innovator might well be seeking to retard diffusinn within the industry to preclude competition from eroding the market profit potential. In the extreme case where the competition perceives high profit potential in the market place but is successfully blocked by the innovator from direct technological imitation, there is the likelihood of alternative innovations being developed. This may involve acceptance or rejection of the original technological concept (replaced by an alternative technological concept). The ability of competitors to develop 'alternative innovation' will also affect the rate of diffusion within the industry.

And so to the second of the diffusion processes - that of adoption of the technology by customers. Where the original innovator is able to control the speed of diffusion within his own industry, so he is at liberty to have some control (assuming market acceptance) of the diffusion amongst customers. This may take the form of controlled distribution or even limited output vis a vis market demand.

Where, however, imitation (controlled by the innovator or otherwise - which includes alternative innovation) takes place, so the rate of diffusion will increase - as both the innovator and his competitors supply the same market(s). Again, the development of superior alternative innovation may actually retard diffusion both within the original innovators own industrial system and within the customer markets.

One further point of clarification of inter-system differences is needed; what may be perceived as innovatory by one customer-market segment may be no more than a (new) application of an existing technology by a supplying industry, hence rates of diffusion may differ considerably between systems (3.303).

TECHNOLOGY IMITATION - DIFFUSION BY COMPETITORS

This section examines the diffusion of technology within the innovator's own industrial system. In an early section the roles of organisational structure, perception of risk and so on were reviewed to explain the in-firm adoption process. Whilst the discussion was specifically orientated towards innovatory behaviour, these same elements likely affect the later-adopters in their own adoption process, although changes in emphasis may be expected (eg levels of risk perception, attitudes of management). The author writes 'likely' because there is a paucity of data relating the differences in adoption processes between the early and late adopters. This section examines those differences in examining the adoption of a technological concept in an industry over time.

LEADERS AND FOLLOWERS

Research evidence has been presented to suggest that particular characteristics are observable which differentiate innovative from non-innovative behaviour (3.304), although not all researchers necessarily hold with the universality of these characteristics (3.305), however one question is continually raised and left unanswered - are innovators perceived as opinion leaders?

Lancaster & White comment ".. little work has been done on the question of opinion leadership in industrial markets compared to consumer goods ... industrial markets would also benefit from knowing whether innovativeness is linked to opinion leadership" (3.306).

Consumer theory strongly suggests that 'opinion leaders' may be highly influential in affecting the rate of diffusion of an innovation (3.307) and it does seem that a priori this idea has been assimilated into industrial diffusion theory; the problem of substantiating opinion leaders importance has led to varied opinion in the literature.

Mansfield and his researchers have suggested the presence of 'leaders' in industrial systems; there was a tendency for

(i) the same firms to be leaders

(ii) for this tendency to be rather weak

(iii) for it to diminish over time (3.308).

But how should a leader be so defined?

Perhaps 'technological leadership' or 'market success'? Casual observation of recipients of the Queens Award for Technological Innovation over recent years highlight the recurrence of certain companies - Marconi, I.C.I., B.P., Lucas - but even if 'leaders of technological innovation' can be identified, can one assume that they are followed by others, a presumption ascribed to by researchers leaning on consumer research? (3.309).

More work is needed in the area of defining the nature of industrial leadership; because observation of an industry does frequently illustrate early and late adopters of technology. Industrial response to innovation seems to be threefold:-

(i) ignore it

(ii) imitate it (passive reaction)

(iii) supercede it (active reaction using alternative innovation)

Levitt has written of companies that have ignored technological advance at their peril (3.310).

Whilst researchers may disagree as to the existence, nature and form of 'opinion leadership' in industrial markets, there seems to be a general acceptance that technological advances become diffused through the adoption of the concept by the competition; "... there seems to be a definite 'bandwagon' or 'contagion' effect. As a number of firms in an industry using an innovation increases, the probability of its adoption by a non-user increases. This is because as experience and information regarding an innovation accumulate, the risks associated with its introduction grow less and competitive pressures mount. Moreover, in cases where the profitability of an innovation is difficult to assess, the mere fact that a large proportion of a firm's competitors have adopted the innovation may prompt the firm to consider it more seriously" (3.311); similarly Fisher & Pry found ".. of the 22 firms studied, all but five made at least some effort to participate in the new technology (3.312).

Follower behaviour is considered to be stimulated by on the one hand increasing competitive pressure to adopt, and on the other a declining risk that adoption will be a failure because of visible experience in the marketplace.

Isnard presents a model of conditions under which the risk from competitive innovations vary (3.313), but generally, evidence is not available to substantiate the claim that risk perception (of the firm towards adoption) necessarily declines for those 'following' the innovator; case evidence is available to suggest that the risk of imitative behaviour is not dissimilar to that facing the innovator. Robertson, in researching Du Pont's costly failure with "Corfam" (18 years and $300m. spent on development), found similar failures by imitator firms; ".. there were at least a dozen imitators in the United Stages, two in Britain and several in Germany, Holland and Japan" (3.314).

For study purposes the researcher must decide when is a competitor a follower? Because of lead times between invention and a subsequent marketable product, it is difficult to identify follower-behaviour.
A follower firm may be influenced by the development progress of a competitor rather than end-product technology, and begin its own development. In the above example from Du Pont, imitators began developing similar synthetics before Du Pont marketed 'Corfam", so that all were victims of the market rejection. It is most difficult to commit a firm to disclosing that it has in fact imitated a competitor! In point of fact the Not Made Here syndrome is more likely to predominate as the management response! Possibly firms develop new technology in a sort of parallel isolationism, working on natural extensions of the current technological state-of-the-art, so that again second to the market has not necessarily followed the innovator, yet might well be influenced by the effect of the innovator's product in the market.
Mansfield (3.315) and Briscoe (3.316) both suggest that early imitators speed up the diffusion processes - both within-industry and amongst customers. Robertson even found that the followers may be more adept at developing market acceptance (3.317), he gives the example of the atomic absorption spectrophotometer (AAS) which was first developed in 1955. The inventor first licenced it to a U.K. firm already skilled and recognised by scientists in the field of analytical instruments, however this company did not adopt the idea wholeheartedly because of the size of investment needed to develop it and also the possible repercussions that might accrue to the current product range. As a result the initial attempt at commercialisation was a failure. Five years later the licence was granted to three other companies, including Perkin-Elmer of the United States who, within four years had developed the product to an unassailable world leadership position - and it was the fourth company to enter

the market.

Similarly, Epstein has found that a lack of competitive pressure to innovate maintains a 'technological status quo'; ".. it took nearly ten years for American manufacturers to become competitive with European rivals .. although U.S. firms had technical competence and manufacturing experience, these were not sufficient. Lacking direct competition prior to the mid-1960's, U.S. firms had not been pressed to develop lower cost, more efficient designs" (3.318).

Identification of follower-behaviour is further complicated by the degree to which a firm is committed to the existing technology. Fisher and Pry found that following the introduction of a new technology it is quite likely that the usage of the old technology will not decline immediately; they found examples of where it continued to expand.

Technology substitution,where sales of the new exceeded the old, ranged from 5 to 14 years (3.319).

Dewhurst (3.320) found that the life span of tyre-textiles tended to be about 35 years, whilst new textiles were being introduced every 10-15 years; in every case the old technology continued to sustain high market demand for some time after introduction of the new, due to both economic (ie cost) and non-economic factors (ie resistance to 'new' technology). This is substantiated by Fisher and Pry who observed that those firms committed to the old technology "continued to make substantial commitments to the old technologies even when their sales had already begun to decline because of the competitive pressures of the new technologies" (3.321). An interesting paradox emerges; later adopters having resisted initially the new technology and responded by greater commitment to the old have exacerbated their risk of new technology adoption.

A distress situation has become a more-distress situation; the risk of committing declining resources (caused by competitive pressure) to a market that has technologically speaking 'moved' ahead may actually prevent a firm from adopting at all, so either moving out of that industry or closing down (3.322). A number of small pottery firms faced with technological reorganisation in the post 1948 reconstruction era chose not to adopt and either went into liquidation or sold out to more progressive firms. One cannot always assume that risk necessarily declines for later adopters through the diffusion process.

INTERFIRM DIFFUSION

Mansfield considers this process as the measure of how quickly an industry substitutes a new technology for old (3.324). Ayres indicated that this process roughly approximated an S-shaped distribution, namely:-

(i) a period of slow initial growth

(ii) a period of rapid exponential growth

(iii) finally, a period where growth slows as performance approaches a natural physical limit asymptotically (3.325); thus following the classical diffusion curve suggested by Rogers.

But what factors affect the rate of interfirm diffusion? A synthesis of the literature suggests a variety of elements:-

(i) Profitability - the expected value of the proposed change vis a vis the old technology.

This also includes:

elasticity of substitution of new for old technology, capital for labour, relative price movements.

(ii) Managerial attitudes of the adopting firm.

(iii) Poor interfirm communications.

(iv) Degree of competitive intensity and market structure seen as the ability of the innovator to control the diffusion process.

(i) Profitability:-

Researchers, certainly of the 'economics school' have lent most heavily on explaining the rate of diffusion in terms of potential profitability "... there exists an important economic analogue to the classic psychological law relating reaction time to the intensity of the stimulus. The profitability of an investment apparently acts as a stimulus, the intensity of which seems to govern quite closely a firm's speed of response. In terms of the diffusion process it governs both how rapidly a firm begins using an innovation and how rapidly it substitutes it for older methods" (3.326).

Mansfield felt that the expected profitability of an innovation is directly related to the probability of adoption and that this probability is smaller for innovations of equal profitability where a large investment is involved; expressed in model form:-

$$\lambda_{ij}(t) = f_i\left(\frac{M_{ij}(t)}{N_{ij}}, \pi_{ij}, S_{ij} \ldots\ldots\right)$$

where

$\lambda_{ij}(t)$ = proportion of firms not using the innovation at time (t) that introduce it by time (t + 1)

N_{ij} = the total number of firms for the jth innovation in the ith industry.

$M_{ij}(t)$ = the number of firms having introduced this innovation at time (t).

π_{ij} = the profitability of adopting the innovation relative to that of other investments.

S_{ij} = the investment required to adopt this innovation as a percentage of the total assets of these firms (3.327).

Support for Mansfield's research is given by Parker, who comments "... the model is capable of explaining practically all the variations in the rate of diffusion of the different innovations concerned" (3.328), and by Griliches "the most plausible single explanation... would thus appear to be the commercial advantage. Users response would appear to hinge on two characteristics:

(i) the larger the stimulus (profit), the faster the reaction

(ii) in an uncertain environment it takes a shorter time to find out that there is an advantage, if that advantage is large" (3.329). Profitability must also be viewed in terms of the costs of transferring from one technology to another; costs not only capital but also labour and raw materials costs, increasing upward movement of such costs can put pressure on a firm to adopt new technologies.

(iii) Managerial Attitudes

However, relating profitability to rate of diffusion does presume that the would-be adopter can identify and 'accurately' measure the profit potential of adoption! Lack of objective data is substituted by 'executive judgment' with its inherent shortcomings. Profit estimates are likely in such cases to be coloured in the light of the managerial attitudes towards adoption of the innovation; hence the adoption behaviour of two competitors viewing the same market potential may diverge considerably.

(iii) Poor interfirm communications

The rate of diffusion of a technological innovation seems likely to be affected by the amount and nature of relevant information circulating within the industry. Often the launch of a new technology (sometimes even before) is marked by a formalised press launch aimed at obtaining maximum utilisation of editorial space to reach prospective customers; it does, however, also inform competitors of the current state-of-the-art; for example EMI (Medical) Ltd. launched a new whole-body X-ray scanner at a world exhibition in the West Indies, where scientific papers were delivered to those assembled, including the opposition (3.330). Moreover, within what is usually considered to be a 'well-informed' scientific community, it is likely that competitor developments are known to others in the industry; as Carter and Williams found "... quick adopters are likely to have excellent communications both inside and outside the firm" (3.331).

Czepiel has suggested the importance of less formal sources and networks of communication "... it is not unusual for competitors actually to make social calls on each other" (3.332). He is suggesting the formation of friendship patterns within the technological system, cemented by regular patronising of technical society meetings, trade associations, exhibitions, possibly university and so on .

Shimshoni has added a further dimension to the work of Czepiel by identifying the importance of mobility of personnel in transferring technical knowledge; "... the movement of a knowledgeable individual from one laboratory or firm to another organisation is a very efficient way of transferring knowledge" (3.333). He found that "... a very large proportion of innovators were associated with the mobility of technical leaders" (3.334).

For example, the Bell Telephone Laboratories are accredited with the invention of the transistor in 1948, but chose not to announce the fact, instead to continue development to achieve higher reliability. Diffusion began as scientists left Bell to form their own companies to develop transistors under licence from Bell (3.335).

(iv) Competitive intensity and market structure; innovator control of the rate of diffusion

Evidence from the literature is minimal regarding the relevance of system influences (eg market structure - number, type of competitors) to the rate of diffusion rather than cause-effect of adoption behaviour. Organic systems are considered to have a higher propensity to innovate (3.336); similarly, various market structures are considered to engender innovation, but rates of diffusion affected by size of industry, number of competitors, number of customers is not conclusive. Mansfield does suggest that empirical studies indicate that the size of firm is a significant factor, namely, that there is an inverse relationship between firm size and the time of adoption (3.337).

Environmental influences have been seen as influencing innovation, for example Ansoff and Stewart, but influence primarily in terms of adoption behaviour rather than explaining the inter-firm speed of adoption (3.338). Twiss suggests that as industries become 'established' the pace of innovation slackens because growth is sustained by market demand for current goods; it is when this growth slackens, and profits fall, that pressures develop for firms to innovate (3.339), however, Twiss is primarily considering earlier adopters behaviour, in fact later adopters might only be incorporating a new technology into their business late into the market acceptance curve.

Again, Twiss tells us little of structural influences.

With particular regard to technological innovation, the rate of diffusion is as much determined by the ability of the innovator to control the distribution of the technology as is customer acceptance. With technological products it is likely that the innovatory firm will have a period of time to exploit its 'monopoly position' in the market place before imitation by the competition. Wasson suggests this lead time is necessary; "... the crucial problems are appropriate design for initial customer needs, especially reliability and freedom from annoying defects, and education of the potential market" (3.340); it is also a time to recover initial development costs! For example, over a period of eighteen months Reynolds International Pen Company held a virtual monopoly on the production of ball-point pens, during which time the company recovered its initial development costs one hundred fold (3.341).

This is not to say that the innovator necessarily always exploits this lead-time to the best of his advantage. Bowmar are accredited as having developed the first hand-held electronic computer in the U.S.A., yet soon lost this advantage through poor production expertise and lack of market vision. IBM, who were second to market, gained market dominance because it perceived a need for software libraries and technical assistance as part of the services offered to the customer.

The innovator is faced with a dilemma. Should he release knowledge, how much and to whom? Lovell found that the innovator can stimulate customer interest through increasing the rate of inter-firm diffusion; "... a good many licencing companies say they granted licences to competitors because they believed they could in this way increase the overall demand for the innovation" (3.342). Lovell also found that competitors, themselves, showed a willingness to take up licences rather than spend resources to circumvent patents; these desires to licence "normally arise out of a desire on the part of the competitor to be free of infringement in product features or technology it has developed and/ or is already using" (3.343).

Yet the dilemma is that the licencee might affect the innovator's own market position, the Japanese bulk-purchased licences post-1945 and have since, according to Lipsey and Steiner erased numerous companies who originally supplied the licences (3.344). Technology diffusion, using licencing agreements, remains a method of gaining a foothold in overseas markets (3.345); as Steele comments "diffusion of technology has become an instrument of international diplomacy" (3.346).

A CASE HISTORY OF INTER-FIRM DIFFUSION (3.347)

The Wankel Engine

The motor industry is not one in which major innovations succeed one another rapidly (especially in engine technology). Most cars still use the Otto-cycle piston engine which evolved in the early years of the century. Innovation seems mainly concerned with constant minor developments of traditional designs and with fashion changes.

In 1951 NSU was a very small technology-orientated firm with approximately 4000 employees; its main business was motor cycles although it did manufacture a small number of cars.

Dr. Wankel, an independent inventor, approached NSU - Dr. Froede (Research Executive), who sold the idea to Dr. von Heydehampf (Chief Executive) and von Frankenberger (Chief Engineer); Professor Baier at the Technische Hochschule, Stuttgart, was called in as an independent third party to assess the worth of the invention. Attitudes to the invention were affected by the distress situation within the company (post 1957) of a rapidly declining motor cycle demand.

Because of the drain on limited resources NSU sought cooperation in development; first Curtiss-Wright and later Citroen joined the development process. 1963 marks the first commercial application, in the NSU Spyder sports car; there soon followed outboard motors, the NSU Ro 80 in particular. (Figure 3.18 presents time scale of early developments). General scepticism for the project remained within the industry up to around 1968; gradually licences were sought and taken out by a number of world wide companies, namely

1951	Dr. Wankel joins NSU as "free collaborator"
1954	Inherent design problems solved : a new triangular piston developed
1957	first test engine runs
1958	opposition by personnel within NSU but championed by chief executive
1959	Need for extra finance for development but no conventional car manufacturers interested; agreement signed with CURTISS-WRIGHT CORPORATION
1962	Tripartite development agreement signed with CITROEN
1963	First commercial applications sold (NSU Spyder)
1968	First interest shown for licences
1969	NSU merged with Auto Union (Volkswagen)
1970	Now 16 major licencees
1971	General Motors seek licence

FIGURE 3.18 THE WANKEL ENGINE : EARLY STAGES OF DEVELOPMENT

Toyo Kogyo (Japan)

Fichtel und Sachs (Germany)

Daimler Benz (Germany)

Outboard Marine (U.S.A.)

Curtiss-Wright (U.S.A.)

Perkins (U.K.)

Rolls Royce (U.K.)

- by 1970, 16 major licencees were involved in diffusing the innovation. It is noticeable that General Motors, the world's largest motor company showed scant notice to the innovation during its earlier years of development (1951-69); ".. the autoengine will remain basically the same as it is now for the rest of the century, chiefly because it is easy to build and maintain. It may be developed and stretched, but not fundamentally changed or supplanted" (G.M.Research Executive 1968). Technological myopia was matched by a general market shortsightedness "... when high-volume production is involved, cost reduction can be more profitable than new products unless they are really revolutionary" (G.M. Marketing Executive 1968).

It was not until after the NSU merger with Auto Union (that includes Volkswagen) and the demonstrated market acceptance (post 1970) that General Motors finally conceded its original stand and sought a licence from the innovator.

A number of points can be highlighted from the Wankel case history:

(i) The source of the invention arose outside the company.

(ii) Initial resistance within NSU was countered by the presence of a product champion (von Heydehampf)

(iii) Innovation in a distress situation.

(iv) Initial diffusion of idea with first Curtiss-Wright and later a more direct competitor Citroen.

(v) Further technology transfer as competition can perceive market success (other early licencees)

(vi) The initial reluctance of General Motors - the largest producer and so most committed to current technology - to become involved in the innovation - a factor suggested by Mansfield's research.

CUSTOMER ACCEPTANCE
AND DIFFUSION

Attention now turns to that second diffusion process outlined in figure 3.17 (3.348), that of the acceptance process within the customer system. Whilst this acceptance process is initiated by the innovator, subsequent behaviour by its competitors (eg imitation by licence, development of alternative technology) will determine this system's rate of diffusion. For clarity of definition, much ignored by researchers, the term 'innovatory customer' is given to the first adopter of the innovation in the customer system. This is deemed important because whilst an innovation may be new to a particular customer system, it may, in fact, have been available, albeit in a different form, in other customer systems. Indeed 'similar' applications may be used by the supplier to convince a particular customer system. Zaltman and Bonoma conclude ".. the notion of the modifiability of the product is not taken into account" (3.349). This is certainly of interest to the researcher of innovation in international markets; for example, Marconi Communication Systems Ltd developed a tele-cine unit which although being electronically highly advanced,has been 'simplified' to aid installation and maintenance in less technical overseas markets (3.350).

A second consideration affecting customer adoption and diffusion relates to the source of the innovatory idea. Earlier, the importance of 'demand-pull' vis a vis 'technology push' was reviewed in terms of securing interest from the customer system (3.351); that is to say, that ideas, generated in the customer system, refined by the supplier (ie the innovator), are more likely to be received favourably by the former system (3.352). The idea may take the form of a direct customer enquiry to solve a technical problem or astute market research on the part of the innovator to match innovation with user needs. Similarly, adoption is eased by close cooperation during development between supplier and customer; for example, Ekco Instruments (part of the Pye Group) developed the world's first electronic fail-safe system for cranes in close cooperation with one of its major customers (3.353).

Customers for technological innovation tend to be other organisations; sometimes consumer end-users are the direct recipients, for example, the Ford Motor Company received the Queen's Award for Technological Innovation for the development of an advanced carburettor system which was installed in the Ford Fiesta (3.354), similarly Sinclair Radionics with its digital calculators.

However, for this thesis, interest in customer-systems is restricted to intra-organisational buying; customer adoption (and subsequent diffusion) is examined in three parts:-

(1) The nature and flow of communications between buyer and seller

(2) The response of the customer

(3) The effect of customer adoption on subsequent diffusion - the 'customer contagion effect'.

COMMUNICATIONS BETWEEN INNOVATOR AND CUSTOMERS

Communications research suggests that the effectiveness of a communication can be seen to be a function of five variables:-

(i) The message

(ii) The channel(s) used

(iii) The source of the message (the communicator)

(iv) The action advocated

(v) The audience

(i) The message

The message must be interpreted (ie decoded) by the customer (audience) as being beneficial to that buying organisation, namely that it has to contain the right 'motivating appeals'.

(ii) The channel(s) used

The credibility of a message can be reinforced or weakened by the channel(s) used to communicate that message. The innovator is faced with the choice of a variety of formal channels - media advertising, public relations/editorial matter, exhibitions, mailed sales literature, the salesforce - to reach the customer, although, in practice, choice may be limited by the innovator's lack of resources. Some doubt has been raised as to whether the innovator understands which appeals to use in which channel .. "advertisers did not correctly perceive the influence of advertising appeals upon the respective market segments concerned" (3.355). Certainly industrial advertising research is less advanced in terms of methodology used and in practice than its consumer counterpart. Blame has been laid at the door of industry itself; small budgets preclude, on an opportunity cost basis, the likelihood that research, possibly costing as much as the original exercise, will be commissioned. Hence channel effectiveness remains subjectively assessed and open to doubt.
In addition to formal channels, research indicates that impersonal channels may play an important part in supplementing or even replacing the latter networks (3.356). ".. the role of friendships maintained by purchasing agents is important and very often ignored or even denied in traditional research" (3.357). Similar networks, forged through joint membership of professional bodies, clubs and so on, particularly if aided by close geographical proximity, may also exist; some indication is provided by Allen who found of technologists "... these key people differ from their colleagues in their orientation towards outside information

sources. They read far more, particularly the 'harder' literature. Their readership of professional engineering and scientific journals is significantly greater than that of the average technologist. They also maintain broader ranging and longer term relationships with technologists outside their organisations" (3.358).

(iii) Source of message - the communicator

Cardozo and Cagley found that in high risk situations industrial buyers sought more information through prefering to deal with 'known' suppliers (3.359); credibility of a message is affected by the buyers' perceptions of the source of the message. Webster found that buyers rated the innovator's salesforce as the most 'trusted' source of information (3.360). These findings add support to the concept of 'source loyalty' proposed by Wind (3.361) and by Cunningham (3.362). Luffman suggests "strong source loyalty between buyers and sellers" (3.363); he feels that the customer is more likely to change suppliers if he is experiencing dissatisfaction with the current supplier than because of the arrival of an innovation by a rival supplier. Alexander refers to trusted sources in terms of 'confidence' - a force cementing relationships between buyer and seller "... the feeling of certainty that the supplier will do as he promises and spare no effort in trying that his claims, with respect to his products and services, can be accepted without serious question and that he can be counted upon to help execute special projects" (3.364); confidence is thus related to known suppliers and their performance in the market place over time.

In contrast Lambert studied the effect of post-choice innovation evaluation as an input to future decision making; in questioning the presence of 'loyalty', he comments "attitude movements of chosen alternatives are not necessarily opposite those of unchosen alternatives and that, in terms of attitude response, criticism is not the inverse of support" (3.365); namely, that each purchase is taken on 'face value'. Neither stance particularly has considered the possible collaboration between buyer and seller as influencing credibility of the seller. Past collaboration or even current will influence the reception of messages generated by the seller.

(iv) The action advocated

Adoption of innovation, especially for the earlier adopters, contains an element of high risk. The action, therefore, being advocated is likely to be calling into question existing practices. In addition competitors will be explicitly or implicitly advocating non-adoption. Evidence suggests that, given the nature of the buying situation, certain channels are less effective for communicating high-risk innovation; that sellers favour direct face-to-face contact, with possible demonstration, as the most effective way of communicating with buyers (3.366). Reaction to the action advocated is examined below.

(v) The audience

The effectiveness of a communication is ultimately judged by the reaction from the intended audience. The problem for the seller is to identify the audience influential in innovation decision making. The audience's response is an aggregation of decoding of the elements (message, media, etc) discussed thus far; a decoding process that takes place within a prevailing 'organisational climate', favouring or unfavouring adoption. The response of the audience is examined in the following section...

CUSTOMER RESPONSE TO COMMUNICATIONS FROM THE INNOVATOR-SYSTEM

How industrial customers buy has been the subject of considerable interest in the literature; Sheth cites over 1000 bibliographic items on organisational buying in a recent literature review (3.367), but feels that their impact has been reduced because researchers have sought to apply concepts direct from consumer-marketing (in particular individual-psychology) rather than applying concepts from organisational theory to organisational buying behaviour. Modern consensus suggests the need to view the process of adoption as group decision-making ".. the study of industrial marketing is basically the study of the behaviour of formal organisations" (3.368), but to retain the recognition that individuals do influence group decision making, ".. it is important to distinguish between the public and private aspects of industrial purchase decisions .. whilst there will generally be consensus and broad knowledge about the public aspect, there is difficulty in isolating and detailing the private aspects of the purchasing officer or any other unit in the buying process" (3.369).

Problems of study are exacerbated by the fact that an innovation adoption decision - a high risk decision - is likely to be a function of a number of decisions made by any number of groups, functional departments and so on. A typical breakdown of this process is to recognise potential differences between:

users
buyers
deciders
influencers (and 'gatekeepers')

For the researcher the problem is to decide and clarify his unit for analysis, as Nicosia and Wind state ".. the choice of an appropriate unit of analysis affects the subsequent and critical choices of variables, their measurement and analytical procedures ... this choice involves complex processes which are generally ignored" (3.370).

Choice of unit for analysis is seen by Nicosia and Wind to be dependent upon the researchers academic discipline; they cite purchasing/marketing models as prescriptive lists of 'do's' and 'donts' which demonstrate

".. a conspicuous lack of explicit assumptions and facts about these buying processes" (3.371). Secondly, they feel economic models have ".. reached a high level of sophistication and the maturity to be encoded into precise mathematical models" (3.372), but that they generally fail to describe the 'process'; "the economists contribution to our understanding of industrial buying behaviour is limited because he overlooks the influence process by which firms become aware of, and evaluate new products" (3.373).

Nicosia and Wind press for interdisciplinary models, viewing organisational buying as a multi-dimensional process; "(they) must include not only activities of the buying process, but also the people who initiate and perform these activities and an evaluation of the results of such activities" (3.374). This view is shared by other researchers, Buchner (3.375), Webster and Wind; the latter conclude that "traditional views of organisational buying have lacked comprehensiveness" (3.376). They present a multi-variable model encompassing economic and non-economic variables -

environmental influences
organisational influences
buying tasks (routine, non-routine)
organisational structure
buying techniques
buying centre (users, deciders, etc)
social (interpersonal) influences
individual behaviour.

In so doing they accept that this untested model should be no more than a framework seeking to identify the elements impinging upon organisational buying, "the framework presented is reasonably complete, although the details clearly are lacking" (3.377).

Less comprehensively, Buzzell has illustrated the multi-role buying process in quoting fourteen different people being involved in the purchase of a new air compressor (3.378), but does accept the difficulty of isolating the importance of any particular person in the making of the decision and the problem of identifying the relative importance of private (personal) goals vis a vis organisational objectives - Feldman and Cardozo call this "a correction for emotional factors" (3.379).

A number of researchers have sought to explain the buying process. Ozanne and Churchill, having synthesised the literature, suggest that pressures on an organisation to adopt innovation arise from five factors (3.380):-

(i) capacity problems : that present equipment is incapable of meeting current or projected output.

(ii) skilled labour problems : similarly, a shortage of skilled operatives creates a pressure on management to shift to less-skilled machines. It is a fact that high technology does not necessarily demand a high level of skill from the operative, though equally it can put pressure upon maintenance and managerial skills within the organisation.

(iii) equipment obsolescence : Ozanne and Churchill are not specific as to the cause of this obsolescence. Whilst it may be replacement of technology at the end of its 'life', it may also be a pressure of technological advances adopted by competitors 'forcing' the adoption by the organisation.

(iv) purchase replacement decisions : Ozanne and Churchill found that companies were tending to integrate backwards, producing what was once supplied because of a technical dissatisfactiion with suppliers.

(v) new task or problem : pressures from an organisation's own customers, requiring a task beyond its own capabilities may pull through innovation from a supplier.

In addition,a number of more immediate pressures, directing attention to a specific supplier, were recognised; Ozanne and Churchill called these 'purchase-directing factors', namely:

quick delivery

cost/benefit comparisons

special product attributes

personal selling

past experience with supplier.

Ozanne and Churchill have sought to provide 'reasons for adoption', but they do not describe how supplier communications is received,and how this information is disseminated to interested parties within the organisation. The literature concerned with industrial customer adoption processes parallels thought outlined earlier when dealing with the innovator's adoption process; ".. the traditional adoption process model can be applied in the industrial setting" (3.381), and so is not repeated here. The importance of 'trialability' is seen as providing 'proof' to decision makers, though it will lead to extended predecision deliberation, that is, the period over which the decision to adopt (or reject) is increased to counter the lack of experience regarding judgment of the new technology. Attempts to provide universal set sequences of stages in the adoption process are questioned by O'Shaughnessy who writes "... there is always a danger in listing such stages of confusing a logical sequence with an inevitable and unvariable process, or of fitting observations into some predetermined sequence and, in effect, assuming what has still to be established" (3.382).

What is not in dispute by researchers, is that organisational buying, like the development of the innovation, is the response of individuals interacting with fellow-members in the organisation. A self-preservation effect of the individual's position in the buying process was highlighted by O'Shaughnessy who referred to it as 'the allocation of buying responsibilities' ... "participants did indicate they gave priority to factors which they would be held accountable" (3.383); this reinforces similar conclusions held by Wind (3.384) and Newall (3.385).

Barnes suggests that the diffusion of risk may be a conscious effort on the part of decision-makers; "it is quite possible that the executive feels uncomfortable with the amount of risk which he perceives, in which case he may seek to spread it among his colleagues" (3.386).

Each individual (or sub-group) involved in the adoption/rejection decision is expected to perform a number of specific goals, namely his prescribed role in the organisation - the Purchasing Officer to ensure delivery, the Technical Manager to ensure performance and so on. These specific goals provide the first level of consideration in the ensuing interaction in the group.

In addition, each individual (and sub-group) interprets these specific goals in terms of his own personal goals, expectations and aspirations - "the buyer synthesises and reconciles the needs of his company with his own personal goals and with those of other individuals and groups in the organisation who impinge upon the purchase decision" (3.387).

Possible reconciliation of diverse goals within the formal context may range from jural settlement - that is an agreement to abide by the majority decision to adopt or reject - the possible outcome being a compromise to 'delay adoption' rather than 'outright rejection' -, to power bargaining and autocratic forms of management decision making. One researcher has found the importance of 'power bargaining' in the speed of adoption, in particular "the power to control information flows" (3.388).

The adoption process for the customer-organisation differs from that of the innovator in one particular aspect - namely, whether initiated by the customer or not, the innovation is sold to the customer by the innovator (or competitor); and sold through formalised channels, the Purchasing Function. So how important is this function in terms of innovation adoption? Answers from the literature present contradictory evidence.. From their studies Zaltman and Bonoma found "the role of the purchasing agent in the adoption of technological innovation is relatively unstudied" (3.389), in a similar vein Mogee and Bean suggest that the literature "has virtually ignored any possible roles played by purchasing agents" (3.390). Whilst a number of researchers - Strauss (3.391), Ammer (3.392), consider the role to be insignificant, Magee and Bean did conclude that "the purchasing agent plays an important role in industrial innovation but is not the principal decision maker" (3.393). Lehmann and O'Shaughnessy feel that the purchasing agent is vital to the decision making process by providing information in four areas:-

(i) reliability of delivery

(ii) reputation of potential supplier(s)

(iii) provision of details of technical after-sales and more questionably

(iv) to help assess product reliability

Newall provides a part answer to this paradox, namely that role is prescribed by the organisational structure. He suggests that the role will vary according to size and structure - "that the highly structured purchase procedure of the larger companies acts as a protective mechanism which reduces or diffuses the level of risk perceived by members of the buying group", whereas "in small companies, such a defence mechanism does not exist" (3.394). Although Newall does not identify the strength of influence of the purchasing agent in either the small or large organisation, his work does support Mogee and Bean's contention that the purchasing agent is likely to be a 'gatekeeper' in structured (mechanistic) organisations. Further supportive evidence is provided by Zaltmann and

Bonoma - "he (purchasing agent) implicitly becomes a decision maker by allowing more favourable information from a favourable bidder to flow up to formal decision makers, while allowing less information of a favourable nature from less favoured bidders to flow up to formal decision makers" (3,395). Marrian suggests that the status accorded to the purchasing agent is important; if it is low he may act as an 'interventionist' in the buying process in a manner to enhance and raise his status (3.396).

Haksansson and Wootz feel that it is the purchasing agent's education that is the most important variable in explaining his role in innovation decisions - "a highly educated purchaser is also sensitive to differences in the degree of risk in the situation" (3.397). Marschak suggests buyers may undertake a kind of 'quasi-marginal' calculation whereby they terminate search (for suppliers) at the point where the marginal cost of search was greater than the expected marginal return (3.398), though he presents no evidence to support this contention! But more specifically, there seems to be a general movement towards risk assessment by the purchasing agent becoming more methodical - "there is some evidence to suggest that there is an increasing use of various analytical techniques .. is tending to give (purchasing) a greater scientific orientation" (3.399). However, it is possibly the purchasing agent's lack of 'technical' education that inhibits his level of contribution to technological innovation adoption decisions; Clemens found, in a study of the U.K. plant equipment industry, that purchaser agent influence was as low as 19% contribution (3.400).

A CUSTOMER CONTAGION EFFECT?

Finally, attention turns to the diffusion of innovation in the customer rather than innovator system. Of particular interest is the effect the adoption by the innovatory customer has upon others in that system (as has already been said, it may have a similar effect upon the attitudes and behaviour of the innovator's competitors). Mansfield's studies support the presence of a similar contagion effect discussed with respect to the innovator system (3.401); as experience of usage and information in the market place increases, so the risks associated with adoption decrease, whilst competitive pressures from earlier adopters help to stimulate the interest of those still yet to adopt. These pressures to adopt, namely competitive pressures, are multi-source as figure 3.19 illustrates:-

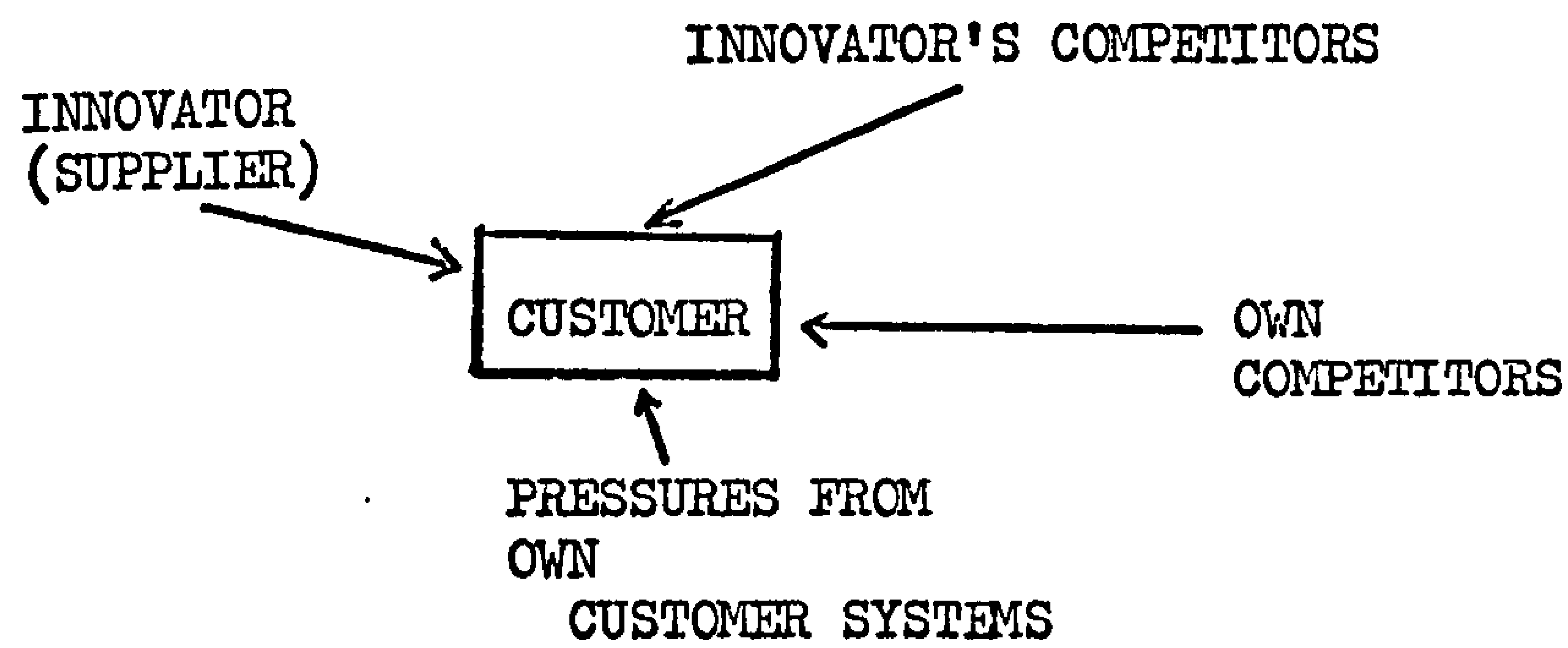


FIGURE 3.19 MULTI SOURCE PRESSURES TO ADOPT

Where researchers have studied diffusion in customer systems as opposed to diffusion in the innovators system, again one finds little support for the theoretical 'S'-shape distribtuion to describe the process; critics include Cooper and Schendel (3.402) and Hayward, who writes "none of the five innovations exhibits the 'bell-shaped curve' and it is considered that this shape is not necessarily applicable in the case of technological innovations" (3.403). An interesting feature of the industrial diffusion process is the time taken for diffusion; Hayward, for example, found time differed between 8 and 18 years, whereas Mansfield found 60% market acceptance could take between 1 and 20 years.

One concept that has achieved coverage in the literature used to illustrate market acceptance over time has been the 'product life cycle' concept (3.404). Although usually viewed from the suppliers perspective it, nevertheless, shows a remarkable similarity with the traditional Roger's diffusion curve as figure 3.20 illustrates:

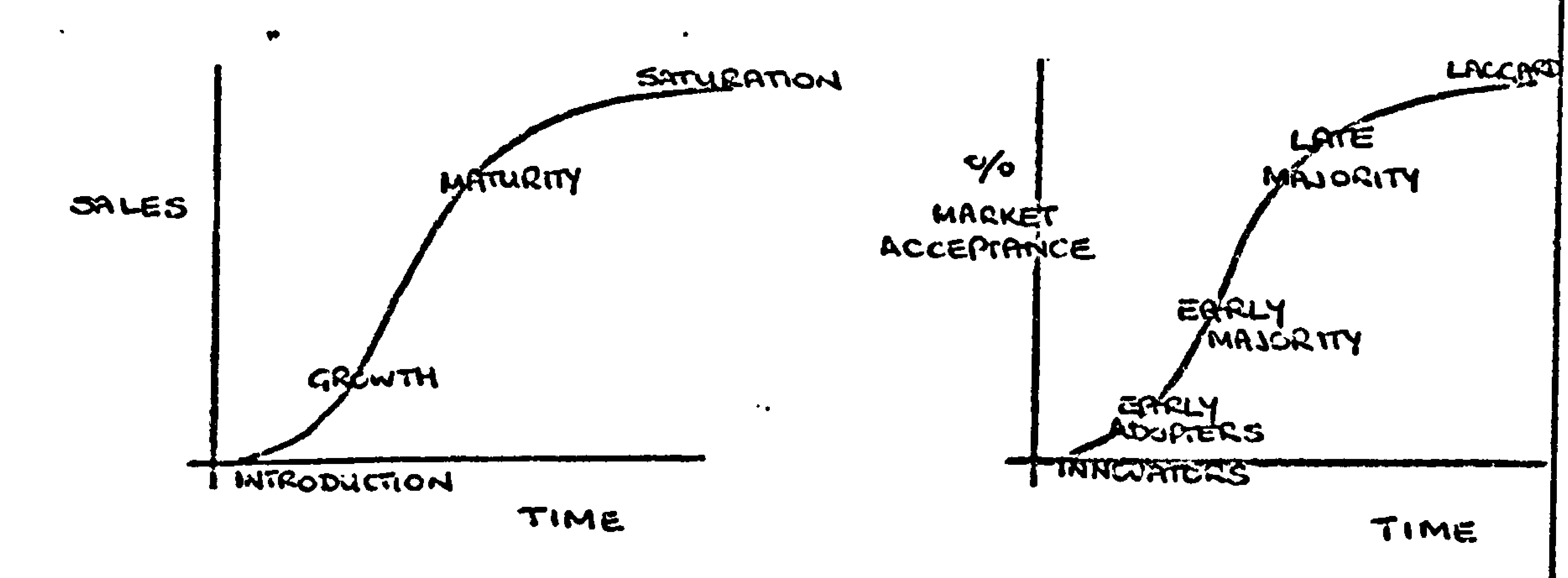


FIGURE 3.20 : THE PRODUCT LIFE CYCLE AND ROGER'S DIFFUSION CURVE

How similar are these two curves? Are they illustrating the same process? If one accepts a product life cycle of a product generic type, then it can be used to describe the sales of that technology over time. It is suggested that the shape of the curve is dependent upon three interacting variables, namely:-

(i) the rate of customer acceptance and rejection

(ii) the ease at which competitors can imitate

(iii) the level of technology inherent in the product.

Similarly Roger's diffusion curve seeks to describe the rate of market acceptance by identifying adopter-types, however Roger's curve classifies adopters in terms of the time of their first adoption. His curve does not cater for repeat adoptions, whereas the product life cycle, as generally presented, does not distinguish between first time and repeat purchases. There is likely a stronger correlation between the two curves in the early stages of the innovation; at the launch (introduction) those buying can be assumed to be the innovators, and that early market development is due primarily to early adopter behaviour and the subsequent contagion effect, but as the product life cycle moves towards maturity, so it does not distinguish between possible early-adopter repeat behaviour and later adopter first-time purchases.

Just as Roger's 'S' shape diffusion curve has its critics, so too does the product life cycle; despite a general acquiescence of the concept among academics and practitioners (eg Fox's study of the Ciba-Geigy Corporation (3.405)), a number of studies testing it empirically have found that it lacks validity (3.406); Dhalla and Yuspeh conclude ".. in some respects the concept has done more harm than good by persuading top executives to neglect existing brands and place undue emphasis on new products" (3.407).

Whilst there may be disagreement as to whether distributions of collective adoption decisions can be 'fitted' meaningfully into theoretical S curves, such distributions do not, in themselves, explain the nature of the contagion effect referred to earlier by Mansfield. One factor that is suggested in activating the diffusion process is the presence of 'opinion leaders', similar to that discussed for innovator systems (3.408). But should the researcher always assume that opinion leaders will necessarily be in favour of adoption? The author found no evidence of research directed towards opinion leadership advocating rejection of innovation.

Lancaster and White comment that "little work has been done on the question of opinion leaders in industrial markets compared to consumer goods .. the characteristics of opinion leaders have been discussed relatively little" (3.409).

Webster found that respondents reported a number of characteristics that identified a company as an 'opinion leader', namely:-

(i) large size

(ii) same industry as followers

(iii) a company seen as committed to new product development

(iv) a growth company

(v) financially successful

(vi) possessing progressive top management.

- however he found only two respondents from fifty that indicated there were certain companies they consistently looked to because those companies acceptance of new products was important to them; it led Webster to conclude ".. opinion leaders, if they exist at all, seem to be rare in industrial markets" (3.410). However, in a more recent study, Banting indicates that customers said it was most influential in their decisions to adopt innovation if they could observe similar firms successfully adopting it, and similarly rejection by other like-firms might cause a rejection-contagion effect "(3.411).

During the author's own investigations, a number of suppliers (ie the innovators) stressed the importance of gaining the acceptance by particular customers as the first stage to obtaining market diffusion. For example -

(i) Railko Ltd. developed a new type of marine bearing which, when adopted by Shell Marine Ltd., provided the subsequent impetus for other customers to adopt (3.412).

(ii) Ekco Instruments enjoyed a similar experience with Lansing-Bagnall regarding electronic systems in fork-lift trucks (3.413).

(iii) It does seem that the opinion leader need not necessarily (as suggested by Webster) be a direct competitor. Sorex Ltd., the world's leading innovator in rodenticides gained market acceptance in U.K. by gaining acceptance of the Ministry of Agriculture who then 'sold' the idea to farmers (3.414).

Researchers also seem undecided as to whether opinion leaders (if they exist) are the innovatory customers; Lancaster and White write "... industrial markets would also benefit from knowing whether innovativeness is linked to opinion leadership (3.415).

Lazer and Bell suggest innovators are different from opinion leaders and other competitors, they suggest the business norms of the innovator (eg attitude to risk) differentiate them from the others and that these differences are perceived by the competitors to the extent where these innovators tend to be watched rather than followed; it is the opinion leader who will relate the behaviour of these 'deviants' closer to the prevailing industry norms and influence the diffusion process (3.416).

The author's own investigations, though limited, failed to establish such a 'black-and-white' distinction, for example, the Railko-Shell Marine and the Ekco-Lansing-Bagnall were situations where innovators were also perceived as opinion leaders in their industry.

Mansfield suggests that the likelihood of a company being a regular innovator diminishes over time:-

(i) if two innovations are reasonably close together in time there was a tendency for the same company to be relatively quick or slow to introduce both

(ii) there is only a slight tendency for technical leadership to be concentrated and this diminishes over time

(iii) if the time separating two innovations increases there is less correlation between the speed of response to the first and then to the second innovation; the time lag between notable innovations can have resulted in structural, managerial and market fortunes for any particular company.

If 'leadership' exists, how is it communicated to 'follower-organisation'? In his questioning of the existence of opinion leaders Webster suggests that because technological innovators are likely to be asked to supply 'more complete information' than perhaps occurs in other markets, which reduces the need for informal product-related interfirm communication (3.417).

In practice it does seem that included in this 'more complete information' buying firms seek reassurances in terms of competitors who have already successfully adopted the innovation; "information from another firm about the use of an innovation is probably the most convincing type" (3.418) - I.C.I. amongst others use successful case histories in the sales literature to convince later adopters. This information need not necessarily follow some form of contact between firms; knowledge of adoption by the former may be convincing enough.

A number of studies substantiate this intangible aspect of communications "... in certain areas of diffusion research impersonal communications have been found to be highly important in the diffusion of information" (3.419). Webster, himself, suggests that as the perceived risk of purchase increases, so would the likelihood that inter-firm impersonal communication (3.420). Possibly interpersonal communication is affected by 'proximity; namely geographical location, industry affiliation, professional trade association memberships and other social interaction. Also, a point raised earlier, the mobility of labour transferring technology.

Zaltman and Bonoma in a comprehensive study suggest 'leadership' is communicated at two levels:-

(i) competitive performance is communicated; this would support earlier suggestions that at least a number of characteristics attributed to opinion leaders are based upon competitive technical success.

(ii) informal contact - trade shows, meetings, etc.

Zaltman concludes "word of mouth communication among buying firms is greatly underestimated" (3.421).

Word of mouth communication between firms can be stimulated by the actions of the innovator (or an imitator); on the one hand adoption contributes to customer experience, and on the other, diffusion can be aided by the innovator providing the opportunity for customers to try the innovation before adoption. Whilst this may not be possible, particular for small companies (ie indivisibility of the technology), this can be circumvented by demonstrations at the innovator's premises, or at a particular customer's premises and inviting others to observe.

Also, there exists for early adopters the risk that technology will be superceded, to the benefit of later adopters. E.M.I. Medical overcame this by undertaking to incorporate technical modifications into earlier customers, at little penalty or cost to the customer (3.422).

This section closes with an examination of the homogeneity of the customer system; is there a propensity for some customers to be regularly more innovatory than others? The distinction between early and late adopters in the customer system is frequently blurred with studies of early and late adopters in the innovator's system.

One of the earliest and oft quoted research studies is that of Carter and Williams, who divided firms into three categories:-

(i) those at the forefront of using technology

(ii) a large middle group, neither leaders nor wholly disinterested in new technology

(iii) those "quite uninterested in science and technology .. perfectly content to continue with traditional methods without even examining the alternatives" (3.423).

In arriving at these conclusions they used a large number of 'characteristics', but did not:-

(i) question how these firms developed these characteristics

(ii) how enduring these characteristics in a firm were over time;

namely, would the same firm continue to be technically progressive.

A more recent study by Webster (3.424), testing innovativeness against size of organisation, found:-

(i) Larger firms are more likely to be able to afford the net new investment required for adoption, and will therefore tend to adopt earlier.

(ii) Larger firms are more likely to be able to absorb the risk of innovation and will therefore tend to adopt earlier.

(iii) Smaller firms are more likely to value technical information provided by the selling firm, and will therefore tend to adopt earlier.

(iv) Smaller firms have less complex decision-making structures and may therefore be able to adopt earlier.

It was apparent from Webster's work that size of organisation alone does not explain 'innovativeness'; Briscoe et al found ".. it is the smaller concerns who appear to respond better for innovation but, unfortunately, they frequently lack both financial resources for capital investment and the requisite technical expertise" (3.425).

Baumgarten provides evidence to suggest that 'educated' managers, working in a favourable organisational environment, tend to adopt innovations earlier (3.426).

Synthesising research in the field led Webster to conclude that early adopters can be identified in terms of:

(i) amount of investment required to adopt. Similarly Hayward suggests that it is the perceived characteristics of the innovation that effects the rate of diffusion (3.427).

(ii) time lapse since previous adoption rather than traditional economic thought (eg Carter and Williams), namely:

(i) firm size

(ii) liquidity

(iii) profitability

(iv) growth rate.

Webster found some indication of 'regular innovators'-he found in this study of commercial jet aircraft, certain companies "have consistently been among the first firms to adopt new aircraft" (3.428) but still felt that "there is no evidence to support the notion that certain firms are watched closely and have a significant influence on others in the industry" (3.429).

3.11 A SUMMARY

The purpose of Section 3 has been to provide a detailed picture of those concepts considered to explain the processes of adoption and diffusion of technological innovation.

It began by illustrating four models to describe the relationships that can develop between an innovatory organisation, its customers and its suppliers. They showed that innovatory pressures could be self-generated, supplier push or customer pull, or any combination of these. It was suggested that the nature of this relationship was influenced by the market structure, the rate of customer acceptance and rejection of technology, the rate of technological change and the prevailing eco-political policies pursued by government.

The source of innovatory pressure was suggested to be important in legitimising innovatory behaviour; it was seen to influence not only in-firm adoption decisions, but also the speed of diffusion amongst competitors and adopting customers. A number of studies were presented to suggest that user need/ demand pull innovation was more likely to be adopted successfully than the self-generated / technology push type of innovation.

There followed a review of definitions of invention and innovation featured in the research literature. It was suggested that in defining "innovation" the need is to relate it to the system (or systems) under investigation. It was only by doing so that the nature of the relationship between the innovation and subsequent adoption and diffusion behaviour could be meaningfully examined; clarity was needed to distinguish between the radical break through type of innovation and that form of technological advance referred to by Langrish as "incremental innovation", namely the gradual up-grading of technological knowledge.

Attention then turned to examining the importance of the organisational structure in facilitating innovatory behaviour. A distinction was made between the informal and formal networks in an organisation; the general conclusion made was that innovatory activity was more likely to take place in an organisational climate sympathetic to innovation, namely in organic/modern rather than mechanistic/traditional systems. Size of firm or level of R & D expenditure were considered of lesser importance. It was felt that whilst the larger firm has the greater ability to innovate in terms of availability of resources, this must be accompanied by a willingness to be innovatory. Research studies were presented to suggest that the adoption process within the firm can be hindered by inter-departmental differences caused by personnel with differing value structures and business orientations; in particular the science based manager with his commitment 'to science' in conflict with the operational manager committed to the business goals of the organisation.

The role of communication networks in adopting organisations was examined and conclusions reached that message effectiveness was determined by the source of that message, its content, the channel used to transmit it and the receivers own situation. The use of New Venture Teams/ Departments as an alternative to the traditional hierarchical structure for progessing innovation was explored. Questions were posed as to the structural strains that could result from the juxtapositioning of two organisational structures. The role and importance of 'innovation champions' were raised and innovation champions were identified as being determining factors in a number of illustrative cases presenting organisational adoption behaviour. One point discussed was the need for an innovation champion to be located high in an hierarchy of an organisation. What was established was the need for power to counter organisational resistance to innovation adoption, which might need a person of seniority but equally an innovation champion could perform successfully with the backing of those in seniority, who act to legitimise his role in the organisation, which may be to champion innovation at any one or number of stages in the in-firm adoption process.

Discussion then turned to examining managerial reaction to risk bearing, given that innovatory behaviour is risk incurring. It was suggested that in the larger organisation the manager is more able to avoid high risk situations by delegation and decision through committees; in any innovation decision the manager was likely to assess risk not only in terms of 'to the organisation' but also in personal terms. The applicability of technological forecasting methods to guage risk in innovation decision analysis was questioned. Where techniques relied heavily upon subjectivity for inputs so there was the likelihood that a pessimistic assessment (and so a pessimistic forecast) would be made by the risk-avoiding manager and vice versa with the risk-taker, so little aiding the original purpose of forecasting, that of seeking to reduce uncertainty to the point of calculable risk. Research evidence from the literature was presented to substantiate this viewpoint. Three case histories were presented to illustrate the major points thusfar discussed in the text.

