

## VOLUME II

### SECTION 4

#### THE ADOPTION AND DIFFUSION OF

#### TECHNOLOGICAL INNOVATION IN THE

#### POTTERY KILN INDUSTRY 250

##### 4.1 INTRODUCTION 250

##### 4.2 TECHNOLOGICAL INNOVATION IN THE POTTERY KILN INDUSTRY 258

##### 4.21 IDENTIFICATION OF INNOVATION BY FIELD STUDY 258

##### 4.22 KILN STRUCTURE INNOVATIONS 1800-1975 264

##### 4.23 INNOVATORY APPLICATIONS OF FUEL 1800-1975 282

##### 4.24 INNOVATIONS IN KILN "HOT-FACE" REFRACTORY LININGS 1800-1975 294

##### 4.25 INNOVATIONS IN APPLYING REFRACTORY LININGS TO THE HOT-FACE OF THE KILN 307

##### 4.3 ADOPTION AND DIFFUSION OF TECHNOLOGICAL INNOVATION IN THE POTTERY KILN INDUSTRY 319 Section Notes 396

### SECTION 5

#### SUMMARY AND CONCLUSIONS

##### 5.1 INTRODUCTION 404

##### 5.2 PROBLEMS OF DEFINING TERMS 405

##### 5.21 "INNOVATION" 405

##### 5.22 "INDUSTRIAL INNOVATORS" 406

##### 5.23 "INDUSTRIAL OPINION LEADERS" 409

5.24	"INDUSTRIAL SYSTEMS"	410
5.25	THE DIFFUSION CURVE	411
5.3	IDENTIFYING CAUSES WHY ORGANISATIONS INNOVATE	413
5.31	THE LEVEL OF TECHNOLOGY	413
5.32	MANAGERIAL ATTITUDES	415
5.33	INDUSTRIAL STRUCTURE	416
5.34	ECONOMIC FACTORS--COMPETITION AND PROFITABILITY	416
5.35	ROLE OF "CHANGE AGENTS"	418
5.36	A PLACID LABOUR FORCE	419
5.37	THE INDUSTRIAL ENVIRONMENT	420
5.38	COMMUNICATIONS	420
5.39	BRIEF SUMMATION OF THE FIELDWORK FINDINGS REGARDING THE SPEED OF DIFFUSION IN INDUSTRIAL SYSTEMS	421

#### APPENDICIES

1.	GENERALISATIONS ABOUT THE DIFFUSION OF INNOVATION (i)
2.	SURVEY I. KILN BUILDERS / DESIGNERS (ix)
3.	SURVEY I: LETTER INTRODUCING SURVEY (x)
	QUESTIONNAIRE (xi)
4.	LETTERS OF CREDENTIAL (xxi)
5.	SURVEY II KILN CUSTOMERS, SUPPLIERS OF TECHNOLOGY (xxiv)
	AND INFORMED SOURCES
6.	SURVEY II QUESTIONNAIRE (xxvi)
7.	THE DEVELOPMENT AND LAUNCH OF "SAFFIL" CERAMIC (xxxi)
	FIBRES BY I.C.I. (MOND DIVISION)

BIBLIOGRAPHY (xLii)

PHOTOGRAPHIC ILLUSTRATIONS

ILLUSTRATION OF A TRUCK/KILN CAR	274
FIREMAN DRAWING A "TRIAL" FROM A BOTTLE KILN c1930	284
MODERN L.T.M. ELECTRICALLY FIRED INTERMITTENT KILN	
ILLUSTRATING THE HEATING ELEMENTS	289
CERAMIC FIBRE IN A PREFORMED STATE	300
"SAFFIL" ALUMINA FIBRE	302
THE COALPORT KILN 1974	304
ILLUSTRATING WIDE VARIETY OF APPLICATIONS OF	
CERAMIC FIBRE IN KILN CONSTRUCTION	306
CERAMIC FIBRE IN ROLL-FORM	308
ELECTRICALLY FIRED L.T.M. KILN AT BRAMHAM POTTERY	
USING "MULLITE CERAMIC CUP" ANCHORS	312
ELECTRICALLY FIRED L.T.M. KILN USING "ROYAL	
WORCESTER ANCHORS"	314
GAS FIRED L.T.M. KILN BEING "VENEERED"	317

## 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 industry. 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 19th, 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)			1956
	N.Staffs	U.K.	N.Staffs as % of U.K.	
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  $1150^{\circ}\text{C}$  and  $1300^{\circ}\text{C}$ , 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  $1030^{\circ}\text{C}$ . 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  $700^{\circ}\text{C}$  and  $750^{\circ}\text{C}$ . If any 'on glaze' decoration is to be used, this further firing fixes the decoration to the ware.



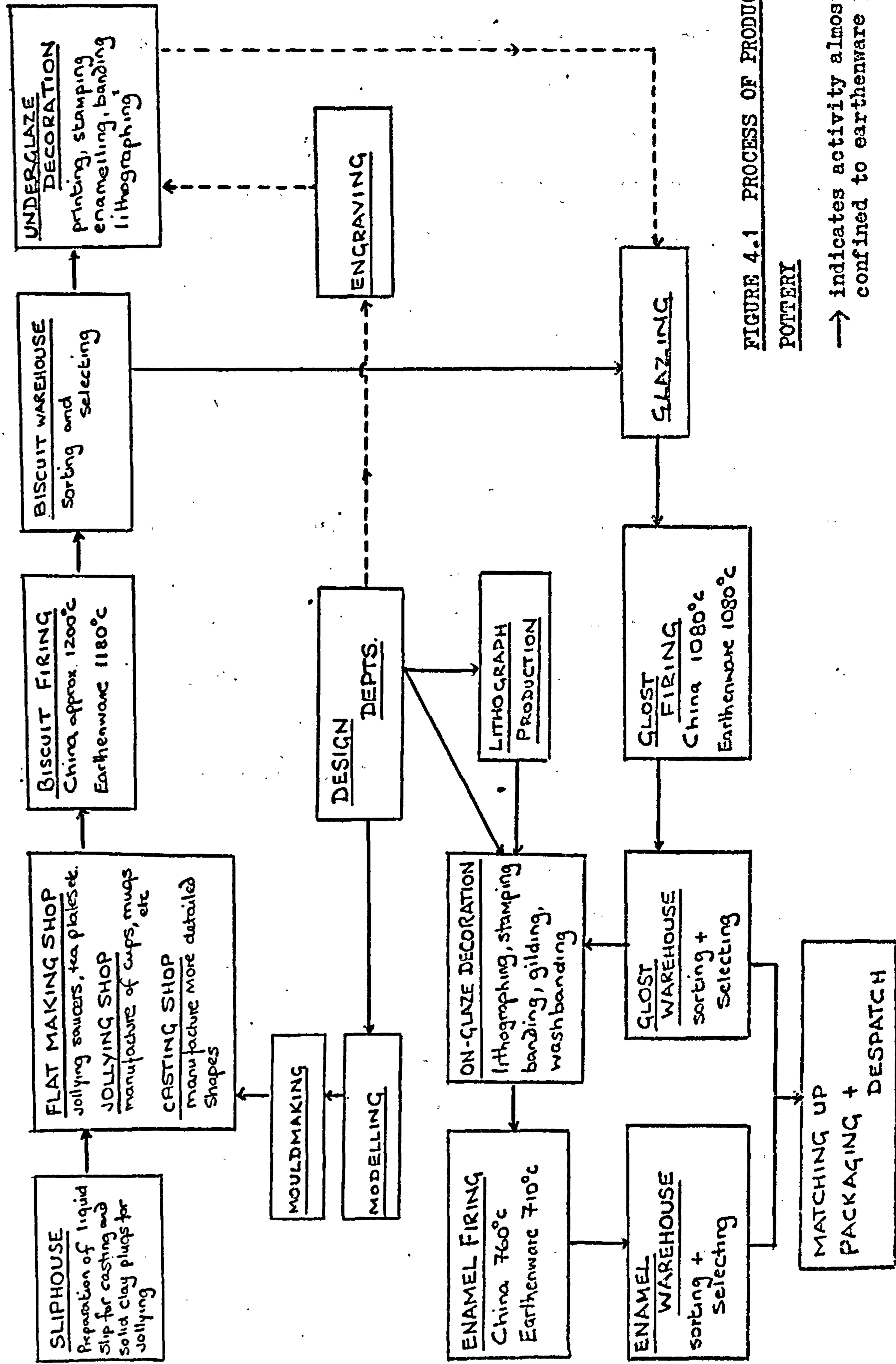


FIGURE 4.1 PROCESS OF PRODUCING POTTERY

→ 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 construction 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 colleagues 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 responding 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 manufacturers), 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
<hr/>	
TOTAL COOPERATION	25
<hr/>	

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

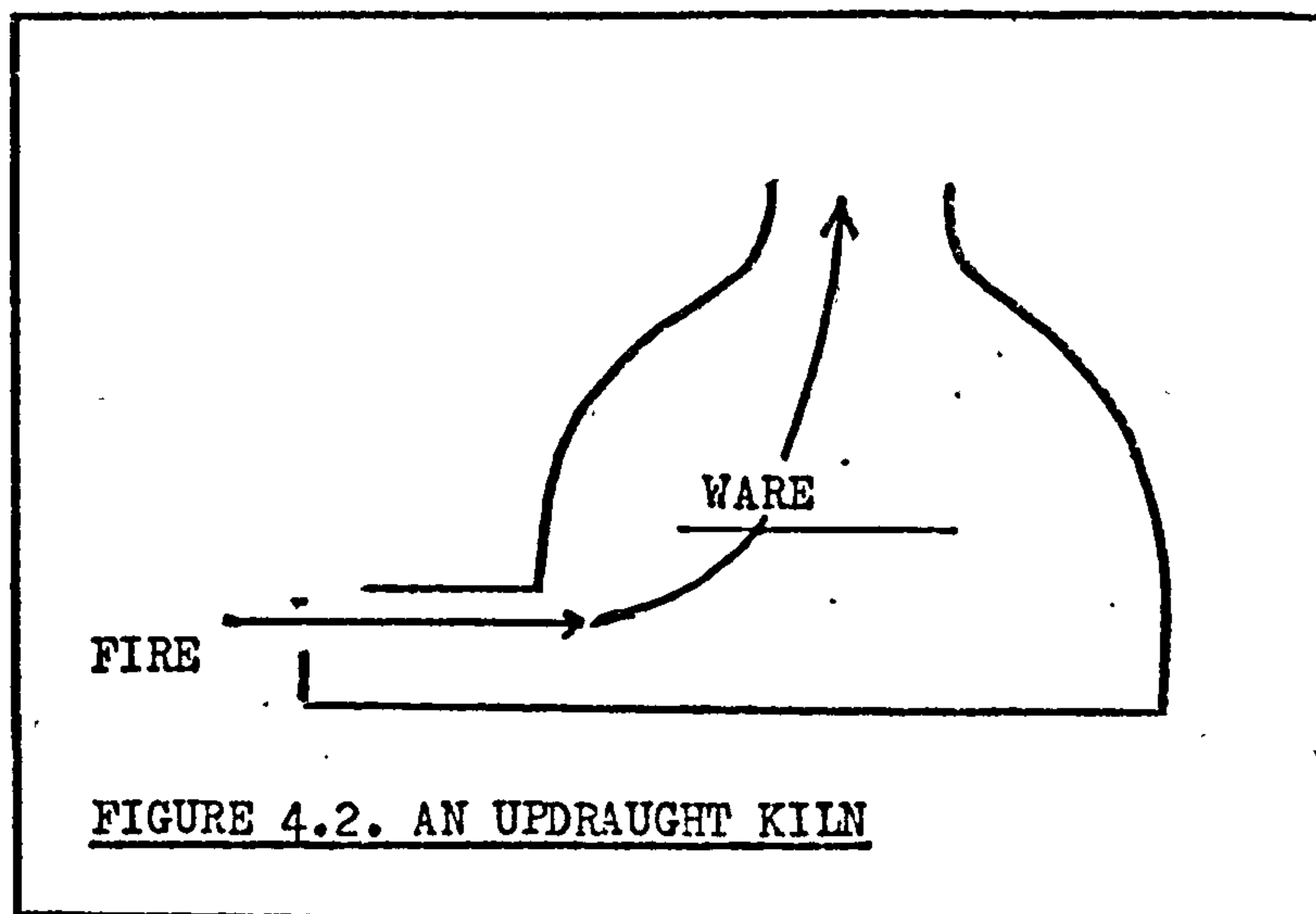
##### EARLY INTERMITTENT KILNS 1800-1956