Having examined the in -firm adoption process, attention turned to two related diffusion processes. It was emphasised that there was a need to clearly distinguish between the diffusion process in the innovator's own system/industry, whether it be technological imitation or an alternative technology, and the diffusion process in the customer system which is influenced by and, in turn, influences behaviour in the original innovator's system. With regard to the innovator's own system both the presence of opinion leaders and a contagion effect were examined. The presence of the former remains contentious. Conclusions were reached that differences between the times when firms adopt a particular innovation can be traced to economic and non-economic factors, in particular managerial attitudes to risk- taking and innovation adoption.

Rates of customer acceptance were discussed, in particular was noted the importance of source of innovatory idea and the methods used by the innovator to communicate with the customer system. Literature concerned with organisational buying behaviour was presented, to highlight criteria for purchasing technological products.

The question of a customer contagion effect was raised; Roger's diffusion curve and the product life cycle concept were used for illustrative purposes. The presence and possible role of opinion leaders formed part of the discussion. Again their presence, and if so their degree of influence upon the diffusion process, remains inconclusive. Some evidence does exist to suggest that some customers are regular innovators but generally more research is needed in this area.

Volume I began with a literature review as to the merging of adoption/diffusion research traditions (Section 1), proceeding to a multi-disciplinary review of the literature concerned with adoption and diffusion processes (Section 2). Section 3 concludes this general literature survey with its particular emphasis upon innovation adoption and diffusion behaviour in industrial systems.

In Volume II, Section 4 presents a literature review and reports field studies conducted in one particular industrial system, namely the Pottery Kiln Industry. The closing section, Section 5, provides the bridge between the theory and practice concerning the adoption and diffusion of technological innovation outlined in this Thesis.

SECTION NOTES:

3.1 What these models do not show is the adoption process within each system.

3.2 Parker : "The Economics of Innovation" Longmans 1974 p2.

3.3 For example, as illustrated by:-
Carter and Williams : "Industry and Technical Progress. Factors Governing the Speed of Application of Science" Oxford University Press 1957.

3.4 Burns and Stalker : "The Management of Innovation" Tavistock 1961: this point is examined in more detail later in the thesis.

3.5 Rothberg : "Product Innovation in Perspective" in Rothberg (ed) Op. cit p.6.

3.6 Bright: "Some Management Lessons from Technological Innovation Research". National Conference on Management of Technological Innovation, Univ. Bradford Management Centre 1968.

3.7 Schrumpeter : "Capitalism, Socialism and Democracy" 3rd ed. Harper-Row 1950 p. 83.

3.8 A number of similar examples are provided by Levitt : "Marketing Myopia" H.B.R. July/August 1960.

3.9 Rothberg : Op. cit p.7

3.10 H.R.H. Prince Philip writing the Foreward in The Engineer p.3.

3.11 eg Clive Jenkins (union leader) called for government/union action to halt/control technological development of 'silicon chips' which endangered loss of jobs.
Trade Union Congress Rpt. 1978.

3.12 Club of Rome : "Limits to Growth" Pan Books 1973.

3.13 Deane : "The First Industrial Revolution : Cambridge U.P. 1969.

3.14 Gabor : "Innovations : Scientific, Technical and Social" Oxf. U.P. 1970.

3.15 Twiss : "Managing Technological Innovation" Longmans 1974 p.3.

3.16 An observation made by Hayward "Diffusion of Innovation in the Flour Milling Industry". European J. of Marketing Vol 6 No. 3 1972 p.195 based on the work of Cook : "A Review of Some Methodological Aspects of Diffusion Research" MSc dissertation Univ. Bradford 1970.

3.17 eg "Project SAPPHO. A Study of Success and Failure in Industrial Innovation" Univ. Sussex 1971.

3.18 eg Ruttan : "Usher and Schumpeter on Invention, Innovation and Technological Change" Quarterly J. of Economics Nov. 1959.

3.19 Usher : "Technical Change and Capital Formation" National Bureau of Economic Research, Capital Formation and Economic Growth 1955.

3.20 Koestler : "The Art of Creation" Pan Books 1959.

3.21 Kuhn : "The Structure of Scientific Revolutions" Chicago Univ. Press 1970.

3.22 Scherer : "Industrial Market Structure and Economic Performance" Rand McNally 1971 p.350.

3.23 Mueller : "The Innovative Ethic" American Management Association 1971.

3.24 Usher : "A History of Mechanical Invention" Harvard U.P. 1954. p.60.

3.25 Redlich : "Innovation in Business". American Journal of Economics and Sociology Vol 10 April 1951 p.291.

3.26 Barnett Op Cit. p.181.

3.27 Gilfillan : "The Sociology of Invention" Univ. Chicago 1935 p.10 (:this was perhaps more a comment of his time, for example an interested reader might refer to the autobiography of Barnes Wallis!)

3.28 Ford & Ryan : "The Marketing of Technology". European J. of Marketing Vol. 11 No. 6 1977.

3.29 Parker : "The Economics of Innovation" Longmans p.25 1974.

3.30 Robertson : "The Process of Innovation and the Diffusion of Innovation" : J. Marketing Vol. 31 Jan. 1967 p.15.
: he refers to his view as "cumulative synthesis".

3.31 For example : Often exporting products to countries less technologically developed may involve the process called "deinvention" - a 'reinventing of the wheel', where the level of technology in the product is reduced to affect congruency with that of the customer's own ability to use the product (and perhaps receive local servicing) and his environment.

3.32 Schumpeter : "The Theory of Economic Development" English translation Harvard Univ. Press 1934 (first published in Germany 1911)

AND

"Business Cycles Vol 1" McGraw Hill 1939.

3.33 Ruttan : Op. cit.

3.34 eg Salter : "Productivity and Technical Change" Dept. Applied Economics Monograph Cambridge Univ. Press 1966.

3.35 Ruttan : Op. cit : he did suggest that invention is best treated as that subset of technical innovations which are patentable - but not all inventions are patented; they vary in size/importance and so on.

3.36 Schumpeter saw innovation as being charcterised by
(i) construction of new plants and equipment
(ii) introduction of new firms
(iii) the rise of leadership of new men. Op. Cit.

3.37 Barnett : "Innovation : The Basis of Cultural Change" McGraw-Hill 1953 p.7.

3.38 Marquis : "The Anatomy of Successful Innovations" in Rothberg (ed). "Corporate Strategy and Product Innovation" p.16.

3.39 Rogers : "Diffusion of Innovations" Free Press 1962 p.13

3.40 Zuckerman Committee : "Technological Innovation in Britain" Cmnd. 3503 1968.

3.41 Rothberg : "Product Innovation in Perspective" p.3-4 in Rothberg (ed) : Op. Cit.
Note the example of Peat et al who have taken Feldman and Armstrong to task regarding their definition of a 'truely innovative product' - the latters' example being where the Mazda radically differed, in terms of consumer perceptions, from the Toyota (a U.S. study).
See Feldman and Armstrong : "Identifying Buyers of a Major Automotive Innovation" . J.Marketing Vol. 39 Jan. 1975 p.47-53 and the response Peat, Gentry and Brown : "A Comment on 'Identifying Buyers of a Major Automotive Innovation'" J. Marketing Vol. 39 Oct. 1975 p.61-62.

3.42 Knight : Op. Cit.

3.43 Levitt : "Innovative Imitation" H.B.R. Sept/Oct. 1966. p.63.

3.44 Levitt : Ibid p.63 :
he concludes: "... on the other hand, when other competitors in the same industry subsequently copy the innovator, even though it is something new for them, then it is not innovation ... it is imitation".

3.45 Baker : "Marketing New Industrial Products" Macmillan 1976 p.5

3.46 p. 154

3.47 Twiss : Op. Cit p.11

3.48 Section 2 p. 21

3.49 Langrish Gibbons, Evans and Jevons et al : "Wealth from Knowledge" Macmillan 1972.

3.50 Or, of course, the opposite eg failure of "Corfam".

3.51 Rothwell : "Innovation in the U.K. textile machinery industry: the results of a postal questionnaire survey"
R & D Management Vol 6 No. 3 1976 p.131-138.

3.52 Booz, Allen, Hamilton : "A Program for New Product Evaluation" in Rothberg (ed) Op. Cit p.163-164.
nb. terms used in matrix as in article.

3.53 Langrish, Gibbons, Evans & Jevons : "Op. Cit. p.7.

3.54 Knight : "A Descriptive Model of the Intra-Firm Innovation Process" J. Business Vol 40 No. 4 1967 p.479-80.

3.55 Twiss : Op. Cit p.12.

3.56 A variety of terms are in common usage: eg 'supply push' and 'demand induced'.
Steele : Op. Cit p.12.

3.57 Woudhuysen : "Information Bridges the Invention/Demand Gap" Design July 1977 p.32.

3.58 Woudhuysen : Ibid p.32

3.59 eg Rothwell : "Characteristics of Successful Innovators" R & D Management Vol 7 No.3 1977.

3.60 Roe : "Making a Scientist". Appollo paperbacks 1959. p.18.

3.61 Steele : Op. Cit p.15.
One notable example is the Polaroid camera .... The idea was turned down by Kodak on the grounds that it would not sell. Since Land's first model (Model 95) more than £100m of 'invention push' investment has been applied to instant-development technology-including the belated arrival of Kodak. However, whilst Land is credited with inventive genius, there is the trace of demand pull ... he is attributed to have said "there has arisen a gulf between the majority who make snapshots as a record and as a gamble, and the minority who can reveal beauty in the medium" ... his product was successfully aimed at the former segment.

3.62 Gerstenfeld : "Effective Management of Research and Development" Addison-Wesley 1970 - suggested a high proportion of non-technical failures are found to be due to the lack of interaction between the marketing and R & D functions.

3.63 Steele : Op. Cit p.15

3.64 eg Nelson, Peck and Kalachek : "Technology, Economic Growth and Public Policy" Brooking Institute 1967 p.28.

3.65 Schmookler : "Invention and Economic Growth" - p.184.

3.66 Schmookler : "The Rate and Direction of Inventive Activity" - p.224 Princeton Univ. Press. 1962.

3.67 Mueller : "The Origins of Basic Invention underlying Du Pont's Major Product and Process Inventions 1920-1950 in Schmookler : The Rate and Direction of Inventive Activity 1962 Princeton Univ. Press.

3.68 Langrish et al : Op. cit. p.xii.

3.69 Robertson : "Innovative Behaviour and Communication" Holt, Rinehart, Winston 1971.

3.70 The Way Report - "Machine Tool Industry" 1970.

3.71 Freeman et al : "Success and Failure in Industrial Innovation Project SAPPHO Phase I" : Centre for the Study of Industrial Innovation. University of Sussex 1972.

3.72 Reekie et al : "On the Shelf" Centre for the Study of Industrial Innovation 1971.

3.73 Marquis : "The Anatomy of Successful Innovations" in Rothberg (ed) : Op. cit p.21

3.74 Mansfield, Rapoport, Schnee, Wagner and Hamburger "Research and Innovation in the Modern Corporation. Conclusions" in Rothberg (ed): Op. cit p.378.

3.75 Levitt : "Innovative Imitation". HBR Sept/Oct 1966 p.63.

3.76 Baker, Siegman and Rubenstein : "The Effects of Perceived Means and Needs on the Generation of Ideas for R & D" IEEE Transmission Engineering Management Vol EM 14 Dec 1967 p.156-163.

3.77 Rothwell : "Marketing and Successful Industrial Innovation" A paper presented at the 11th Marketing Theory Seminar University of Strathclyde 1973.

3.78 Rothwell : Op. cit p.2-12.

3.79 Peplow : "Design Acceptance" in
Gregory (ed) : "The Design Method" Butterworth 1960.

3.80 Nicholson : "Market Research and R & D priorities"
Management Decision Vol 9 Summer 1971.

3.81 Materials Advisory Board : "Report on the Ad Hoc Committee on Principles of Research-Engineering Interaction"
U.S. National Research Council 1966.

3.82 Seiler : "Improving the Efficiency of R & D" McGraw-Hill 1965.

3.83 "The Conditions for Success in Technological Innovation"
O.E.C.D. Report 1971.

3.84 Marquis : Op. cit p.22.

3.85 Marquis : Op. cit p.22.

3.86 Rothwell : "Innovation in the U.K. textile machinery industry : the results of a postal questionnaire survey"
R & D Management Vol 6 No.3 1976 p. 132.

3.87 Namely : Class 1. Radical breakthrough
2. Major innovation
3. Incremental innovation
4. Improvement.

3.88 Rothwell : Op. cit p.132.

3.89 Little : "New Focus on New Product Ideas"
Business Quarterly (Canada) Summer 1974 p.62-69.

3.90 Scott : "Organisation Theory". Irwin 1967 p.122-123.

3.91 For example, as illustrated in
Homans : "The Human Group" Harcourt, Brace, World 1950
also Silverman : "The Theory of Organisations" Heinemann (1976).

3.92 "Boundaries are the demarcation lines or regions for the definition of appropriate system activity, for admission of members into the system, and/or other imports into, and exports out of the system" - Kast and Rosenzweig "The Modern View : A Systems Approach" in Beishon & Peters : "Systems Behaviour" Open Univ. Press 1972 p.20.

3.93 The reader is alerted to the use of two seemingly interchangeable terms used - 'boundary' and 'interface' (-"the area of contact between one system and another" Kast & Rosenzweig Op. cit p.20). The latter term is used hereafter eg. see Problems of Marketing : R & D Interface.

3.94 Kast & Rosenzweig : "Organisational Structure" in Beishon & Peters (eds) "Systems Behaviour" Open Univ. Press 1972 p.248

3.95 Knight : "A Descriptive Model of the Intra-Firm Innovation Process"
J. Business Vol 40 No.4 1967 p.490-493.

3.96 Cyert & March : "A Behavioural Theory of the Firm" Prentice-Hall 1963.

3.97 For example Perrow : "The Analysis of Goals in Complex Organisations" American Sociological Review Vol 26 No.6 1961 p.854-866.

3,98 Argyris : "Personality and Organisation. The Conflict between System and the Individual"

3.99 Some caution needs to be exercised re interpretation of Kast and Rosenzweig's work in avoiding over-generalising the role of this mechanism as always being anti-innovationary. In those firms (systems) more innovatory per se whilst maintenance mechanisms will likely act as 'breaks to the innovation process', nevertheless innovation is more likely than in those firms less innovatory per se.

3.100 Katz & Kahn : "The Social Psychology of Organisations"

3.101 Taqiuri & Litwin (eds): "Organisational Climate" 1968 p.8

3.102 Ford : "Good Ideas ÷ The Wrong Corporate Orientation = 0" Human Resource Management. Fall 1976 p.19.

3.103 Kettering : "Concentration, Invention and Innovation" U.S. Senate Antitrust Subcommittee. Washington DC Government Printing Office 1965 p.1099.

3.104 Fast : "New Venture Departments. Organising for Innovation" Industrial Marketing Management Vol 7 April 1978 p.78

3.105 Caves : "American Industry. Structure, Conduct and Performance" Prentice Hall 3rd ed. 1972 p.98-99.

3.106 Mansfield et al : "Research and Innovation in the Modern Corporation" Macmillan 1972.

3.107 Baker : "Marketing New Industrial Products" 1973 p.49.

3.108 Stinchcombe : "Social Structure and Organisations" in March : "Handbook of Organisations" Rand McNally 1965 p.143-44.

3.109 Cunningham and Hammouda : "Product Planning in Engineering Companies. A recent research study" European Journal of Marketing Summer 1969 p.78.

3.110 Chandler : "Strategy and Structure" M.I.T. Press.

3.111 Daniel : "Reorganising for Results" H.B.R. Nov. 1966 p.96.

3.112 For example
Mansfield : "Industrial Research & Technological Innovation"
Norton & Co. 1968.
also
Scherer : "Firm Size, Market Structure, Opportunity and the Output of Patented Invention"
American Economic Review Dec. 1965.

3.113 Eiloart : "Fanning the Flame of Innovation"
New Scientist 11 Sept. 1969 p.536.

3.114 Roberts : "Technology strategy for the European Firm"
Industrial Marketing Management Aug. 1975 p.195-196.

Sources used:-
Jewkes, Sawers & Stillerman : "The Sources of Invention"
Macmillan 1958.
Enos : "Petroleum, Progress & Profits"
M.I.T. Press 1962.
Peck : "Inventions in the Post-War American Aluminium Industry" in
Nelson (ed) : "The Rate & Direction of Inventive Activity : Economic and Social Forces"
Princeton Univ. Press 1962.
Hamberg : "Invention in the Industrial Research Laboratory"
J. Political Economy Vol 71 p.95-115.

3.115 Layton, Harlow and de Hoghton : "Ten Innovations"
A study commissioned by the Central Advisory Council for Science and Technology 1968 p.5.

3.116 S.P.R.U. Survey prepared for the Bolton Committee of Enquiry on Small Firms Cmnd. 4811 1971.

3.117 Layton et al : Op. cit p.10.

3.118 Reported by
Rothwell : "Marketing and successful Industrial Innovation"
11th Marketing Seminar. Univ. Strathclyde 1973 p.2-9.

3.119 Eiloart: Op. cit p.536.

3.120 Myers and Marquis : "Successful Industrial Innovations"
National Science Foundation No. 17 1969.

3.121 task specialisation ; "the state of segmentation of the organisational system into subsystems, each of which tends to develop particular attributes in relation to the requirements posed by its relevant internal or external environment" from
Pfiffner & Sherwood : "Administrative Organisation"
Prentice-Hall 1960 p.75.

3.122 Parsons : "Structure and Process in Modern Societies"
Glencoe Free Press p.60-96.

3.123 As management is involved in all three levels it seems more precise to interpret this second level as being where task performances are organised - hence 'organisation level'.

3.124 Petit : "A Behavioural Theory of Management"
Academy of Management Journal Dec. 1967 p.348.

3.125 Based on the discussion one might offer a revised matrix - at the Technical Level

TYPE OF MANAGER	TASK	VIEWPOINT	TECHNIQUES USED	TIME HORIZON	DECISION MAKING STRATEGY
R & D (scien-tific)	scientific technical	scientific problem-solving	scientific method	longer run	computational related to technology and the state-of-the-art
MARKET-ING (opera-tional)	commercial-isation of firm's products	commerce economic	qualitat-ive & quantitat-ive method	shorter run	computational compromise and judgmental related to market forces

3.126 For example
Rushing : "The Effects of Industry Size and Division of Labor on Administration"
Administrative Science Quarterly Sept. 1967 p.273-295.
The reader is referred to the work of Woodward for a depth investigation of this particular problem Woodward : "Industrial Organisation. Behaviour and Control 1970.

3.127 Haggerty : "The Process of Technological Innovation"
N.A.S. Publication No. 1726 1969.

3.128 Thompson : "Bureaucracy and Innovation"
Administrative Science Quarterly June 1965 p.1.

3.129 The reader can find comprehensive literature of 'Bureaucracy' in

Weber : "The Theory of Social and Economic Organisation"
NY Free Press 1964.

3.130 Thompson : Op. cit p.11

3.131 For example
Dalton : "Conflict between Line and Staff Managerial Officers"
American Sociological Review Vol 15 1950 p.342-351.

3.132 Etzioni : "Modern Organisations"
Prentice Hall 1964 p.8.

3.133 A point taken up by
Evan and Black : "Innovation in Business Organisations"
Journal of Business Vol 40 1967 p.526.
refer also
Churchman and Schainblatt : "The Researcher and the Manager. A dialectic of implementation"
Management Science Vol XI Feb. 1965.

3.134 For example refer
Burns and Stalker : "The Management of Innovation" Tavistock 1966
Lawrence and Lorsch : "Organisation and Environment. Managing Differentiation and Integration" Harvard 1967.
Pugh et al : "Context of Organisational Structures"
Administrative Science Quarterly Vol 14 1969.

3.135 See Hower and Lorsch. "Organisational Inputs" in Seiler : "Systems Analysis in Organisational Behaviour" Irwin 1968 p.168 ff.

3.136 Thompson Op. cit p.13

3.137 Thompson Op. cit p.2

3.138 Aiken and Hage 1971

3.139 Drucker : "Management : Tasks, Responsibilities, Practices"
Harper and Row 1974 p.799.

3.140 Ansoff and Brandenberg : "A Language of Organisational Design"
Management Science Aug. 1971 p.729.

3.141 Hill and Hlavacek : "The Venture Team. A New Concept in Marketing Organisation"
Journal of Marketing Vol 36 July 1972 p.44.

3.142 Fast : "New Venture Departments : Organising for Innovation"
Industrial Marketing Management Vol 7 April 1978 p.80.

3.143 Fast: Ibid p.80.

3.144 Fast: Ibid p.80.

3.145 March and Simon : "Organisations" Wiley & Sons 1958 p.187
refer also
Selznick : "Leadership in Administration" Harper & Row 1957.
p.41-42.

3.146 Hanan : "Corporate Growth through Venture Management"
H.B.R. Jan/Feb 1969 p.44.

3.147 Towers et al : "Venture Management" NY Free Press 1970.

3.148 Vesper and Holmdahl : "How Venture Management fares in Innovative Companies"
Research Management May 1973.

3.149 Fast : Op. cit p.87

3.150 Hill and Hlavacek : Op. cit p.46.

3.151 refer Wilson : "Innovation in Organisation. Notes towards a Theory" in
Thompson (ed) "Approaches to Organisational Design"
Pittsburgh 1966 p.193-218.

3.152 Berenson : "The R & D : Marketing Interface. A General Analogue Model for Technology Diffusion"
J. Marketing April 1968 p.8.

3.153 Colburn and Pigford : "General Theory of Diffusional Operations" in Perry (ed) "Chemical Engineers Handbook"
McGraw-Hill 1950 p.538-552.

3.154 Berenson : Op. cit p.10.

3.155 Though, in practice an unstable/dynamic equilibrium because of the time scale of diffusion between C_1 and C_3.

3.156 Elliott and Margerison : "Affective Dissonance amongst Professional Personnel : Unpub. Research Rept. Univ. Bradford 1970

3.157 Moore and Renek : "The Professional Employee in Industry"
J. Business Vol 27 No.1 Jan. 1955.

3.158 Barnes : "Organisational Systems and Engineering Groups"
Harvard Graduate School Rept. 1960.
Similar comment can be found in
Reekie : "A Fresh Look at the Marketing : R & D Interface"
11th Marketing Theory Seminar. Univ. Strathclyde 1973.

3.159 Parmenter and Garber : "Creative Scientists Rate Creativity Factors"
Research Management Nov. 1971.

3.160 Kaplan : "Some Organisational Factors affecting Creativity"
I.R.E. Transactions on Engineering Management March 1960
and
Gerstenfeld : "Effective Management of Research and Development"
Addison-Wesley 1970.

3.161 Steele : Op. cit p.157-159.

3.162 Quinn and Mueller : "Transferring Research Results into Operations" in Rothberg (ed) : Op. cit p.389.

3.163 Zopporth : "The Use of Systems Analysis in New Product Development"
Long Range Planning Vol 5 No. 1 March 1972 p.24.

3.164 Muse and Kegerreis : "Technological Innovation and Marketing Management"
J. Marketing Oct. 1969 p.5.

3.165 Thomas and Goodwin : "An Examination of the Management of the Research and Development : Marketing Interface in Several British Companies"
Quarterly Review of Marketing Autumn 1976 p.1-2
The 4 reports they used were:-
Technological Innovation in Britain - HMSO 1968
Project SAPPHO - Univ. Sussex 1970
The Way Report - Machine Tool Industry HMSO 1970
On the Shelf - Centre for the Study of Industrial Innovation July 1971

3.166 Hanan : "Effective Coordination of Marketing with Research and Devopment" in
Rothberg (ed) Op. cit p.207

3.167 Catt : "Management against Innovation"
Business Graduate Summer 1976 p.4-6
see also
Libien : "Product Design is Everybody's Business"
Managerial Planning Jan/Feb 1977 p.30-33.

3.168 Muse and Kegerreis : Op. cit p.4.

3.169 Steiner : "The Creative Organisation. A summary"
in
Rothberg (ed) : "Corporate Strategy and Product Innovation" p.262.

3.170 Cunningham and Hammouda : "Product Planning in Engineering Companies. A recent research survey"
European J. of Marketing Summer 1969 p.83-84.

3.171 Formal and informal structures in business organisations.

3.172 For example:
Robertson : "Information flow and industrial innovation"
Aslib Proceedings Vol 25 No.4 1973.
also
Rothwell and Robertson : "The role of communications in industrial innovation"
Research Policy Vol 2 1973
and
Rothwell and Robertson : "The contribution of poor communications to innovative failure"
Aslib Proceedings Vol 27 No.10 1975
: article contains a number of brief extracts of case studies for illustrative purposes.

3.173 Pedraglio : "Getting into Shape to Manage New Products"
European Business Summer 1971.

3.174 Steele : "Innovation in Business" p.134

3.175 Morton : "Organising for Innovation. A systems approach to Technical Management"
NY 1971 p.62-72.

3.176 Likert : "The Human Organisation" McGraw-Hill 1967 p.156.

3.177 Likert : Ibid p.156.

3.178 Steele Op.cit. p.137.

3.179 The author feels it important to point out that all researchers implicitly (and sometimes explicitly) regard 'communications in organisations' as inefficient. Hence the prescriptive nature of their work!

3.180 Steele Op.cit p.137.

3,181 Steele Op.cit p.138.

3.182 Steele Op.cit p.139.

3.183 Seidman : "Barriers to Technical Innovation"
Science and Public Affairs : Bulletin of the Atomic Scientists
March 1971 p.30.

3.184 Layton, Harlow and de Hoghton : "Ten Innovations"
Central Advisory Council for Science and Technology, 1968 p.3.

3.185 Cunningham and Hammouda Op.cit p.84.

3.186 Ansoff and Stewart : "Strategies for a Technology-Based Business" in

Rothberg (ed) : Op.cit p.75.

3.187 Johnson and Jones : "How to Organise for New Products" in
Rothberg (ed) Op.cit p.181.

3.188 Twiss : "Managing Technological Innovation"
Longman 1974 p.14.

3.189 Proceedings of the Special Committee on Science Policy of the Senate of Canada No. 21 Jan 1969.

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VOLUME II

APPENDICIES

PHOTOGRAPHIC ILLUSTRATIONS

SECTION 4 : THE ADOPTION & DIFFUSION OF TECHNOLOGICAL INNOVATION IN THE POTTERY KILN INDUSTRY

4.1 INTRODUCTION

The European Pottery Industry, beginning in Italy and Spain, evolved from that of simple establishments of the Near East and Persia (4.1). The early potters were sited either adjacent to the fuel, or to the clay deposits, which were the essential raw materials for basic production of pottery.

Pottery production in the U.K. (like elsewhere in Europe) tended to be concentrated in small, localised areas. The gradual rise in percapita income through the 17th. and 18th. brought forth a growing demand for domestic pottery; the pressure to produce large volume was the impetus for an upsurge in interest in the industy. From the 'industrial revolution' (circa 1760) emerged the entrepreneurial drive of Wedgwood, Spode, Minton, Adams, Woods and the Elser Brothers and so marked the beginning of the modern pottery industry in the U.K. (4.2). Canal systems were opened, coal-mining flourished, and Stoke-on-Trent became the centre for this new pottery industry.

But why Stoke-on-Trent? Prior to this upsurge in interest the area already had a flourishing butter-pot making industry for the Midland's dairy industry, but the main attractions in the eighteenth century were the close proximity and abundance of marl (red clay), ample water supplies, and good firing coal. It was found that coal from the North Staffs Coalfield contained only minimum traces of minerals harmful to the firing of pottery; as Hind comments ".. in no case, in the important seams of North Staffordshire, is the sulphur content extremely high, as occurs in many seams in other parts" (4.3)

Family businesses were adequate basic units of the industry in the C19th, mainly because capital requirements were modest. Skilled craftsmen would rent premises/build a kiln and gradually build-up a business with the help of brothers and sons, nephews and cousins. "Families could supply adequate management so long as the industry was organised on a craft basis and technological expertise was restricted to a fairly superficial understanding of forming and firing clays" (4.4). Takeovers and amalgamations were frequent, families would add factories to their existing ones as the size of the family increased, or sell-off factories as the size of the family decreased.

By 1849, there were over 200 pottery works in the Stoke-on-Trent area (4.5); a pool of skilled labour and a geographical area known as 'the Potteries' Nowadays about three quarters of all Britain's pottery production comes from 'potbanks' concentrated within the Stoke-on-Trent area (4.6); other areas of importance are Derby, Worcester, Bristol,Poole and Glasgow. In 1938 half the working force of Stoke-on-Trent was employed in the pottery industry (4.7); due to more diversification of industry within the area this is now approximately 30%. Table 4.1 indicates that in 1963 approximately 82% of the labour force engaged in the manufacture of pottery was located in North Staffordshire (4.8). Close links exist between these other areas and the Potteries, either through formal organisational ties (eg Royal Worcester-Spode Ltd), or affiliations to trade associations /societies (eg. British Pottery Manufacturers Federation; British Ceramic Research Association) located in the Potteries -".. it is to North Staffordshire that even overseas companies turn naturally when they encounter some yet unknown quirk of the natural materials which make pottery as unpredictable as farming" (4.9). Similarly, the largest single exhibition of ceramic machinery in the world takes place every two years in the Potteries - INTERCERAMEX - " is now the largest trade fair in the world devoted exclusively to ceramic plant and supplies" (4.10)

Sector	Employees in 1963 (1000) N.Staffs	U.K.	N.Staffs as % of U.K.	1956
Domestic ware	29.5	31.5	94	93
Tiles	4.9	7.2	68	77
Sanitary ware	1.9	4.3	44	42
Electrical ware	3.7	6.0	62	57
	40.0	49.0	82	77

TABLE 4.1 LOCATION OF THE POTTERY INDUSTRY, NORTH STAFFORDSHIRE & ELSEWHERE 1956;1963

The pottery industry is highly diversified, supplying an extremely wide range of markets at home and abroad. Each sector tends to have specialised managers and workers. There are even separate Trade Associations. The mobility of labour tends to be much greater within each sector than between sectors. Consequently, adoption of technology and mechanisation has been at different rates, partly because of the perceived relevance of a particular technology to that particular sector. (4.11)

The dependence of the industry on those early raw materials has long since diminished; today, the marls have long been of little importance because of the increased use of china clay from Cornwall (4.12), and ball clay from Devon and Dorset, whilst the development of alternative fuels - gas, electricity and oil - has reduced the importance of coal as a primary fuel (4.13).

One essential ingredient in the production of pottery is the firing of the product, either to harden it or to affix decoration in some form or another. This firing is done by a 'kiln'.

The kiln used to produce ceramics was one of man's earliest tools, the primitive form of which dates back to at least 8000 B.C., and perhaps much earlier. The earliest kilns, however, were little more than modified bonfires. The exact style of kilns used in prehistoric times is conjectual, but it has been assumed that firing methods in the remote past were similar to those practised by primitive peoples today; the earliest kilns were known as 'earth clamps', similar to those used for the production of charcoal. Kiln technology increased in leaps and bounds following the upsurge in demand for pottery identifiable with the 'Industrial Revolution' (C18th); early forms of kilns could not cater for the latent demand with non-mass production techniques, nor could they be used to produce uniform (high) quality of ware. Improved refractories, better arrangements for the circulation of heat, the introduction of coal for fuel enabled the attainment of higher temperatures and (relatively speaking) more efficient production of ware.- this was achieved through the development of the 'bottle kiln' (4.14).

Nowadays firing takes place at one, two, sometimes three, stages in the production of pottery - as the flow diagram below illustrates, Figure 4.1. (4.15).

(i) Biscuit Firing : involves the highest temperatures in the firing process, between 1150°C and 1300°C, depending upon the type of ware being fired. Biscuit firing, being the first firing, hardens the molded clay.

(ii) Glost Firing : glost firing temperatures tend to be around 1080°C. The biscuit ware is dipped in a glaze solution and is fired again to 'fix' the glaze. Also this firing will fix any ' underglaze decoration' being used. Recent pressures from customer-sources, notably the USA markets, have sought to reduce the lead content in glazes (perceived as a potential health hazard); this put pressure on the Glost Firing process to increase the firing temperatures to 'burn out' the lead content.

(iii) Enamel / Decorating Firing : operating temperatures range between 700°C and 750°C. If any 'on glaze' decoration is to be used, this further firing fixs the decoration to the ware.

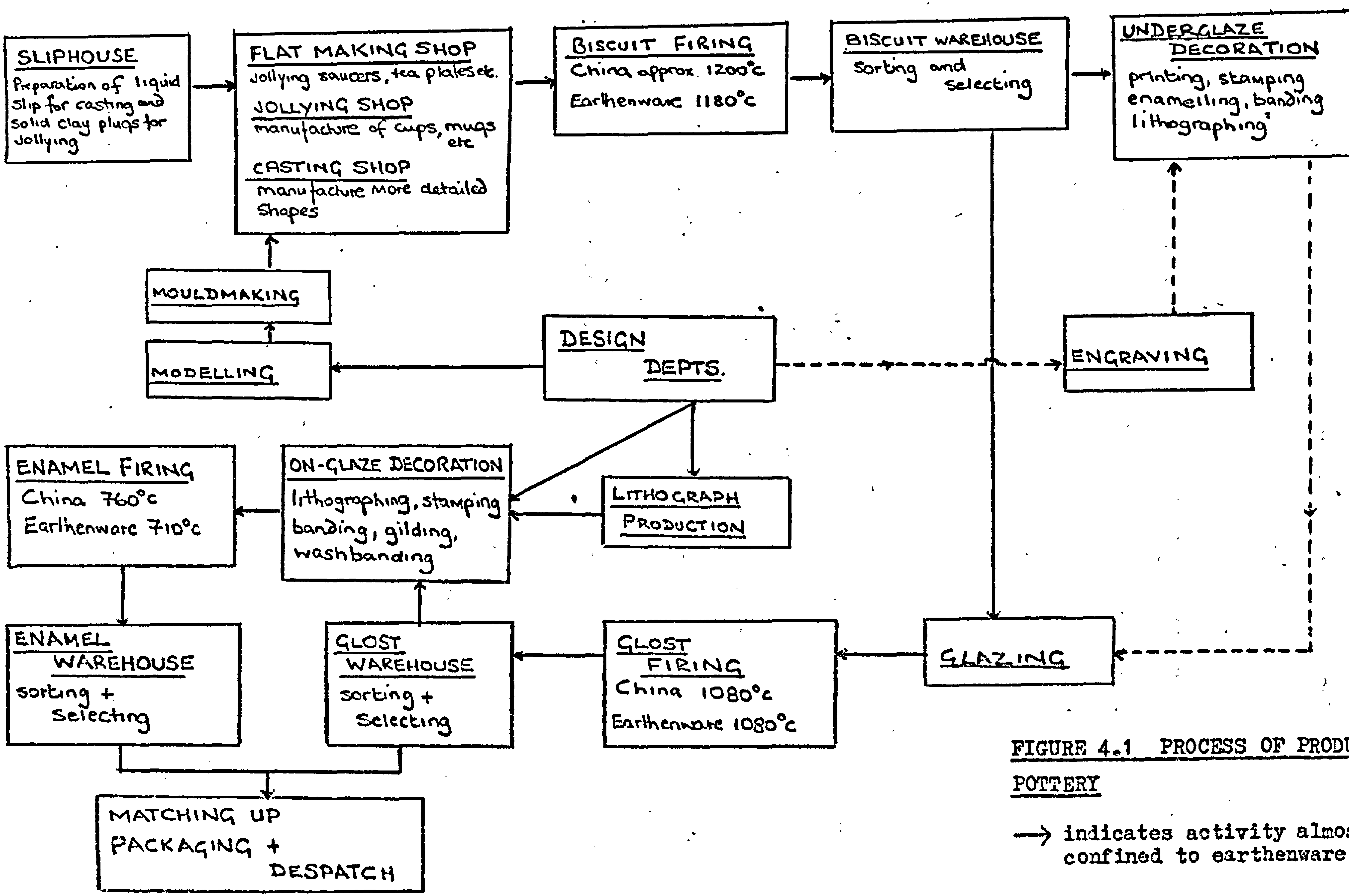


FIGURE 4.1 PROCESS OF PRODUCING POTTERY

⟶ indicates activity almost exclusively confined to earthenware production

Generally, kilns are specifically designed to cater for one of these particular firing processes. Initial innovatory pressures on kiln technology have usually been at the higher firing temperatures (ie biscuit and glost firing); the subsequent technological advance is more easily integrated into the decorating firing process(4.16). Traditionally, kilns were built of brick and formed an integral part of the pottery manufacturer's premises (4.17); the pottery manufacturer would engage the help of specialist brick layers to assist in the contruction of the early 'bottle'kilns, but the knowledge of construction usually lay with the manufacturer himself; the famous'Minton oven' (4.18)is a notable example. Today a number of the larger pottery groups are equally as versed in kiln technology as the builders! The need for highly specialised kiln builders did not arise until the advent of the tunnel kiln in the 1920's, with its entirely new firing technology. The rapid fading of dependence upon traditional practices, accelerated since the 1950's (that is, the utilisation of construction materials other than brick, the use of refractory hot-face materials other than brick, the use of fuels other than coal) has led to the development of specialist kiln builders. In addition, both the M.E.B. (electricity) and the Gas Board have specialist offices based in the Potteries dealing specifically with fuel technology in kiln building.

Today, operating in the U.K. there are about 20 kiln suppliers to the ceramic industry. This includes a number of non-U.K. companies - Riedhammer (West Germany), S.I.T.I. (Italy) and the Interkiln Corporation (USA). With the exception of only two companies - Gibbons Bros (Brierly Hill, West Midlands) and Catterson-Smith (Essex) all the major companies were initially founded in the Potteries or have since opened sales/technical offices in the district. Relative to their customers, these kiln builders are generally smaller in size (notable exceptions being Gibbons Bros and Riedhammer); the effect of their comparable sizes in the innovation process is reviewed later.

4.2. TECHNOLOGICAL INNOVATION IN THE POTTERY KILN INDUSTRY

4.2.1. IDENTIFICATION OF INNOVATION BY FIELD STUDY

For the purpose of this thesis it was decided to identify the self-percepts of the industry as to what have been major innovations; it was considered more methodologically correct given the nature of the questions to be asked. Scope of enquiry was limited to organisations operating in the U.K. market. Two, independent, studies were conducted; the first directed at the kiln-builder and the second to influencers of the kiln-builder's decision to innovate and a number of acknowledged 'informed sources' (viz. industrial consultants, academics).

THE KILN BUILDER STUDY

FRAME: A list of 24 firms was compiled using trade directories, presence at the INTERCERAMEX exhibition and informed sources. The frame was considered to include every major kiln supplier operating in the U.K. pottery industry (4.19).

DATA COLLECTION: Construction of the questionnaire was developed with helpful advice from colleques in the Ceramics Department (North Staffordshire Polytechnic); this was done in favour of piloting given the small size of the frame. Initially, a covering letter and questionnaire were mailed to each of the 24 companies (4.20). Follow-up personal interviews were made to 8 of the rsponding companies.

RESPONSE RATE

22 replies were received.

5 proved inapplicable - these companies did not in fact supply the pottery industry.

1 (BRICESCO) was " too busy to cooperate".

Therefore 16 from 19 pottery kiln builders agreed to cooperate - that is a response rate of 84%.

This high response rate of cooperation can be partly attributed to a prior exploratory meeting with Mr. Sam Jerrett (Director. Pottery Manufacturers Federation), whose favourable letter of credential, in addition to that from Dr. G. Gittens (Head. Ceramics Department, North Staffs Polytechnic) and Mr. R.S. Mason (Project Tutor, University of Salford) served to generate a high level of interest in the study (4.21).

FINDINGS

SIZE OF COMPANY & R & D COMMITMENT

Only 3 firms had more than 100 employees. For the rest, between 50 and 75 employees was the norm. Response to 'annual turnover' suggested firms were comparable in size and structure in terms of their interest in the pottery kiln industry. The larger companies (viz Gibbons Bros and Riedhammer) have more diverse interests, in particular heat treatment/furnaces in the iron-and-steel industry; their interest in the pottery kiln industry, because of its comparative size, tended to be no more than the smaller firms who specialised predominantly in this industry.

Only 1 firm reported spending more than 5% of its annual turnover on R & D (James Birks Ltd); and it was the larger firms that reported more personnel engaged in full-time R & D.

A typical response from the smaller firm being ..." we have no precise budget as such. We are ready at any time to investigate new materials, new design, new techniques and to spend whatever time and money is necessary. The business of R & D is therefore under constant consideration.

We have no full-time personnel involved in R & D, but three people spend a proportion of their time involved in this area " (CATTERSON-SMITH).

MARKETS SERVED WITHIN THE POTTERY INDUSTRY

Diversity of interests were identified - specialist ceramics, sanitaryware, electrical ceramics, tableware (earthenware, china & porcelain); each respondent did supply the high unit value tableware segment.

IDENTIFICATION OF INNOVATIONS (4.22)

The respondents were asked to state if they considered there to have been 'technological watersheds' in kiln development in the pottery industry. The response was as follows:

YES	11
NO	4
d/k	1

Follow-up personal interviews suggested that the NO's were attributable to a perception that kiln development has been a gradual, continuous technological progression rather than identifiable 'step-ups' in technology. Of the 11 that responded YES, the main 'watersheds' were identified as follows:-

Changes in kiln structures : - the tunnel kiln which allowed higher production volume per firing (DRAYTON KILNS) - the introduction of rapid-firing techniques; transportable kilns; roller-hearth kiln (JAMES BIRKS)

- modular (PACKAGE) kiln permitting off-side construction (GIBBONS BROS).

Changes in fuels & Burners : - the utilisation of alternative fuels to coal which allowed non-muffle firing (GIBBONS BROS)

- application of electricity leading to close temperature control (RIEDHAMMER)

- the recuperative burner (SHELLEY FURNACES).

Changes in refractory materials - insulating firebricks (KILNS & FURNACES)

- low thermal mass materials (JAMES BIRKS)

- ceramic fibre insulation (CATTERSON-SMITH)

KILN CUSTOMERS, SUPPLIERS TO KILN BUILDERS AND 'INFORMED PERSONS' STUDY

A complimentary study was undertaken of end-users (kiln-buyers/ pottery manufactuers), materials suppliers to the kiln-builder, and 'informed persons' (consultants, educationalists). The objective of this second study was to substantiate the findings of the earlier study.

FRAME : A list of 49 firms was compiled using trade directories and presence at the ceramics trade exhibitions. It was decided to treat the subsidiaries of the major pottery groups as exclusive units, as they tend to operate as independent profit units, with a high degree of freedom to purchase (amongst other items) new capital/ technological equipment.

All the major pottery groups were represented in this Frame; it includes only companies etc. operating in the U.K. market. (4.23)

DATA COLLECTION : Construction of the questionnaire followed the format of the Kiln Builder study, only the emphasis was changed to make it more meaningful to the respondent-group; length was reduced to eight information questions.

Initially a covering letter, letters of credential and questionnaire were mailed to each of the 49 companies in the Frame (4.24). Follow -up personal interviews were made to 10 of the respondents.

RESPONSE RATE

Of the 49 questionnaires sent out

37 replies were received.

12 proved unapplicable - the comment being they were not qualified/experienced to comment on the questions raised in the survey.

Table 4.2. shows the final response rate.

END-USERS	11
OTHERS	14
TOTAL COOPERATION	25

TABLE 4.2. RESPONSE RATE. SURVEY II

Again it was felt, cooperation was achieved by use of the letters of credential. Of the null-replies, further investigation suggest that the lack of response was likely due to the Survey being not applicable; only 2 of the pottery manufacturers (end-users) who were mailed the questionnaire refused to cooperate. Hence the response rate (61% of applicable respondents - 25/37) leans towards a pessimistic estimation.

FINDINGS

IDENTIFICATION OF INNOVATIONS (4.25)

Similarly to Survey I, each respondent was asked to state whether they considered there have been 'technological watersheds' in pottery kiln development. Table 4.3. illustrates the responses:-

	END USERS	OTHERS	TOTAL
YES	10	10	20
NO	1	2	3
no answer	-	2	2

TABLE 4.3.

Table 4.4. shows answers given by respondents who indicated technological watersheds (4.26).

	Responses END USERS	OTHERS	TOTAL
1.1. changes in fuel technology	5	8	13
1.2. low thermal mass, ceramic fibres	6	6	12
1.3. the tunnel kiln	5	4	9
1.4. new intermittent kilns	4	3	7
1.5. developments of burners	2	3	5
1.6. process of 'fast-firing'	4	1	5
1.7. 'open-flame' firing	3	1	4

(note: multiple responses possible)

TABLE 4.4.

The conclusions reached in the Kiln Builder Study regarding identification of kiln innovations, namely

Changes in Kiln structures

Changes in fuels

Changes in refractory materials

as the main areas of study, were clearly substantiated.

4.2.2. KILN STRUCTURE INNOVATIONS 1800-1975

EARLY INTERMITTENT KILNS 1800-1956

The earliest forms of pottery kiln had been found wanting for three reasons:-

(i) could not produce uniformity of quality

(ii) batch size was small

(iii) long firing cycle

The period known as the Industrial Revolution is marked in the potteries industry by the rapid introduction of the 'bottle kiln'. The bottle shape is first attributed to Boettger, a German, who developed such a kiln in 1710..." the kiln was elongated upwards into a bottle shape with a chimney at the top. This greatly increased the draught and fuel burning capacity" (4.27). Coke and coal were used for fuel (replacing wood) and with a strong updraught sufficient heat was released to achieve very high temperatures (around 1200 C). The attainment of high temperatures pointed the way to a better quality fired product. But what is meant by 'updraught'?

A fire is lit at the bottom of the kiln chamber, heat travels up through a lattice-like floor and passes through the ware and out through a chimney at the top of the kiln (4.28) - as the diagram overleaf illustrates (Figure 4.2):-

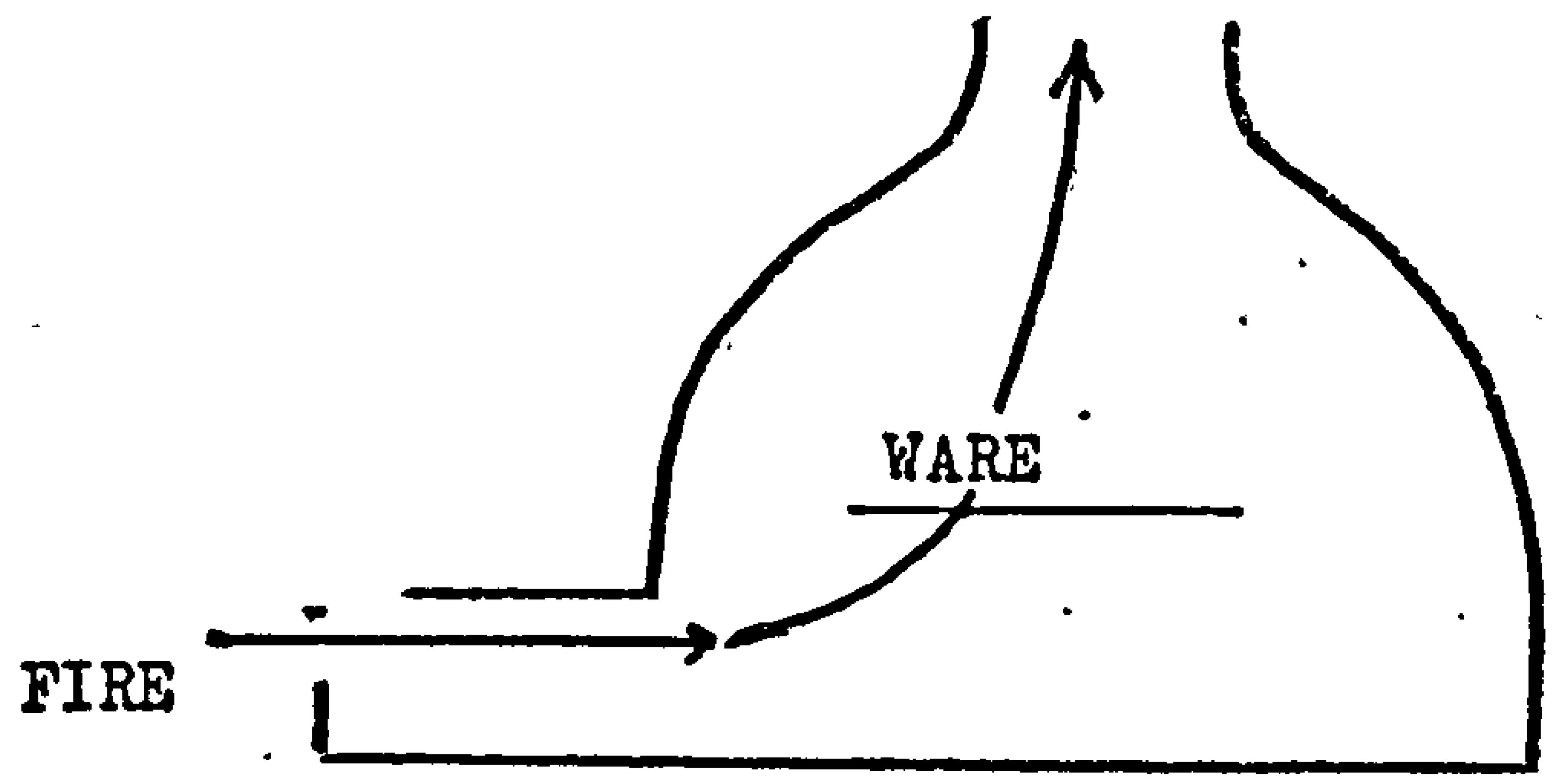


FIGURE 4.2. AN UPDRAUGHT KILN

The bottle kiln then, was a large batch intermittent kiln that could take anything up to a week to complete a firing cycle - from loading to reloading unfired ware in the kiln.

Industrial historians seem unable to agree on who was responsible for introducing the bottle kiln into Britain; Wedgwood, Spode, Adams have all been accredited for this act. Nevertheless, by 1780 the updraught bottle kiln - as high as 70 feet - becomes a common feature in the production of pottery, used for fiing a glost stage in the first floor chamber, and a biscuit stage in an upper floor chamber - as illustrated below:-

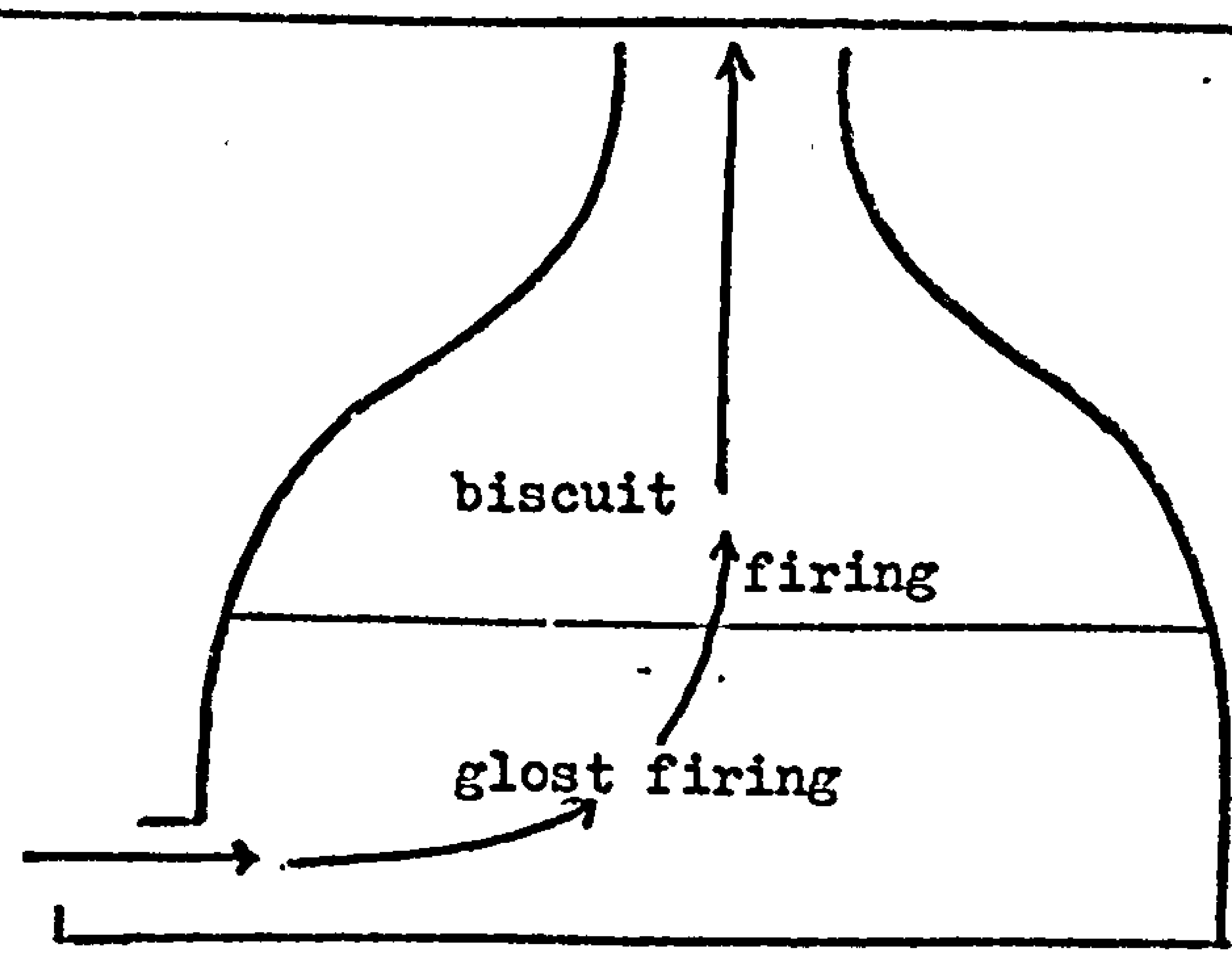


FIGURE 4.3.

MODIFIED 2 FIRING UPDRAUGHT KILN

In many cases, the pottery factory was constructed 'around the kiln', where the ground floor, leading to first kiln chamber, was the Glost Department, and the first floor, leading to the upper kiln chamber, was the Biscuit Department. As the firms grew, and because pottery needs a number of firings during manufacture, several kilns were needed for each type of firing so it was quite commonplace for a single works (by 1880) to have anything up to twenty five bottle kilns.

An early technical problem that caused many kiln failures, was the stress of the heavy upper chamber and chimney on the lower chamber. Kilns, in response, were built with walls 18" - 20" thick, and externally-braced by heavy iron bands. Brick failure at the hot-face was a constant problem, causing frequent kiln rebuilds.
An early development (circa 1820) was the introduction of a 'hovel'. The hovel (chimney) was constructed outside the main part of the kiln, which made the inner sections easier to repair without disturbing the outer chimney. Often the hovel was built large enough to cover the whole kiln like a hat; the firemen tending the ware then worked within the hovel, as the diagram overleaf illustrates (Figure 4.4.).

The next stage in development (circa 1850) was the 'down-draught' kiln, The down-draught kiln works on the principle that heat is introduced and the flames are deflected upwards into the chamber, down through the ware and out through a chimney flue in the kiln floor - as figure 4.5. illustrates overleaf:

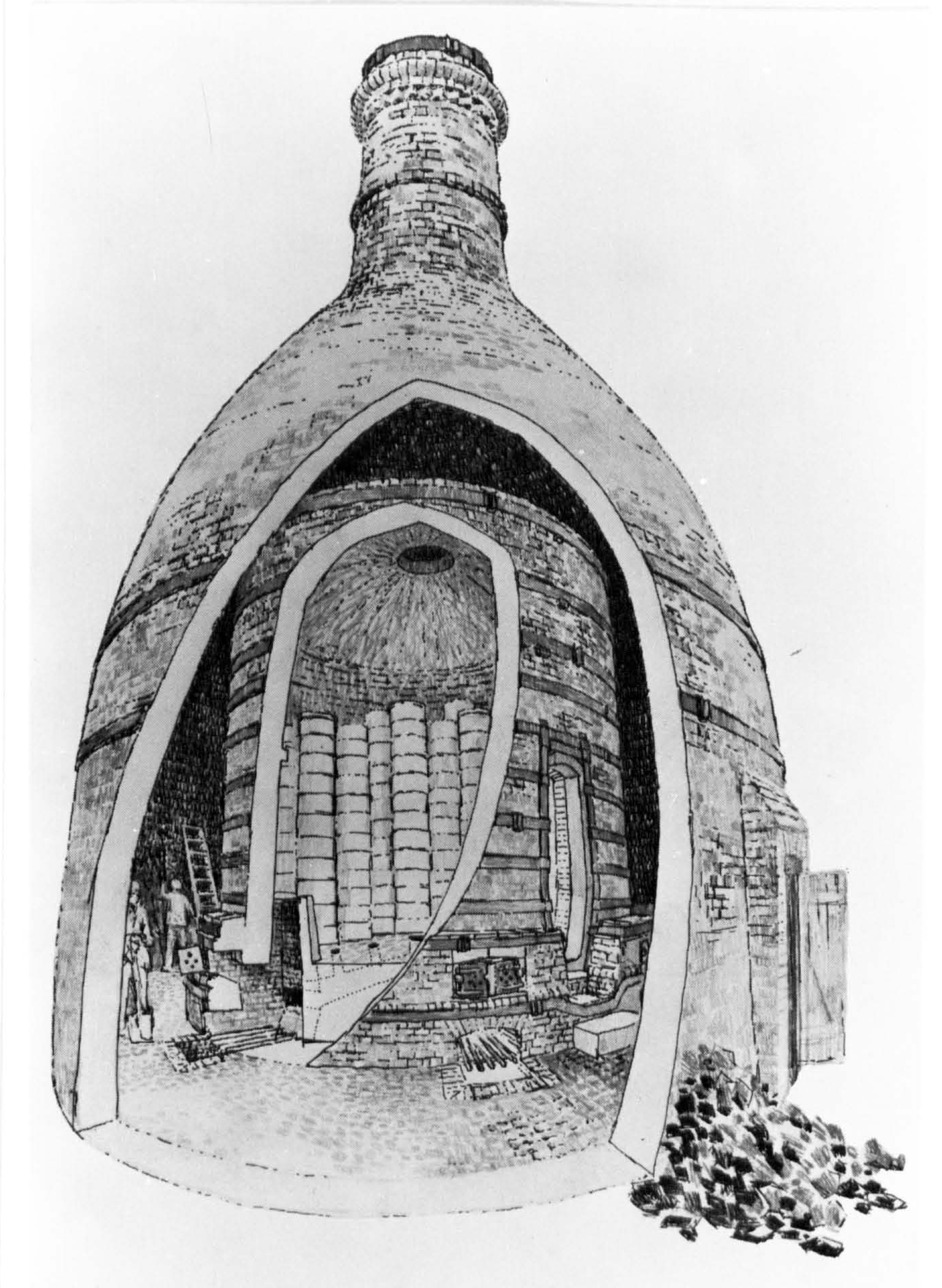


FIGURE 4.4. HOVEL-TYPE BOTTLE KILN

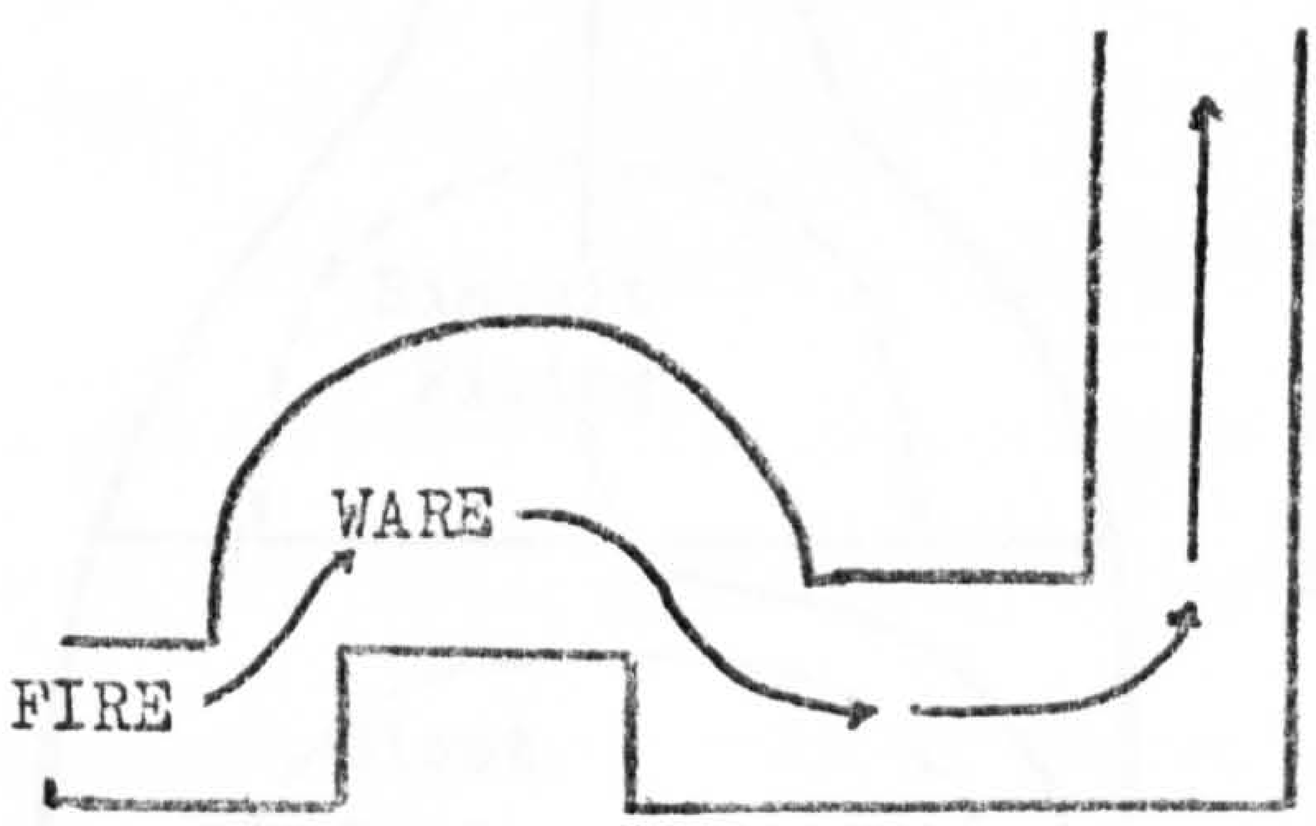


FIGURE 4.5.

DOWN DRAUGHT BOTTLE KILN

Although this type of kiln was found to use less fuel (itself not a major consideration at this time) and produced well-fired ware, it was never adopted in this form in the U.K. pottery industry. One drawback was that it needed a larger, taller chimney to create the draught, but the feeling in the industry was that it did not provide uniformity in firing; as Hind concludes (in 1920), the down-draught principle was "an unqualified failure for pottery" (4.29).

If one accepts Boettger first bottle shaped kiln as the beginning of modern kiln technology, then the second major watershed must be seen to be "Minton's Oven" patented in 1873, and seen to represent " the ultimate refinement of this(bottle) idea" (4.30).
Minton's kiln embraced all known-technology of the time; it was a two-stage/chamber kiln, where the bottom stage incorporated the down-draught firing principle, and the upper stage was a simple updraught-figure 4.5. illustrates:-

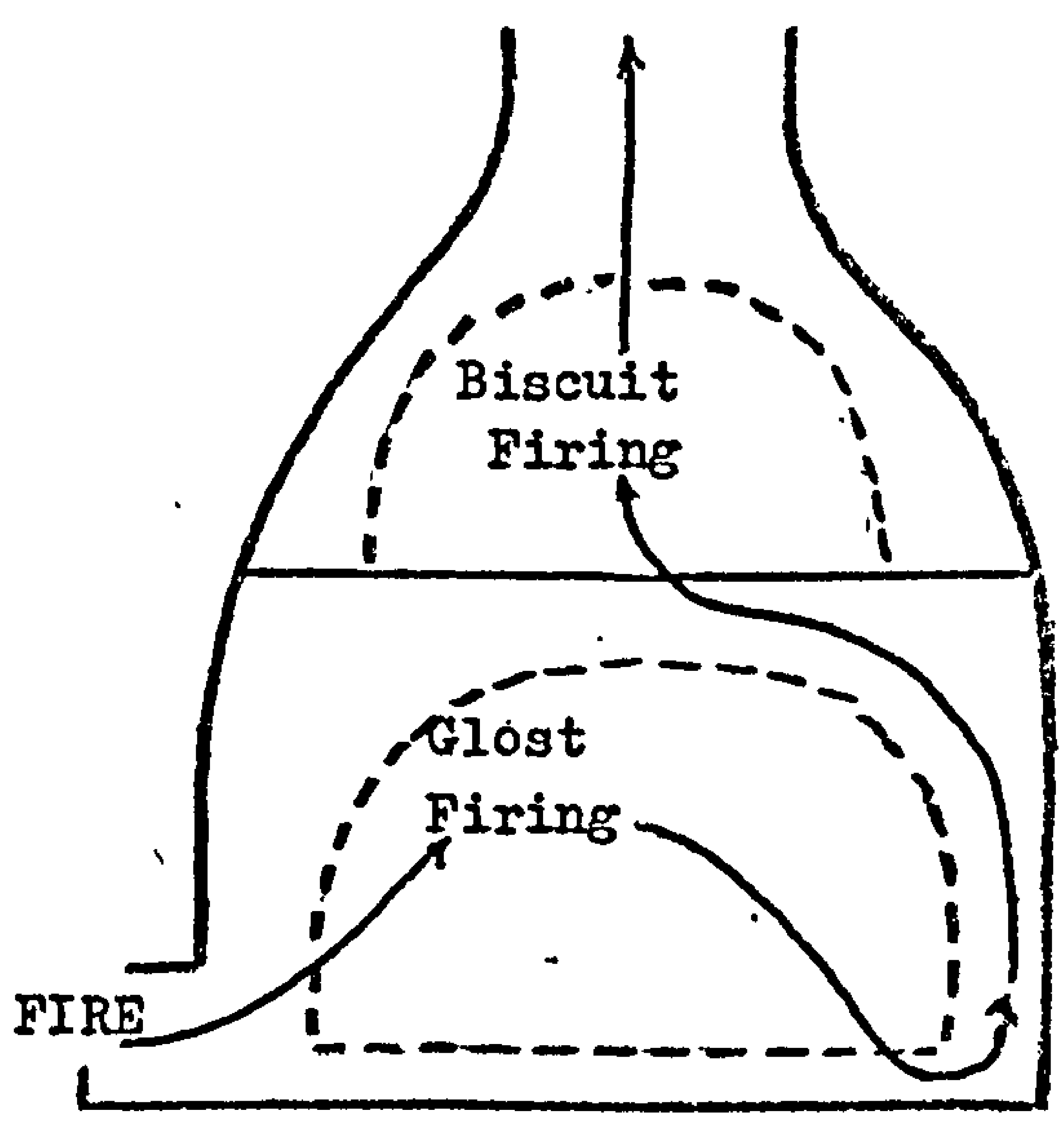


FIGURE 4.6.
MINTON'S OVEN
Circa 1880

This kiln, built by the end-user/manufacturer, made maximum use of the heat from the fires. The ascending gases passing through the wall flues gave heat back to the lower chamber by radiation; an arrangement which prevented the temperature in the upper chamber from rising too hot for even-biscuit firing. The Minton-type kiln, first used at the Minton factory 1872, with few technological refinements (except instrumentation) to its structure was adopted by the whole pottery industry, being commonplace in the industry up to 1958.
As Rhodes notes .. " the improved design of kilns in Europe during the nineteenth century had to do entirely with the construction and draught of the kilns rather than with fuel, for coal and wood continued to be the only fuels available for ceramic firing until alternatives are used in the early part of this century" (4.31).
Whilst the bottle kiln facilitated production on a scale never before attained, it was grossly inefficient due at first to structural problems, but later due to increasing costs of labour needed in attendence during a firing cycle (it was quite common for the fireman to stay on duty throughout the whole firing cycle - forty eight hours!); the increasing cost of and availability of good fuel through the late nineteenth and early twentieth centuries; the growing alarm at atmospheric pollution (4.32); the quality that could be fired, and the high rejection rate. This high rejection rate was due to the disuniformity and contamination of the ware during firing. Because of the dirty fuel, all ware to be fired,had to be placed, by hand, in containers called 'saggars' in an endevour to protect the ware from the dirty kiln atmosphere (4.33). One alternative method that was developed - circa 1890 - was the 'muffle'. A muffle was an inner lining which was set inside the kiln. The flames from the burners

are directed outside the muffle, and the ware inside it is exposed neither to flame nor combustion gases. Its first application was in the smaller decorating kilns, where the atmosphere could most harm the gold decorations, but soon it was seen that muffling could avoid the use of saggars, which were space consuming and had a relatively short life (like all early refractory materials). Those manufacturers not adopting pointed to the fact that all muffles tend to impair the efficency of the kiln because per unit of energy necessary to fire the ware is higher for a muffled-kiln, and early developments of muffles also presented problems of uniformity of firing (ie. even-quality).

EARLY TUNNEL KILNS 1800-1960

By the early 1900's, the bottle kiln became a victim of its own success. Demand for pottery had continued to grow throughout the nineteenth century and it became apparent that present kilns could no longer cope with the ware being produced - the firing process was becoming a 'bottle-neck' for the manufacturer. Although the short-term answer was to build more bottle kilns, and this was done, partly this was not always possible because of unavailability of space for expansion; it was more pressing to utilise existing factory space more efficiently. Modern mass production of pottery was facilitated by the development of the continuous kiln - the 'tunnel kiln'.

Recognised by the industry to be a major watershed in pottery kiln technology, the first tunnel kiln to be successfully introduced was designed by Conrad Dressler and built at the Chesterfield Pottery in 1912, although development of the concept spans back to the 1850's. Simply, the tunnel kiln consists of three stages

(i) preheat zone

(ii) firing / soak zone

(iii) Cooling zone

(Figure 4.7. illustrates)

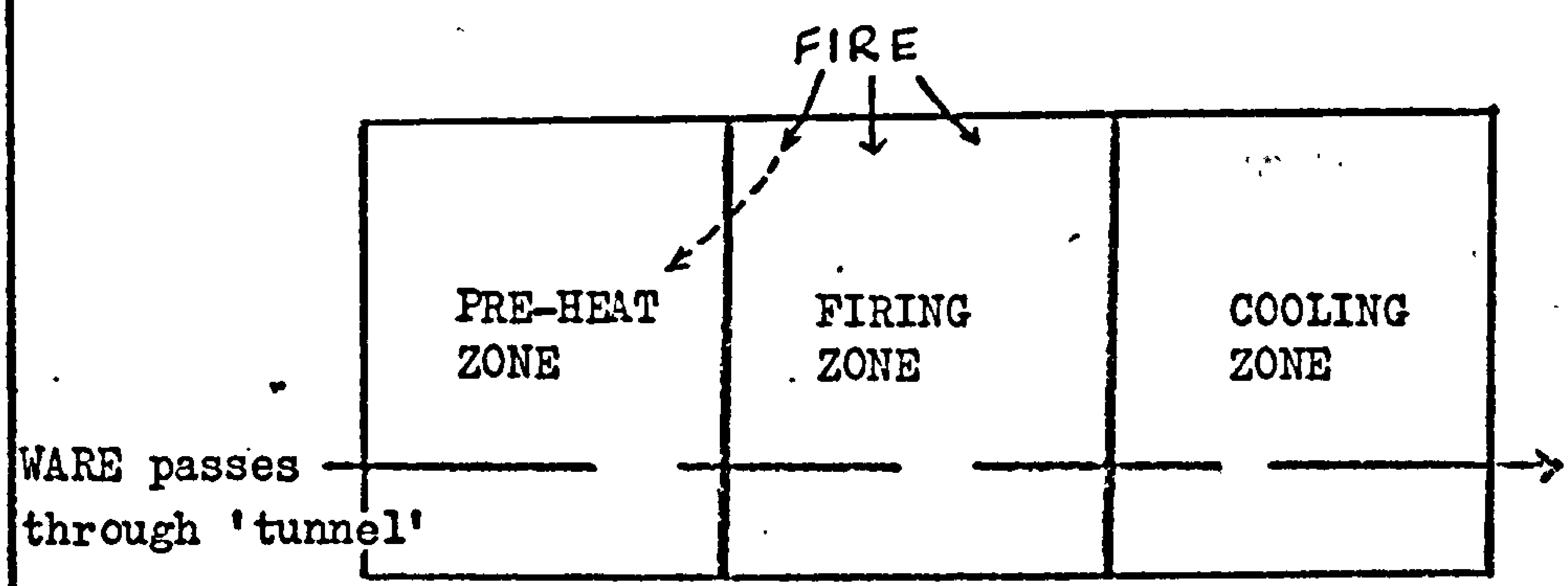


FIGURE 4.7. A TUNNEL KILN

The ware enters at one end of the tunnel, continuously, and emerges at the other end, fired, around 30 hours later.
The development of the first continuous kiln is attributed to Hoffman and Licht (1858), whose work was based on a study of the regenerative furnaces then used in the iron-and-steel industry. They suggested that ware could be transported slowly through a tunnel towards a hot zone in the middle of the heating cycle, and then drawn out at the cooling end (it was seen as a promising idea, improving upon the bottle kiln - an intermittent- which had to be loaded by hand, fired, allowed to cool down, unloaded by hand). Even earlier records identify embryonic tunnel kiln ideas: in 1751 a tunnel kiln was operating in Vincennes (France) firing on-glaze decoration on porcelain; Yordt patented a tunnel kiln in Denmark (1840), as did Peters in England (1858). Early failures are attributed to technical problems rather than market demand; failings such as inadequate seals between the firing chambers which led to heat loss (and explosions!), mechanism failure of transport through the kiln, helped the growing scorn at the idea (because as stated, intermittent kiln technology was very

advanced circa 1870). Nevertheless, records show that Boch patented what is considered to be the first operational tunnel kiln in England in 1877. His success is attributed to him solving the sealing problem, but the kiln failed to produce uniform fired ware - in retrospect this was due to his tunnel not being long enough.

One outstanding failure was a tunnel kiln patented by a Mr. Boult, in 1908, which incorporated a tank of water below it, on which barges floated the ware through the kiln. Poor sealing allowed hot coals to come in contact with the water ....

The technological development of the tunnel kiln was being arrested by the level of known fuel technology. Coal was the major fuel; it was dropped through holes in the roof, or inserted at the side of the kiln, but firing was a very hit or miss affair. The pottery industry had declared the tunnel kiln as not suitable for firing ware, because of the inability to make precise heat adjustments, needed to control the firing of pottery.

Conrad Dressler's tunnel kiln (1912) provided the key to diffusion, using producer gas rather than coal as the fuel (4.34). Moore and Campbell add to the choice of fuel alternatives with the first electric tunnel kiln built for Mintons in 1927. Cost advantages to be gained by tunnel kiln adoption were outlined by Hind in 1937 ... he compared a Dressler gas-fired tunnel kiln against a coal-fired bottle kiln:-

Firing earthenware biscuit/cost per saggar of ware(d.)

	TUNNEL	INTERMITTANT
Labour costs	2.43	3.35
Saggars	0.64	1.33
Fuel	1.60	3.09
Repairs	0.19	0.57
Premises (inclu. depreciation, supervision)	2.02	0.74
	6.88d.	9.08d.

From it's beginning the tunnel kiln demonstrated a major technical weakness; " many major tunnel kiln installations have been disappointing from the standpoint of control and of quality and uniformity of the ware produced" (4.35). This problem remained with the tunnel kiln designer into the 1950's as the move was towards faster firing cycles (4.36). An early answer was the attitude ' you cant make a tunnel kiln too long' - certainly, improper heat distribution in the preheat zone demanded a longer soaking period in the firing zone, implying that the firing zone should be lengthened.

All pre-war tunnel kilns used trucks or 'kiln cars' to transport the ware through the tunnel, a new form of tunnel kiln was tried by Leighton Pottery (1939) Ltd. in 1946 when Birlec built a 'belt' tunnel kiln for them. The 'belt principle' was taken from the iron-and-steel industry; it consisted of a metal conveyor belt, which transported the ware through the tunnel. It had a number of seeming advantages:-

(i) easier to load and unload
(ii) easier to maintain
(iii) thermically absorbed less energy
(iv) required less capital equipment (ie kiln cars)

In practise it presented a number of problems. In the iron-and-steel industry, operating temperatures were around 600 - 700°c, but for use in the potteries temperatures needed to exceed 750°c and be maintained around 1100°c to fire glost or biscuit. This first kiln was so designed to fire glost; it was found that when operating constantly at these high temperatures the metal belt 'stretched' and became too contorted to se, so needing costly replacement. A number of these kilns were built between 1946 and 1953 (mainly because alternative types of kiln were in short supply); their use was restricted to lower temperature decorative firing.

PHOTOGRAPH ILLUSTRATION OF A TRUCK / KILN CAR

The idea was soon discarded in favour of the traditional kiln-car concept.

Another tunnel kiln development which took place, as a direct consequence of technical limitations to tunnel width (4.37), was the construction of twin (and later multi-passage) tunnel kilns. As figure 4.8. below shows, the ware passed in opposite directions along tunnels constructed in parallel. Intended benefit was that

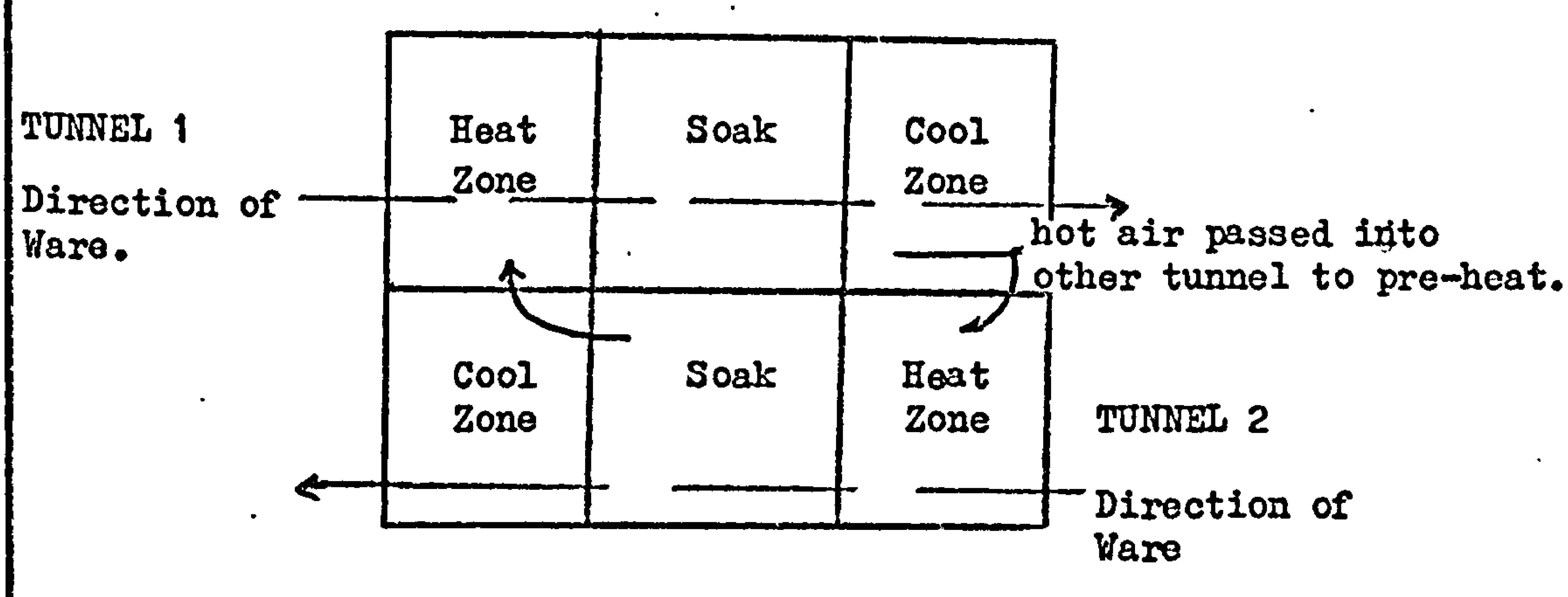


FIGURE 4.8. TWIN-PASSAGE TUNNEL KILN PRINCIPLE

heat being disappated in the cooling stages could be used to pre-heat the alternative tunnel. The first electric passage twin tunnel was commissioned in 1948. A number of gas-fired tunnels were also built using the twin, multi-passage principle.

Some early post-war passage tunnel kilns were designed to use 'sliding-batts' rather than kiln trucks. The principle was very simple; the ware was loaded on 'batts' made of refractory material (pallet-like design) and then pushed, end on, by mechanical means through the kiln. Problems arose when a batt would ride-up on the one innediately in front. Subsequently the kiln had to be turned off to clear the tunnel;

the idea was soon discarded ".. there have been some costly failures.. the sliding-batt kiln" (DOULTON SANITARYWARE (4.38)).

MODERN INTERMITTENTS 1948-1975

The intermittent kiln provides the manufacturer with flexibility in production to cater for cyclical demand patterns. From the late 1700's until the end of World War II, the only available intermittent had been the coal-fired bottle kiln with its grossly inefficient throughput. Early tunnel kilns gained acceptance as much through a desire to increase efficient throughput as to increase the scale of operations, nevertheless tunnel kiln scale of output is not always suitable for every end-user. Tunnel kiln and intermittent are not totally substitutable; as a result a latent demand still existed for a more efficient intermittent kiln.

Although records suggest Gibbons Bros. were interested in prototype gas-fired intermittents prior to 1939, the first 'modern' intermittent was self-built by Lockett, of Edwards and Lockett in 1946. The Company was interest in special decorative ware (figurines etc) and this electrically fired kiln was designed to give the Company more efficient small-scale (than through a tunnel kiln) production than the bottle kiln. Advances made in heater-element technology allowed the newly formed Midlands Elecricity Board (1948) to design and develop new higher temperature electric intermittent kilns; the first being built by Hawkins at the Spencer Stevenson Pottery in 1952 (4.39). Essentially a large box (like a domestic oven) these new electric intermittents developed during the 1950s represented a considerable departure from existing kiln construction. One novel development, pioneered by Donald Shelley was the 'top-hat kiln' (similar models are referred to as 'dome kilns''bell-type kilns'); the kiln hearth was fixed, loaded with ware and the kiln (supported on a gantry) was lowered over the ware and then fired. It eliminated the need for doors and provided a well-sealed enclosure. It also provided a degree of flexibility because with a number of hearths, one hearth could be being fired whilst another was being loaded, another unloaded yet using the same kiln.

These changes in methods of kiln construction mark the emergence of a number of new kiln building companies to cater for the increase in demand- Hawkins (later James Birks), Electrical Rewinds (later Kilns & Furnaces), Litherland Elements (later part of Shelley Furnaces), Donald Shelley (founder Shelley Furnaces later D. Shelley Ltd.).

In direct response to the increase in demand for intermittents (and the decline in tunnel kilns) the Gas Board became interested in developing a gas-fired intermittent which would fire biscuit and glost cheaper than the electric intermittent".. to answer an industry need for an intermittent kiln of intermediate capacity which would offer better uniformity of product than was possible with the tunnel kiln being designed"(4.40). The first gas-fired intermittents were installed as prototypes at Spode Ltd and Thomas Poole Ltd in 1957; the first commercial-built kiln was installed by James Birks for Amerson Pottery in 1958 (4.41). These early intermittents were called 'shuttle kilns', because the design permitted a kiln operator to load ware on kiln trucks similar to those used in tunnel kilns (as opposed to the slow hand loading - saggars in the bottle kiln); indeed the shuttle kiln was really the 'Firing Zone' of a tunnel kiln, but it introduced batch production with easy loading, unloading. Actual performance of these first kilns is recorded as poor, but they provided the impetus for new intermittent designs, as one writer comments "... designers recognised that tunnel kiln design had very little to do with the design of intermittents" (4.42).

It was found that efficiency increased, and costs of construction decreased, " as the dimensions of the kiln approached those of a cube". Kiln Walls were built of insulating fire brick (4.43) (I.F.B.), a lighter but more thermally efficient refractory than traditionally used. Developments in high velocity burners (4.44) allowed kilns of two-car width to be built,; doubling throughput at very little extra cost.

Recent developments in ceramic fibre refractories (4.45) have added still further inpetus to intermittent design and demand (post 1974); as one writer comments ".one of the recent moves that is being made is to design the kiln around the (fibre) lining "(4.46). Size and weight has been reduced (introducing portable kilns, eg. James Birks' "ECONOMIKILN") and efficiency has increased (4.47), so sustaining end-user interest in modern intermittents.

TUNNEL KILN DEVELOPMENTS 1960-1975

The first major changes to tunnel kiln design ironically follow the apparent failings of the newly introduced intermittent 'shuttle kilns'; the traditional arch-shaped tunnel was brought into question regarding the level of thermal efficiency. It seems quite definite that the radical changes in intermittent kilns during the 196 0s (including their increasing levels of efficiency) affected the designing of tunnel kilns ".. we're doing a lot of things today in the design of tunnel kilns which are exactly opposite the way we did them ten years ago... structurally, modern tunnel kilns differ from their predecessors mainly in the flat-arch construction " (4.48).

One interesting development, tho' not a success, was the 'hoverkiln'. The ware moved through the kiln on trays supported on a cushion of hot air. The drawback was coping with dust which became deposited

on the ware caused by the disturbed atmosphere.
Greater use of insulating firebrick gave better insulation which increased throughput and resulted in kilns becoming shorter".. an 175 ft kiln will now do the firing of a 250 ft/ 260 ft kiln of 1950" (4.49). Increasing labour costs and the difficulty of obtaining skilled labour have directed innovation towards increased automation".. the advantages of a fully automated tunnel kiln are considerable, much more flexible production, substantial labour savings and a reduction in manpower problems generally, so that the higher installation costs are quickly recouped" (4.50).
A further tunnel kiln variant was the 'roller hearth kiln' which used rollers rather than kiln trucks. Similar in concept to the early Birlec 'belt kiln', the ware moves through the tunnel on batts, on a series of rollers. Although introduced in 1966, operational / technical problems have precluded widespread industry acceptance. Gittens found only one example that had been fully integrated into an existing product line (4.51); and by 1977".. only three have been installed in the country" (4.52).
Historically a kiln was fitted with a tall chimney to induce draught through the kiln and also to remove gases/waste given off by the combustion of the fuel. Both intermittents and tunnel kilns therefore needed a chimney, be they fired by coal, gas or oil; the exception being the electrically fired kiln which does not need a chimney as it does not work on the reduction process, nor does it produce the same waste gases needing extraction. Today's kilns still require chimneys, but the move is towards recycling the lost energy that is 'going up the chimney', and also to redirect the waste gases back into the kiln to reduce atmospheric pollution. Modern tunnel kilns are being designed as integrative firing/ drying systems,".. by itself the

(tunnel) kiln generating heat for drying has a higher fuel consumption than the one without heat recovery, a difference which can amount up to 30% ... looking at drying and firing combined, however, the system with the kiln supplying the heat for drying has the lower fuel consumption as compared to separate kiln, dryer systems" (4.53). Current developments, developments in construction materials, have made kilns lighter and more compact, giving rise to 'transportable tunnel kilns' - 'PORTAKILN' (BRICESCO), 'PACKAGE KILN' (Gibbons Bros). Also, a recent development (1975), as yet unadopted in this country but in Poland and the USA, is the Gibbons 'OCTOPUS SYSTEM' which is a coal-fired tunnel kiln - powdered coal is injected directly into the kiln where it burns in suspension, overcoming the unequal firing problem encountered in those first tunnel kilns (circa 1900). Innovations in the pipeline include development work on perfecting 'rapid-firing' techniques. Since the 1800's technological improvements (better fuels, materials, kiln design etc) have reduced firing cycles from a week, to days, to around fifteen hours (for an intermittent kiln using the newly developed ceramic fibres); the latest developments, both in intermittents and tunnel kilns is to reduce this firing cycle to minutes! As early as 1967, the B.C.R.A. built their "QUICKFIRE KILN" in collaboration with Shell Research (who are providing the gas/oil burners) which achieved a 37 minute firing cycle; this was later reduced to 28 minutes (and in one case to 8½ minutes). At present only small pieces or thin-ware (eg a porcelain plate) can be fired in this way. Although there is no immediate prospects of this method being adopted into current production flows, Kilns and Furnaces Ltd. introduced a laboratory kiln (electric intermittent rather than tunnel) at the Interceramex'76 Exhibition which can fire to 1600°C in 7 minutes using special KANTHAL elements. As one writer concludes " .. the fast-fire in its development has really only started. Many ways are unknown. Increasing knowledge of the thermal properties of raw materials and bodies and a further intensified cooperation between production experts, kiln-builder and machinery producer will help to advance modern technology" (4.54).

It is unlikely that the tunnel kiln can be challenged wherever high volume, low cost, continuous production is required. However, the intermittent has been well adapted to modern mechanised manufacturing operations, yet remains the most flexible form of firing ware, having greatly improved fuel efficiency. Modern developments have led one writer to comment .. " if present trends in tunnel kiln design continue, the similarity between a tunnel kiln and a shuttle, intermittent, kiln will become even more striking, and the design technology of the two types will have even more points in common" (4.55).

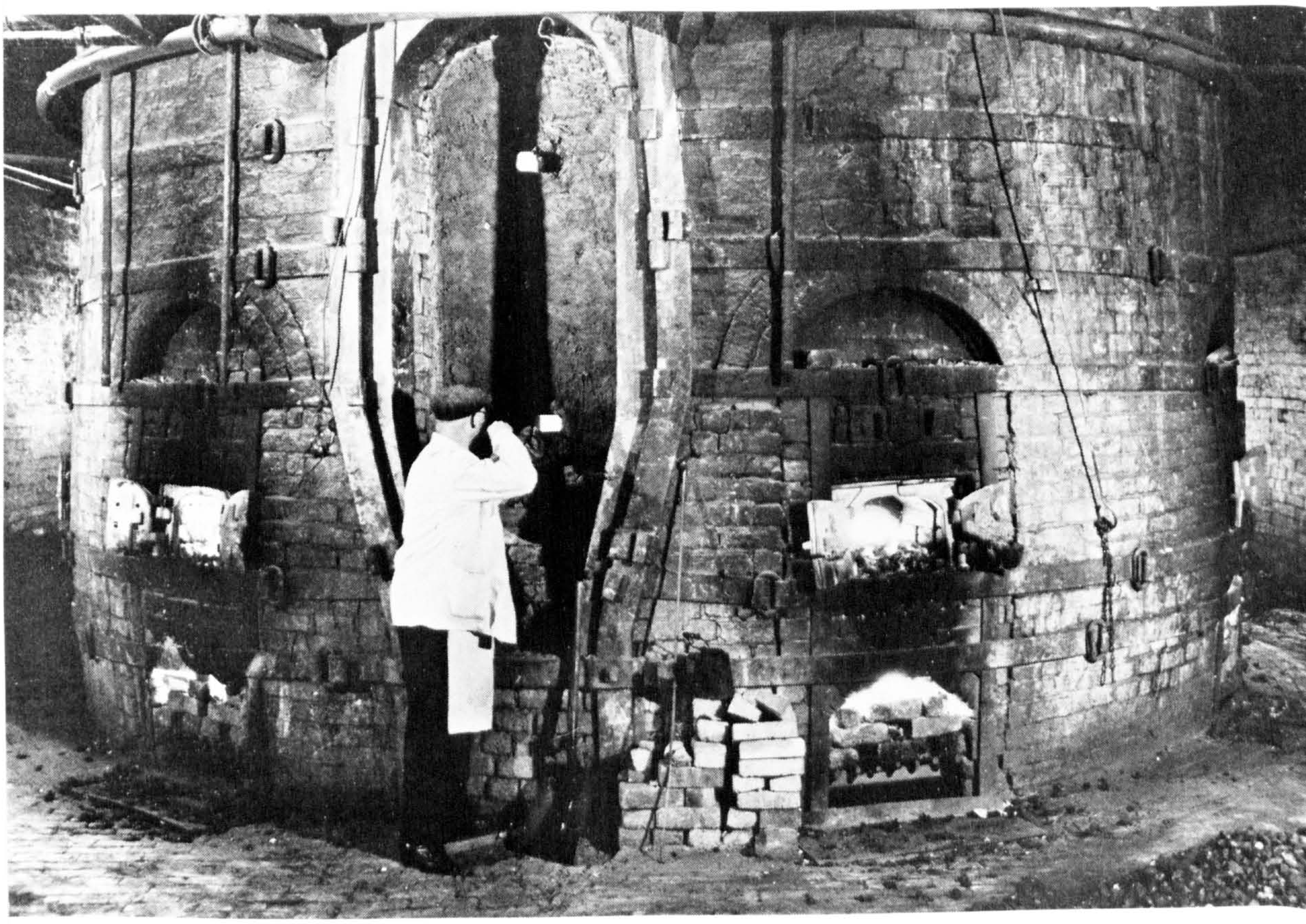
4.2.3. INNOVATORY APPLICATIONS OF FUELS 1800-1975

COAL 1800-1956

The coal from the North Staffordshire Coalfields was found to be virtually sulphur-free, ideal for the production of pottery. The early bottle kilns were fired entirely using coal from local sources. However, it was dirt from the smoke rather than sulphur content which precluded open-firing of the ware; ware had to be loaded in saggars, which in turn were loaded into the bottle kiln. The firing process was dirty and time-consuming. Once a kiln had been loaded, fires were lit in the firemouths and re-stoked ('baited') at intervals usually of about 4 hours. At the early stages of the firing the temperature was kept low while the moisture in the ware was driven out. This was known as 'smoking'. After about 48 hours the temperature was at its peak, between 1000°c and 1250°c; this temperature was maintained for approximately 2 or 3 hours, to allow the ware to 'soak' and then the fires were left to go out. The ware was then unloaded, the ashes raked out and the kiln was ready for reloading (assuming no repairs were necessary). Muffles were introduced (4.56) to avoid direct contact between the 'dirty flame' and the ware; the use of muffles reduced the efficiency of the kiln, but as fuel was plentiful, this was not such a major consideration for the end-user. As late as 1937 Hind sums up this attitude when he writes " the aim of all firemen is to produce good ware with only secondary consideration for the fuel consumption ... this is as it should be" (4.57).
The firing of ware, using coal, became a skill; the fireman's function was regarded as the most important man in the factory; he was expected to stay by the kiln throughout the whole firing process. Temperature

control during firing was carried out by taking 'trials'. Around the kiln at regular intervals were holes which were blocked with a loose brick during the firing. The fireman was able to remove a brick to draw out a trial, using an iron poker. There were no thermometers which could withstand the high temperatures which the kilns reached. Most of the firing was done by (experienced) guesswork. The colour of the flame was sometimes used as a guide, but often proved unreliable. Another method were the 'trials'; by observing the colour of the piece of pot the fireman would judge the stage of firing. Josiah Wedgwood did many experiments to find ways of measuring the temperature accurately. He made use of the fact that when the pottery is fired, it contracts. He fired small pieces of pottery and withdrew them from the kiln at intervals and measured them on a special gauge. It was from Wedgwood's experiments that modern pyroscopes have developed (4.58). Finer control of fuel inputs does not become a reality until the 1920s when alternative fuels to coal are introduced.

The maintenance of coal as the primary power source in the pottery industry was due primarily to the importance of the bottle kiln in the production process. Although alternative fuels became available during the early twentieth century, the bottle kiln remained a 'coal-firer'; as long as it remained, so did the demand for coal.



PHOTOGRAPH FIREMAN DRAWING A 'TRIAL' FROM A BOTTLE KILN C.1930

Courtesy : GLADSTONE POTTERY MUSEUM

There was a marked decline for coal from the industry throughout this period (1800-1956) as manufacturers introduced tunnel kilns which used alternative fuels; table 4.5. shows the change in demand:

1900	Over 2 million tons of coal
1939	1.5 million tons
1956	100,000 tons

TABLE 4.5. DEMAND FOR COAL IN THE POTTERY INDUSTRY 1900 - 1956

Coal usage continues to decline during the early post war period. Few new bottle kilns were commissioned (post 1946); tunnel kilns were the choice for the post-war reconstruction business. However, coal was still the primary power source in the industry.

PRODUCER GAS - TOWN GAS 1912 - 1956

Early gas kiln developments used what is termed 'producer gas'; the gas was produced by the end-user at his factory, using coking coal. An equally dirty flame and pollutant were produced. The Dressler kiln (1912) needed 'muffles' to avoid direct flame contamination of the ware being fired. Early fuel burners were simple gas-jets, ignited by the kiln operative. As early as 1920, Harrop, experimenting with gas (and oil) as fuels for tunnel kilns, found that heat could be directed to different parts of the kiln and that the velocity of burner gases could be used to penetrate and heat up the centre of the tunnel. The early nozzle burners did not achieve very high velocity by today's standards. Kiln designers were primarily interested in penetration and 'reach', which in narrow tunnel kilns could be accomplished at relatively low velocities. A further limiting factor was that it was found that back-pressures increased as the diameter of the burner aperature decreased, so complicating the problem of burner design. Problems of uniformity of firing, caused by lack of knowledge of burner technology, limited the size of tunnel kiln development and the advancement of gas as a fuel for firing pottery. The introduction of 'town gas' with the opening of the Etruria Gas Works (1922), added impetus to gas adoption. For the manufacturer it was seen to have the following benefits:-

(i) it gave a more efficient heat, that is, better fired ware and shorter firing cycles.

(ii) added cleanliness to the factory

(iii) reduced the need for the end-user to have to maintain a producer-gas plant; this meant savings on coking fuel, factory space and number of operatives needed.

Town gas, refined at source, tended to be cleaner (more sulphur-free) than producer gas, so promising a much more effective production process. However, it was not until 1932 that the first tunnel kiln using town gas was built by Gibbons Bros for Conway Pottery. For the first time ware was glost-fired 'open-flame' (ie non-muffled), using saggars, because the fuel burned so much cleaner. Although this kiln demonstrated immediate benefits to the end-user, there was a time-lag in diffusion in the industry (4.59).

ELECTRICITY 1920 - 1956

Catterson-Smith (kiln builders) report having an experimental electric kiln in operation decorating domestic ware, in 1920. Early development problems were related to the lack of knowledge regarding combustion properties and the behaviour of metals at these high temperatures. Unlike kilns fueled by any other means, electric kilns do not work on the principle of reduction, nor do they rely upon up-draught or down-draught to achieve high temperatures; development limitations during the period 1920 - 1926 were in connection with perfecting heating elements capable of achieving high temperatures. Catterson-Smith are credited with developing silicon-carbide (SILIT) heating elements which could achieve consisten operating temperatures of around 750°c, potentially within the temperature range needed for decorative firing. However the first electric kiln-a tunnel kiln-built for the pottery industry, to fire decorating ware, was by Moore and Campbell for Mintons in 1927. Although primarily a full-scale 'experiment', the trial period identified a number of advantages over competitive fuels:-

(i) the operator could achieve much greater accuracy with temperature control.

(ii) it had a much better controllable distribution of heat.

(iii) there were no waste products of combustion (eg ash).

(iv) there was no need for a chimney / fire to be constructed; hence it was easier to construct an electric kiln, and to 'fit it' into the existing layout of the factory.

(v) there was no fuel handling, nor the need to arrange disposal of fuel waste (eg ash).

(vi) there was less waste heat (viz. up the chimney), fumes of combustion, or noise (the draught principle causes a 'roaring' sound).

(vii) for the time it was a much cleaner form of firing, so especially suitable for decorative firing.

(viii) offered improvement in the health and working conditions of the kiln operatives and for those working in close proximity to the kiln.

(ix) offered savings in labour costs with less need to supervise whole firing cycle and level of skill needed by kiln operatives was less than for other fuels.

(x) offered lower maintenance costs, although in practice early heating elements were prone to regular failure, and kiln life was shorter because of the level of refractory material technology.

(xi) offered potentially less fire hazards.

(xii) the cleaner town gas was not immediately available (on-supply) to every pottery manufacturer (4.60).

The success of the Moore-Campbell kiln caused the major kiln builder of this time - Gibbons Bros - to undertake extensive development of electrically fired tunnel kilns.

Early electrically-fired tunnel kilns displayed a basic technical problem. The nickel-chrome heating elements were prone to failure if operated constantly at firing temperatures, and a tunnel kiln, to be operated economically, has to be run 24 hours per day, 7 days per week at a firing temperature.

PHOTOGRAPH MODERN L.T.M. ELECTRICALLY FIRED INTERMITTENT KILN ILLUSTRATING THE HEATING ELEMENTS

This technical problem remained a block to widespread industry adoption until after the cessation of hostilities (post 1945). The impetus for technical innovation came from the fuel supplier (ie M.E.B.) rather than kiln builder or user(4.61). In addition to pioneering a new structure (ie. the development of the electric intermittent), the nickel-chrome elements were replaced by advanced heating elements designed in Sweden (KANTHAL ELEMENTS) which solved the operating temperature problem.

OIL 1920 - 1956

A survey of kilns in operation in 1915 finds no evidence of kilns fired by oil (4.62). Oil did feature in early tunnel kiln development but was found difficult to use " ... the first applications to ceramic tunnel kilns failed owing to inexperience with the burners" (4.63). To ignite fuel oil, it needs to be vapourised and mixed with air. The fuel burns with considerable smoke in the early stages of firing and causes considerable deposits of carbon inside the kiln; like producer gas, all early oil tunnel kilns were 'muffled'. Equally, early developments were prone to dangerous malfunction, when the motor driving the blower (which mixes vapourised oil and air) failed; without sufficient air, the oil ran down the sides of the kiln, ruining the 'charge' and liable to explode. Like gas, oil did have advantages over traditonal firing using coal:

Firing temperatures could be more easily controlled.

but it also had a number of disadvantages which arrested diffusion:

(i) the problem of oil storage; oil was space consuming, smelly and dirty

(ii) the oil-fired kiln was very noisy in operation; noise caused not only by the up-draught, but also the operation of the air blower used to mix oil and air.

(iii) there was a constant danger of fire

(iv) there were problems of smoke emission at the beginning of the firing cycle.

Hind concludes ".. since there is little to choose now as regards price between town gas in many districts and oil, and since it is more expensive than producer gas, its future in this country would appear to be limited unless the present taxation policy is altered (4.64).

Both oil and gas fuels benefitted from the advances made in fuel burner technology post-1950.

FUEL AND BURNER DEVELOPMENTS 1956 - 1975

Innovatory use of fuel is inextricably linked with developments in fuel burner technology. An early limiting factor to the market acceptance of oil and gas fired tunnel kilns was the problem of achieving an even-distribution of heat across the ware in the kiln; the firing cycle had to be extended to ensure that those items in the middle of the kiln (ie those furthest from the burners) were sufficiently fired. As a direct consequence tunnel kilns were built no more than 5ft across; a width of one truck, which was a limiting factor on throughput; burners could not maintain a level of heat intensity beyond this range.

This problem applied to all tunnel kilns (except electrically fired); in theory burner systems were interchangeable but in practice once a a burner system had been installed no further alteration took place; the notable exception being the transition from producer to town gas (1938-48) and gas-to-oil-to-gas (1966-70). These burners were called 'low velocity burners'. The technological watershed is provided with the introduction of higher velocity burners; " it remains a most question as to who first recognised that high velocities would induce a considerable mixing of the kiln gases with the combustion products and that the effect could provide beneficial in the firing of ceramic kilns" (4.65). Certainly the Gas Board's Midlands Research Centre began development work on advanced burner-block assemblies and 'nozzel mixers'(using Stordy nozzels) in the early 1950's. The first really high velocity burners did not materialise until the early 1960's (built by Stordy), intended first to be incorporated into the new gas-fired intermittents and secondly to provide more efficient firing using natural gas. The main characteristic of the high velocity burners is the high speed at which the combustion gases exit the burner "..(they) produce a significant improvement in the kiln temperature uniformity. The turbulence taking place as a consequence of this permits heat transfer in the ware being fired to be greatly improved "(4.66); and"present day high velocity burners can handle widths (of kilns) in excess of 21 feet, and burners of even higher velocities are expected to be developed in the future" (4.67). Dual fuel burners have been available in the pottery kiln industry since the mid-1950's; the attraction is the flexibility enabling advantage to be taken of changes in price and variances in fuel availability. Early technical problems (eg efficiency of jet nozzles) and abundance of 'cheap' fuel did not encourage manufacturers to adopt dual-fuel burners, however, recent fuel price increases and scarcities have led to re-interest in this concept.

A more recent burner development has been the 'self recuperative burner', once again developed by the Gas Board Midlands Research Centre. The basic principle of the recuperative burner is that all the waste gases are taken out of the kiln through the burners and recycled back into the kiln, thus offering potential fuel/energy savings. The Gas Board and Shelley Furnaces have installed two trial kilns, at Regent Pottery (Doultons) firing tableware, and Gimsons (Norton Industrial Ceramics) firing refractories; early results have recorded fuel savings between 32% and 42% (4.68). No other examples have yet been installed.

4.2.4. INNOVATIONS IN KILN HOT-FACE

REFRACTORY LININGS 1800 - 1975

Early kiln builders paid little or no attention to the importance of insulation when examining kiln efficiences; plentiful supplies of fuel precluded attention whilst the drive was to perfect the quality of the ware. Searle makes no reference to the role of insulating materials in his authorititive work in 1915 (4.69). By 1937 Hind writes that he sees kiln technology limited by two factors:-

(i) knowledge of fuel technology

(ii) the need to develop improved refractories (4.70)

However, as has been pointed out (4.71), attention concentrated more on fuel technology TO PRODUCE BETTER WARE rather than to necessarily make better utlilisation of energy used.
But what exactly are refractory materials? What is their role in the operation of the kiln? And why have they assumed such dominant importance in recent years?
The materials used to construct a kiln, especially those used at the 'hot-face' (ie. at the point of contact with heat), affect the level of efficiency of the kiln through what are called 'heat flow'. Figure 4.9. (overleaf) shows the heat flow for a typical kiln:-

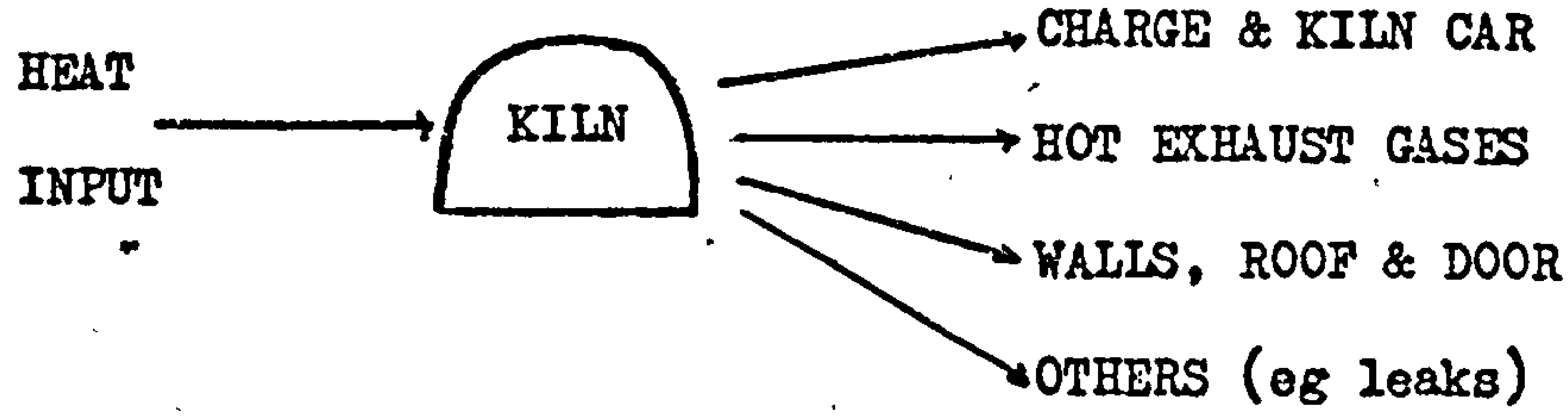


FIGURE 4.9. HEAT FLOWS IN A KILN

The efficiency of the kiln depends upon the relative heatflow in to the 'charge' (ie the ware) and, by normal convention, this includes the trolley/ kiln car as compared with the total heat input.

For a tunnel kiln operating at equilibrum, the heat flow into the lining of the kiln is just equal to the heat losses from the cold-face. With a sufficiently thick wall and good recuperation of waste gas heat, the overall heat losses can be small. Kiln efficiency can be high and is very little affected by the thermal mass of the refractory lining.

For the intermittent kiln, the thermal mass of the lining is much more important, and it is this factor which largely determines the heatflow into the lining. Depending upon the cycle, efficiences can be as low as 10% because all the heat stored in the lining has to be replaced on each firing cycle.

For the electrically heated kiln there is no flue loss, and so kiln efficiency is generally higher than for a similar oil,coal, or gas fired kiln. However, the cost of electricity is much higher and so savings in electrical energy are more attractive to users than equivilent savings in other fuels.