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

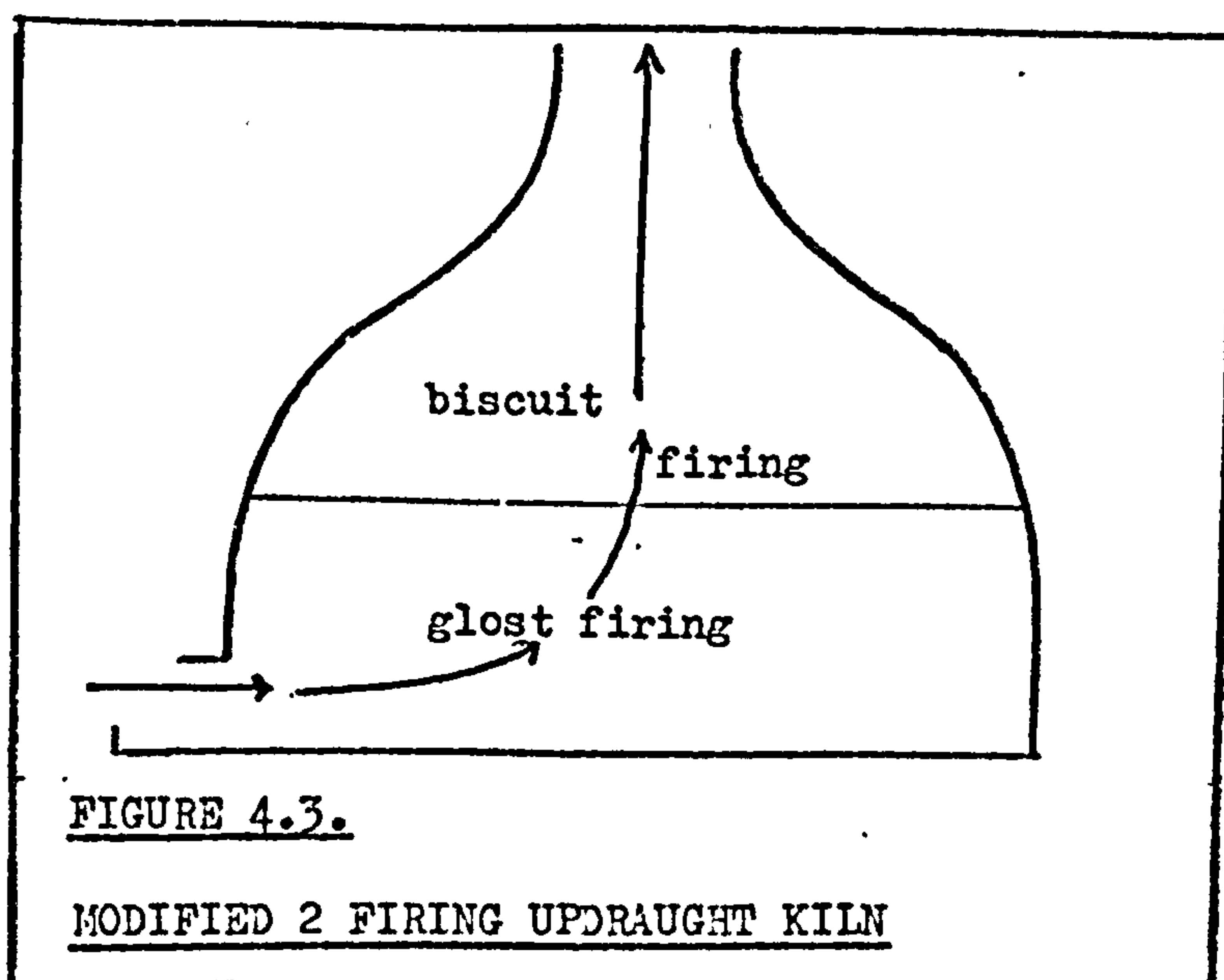
The period known as the Industrial Revolution is marked in the potteries industry by the rapid introduction of the 'bottle kiln'. The bottle shape is first attributed to Boettger, a German, who developed such a kiln in 1710..." the kiln was elongated upwards into a bottle shape with a chimney at the 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):-



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 firing a glost stage in the first floor chamber, and a biscuit stage in an upper floor chamber - as illustrated below:-



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 Bišcuit 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:



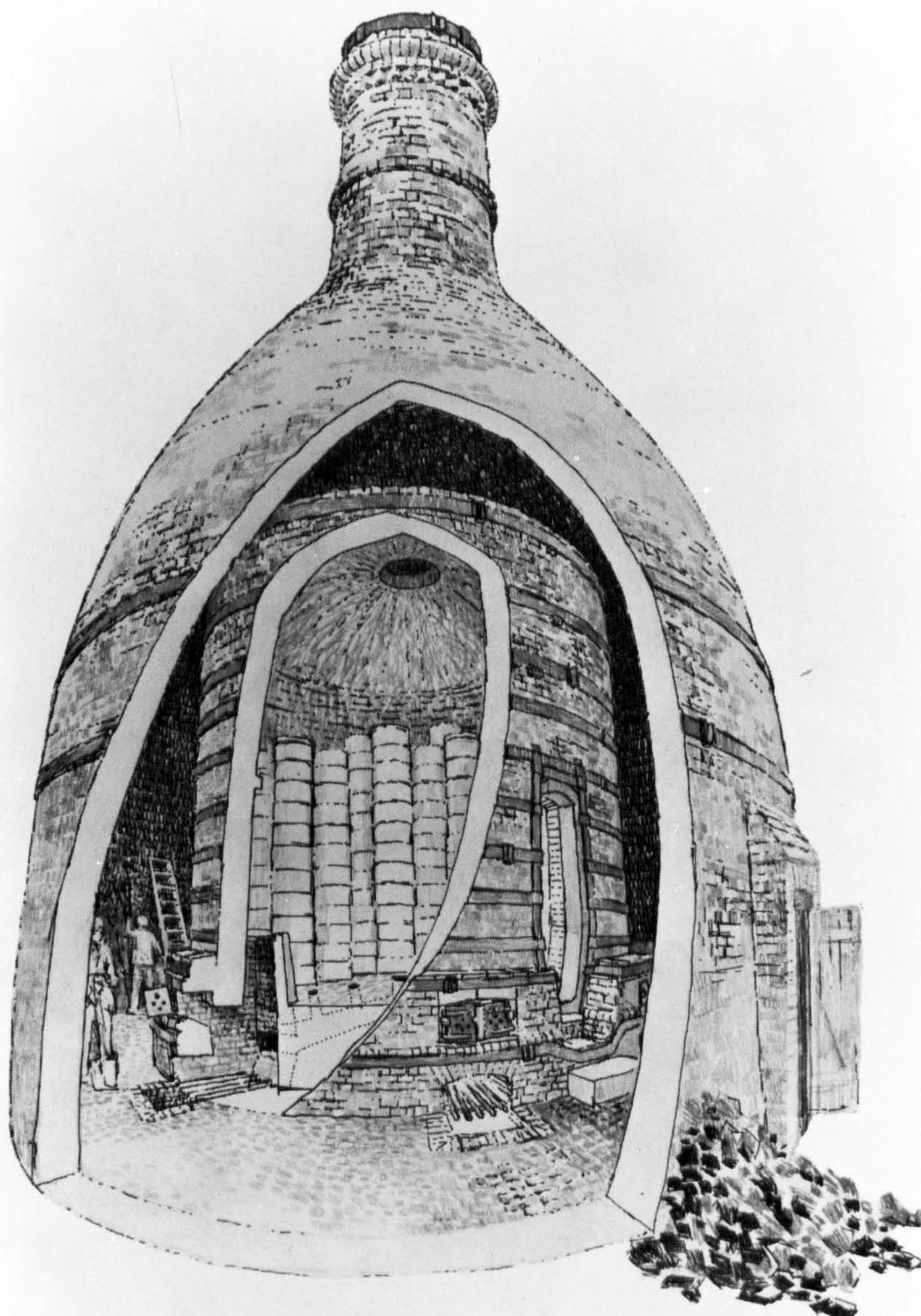


FIGURE 4.4. HOVEL-TYPE BOTTLE KILN

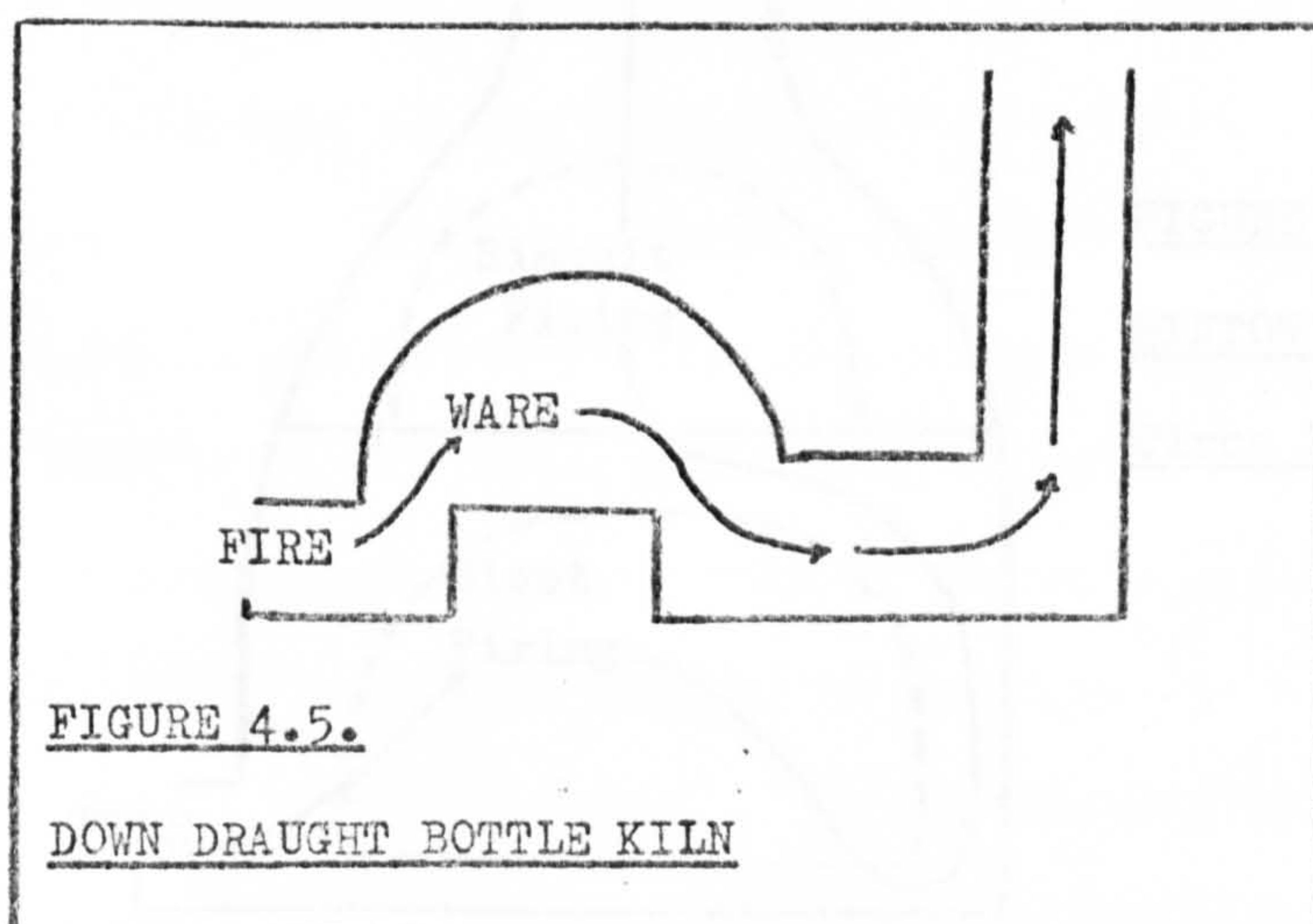


FIGURE 4.5.

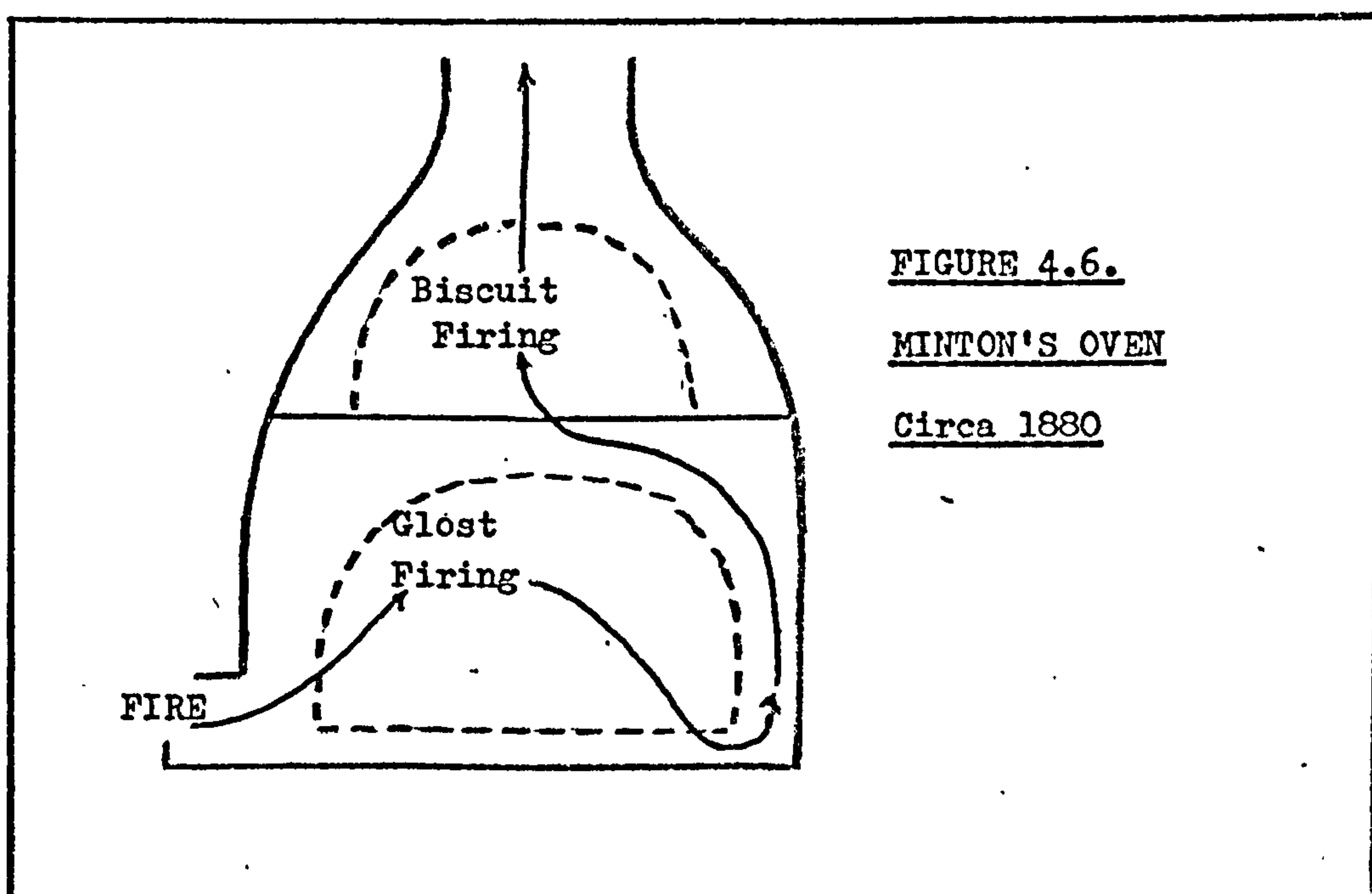
DOWN DRAUGHT BOTTLE KILN



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:-



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 attendance 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 endeavour 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 efficiency 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

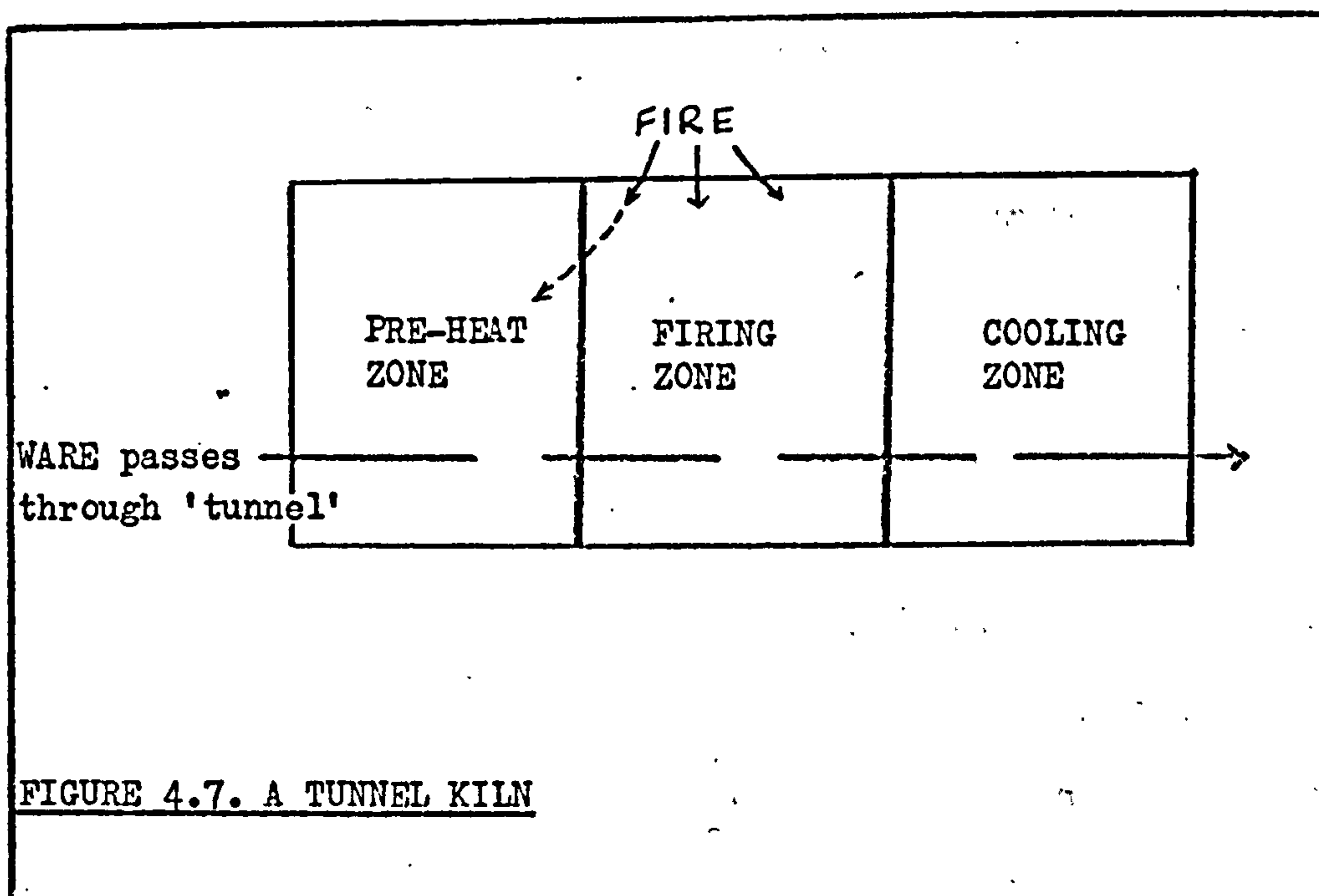
By the early 1900's, the bottle kiln became a victim of its own success. Demand for pottery had continued to grow throughout the nineteenth century and it became apparent that present kilns could no longer cope with the ware being produced - the firing process was becoming a 'bottle-neck' for the manufacturer. 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)





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. Boulton, 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.)