The emerging interest in the importance of refractories has led one technologist to write: " I feel that after fuel and burner system developments, refractory developments have probably had the greatest single influence on improving furnace design" (4.72).

The early intermittent bottle ovens were constructed of a similar brick to elsewhere in the factory (although later models were built of more resistant fire clay brick): the immense stress caused by the structure (4.73) and the constant high operating temperatures, resulted in the need for regular kiln hot-face rebuilds. In addition efficiency was extremely low-certainly less than 10%- because the bricks used absorbed the heat generated by the kiln (ie. had a high thermal mass): the walls, saggars (if used), muffles (if used) all absorbed energy before the ware in the kiln could reach a temperature sufficient to be fired.
Cogniscant of the problem, brick suppliers gradually upgraded the resistance-to-heat of the brick using fireclay : actual records are not available but it seems adoption by kiln builder / manufacturer was rapid, on the grounds that better hot-face resistance meant fewer rebuilds and so fewer losses in production.
Partly the search for better refractory materials was deflected by the advent of the tunnel kiln (in the 1920's). The tunnel kiln, although constructed from the same type of firebrick, was seen to be more efficient. This is bacause once a tunnel kiln has reached its operating temperature, the long period at this temperature reduces the relative importance of the refractories used - it was the heating, cooling and reheating of the intermittents that was causing the problems. Existing refractory materials were

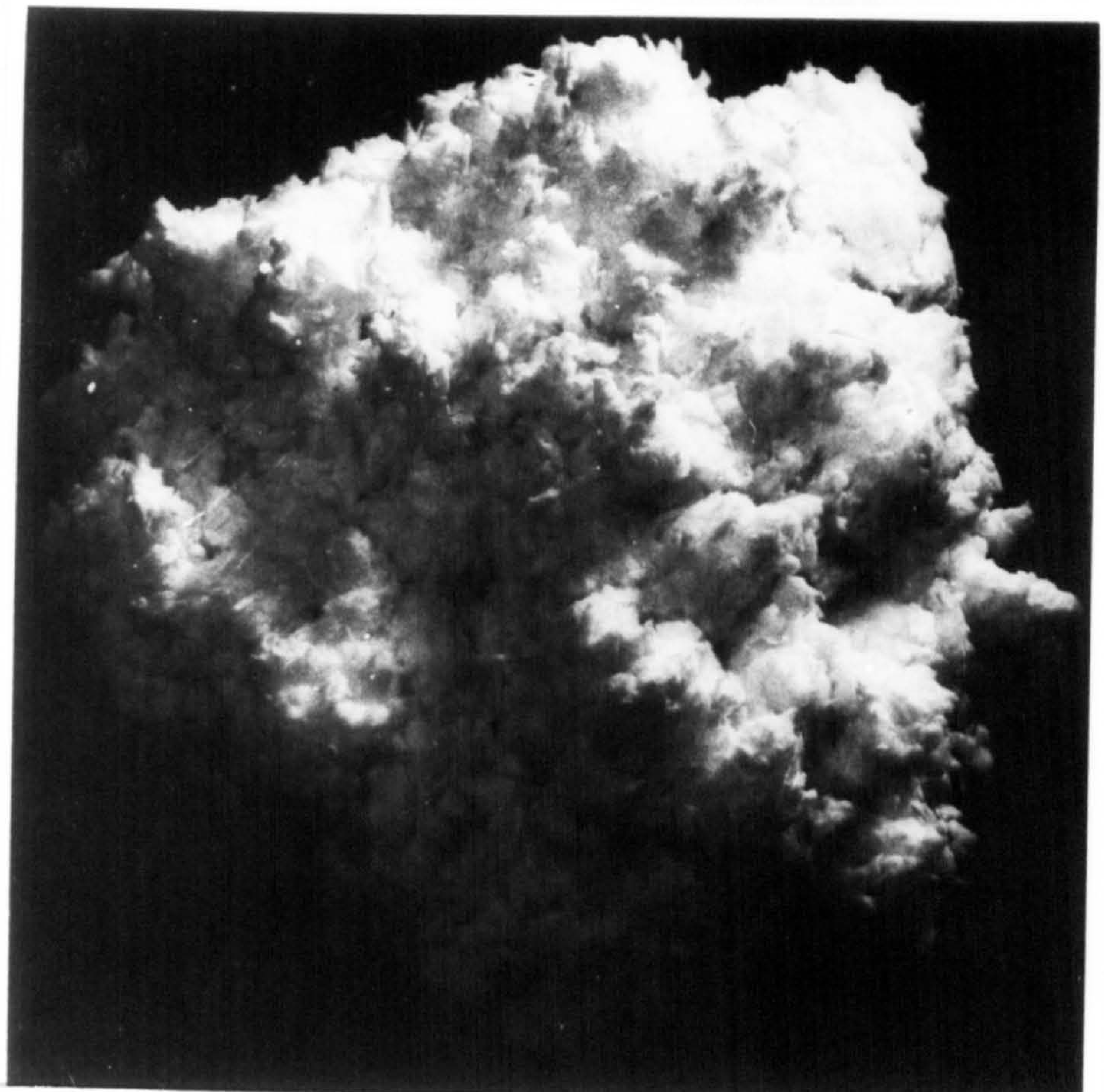
sufficient to match the level of technology of early C20th tunnel kilns, but not so for the intermittents. Advances are made, during the 1930's, with the introduction of the 'insulating firebrick' (I.F.B.). The term is applied to a form of brick that was lighter than the traditional firebrick, but suitable for direct exposure to kiln gases in the combustion zone. It was made from the same type of refractory clays used in regular firebrick. The light-weight was obtained by porosifying the structure. It was found that insulated firebrick could be ground to exact size after firing, so allowing closer tolerances than were possible with traditional firebrick which were fired to size. This increased the level of kiln performance because it could be built better, with fewer leaks. The reduced weight meant a lower heat storage value which meant that less fuel was required to bring an I.F.B. up to kiln operating temperature: similarly, a kiln constructed (at the hot-face) in I.F.B. could be cooled more rapidly because the relatively low heat storage requires less heat be removed from the kiln-linings. Adoption was retarded by a number of technical limitations: these bricks were found to be unsuitable for locations where they were subjected to physical punishment (eg. being struck with firing tools or heavy implements) because they damaged more readily than heavy brick. They did not have so high a resistance to erosion as heavy brick when subjected to dust, ash or other particles in a gas stream moving at high velocities. This problem was partly overcome by the coating of the hotface surface with a chrome-mortar to improve the resistance against abrasion (circa 1943). Again resistance to adoption was due to the relative costs of I.F.B. compared with normal firebrick, given that comparisions were less likely to be made in terms of kiln efficiences!

Evidence provided by Berliner in 1950 quotes the use of I.F.B. reducing the firing cycle of an intermittent kiln from 192 to 170 hours, with a resultant fuel saving of 21% (4.74).
Growth of I.F.B. parallels the post-war reconstruction period and remains the dominant refractory hot-face material (with few technological improvements) until the introduction of 'ceramic-fibres' in the 1970's.

The Carborundum Co. introduced the first ceramic-fibre (FIBERFRAX) in 1953; this fibre was an amorphous material composed chemically of Al_2O_3 (alumina) and S_iO_2 (silica), it being formed by melting a mixture of tabular alumina and commercially pure silica sand in an electric arc furnace at approximately 1980°c. The resultant product is a light, fluffy-like, refractory fibre suitable for modelling into many forms. It was found to have a number of technological advantages vis a vis brick refractories:

(i) it did not spall
(ii) shrink
(iii) expand
(iV) was low in heat storage

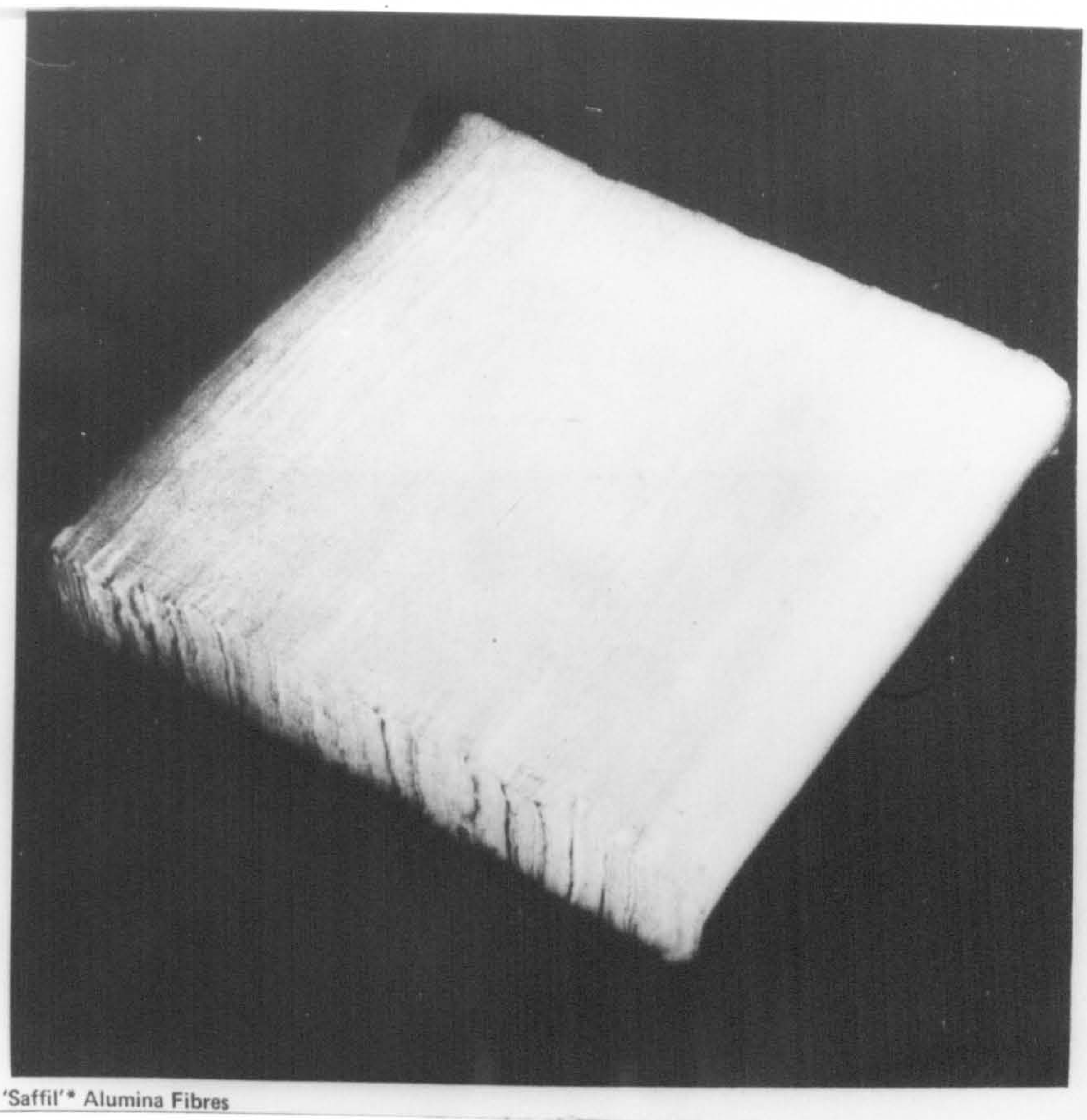
In 1973 Carborundum introduced a 'second generation' of ceramic fibres - FIBERFRAX H - in an attempt to stimulate an almost uninterested market; ".. it is an entirely new departure which significantly extends the range of environments in which fibre can be used and is the only ceramic fibre of its type being produced in quantity in the U.K." (4.75). This new form of fibre facilitated operational temperatures up to 1250°c, due to a change in the chemical composition - the alumina content is increased to 62% (4.76). Enthusiastically Barker writes "... the form of refractory with the greatest potential growth in furnace construction is undoubtedly ceramic fibre" (4.77).



PHOTOGRAPH CERAMIC FIBRE IN A PREFORMED STATE

The first commercial kiln using higher temperature fibres, an electric intermittent, was built for Aynsley China by the Drayton Kiln Company in 1972. Whilst designed for decorating firing the technological concept of fibres was seen to have application for all firing processes; "it is intended to develop this potential which should eventually embrace glost and biscuit apllication" (4.78). Subsequently, Aynsley China, in 1974 had commissioned the first fibre-lined kiln for biscuit firing;"the first kiln of its kind built in the U.K. or anywhere in Europe" (4.79).

Within six months of this first L.T.M. biscuit kiln (4.80) being commissioned, I.C.I. (Mond Division) introduced a 'third generation' fibre "... lightweight thermal insulating materials based on refractory fibres have, for a number of years, given good service in furnace insulation and similar applications. The range of applications is now extending considerably, thanks to the introduction of high-performance alumina fibre insulants" (4.81). SAFFIL (4.82) was found to have a number of tedhnological advantages over all other inorganic refractory fibres (4.83).


'Saffil'* Alumina Fibres

PHOTOGRAPH 'SAFFIL' ALUMINA FIBRE

Courtesy: I.C.I. (Mond Division)

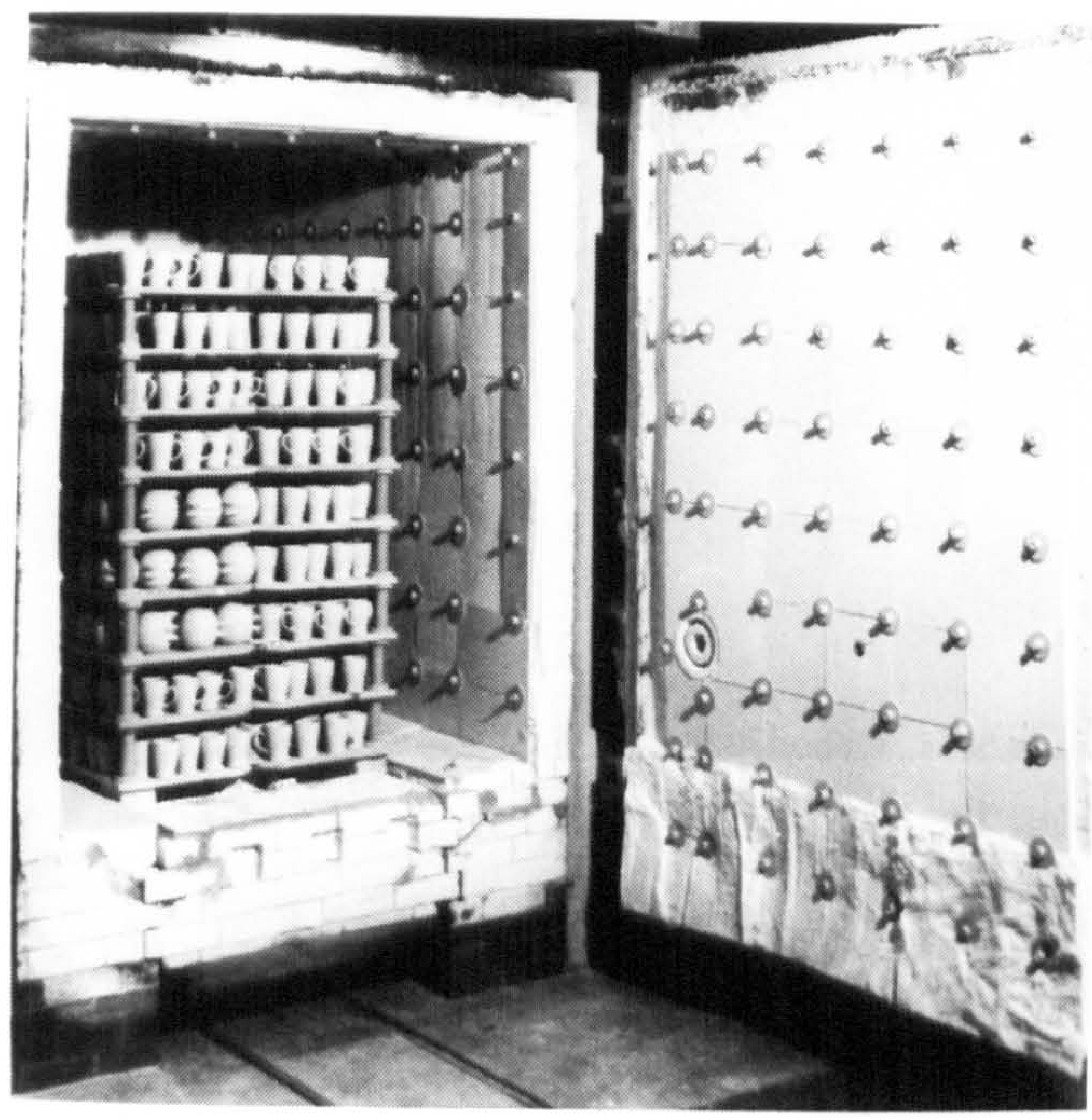
The first kiln, using SAFFIL fibres, was built for the Wedgwood Group's Coalport Factory in 1974 by Shelley Furnaces. It was a gas fired intermittent kiln for biscuit firing.

The technological advantages became apparent. The heating-up rate for a kiln constructed of brick is limited by the rate at which the (brick) lining can be heated without causing 'spalling' (ie. cracking under thermal stress). Ceramic fibres (SAFFIL in particular) were found to be almost completly immune to thermal shock; the heating-up rate in a fibre-lined kiln was determined only by composition of the ware itself. This meant that 'firing cycle' (from entry to exit of kiln) was drastically reduced, as table 4.6 showing the operating schedule for the Coalport kiln illustrates:

KILN LINING AT HOT FACE	CYCLE HOURS (hollow-ware)			
	HEAT	SOAK @1250°C	COOL	TOTAL CYCLE
I.F.B. BRICK	15.5	1.0	11.0	27.5
SAFFIL FIBRE	7.5	1.0	8.0	16.5

TABLE 4.6. OPERATING SCHEDULE. COALPORT KILN (1974)

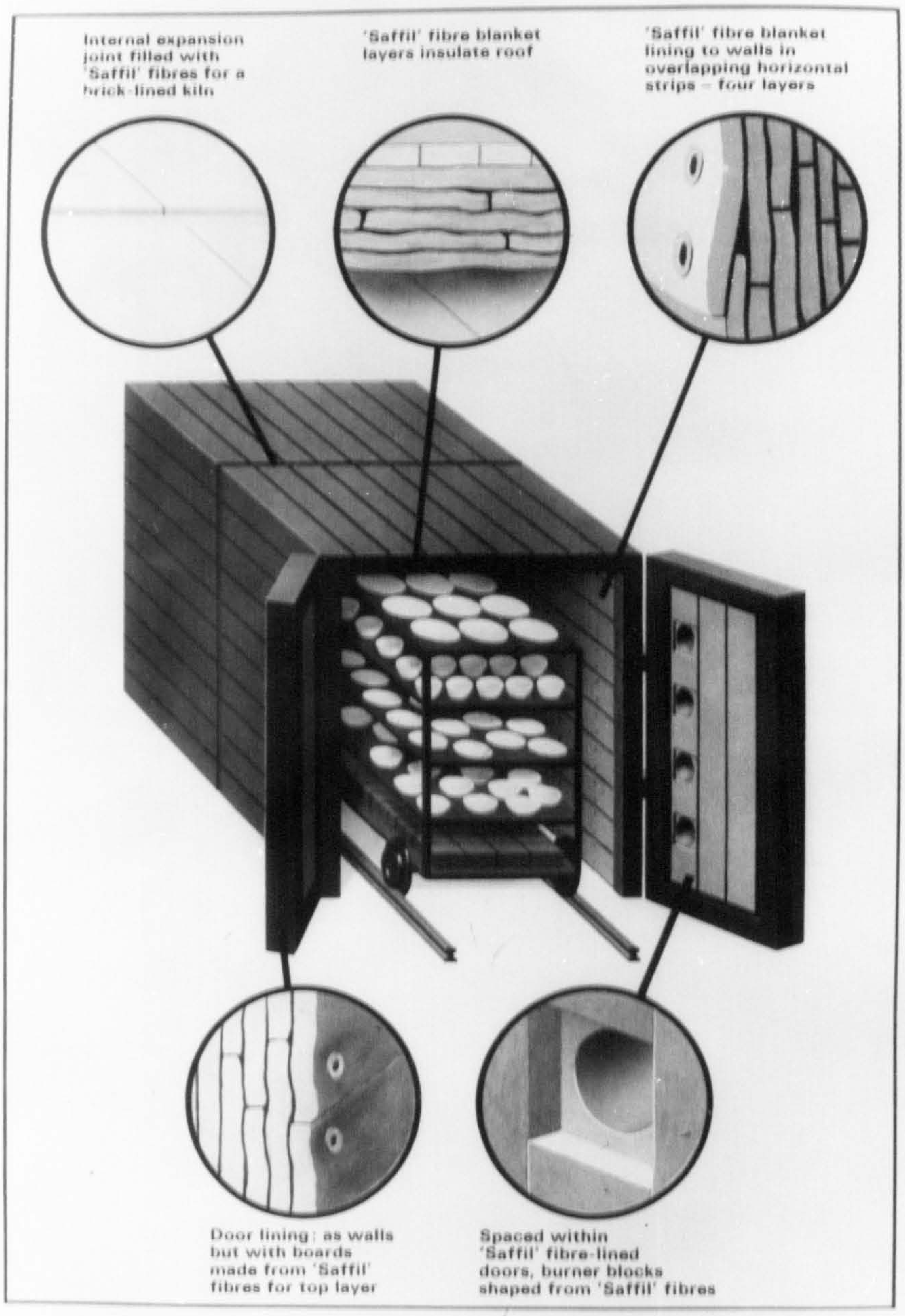
It is necessary to 'soak' hollow-ware for one hour at 1250°C. Given the same input of heat/fuel, the ware can be raised to this temperature in 7½ hours rather than 15½ hours for the brick-lined kiln. This is a direct result of the extremely low thermal mass of the fibre linings(ie. they absorb less heat). In addition, low heat storage means that the fibre linings cool down more quickly.



PHOTOGRAPH THE COALPORT KILN 1974

built by Shelley Furnaces.
Gas-fired using 'SAFFIL' fibre and
Royal Worcester Anchors.

and the overall cycle time for the fibre lined kiln is much reduced, increasing kiln availability by some 66%. One observer comments, eighteen months on from the Coalport kiln's commission "... as applications and know-how become more readily available, it seems that we will see an increasing use of fibre ceramics" (4.84).



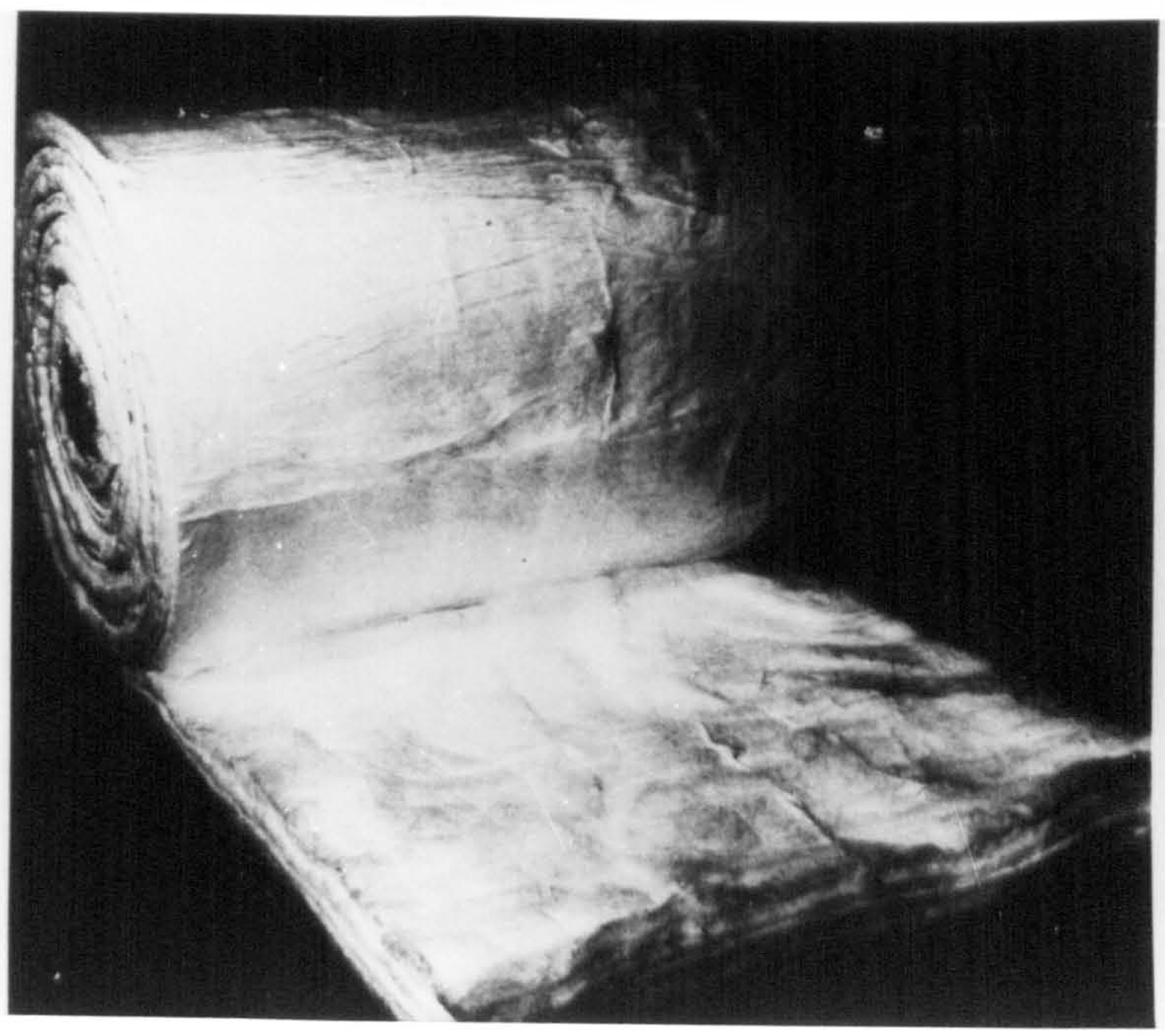
PHOTOGRAPH ILLUSTRATING WIDE VARIETY OF APPLICATIONS OF CERAMIC FIBRE IN KILN CONSTRUCTION

Courtesy: I.C.I. (Mond Division).

4.2.5. INNOVATIONS IN APPLYING REFRACTORY LININGS TO THE HOT-FACE OF THE KILN

With the earliest bottle kilns, the 'hot-face', made of brick, was an integral part of the kiln's construction (4.85). With the development of the hovel type kiln, the hotface was seperated from the main construction to facilitate less structural strain, easier loading, better firing and easier maintenace. These kilns, like the latter development - the tunnel kiln - were built of brick and cement. Both brick and cement were products of fireclay; though it was the cement rather than the brick that needed the constant attention because it has less strength, tending to flake after numerous firings. As such the refractory lining - the brick and the cement - were the hot-face lining, though during the 30's, experiments began using layers (boards) of 'mineral wool' to replace layers of brick not at the hotface (kiln became lighter, cheaper to construct). No consideration was given to this area until the advent of ceramic fibres as refractory materials. Numerous commentators in the early days of development of L.T.M. materials laid stress to one of the major limiting factors to fibre development as ..." fastening techniques being both expensive and conducive to heat loss" (4.86).

When ceramic fibres were first introduced into pottery kilns, they came in the form of either long rolls of fibre (like roof insulation) or in board-like form.



PHOTOGRAPH CERAMIC FIBRE IN ROLL-FORM

The method of fixing the fibres to the kiln was to impale successive layers on threaded metal studs, welded or bolted to the kiln's steel or brick casing, holding the final layer in place by washer and nut, or threaded washer - as Figure 4.10. illustrates:-

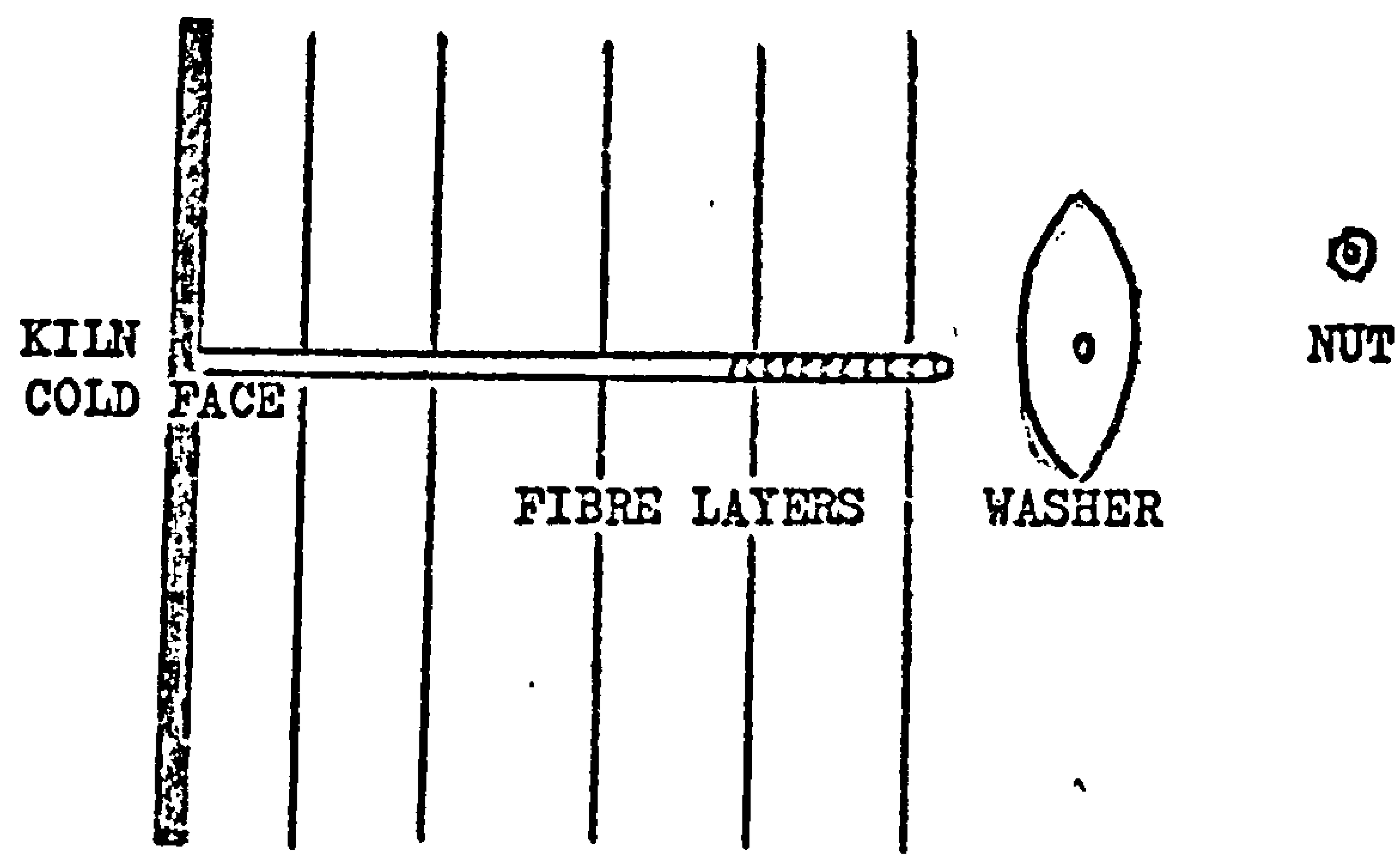


FIGURE 4.10. TRADITIONAL METAL ANCHORING METHOD

Type of metal stud used was governed by the kiln's hot-face temperature (4.87).

(i) up to 930°C - 309 stainless steel

(ii) 930°- 1170°C - 601 inconel nickel-chromium

A number of early technical problems arose as kiln temperatures, using fibres, were increased; it was anchorage failing that were causing fibres to be viewed in a poor light by the industry; as one writer comments... " poor anchor welds are the cause of 60% of refractory lining failures" (4.88). But not only were there problems of fixing the anchors to the kiln wall, but also the metals used in anchor-construction began to undergo chemical change at these high temperatures, which in turn affected the contents being fired ... " principally due to oxidation and vanadium attack (4.89); traces of metal oxides from the fixings were found to discolour the ware. So although higher temperature fibres became available around 1972, the availability of anchors to sustain these temperatures acted as the block to adoption (4.90). Some early efforts to solve this problem included sticking pieces of fibres over the metal studs. This tended to reduce the possibility of oxidisation, but meant that whole sections of the fibre wall had to be damaged if repairs needed doing. The fibre covering the studs would bond to the other fibre making accessibility to the studs impossible without damaging the kiln wall - and one of the intended benefits of fibre linings was that 'it was cheap and easy to repair'. Also, the cost of the metal used in stud-making was extremely high, precluding a need to constantly replace them.

Dr. Langman at I.C.I. considers that finding a suitable anchor for SAFFIL - which was designed to operate up to 1400°C (later 1600°C) - as one of the earliest development problems.

Two similar anchor alternatives were developed in 1972/73 in direct response to the needs of the fibre suppliers.

The first, the 'Mullite Ceramic Cup', was developed by Morganite Ceramic Fibres. It is a threaded rod which can be stainless steel or refractory alloy (eg inconel). A ceramic cover plugged with ceramic fibre protects the metal from the temperatures at the hot-face. The choice of metal for the pin depends on the temperature expected at its tip which, in turn, depends upon the thickness and type of the various insulating layers and the composition of the kiln atmosphere - Figure 4.11. illustrates:-

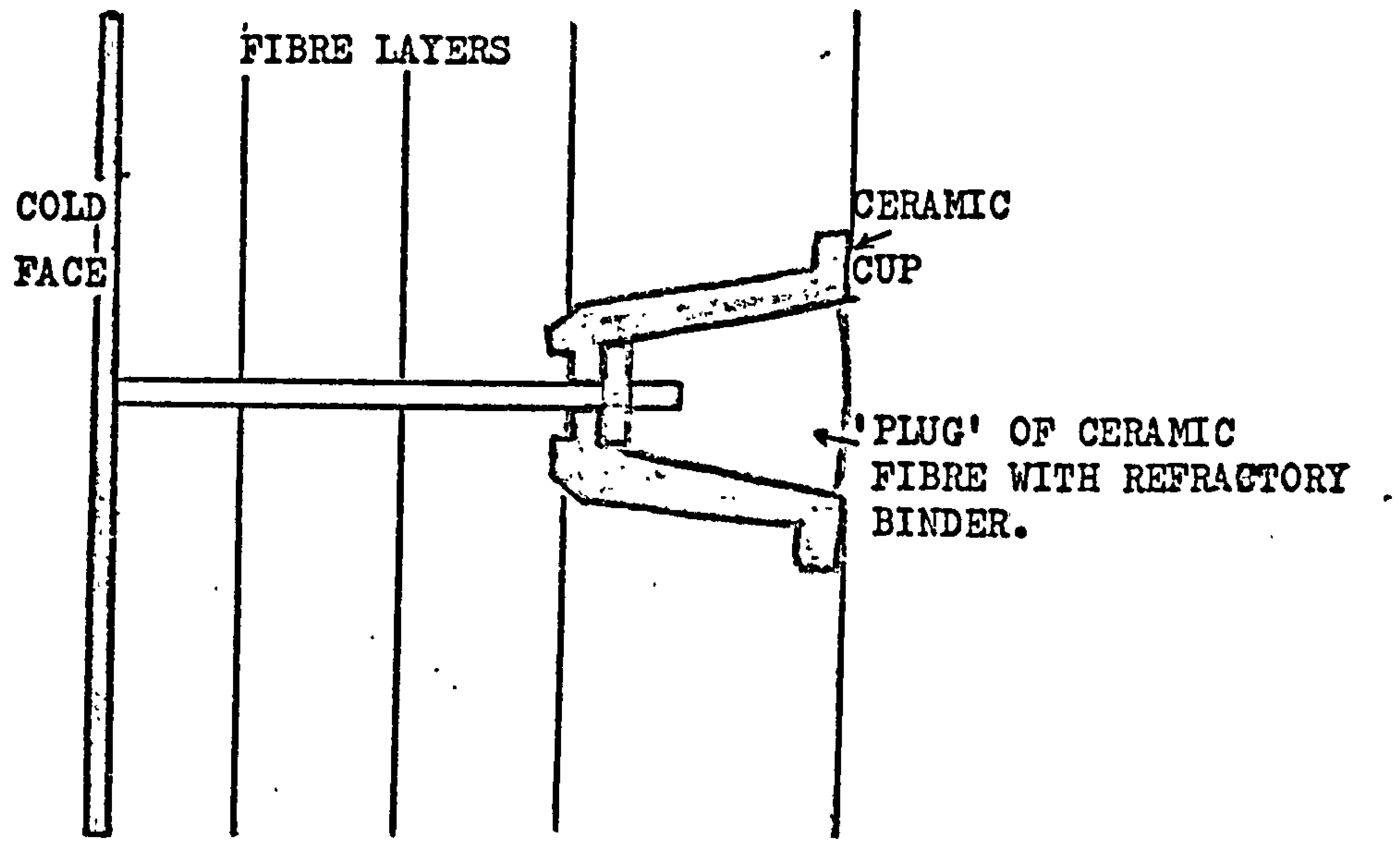
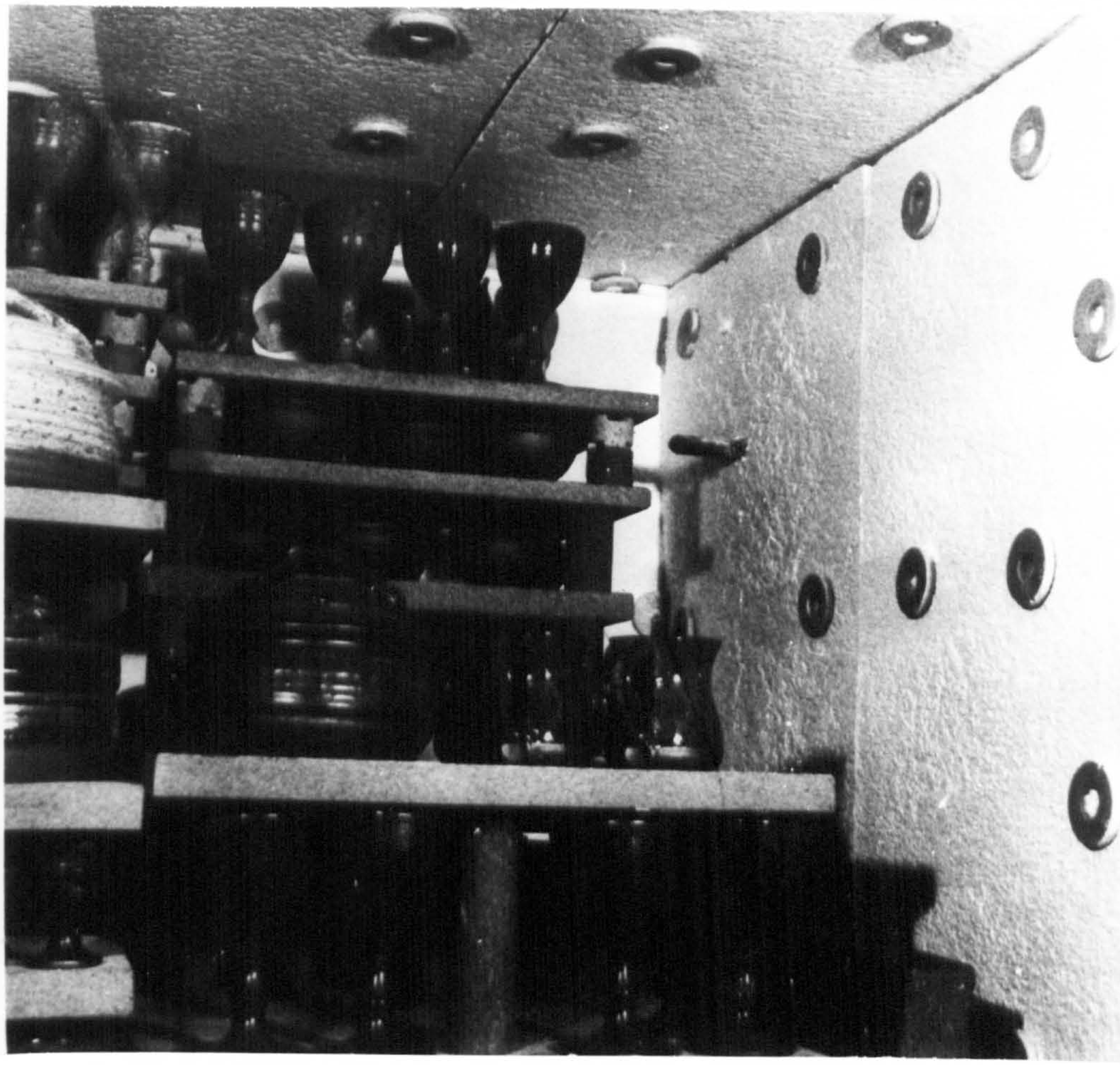


FIGURE 4.11. MORGANITE : MULLITE CERAMIC CUP

This method has been successfully tested up to 1450°C; an example of application is shown in the photograph below.



PHOTOGRAPH ELECTRICALLY FIRED, L.T.M. KILN AT BRAMHAM POTTERY (installed 1975) USING 'MULLITE CERAMIC CUP' ANCHORS.

The second method was developed by Royal Worcester Industrial Ceramics. Alumina fibres (SAFFIL) rather than metal are used for fixing through those layers of fibre most subjected to high temperatures; the metal fixing is located so far from the hot-face that it cannot limit the temperature capability of the system - Figure 4.12. illustrates:-

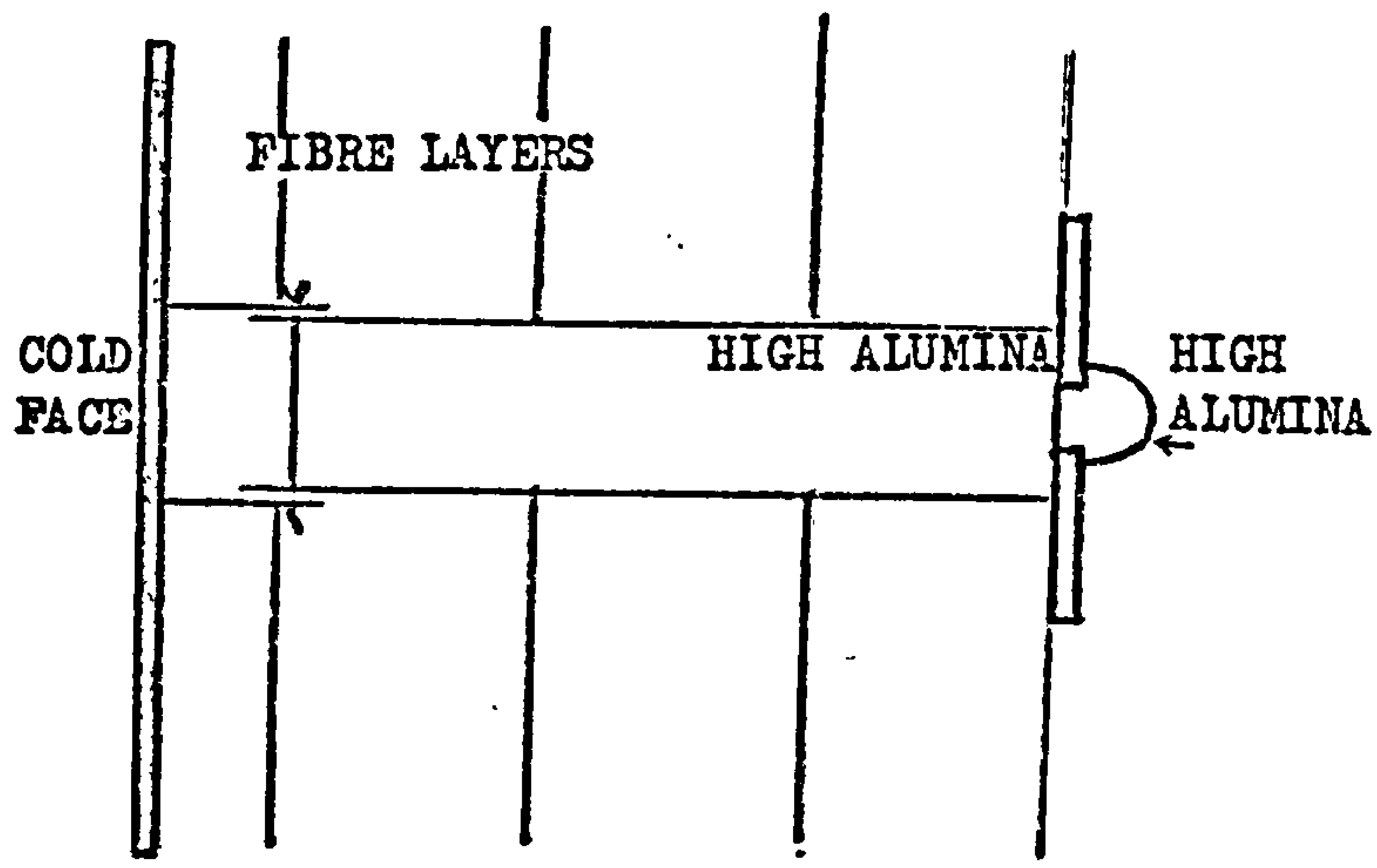


FIGURE 4.12. 'ROYAL WORCESTER ANCHOR'

The Royal Worcester Anchor was successfully used in the first SAFFIL- lined kiln - Coalport, Wedgwoods 1974. There ceramic system has been successfully tested up to 1550°C.

By the time the first biscuit fibre-lined kilns were commissioned, 'anchor technology' was sufficient to cater for market needs. Nevertheless, installation methods were still difficult and slow- studs had to be located every 5-6", checked after every firing for tightness and so on. Also, the present method of anchoring, tended to preclude the use of fibre in existing kilns. Some attempts were made in the USA to fix studs to existing brickwork kilns, but a much more simple method was devised - called 'veneering'.

PHOTOGRAPH ELECTRICALLY FIRED L.T.M. KILN USING 'ROYAL WORCESTER ANCHORS'

Existing refractory cements were used to stick the fibre to the existing brickwork. This method much simplified installation and increased the overall rate of adoption of fibres as existing kilns could relatively easily be converted. Although overall not as effective as a kiln specifically built of fibre linings, three benefits vis a vis refractory brick were evident:-

(i) by restricting the heat flow and reducing the actual brick temperature, the heat absorbed by the kiln lining is considerably reduced, hence major fuel economies.

(ii) by restricting the heatflow to the lining, the time taken for the kiln to reach working temperature is reduced, and so output is increased.

(iii) by reducing the average temperature of the brickwork and also the temperature profile within the bricks, the risk of 'spalling' is reduced, and so maintenance costs are reduced.

From data provided by ICI/Morganite Fibres it seems best fuel savings, using 'veneering', are achieved when the cycle time is short and the kiln working temperature is high. The cost of a 51 mm. veneer of SAFFIL fibre is about £100/m^2. For a kiln heated to around 1300°c in 12 hours, the fuel savings are worth (1978) about £1.00/m^2/cycle. The cost of 'veneering' is recovered in 100 cycles; at four firings per week, the payback period is around 6 months. These savings do also depend upon the thermal mass of the brickwork; the thicker and denser the kiln brickwork, the greater is the saving achieved by veneering. Hence it became an attractive proposition where end-users could uprate (usually) their oldest kilns. A number of kiln builders - James Birks Ltd; Shelley Furnaces; BRICESCO have used veneering to establish themselves as L.T.M. kiln builders, and to stimulate interest from end-users in the product. One of the earliest recorded 'veneering projects' was carried out by James Birks for Aynsley China towards the end of 1975 (4.91); I.C.I. market estimates forecast by 1980 for veneering to have completely superceded the traditional 'wallpapering' method using traditional forms of anchorage - as Figure 4.13. illustrates:-

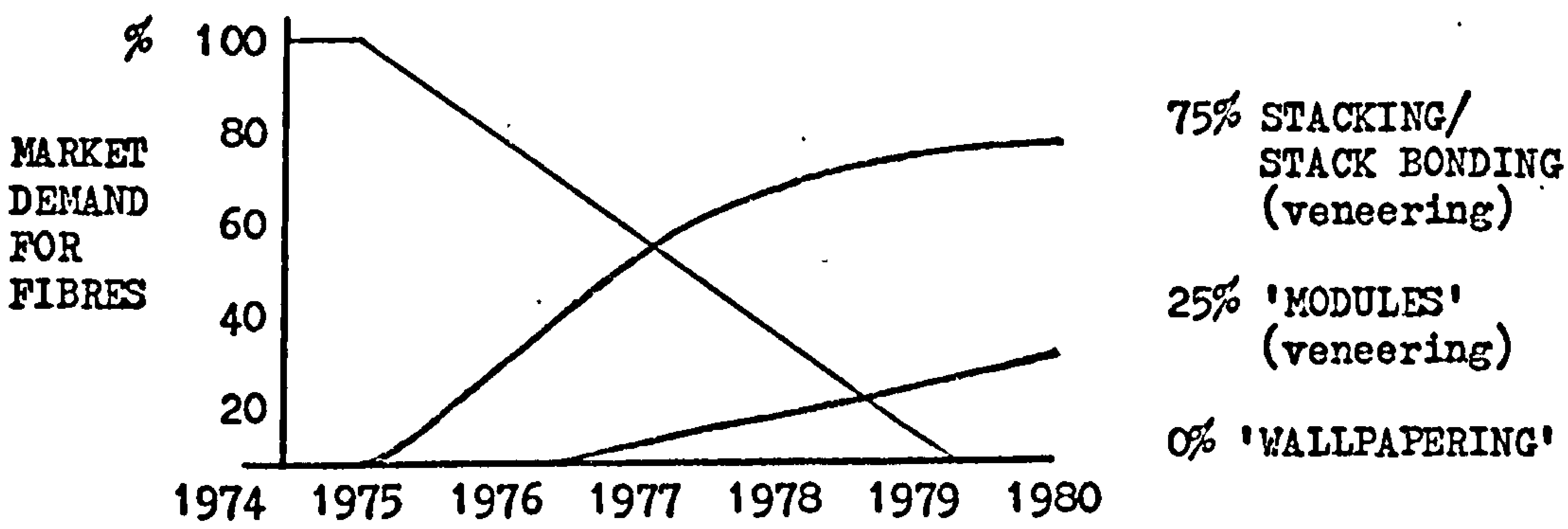


FIGURE 4.13. MARKET DEMAND & TRENDS FOR CERAMIC FIBRES I.C.I. ESTIMATES DR. LANGMAN (Marketing)

Whilst simple venneering has captured the rebuild demand, other alternative forms of anchoring fibre to the kiln wall have since been developed. As early as 1974 it was recognised that the hardest part of the kiln to construct, using fibres, was the ceiling - indeed a number of early failures were due to the roof collapsing (eg the first kiln at Aynsley); Clinotherm Ltd developed its block-like product (using existing fibres) to build ceilings (4.92) - this has become known as 'stacking' or 'stack-bonding'. Strips of ceramic fibre are fixed, edge-on, by refractory cement to a

PHOTOGRAPH GAS FIRED L.T.M. KILN BEING 'VENEERED'

Courtesy : James Birks (Kiln Builder)Ltd.

rigid backing of vermiculite block which, in turn, is fixed by steel pins to a steel back plate. A back-up of mineral wool between the vermiculite block and back plate keeps the thickness and thermal mass of the lining to a minimum. The primary orientation of individual fibres in the hot-face layer is at right angles to the kiln-lining, which was found to have an interesting property. It was found that lower temperature fibres could withstand temperature increases if constructed in this manner; it has meant that FIBERFRAX H (Carborundum) and CERAFIBER (Johns-Manville) have been able to complete with SAFFIL (ICI) at some of the higher temperatures (4.93). Nowadays, in addition to Clinotherm, Dettrick, (DETRICK MODULES), Sauder Industries (PYRO-BLOC) and Johns-Manville (Z BLOCK) all manufacture blocks and modules. Though all methods are termed 'veneering' because in some way the fibre is stuck to a surface, 'stack-bonding' denotes a-fixing the fibres, edge-on, direct to the kiln wall, whereas 'modules are where the fibre is stuck, edge-on, to a backing plate, which is then fixed to metal anchors on the kiln wall.

4.3 ADOPTION & DIFFUSION OF TECHNOLOGICAL INNOVATION IN THE POTTERY KILN INDUSTRY

AN INTRODUCTION

Thus far a number of major technological watersheds have been introduced to the reader. Attention now turns to the interactive effect between the technological innovation and the industrial system(s) into which each was introduced. Over the period of examination, in particular since the 1920's, the environment of the system was in flux, emitting forth pressures to innovate, as in turn, innovation changed the system-environment. As will be illustrated, the establishement of clear cause-effect, independent-dependent variable is clouded by this interactive effect.

CHANGING INDUSTRY STRUCTURE AND INNOVATION (1800 - 1975)

Over this period of study a number of clearly identifiable changes in the structure of the pottery industry can be seen.
In its earliest days the pottery industry was typified by small family businesses. Capital requirements for establishment were modest, enabling the skilled artesan to rent premises, construct a kiln and gradually build up the business with the help of brothers and sons, nephews and cousins. Business failures were common, takeovers and amalgamations were frequent as successful families added factories to their existing ones as the size of the family increased. Warrillow reports over 200 pottery concerns concentrated in the Stoke-on-Trent area by 1849 (4.94). Output tended to be

increased by merger or acquisition rather than thro' technical advance; the structure of the industry - many (still) small firms - tended to preserve the technical status quo. so much so that 'Mintons Ōven' (4.95), first perfected in 1872 , was still the principal kiln used in the industry into the early twentieth century. Family control and poor economic performance are seen as principal contributors to the slow diffusion of the tunnel kiln, first introduced in the late 1920's.

At the outset of World War II a Government Concentration Scheme came into force, involving the closure of conversion to war-work of around 120 pottery factories. At the cessation of hostilities, some efforts were made to raise a fund to purchase these factories cooperatively, and to modernise them. The scheme was abandoned because modernisation on such a scale was beyond available resources of the industry; it was left to the individual factory owners and operators to rebuild an industry and to regenerate pre-war markets whilst being unable to close down to effect modernisation. What modernisation that did take place tended to be contained within the domain of the original factory"... frequently this resulted in factories rebuilding themselves, around themselves while maintaining, and in many cases, seeking to increase output"(4.96).

World War II, the Government Concentration Scheme and the subsequent upsurge in demand for pottery, post - 1948, had a profound effect upon the industry's structure. If wrested in many cases the ties of control away from the original family-entrepreneurs. The need for greater production speeded up the adoption of the tunnel kiln with its promise of uniterrupted flow of output, but the innovation was a two-edged blade. The tunnel kiln required more space than was often available to the small firm operating on the same cramped site since the 1800's. It also required utilisation at near capacity on shift working to be profitable. Whilst the market potential was there to justify expenditure, the cost of installation and operation of the tunnel kiln were frequently beyond the capital resouces of small firms. The introduction of a tunnel kiln disrupted the balance of the production process, so involving firms in substantial supplementary expenditures on buildings, process equipment and the recruitment of skilled labour, scarce after the war. In addition fuel and materials costs pressurised firms to mechanise to keep costs under control. Changes in technology demanded scientific trained managers and kiln operatives, which was difficult for the craft-orientated firm to integrate into still further, the block on the home market by the Government (1946-52) as virtually all production was channelled overseas to earn hard currency developed an immediate need to reassess the firm's marketing, selling procedures; many smaller firms found they could not do so. Many went into liquidation others sought solace and survival in mergers, "... mergers tended to create a feeling of uncertainty and this triggered off further mergers. Owners became convinced that it was essential to grow to survive in competition with larger groups" (4.97). The resultant mergers tended to reduce the family influence in the industry. However the rationalisation did provide an impetus for the adoption of new technologies:-

For example, Allied English Pottery acquired Booth and Colclough Ltd in 1948; between 1948 and 1952 six new tunnel kiln systems had been introduced. In addition the same company's acquisition Ridgeway and Adderley Pottery in 1953 coincided with the adoption of new electric and gas tunnel kilns. A new trend arose in this period, that of acquisition from firms not traditionally associated with the pottery industry; A.E.P. was a subsidiary of Spearshaft Industrial Group Ltd.; Barratts of Staffordshire was taken over by Great Universal Stores in 1948 and finance became available for modernisation; two new gas-fired tunnel kilns were commissioned in 1950.

The structure of the industry underwent a further re-orientation following the implematation of the Clean Air Acts, after 1956 (4.98); further mergers were triggered off (in particular the formation of Staffordshire Potteries (Holdings) Ltd.) where eleven companies merged to be relocated at one site). Again small, less technologically advanced firms were faced with an immediate transference of technology away from the bottle kiln or go into liquidation. As figure 4.14. illustrates, it led to another round of mergers, the reverberations of which were felt in to the 1960's. In addition the downswing in world demand for pottery in the late 1950s - early 1960's (4.99) left firms with spare capacity; the mergers and acquisitions of this period did not therefore generate purchases of new technology as circa 1956, but rather allowed those stronger firms to purchase in many cases technology obtained only a few years earlier.

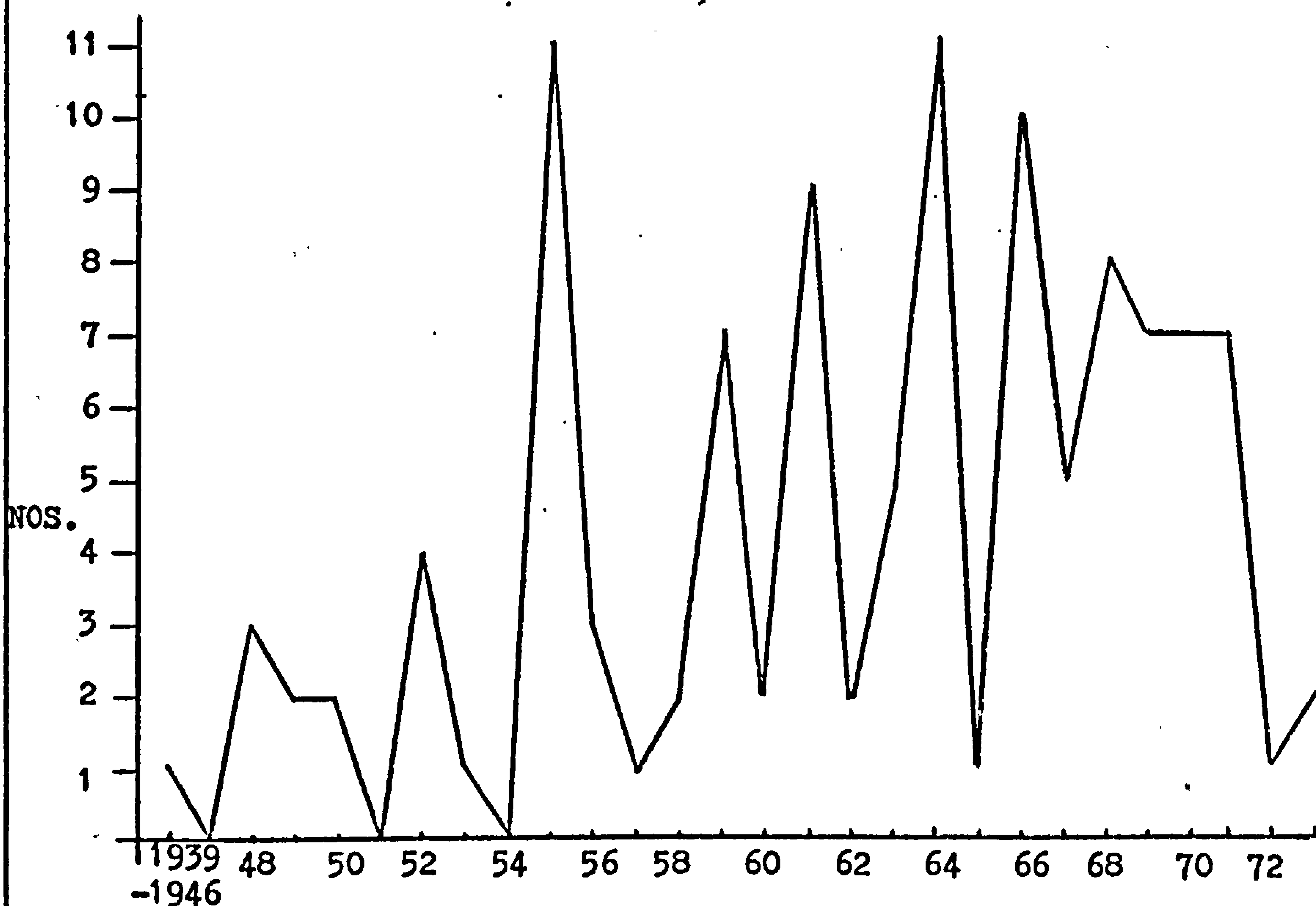


FIGURE 4.14. MERGERS & ACQUISITIONS IN THE POTTERY INDUSTRY 1939-73

For example, H & R Johnson merged Richards Tiles with Campbell Tiles in 1965; both firms had purchased numbers of gas fired tunnel kilns only few years previous. This is the period that marks the commencement of the structure as is prevalent today; that is the formation of a number of large pottery groups, Wedgwood, Staffordshire Potteries, Doulton (later Doulton-AEP), Allied English Potteries. It also marks the growing interest of firms outside the industry acquiring pottery interests(in addition to G.U.S. and Spearshaft Industries mentioned earlier)... Crown House Investments Ltd acquired A.B.Jones and Sons Ltd; (1966)

Robin Wools of Bradford acquired Jackson and Gosling Ltd, Grosvenor China Ltd in 1966. Great Universal Stores bought Furnival (1913) Ltd in 1967. In addition a number of American companies sought diversification in this area- Semart Importing Co. acquired Enoch Wedgwood (Tunstall) Ltd and Crown Staffordshire China Co. Ltd, both in 1964; Carborundum Ltd bought W.T. Copeland & Sons Ltd (Spode Ltd) in 1966 and Interpace Corporation (USA) acquired Myott, Son and Co. Ltd in 1969.

The 'management mood' of the time is captured by the Wedgwood Chairman, (now Sir) Arthur Bryan "... the reasons for take-overs and mergers in this industry are many and numerous. These are not the monopolistic groupings of the giant cartels, but a genuine and necessary step forward in the industry's structure, permitting it to develop and use modern methods, to retain and improve its market and name overseas" (4.100).

Although Sir Arthur's words have rung true in the 1970's with a greater marketing emphasis reflecting the need to match resources to market needs - including the switch to more flexible intermittent kilns - the structure of the late 1960's has by no means remained constant. A number of firms buying-in from outside experienced trading difficulties; Semart Importing sold Crown Staffordshire to the Wedgwood Group (1973); Robin Wools closed both its acquisitions only three years later (1969); Carborundum Ltd. sold Spode Ltd to the Royal Worcester Porcelain Co. in 1975/6.

Even the well-established A.E.P. group experienced integrating problems in the late sixties but were fortunate to have included within the ultimate holding company (S. Pearson & Co. Ltd) a merchant bank (Lazards); S. Pearson's acquired the Doulton Group in 1971 and then began a 'painful' merger of Doulton - A.E.P.

In retrospect the move can judged as buying in pottery-management expertise, as the Doulton management, although on the face of it taken-over, have retained the control of authority.

Similarly the structure of the pottery-kiln manufacturer has undergone change since the 1800's. Traditionally the end-user would construct, or sub-contract the brick laying for the bottle kilns (even into the 1950's the background of many kiln companies were as 'skilled bricklayers'). The development of firms specialising in kiln development/construction in the pottery industry comes with the emergence of the tunnel kiln in the 1920-30's; the name of Gibbons is paramount in this period;a firm already established in other heat-processing areas (eg. Iron and Steel). With only one exception (incidentally the first electrically fired tunnel kiln at Mintons 1927), Gibbons were responsible for all the major electric tunnel kilns laid down up to 1939. Similarly with the gas tunnel kilns, Gibbons were able to establish itself by transferring technical knowledge developed outside the industry a number of other companies did emerge, Smith and Hine, the Davies Company (now both ceased trading) and the Harrop Ceramic Service Company (now BRICESCO). The emergence of the electric intermittent kiln (post 1950) brought forth further new entrants to the industry in addition to those already established (Hawkins, (now James Birks) MacDonald Furnaces, BRICESCO, Gibbons), notably Litherland Elements (now part of Shelley Furnaces/ William Boulton Group) and Electrical Rewinds (now Kilns and Furnaces). Both entered the industry with knowledge of 'electrical technology' necessary to develop the new electrical intermittents.

Further structural changes in the industry's composition began in the late 1960's as the pattern of end-user demand swung away from tunnel kilns in favour of intermittents. Gibbons, for so long regarded as an innovator in the pottery kiln industry has, since about 1965, withdrawn from the industry. It argues that the size of potential demand is only marginal to its interests in iron-and-steel and other heat-treatment processes. It's CPB Division does still produce to order but general maintenance and servicing is left to the smaller kiln-building companies. A number of sources confirm an almost total disinterest by Gibbons in ceramic fibre technology.

However, the transference of technology and experience is evident by the number of ex-Gibbon personnel still involved in the industry; Passmore (DRAYTON KILNS), Dickins (KILN DEVELOPMENT ENGINEER M.E.B.). The rapid development of ceramic fibres in the 1970's, which has radically altered the design and construction of kilns has speeded up the arrival of further new-comers to the industry; in particular the 'veneering process' (4.101) which has much simplified construction. A number of new firms have entered and captured immediate market share; notably D.I.S. (Stoke-on-Trent Ltd), established in 1976, built a gas-fired, ceramic fibre-lined intermittent kiln for Dudson Bros. in the same year.

Whereas examples have been presented to show that structural change in the pottery manufacturer's system has facilitated change, invariably in the kiln builder's industry it has been the emergence of innovation which has precipitated structural change.

INDUSTRIAL LEADERSHIP AND INNOVATION

In response to the research carried out by Webster (4.102) into opinion leadership in industrial systems, fieldwork was conducted to identify the presence of such leaders in the pottery kiln industry (4.103). Each respondent to the Kiln Builder Study was asked if they considered that there were firms operating in the U.K. market who were first to develop major technological improvements (4.104).

The response was

YES	5
NO	8
DONT KNOW	3

Follow-up personal interviews suggested that the NO/DONT KNOW response was given for eithrone of two reasons:

(i) a reluctance to give credit to a competitor

(ii) a response that no firm was 'consistently first';
"several firms have developed <u>one</u> technological improvement, but no firm is <u>consistently</u> among the first" (D. SHELLEY LTD)

Table 4.7. presents the major innovations by kiln builder(overleaf).

	BUILDER	DATE
MODERN COAL INTERMITTENT	self-built	circa 1880
(Minton's Oven)		
GAS-FIRED TUNNEL KILNS	Dressler	circa 1913
experimental		
glost firing	Gibbons	1932
biscuit firing	Gibbons	1934
decorative (muffled)	Gibbons	1937
ELECTRIC-FIRED TUNNEL KILNS	Mocre-Campbell	1927
decorative firing		
glost	Gibbons	1938
biscuit	Gibbons	1946
glost(belt rather than truck)	Birlec	1946
decorative (belt)	Birlec	1947
glost passage-kiln	Gibbons	1948
biscuit passage kiln	Birlec	1953
GAS FIRED INTERMITTENTS	Gibbons	1939
experimental		
glost/biscuit	Birks/W,Mid. Gas	1958
ELECTRIC FIRED INTERMITTENTS		
decorative	Lockett(self-built)	1946
biscuit	Hawkins/MEB	1952
glost	Hawkins/MEB	1953
GAS FIRED CERAMIC FIBRE LINED KILN		
biscuit	Shelley/ICI	1974
glost	Shelley	1975
ELECTRIC FIRED CERAMIC FIBRE LINED KILN		
decorative	Drayton/MEB	1972
glost/biscuit	Drayton/MEB	1974

TABLE 4.7. KILN INNOVATORS 1800 - 1975

From the 5 YES responses, four firms were named:

SHELLEY FURNACES (twice)

GIBBONS BROS

MORGANITE CERAMIC FIBRES

PYE-ETHER LTD

Interestingly, only Shelley Furnaces and Gibbons Bros. are kiln builders! Morganite supply refractory linings and Pye-Ether fuel burners.

It became clear from the personal interviews that the time perspective used to ordain 'leadership' varied between respondents. Gibbons Bros featured because of the company's long history of 'firsts' in the industry, in particular early developments in tunnel kilns (1920s - 30s), whereas Shelley Furnaces receive the accolade for more recent achievements, in particular, being instrumental in the construction of the first commercially successful ceramic fibre-lined kiln for the Wedgwood Group (1974).

Factors attributed to these companies' positions of prominence were (4.105):-

(i) skilled labour force

(ii) company profitability

(iii) an efficient management structure

(iv) sales volume

The number of scientific personnel employed and size of the R & D budget were considered to be of a lesser importance.

All respondents were asked to specify 'influencers' within the industry-system; those not necessarily innovating but who are 'watched' within the industry. Response, as to whether such influencers existed, was divided evenly (4.106).

YES 8

NO 8

Of the NO's it was difficult to ascertain as to whether the respondent was reluctant to admit following a competitor. The general response was that the structure of the industry - relatively few kiln builders - led to a constant surveillence of all competitors.

From those respondents who indicated that 'influencers' did exist, the following companies were named:

SHELLEY FURNACES

GIBBONS BROS.

JAMES BIRKS

DRAYTON KILN

In order to reaffirm the identification of leaders/influencers a similar exercise was conducted in the second field study (to Kiln Customers, Suppliers and Informed Persons) (4.107). Each respondent was asked if they considered there to be a kiln builder operating in the U.K. who was consistently amongst the first develop and produce major technological improvements in pottery kilns; for sake of comparison responses of end-user are separated from the other interviewers. Table 4.8. illustrates:-

	END-USERS	OTHERS	Σ
YES	8	4	12
NO	2	5	7
Dont Know	1	5	6

TABLE 4.8. IDENTIFICATION OF LEADERS BY RESPONDENTS TO SURVEY II (4.108)

Comments from the NO/Dont Knows was attributed to the interpretation of the word "consistently'; it was felt that the same firms did not consistently innovate. Some indication was given that the pressure to innovate ".. comes from outside the kiln industry" (EUROTHERM) - a point examined later.

Having presented a list of kiln-builders (4.109), each respondent was asked to rank three 'whom you feel are leaders of their industry'. An overall ranking was estimated using an arbitrarily selected series of weightings namely:

a firm ranked 1st - weighting of 4
2nd - weighting of 3
3rd - weighting of 2
a firm named but no rank - weighting of 1

Table 4.9. shows the computed average ranking (response x weighting) reported by end-users (ie pottery manufacturers), other respondents, and a comparison with the results obtained from Study I:-

RANKING KILN BUILDER.	RANKING ALL RESPONDENTS	RANKING END-USERS ONLY	RANKING OTHER RESPONDENTS ONLY	IDENTIFIED AS INNOVATOR INFLUENCER IN SURVEY I
BRICESCO	1	1	1	
GIBBONS BROS.	2	2	3	*
RIEDHAMMER	3	3	6=	
DRAYTON KILN	4	4	4	*
SHELLEY FURNACES	5	6	2	*
JAMES BIRKS	6	5	6=	*
KILNS & FURNACES	-	-	5	

TABLE 4.9. TOP SIX RANKED INNOVATORY KILN-BUILDERS

Generally one sees a high degree of agreement between 'leaders' as identified by end-users and by other respondents; each clearly identify the industry leader as BRICESCO. The most marked disagreement between the two respondent-groups are the ranking of RIEDHAMMER and SHELLEY FURNACES. One possible explanation hinges on the fact that Shelley Furnaces have been instrumental in a number of modern developments, manifest more in dealings with suppliers than with end-customers, whereas Riedhammer have been a consistent steady performer in the industry. Although Riedhammer claim early interest in ceramic fibre development, it has yet to complete a commissionable kiln, although one is presently under construction. In addition Riedhammer have sought to speed up its assimilation of current technical knowledge by recruiting personnel from

BRICESCO. What is less explainable is the clear nomination of BRICESCO in Survey II yet which did not feature at all in Survey I. The company itself declined to participate in Survey I (to Kiln Builders) but some indication from other kiln builders, responding, independently, might have been expected to justify the company's nomination of 'leader' by the latter group of respondents in Survey II. It does raise the question as to whether different perspectives of 'leadership traits' existed between industrial systems, though both sets of respondents were asked to relate 'leadership' to the same criteria - sales volume and technical achievement. One indication provided was that end-users and suppliers involved in the adoption of ceramic refractory fibre were less supportive of BRICESCO's premier position, so possibly varying time scales for attributing 'leadership' nomination might have caused spme of the discrepancy. It became apparent that BRICESCO are perhaps the least helpful and communicative of all the kiln companies operating in the industry and so other builders were less inclined to give credit to a successful competitor. The outcome does raise a methodological problem of leadership identification in industrial systems.

The identification of leaders/influencers is of less importance than the subsequent examination of their relative importanoe in the adoption, diffusion process. From the personal interviews of kiln builders some indication was given that pressures to innovate arose in the end-user system rather than in the kiln-builder system, that is demand-pull rather than technology-push innovation. To substantiate these findings, respondents to Survey II were asked to consider a number of innovation pressure sources and to rank their importance (4.110). Again a distinction was made between responses made by end-users and other respondents to identify possible differences. As before, an overall average ranking for each pressure source was completed using simple weightings; Table 4.10 illustrates:

INNOVATION PRESSURE SOURCES	RANKINGS END-USERS (Customers) ONLY	OTHER RESPONDENTS	ALL RESPONDENTS
Customer Influence	1	1	1
Competitive Pressure	2	2	2
Kiln Builders own R & D	3	4	3
Supplier Influence	4	3	4

TABLE 4.10. INNOVATION PRESSURE SOURCES ON THE KILN BUILDER AS REPORTED BY KILN CUSTOMERS, SUPPLIER AND INFORMED PERSONS

The findings sustantiate that the main source of pressure on the kiln-builder comes from the customer, either through direct requests to incorporate new technology or indirectly through competitive pressures where other kiln builders are satisfying market needs better. Supplier influence is rated somewhat higher by suppliers (as might be expected) but the low ranking of the importance of technology push, that is, the builders own R & D, reinforces the findings presented earlier where builders themselves considered size of R & D budget not a prerequisite for leadership.

The implications are clear. Innovation and the subsequent diffusion (in the kiln building system) are dependent upon the behaviour of the end-user (pottery manufacturers) system.

Given the importance of the end-user system regarding the rate of technological innovation, can 'leadership' be identified? In attempting to answer this question two comprehensive investigations were undertaken, using Rogers adopter categories (4.111). Criticism of his research methodology has been in terms of its 'predictive ability' rather than the formulation of what are only 'ideal types'. He delineated adopters using five categories, identified by the first 2½% to adopt (Innovators), the next 13½% (Early Adopters), next 34% (Early Majority), next 34% (Late Majority) and the final 16% as Laggards. Obviously such as approach can only be practically used on historical data when the innovation is known to have completely diffused. This is seen to apply in both the examples provided below, where the last commissioned electric tunnel kiln was circa 1953 and the last commissioned gas tunnel kiln was circa 1969. For comparative purposes both examples included only firms manufacturing domestic pottery.

THE DIFFUSION PROCESS FOR ELECTRIC FIRED TUNNEL KILNS 1927 - 1953 : IDENTIFICATION OF ADOPTER CATEGORIES

Between 1927 and 1953 62 pottery manufacturers adopted this type of kiln. Table 4.11. presents the complete list, delineated using Roger's adopter categories, and Figure 4.15. presents the results in a cumulative/diffusion form expressed over time.

	Mintons A. Wood + Sons	INNOVATORS 1927-30
Empire Porcelain A. Meakin J. Maddock J + G Meakin	Coalport China W.H. Grindley Wiltshaw + Robinson Paragon China	EARLY 1931-39 ADOPTERS
Susie Cooper Wedgwood Shelley Pottery Barker Bros. Hudson + Middleton Leighton (1939) Ltd. Thos. Pool / Gladstone Palissy Pottery Shore + Coggins E. Brain Thos. Cone Booth + Colclough	Jackson + Gosling Geo. Clewes Ltd. A. Clough J. Tams Crown Staffs Staffs Teaset J. Shaw A.B.Jones Salisbury Crown	EARLY 1939-49 MAJORITY
N.S. Tech. College Wade Heath C.W.S. E. Cotton T.C. Wild Washington Pottery Parkhall Pottery Cartwright + Edwards J. Aynsley J.H. Barratt (1929)Ltd. Midwinter Dunn-Bennett	R. Sudlow Biltons (1912) Ltd. Adderley Chapmans (Longton)Ltd. James Kent Lawley GP Broadhurst Pottery Ford + Sons Diamond Tile	LATE 1949-51 MAJORITY
Rosina China Davidson Ltd. Radford Forrester + Sons	Wildblood + Taylor Keele St. Pottery Staffs Pottery Thos. Lawrence H. Aynsley + Co.	LAGGARDS 1951-53

TABLE 4.11. DIFFUSION PROCESS FOR ELECTRIC-FIRED TUNNEL KILNS

From the first to last recorded commissioning of an electric fired tunnel kiln time span approximately 26 years. Whilst the causes, and consequences explaining the lag between first adopters and others are investigated elsewhere in the text, the reader is able to compare this industrial diffusion example with those quoted earlier in the text (4.112), with similar extended adoption times. The somewhat apparent reluctance to follow without ' proof of performance' (albeit technical and / or economic) is demonstrated by the fact that there was a three years gap between the first commissioned kiln, at Mintons, and the second at Wood and Sons. Early resistance to electric firing lay partly in the manufacturers commitment to his existing capital on the grounds of the level of technical knowledge in the firm and his inability to consider replacing capital due to poor profit performance. Electric kilns, although relatively simple to operate probably appeared the greatest departure at the time to current firing practices. It may have seemed difficult to reconcile early potters, given the small scale of operations, to having possibly coal-fired (bottle-kilns) intermittents, gas-fired biscuit/glost tunnel kilns and eledtric fired decorating tunnel kilns in one factory! Fuel and labour economies were best achieved using the fewest number of permutations on one site; the apparent benefits of electric decorative firing (greater fuel and kiln efficiency, less wastage of fired ware) could be offset by the higher cost of fuel together with the problems of integrating electric firing into existing production practices. Hind comments in 1937 (although wrongly as Table 4.11. suggests) ".. there are no electric kilns in the U.K...

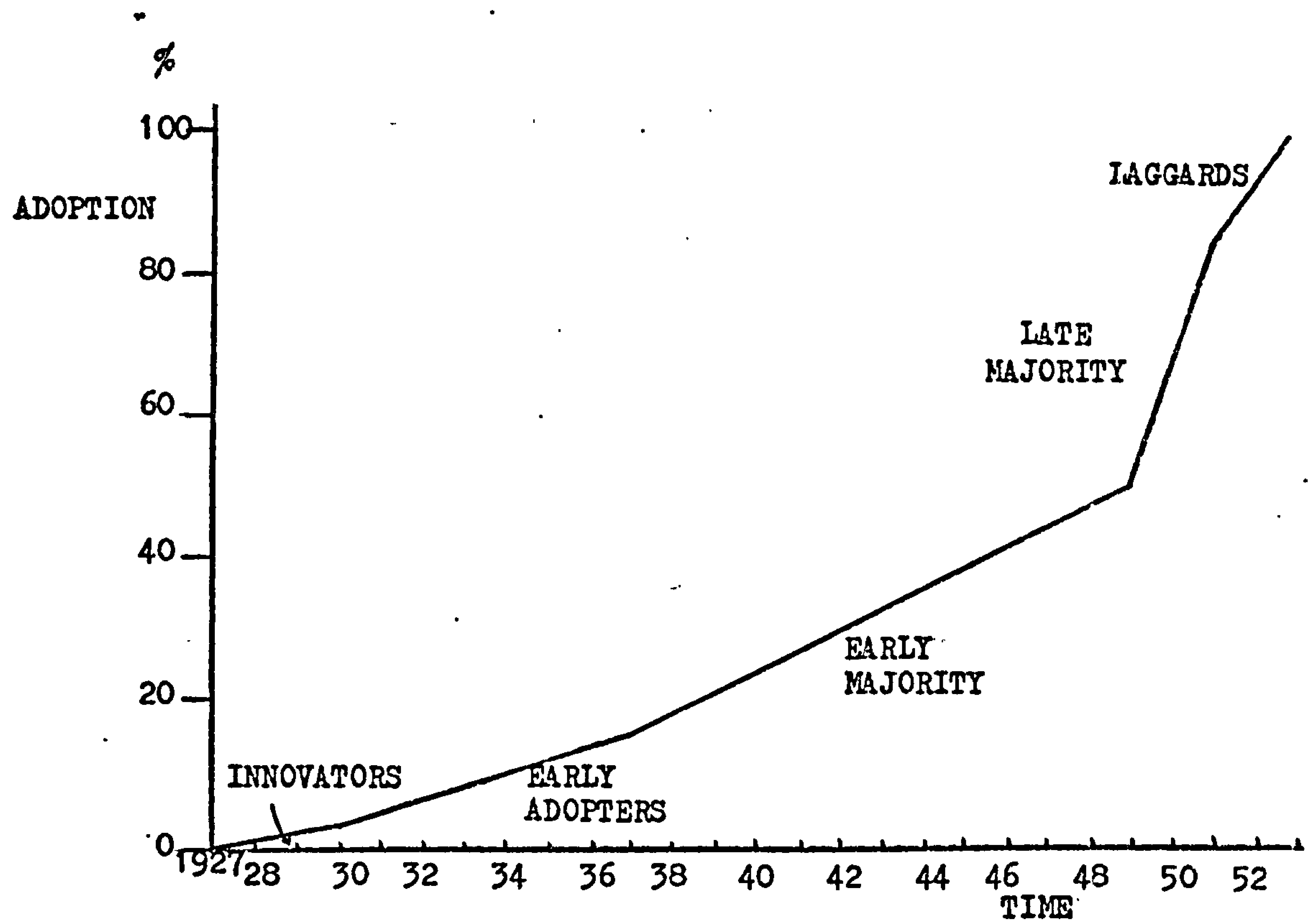


FIGURE 4.15. DIFFUSION PROCESS ELECTRIC-FIRED TUNNEL KILNS 1927-1953

the subject has received no practical attention whatsoever in this country... there is no immediate project of extensive British development (of electric kilns) on account of the high cost of the power " (4.113). It does seem to indicate that there was little cross-fertilisation of ideas, experiences on electric firing between firms up to the beginning of the second world war. Doubtlessly the period of war distorted the diffusion curve, where the Early Majority stage spans ten years (4.114), whereas the late Majority and Laggard stages, again due to exogeneous factors (the subsequent upswing in demand), were comparatively short (namely two years). On the face of it, this diffusion curve certainly corresponds more to a theoretical J-shape rather than the traditional S-shape (4.115).

THE DIFFUSION PROCESS FOR TOWN GAS FIRED TUNNEL KILNS 1932 - 1969 : IDENTIFICATION OF ADOPTER CATEGORIES

Between 1932 and 1969 85 pottery manufacturers adopted this type of kiln. Table 4.12. presents the complete list (again using Roger's adopter categories),

	Conway Pottery	INNOVATORS 1932-36
	Portland Pottery	
Smith + Warrilow	C.W.S.	EARLY ADOPTERS 1936-37
T.A. Simpson	Alcock Lindley,Bloor	
Mintons	J. Maddock	
J.T. Grice	Minton-Hollins	
Copelands (Spode)	T + R Boote	
Denis Alexander		
Geo. Wade	Sadler Pottery	EARLY MAJORITY 1937-48
Howard Pottery	Elgreave Pottery	
Modern Ceramics	Doulton	
Biltons(1912)Ltd	Wedgwood	
Booth + Colclough	Broadhurst Pottery	
Barker Bros.	Bridgwood	
Wade Heath	Gibsons Pottery	
Johnson Bros.	Floral China	
J + G Meakin	Enoch Wedgwood	
A.Wood + Sons	Globe Pottery	
A.G. Richardson	W.H. Grindley	
S. Fielding	Shaw + Copestake	
RH + SL Plant	W.Adams	
T.C. Wild	Beswick	
A. Meakin		
W. Kent		
J.E. Heath	Cartwright + Edwards	LATE MAJORITY 1948-55
Crown Staffs	A. Clough	
Geo. Jones	Staffs Pottery	
Myott + Sons	Midwinter	
J. Shaw + Son	N.S. Pottery	
Denton China	Thos.Poole/Gladstone	
Burgess + Leigh	Staffs Teaset	
British Anchor	Adderley	
E. Brain	E. Cotton	
Barratts of Staffs	Taylor + Kent	
Hammersley China	Eddowes	
New Chelsea Porcelain	Paragon China	
Price Bros.	J. Aynsley	
A.J. Wade	Shore + Coggins	
Dunn-Bennett		
A.B. Jones		
Wildblood + Taylor	Arrowsmiths	LAGGARDS 1955-69
Swinnerton Pottery	A.T. Finney	
Amerson Pottery	Grove China	
Trentham Victoria	Thos. Cone	
J. Tams	Paramount Pottery	
H + E Smith	A.J. Wilkinson	

TABLE 4.12. DIFFUSION PROCESS FOR GAS-FIRED TUNNEL KILNS

and Figure 4.16. present the cumulative diffusion curve.

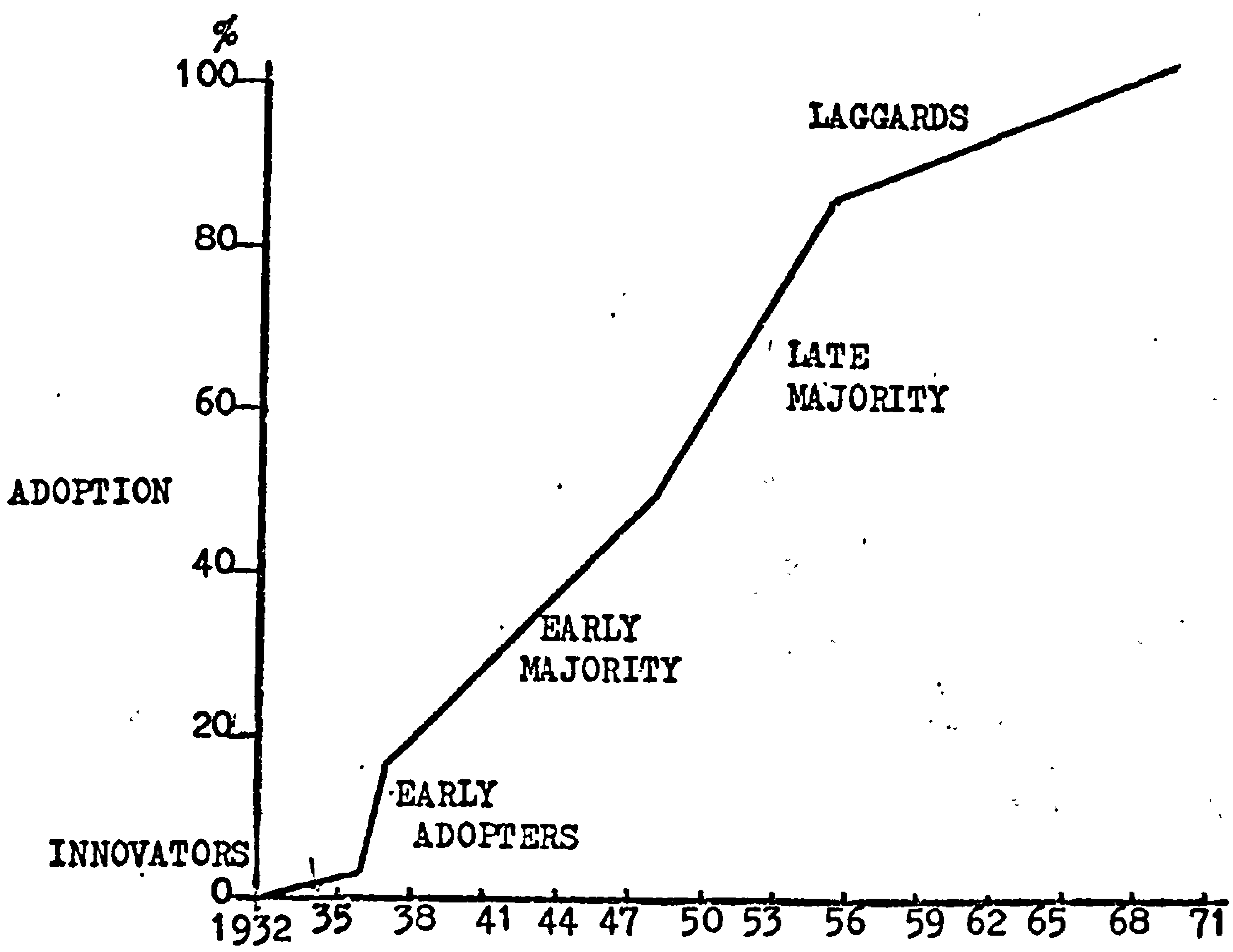


FIGURE 4.16. DIFFUSION PROCESS TOWN GAS-FIRED TUNNEL KILNS 1932 - 1969 (DOMESTIC POTTERY USERS ONLY.)

The first gas-fired tunnel kilns in fact were developed, by Dressler as early as 1912, but were fired using 'producer-gas' (4.116). Although town-gas became available circa 1922, the transition from producer gas to town gas firing was slow because of a number of factors:

(i) end-users commitment to existing capital plant; producer-gas kilns were still virtually new, and certainly not depreciated, when town gas became available in the 1920's.

(ii) the availability of supply of town gas; the gas industry was still involved in laying pipelines.

(iii) a general resistance to innovation

(iv) the initial costs of town gas (both costs of conversion and cost per therm) slowed the diffusion process

The first town gas-fired tunnel kiln built by Gibbons (using the Dressler design under licence) was in operation at the Conway Pottery in 1932. Although records show that the second adopter was the Portland Pottery (1936), this only describes the diffusion process amongst producers of tableware/decorative china. The tile manufacturers were quicker to recognise the benefits of this method of firing, as Figure 4.17. illustrates (overleaf). Between 1933 and 1938, all the major tile manufacturers of that time had installed town gas fired tunnel kilns for biscuit and glost firing. Further new firms became involved immediately post war as housebuilding began; the last recorded 'first purchase' was Barratts Tiles as late as 1956/57, a period marked by the first gradual and later speedy transition to other forms of more economical fuel and the restructuring of the industry. Up to this period most houses built included more than one fireplace, but as the demand for central heating and gas fires the market for fireplace tiles contracted considerably. A number of companies ceased trading, others moved into the production of domestic earthenware, whilst others sought survival in mergers and acquisitions in particular the merging of H & R Johnson and Malkins tiles (1964); Richards and Campbell Tiles in 1965 and the subsequent merger of H & R Johnson and Richards-Campbell Tiles in 1968. With this latter merger Johnson-Richards Tiles (now the major producer) instigated a new fuel policy

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FIGURE 4.17 DIFFUSION PROCESS TOWN-GAS FIRED KILNS 1933-1971: TILE MANUFACTURERS

(butane and oil) which resulted in a steep net decline in the use of gas fired tunnel kilns in the industry.
For technical and economic reasons, to be discussed later, the diffusion of this kiln type amongst domestic pottery manufacturers was much slower, extending over a period of 34 years; the diffusion curve representing the more traditional S-shape common in diffusion literature.

Before seeking to examine the causes of rates of diffusion the question remains 'are there firms (end-users) who are regularly innovatory'? Is there an identifiable innovatory trait? And if so, what is its nature? Earlier it was established that pressures to innovate in kiln technology more likely arise in the end-user system. What was less certain from the research was whether such pressures arise from the same end-users over an extended period of time. Writers have stressed the importance of the 'time' variable in diffusion studies, yet it is this self-same variable that makes difficult, comparisons in industrial systems. Innovation of the discontinous type appears infrequently in industrial systems and having once appeared, is likely to alter the system's environment. In addition the industry is constantly in a state of change due to changes in not only technology but also nature of ownership, competition, market demand, government and legal regulations and so on. In effect the conditions which possibly led a firm to be innovatory in one time period may have so changed in a second time period as to make meaningful comparisons difficult. For example Table 4.11. presented innovators and early adopters for the electric tunnel kiln, but as Table 4.13. (overleaf) shows, ownership and with it managerial style, product ranges and so on have changed.

Equally investigation cannot be undertaken to judge why innovation took place because of the temporal gap.

MINTONS	now controlled by AEP-Doultons
A.WOOD + Sons	still independent
EMPIRE PORCELAIN	acquired by Qualcast Ltd, closed 1967
A. MEAKIN	now part of Myott-Meakin Ltd.
J. MADDOCK	still independent
J + G MEAKIN	now part of the Wedgwood Group
COALPORT CHINA	now part of the Wedgwood Group
W.H. GRINDLEY	acquired by A. Clough Ltd.
WILTSHAW + ROBINSON	present cannot be traced
PARAGON CHINA	AEP-Doulton

TABLE 4.13. CURRENT OWNERSHIP OF EARLY ADOPTERS OF ELECTRIC FIRED TUNNEL KILNS

Table 4.14. below highlights the major kiln innovations and innovatory organisations (where records permit);

INNOVATION	INNOVATORY END-USERS
Electric fired Tunnel Kiln (1927-53)	MINTONS A WOOD + SONS EMPIRE PORCELAIN A.MEAKIN J. MADDOCK J+G MEAKIN COALPORT CHINA
Gas fired Tunnel Kiln (1932-69)	CONWAY POTTERY PORTLAND POTTERY SMITH+WARRILOW MINTONS J.T. GRICE SPODE LTD.
Electric fired Intermittents (1956-72)	EDWARDS+LOCKETT SHELLEY POTTERIES EMPIRE PORCELAIN
Gas fired Intermittents (1957-74)	SPODE LTD. THOS. POOLE/GLADSTONE CHINA AMERSON POTTERY
Elec. fibre lined Intermittents (1972-)	AYNSLEY CHINA ROSINA CHINA
Gas fibre lined Intermittents (1974-)	COALPORT (WEDGWOOD) DUDSON BROS. BRAMHAM POTTERY

TABLE 4.14.

Although certain organisations, Minton, Empire Porcelain, Spode, Coalport China, do feature as innovators of a number of new technologies, of less certainty is why this should be so. This scope of this particular piece of research did not encompass the further depth in historical research that would have been necessary to establish innovation rationale during the 1920's-50's indeed, reasons for slow diffusion will be presented. The radical restructuring of the industry between the 1920's and today gravitate against identifying reasons.

As to the influence adoption has upon other firms can be partly discussed in terms of the observable slow diffusion processes. It seems less likely that firms adopt because so-and-so has but rather because there are observable benefits from doing so;however varying degree of managerial conservatism of the same facts may account for some adopting earlier than others (4.117). On the other hand, the recent launch of SAFFIL ceramic fibre by I.C.I. was (it is believed by the supplier) assisted in achieving market acceptance by the adoption of the Wedgwood Group at the Coalport Works.

Evidence was provided to suggest that it is now common practice to receive competitors on factory visits to demonstrate the operation of new technologies (although findings/output tend to be witheld) which does aid the diffusion of the concept; what is less certain is whether the site where the demonstration is held (ie. the innovating organisation)itself aids credibility! Certainly this is an area where more research is needed.

ECONOMIC PERFORMANCE

AND INNOVATION DIFFUSION

A number of writers consider the rate of adoption and diffusion to be predominantly (or entirely) a function of economic performance; what is less clear is to whether past or future projected performance should be considered. In practice it becomes difficult to isolate any particular variable in such a definite way, because economic performace itself is a function of a wide number of influences - technology, demand competition, government legislation, even wars. These influences in turn affect managerial attitudes towards risk taking and perspectives of profit expectations.

The initial growth period for the pottery industry (1800-1900) began to decline after the end of the first world war. During the 1920's the industry contracted and suffered severe fluctuations in output (Figure 4.18. illustrates output 1925 -1974).

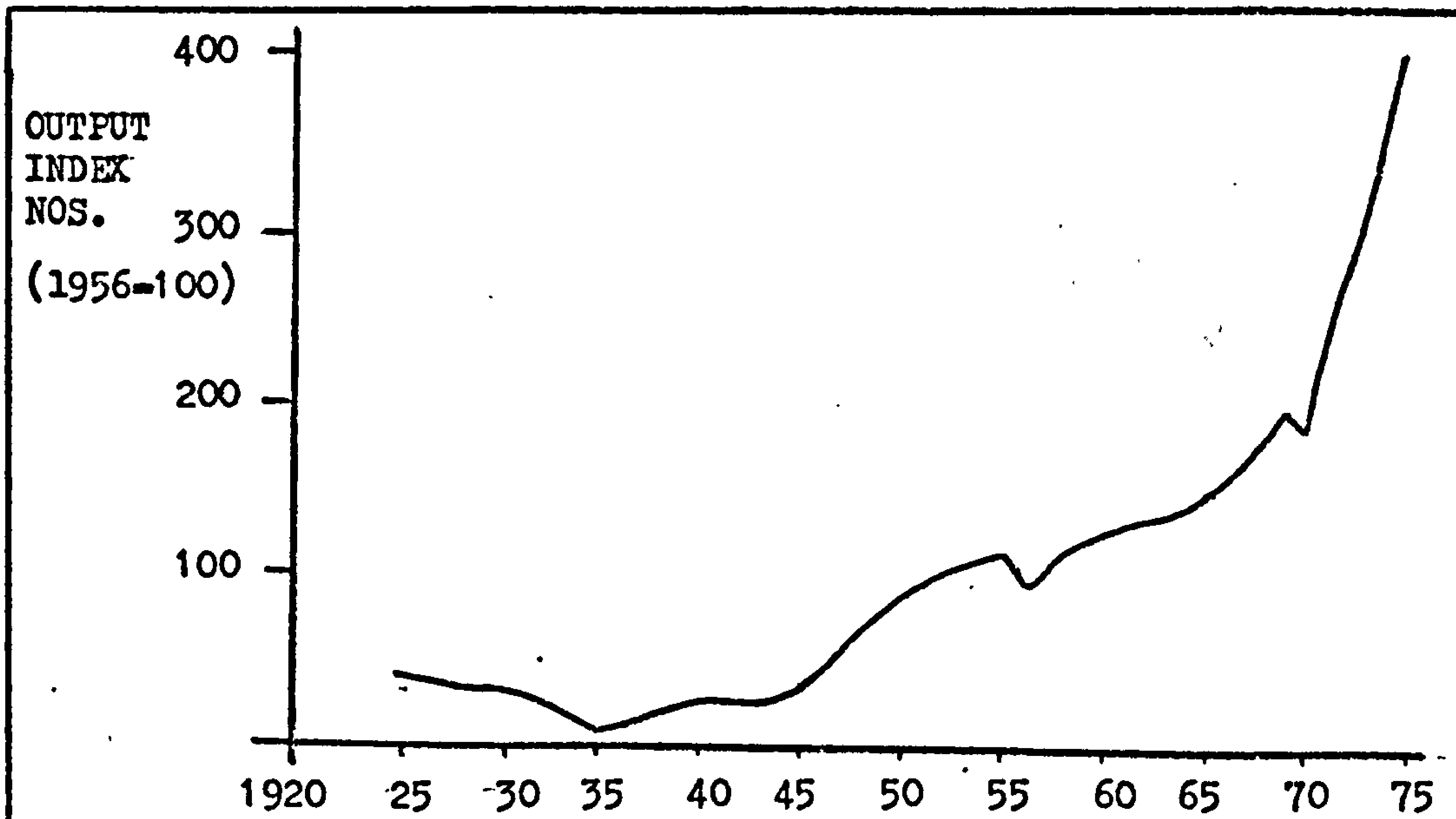

FIGURE 4.18 POTTERY INDUSTRY OUTPUT 1925-1974

(Source Annual Abstracts)

Over this period the rate of profit on turnover was about 4% (4.118). Along with other staple British industries, such as wool,cotton,and coal, the pottery industry suffered from a loss of export markets and a failure of the home market to take-up the slack; the outcome was high excess capacity; Figure 4.19. illustrates export details for the industry over the period 1935-1973: the reader should note that export volume rather than value is depicted because of its closer correlation with kiln capacity, however in terms of value, china ware per thousand ton far exceeds the other two categories (4.119).

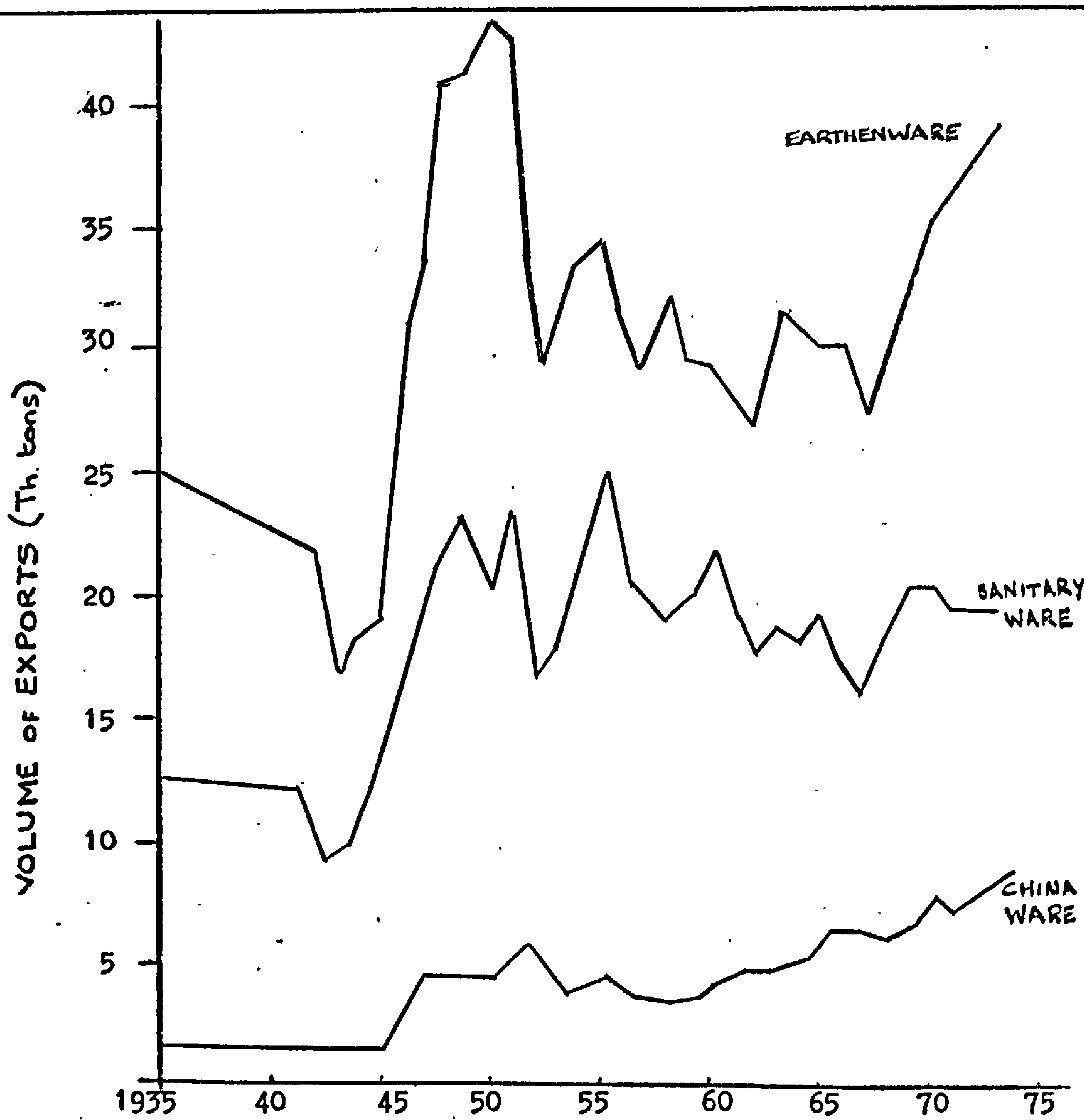

FIGURE 4.19. EXPORTS 1935-1973

There was a substantial boom between 1945 and 1955; from 1945 until 1952, all first grade pottery production was Government-directed overseas in a bid to generate foreign currency (Figure 4.19. illustrates the effect); increased sales (demand outstripped supply) were given a much higher priority than technological development. The loss of war-time production for both exports and the home market was made good by the boom. In the immediate post-war years many small firms entered the industry, made high temporary profits, then faded after 1955. For the established firms, resources to replace aging technology were not always readily available; the 1920's and 1930's had not been too profitable and it was customary for firms to depend upon retained profits to finance investment, to do otherwise might lose 'family control'. Buildings and equipment were antiquated and unsuited to the post-war market conditions, scarce labour and high wages.

It was the advent of the tunnel kiln in the 1920's which provided the means for the industry to

(i) achieve economies of large scale

(ii) produce better ware

There exists no collaborated evidence to suggest Mintons or A.Wood and Sons (electric fired tunnel kiln innovators) or Conway Pottery or Portland Pottery (gas fired tunnel kilns innovators) were anymore profitable before or immediately after adoption. Indications are that adoption of technological innovation was closer related to the desire to produce better, uniform ware.

It is noticeable that the early adoption stages for both electric and gas-fired tunnel kilns take place during a period of depressed economic performance in the industry and market. No doubt the

period of war (1939-45) distorted the forecasts and expectations of the early adopters but it did mean that they were more capable of marketing the upsurge in demand post 1946. It is easier to match Early Majority categories to industry performance, who adopted more likely in reaction to market forces rather than following earlier adopters. Certainly market demand influenced the diffusion process for both innovations in its later stages.
The immediate post-war boom period tailed off around 1951, and was most marked by a fall in export demand (partially caused by the firms themselves switching to home market demand which was 'easier' to satisfy). The consequences of the Clean Air legislation (1956) are discusses elsewhere (4.120) but as output fell during the period of technology-replacement, so did profits. The period 1956-1964 is marked by slow growth and a further instructing of the industry through mergers and acquisitions, discussed earlier (4.121). The favourable upturn in economics at home and overseas (especially after devaluation of stirling) marks an increase in the demand for pottery in the mid 1960's. The point must be reemphasised regarding the importance of exports to the pottery industry. The British pottery industry is highly dependent upon a buoyant export market, so much so that export performance is used as the indicator of business fortune.
In 1910, approximately 33⅓% of the industry's total output was exported. As Table 4.15. shows this concentration has not diminished:

YEAR	TOTAL SALES	EXPORT SALES	% OF TOTAL
1956	28195000	17.100,000	60
1960	33894000	17300 000	51
1965	41477000	19.900 000	48
1970	51777000	30400 000	59
1972	77135000	38000 000	49

Table 4.15. POTTERY INDUSTRY : EXPORTS AS A PERCENTAGE OF TOTAL INDUSTRY SALES

If one considers that for many companies exports account for 75% plus of total output, upswings and downswings of these markets affect decisions to purchase technology.

MANAGERIAL ATTITUDES

AND INNOVATION ADOPTION

It has been suggested that output/sales performace alone does not fully explain the causes of technological innovation adoption in the pottery / pottery kiln industry. Traditionally owners and managers in the industry were perceived to be most conservative; as Eyles comments "... the age-old empirical methods to which many British potters paid indiscriminate homage, often mistrusting the findings of ceramic scientists; the dynastic family influence particularly marked in Staffordshire; the lure of quick personal profits without regard for future needs of their factories; the deeply rooted conservatism and resistance to change in what was still mainly a craft industry; the romantic but often fictitious aura of mystique that pervaded much of the industry- these were insidious dangers in an age in which the fruits of scientific research, modern technology, mechanisation, market research and similar trends in production and selling were being exploited not only by newer industries, untrammelled by the past, but also by modern potters in the United States and other countries"(4.122).

Eyles comments seem unheeded when two researchers, commenting on the early adoption of ceramic refractory fibres in the early 1970's, write "... although ceramic fibre blanket insulation has been in use for several years as high temperature furnace lining material.. little investigation has been made of its physical properties" (4.123). As part of the study, investigation was made as to kiln builder attitudes towards technological innovation (4.124). Each respondent (to Survey I) was presented with a number of pre-tested relevant statements and asked for their agreement or not. Responses were as follows:- (table 4.16.)