	<u>TUNNEL</u>	<u>INTERMITTANT</u>
Labour costs	2.43	3.35
Saggars	0.64	1.33
Fuel	1.60	3.09
Repairs	0.19	0.57
Premises (inclu. depreciation,	2.02	0.74
supervision)	<u>6.88d.</u>	<u>9.08d.</u>

From its 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  $600 - 700^{\circ}\text{C}$ , but for use in the potteries temperatures needed to exceed  $750^{\circ}\text{C}$  and be maintained around  $1100^{\circ}\text{C}$  to fire glaze or biscuit. This first kiln was so designed to fire glaze; it was found that when operating constantly at these high temperatures the metal belt 'stretched' and became too contorted to use, 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.

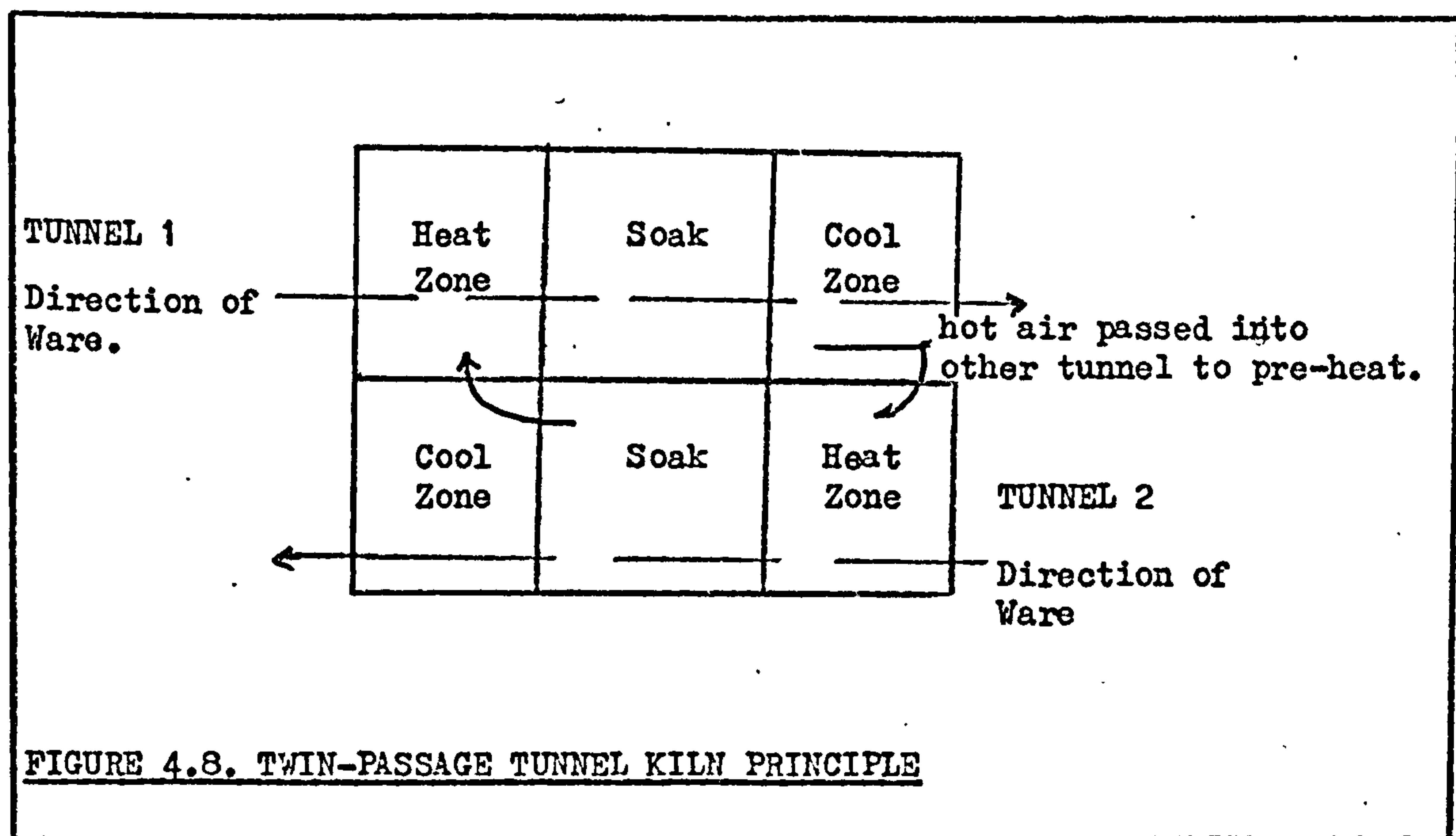
PHOTOGRAPH

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



heat being dissipated 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 immediately 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 Electricity 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 impetus 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 1960s (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  $8\frac{1}{2}$  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  $1600^{\circ}\text{C}$  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  $1000^{\circ}\text{C}$  and  $1250^{\circ}\text{C}$ ; 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).

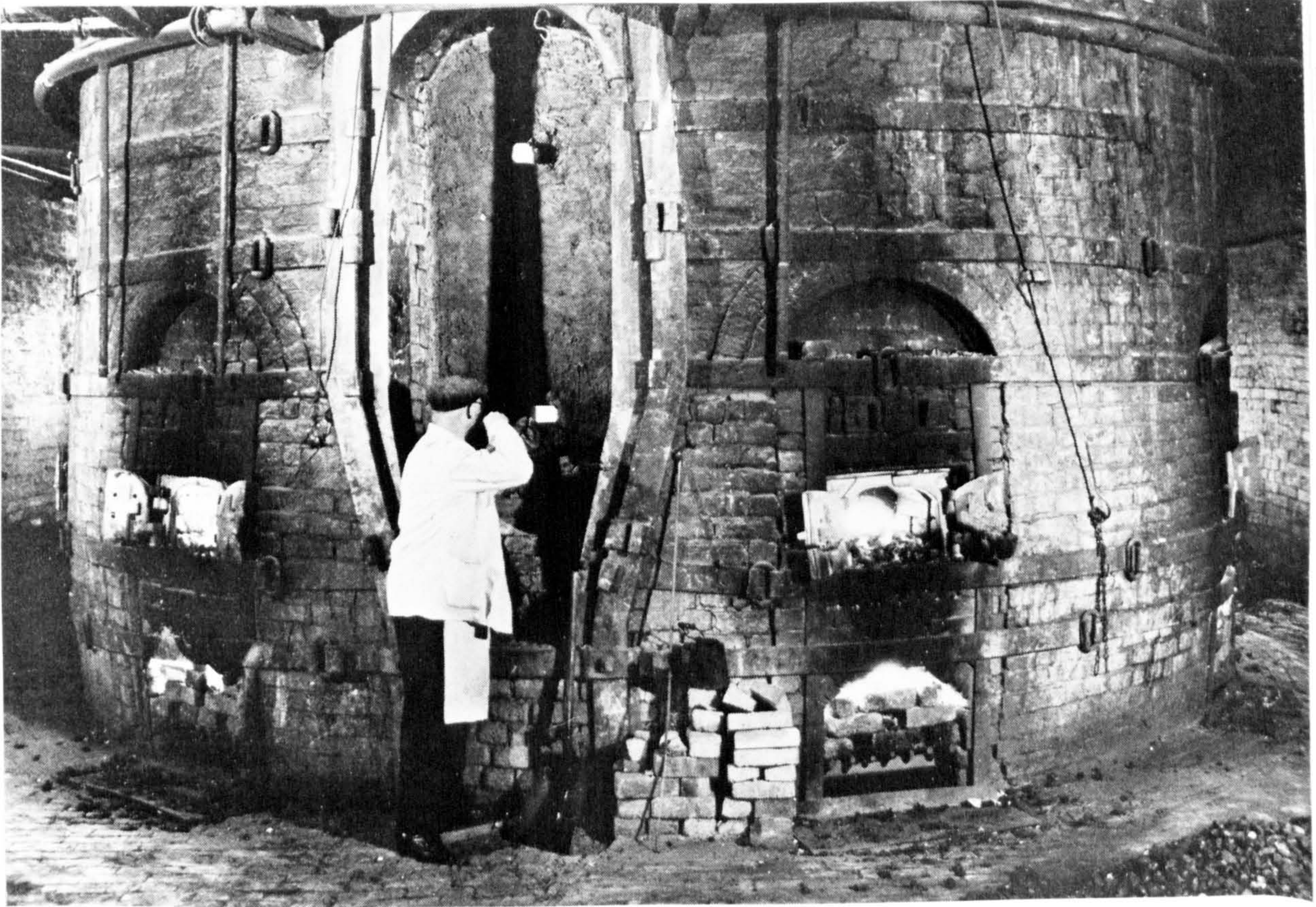
The firing of ware, using coal, became a skill; the fireman's function was regarded as the most important man in the factory; he was expected to stay by the kiln throughout the whole firing process. Temperature



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) guess-work. 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 pyrosopes 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 aperture 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 consistent 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 Minton's 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 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 efficiencies; 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 authoritative work in 1915 (4.69). By 1937 Hind writes that he sees kiln technology limited by two factors:-