	Stron -gly Agree	Agree	Neither Agree nor Disagree	Disa -gree nor	Stron -gly Disa gree	No Answer
1. WE BELIEVE THERE IS A NEED TO BE AT THE FORE FRONT OF POTTERY KILN DEVELOPMENT.	6	3	5			2
2. THERE IS PRESTIGE TO BE GAINED FROM BEING FIRST.	3	7	2	3		1
3. WE LISTEN TO WHAT THE CUSTOMER WANTS AND THEN WE MAKE IT.	4	5	5			2
4. THERE ARE PROFITS TO BE GAINED BEING FIRST.	3	4	2	6		1
5. PROVEN METHODS ARE BEST.		7	3	3		3
6. WHY CHANGE FOR CHANGE SAKE.	5	5		3	2	1
7. NEW PRODUCTS ARE ASSOCIATED WITH DEVELOPMENT, PRODUCTION & SELLING PROBLEMS.	2	10	2			2
8. WE BELIEVE IN LETTING OTHER FIRMS FIND THE PROBLEMS AND THEN WE IMPROVE THEIR IDEAS.			7	4	3	2
9. WE ALWAYS SEEM TO NEED NEW MEN + EXPERTISE TO GET IT RIGHT.				9	4	3
10. ITS TOO COSTLY TO PERSUADE CUSTOMERS TO ADOPT NEW IDEAS.		3	3	8		2
11. NEW PRODUCT DEVELOPMENT IS TOO RISKY.		2	4	8		2

TABLE 4.16. KILN BUILDER RESPONSES TO STATEMENTS RE ADOPTION OF TECHNOLOGICAL INNOVATION

Few respondents disagreed with statements concerned with maintaining the technological 'status quo' - namely statements 5, 6 and 7, whilst still maintaining the need to be 'at the fore front of kiln development' (statement 1) with the accruing prestige (statement 2); no firm was prepared to indicate that it followed development experience of other firms (statement 8). Similarly it seems that technological innovation can be catered for within the firms current 'technical experience' (statement 9) although the industry observed over the time period 1920-75 does suggest that it was the inability to adjust to new technologies (eg coal to gas/electric firing) that led to the demise of some and the establishment of new kiln building firms.

Consensus to 'we listen to customer needs' (statement 3) need not necessarily indicate a 'marketing orientation' as suggested by the SAPPHO studies but rather provides supportive evidence that sources of pressure to innovate arise outside the kiln builder system. Hence the negative response to innovation and risk (statement 11); close cooperation with end-user, operating to end-user specifications, as happened with Wedgwoods/Coalport and Shelley Furnaces in the development of the first gas-fired ceramic fibre lined intermittent kiln, reduces the innovatory risk to the builder.

Estimates were made to identify, if any, differences in response - deviations from an average industry response - made by those kiln firms specified as innovatory or possessing 'leadership traits' (4.125). Figure 4.20 (SHELLEY FURNACES) and 4.21. (GIBBONS BROS) contrast innovators vis a vis the industry average response.

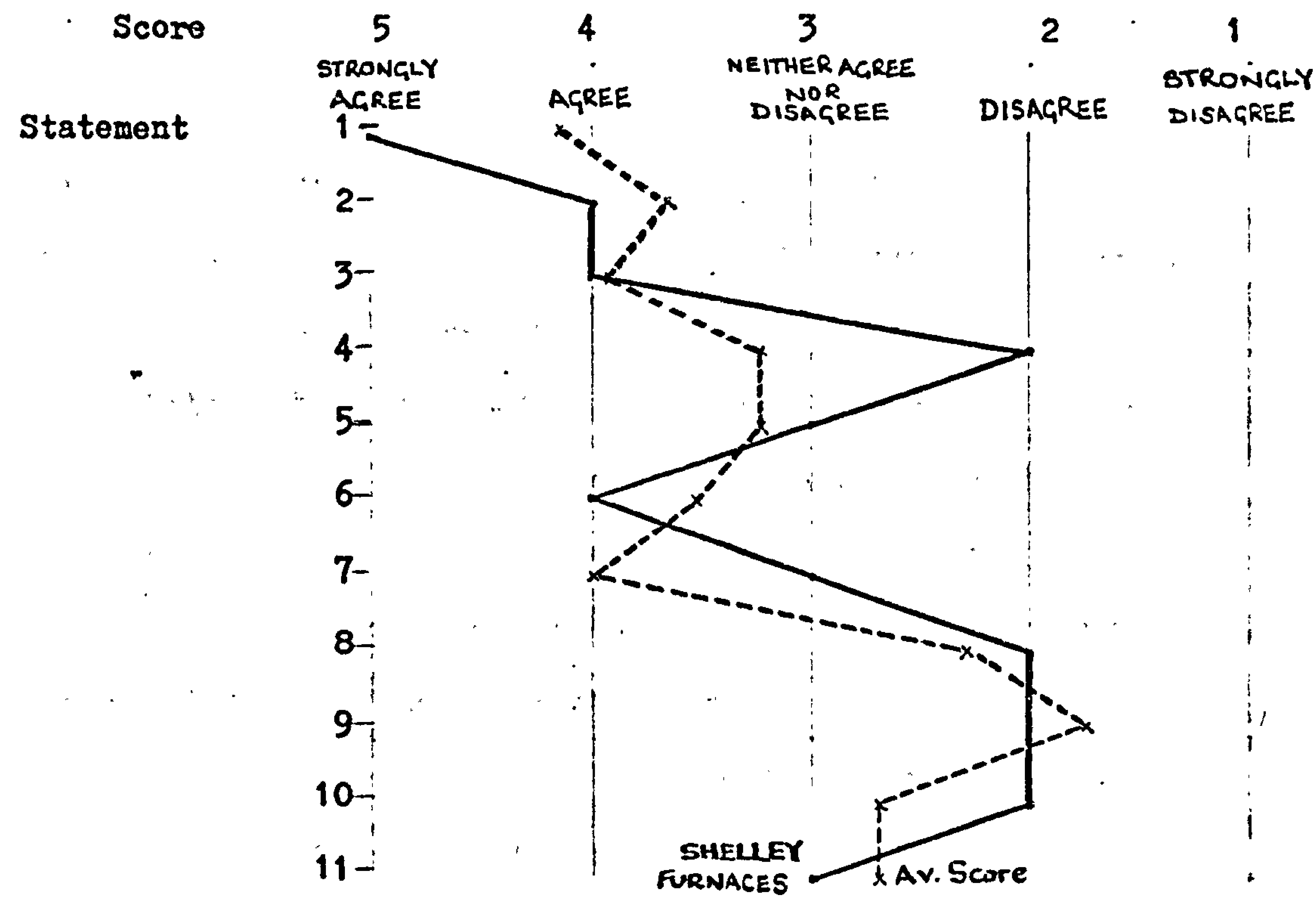

FIGURE 4.20 RESPONSES MADE BY SHELLEY FURNACES VIS a VIS AN ESTIMATED INDUSTRY AVERAGE

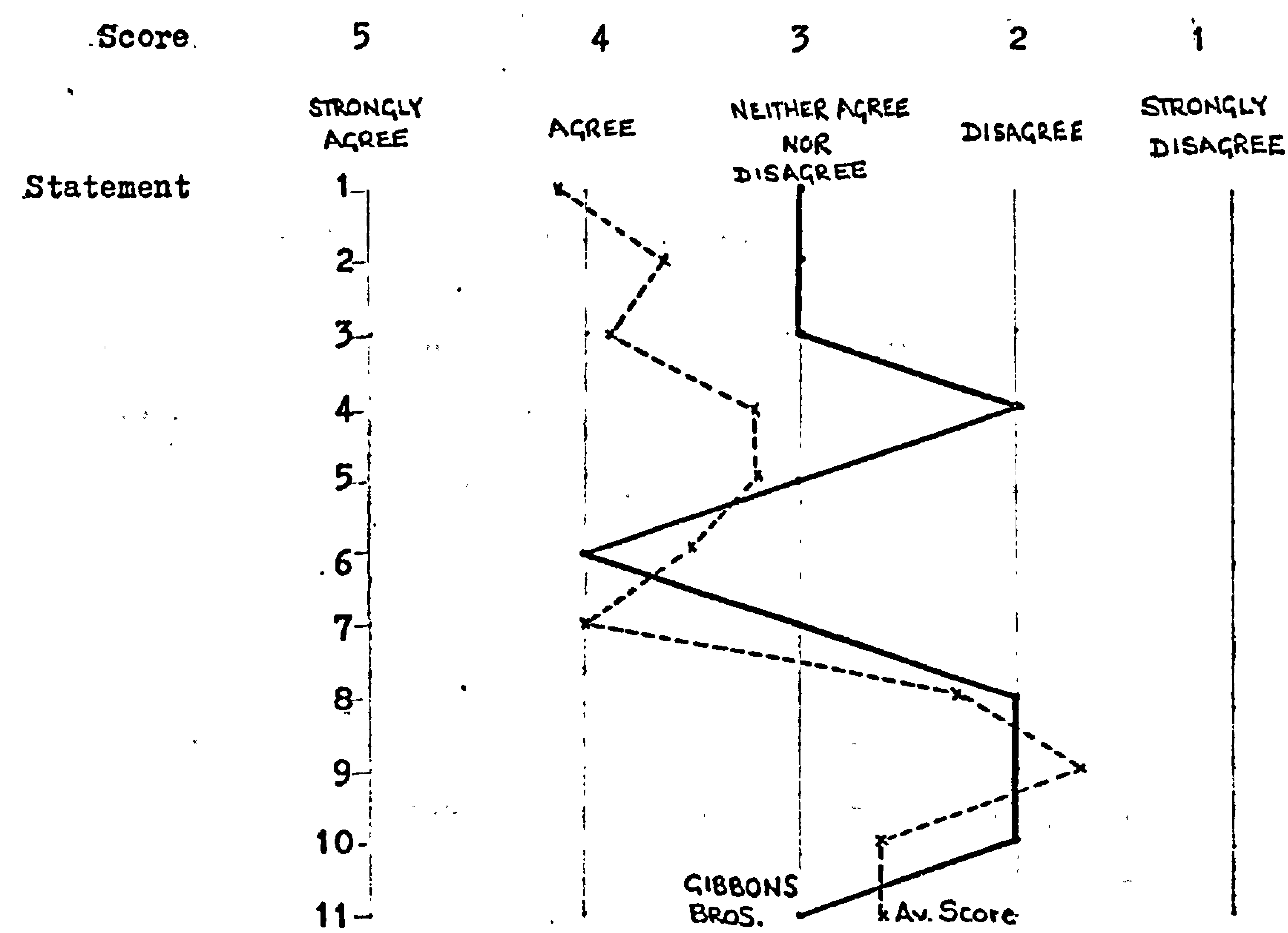

FIGURE 4.21. RESPONSES MADE BY GIBBONS BROS.

For both firms identified as innovatory, deviation from the average industry response tends only to be in a matter of degree. Gibbons did take a more 'neutral' stance to being at the forefront of kiln technology (statement 1); this is manifest in the company's response to current kiln developments in ceramic fibres and intermittent kilns. Though undisputed innovators of tunnel kilns Gibbons have shown much less interest in current developments, having moved somewhat away from supplying this (to them) small market segment. Shelley Furnaces, on the other hand, instrumental in recent kiln innovations, reacted more positively, whether in agreement or disagreement, than the 'average response'. Of interest, both Gibbons and Shelley Furnaces disagreed as to the profitability accuring to being first to market (statement 4). Given that both can be accredited by an observer as having been innovatory it raises an interesting point in that possibly non-innovators think there are profits accuring to those who are first, whilst those firms who are innovatory, from experience, recognise the costs of getting a new product to the market place.

Further investigation was made regarding the two other firms nominated as 'influencers' - JAMES BIRKS and DRAYTON KILNS; as before, Figures 4.22 and 4.23 compare responses against the estimated average response. (overleaf)

As with the 'innovators', the responses made by James Birks are more positive (whether in agreement or disagreement) than the 'average response'. Unlike the aforementioned firms, James Birks strongly agrees that profitability can be as a direct result of innovatory behaviour. As one of the more recent additions to the

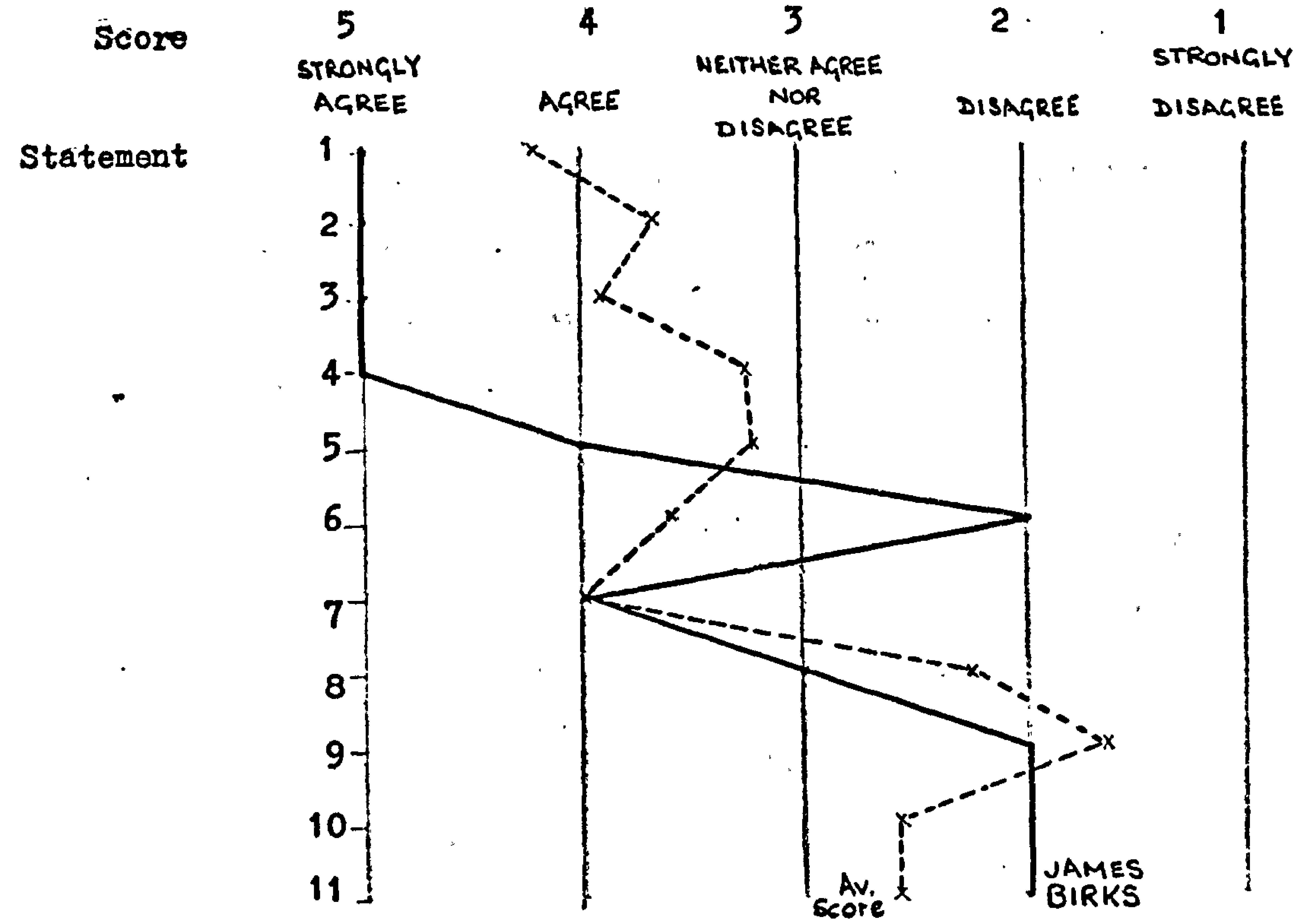

FIGURE 4.22 RESPONSES MADE BY JAMES BIRKS

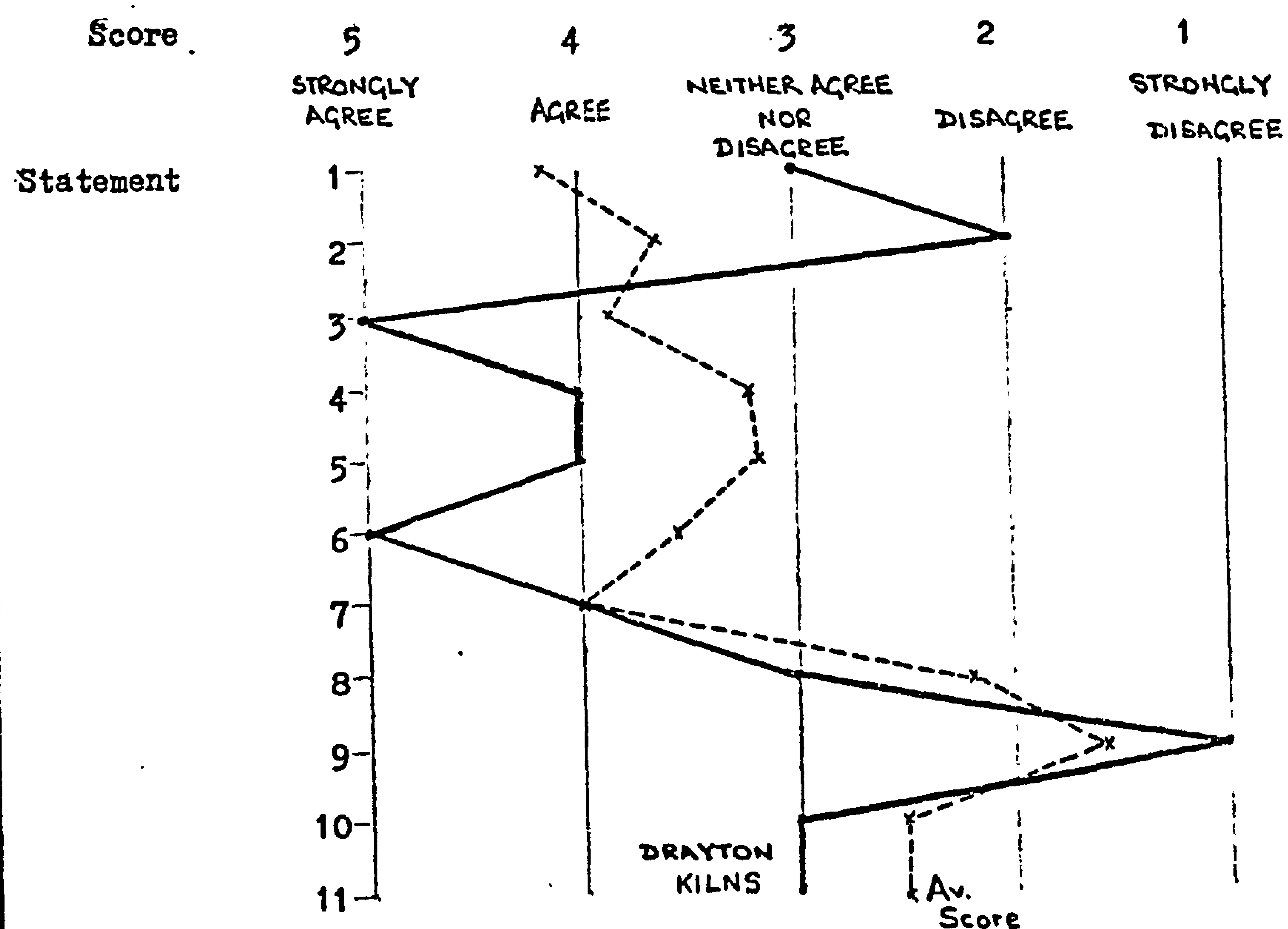

FIGURE 4.23 RESPONSES MADE BY DRAYTON KILNS

industry its success can be traced to a willingness to try new ideas (eg ceramic fibres); this is evident from the response to the technology 'status quo' statement (ie statement 6), which is in disagreement to not only the 'average response' but also Shelley Furnaces and Gibbons Bros.

Similarly, the responses made by Drayton Kilns tend to agree, only more emphatically, with the 'average response', with the exception of innovation and profitablity (statement 2). Its initial interest in ceramic fibres resulted in a number of development teething problems which proved costly to the firm (circa 1972).

As Figure 4.24, when responses of the four firms were compared,

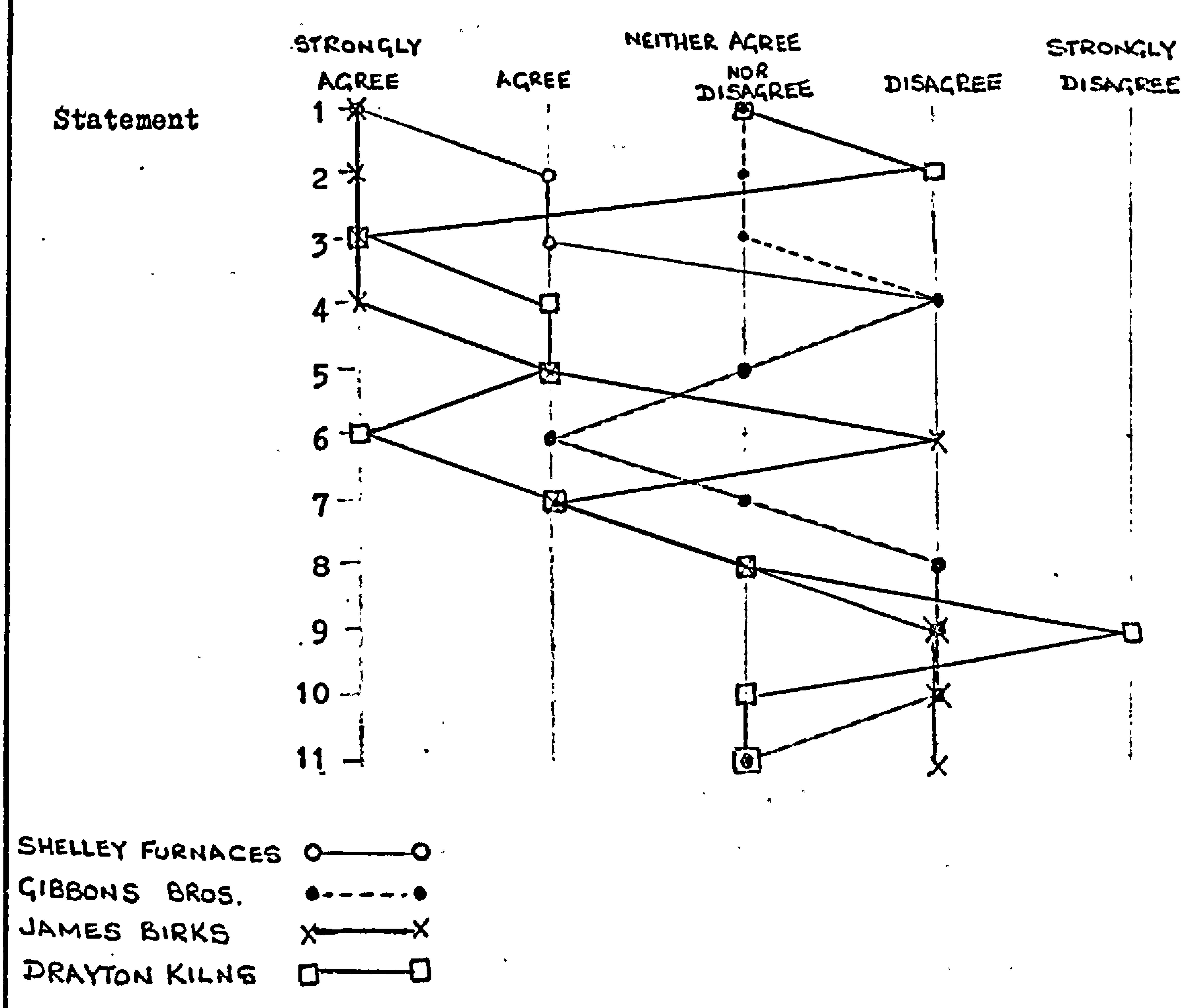

FIGURE 4.24 COMMON ATTITUDES TO INNOVATION?

there was little ground to generalise that innovators and/or influencers subscribed to the same common attitudes towards technological innovation, even when operating with the same industrial system.

C0nsideration was given to relating responses to the size of R & D budget indicated by each respondent; a number of observations were made:

(i) <u>R & D Budget Size and Statement 1 : " we believe there is a need to be at the forefront of pottery kiln development"</u>.

(Table 4.17 illustrates responses).

SIZE R & D BUDGET (as % of turnover)	RESPONSE TO STATEMENT 1					
	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE	NO ANSWER
LESS THAN 1%	2		5			
1 - 5	3	3				2
+ 5%	1					

<u>TABLE 4.17</u>

Those firms proportionally committing more resources to R & D expressed more emphatic agreement with the need to be at the forefront of kiln development; there was, proportionally, a greater 'neutral response' from those firms spending less on R & D.

(ii) <u>R & D Budget Size and Statement 3 : " we listen to what the customer wants and then we make it"</u>.

(Table 4.18 illustrates responses).

SIZE R & D BUDGET (as % of turnover)	RESPONSE TO STATEMENT 3					
	SA	A	N	D	SD	NO ANS
LESS THAN 1%	3		4			
1 - 5		5	1			2
+ 5%	1					

TABLE 4.18

Generally there was agreement irrespective of size of R & D commitment; however, evidence provided from the Survey, including end-users, reinforces the suggestion that the pressure to innovate arises outside the kiln builder's own industrial system, so that response to Statement 3 outlined above, is in response to innovative pressures rather than initiating innovative pressures, as responses to Statement 10 illustrate...

(iii) R & D Budget Size and Statement 10 : "its too costly to persuade customers to adopt new ideas".

(Table 4.19 illustrates responses).

SIZE R & D BUDGET (as % of turnover)	RESPONSE TO STATEMENT 10					
	SA	A	N	D	SD	NO ANS
LESS THAN 1%			3	4		
1 - 5		3		3		2
+ 5%				1		

TABLE 4.19

The adoption process for the end-user / manufacturer generally includes a 'trial period'. As such, a new technology is constantly refined as both end-user and kiln builder 'learn through experience'; hence it is not too costly to persuade customers to adopt new ideas

(i) because the ideas are frequently generated by the end-user, and

(ii) development costs, during the 'trial periods' tend to be borne by all parties involved.

Discussions with kiln-builders suggested that the need to persuade the customer was in terms of 'that particular firm's ability to solve the problem at the right price' rather than 'selling new technology to the end-user!

(iv) R & D Budget Size and Statement 8 : "We believe in letting other firms find the problems and then we improve their ideas".

(Table 4.20 illustrates responses).

SIZE R & D BUDGET (as % of turnover)	RESPONSE TO STATEMENT 8					
	SA	A	N	D	SD	NO ANS
LESS THAN 1%			3	1	3	
1 - 5			3	3		2
+ 5%			1			

TABLE 4.20

From the responses, all firms did not agree with what was essentially an admission of a 'follower relationship' even those firms spending proportinnally less on R & D did not admit to a policy of adopting the ideas of other firms.
Discussions suggested that maintaining a technological 'status quo' was seen as somewhat desirable by virtually all the firms; it was the willingness of a kiln builder to get involved with new ideas championed by an end-user that essentially identifies innovatory kiln-builders from the other firms.

Attention was also given to the personnel involved in innovation development (4.126). Responses as to who the main personnel involved in the development of new kilns were varied, as might be expected given the size of these firms and the response to the number of full-time R + D personnel employed in each firm...
Responses were as follows:-

NO full-time R & D personnel	7
1 - 5 persons	9

Personnel mentioned included managing and technical directors; works managers; service engineers; technical salesforce.
This point was further emphasised (in question 11) that 15 of the 16 firms reported development decisions were 'group decisions'; the major 'other influences' reported were:-

Any technical member of staff	8
Managing Director / Chief Executive	3

(and 2 reported 'customer influence')

The personal interviews tended to strengthen the view that development work progressed in harmony with customer requirements; it was frequently pointed out by respondents that each kiln presented a different problem.

With respect to the need for formal business training, responses were as follows (4.127):

STRONGLY AGREE	4
AGREE	7
NEITHER AGREE NOR DISAGREE	3
did not answer	2

Agreement seems unanimous regarding the importance of business/management training; it was demonstrated that, with one exception, at least one member of each firm possessed formal education up to 'Pottery Manufacturers Certificate'; evidence of more technical training (BSc degrees etc) was less, and few technical managers had higher general management training (HNC/HND etc).

Respondents were also asked if the firm undertook any 'systematic forecasting' of technological requirements (4.128):

This question received a mixed response:

YES	4
NO	7
did not answer	5

For those replying NO - that systematic forecasting played no role - two main reasons arose:-

(i) lack of knowledge of 'systematic'forecasting techniques.

(ii) respondents stressed reliance upon customers to estimate their needs, hence there was less pressure to forecast themselves.

R & D development programmes were not necessarily linked to forecasted future developments in the market place.

In response to the question-was innovation development part of a general marketing policy?-replies were as follows (4.129):

YES	11
NO	4
did not answer	1

However, the personal interviews tended to suggest that 'marketing' very much was 'selling'. In none of the firms interviewed was there a person designated with a 'marketing title', nor seen to be carrying out a broader marketing rather than a sales/technical sales function.

This emphasis on 'selling' was substantiated by a subsequent question (4.130) where 'sales effort' was considered to be a major factor in the success or failure of a new product; selling the firm's ability to provide a(customer demanded) technology is as important as the technology per se.

In order to identify a general attitude towards innovation an unstructured question was put to each respondent in the kiln builder survey (4.131) based on the conclusions made by Gaye and Smyth concerning the time taken for the tunnel kiln concept to be accepted in the industry : " one study of the pottery kiln industry indicated that it took nearly 40 years for the widespread acceptance of the tunnel kiln". Can you suggest why you feel it takes so long for new ideas to be accepted in your industry?

Of the ten replies received only one was prepared to state that "it doesnt" (D.Shelley) and this reply was qualified as can be seen below. Of the remainder, replies could either be classified as 'economic reasons' or, as the majority (70%) indicated, a more general conservative attitude to change. The responses are reproduced as indicated on the questionnaires:

Economic Reasons:

"I would not think it any worse in the pottery kiln or pottery industry than in any other in this country. It is a reflection of all the attitudes of all the parties involved and the matter of capital costs, expected returns and government policy on taxation, capital allowances, and the general economic situation.
In any case tunnel (or continuous) kilns are not the best answer in all circumstances (CATTERSON-SMITH).

"lack of capital for use in plant purchase" (SHELLEY FURNACES)

"kiln design, especially of tunnel kilns has not been fully formalised as a mathematical business, and much of early usage was on a 'suck-it-and-see' basis. Hence very slow improvement in design and technology.

The cost of building experimental kilns is too high for any normal R & D work due to small potential market. Great shortage of capital in the pottery industry, especially pre-1945, did not assist technical change; also, benefits of tunnels not always very apparent" (DONALD SHELLEY).

General Managerial Attitudes:

"experience is usually given precedence" (RAMSELL-NABER)

"often because of the conservative nature of the user and manufacturer within the ceramic industry, for various reasons" (WENGERS LTD).

"the industry as a whole is very conservative" (GIBBONS BROS).

"tradition, initial and considerable expense in developing new kilns" (DRAYTON KILNS)

"because quite often people take the attitude -'why change the old method, it is as good as any'. Also firms are not prepared to put enough capital into new ideas" (BIRKS)

"reluctance because of

bad experiences

lot of work and many orders

tradition in the industry" (RIEDHAMMER)

"when the tunnel kiln was first introduced potteries were usually small family businesses and old traditions die hard. The majority of owners did not like change and labour was cheap. Today, management is far more technically advanced and new ideas are more readily accepted" (KILNS & FURNACES).

The same question was asked of respondents to the second survey (4.132). As it has been established that it is this system rather than the kiln builder per se which is the prime mover in innovation development and diffusion, respondents tended to produce more 'economic reasons' for slow diffusion however, again as many replies were given underlining the conservative nature of the industry; only 2 from 22 replies definitely argured against the statement:-

" I disagree that it takes the pottery kiln industry a long time to accept new ideas. Once can cite several new ideas which,after proper R & D and proven site trials, have been accepted very quickly by the industry eg. ceramic fibres, recuperative burners systems, package tunnel kilns, high velocity burner systems, dual fuel burners, top-hat and the moving-hood type of kilns" (DOULTON INSULATORS).

"some of the early developments were due to the enthusiasm of individuals like Dressler, Moore and Campbell, but supplier influence has been very important since the 1930's: eg. town gas becoming available; MEB promoting electricity sales; influence of burner, instrument and refractory manufacturers. Recently ceramic fibre manufacturers have succeeded in introducing their product in intermittent kilns and have saved energy and increased output. The tunnel kiln was a very radical departure from the traditional coal-fired bottle oven, and the time that it took to become established is not a fair measure of the pottery industry's ability to accept new ideas. New ideas in firing are often taken up very quickly" (HOLMES - B.C.R.A.).

For the rest ...

<u>Economic Reasons</u>:

" it is a high investment, lasts a long time so replacement is slow. There is a very conservative outlook peculiar to the ceramic industry" (SMITHS INDUSTRIES).

"it may have taken forty years for the widespread introduction of continous firing but this was probably due to shortage of capital rather than non-acceptance of the concept" (SPODE).

"at the time of the study quoted above, this industry was divided into many small, under capitalised units; this alone is a massive 'delaying factor'. Acceptance of the principle and the construction of the firing facility may be many years apart" (WORCESTER ROYAL PORCELAIN).

"the slow acceptance of tunnel kilns in the 1920's and 1930's was influenced by capital turnover, capital outlay, space and flexibility in relation to sales requirements. At the present time I think the industry is progressive and readily considers new ideas, particularly since the fuel crisis in 1973"
(H R JOHNSON-RICHARDS LTD).

"there are many examples of new ideas accepted and developed quickly within the industry. The whole of a factory's revenue stems from the volume and quality of ware fired. All processes converge at the firing stage. In the 1930's tunnel kilns were hit-or-miss and many in fact missed! With a low profit industry very few firms could take the gamble and those that did were closely watched by the others. No subject was as detailed, discussed and analysed by potters as the tunnel kiln firing process. The idea was accepted when proved by the pioneers with the cash to gamble" (ENOCH WEDGWOOD (Tunstall)).

"lack of capital!" (COLEFORD BRICK & TILE CO.).

"it may have been forty years, but I would not accept this as a present-day attitude - economics of production are the main factors affecting decisions and also environmental control" (TWYFORDS).

"with a traditionally low profit industry no one is in a great hurry to tear out workable equipment/kilns until they are forced to do so - possibly when planning new buildings. It was often difficult to build tunnel kilns into old buildings;the incentives to do so were less when fuel and labour were cheap" (TAYLOR & KENT).

"tunnel kilns represented a high capital outlay, especially to the smaller 'family' firms of 40/50 years ago. It required a brave man with cash reserves to undertake the comparatively large capital investment required. A wrong decision might well have meant bankruptcy" (J. HEWITT & SON (FENTON) LTD.).

<u>General Managerial Attitudes</u>:

A number of respondents merged economic and conservative attitudes:

"lack of capital; until 15 years ago backward managerial attitudes. Any innovation must be seen to be compatible with present technology, hence innovations tend not to be too different from existing practices. Also the buyer takes some time to decide upon a new practice - one buyer tries a new kiln, others come and see it in operation, they deliberate and see if it fits their needs" (G. WOLLISCROFT).

" in the past the causes were intelligent caution, lack of knowledge and lack of sufficient capital by small manufacturers. The tunnel kilns of the time had many disadvantages, notably lack of flexibility in response to trade variations for quantity and type. Current pottery groups have adequate capital and staff. Current adoption of new ideas is quick, tempered only with caution about durability of new kilns and their cost-effectiveness. There have been some costly failures (eg. sliding-batt kilns)" (DOULTON SANITARYWARE).

"because the installation of tunnel kilns demanded revision of the layout and workflow of the factory, with all it's attendent problems and costs; because it reduced the parameters of production flexibility; because the industry is basically conservative" (A.G. HAYEK).

Others were more explicit as to the conservative nature of the industry:

"our experience takes us much further than just the pottery industry. The clay industry is very old and steeped in tradition - two inhibitors to progress! People are often loath to change to new ideas, particularly as they often do not understand the technicalities involved. Only comparatively recently have big strides been made in technical understanding. Often people have known what will happen in certain circumstances, but not why! " (ALFA AGGREGATES).

"this problem of acceptance has now changed because of management's approach to new technology" (WEDGWOOD).

"being a very conservative industry (family concerns) there has not been the investment there should have been; is a low profit product" (CARBORUNDUM).

"as an industry, ceramics would seem to be one of the most conservative; at the last but one Interceramex (ie 1974) a new (?) kiln carried equipment of 1930 vintage! " (NU-WAY ECLIPSE).

"because it is one of the most backward and conservative in the country" (EUROTHERM).

"the longterm history of the industry encourages workers and lower management to stick with established techniques and traditions. Upper management are faced with very high capital investment" (AUTO COMBUSTIONS HOISTRACK).

"localisation of industry. The old fashioned idea that the pottery manufacturer was more technically competent than the kiln supplier" (C.C.I. LTD.).

"because experience has proved that in this industry in particular, new ideas and new machinery very often fail. This has made one very cautious in one's approach and no doubt some people feel why change from something that is working to something very often untried. I feel suppliers could help a lot here by putting out more lines for longer trial periods" (PORTMEIRION).

End-users (the pottery manufacturers) attribute the slow rate of innovation diffusion primarily to economic reasons - profitability, captial for investment (which has been pointed out, largely came from generated profits) - whereas suppliers to the industry and the kiln builders themselves, comment on the conservative nature of managerial decision-making in the industry.

For the pottery manufacturer economic criteria are seen as the cause, whereas for others the consequences of innovatory behaviour. It does seem from the responses that the conservative attitude has mellowed somewhat with the rise of the 'professional manager' as fas as the pottery manufacturers themselves are concerned, but that this view was not substantiated by other respondents.

'CHANGE AGENTS' IN THE DIFFUSION PROCESS

Although it has been established that the end-user 'pulls through' kiln innovation, a number of 'change agents' have been identified as influential in innovation development and the subsequent diffusion of that innovation (4.133).

Midland's Electricity Board

The formation of the M.E.B. in 1948 provided the impetus for growth in interest in this fuel for firing kilns. The newly formed organisation (a product of nationaliation), motivated by a desire to promote electricity sales in the pottery industry, began by offering attractive tariffs to induce manufacturers to install and/or continue using electric tunnel kilns; the number of electrically fired tunnel kilns in operation in the industry peaked during the period 1948-54. But more significahtly was the decision by Scholefeld (MEB technical executive) to recruit a kiln designer from Gibbons Bros. (a P.J. Dickins). Dickins's brief was to examine the potential of electrically fired kilns, in particular to develop an alternative intermittent kiln to the grossly ineffecent traditional bottle-kiln. At this time no viable alternatives existed. The M.E.B. designed and built a prototype electric intermittent kiln in 1951 (4.134);"the use of this kiln was then offered to pottery manufacturers for them to assess both performance and economy when compared with other firing fuels" (4.135). The favourable response by industry was almost immediate. By 1952 an MEB - designed electrically fired intermittent kiln for decorative firing was installed at the Spencer-Stevenson

Pottery by Hawkins (kiln builder) (4.136).

Success with the decorating kiln encouraged the MEB to design kilns for firing higher temperatures using the newly available heating elements from Sweden (4.137). The first glost-firing intermittent using electricity (again built by Hawkins) was installed at Shelley China (now part of AEP-Doulton Group) in 1953. Reluctance on the part of the end-user to allow the MEB to use the kiln to demonstrate the benefits to other potential users hindered the diffusion process (4.138).

It was as a direct consequence that the MEB built a similar kiln at Longton (Stoke-on-Trent) on its own premises, to which interested end-users were invited to undergo feasibility trials.

Figure 4.25. (overleaf) illustrates the rapid growth in electric intermittents that took place soon after:-

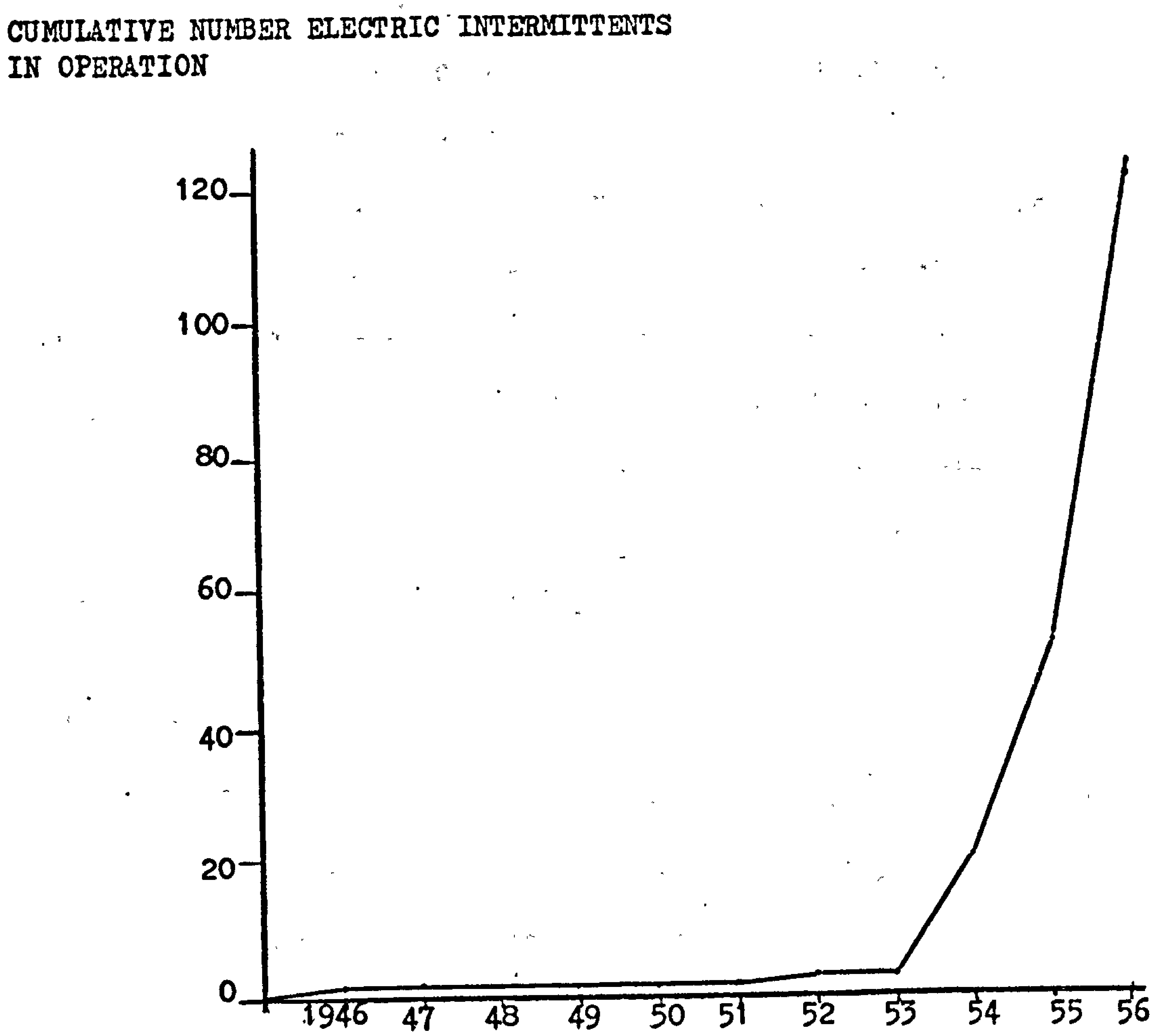

FIGURE 4.25 ELECTRIC INTERMITTENT KILNS IN OPERATION 1946-1956

Source
MEB RECORDS

The M.E.B. sought to provide encouragement to a number of new kiln building companies - for example Hawkins (later James Birks), Litherland Elements (now Shelley Furnaces/William Boulton Group) and Electrical Rewinds (now Kilns and Furnaces).

The emergence of ceramic fibre as high temperature refractory material in the 1970's, with the resulting increase in kiln-fuel efficiency, has made electric firing an attractive alternative.
Again the MEB were instrumental in the development of the innovation.
The first low thermal mass fibre-lined kiln to be built in the U.K. was designed by P.J. Dickins, in 1971. This prototype, using Morganite TRITONWOOL, was built on MEB premises, to which end-users were invited to use the kiln for trial periods; amongst these invitees was Aynsley China who placed the first order. Drayton Kiln (headed by W. Passmore, like Dickins, an ex-Gibbons employee) collaborated on design and installation. As one source notes".. the MEB are acknowledged to be the instigators of the utilisation and adaptation of ceramic fibre" (4.139).

The Gas Board : British Gas

The initial impetus to tunnel kiln acceptance was aided by the change over to (relatively) cleaner town-gas, in 1922.
In the field of tunnel kiln/burner developments, the Gas Board has had a number of successes; it's Midlands Research Centre began development work on advanced burner-block assemblies and 'nozzel mixers' in the early 1950's to overcome what was then a low velocity burner problem (4.140). It was also instrumental in the development of the 'self-recuperative burner' (4.141). In collaboration with Shelley Furnaces two trial kilns (installed at Regent Pottery / Doultons and Gimson/Norton Industrial) have been showing between 32% and 42% savings on fuel costs (1975).
Involvement with the Wedgwood / Coalport fibre-lined kiln (commissioned 1974) led to the establishment of the West Midlands Gas Technical Consultancy Service in 1975, offering a variety of services to the kiln industry:-

(i) arrangement of design and installation of new plant, incorporating new gas-engineering techniques.

(ii) survey existing gas-fired plants and report on performance and safety.

(iii) upgrade plant and controls to meet latest regulations and codes of practice.

(iv) redesign or modify equipment to increase productivity.

(v) arrange regular plant maintenance (4.142).

Refractory Materials Suppliers

Other recent influential change agents have been the suppliers of ceramic fibre for refractory purposes-in particular Carborundum Co. and I.C.I. (Mond Division). Developments in higher temperature fibre (circa 1972/3) allowed both these companies to become involved in joint-collaboration development programmes with end-user, kiln builder and fuel supplier. For example, I.C.I., keen to promote interest in 'ceramic fibres' agreed to a number of 'quarantees' to both Wedgwoods and Shelley Furnaces during the early development stages. And it was I.C.I. who used the findings from the trial period at the Coalport factory to stimulate interest in the kiln/ pottery industry; the company now has sufficient experience to have developed computer simulation models to advise end-users on kiln size, kiln performace and so on.
Furthermore it is noticeable that the articles on fibres appearing in the technical journals were written by senior technical personnel attached to the major fibre suppliers (4.143).

FURTHER PRESSURES

AFFECTING THE RATE OF DIFFUSION

During the research conducted for this thesis it became clear that a number of pressures, external to the industries under review, had contributed to the rates of diffusion for technological innovation. Stress has already been laid as to the dampening effect made by the 1939-45 war. Reference to figures 4.18 (output) and 4.19 (exports) illustrate this fact; similarly figure 4.17, for example, illustrates the slowing down of adoption of technology during this period.
Subsequent government direction of output into exports created an imbalance in the industry in favour of export market segments (the dependence upon which is now coming home to manufacturers 1978) but moreover, excess demand in this period caused firms to postpone new capital purchases in favour of continuance of production; the consequences have been discussed elsewhere (4.144).

A more recent highly significant influence upon technological innovation has been the concerted effort by government to control atmospheric pollutants. As will be pointed out, technological innovation has been both cause and consequence of these pressures. To explain more fully it is necessary to retrace the developments in pollution control in the industry.
The pottery industry was initially founded on Staffordshire coal. By 1900 there were over 2300 coal-fired bottle kilns operating in the Stoke-on-Trent area (4.145), contributing to a heavily polluted atmosphere. George Bernard Shaw, on a visit to the Potteries, remarked ".. if chimneys smoke like that you will have a large

graveyard"; Warrilow records around 4000 deaths between 1895 and 1900 which can be directly attributable to forms of silicosis and lead poisoning (4.146).

Attempts were made as early as 1820 to limit smoke emission, at the Spode factory, but records indicate they failed; the idea being to recycle the smoke back into the kiln (4.147).

A bill was brought before Parliament - the Smoke Prohibition Bill - in 1850, which made provision for local controlling bodies to monitor industrial smoke and effluence. It was left to the local body to decide what constituted a'health hazard'. This Bill was not implemented to any great extent against the pottery industry because of the powerful opposition from the manufacturers; "... it was decided that the Act should not affect (the Potteries)" (4.148). Pressures on manufacturers to bring change to the firing process were thus averted, although a comment of these times presents an alternative picture of the industrial environment; "... as travellers approached the neighbourhood, they saw it enveloped in smoke to such a degree that everything was obscured, and on arriving at Stoke they saw the tall chimneys...vomiting forth dense clouds like the crater of a volcano" (4.149).

The Sanitary (Smoke Abatement) Act was introduced in 1867; "... any fireplace or furnace which does not, as far as practicable, consume smoke arising from the combustible use.. within the district of a nuisance authority... shall be prosecuted". Though persued with more vigour by the nuisance authorities, it failed to create any impact in the pottery industry due to the clause 'as far as practicable'. This clause provided the manufacturer, as long as he tried' to control smoke, with immunity from the law. One method of avoiding the Act was for a manufacturer to begin a firing cycle at night so that accurate assessment of smoke emission could not be made.

Similarly, the Smoke Abatement Act (1920) had little effect upon the pottery industry. By this time, in addition to the still large number of coal-burning kilns, there were the equally pollutant producer-gas tunnel kilns beginning to appear.

One hundred years of abortive pollution control by central government ended with the introduction of the Clean Air Acts in 1956. Parliament made it illegal for industrial chimneys to emit 'dark smoke'. As the Act stood, it proposed a reduction in the level of smoke pollution below which even the most efficient bottle kilns could operate. Although the Acts were not directly aimed at the Pottery Industry but reflected more a general inclination to reduce industrial pollutants they nevertheless called for a radical re-assessment of current kiln technology and operation. Immediate impetus was given to the adoption of cleaner firing fuels, in particular electric firing which at that time provided the only viable alternative intermittent firing process (Figure 4.26 illustrates) overleaf.

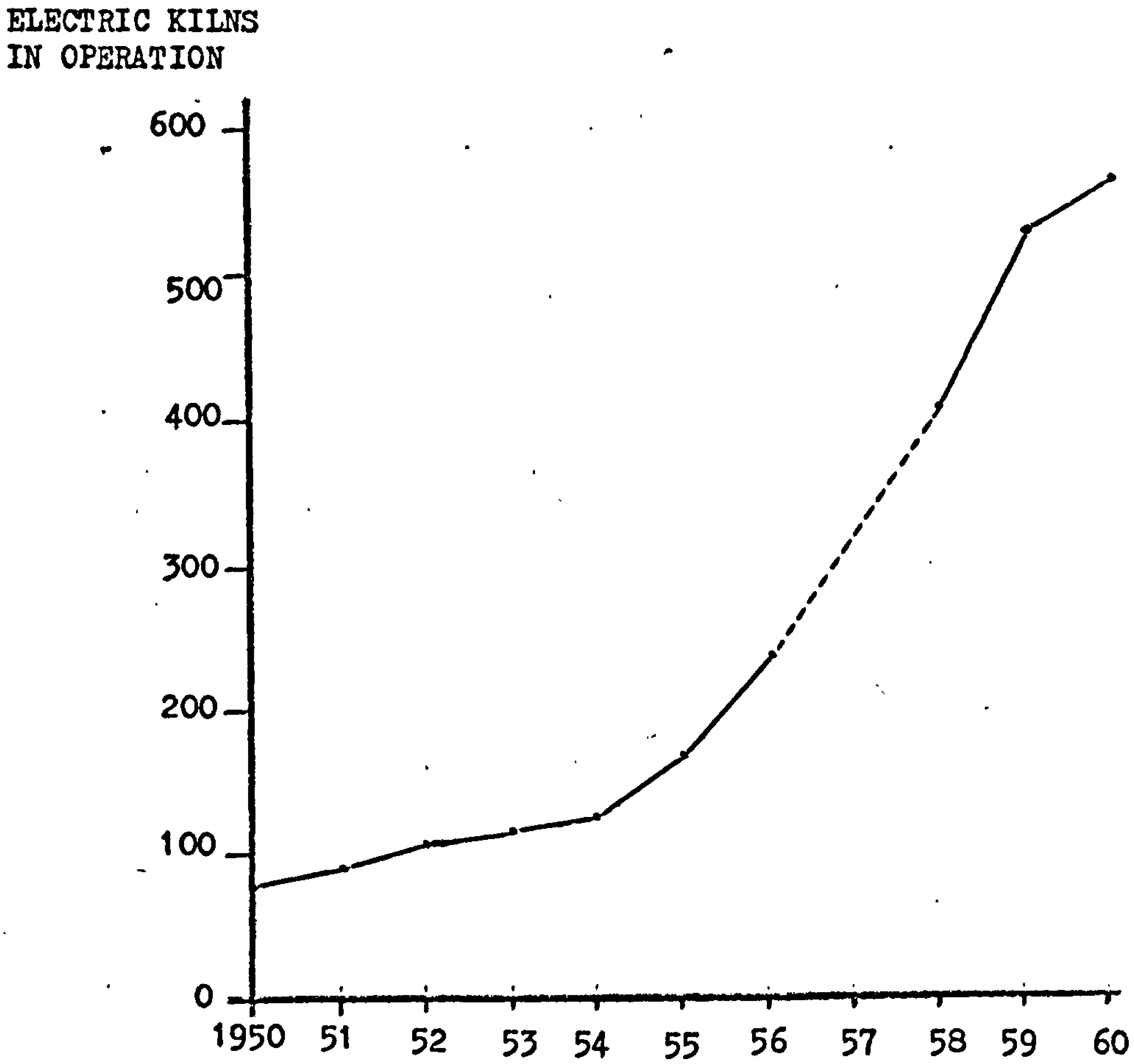

FIGURE 4.26 SUBSTITUTION OF ELECTRIC KILNS 1950-1960

In the intervening years between 1956 and 1958, when the Bill finally gained Royal Assent, powerful manufacturer lobbies pleaded for more time to make the necessary transition from coal to alternative fuels. Coal firing continued after 1958 as manufacturers chose to pay the fines imposed; arguments that high quality ware could only be produced using the old methods received little sympathy. In point of fact, as Figure 4.27 illustrates, the Acts merely accelerated the life cycle for kilns fired using coal, forcing traditional manufacturers to adopt already available alternative technologies.