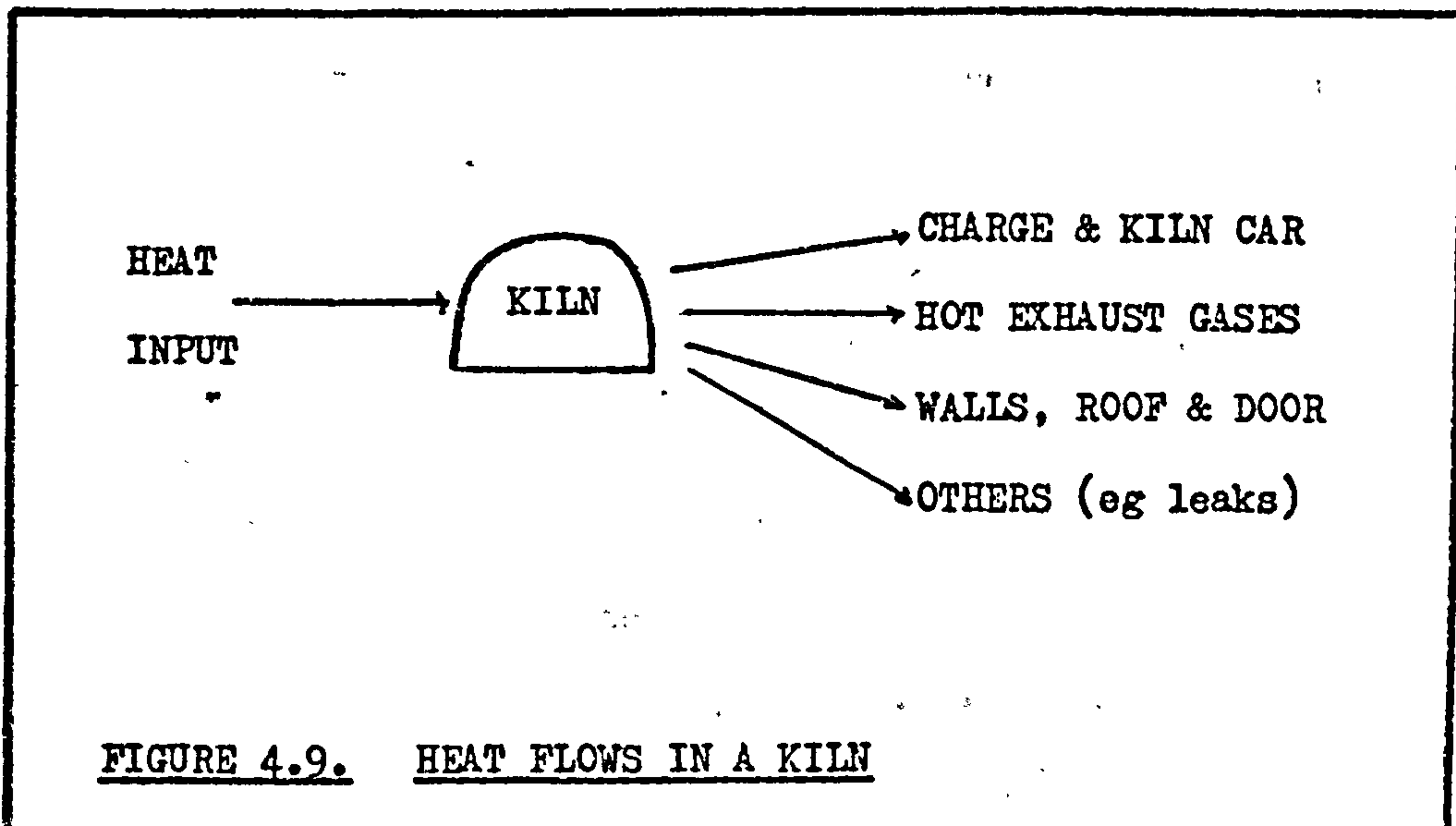
- (i) knowledge of fuel technology
- (ii) the need to develop improved refractories (4.70)

However, as has been pointed out (4.71), attention concentrated more on fuel technology TO PRODUCE BETTER WARE rather than to necessarily make better utilisation 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:-



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 equilibrium, 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, efficiencies 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 equivalent 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.

Cognisant 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 because 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 lightweight 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 to 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 comparisons were less likely to be made in terms of kiln efficiencies!

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 T.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.

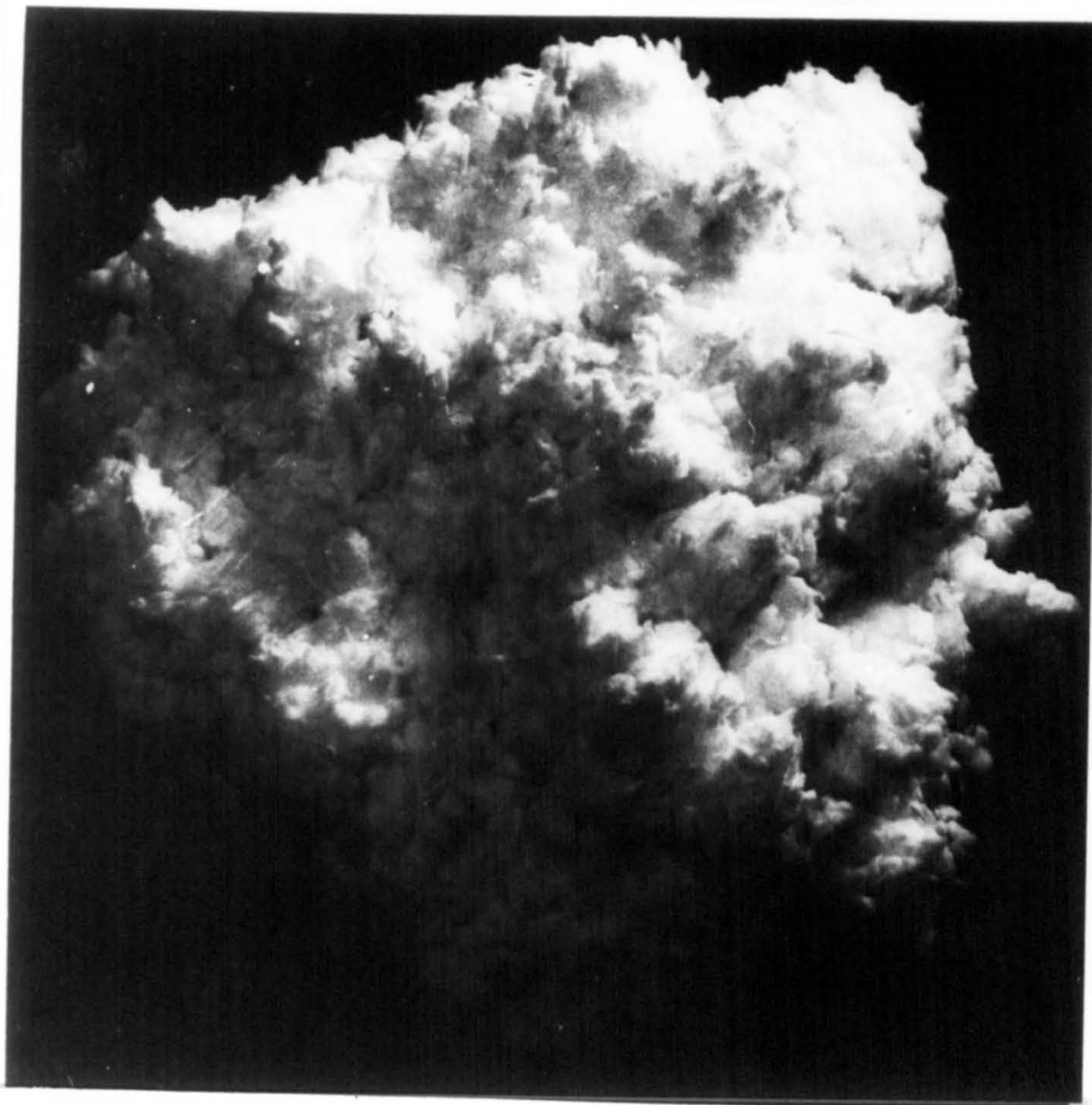
The Carborundum Co. introduced the first ceramic-fibre (FIBERFRAX) in 1953; this fibre was an amorphous material composed chemically of  $Al_2O_3$  (alumina) and  $SiO_2$  (silica), it being formed by melting a mixture of tabular alumina and commercially pure silica sand in an electric arc furnace at approximately  $1980^\circ C$ . 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  $1250^\circ C$ , 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).



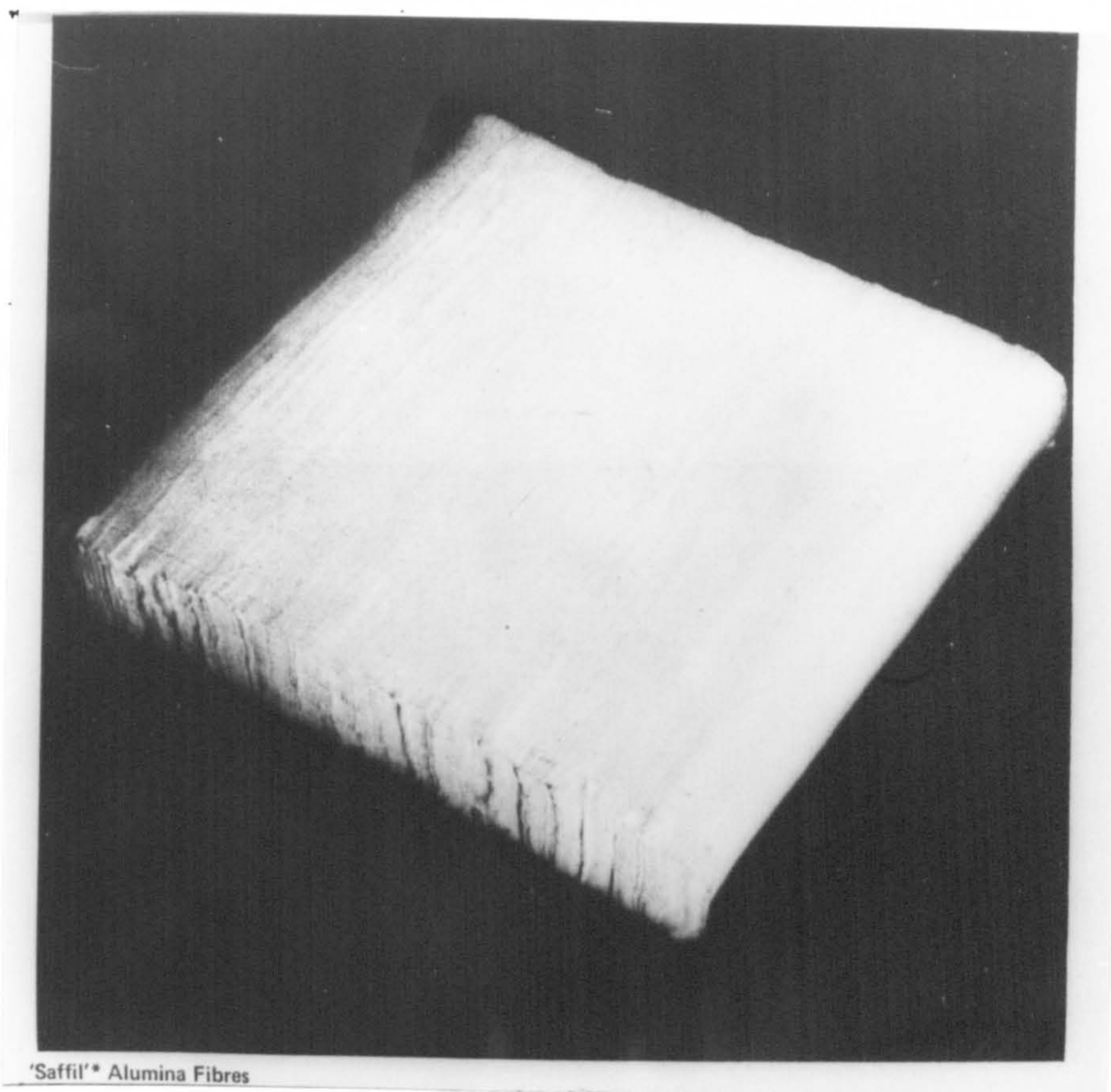
PHOTOGRAPH

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 glöst and biscuit aplication" (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).





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.