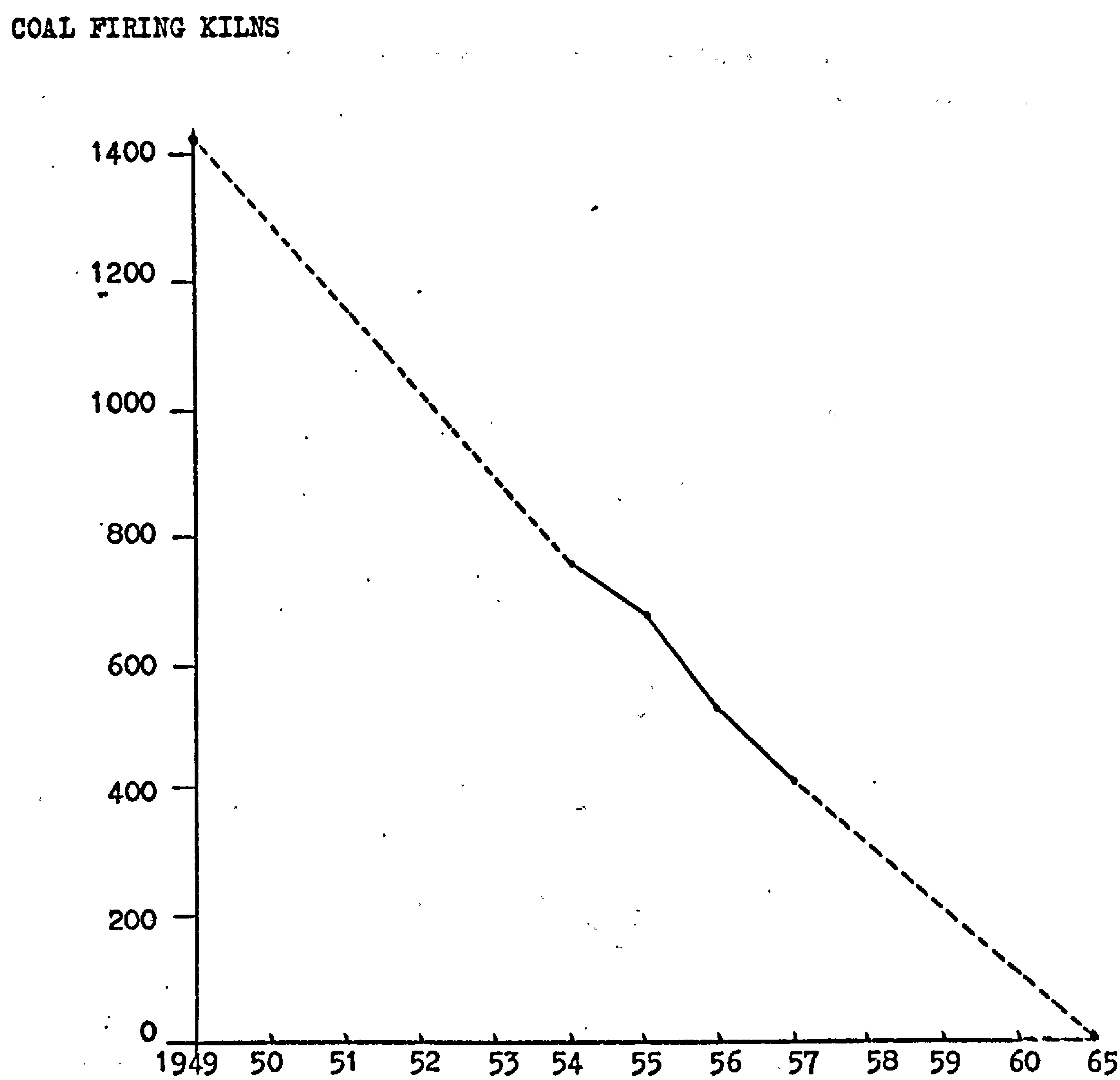

FIGURE 4.27 DECLINE OF COAL-FIRING KILNS

Galbraith comments "... the old bottle kilns were rendered obsolete by the Clean Air Acts and were dèmolished at an alarming rate"(4.150). Between 1957 and 1967, the total energy usage per year in the pottery industry dropped by about 27 million therms in spite of the fact that pottery output rose. The reason was that almost 42 million therms of coal were replaced by less than 15 million therms of electricity, town gas (later natural gas), oil and L.P.G., because modern firing methods proved to be several times as efficient as traditional coal firing;

Figure 4.28 illustrates the changing pattern in fuel usage.

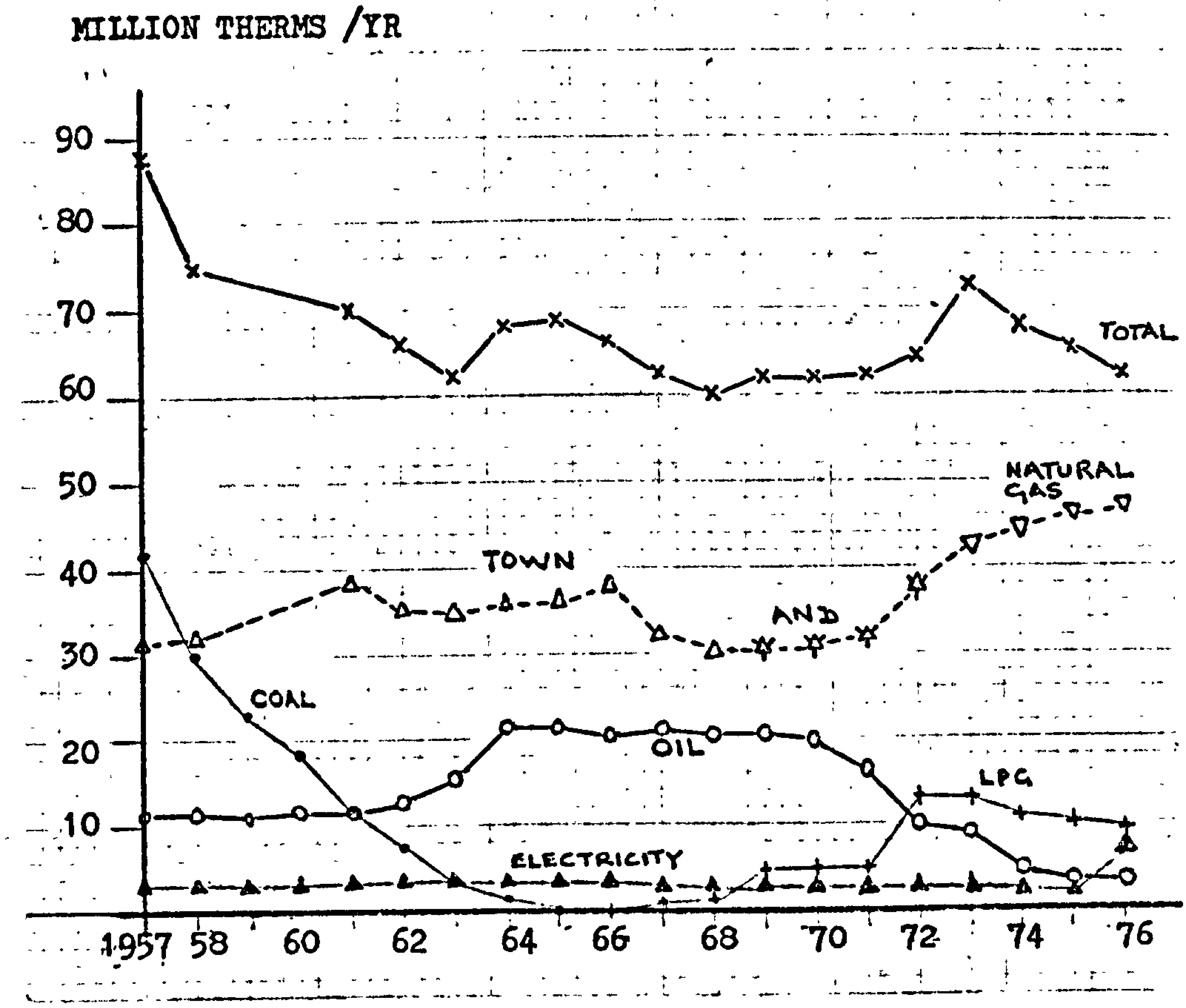

FIGURE 4.28 CHANGING PATTERN OF ENERGY USAGE FOR POTTERY FIRING 1957-1976: SOURCE B.C.M.F.

The consequences of these Clean Air Acts also led to a restructuring of the industry and the impetus for the formation of the larger 'groups' dominant in the industry; this restructuring, in turn, enabled the 'survivors' to apply new technologies.

In addition to those aforementioned external influences, a number of others bear mention. Oil fired kilns have twice been affected by international shortages; the Suez Crisis in 1956 and the later Arab/Israeli crisis post-1973 and the subsequent re-appraisal on oil prices by OPEC. Oil and L.P.G. have declined in popularity

although dual fuel burners, gas-oil, allows the manufacturer fuel flexibility.
Fuel-costs fluctuations are seen to influence the popularity of firing methods; the withdrawl of favourable tariffs by the MEB circa 1954 tended to decelerate the growth rate. The rise in electrcity costs has terminated the diffusion of electric tunnel kilns. Electric firing is now mainly restricted to the glost and decorating firing of tableware, but its importance should not be underestimated. The efficiency of electric kilns is at least two or three times that of oil,and better than gas, which means that a greater weight of ware is fired by electricity than by oil; and the value of the ware fired by electricity is many times greater because it is used to fire high-value tableware/decorative china, whereas oil and gas tend to be used to fire low unit-value tiles and sanitary ware; as Dickins (MEB) writes "... statistics show that usage of electricity for pottery firing has been stable over the past eight years in spite of increasing competition from North Sea Gas. Recent developments such as low thermal mass linings and precision temperature control systems, and the introduction of competitive electricity tariffs have ensured that the electric kiln will continue to be utilised, particularly in the high quality sector of the industry" (4.151).

A comment is needed on the influence of organised labour on the rate of technological diffusion in the pottery industry. Labour was first organised in 1824, faded and re-emerged in a number of guises throughout the C19th, but gained no meaningful bargaining power until 1882 with the formation of the National Order of Potters.

Eventual amalgamation of a number of craft societies did not occur until 1920 with the formation of the National Society of Pottery Workers (now the Ceramic Allied Trades Union).

With the notable exceptions of 1825 and 1836, when two bitter strikes did take place (with no notable success to the union), union activity has been virtually without conflict; wages rather than working conditions have been the area of union-management negotiations; "... the absence of strikes in the past means that there is an absence of a 'strike culture' among pottery workers in the present" (4.152).

Although not documented, discussions with both union officials and management suggest a number of reasons for this absence of a 'strike culture":

(i) Size of firm : although the size of firm has tended to increase, it is much evident that the paternal aspect of the small firm re the relationship between 'master and servant' remains.

(ii) Constitution of the labour force : about 60% of skilled jobs are occupied by women who, traditionally, are less 'unionised'.

(iii) Continuity of service : ".. in many factories there is now a fourth or fifth generation relationship between the owner and craftsmen's families" (4.153).

(iv) Family commitment to the firm : traditionally a firm has employed personnel from the same family. This does mean that it is very difficult for a family to withdraw its labour (although no suggestion is made to suggest that this is the firm's rationale).

(v) Flexibility and scarcity of labour : again traditionally the pottery worker has accepted the principle of flexibility between jobs in the factory. He has not resisted change of job either in the short run (say an overload in one particular process) or long term as one technology has supple - mented another. Figure 4.29 (overleaf) shows how employment has not arisen at the same rate as the number of operating establishments. Growth in the industry has thus absorbed 'redundant' skills, just as technology has replaced labour-intensive practices.

Also, because of the scarcity of skilled labour, it has been relatively easy for a dissatisfied oper-ative to find a position elsewhere with a less tech-nologically advanced firm.

(vi) The traditional industry : because technological change has been slow, the need for labour to adapt to such change has equally been slow.

(vii) Better pay and conditions : acceptance of new kiln technology has been relatively easy because of the subsequent improvements to working conditions and remuneration. Traditionally a piece-work industry, improved technology has increased the earnings potential of the workforce.

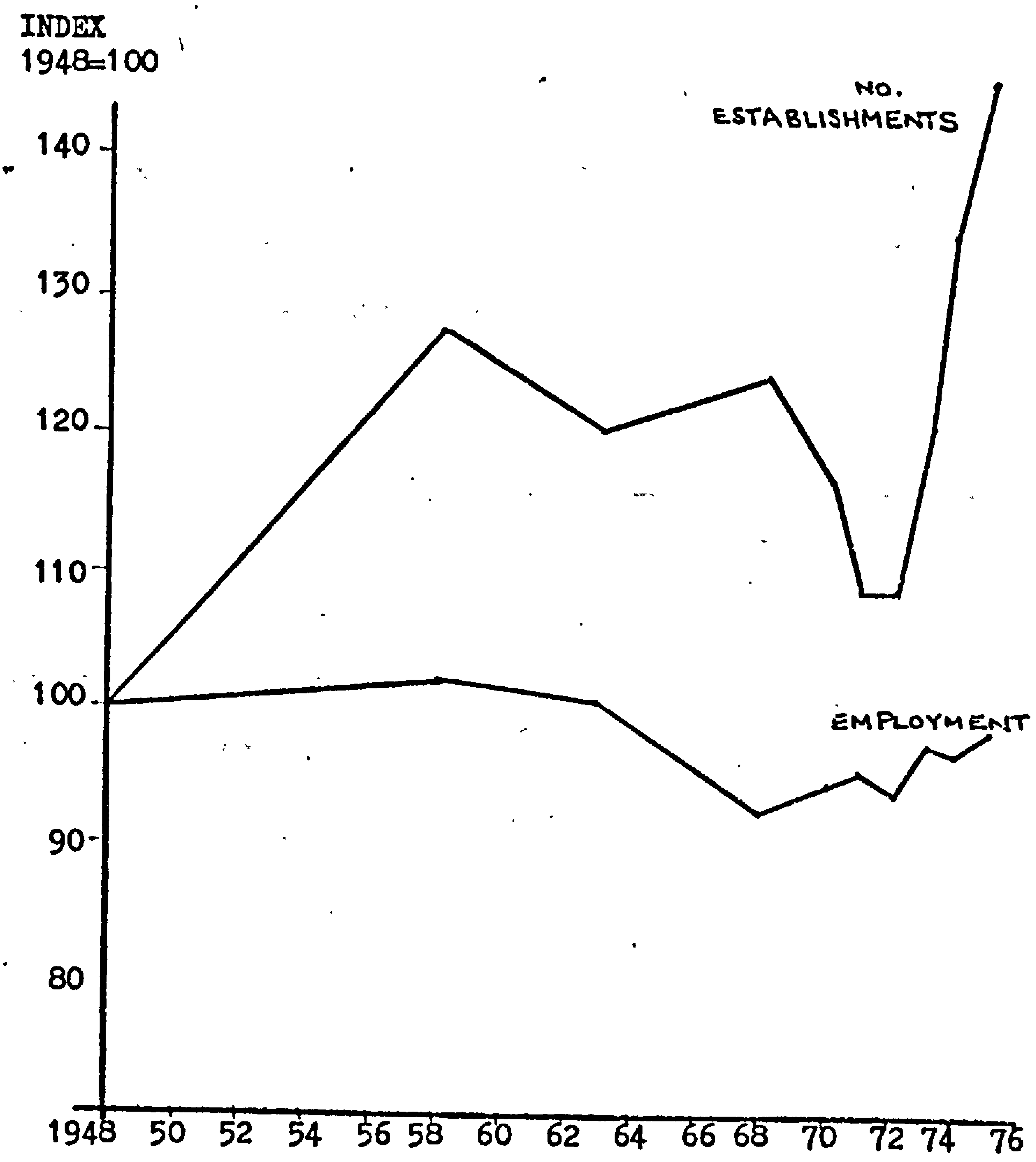

FIGURE 4.29 EMPLOYMENT / ESTABLISHMENTS IN THE POTTERY INDUSTRY 1946-75

INNOVATION AND

INFORMATION SOURCES

Each responding kiln builder (Survey I) was asked to emphasise the importance of a number of information sources seen as influential in the innovation process; Table 4.21 presents the responses:

	MOST IMPORTANT	IMPORTANT	NOT SO IMPORTANT	NO IMPORTANCE AT ALL	NO ANSWER
1. OWN R & D EXPERIENCE	5	7			4
2. INFORMAL CONTACT BETWEEN FIRMS	6	3	4		3
3. FORMALISED CONTACT		5	5	3	3
4. INDUSTRY/ PROFESSIONAL PUBLICATIONS	2	7	4		3
5. B.C.R.A.		6	5	2	3
6. EDUCATIONAL/OTHER RESEARCH INSTITUTIONS	2		6	3	5
7. LIASON WITH FORMER CUSTOMERS	5	6		2	3

TABLE 4.21. KILN BUILDERS' RESPONSES TO INFLUENTIAL INFORMATION SOURCES IN THE INNOVATION PROCESS (4.154)

From the replies received it can be seen that each of the sources was seen to rate important or most important by some respondents. Considering for the moment only those rated 'most important', informal contact between builder and customer is strongly emphasised. This reinforces conclusions reached elsewhere in the text that the innovation development process is a process of collaboration between builder and end-user. Interesting is the high response to 'own

R & D experience'; it reinforces the belief that the initial contact between builder and end-user is as much to convince the end-user that the kiln builder is capable of building the kiln (technologically competent) as to convince the end-user of the technology's potential per se.

Less favourable response was received for the B.C.R.A. (British Ceramic Research Association) located in Stoke-on-Trent. Informal discussions tended to suggest that a 'gap' existed between current -day practice of the kiln builder and the research work being conducted by the BCRA; a technological gap of comprehension. As is pointed out later in the text, this gap seems to be bridged by the end-user who considers the BCRA more important, and then communicates to the kiln builder.

Technical publications were received favourably possibly due to the major suppliers of kiln technology to write exploratory articles in all the British, American and German industrial publications. It does seem that kiln builders themselves do not bother to contribute articles; technical papers highlighting an adoption of a technological innovation invariably are written by either end-users or the materials-suppliers to the kiln builder (4.155).

Educational institutions were accorded little importance, which seems to fit with their earlier response to formalised management training. A second communication gap seems to exist.

Investigation was undertaken to ascertain whether the responses of those builders considered to be either 'innovators' and/or 'influencers' differed from a calculated 'industry average' (4.156), Figures 4.30 (SHELLEY FURNACES) and 4.31 (GIBBONS BROS) illustrate the responses made by the designated 'innovators':-

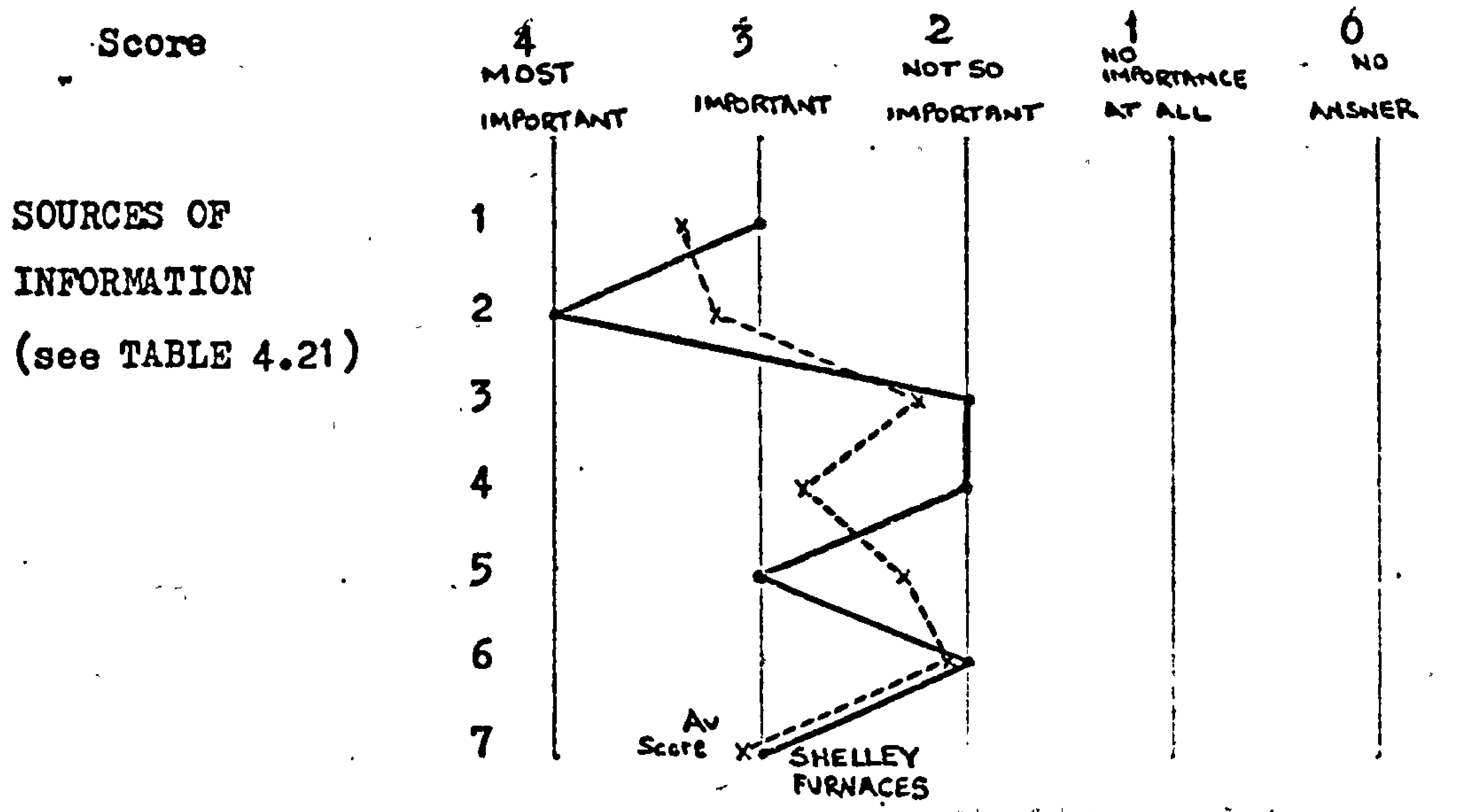

FIGURE 4.30 SHELLEY FURNACES

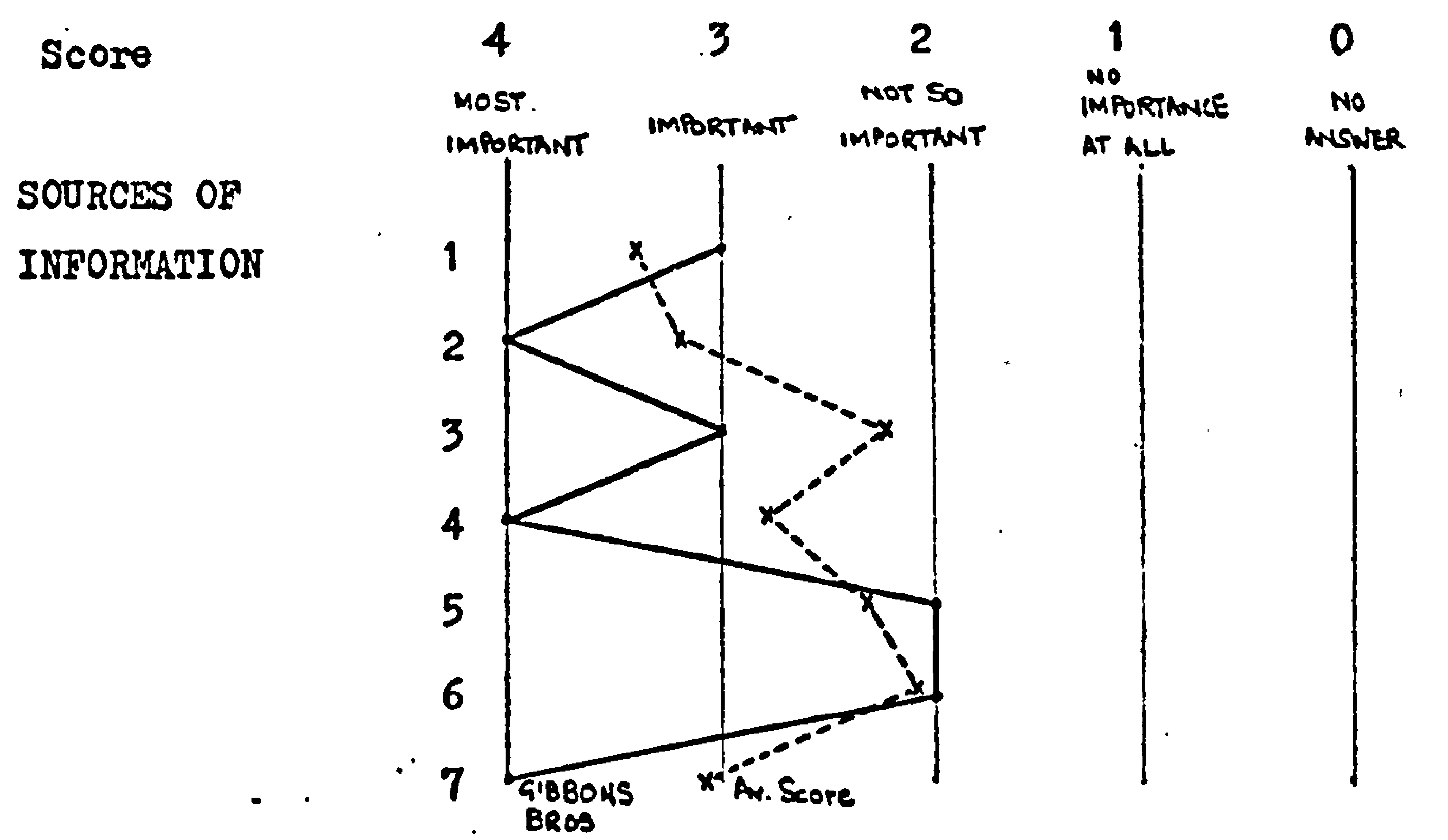

FIGURE 4.31 GIBBONS BROS

Shelley Furnaces and Gibbons Bros demonstrated considerably similarity in their responses when compared with the industry average. Shelley Furnaces did rate the BCRA somewhat better than average due to the number of development programmes that have been undertaken between the two organisations. Gibbons Bros, being one of the few kiln builders to regularly contribute to the professional /technical journals, tended to rate this source of information more highly than the average.

With regard to named 'influencers', Drayton Kiln declined to answer; the responses made by James Birks are illustrated in Figure 4.32 below:-

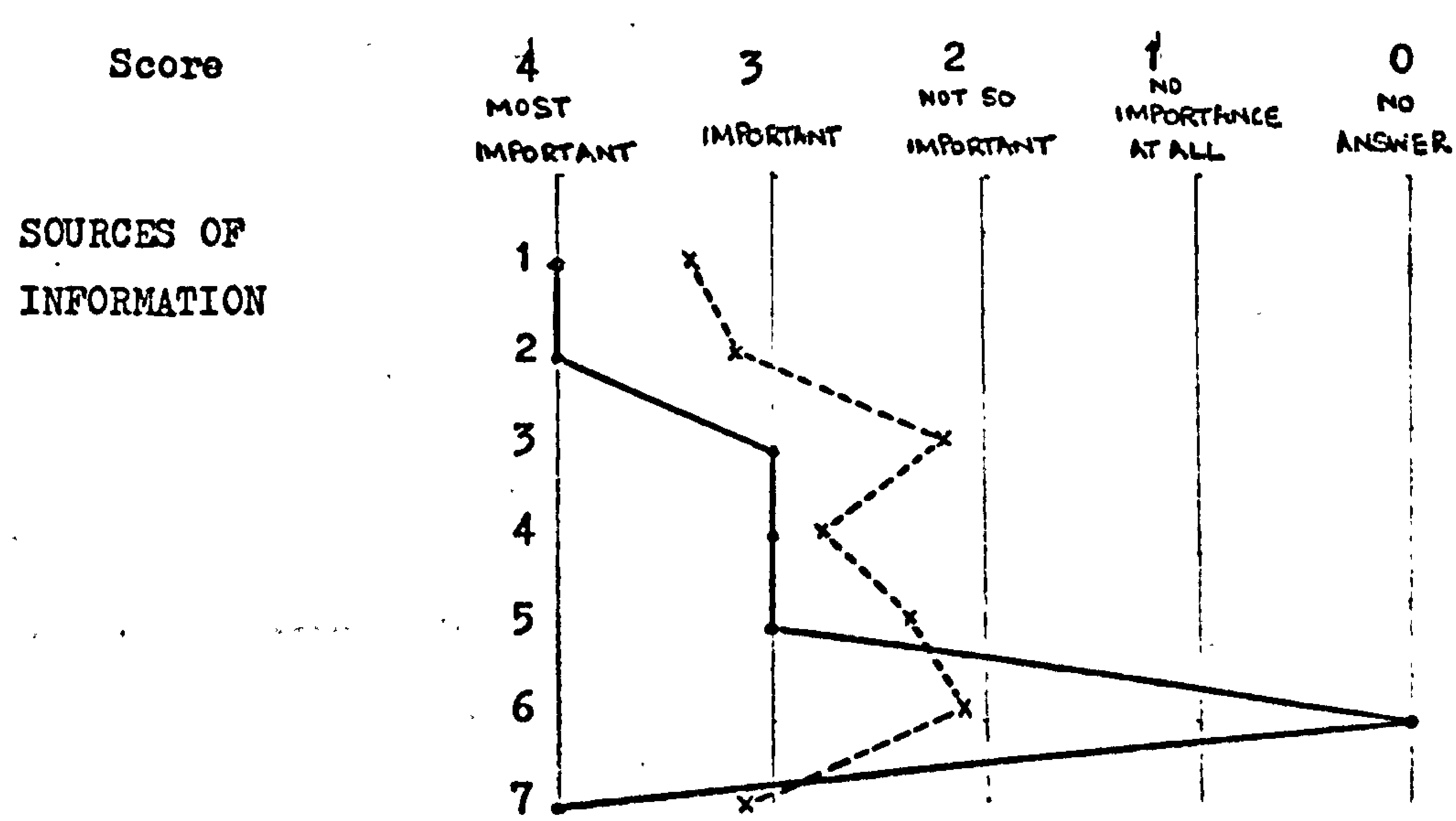

FIGURE 4.32 JAMES BIRKS

James Birks rated every source of information as more important than the industry average with the exception of the importance of educational institutions; possibly this was due to the source of the questionnaire? Discussion failed to identify necessarily why these responses should be so except that a general air of enquiry and receptivity to information was conveyed by the company. It was this company that alone reported committing more than 5% of turnover to R & D expenditure.

To constrast these findings, respondents to Survey II were also asked to comment on information sources re their importance in communicating new kiln technology (4.157). Once more a distinction was made between end-users (Table 4.22) and other respondents (Table 4.23) to identify, if any, perceptual differences:

TABLE 4.22 End-users

	MOST IMPORTANT	IMPORTANT	NOT SO IMPORTANT	NO IMPORTANCE AT ALL
Formal contact with kiln builder	4	5	2	
Informal contact with kiln builder	5	2	4	
'thro' the industry grapevine'	4	5	2	
Industry/professional publications	1	6	4	
B.C.R.A.	3	5	1	2
Educational/research institutions		1	5	5
Interceramex (exhibition)	1	4	4	2

Σ 11 respondents to question

TABLE 4.23 Other respondents.

	MOST IMPORTANT	IMPORTANT	NOT SO IMPORTANT	NO IMPORTANCE AT ALL
Formal contact with kiln builder	5	4	4	
Informal contact with kiln builder	5	7	1	
'thro' the industry grapevine'	5	5	3	
Industry/professional publications	3	5	5	
B.C.R.A.	3	4	2	4
Educational/research institutions	2	2	6	3
Interceramex. (exhibition)	1	8	4	

Σ 13 respondents to question

Comparison of responses was made by constructing two average responses profiles in a similar manner to that discussed earlier, Figure 4.33 illustrates:-

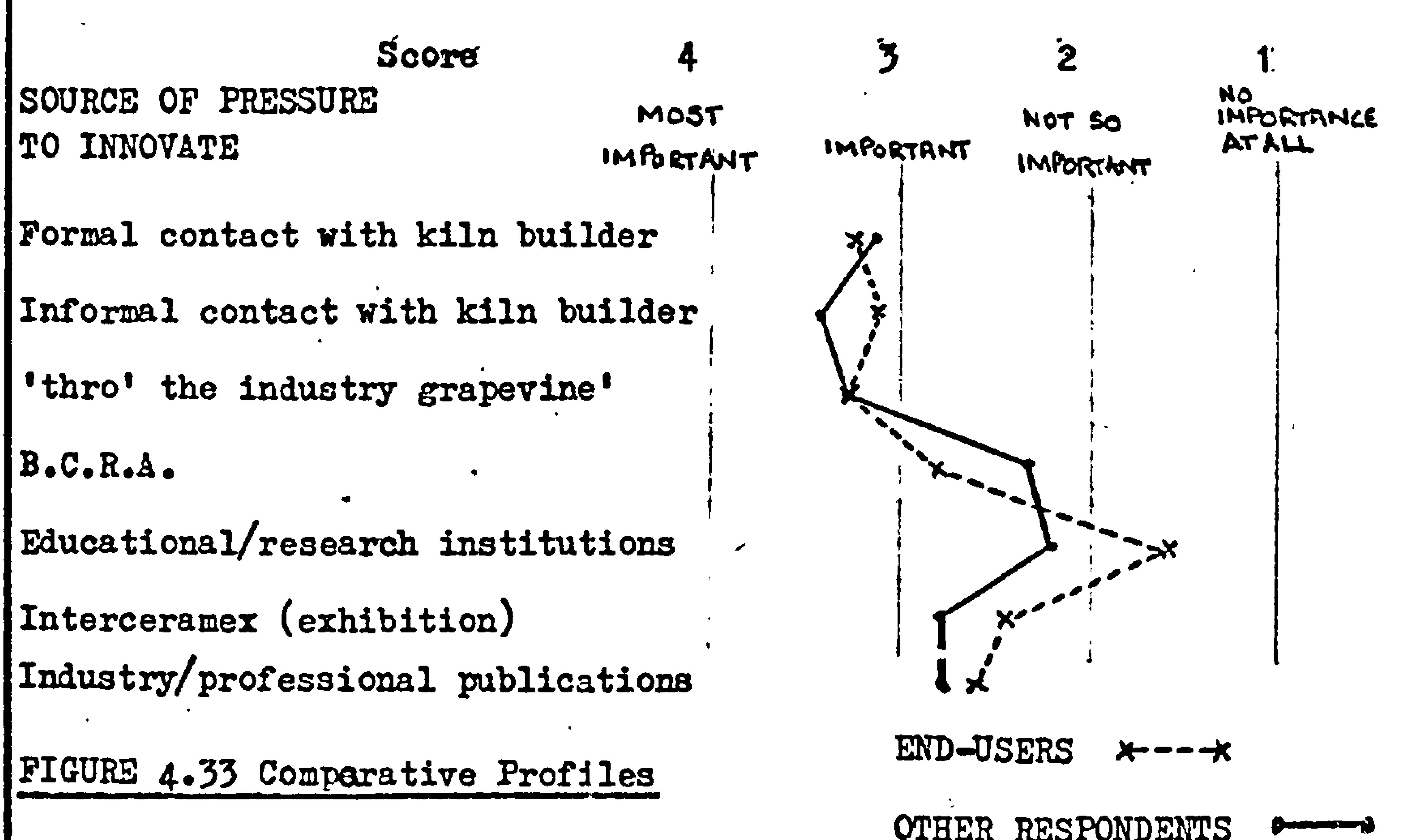

FIGURE 4.33 Comparative Profiles

Both sets of respondents reported informal and formal face-to-face contact as important, substantiating the conclusions earlier. Discussion suggests that it is difficult to make a clear distinction between 'formal' and 'informal contact'; the nature and size of the industry, where builder and end-user/suppliers mix regularly at meetings, exhibitions and so on, tends to result in most discussions being 'informal' until contracts are ready to be signed. Cases were quoted where kilns have been installed on a handshake and operated over considerable trial periods before formalised agreements have been entered into. The close-knit environment of the interdependent systems explains the importance accorded to the 'industry grapevine'. Close geographical proximity shortens communication distance and also seems to result in a mobility of skilled labour between industrial systems. Even those companies located outside the Stoke-on-Trent area invariably approach recruitment through the Potteries evening newspaper- The Evening Sentinel. Successful kiln building engineers have been seen to leave companies to begin independently; for example, W.Passmore (DRAYTON KILNS formally with GIBBONS BROS.), D. Shelley (DONALD SHELLEY LTD, formally with Shelley Furnaces), P. Dickins (M.E.B, formally with GIBBONS BROS.) (4.158).

Discussion confirmed that the more formalised information sources - BCRA,educational institutions, exhibitions - rated lower; this was similarly found for the kiln builder. Frequently it was reported that the work done by the formalised research institutions was 'a little too far ahead of the industry's present and immediate-future needs'.

SECTION NOTES

4.1 For an excellent description of the methods of Islamic potters refer
Wulff: "The Traditional Crafts of Persia"
M.I.T. Press 1966.

4.2 From the profits from his pottery business, Josiah Wedgwood was able to sponser / subsidise Charles Darwin's (his nephew) "Voyages of Discovery".

4.3 Hind : "Pottery Ovens. Fuels and Firing"
British Pottery Manufacturers' Federation 1937 p.24

4.4 Gaye & Smith : "The British Pottery Industry"
Butterworths 1974. p.37

4.5 Warrillow : " A Sociological History of the City of Stoke-on-Trent" Ironmarket Press 1977. p.396

4.6 City of Stoke-on-Trent consists of six towns: Stoke. Longton, Fenton, Burselm, Tunstall and Hanley.

4.7 It is likely the figure was in excess of 75% circa 1900.

4.8 Gaye & Smith : Op. Cit p.14

4.9 S.Jerrett (Director. British Pottery Manufacturers Federation) Writing in the Evening Sentinel Industrial Review 15.3.1977,

4.10 Evening Sentinel : Interceramex '76 Special
20.9. 1976.

4.11 eg. adoption and diffusion of fuel technology p. 385

4.12 One of the U.K.'s earliest canal system - ETRURIA to MANCHESTER - was commissioned by Josiah Wedgwood to bring china clay from Cornwall, and to transport finished ware (pottery) out of the district.

4.13 see 4.2.3. "Innovatory Applications of Fuels" p. 282

4.14 a 'bottle kiln' is described 4.2. "Kiln Structure Innovators" p. 264

4.15 The author is indebted to L.B. Trustrum for his guidance in the construction of Figure 4.1.

4.16 Tho' this is not always the case as was demonstrated in development problems with ceramic refractory fibres p. 294 ff

4.17 P. 264 ff

4.18 discussed p. 268

4.19 Sample Frame. Appendix 2 p. (ix)

4.20 Covering letter, Questionnaire Appendix 3 p. (x)

4.21 Letters of Credential. Appendix 4 p.(XXi)

4.22 Text gives survey response to QUESTIONS 1 & 2 KILN BUILDER STUDY. Forbrevity, indication by footnote will be given where responses from studies are quoted as thus 'QUESTION 1 KILN BUILDER STUDY' etc.

4.23 Sample Frame Appendix 5 p. (XXiV)

4.24 Covering Letter, Letters of Credential & Questionnaire Appendicies 2,4 & 6 p.

4.25 QUESTIONS 1,2 KILN USERS .... STUDY.

4.26 A distinction was made between 'end-users', that is the kiln builder's customer, and other respondents' to ascertain differences in self-percepts.

4.27 Rhodes: "Kilns. Design, Construction and Operation" Pitman 1969 p.40

4.28 Gregory : "Kiln Building" Pitman 1977. p.19

4.29 Hind : Op. Cit p.122

4.30 Rhodes : Op. Cit p. 51

4.31 Rhodes : Op. Cit p.4

4.32 the effect of pollution control upon kiln technology diffusion is considered p.379 ff

4.33 Saggar stacking can be seen in Figure 4.4 p. 267

4.34 Merits of producer gas are reviewed 4.2.3. "Innovatory Applications of Fuels" p.282

4.35 Dressler : "Symposium on Importance of Thermal History - Problems of Firing Ceramic Ware in Tunnel Kilns"
American Ceramic Society Bulletin Vol. 18 No. 11 1939. p.412

4.36 Dinsdale : "Ceramics. A Symposium"
British Ceramic Society 1953 p.381

4.37 Width of tunnel kiln was limited by state of knowledge with respect to 'velocity burners'. p.291 ff

4.38 QUESTION KILN USERS.... STUDY.

4.39 The importance of the M.E.B. and the Gas Board as 'Change Agents' is examined later p. 374 pp

4.40 McFadden & Remmey : "The Jet-Burner - A New Concept in Fast Precision Firing".
American Ceramic Society Bulletin Vol. 41 No.3 1962 p.160

4.41 Futther details can be found p.319 ff

4.42 ANON: Ceramic Bulletin Vol 36 No.9 1977. p.794

4.43 Ibid p.795

4.44 further details p.291 ff

4.45 further details p.298 ff

4.46 ANON :"Refractory Fibres. A Growing Success"
Refractories Journal June 1974. p.11

4.47 Coudamy : "A New Generation of Intermittent Kilns"
Interceram No. 4 1977. p.270

4.48 Bushman in Ceramic Bulletin Vo. 36 No. 9 1977. p.795

4.49 Brush : "Today's Kiln Ready for Tomorrows Demands"
Ceramic Industry Magazine. August 1971. p.20

4.50 Passmore (DRAYTON KILNS) : "Sentinel Special Interceramex '78".
Evening Sentinel 19.9.1978. p. 1

4.51 Gittens : "Kilns and Firing"
Trans. Journal British Ceramic Society Vol. 75 1976 . p.xvi

4.52 Holmes: " Developments in Pottery Firing 1967-1977"
British Ceramic Society. Paper May 1978. p.30

4.53 Lingl : " Energy - conscious Kiln design"
Canadian Clay & Ceramics Sept. 1977 p.8

4.54 Harms : "The Integration of the Fast-Firing Kiln in the Modern Porcelain Factory"
Interceram No. 4 1977 p.276

4.55 ANON : Ceramic Bulletin Vol. 36 No.9 1977. p.792

4.56 "muffles" p. 269-70

4.57 Hind. Op. Cit p.69

4.58 Science Museum. " Josiah Wedgwood - The Arts and Sciences United" 1978.

4.59 See p. 339 ff

4.60 eg. Prinknash (Abbey) Pottery is located in rural Gloucestershire and uses an electrically-fired system of kilns due to unavailability of other fuels.

4.61 The importance of the M.E.B. as a'Change Agent' p.374

4.62 Searle : " Kilns and Kiln Building" 1915.

4.63 Hind : Op. Cit p.134

4.64 Hind : Op. Cit p.134

4.65 ANON : Ceramic Bulletin Vol. 36 No.9 1977. p.794

4.66 Coudamy. Op. Cit p.270

4.67 ANON : Ceramic Bulletin Vol. 36 No.9 1977. p.795

4.68 Bryan, Masters & Webb : "Application of Recuperative Burners in Gas-Fired Furnaces"
Communication No. 952 presented at a meeting of the Institution of Gas Engineers. London. Nov. 1974.

4.69 Searle : "Kilns & Kiln Building" 1915.

4.70 Hind : Op. Cit p.56

4.71 eg. see " Coal 1800-1956" p.282

4.72 Ash : " Ceramic Fibre-Blanket Furnace Linings"
British Clayworker Vol 79 No. 935 1970. p.34

4.73 refer p. 266

4.74 Berliner etal : "Kilns" N.Y. 1951. p.27
Note present day (1978) firing cycles for intermittent kilns are approximately 16 hours.

4.75 Tordoff : " Fiberwall-lined Kilns have potential in the ceramics industry"
Ceramics June 1973. p.6

4.76 Ogden : " Ceramic Fiber Furnace Linings extend Service Temperatures Economically"
Industrial Heating Vol. 40 No. 5 1973. p.906
: he suggests developments could allow operational temperatures in excess of 1300°C.

4.77 Barker : "Developments in Furnace Lining Techniques"
Refractory Engineering (Summer) 1973 p.23

4.78 Tordoff : Op. Cit p.8

4.79 ANON : "Refractory Fibres. A Growing Success"
The Refractories Journal June 1974 p. 11 see also
ANON : "New Biscuit Kiln a Fuel Saver"
Ceramic Industries Journal June 1975.

4.80 "L.T.M." : low thermal mass

4.81 Langman : "Furnace Builders. Users warm to alumina fibres"
Chartered Mechanical Engineer Sept. 1977. p.92

4.82 SAFFIL - 'safe filament' - was chosen as the brand name to contrast it with asbestos.

4.83 Development of SAFFIL. Appendix 7 p. (XXXi)

4.84 ANON : "Refractory Fibres"
Euroclay No. 2 1976. p.24

4.85 p. 266

4.86 ANON :"Modules overcome Ceramic Fibre Problems"
Ceramics Industries Journal Dec. 1974. p.53

4.87 Ceramic Age Jan 1973. p.22

4.88 Walker : "Why Anchors come out"
Industrial Heating Vol. 38 No. 6 1971 p.1105

4.89 Ash : "A World Survey of Low Thermal Mass Design & Construction Techniques"
Refractory Engineering Autumn 1975. p. 9

4.90 A point reaffirmed by a number of writers:
(i) Fidler : "Ceramic Fiber-lined Furnaces Installation Procedures"
Industrial Heating Vol 39 No. 10 1972 p.1095

(ii) Saunders: "Ceramic Fiber Furnace Lining Systems Applications, Manufacture, Installation"
Industrial Heating Vol 41. No. 4 1974. p.58

(iii) Fidler : " Energy Conserving Ceramic Fiber Linings for Heat Treating Furnaces".
Industrial Heating Vol 41. No. 5 1974. p.71

4.91 The first recorded exercise on'veneering' is attributed to Morganite Ceramic Fibres development project at a steel plant September 1975; this is quoted in an article published 1977 proving that the technique is still working two and a half years later...
ANON : "Veneer Lining Success"
Refractories Journal Vol 52. No. 4 1977 p.20

4.92 ANON: "Modules overcome ceramic fibre problems"
Ceramics Industries Journal Dec. 1974. p.53

4.93 Jeffers: "Installation System cuts Fiber lining costs"
Brick + Clay Record Vol. 170 No.6 1977 p.30

4.94 Warrillow: Op. Cit p.396

4.95 p.268

4.96 "Britain's Pottery Industry" British Pottery Promotions Service Ltd. 1966 p.6

4.97 Gaye & Smyth : Op. Cit p.38

4.98 p. 381 ff

4.99 p. 349 ff

4.100 Sir A Bryan at a Royal Society of Arts Lecture London November 1970.

4.101 p. 313 ff

4.102 p. 216 ff

4.103 An Introduction to the Fieldwork carried out as part of this Study has been presented: Section 4.2.1. P. 258

4.104 QUESTION 3 KILN BUILDER STUDY

4.105 QUESTION 4 KILN BUILDER STUDY

4.106 QUESTION 5 KILN BUILDER STUDY

4.107 A similar introduction to this study can be found p. 258 ff

4.108 QUESTION 3 KILN CUSTOMER, SUPPLIER, INFORMED PERSON STUDY

4.109 QUESTION 4 KILN CUSTOMER... STUDY

4.110 QUESTION 6 KILN CUSTOMER ... STUDY

4.111 p. 56 ff

4.112 Section 3. For example those findings for different products p. 169

4.113 Hind : Op. Cit p.186

4.114 Environmental influences on diffusion p. 379

4.115 S or J shaped diffusion curves p.61 ff

4.116 p. 285

4.117 p. 353

4.118 Board of Trade "Pottery" Working Party Report HMSO London 1946.

4.119 For example, Value of Exports. 1972
Chinaware : 8.6 thousand tons, value £12.9m
Earthenware : 42.0 thousand tons, value £20.7m
Sanitaryware: 19.0 thousand tons, value £4.4m

4.120 p. 381

4.121 p. 319 ff

4.122 Eyles : "Royal Doulton 1815 - 1965"
Hutchinson. London 1965 p. 53-4

4.123 Scowcroft & Padgett : "The Structure and Thermal Behaviour of Ceramic Fibre Blanket"
BCRA Technical Papers Vol 72 No. 3 1974 p.4

4.124 QUESTION 9 KILN BUILDER STUDY : the order statements presented in Table 4.16 differs from the questionnaire where statements were ordered to avoid possible sequential response bias.

4.125 To estimate the Average Industry Response, a method similar to that described on p.331 was used.

4.126 QUESTIONS 10,11 KILN BUILDER SURVEY

4.127 QUESTION 12 KILN BUILDER SURVEY

4.128 QUESTION 13 KILN BUILDER SURVEY

4.129 QUESTION 16 KILN BUILDER SURVEY

4.130 QUESTION 18 KILN BUILDER SURVEY

4.131 QUESTION 21 KILN BUILDER SURVEY
Quote taken from : Gaye & Smyth :"The British Pottery Industry" Butterworth 1974 p.28

4.132 QUESTION 8 KILN USER... STUDY

4.133 definition of 'change agent' p. 45

4.134 The reader is reminded that the first electric intermittent kiln was self-built for Edwards + Lockett in 1946, but made little impact with the rest of the market.

4.135 Evening Sentinel : "Interceramex '76" 20. Sept 1976

4.136 By convention in the industry, neither the Gas Board nor the M.E.B. actually build commercial kilns; they 'assist' with design, insta llation and field trials.

4.137 discussed p. 290

4.138 Generally, it has always been (and still is) customary for end-users to receive visits from other end-users to view recent technological developments.

4.139 Evening Sentinel : "Interceramex '76" 20 Sept. 1976

4.140 a technical limitation to tunnel kiln development p.291

4.141 p. 293

4.142 Source: West Midlands Gas Technical Consultancy Sevice

4.143 For example
Ogden (CARBORUNDUM): "Applications + Economics in the Use of New Higher Temperature Ceramic Fibre Insulation Refractories"
Refractory Engineering. Winter 1973 p.28
Frayatt (MORGANITE): "Major Fuel Savings with Ceramic Fibre"
Maintenace Engineer Vol 18 No.3 1974 p.58
Langman (I.C.I.) : "Furnace Builders. Users warm to alumina fibres"
Chartered Mechanical Engineer. Sept. 1977 p.92

4.144 p. 320

4.145 Warrillow : Op. Cit p.394

4.146 Ibid p.394

4.147 the principle is now being developed as the 'recuperative burner.'

4.148 Warrillow : Op. Cit p.421

4.149 Dr. Garner's "Chronicles on the Potteries" 1850

4.150 Galbraith. Report for the North Staffs Chamber of Commerce 1976.
By 1976 only 56 bottle kilns were still standing, and only 1 in working order at the Gladstone museum; this was fired for the last time in 1979.

4.151 P.J. Dickins (1979 MEB): private correspondence with the author.

4.152 Gaye& Smyth : Op. Cit p.224

4.153 ANON: British Pottery Industry. Op. Cit p.9

4.154 QUESTION 19 KILN BUILDER SURVEY

4.155 The importance of 'editorial matter' in promoting technological innovation is examined in
Clements : The Role of Advertising in Launching Technological Innovation :"A users perspective" to be published by the Advertising Association 1980.

4.156 Method for computqting this average was discussed p.331

4.157 QUESTION 7 KILN USER .... STUDY.

4.158 A very recent development-June 1979-Riedhammer UK have begun to recruit personnel from other kiln builders (eg BRICESCO) to establish itself in the intermittent - ceramic fibre lined kiln market segment.

SECTION 5 : SUMMARY AND CONCLUSIONS

5.1 INTRODUCTION

This Section concludes the Thesis by reviewing the fieldwork (Section 4) in the context of the literature review highlighted in the preceeding sections. It was suggested that the establishment of epistemological links between concept and operation has been weakened by a lack of clarity of defining terms used in this area of investigation. Consequently comments are made on some of the major terms used.

Also highlighted was the dichotomy that exists between process-orientated research (seeking 'causes' of innovatory behaviour) and results-orientated research (highlighting 'consequences' of innovatory behaviour). The traditional emphasis has been upon the establishment of a link between "innovativeness" (ie a propensity to innovate) and "economic criteria". More recent works have served to develop a wider consideration of contributing factors; the Thesis introduces the pressures to innovate illustrated in the fieldwork.

5.2 PROBLEMS OF DEFINING TERMS

A lack of clarity and understanding of terms used in research aggrevates the problem of explaining the industrial adoption and diffusion processes.

5.21 "INNOVATION"

The key to this area of study is a clear definition of the term "innovation", although this clarity is seldom determinable from the literature. What is questionned here is not so much the nature of the innovation (eg Continuous, Dynamically Continuous, Discontinuous) but rather how those innovating perceive the innovation, the inherent risks of adoption and so on. To those ends the researcher needs to ascertain from the members of a system (s) themselves what they consider to have been innovations. The fieldwork was used to elicite nominations of innovations from the systems studied. An open-ended question led to a considerable level of agreement amongst respondents in the first system studied (ie kiln builders). A subsequent study of related industrial systems reinforced and substantiated these findings. It was these innovations that were subsequently investigated. The fact that some respondents failed to perceive some, or all of these 'technological watersheds' (more specifically the Discontinuous-type innovation) but rather reported technological innovation as a continuous development process does not invalidate this approach, but rather validates the self-nomination approach because survey responses to questions will depend upon a respondent's perception of what is, or what isnt, an innovation.

This self-nomination approach does have a reporting-back problem; ones perception of what is "technologically advanced" is, in part, governed by one's own state of current technical knowledge, in the sense that past innovatory achievements may be viewed as less advanced by respondents viewing the process in retrospect. Hence what might have been perceived at the time as a "giant step for mankind" is viewed, in retrospect, as a natural technological progression.

5.22 " INDUSTRIAL INNOVATORS"

The literature highlights two related problems; namely the identification of 'industrial innovators' and 'how these innovators differ from other members of their system.'
Even where accurate records exist, there remains a methodological problem in using 'the firm' as the unit of definition. Whilst this is the common method used (indeed is used by this Thesis) it tends to ignore the adoption process undertaken within the firm, in particular how the elements which constitute the adoption decisions can change overtime, for example due to changes in (decision-making) personnel, the firm's competitive situation; changes which can affect a firm's outwardly propensity to innovate. Whilst we use the firm as our unit of measure when plotting diffusion are we necessarily comparing like-with-like over time-is the Wedgwood's of 1920 the same as in 1970?
Furthermore, the decision to innovate within a firm usually involves a collective decision making process. This may introduce a methodological problem to the researcher, namely how to identify the "firm's collective attitude" towards innovation by the usual procedure of surveying one or a small number of personnel in the

firm. This problem is exacerbated when seeking historical data, where original decision-making personnel are no longer available. Whilst this Thesis attempted to overcome this problem by cross-referencing and seeking responses from senior executives/owners of capital, the fact remains that the researcher is confronted with personalised responses that may or may not reflect the raison d'être for that firm's innovatory behaviour.

From historical records some indication was obtained of firms who had been first to market with a particular technological innovation. There remains the question of what should be considered the moment of innovation; should it be the time the innovation (in this case) was commissioned or perhaps when commitment was made to adopt a particular technological innovation? It bears consideration because in a number of cases the dates of commissioning ascribed to particular firms are so close (given the laying-down time for the plant) that leader-follower behaviour cannot necessarily be infered. It may be, for example, constructional delays and so on that govern the sequence of adoption rather than adoption decisions per se.

To substantiate historical records, the systems were asked to nominate firms considered "to be innovatory". Whilst some agreement between respondents was indicated (and substantiated by historical records) there was a noticeable reluctance to:

(a) possibly give 'credit' to a competitor

and (b) viewing innovatory behaviour over a time period of 50 - 100 years introduced a response that tended to suggest no firm demonstrated a consistent propensity to innovate (indeed a large number of firms currently in the industry have been established less than thirty years).

In addition, two firms named as innovators might not have been considered (by an independent observer) to be part of the kiln builder's immediate industry, both being materials suppliers to kiln builders.

Some agreement regarding nominated innovators was obtained by the second study (to kiln users etc) but again was influenced by the respondent's time horizon, a point examined later. There was one notable exception; one kiln builder was ranked the most innovatory by the second study yet featured nowhere in the nominations by fellow kiln builders. The kiln builder thus identified,(BRICESCO), itself chose not to participate in the study. An attempt to clarify this discrepancy using subsequent interviews was made; it was found that BRICESCO was acknowledged to have excelled, like Gibbons Bros, in early tunnel kiln development for the heavy clay manufacturing segment (tiles, sanitaryware). Like Gibbons Bros. it was seen as a well established firm, unlike a number of its contemporaries who only emerged post-1950. It is likely varying time perspectives explains the paradox; the manufacturers remembering early notable developments whilst the competitors noting that BRICESCO (like Gibbons) have been less active in more recent technological innovations. The identification of industrial innovators when studied over time remains problematical.
Studies have sought to identify the ways in which innovators differ from others in their industry. Several research studies (eg Carter and Williams, SAPPHO studies) have sought to highlight particular characteristics but those identified by the system as being "innovatory" demonstrated little variation (in their responses to the survey) in management practice, attitudes,

organisational size, expenditure on R & D, uses of communication, sales success, from the industry norm.

Partly this seems attributable to the industrial system. Perceived by the system-members as well as by the researcher as traditional in outlook, theory would suggest that it is less likely to find innovators deviating from the technological status quo.

Secondly, a general observation was made that the interaction between builder, customer and supplier (to the builder), and their relevant sizes affects who innovates and where the initial innovatory pressures arise.

5.23 "INDUSTRIAL OPINION LEADERS"

The existence and nature of opinion leaders in industrial systems remains contentious in diffusion literature. The method developed in communication studies post the Coleman Drug Study (1966), self nomination by system members, was used to identify firms considered by other firms to lead in technological development. A number of firms were nominated as innovators. The general conclusion was that firms are not followed but rather are 'watched'; this distinction indicates an unwillingness to admit to a leader-follower relationship-50% of respondents admitted "watching behaviour". What emerged was rather a "general surveillance of the competitive situation".

The identifaction of opinion leaders and subsequent influence on diffusion was made obscure by the overt influence exerted by suppliers (eg ICI,Pye Ether)and end-users (eg Wedgwood,Aynsley China). Moreover, whilst the source of innovatory pressure was found to arise outside the kiln builder system, nevertheless both suppliers and end-users chose to relate to acknowledged successful firms in the builder system. Whilst this correlates well with designated "innovatory builders", the effect of this adoption upon later adopters remains unclear because of the difficulty of establishing clear leader-follower relationships, using observation or self-reporting procedures.

5.24 " INDUSTRIAL SYSTEMS"

Katz emphasies the importance of the system in diffusion studies indeed communication studies have gained by examining "whole systems". As a consequence this Thesis set out to involve every kiln builder operating in the U.K. supplying the pottery industry. In practice respondents revealed system members not initally considered by the researcher. It does suggest that care is needed in defining system boundaries in communication studies. Equally, the interlocking nature of influence patterns between related systems increases the need to examine the scope of any study when seeking to identify influence sources. This Thesis began with the kiln builders as the focal point of interest in seeking to satisfy objectives - for purposes of conducting fieldwork only the U.K. market could be investigated although kiln technology is worldwide with developments in the USA and Germany. However all the major free-world suppliers featured in the fieldwork-but it was found necessary to investigate suppliers and kiln end-users to explain the adoption and diffusion of kiln technology. The drawing of system boundaries raises methodological points over a number of earlier diffusion studies in terms of identifying the initial causes rather than subsequent results of innovatory behaviour.

5.25 THE DIFFUSION CURVE

The mapping of the diffusion process using curves S or J shaped is well-established in diffusion research; it is the universality of shape that is argued in the literature. What remains more contentious is the use of prescribed mathematical formula to predict future innovatory behaviour using stages in the diffusion process.

Using actual historical data two diffusion curves were plotted and were seen to demonstrate the general shape described in the literature.

The diffusion curve plots market acceptance against time of adoption. The use of "time" is considered fundamental to the process. However it is suggested that using "time" affects the predictability of diffusion curves describing technological innovation. In each of the cases mentioned it was seen that the diffusion process was interrupted by exogeneous events - war, government intervention and so on - that, in retrospect, can be seen to have altered (here,retarded) the diffusion process.

What is evident is that the time taken to diffuse major technological innovation (the time scales for kiln technology were not significantly different from those quoted in the literature for other technological innovations) allows the infusion of variables which change the conditions under which adoption decisions (and subsequent diffusion) take place. Hence comparisons between earlier and later adopters regarding conditions of adoption remains questionnable in terms of using the former to predict the latter adoption behaviour.

Such were the impact of these intervening events that the causes of adoption prior to the event differed considerable from those preceeding the event; indeed the event itself became the cause of subsequent adoption behaviour.

This is not to underestimate the importance of mapping diffusion curves; such action serves to highlight the consequences of these (and other) influences, but equally the possibility of such variables occuring over extended time periods, like in technological forecasting methods per se, questions the use of mathematical formulae to describe and predict future technological adoption behaviour. It should be stated that inherent problems arise regarding the establishment of accurate historical data. Problems arose as to establishing precise dates of adoption due to memory recall or inaccuracies in company records (where such records existed), changes in industrial structure (eg firms had "disappeared" between the time of adoption and time of the study).

5.3 CAUSES OF INDUSTRIAL INNOVATION

In adopting a process rather than results orientated approach this Thesis concludes by highlighting those factors found influencing technological innovatory behaviour. The literature contains varied reasons why organisations engage in innovatory behaviour. Such reasons have recently moved away from explanations solely related to economic factors such as profitability per se. The study identified a number of innovatory pressures. It remains conjectural as to the relative strengths of these pressures. Certainly some factors were reported more frequently by respondents but as the reader will see, the interrelated nature of these pressures makes the establishment of cause-effect relationships of isolated variables that much more difficult.

5.31 THE LEVEL OF TECHNOLOGY

It was clear form the study that industrial diffusion cannot be meaningfully investigated without due consideration of competing technologies. At any period in time an innovation may be competing for adoption not only with the technology it is threatening to supplant but also parallel innovations and competing technology, as occured with gas/oil tunnel kilns and electric tunnel kilns competing with each other as well as offering superior technology to the coal fired bottle kiln in the 1920's – 30's.
In addition, the adoption of innovation itself can provide the impetus for further innovation. Technological bottlenecks, created by the implementation of technology, pressurise firms to further innovation to balance the technical knowledge status quo. Numerous examples were found:-

(i) TUNNEL KILN DEVELOPMENT

CHANGE IN FUEL

↓

CHANGE IN BURNER TECHNOLOGY

↓

CHANGE IN TUNNEL KILN SHAPE

(ii) MODERN INTERMITTENTS

DEVELOPMENT OF L.T.M. REFRACTORY FIBRE

↓

DEVELOPMENT OF "ANCHOR TECHNOLOGY"

↙ DEVELOPMENT OF PORTABLE KILNS

↘ CHANGES IN REFRACTORY FIBRE APPLICATIONS.

The consequences of diffusion of one innovation were seen to contribute to the causes of further innovation. One element highlighted in the literature seen as accelerating the rate of diffusion is "Trialability", in particular, visible evidence of performance. Numerous examples presented themselves, for example the first electric tunnel kiln, commissioned by Mintons (1927) was considered a trial operation, as was the introduction of ceramic refractory material forty five years later at Aynsley China and Wedgwoods. Perhaps peculiar to the industry is the commonplace practice for competing firms to be allowed to see a new piece of equipment in operation. In only one reported case did an end-user (pottery manufacturer) refuse to open his doors to his competitors. The effect was for the MEB to construct its own trial kiln and invite comment from the industry (the role of change agents is dealt with later). What was found interesting was that a lack of understanding of the technology does not necessarily inhibit adoption and diffusion. Trial and error and "it works" were sufficent to begin the diffusion of a technological innovation.

5.32 MANAGERIAL ATTITUDES

In line with recent studies this Thesis endorses the importance of managerial perspectives in the adoption of technological innovation. It was seen that such attitudes and predispositions to innovate did vary over time due to changes in the competitive situation, the structure of firms,and in the industry. The strong emphasis upon family ownership and control, together with a craft-orientation, gravitated against a general propensity to accept technological change, endorsing the importance of an organisation's "climate" (Tagiuri & Litwin).
It was evident that prevailing "attitudes" (a general propensity to innovate might be a more meaningful descriptor) affected how other innovation influences were perceived. For example, it was the interpretation of economic factors rather than these "facts" themselves, which influenced how the perceived risk was assessed and adoption decisions made. Managerial attitudes can be considered to be an overriding cause of the speed of adoption and diffusion of technological innovation, generally formed by past innovation

experiences, first or second-hand, in conjuction with the prevailing organisational and competitive climates.

5.33 INDUSTRIAL STRUCTURE

Self-report by the systems studied suggested that they were "traditional in outlook", based upon family ownership and with an emphasis upon artisan-excellence. Evidence was presented to show that structural change itself occurred as a consequence of innovation (eg the industrial restructuring, post-1956 Clean Air Acts and the demise of the bottle kiln) and also a cause of innovation; for example, changes in firm's size,mergers and acquisitions provided synergistic opportunities for the implementation of new technologies precluded earlier by the nature of the structure.

5.34 ECONOMIC FACTORS - COMPETITION AND PROFITABILITY

Traditionally economic factors were considered in the literature to be the prime movers of technological innovation (ie "relative advantage" expressed in economic terms); anticipated profitability, possibly through experience, being the cause, and subsequent rewards reinforcing the propensity to innovate in a future time period.

This perspective assumes a continuity of experiences which in practice is altered by the time scales involved and the subsequent changes in structures and attitudes between major technological innovations. If this self-reinforcing perspective was true, innovation would become a regenerative process, with success breeding success through successive applications of technology.

This was not substantiated by this study; successful firms (at any one point in time) did not necessarily reinvest in new technology to seek to perpetuate their positions. Firms often chose not to grow beyond a "complacency size" because of the fear of loss of family control; rewards for entrepreneurial endevour were frequently "leaked" from the industry rather than reinvested.

Profitability for the industry was observed to be low and this fact has influenced the propensity not to innovate, but this must be viewed in the light of an unwillingness to borrow capital for investment because of the possible dilution of managerial control. Profit opportunities were interpreted in the light of such constraints.

Competitive influences were not cfedited with having much effect upon adoption decisions; indeed the nature of the systems studied led firms to watch each other with a kind of awe when one of them was implementing new technology. Immediate technical success itself did not necessarily stimulate immediate imitation, but the subsequent increase in "better ware" (rather than profits per se) served to create an interest in the technology. Examples were given of competitors sharing trial situations with a pooling of experiences.

The findings of this Thesis are limited in terms of determining whether profits pulled through innovation or vice versa. Certainly prior to 1939 innovation took place in a climate of falling profits and industrial depression. The upsurge in demand, especially in exports, immediately post-war led to an inverse propensity to innovate, as the desire to reestablish old and new markets led to a postponement of technological innovation.

Again, as profits and output fell post-1956, innovation took place.

Because of these observations it is difficult to propose a cause-effect relationship between increasing profitability and a propensity to innovate; innovation was observed to take place in distress rather than slack situations, inresponse to changes in profits rather than in anticipation of achieving increased profitability.

5.35 ROLE OF "CHANGE AGENTS"

The identification and importance of "change agents" in industrial systems has received little attention in the research literature. The concept has been developed from the findings of medical and rural sociologists, consequently it tends to be restrictive for explanatory use in industrial systems (viz " a professional who influences innovation decisions in a direction deemed desirable by a change agency"). From this study, change agents - considered to be links between systems as opposed to opinion leaders who link within systems - were observed operating from a number of sources. The British Ceramic Research Association represents the change agent formally charged with infusing new technological ideas into the industry. However, this institution, like educational-research establishments, received a "low influence rating" from respondents to the study, being seen as "too-advanced" for the day-to-day needs of the industry. Where it had been influential is through a two-step flow to particular firms within the industry, who have then communicated the innovation to other firms within the industry (often by example).

Other change agents were seen to be stimulating the adoption/diffusion processes, such as end-customers, fuel suppliers, materials suppliers (though in a competitive situation stressing self-interest). Whilst the degree of encouragement provided (eg trial facilities, absorption of risks and costs-sharing) varied, their influences was observed as considerable.

5.36 A PLACID LABOUR FORCE

Organisational resistance to change is usually considered from a manageral context with minimal consideration as to the possible role of (organised) labour in the adoption/diffusion process. Yet in an unionised system such resistance may affect not only adoption in any particular firm, but also the rate of diffusion in the industry. Although the works in the Pottery Industry have over 150 years of unionised history, little evidence was available to suggest that kiln technology has been resisted on any substantial scale. Implementation of kiln innovations has generally led to favourable improvements in working conditions and better earnings potential, which have outweighed the reductions in manning levels. Scarity of skilled labour has allowed operatives to seek employment in organisations with their desired level of kiln technology, or to retrain in the new technology or to retrain for another job within the organisation (demarkation disputes are infrequent in an industry that accepts labour flexibility and mobility). It is true to say that the systems themselves - traditional in outlook with limited radical change- have not provided a climate of conflict because change of working practices have been so gradual.

5.37 THE INDUSTRIAL ENVIRONMENT

A number of pressures to innovate were identified which could be considered beyond the immediate control of the innovating decision-maker. Such factors were observed to be both causes and consequences of innovatory behaviour. For example Governmental direction of production into exports in the early post-war (1946-52) period is considered to be the prime reason for the postponement of technological re-equipping. Similarly, failure to adopt newer, cleaner firing methods contributed towards the changes in pollution legislation in 1956, which, in turn, fundamentally changed the level of technology in the industry and the industry's structure itself. Other examples include the effects of relative fuel prices(by taxation,Government direction and so on) which influenced the relative attractiveness of particular methods of combustion; world wars, the Arab-Israeli conflicts and subsequent international oil-price movements have influenced the rates of diffusion for innovations diffusing at these particular times. In turn the recent energy crisis has provided a new impetus for better fuel-efficient kilns.

5.38 COMMUNICATIONS

The literature stresses the importance of "communications" in the diffusion process. To understand its role it is necessary to consider what is communicated - the message - and how it is communicated - the channel used.

Various channels were tested as sources of innovatory ideas and pressure. A general conclusion reached was that informal channels rated more highly with the respondents. Possibly this was due to the system investigated; both geographically (location) and socially, kiln builders, customers and suppliers were known to each other, often sharing similar (technical) backgrounds, and in some cases common technical experience. As a result, word of mouth and "grapevine news" tended to be rated higher than formal contact through the salesforce. Similarly, the industrial practice of inviting competitors to view technology on trial speeded up the awareness and interest stages of adoption by providing meaningful "second-hand" personal experience. A number of trial cooperations were traced to friendship patterns cemented by some-company backgrounds. The existence of industrial opinion leaders has been raised elsewhere. Attempts were made to relate channels used by nominated leaders in comparison with other firms in the industry; it was established that they do not necessarily use different channels but it is less clear whether they differ in what they do with the information so collected. Opinion leaders as "gatekeepers" of informal networks were not clearly established; apparently whilst firms are watched and respected for past successes, their opinions are not necessarily actively sought (or at least this point was not reported in the study).

Both formal channels (exhibitions, meetings, promotion) and informal channels were identified operating in the system studied. Informality was seen as the key source of information.

5.39 BRIEF SUMMATION OF THE FIELDWORK FINDINGS REGARDING THE SPEED OF DIFFUSION IN INDUSTRIAL SYSTEMS

(i) Retarding Factors

(a) The traditiohal, conservative perspective of the end-user increases the reluctance to make technological innovation decisions.

(b) The historical structure of the industry; the 'small family controlled unit' with inadequately trained scientific and business managers.

(c) The availability of resources in a low profit, high waste industry to allow the end-user to finance technological risk.

(d) The size of the pottery kiln market (both new and replacement demand) inhibits the kiln-builder from large scale R & D commitment and explains why kiln builders tend to remain small service units.

(e) The adoption of new kiln technology can affect the rest of the production process, so pressures exist to maintain the production status quo.

(f) Possible lack of entrepreneurial flair to undertake risk unlike earlier periods in the industry's history.

(ii) Accelerating Factors

(a) The close-knit nature of the industry does mean that a successful adoption of an innovation is quickly communicated through the industry, so accelerating the diffusion process. Note, however, a failure is likewise quickly communicated and acts to reinforce the traditional, technology status quo stance.

(b) Recent mergers within the pottery industry have provided larger firms with more resources available for investment, also better qualified scientific and business personnel.

(c) The increasing involvement of change agents - fuel suppliers (Gas Board, MEB, Shell Oil) and refractory material suppliers (ICI, Carborundum).

(d) Exogenous pressures pulling through technological change, for example the world fuel crisis post 1973.

(e) The emergence of entrepreneurial flair in the kiln builder system (eg James Birks, Donald Shelley); builders who are prepared to develop technologies (primarily refractory fibres and portable kilns) in anticipation of end-user demand.

(f) The presence of research facilities at the BCRA and other research / educational institutions.

(g) The widely circulated (but less consulted) technical media.

APPENDIX 1 GENERALISATIONS ABOUT THE DIFFUSION OF INNOVATIONS

(Source. Rogers & Shoemaker p347-385)

Communication of Innovation

1. System effects may be as important in explaining individual innovativeness as such individual characteristics as education, cosmopoliteness, and so on.
2. Earlier knowers of an innovation have more education than later knowers.
3. Earlier knowers of an innovation have higher social status than later knowers.
4. Earlier knowers of an innovation have greater exposure to mass media channels of communication than later adopters.
5. Earlier knowers of an innovation have greater exposure to interpersonal channels of communication than later adopters.
6. Earlier knowers of an innovation have greater change agent contact than later knowers.
7. Earlier knowers of an innovation have more social participation than late knowers.
8. Earlier knowers of an innovation are more cosmopolite than later knowers.
9. Later adopters are more likely to discontinue innovations than are earlier adopters.
10. Innovations with a high rate of adoption have a low rate of discontinnance.

11. Traditional individuals are more likely to skip functions in the innovation-decision process than are modern individuals.
12. There are functions in the innovation-decision process.
13. The rate of awareness-knowledge for an innovation is more rapid than its rate of adoption.
14. Earlier adopters have a shorter innovation-decision period than later adopters.
15. The relative advantage of a new idea, as perceived by members of a social system, is positively related to its rate of adoption.
16. The compatibility of a new idea, as perceived by members of a social system, is positively related to its rate of adoption.
17. The complexity of an innovation, as perceived by members of a social system, is not related to its rate of adoption.
18. The trialability of an innovation,as perceived by members of a social system, is positively related to its rate of adoption.
19. The observability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption.
20. The degree of communication integration in a social system is positively related to the rate of adoption of innovations.
21. Earlier adopters are no different from late adopters in age.
22. Earlier adopters have more years of education than do later adopters.
23. Earlier adopters are more likely to be literate than are later adopters.
24. Earlier adopters have higher social status than late adopters.

25. Earlier adopters have a greater degree of upward social mobility than do later adopters.
26. Earlier adopters have larger sized units (farms etc) than do later adopters.
27. Earlier adopters are more likely to have a commercial (rather than a subsistence) orientation.
28. Earlier adopters have a more favourable attitude towards credit (borrowing money) than later adopters.
29. Earlier adopters have more specialised operations than later adopters.
30. Earlier adopters have greater empathy than later adopters.
31. Earlier adopters are less dogmatic than later adopters.
32. Earlier adopters have a greater ability to deal with abstractions than do later adopters.
33. Earlier adopters have greater rationality than later adopters.
34. Earlier adopters have greater intelligence than later adopters.
35. Earlier adopters have a more favourable attitude towards change than later adopters.
36. Earlier adopters have a more favourable attitude towards risk than later adopters.
37. Earlier adopters have a more favourable attitude towards education than later adopters.
38. Earlier adopters have a more favourable attitude towards science than later adopters.
39. Earlier adopters are less fatalistic than later adopters.
40. Earlier adopters have higher levels of achievement motivation than later adopters.
41. Earlier adopters have higher aspirations (for education, occupations etc) than later adopters.

42. Earlier adopters have more social participation than later adopters.

43. Earlier adopters are more highly integrated with the social system than later adopters.

44. Earlier adopters are more cosmopolite than later adopters. (ie. measures of cosmopoliteness include trips to cities, exposure to cosmopolite communication channels.)

45. Earlier adopters have more change agent contact than later adopters.

46. Earlier adopters have greater exposure to mass media communication channels than later adopters.

47. Earlier adopters have greater exposure to interpersonal communication channels than later adopters.

48. Earlier adopters seek information about innovations more than later adopters.

49. Earlier adopters have greater knowledge of innovations than later adopters.

50. Earlier adopters have a higher degree of opinion leadership than later adopters.

51. Earlier adopters are more likely to belong to systems with modern rather than traditional norms than later adopters.

52. Earlier adopters are more likely to belong to well integrated systems than are later adopters.

53. Interpersonal diffusion is mostly homophilous (on such variable as social status, education, mass media exposure, cosmopoliteness, change agent contact and innovativeness)

54. When interpersonal diffusion is heterophilous, followers seek opinion leaders of higher social status.

55. When interpersonal diffusion is heterophilous, followers seek opinion leaders with more education.

56. When interpersonal diffusion is heterophilous, followers seek opinion leaders with greater mass media exposure.
57. When interpersonal diffusion is heterophilous, followers seek opinion leaders who are more cosmopolite.
58. When interpersonal diffusion is heterophilous, followers seek opinion leaders with greater change agent contact.
59. When interpersonal diffusion is heterophilous, followers seek opinion leaders who are more innovative.
60. Interpersonal diffusion is characterised by a greater degree of homophily in traditional than in modern systems.
61. In traditional systems followers interact with opinion leaders less (or no more) technically competent than themselves, whereas in modern systems opinion leaders are sought who are more technically competent than their followers.
62. Opinion leaders have greater exposure to mass media than their followers.
63. Opinion leaders are more cosmopolite than their followers.
64. Opinion leaders have greater change agent contact from their followers.
65. Opinion leaders have greater social participation than their followers.
66. Opinion leaders have higher social status than their followers
67. Opinion leaders are more innovative than their followers.
68. When the system's norms favour change, opinion leaders are more innovative; but when the norms are traditional, opinion leaders are not especially innovative.
69. When the norms of a system are more modern, opinion leadership is more monomorphic.
70. Change agent success is positively related to the extent of change agent effort.

71. Change agent success is positively related to his client orientation rather than change agency orientation.

72. Change agent success is positively related to the degree to which his programme is compatible with clients' needs.

73. Change agent success is positively related to his empathy with clients.

74. Change agent contact is positively related to higher social status among clients.

75. Change agent contact is positively related to greater social participation among clients.

76. Change agent contact is positively related to higher education and literacy among clients.

77. Change agent contact is positively related to cosmopoliteness.

78. Change agent success is positively related to his homophily with clients.

79. Change agent success is positively related to the extent that he works through opinion leaders.

80. Change agent success is positively related to his efforts in increasing his clients' ability to evaluate innovations.

81. Mass media channels are relatively more important at the knowledge function and interpersonal channels are relatively more important at the persuasion function in the innovation-decision process.

82. Cosmopolite channels are relatively more important at the knowledge function and localite channels are relatively more important at the persuasion function in the innovation-decision process.

83. Mass media channels are relatively more important than interpersonal channels for earlier adopters than for later adopters.

84. Cosmopolite channels are relatively more important than localite channels for earlier adopters than for later adopters.

85. The effects of mass media channels, especially among peasants in less developed countries, are greater when these media are coupled with interpersonal channels in media forums.

86. Stimulators of collective innovation-decisions are more cosmopolite than other members of the social system.

87. Initiators of collective innovation-decisions in a social system are unlikely to be the same individuals as the legitimisers.

88. Rate of adoption of a collective innovation is positively related to the degree to which the social systems legitimisers are involved in the decision-making process.

89. Legitimisers of collective innovation-decisions possess higher social status than other members of the social systems.

90. The rate of adoption of collective innovations is positively related to the degree of power concentration in a system.

91. Satisfaction with a collective innovation-decision is positively related to the degree of participation of members of the social system in the decision.

92. Member acceptance of collective innovation-decisions is positively related to the degree of participation in the decision by members of the social system.

93. Member acceptance of collective innovation-decisions is positively related to member cohesion with the social system.

94. A supportive relationship between the adoption unit (a subordinate) and the decision unit (a superior) leads to more upward communication about the innovation.

95. An individual's acceptance of an authority innovation-decision is positively related to his participation in innovation decision-making.

96. An individual's satisfaction with an authority innovation-decision is positively related to his participation in innovation decision-making.

97. When an individual's attitudes are dissonant with the overt behaviour demanded by the organisation, the individual will attempt to reduce the dissonance by changing either his attitudes or his behaviour.

98. The rate of adoption of authority innovation-decisions is faster by the authoratitative approach than by the participative approach.

99. Changes brought about by the authoritative approach are more likely to be discontinued than those brought about by the participative approach.

100. Change agents can more easily anticipate the form and function of an innovation for their clients than its meaning.

101. The power elite in a social system screen out potentially restructuring innovations while allowing the introduction of innovations which mainly affect the functioning of the system.

102. The power elite in a social system especially encourage the introduction of innovations whose consequences not only raise average levels of 'good' but also lead to a less equal distribution of good.

APPENDIX 2 SURVEY I KILN BUILDERS/DESIGNERS

Catterson-Smith Ltd.

William Boulton Group / Shelley Furnaces Ltd.

Gibbons Bros. (C.P.B. Division)

Kilns & Furnaces Ltd.

Wengers Ltd.

James Birks (Kiln Builder) Ltd.

Interkiln Corporation of America

Vincenti Officine e Fonderie

Ludwig Riedhammer (UK) Ltd.

D. Shelley Ltd.

BRICESCO Ltd.

Industrial Furnaces Ltd.

Unifurnaces Ltd.

Technoceramica Ltd.

Morando Impianti SpA

J.W. Ratcliffe & Sons Ltd.

Bushe Kilns Ltd.

Webcot Kilns & Furnaces Ltd.

Ramsell Naber Ltd.

Harrison Mayer Ltd.

Cromartie Kilns

Fuel Furnaces Ltd.

Fulham Pottery Ltd.

Hans Lingl (UK) Ltd.

North Staffordshire Polytechnic
Director J. F. Dickenson BSc(Eng), PhD, CEng, FIMechE

Department of Business and Legal Studies (x)

Head of Department
A. D. Ramsay BCom, DipCom, MBIM

North Staffordshire Polytechnic
College Road, Stoke-on-Trent ST4 2DE
Telephone 0782 45531

Our ref B/MAC/LW Your ref

Dear Sir,

As a member of staff at the North Staffordshire Polytechnic at present undertaking research for a part time degree (at the University of Salford), I am anxious to gain your help in carrying out some research into the pottery kiln industry's attitudes and performance in product development. All information used would be treated with the greatest confidence and full anonymity, where requested, would be preserved. This research is solely for educational purposes and is in no way sponsored by any industrial or commercial body.

I enclose three letters from notable referees who are prepared to endorse the nature of my research.

I look forward to your assistance.

Yours faithfully,

M.A. CLEMENTS
Senior Lecturer in Marketing.

NORTH STAFFORDSHIRE POLYTECHNIC

DEPARTMENT OF BUSINESS AND LEGAL STUDIES

POTTERY KILN MANUFACTURERS SURVEY I

NOTES AND INSTRUCTIONS

1. This Questionnaire is being sent to a limited, but representative cross-section of firms involved in the manufacture of kilns for the Pottery Industry - your answers are essential to provide a meaningful result.

2. In view of the differences in size between firms, certain questions are obviously less appropriate for the smaller firm. However, there are no 'right answers' and you should indicate (✓) the alternative which most accurately reflects the situation in your firm.

3. The nature of the information sought does require a reply from a senior executive who has an overall perspective of the firm's activities.

4. All information will be treated with the greatest confidence and full anonyminity preserved. No information appertaining directly to your firm will be published without your prior permission.

5. Please return the completed questionnaire as soon as possible in the enclosed stamped addressed envelope, or direct to:

Michael A. Clements,
Department of Business and Legal Studies,
North Staffordshire Polytechnic,
College Road,
Stoke-on-Trent.
ST4 2DE

POTTERY KILN MANUFACTURERS SURVEY I

NAME OF FIRM James Birks Kiln Builder + Contractor

STATUS OF RESPONDENT

SIZE OF FIRM

Number of Employees	23			

Would you say that your ANNUAL TURNOVER is

Less than the Industry's Average	
About Average	✓
Above the Industry's Average	

BUDGET FOR RESEARCH AND DEVELOPMENT

(as a percentage of Annual Turnover)

Less than 1%	
Between 1% - 5%	
More than 5%	✓

NUMBER OF PERSONNEL INVOLVED IN FULL-TIME RESEARCH AND DEVELOPMENT

0 persons	
1 - 5 persons	✓
6 - 10 persons	
More than 10 persons	

PLEASE INDICATE THE SECTORS OF THE POTTERY INDUSTRY THAT YOU HAVE SUPPLIED WITH KILNS:

Domestic /Hotelware	✓
Industrial Ceramics	✓
Tiles	✓
Others · eg.	

QUESTION 1

Given that there are continual modifications to existing Kiln technology, do you consider that there has been technological "watersheds" in (pottery) kiln manufacture?

YES	✓
NO	
Dont Know	

If YES then:

QUESTION 2

Could you please identify what you feel have been the major technological 'break throughs' in kiln technology since 1900.

TUNNEL KILNS

TRANSPORTABLE KILNS

LOW THERMAL MASS MATERIALS.

INSTRUMENTATION ETC.,

QUESTION 3

Are there firms within the U.K. market that are consistently among the first to develop and produce major technological improvements to pottery kilns?

YES	✓
NO	
Dont Know	

If YES, please name firm(s)

MORGANITE CERAMIC FIBRES.
PYE ETHER LTD

QUESTION 4

Are there any distinguishing characteristics of these firms which you feel accounts for them being first?

YES	✓
NO	
Dont Know	

If YES, please look at the following list and indicate accordingly:

	Extremely Important	Very Important	Not so Important	Not Important At all
Size of Assets	✓			
Size of Research Budget		✓		
No. of Employees			✓	
Sales Volume		✓		
No. of scientific personnel employed	✓			
Efficient management structure	✓			
Company profitability	✓			
Skilled labour force	✓			

Others (please specify)

QUESTION 5

Are there firms that consistently influence other competing firms in the development and production of new kiln technology?

YES	✓
NO	
Dont Know	

QUESTION 6

Are these the same firms that are first to develop and produce major technological improvements? (of QUESTION 3)

YES	✓
NO	
Dont Know	

If NO, please name firm (s)

QUESTION 7

Are there any distinguishing characteristics of these firms that you feel might account for this influence?

YES	✓
NO	
Dont Know	

If YES, do these characteristics

correspond with those in Question 4

YES.	✓
NO	
Dont Know	

If then NO, please indicate these characteristics

QUESTION 8

Is this influence the result of one firm knowing 'through the grapevine' that a competitor is developing a new kiln?

YES	
NO	
Dont Know	✓

If NO, please comment on the nature of the influence

THE FOLLOWING QUESTIONS RELATE TO YOUR OWN FIRM'S POLICY TOWARDS NEW PRODUCT DEVELOPMENT

QUESTION 9

Do you feel your Firm's attitudes towards new product development are . . . . (Please indicate ✓ accordingly)

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
'We believe there is a need to be at the forefront of pottery kiln development'	✓				
'Proven methods are best'		✓			
'Why change for change sake'				✓	
'There is prestige to be gained from being first'	✓				
'There are profits to be gained from being first'	✓				
'New products are associated with development, production and selling problems'		✓			
'We believe in letting other firms find the problems, and then we improve upon their initial ideas'			✓		
'We always seem to need new men and expertise to get it right'				✓	
'Its too costly to persuade customers to adopt new ideas'				✓	
'We listen to what the customer wants and then we make it'	✓				
'New product development is too risky'				✓	

QUESTION 10

Who are the main personnel involved in the development of new kilns within your Firm?

(Please indicate only rank of personnel, committee etc.)

Managing Director, Gas Consultant Engineer
Electrical Engineer, Works Engineer.

QUESTION 11

Do those who are the most important in making these decisions (on kiln development) turn to others within the Firm for further opinions.

YES	✓
NO	
Dont know	

If YES, do you know to whom?

Various foremen.

QUESTION 12

"It is necessary for the Firm's executives and middle management to have formal business training"

Do you -

Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
✓				

QUESTION 13

Do you consider that systematic forecasting techniques can be used to aid the decision to add a new idea to the production line(s)?

YES	✓
NO	
Dont Know	

QUESTION 14

Have you found certain types of customer within the pottery industry more receptive to new products than others?

YES	✓
NO	
Dont Know	

If YES, please indicate industrial sector

Domestic/hotelware	
Industrial Ceramics	✓
Tiles	
Others, (please specify)	

QUESTION 15

"primarily new product development should be the result of in-firm research and development"

Do you -

Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
✓				

QUESTION 16

Have any modifications ever been introduced after the prototype stage as a result of user-experience?

YES	✓
NO	
Dont Know	

QUESTION 17

Is new product development part of a general marketing policy?

YES	✓
NO	
Dont Know	

QUESTION 18

Is sales effort a major factor in the success or failure of a new product?

YES	✓
NO	
Dont Know	

QUESTION 19

Please indicate any of the following sources of INFORMATION which you see as important in the development of new kiln technology

	Most Important	Important	Not so Important	No Importance At all
Own R & D experience	✓			
Informal contact between firms	✓			
Formalised contact between firms		✓		
Industry/Professional publications		✓		
The Research Association		✓		
Educational/Research Institutions				
Liaison with former customers	✓			

Others (please specify)

QUESTION 20

Often new technology can have far-reaching repercussions in an industry. Do you feel this is true of the industry you are in?

YES	✓
NO	
Dont Know	

If YES, could you please explain your reason for your answer

If a new idea dosn't quite go according to plan then it is quite easy for Kilns to explode or become a fire hazard, therefore all instrumentation refractory and how Thermal Mass Materials have to be thoroughly tested etc. Also they can affect the economic [illegible]

BRITISH CERAMIC
MANUFACTURERS' FEDERATION

FEDERATION HOUSE, STATION ROAD
STOKE-ON-TRENT, ST4 2SA
TELEPHONE: STOKE-ON-TRENT 0782 48631
TELEGRAMS: "FEDERATE, STOKE-ON-TRENT"

TO WHOM IT MAY CONCERN

MICHAEL A. CLEMENTS

Mr. Clements has discussed with me his intention of preparing a thesis for his Ph.D on "Kiln Manufacturers in the Pottery Industry".

I am satisfied at his approach to this work is a very serious and sincere one and could probably fill what might be found to be a gap in the socio-industrial history of the Industry and thereby be a valuable contribution.

I would hope that he could be accorded such facilities as he might reasonably hope to receive from those manufacturers he approaches.

Director

5 February 1976

University of Salford

Salford M5 4WT

Department of Business and Administration

Professor of Management Studies
H McKinlay
(Chairman of Department)

Telephone 061-736 5843
Telex 668680 (Univ Salford)

RSM/PDMcE

15 January 1976

To whom it may concern

Mr M A Clements, Senior Lecturer in Marketing at the North Staffordshire Polytechnic, is currently registered as a part-time PhD candidate with the University of Salford. It is hoped that the research programme will be centred on an investigation on product innovation in the pottery kiln industry and as research supervisor, I strongly support Mr Clements' request for manufacturer cooperation in making the relevant information available to him over the coming months. All such information will be treated as entirely confidential where necessary and I have no reservations as to Mr Clements' responsibility and trust worthiness.

signed ..R. S. Mason..........
R S Mason
Senior Lecturer in Marketing
Supervisor of Postgraduate Management Courses.

APPENDIX 5 SURVEY II KILN CUSTOMERS, SUPPLIERS OF TECHNOLOGY & INFORMED SOURCES

COOPERATED

O. Riley (North Staffs Polytechnic)

C.C.I.

Auto Combustions Hoistrack

B.C.R.A.

J.Hewitt's

G. Wolliscroft

Industrial Pyrometer

Eurotherm

A.G. Hayek

Donald Shelley Ltd.

Coleford Brick & Tile

Twyfords

Smiths Industrial (Ceramics Division)

Spode

Doulton Industrial

Portmeirion Potteries

Taylor and Kent

Josiah Wedgwood Group

Carborundum

Enoch Wedgwood's

Worcester Royal Porcelain

Alfa Aggregates

Nu-Way Eclipse

H & R Johnson-Richards

Doulton Sanitary

DID NOT COOPERATE:

British Ceramic Pottery Manufacturers Assoc.

Diamond Refractories

Norton Industrial Products

Morgan Refractories

Callender Brick & Fireclay

Stealite & Porcelain Products

Bullers

Taylor & Tunnicliff

Staffordshire Potteries

Henshall, Bamford & Ptnrs

Price-Pearson

Govencraft Potteries

FOUND NOT APPLICABLE

Clark Ceramic Consultants

Stein Refractories

H.R. Holfield

Acme Marl

Accrington Brick & Tile

Anderman & Ryder

Hoben-Davis

Begg, Cousland

Consultant Gas Engineers

Advanced Materials Engineering

Whitehouse Brick & Tile

NORTH STAFFORDSHIRE POLYTECHNIC

DEPARTMENT OF BUSINESS AND LEGAL STUDIES

POTTERY KILN INDUSTRY
SURVEY II

NOTES AND INSTRUCTIONS.

1. This Questionnaire is being sent to a limited, but representative cross-section of personnel whom it is felt will be familiar with the U.K. Pottery Kiln industry: your answers are essential to provide a meaningful result to the survey.

2. There are no 'right answers'. You should indicate the alternative which most accurately reflects your point of view.

3. The nature of the information sought does require a reply from a senior executive/informed person who has an overall perspective of the situation.

4. All information will be treated with the greatest confidence and full anonymity preserved. No information appertaining directly to yourself or your firm (where applicable) will be published without your prior permission.

5. Please return the completed Questionnaire as soon as possible in the enclosed S.A.E. or direct to -

M.A. Clements,
Department of Business and Legal Studies,
North Staffordshire Polytechnic,
College Road,
STOKE-ON-TRENT ST4 2DE.

POTTERY KILN INDUSTRY SURVEY II

Name of Firm (if applicable) SPODE LTD.

Name and Status of Respondant R B JONES

DIVISIONAL TECHNICAL MANAGER
ROYAL WORCESTER - SPODE LTD.

Question 1

Given that there are continual modifications to existing kiln technology do you consider that there has been technological 'watersheds' in (pottery) kilns?

Yes	✓
No	
Dont know	

Question 2

If you answered Yes to Question 1, could you please briefly identify what you feel have been the major technological 'breakthroughs' in kiln technology since 1900?

THE CHANGE FROM COAL TO OTHER FUELS
" " " INTERMITTENT TO CONTINUOUS FIRING
" " " SAGGAR TO OPEN SETTING
THE INTRODUCTION OF LIGHT WEIGHT INSULATION
INTRODUCTION OF STEAM INTO DECORATING KILNS

Question 3

Are there firms within the U.K. market that are consistently among the first to develop and produce major technological improvements in pottery kilns?

Yes	✓
No	
Dont know	

Question 4

Could you please look at the following list of pottery kiln manufacturers and indicate three firms whom you feel are the leaders of their industry.
Please rank 1, 2 and 3.

Brisesco	✓
R.M. Catterson-Smith	
Cromartie Kilns	
Diag/Kera	
(The) Drayton Kiln Co.	
Gibbons Bros (CFB) Division	✓
Industrial Furnaces Limited	
Interkiln Corp of America	

James Birks, Kiln Builder	
Kilns & Furnaces Limited	
Ludwig Riedhammer	✓
Ramsell Naber Limited	
Shelley Furnaces/Firegas Kilns	
Vincenti Fonderie (Italia)	
Wengers Limited	

Others (please specify and rank)

SITI (EQUAL FIRST WITH RIEDHAMMER)

Question 5

Does this market leadership stem from-

Sales Volume	
Technical achievements	
Both	✓

Question 6

Do you feel that the sources of pressure upon the kiln producer to develop and produce new ideas originate from:

(Please rank)

Own R. & D.	2
Competitive pressures	1
Customer influence	4
Supplier influence	3

Other sources (please specify and rank)

Dont know

Question 7

Please look at the following SOURCES OF INFORMATION and indicate how important you feel they are in the communicating of new kiln technology.

	Most Important	Important	Not so Important	No importance at all
Formal contact with kiln manufacturer		✓		
Informal contact with kiln manufacturer			✓	
Through the Industry 'Grapevine'			✓	
Industry/Professional publications		✓		
The Research Association	✓			
Educational/~~Research~~ Institutions				✓
Interceramex			✓	

Any others (please specify)

____

____

Question 8

One study of the pottery kiln industry indicated that it took nearly 40 years for the widespread acceptance of the "tunnel kiln". Can you suggest why you feel it takes this length of time for new ideas to become accepted in this industry?

IT MAY HAVE TAKEN 40 YEARS FOR THE WIDESPREAD INTRODUCTION OF CONTINUOUS FIRING BUT THIS WAS PROBABLY DUE TO SHORTAGE OF CAPITAL RATHER THAN NON ACCEPTANCE OF THE CONCEPT.

Question 9

By now you will have appreciated that the generalised nature of this Questionnaire does not allow for a discussion on any finer points of detail. Would you be willing to allow me to come and visit you, at your convenience, to discuss the information outlined in your answers?

Yes	✓
No	
Dont know	

CLOSE OF QUESTIONNAIRE.

May I take this opportunity to thank you for your co-operation in my Doctoral Research.

Michael A. Clements

Michael A. Clements

February 1977.

APPENDIX 7 THE DEVELOPMENT & LAUNCH OF 'SAFFIL' CERAMIC FIBRES BY I.C.I. (MOND DIVISION) (1)

"Lightweight thermal insulating materials based on refractory fibres have, for a number of years, given good service in furnace insulation and similar applications. The range of applications is now extending considerably, thanks to the introduction of high-performance alumina fibre insulants" (2). This innovation-high performance alumina fibre-is called "SAFFIL". 'SAFFIL' is a trade name for a new ICI (Mond Division) inorganic fibre composed of alumina, which is capable of withstanding continuous hot-face temperatures up to 1600 c compared with around 1200 c for other alumino-silicate fibres. Its properties absorb less heat, thereby saving fuel, and give shorter warm up and cool down times, thereby allowing greater through put from a kiln so lined.

The Initial Development

The reader is likely to be familiar with organic fibres, either natural like cotton and wool, or synthetic like nylon or terylene. He is less likely to be familiar with the growing family of inorganic fibres, such as asbestos, synthetic glass and mineral fibres. During the Sixties general research attention focussed on new high performance inorganic fibres such as boron nitride, silicon carbide and carbon fibre. Partly this attention is attributed to the chemicals industry seeking advances in these materials, but also it was apparent that development in user-technology had created gaps for new products in the market.

Foster suggests four factors which led ICI to commence research into inorganic fibres in the late 1960's (3):-

(1) The Mond Division had a set of fairly old stable products, which brought pressure from the Main Board to actively seek new ventures.

(2) There was already research and development being carried on elsewhere on carbon fibres (viz Rolls Royce and associates) and on other inorganic fibres, mainly for material reinforcement, but all were still sophisticated and costly to produce.

(3) Governmental and environmental pressures were building up on the dangers of asbestos as to its production and applications in industry.

(4) Mond Division possessed considerable expertise in allied fields, for example, in crystallisation, as a result of producing millions of tonnes per year of basic inorganic products such as salt and sodium carbonate.

One such fibre, forms of alumino-silicate made by melt-spinning high purity clays (eg kaolin) already occupied a place in this gap and was showing substantial growth in the refractories field, replacing fireclay brick in kiln linings in a number of industries (4). These Bibres had developed to maximum sustained operational temperatures of around 1200 c. ICI envisaged developing a fibre to withstand hot-face temperatures up to 1600 c.

The R & D Phase 1969-1972

At the outset, research was necessary to examine the various methods of producing fibres, selecting suitable raw materials and circumventing published patents in this area. Within a year R & D had developed "SAFFIL" fibres (5); these are created by spinning from solutions of metal compounds instead of by melt-spinning. The product of the spinning process are fibres 95% alumina in content, uniform fine diameter (between 2 and 4 microns), with a stable length of a few centimetres. Unlike competitive fibres, this product is free from lumps of non-fibrous impurities (called 'shot') and has a non-irritant silky handle. Looking like cotton wool, it was found to withstand very high hot-face temperatures as envisaged, to be chemically resistant to all normal kiln atmospheres, and to have a much greater resilience ('springback') over its whole temperature range than any other inorganic refractory fibre. Early R & D production quantities were limited to around 0.5 tonnes per year from a laboratory rig. Development progress was hampered by lack of sufficient fibres, insufficient knowledge about the chemical properties and a 'cloak of secrecy', since for much of the process it was either not possible or desirable at this stage to patent it. At this time (1970) around 50 different applications were under investigation, but development research indicated three possible large tonnage prospects:-

(1) As a catalyst substrate, particularly for emission control on USA cars.

(2) For thermal insulation

(3) As a harmless replacement for asbestos.

Although still a secret process, by 1971 the project was considered advanced enough to justify testing market reaction to the new product. The pressure to consider end-user interests so early in the development process was that ICI's then normal policy of delaying any form of formal market research had in the past led to numerous product, user problems following introduction.

The basis of this research was that members of the venture team visited selected possible end-users, secrecy agreements were entered into, and the product was tested at the end-user's premises. Favourable results from this research led to the investment in a pilot plant (K-Rig) in 1971, costing approximately £200000. This pre-production rig could produce between 5 and 10 tonnes of fibre per year.

Pre-Commercialisation 1972-1974

Initial enquires and interest acted as conviction for the ICI Main Board who sanctioned, in 1972, £2m for the construction of a commercial production plant (Pioneer Rig) at Widnes. Production capacity was to begin in two stages:-

(1) Initally it would produce between 100 and 150 tonnes per year (enough fibre for 200-300 kilns) - this first stage was completed in 1974.

(2) As market demand grew so fibre production would be increased to around 300 tonnes per year - expected completion of this stage is mid - 1979.

Pioneer was given three objectives:-

(1) Produce the fibre for sale at commercial prices.

(2) Produce the product for applications development.

(3) Develop the process to define product quality and cost.

As Foster explains " We took the view that in order to obtain accurate information on long term market demand, it was necessary to price at a level that would give a satisfactory return from a fully commercial plant. Of necessity, this meant that we were by no means covering our costs in the early years, but it did get the market moving, and gave us firm guidelines as to the real size of that market" (6).

Early development had established a number of facts:-

(1) The fibres were technically much more difficult to produce on a large scale than had been envisaged. This meant more sophisticated raw materials and production expertise were needed, so escalating costs.

(2) Initially a range of fibres had been envisaged using two elements - alumina and zirconia; development indicated that only the alumina fibre possessed the best combination of cost and chemical properties.

(3) Similarly, applications became abandonned or refined; 'SAFFIL' fibres were directed to one major application area - high temperature insulation.

(4) As Project SAFFIL developed, so the present organisational structure became unsuitable. From 1969 to 1972 the R & D team had grown from a few senior chemists to around 60 personnel, with additional support from Mond Division's Engineering Department; in 1974 a commercially-orientated manager was introduced into the team, although the project was still the responsibility of R & D Management. His function was to examine all commercial implications for 'SAFFIL' in the market place. Also, organisational links were begun with the senior management of one of the Division's Product Groups, with a view to the control of the product, as is normal policy at ICI, passing from the Research Department to a Product Group as the project attained 'commercial importance'.

Foster recalls early market development policy being governed by three factors (7):-

(1) Given the high level of resources committed to the project, the product was to be launched in all the major industrial nations of the world.

(2) ICI Mond Division had no salesforce with experience in the refractory industry, and in two of the major industrial countries (USA and Japan) virtually no salesforce at all.

(3) The fibre had to be transformed into 'useful forms for end-users'; it was recognised that a high level of expertise would be necessary to design and install the fibres into kilns.

Launch into the Pottery Industry 1974
-Wedgwoods the Innovator

The first full-scale kiln to use 'SAFFIL' fibres as the hot-face linings was brought into commission in November 1974; this was a kiln for firing biscuit at Josiah Wedgwood's Coalport factory and built by Shelley Furnaces.

As has been illustrated earlier in this section, interest in 'ceramic refractory fibres' was already present in the pottery industry; reluctance by the user to adopt was that the existing fibres were not proven satisfactory in the biscuit-firing range (around 1250 c) and also the method of fixing the fibres to the kiln was fraught with production problems at these temperatures; for the builders and installer, with little actual demand by the end-user, the more traditional refractory fibres were being used. Against this backcloth, Wedgwoods, knowledgable of 'SAFFIL', approached Shelley Furnaces to quote for a new kiln using this product (8). Construction of this first kiln became a tripartite agreement. ICI, in order to promote interest in the innovation, agreed to a number of 'quarantees' (still a commercial secret) to both Wedgwoods and Shelley Furnaces; primarily these were to provide technical backup etc if results proved less than anticipated. It was decided that the product was not to be 'given away' because:-

(1) A successful conclusion to this contract would be used to convince the ICI Main Board of the product's potential and

(2) It was hoped to avoid claims from other fibre suppliers of 'unfair competition', suppliers who later might be needed to market 'SAFFIL'.

This kiln was 'blanket lined' and provided the builder and materials supplier with an excellent opportunity to get a 'before' and 'after' compansion because it was constructed alongside a kiln of the same size, insulated by firebrick. The data obtained suggested energy savings as much as 35% could be achieved, depending on

(i) Length of firing cycle, which depended upon

(ii) What was being fired in the kiln

By 1977 a number of pre-set landmarks had been achieved by ICI:-

(1) Cumulative sales had exceeded £1m.

(2) Product and applications were clearly defined.

(3) Commercial viability and market interest had speeded up the need to transfer product responsibility from the R & D budget to a Product Group.

The Main Board sanctioned a further £7m to begin the second stage production of the Pioneer Rig; responsibility for 'SAFFIL' was transferred to the General Chemicals Group. Formal recognition of the innovation came in 1978 with the Queeens Award for Technological Innovation.

'SAFFIL' MARKETING POLICY

The first commissioned kiln, that at Coalport, was the direct result of cooperation between ICI, an innovatory kiln builder and an innovatory end-user. Soon after this kiln was brought into production, ICI entered into an agreement with Babcock and Wilcox (and associates) in 1975 - who became sole distributors for 'SAFFIL' fibres. Babcock and Wilcox (ie Morganite in the UK) are the largest manufacturer of lower grade insullating fibres (ie alumino-silicate fibres such as Triton 'Kaowool') in the world; they saw 'SAFFIL' as an essential addition to their range, both for direct re-sale and also to be used to blend their existing fibre range. Essentially the agreement (in the UK) is that end-users, kiln builders and other fibre-customers cannot buy 'SAFFIL' direct form ICI at a price less than that price they would have to pay Morganite. Today, although ICI does deal with other fibre companies (eg Dettrick, Sauder Industries), it has become a 'raw material supplier' moving away by choice from the end-user market place "... These agreements have worked extremely well and have enabled ICI to move back to the position it desired, namely a raw material supplier to the industry without going too far down-stream into areas where it had no special expertise to offer" (9). This has become traditional ICI marketing policy regarding launching new technological products (eg terylene); the market is developed in conjuction with end-users, intermediary support is stimulated and convinced and ICI withdraws back to a supplier situation.

ICI undertook to communicate 'SAFFIL' to the market place using a widely publicised Press Conference (March 1974) (10); interest was stimulated throughout the technical press. Sales interature became available for distribution through intermediaries(eg Morganite), but gradually ICI direct-interest has reduced. Nowadays, orders received direct from customers are analysed and referred to the most suitable fibre supplier/associate. A regionalised technical salesforce is maintained, offering technical advice to builder and end-user alike, this includes a computer programme which can calculate expected fuel consumptions, compare performance of fibre linings vis a vis refractory brick "... this is something that to my knowledge no one else can offer" (11). Some advertising is used in selected technical journals and the Coalport kiln has been featured in ICI's corporate image campaign - 'Ideas in Action'. Dr. Langman explains the policy of 'continued presence' in the market place as the need to maintain ICI's name, which is believed to have a good image, in the market place which in turn, helps it's associates to sell more 'SAFFIL'.

AND THE FUTURE.....

ICI (Mond Division) with the second stage of Pioneer Rig due in operation early 1979, is now working on the second generation of 'SAFFIL' fibres; the aim is not directed towards increasing the chemical properties of insulation beyond the 1600 c, but rather to produce the same level of performance at a lower price. This it is felt will remove the remaining economic barrier to adoption.

NOTES

(1) The writer acknowledges the considerable contribution to this section provided by Dr. Langman (ICI Mond Division). The information was collected over five unstructured question-answer sessions at ICI Headquarters, Runcorn.

(2) Langman: "Furnace Builders: Users warm to Alumina Fibres" Chartered Mechanical Engineer. Sept 1977 p 92.

(3) Foster: "The Management of Innovation-The Development of 'SAFFIL' as a Case Study"
Unpublished paper: ICI Mond Div. Marketing Dept. Nov. 1977 p2

(4) For example, Carborundum Co.'s ' Fiberfrax' had been available since early 1953.

(5) The research was undertaken by a venture team led by an established/acknowledged 'product champion' - Derek Birchall - whose speciality was the area of crystal formation and the properties of solids. An earlier success from a team under his leadership was 'Monex' - a dry-powder fire-fighting agent.

(6) Foster: Op cit p.2

(7) Foster: Op Cit P.4

(8) Symes reports that Wedgwoods own research team had made a detailed study of using ceramic fibres - Symes: "Energy Savings in Intermittent Processes"

(9) Foster: Op cit P.4

(10) Tarling: " Getting new technical ideas onto the market has its problems"
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(11) Symes: Op cit P.4

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