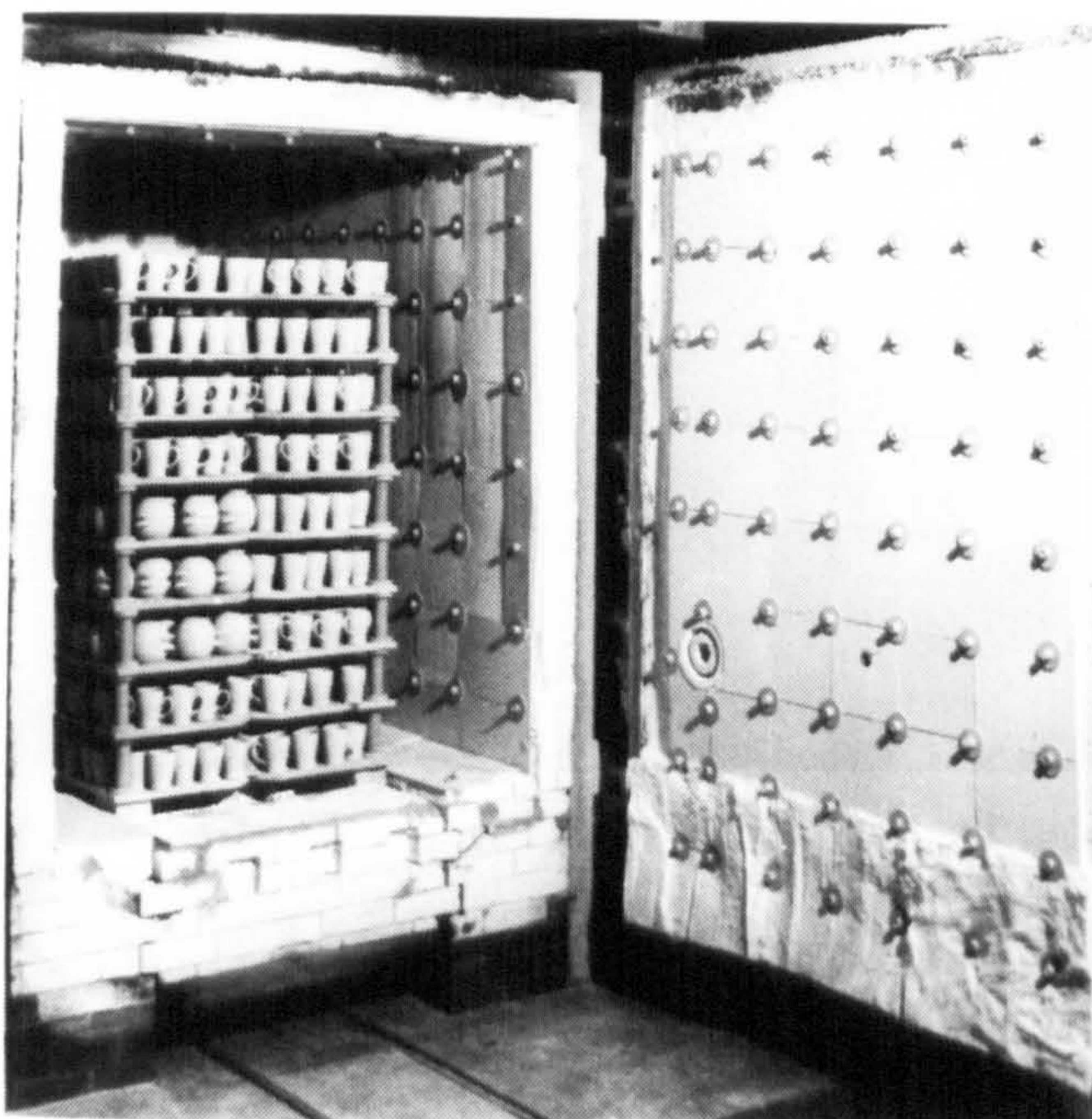
The technological advantages became apparent. The heating-up rate for a kiln constructed of brick is limited by the rate at which the (brick) lining can be heated without causing 'spalling' (ie. cracking under thermal stress). Ceramic fibres (SAFFIL in particular) were found to be almost completely immune 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.





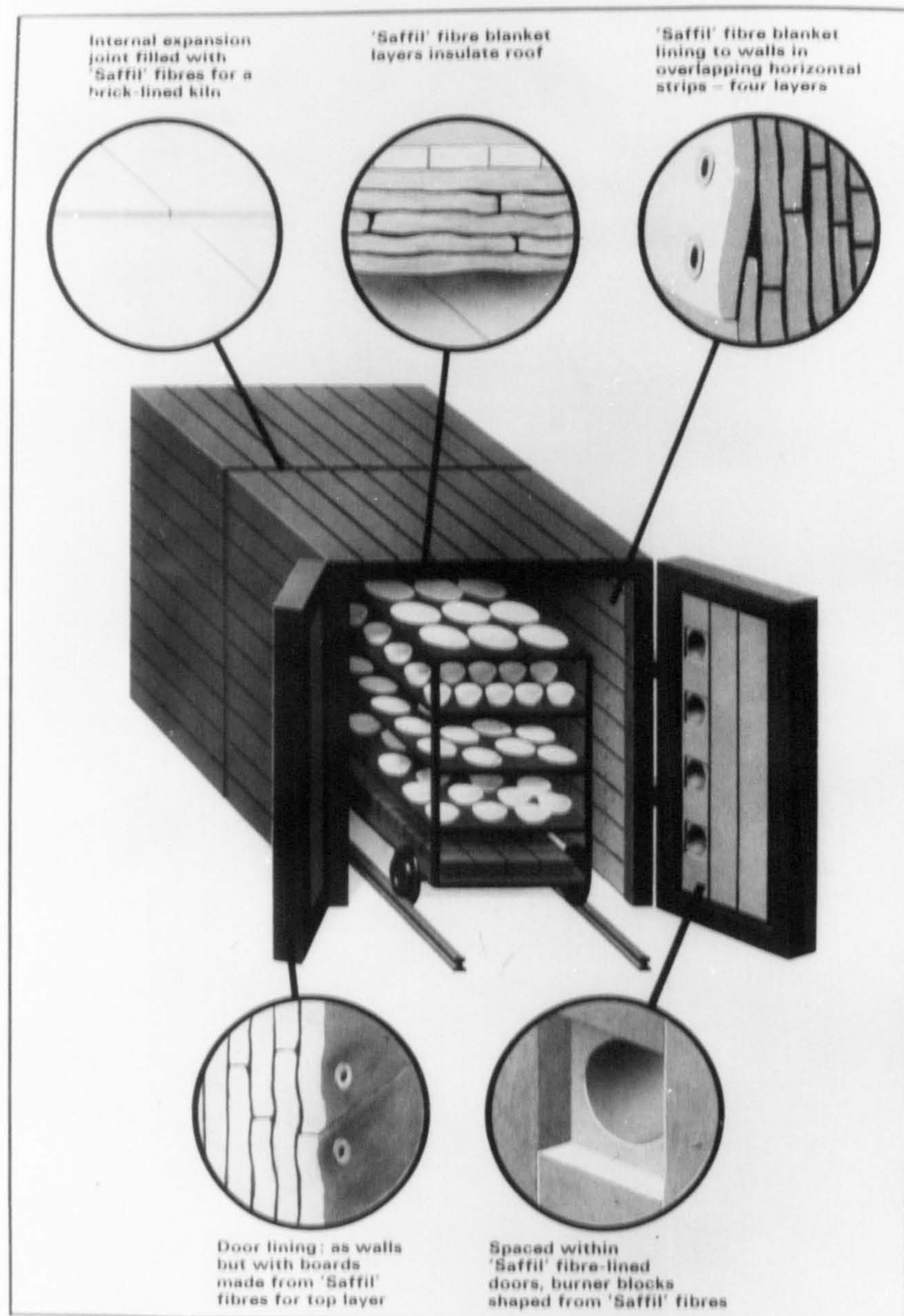
PHOTOGRAPH

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).

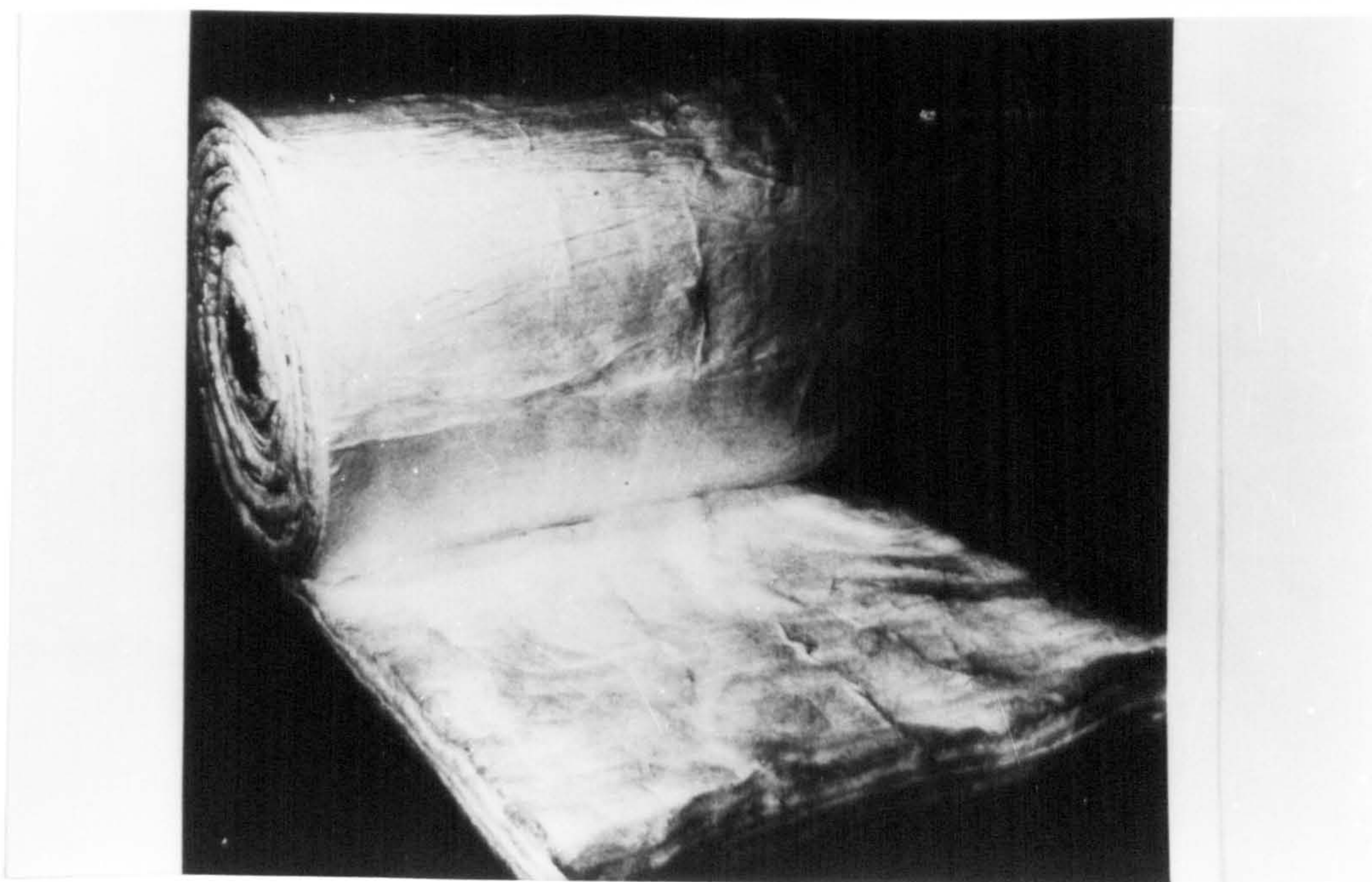


#### 4.2.5. INNOVATIONS IN APPLYING REFRACTORY LININGS TO THE HOT-FACE OF THE KILN

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 separated from the main construction to facilitate less structural strain, easier loading, better firing and easier maintenance. 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.

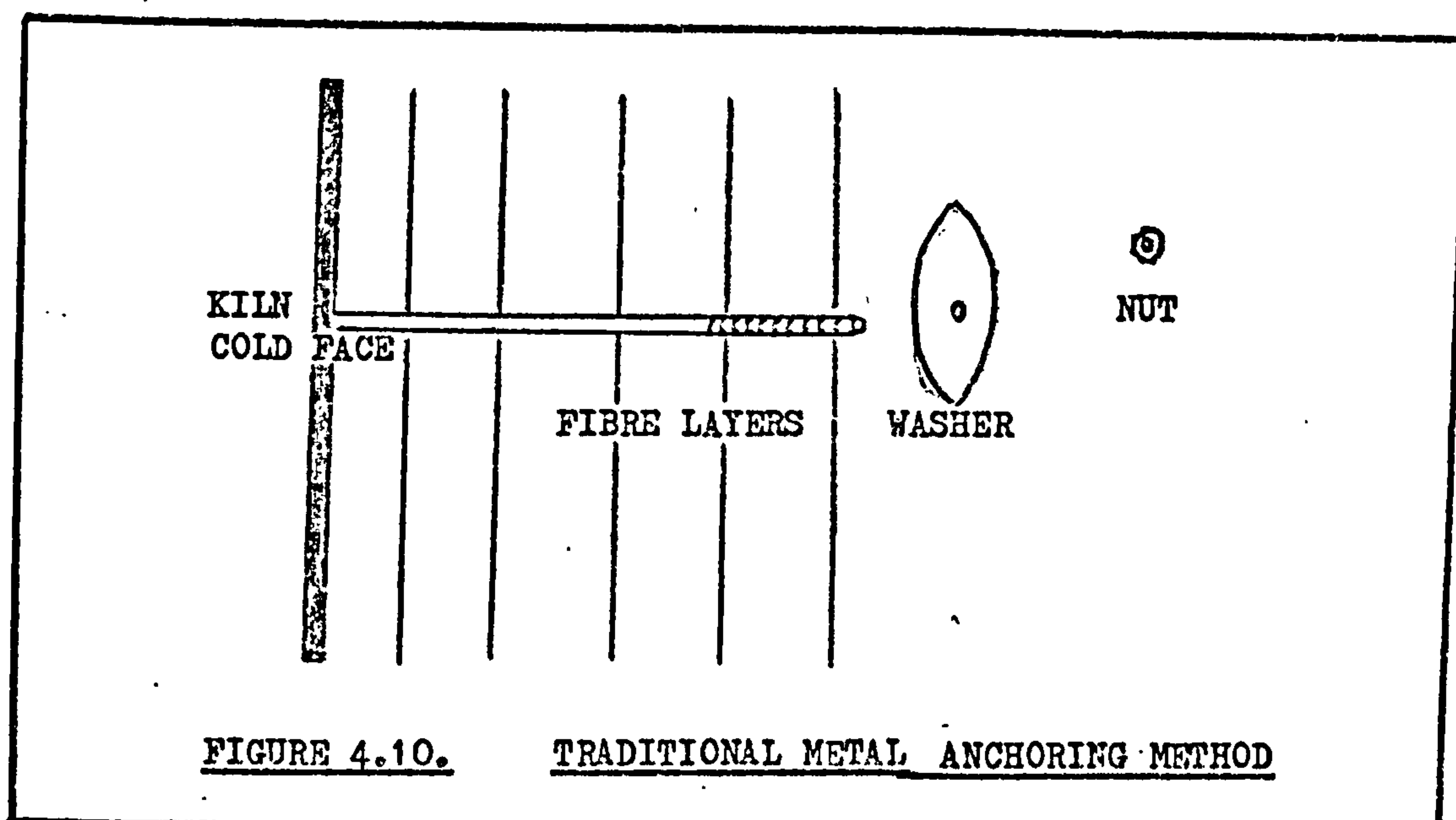




PHOTOGRAPH

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:-



Type of metal stud used was governed by the kiln's hot-face temperature (4.87).

- (i) up to  $930^{\circ}\text{C}$  - 309 stainless steel
- (ii)  $930^{\circ} - 1170^{\circ}\text{C}$  - 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



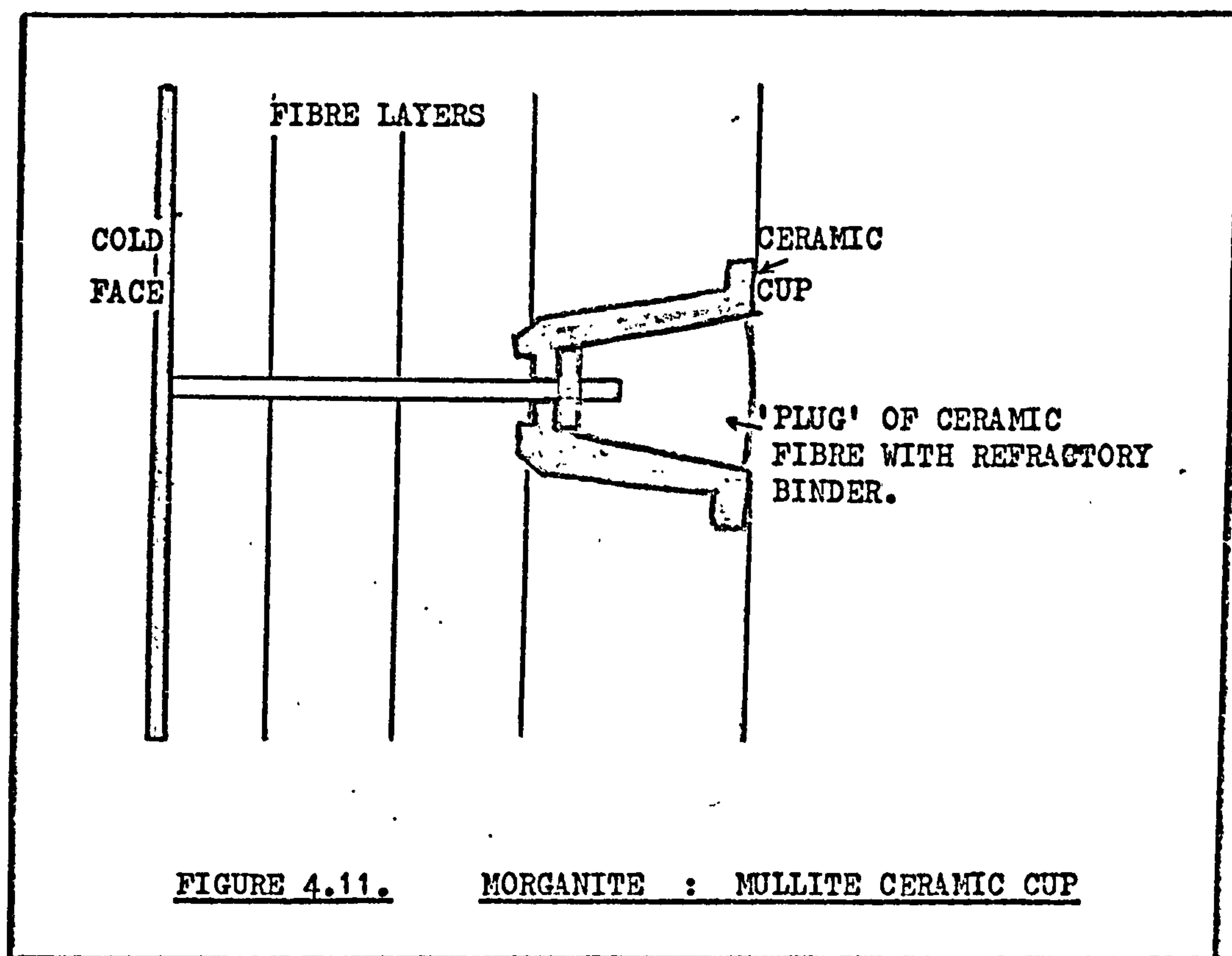
fired ... " principally due to oxidation and vanadium attack (4.89); traces of metal oxides from the fixings were found to discolour the ware. So although higher temperature fibres became available around 1972, the availability of anchors to sustain these temperatures acted as the block to adoption (4.90). 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  $1400^{\circ}\text{C}$  (later  $1600^{\circ}\text{C}$ ) - 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.

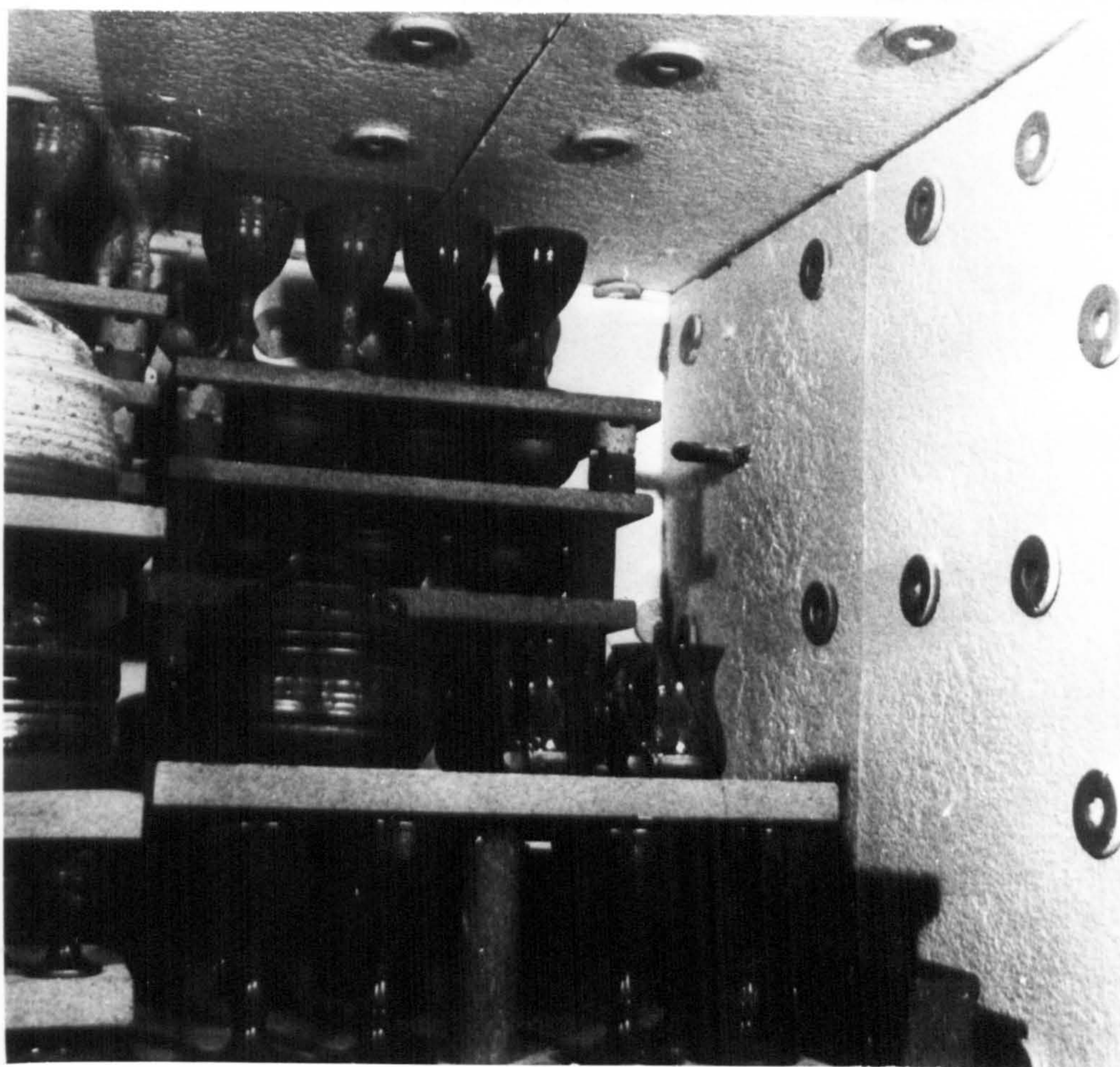
The first, the 'Mullite Ceramic Cup', was developed by Morganite Ceramic Fibres. It is a threaded rod which can be stainless steel or refractory alloy (eg inconel). A ceramic cover plugged with ceramic fibre protects the metal from the temperatures at the hot-face. The choice of metal for the pin depends 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:-





This method has been successfully tested up to  $1450^{\circ}\text{C}$ ; an example of application is shown in the photograph below.





PHOTOGRAPH

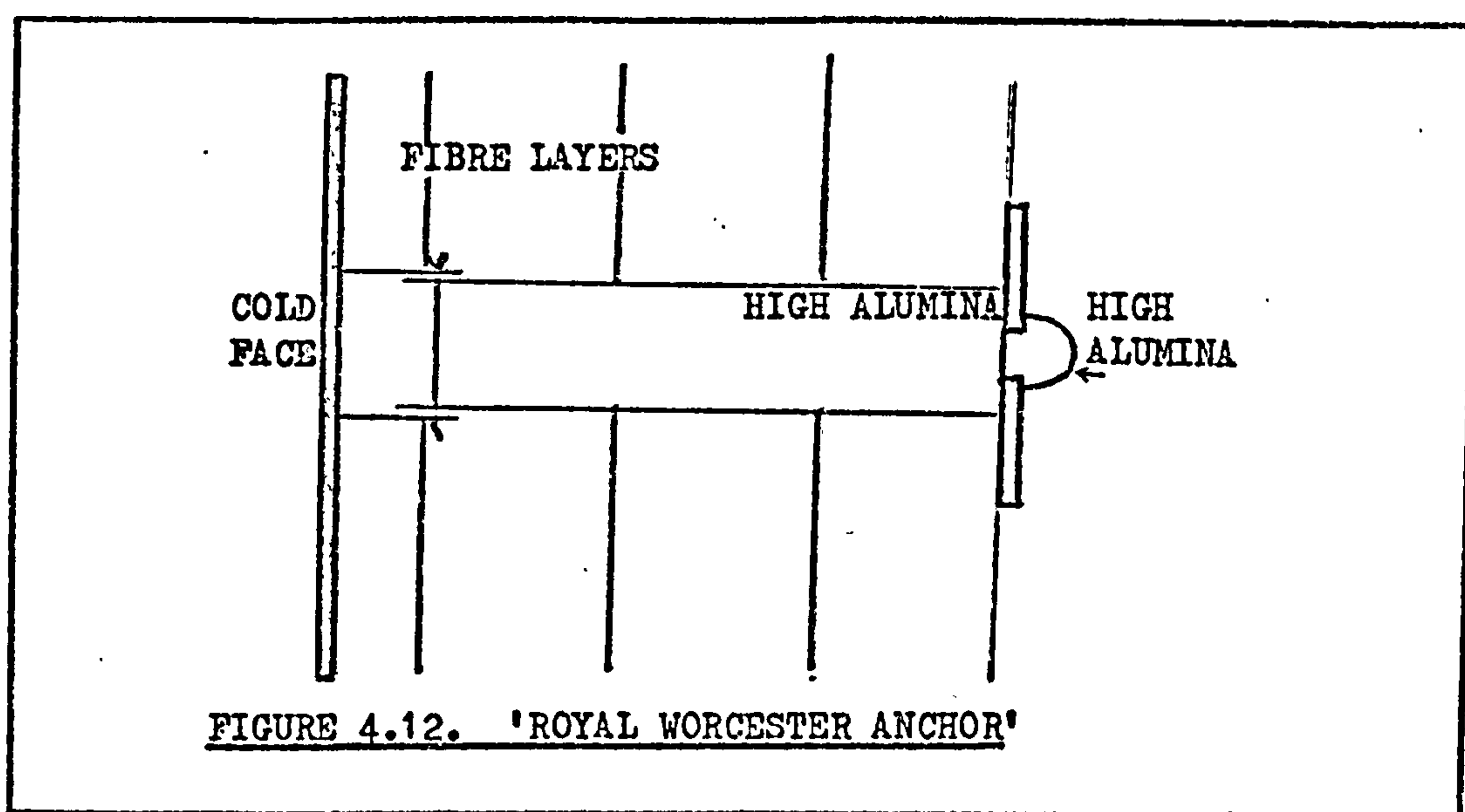
ELECTRICALLY FIRED, L.T.M. KILN AT

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:-



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'

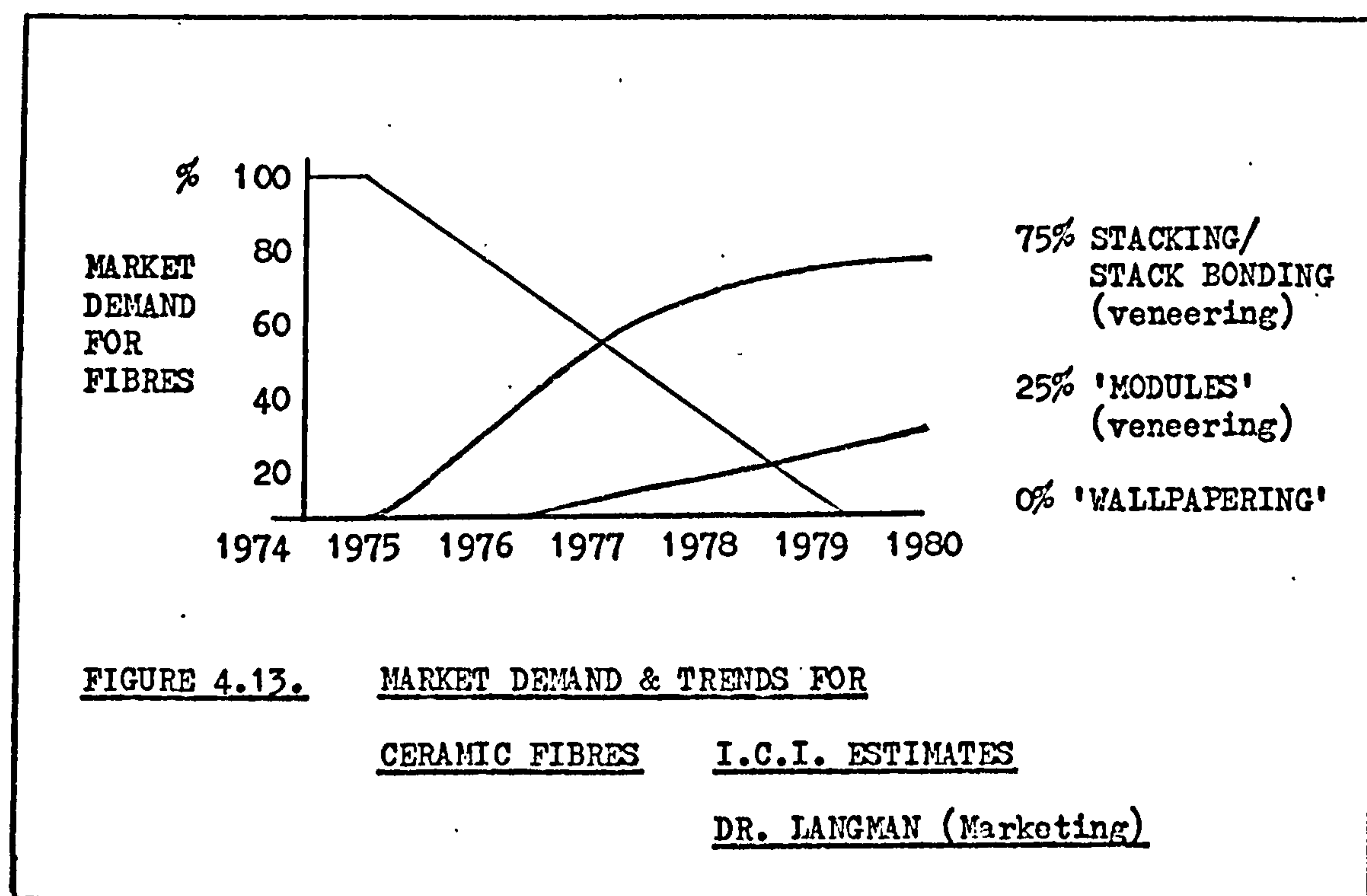


Existing refractory cements were used to stick the fibre to the existing brickwork. This method much simplified installation and increased the overall rate of adoption of fibres as existing kilns could relatively easily be converted. Although overall not as effective as a kiln specifically built of fibre 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<sup>2</sup>. For a kiln heated to around 1300°C in 12 hours, the fuel savings are worth (1978) about £1.00/m<sup>2</sup>/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 superseded the traditional 'wallpapering' method using traditional forms of anchorage - as Figure 4.13. illustrates:-



Whilst simple veneering 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 compete 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 establishment 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 artisan 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 Oven' (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 uninterrupted 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

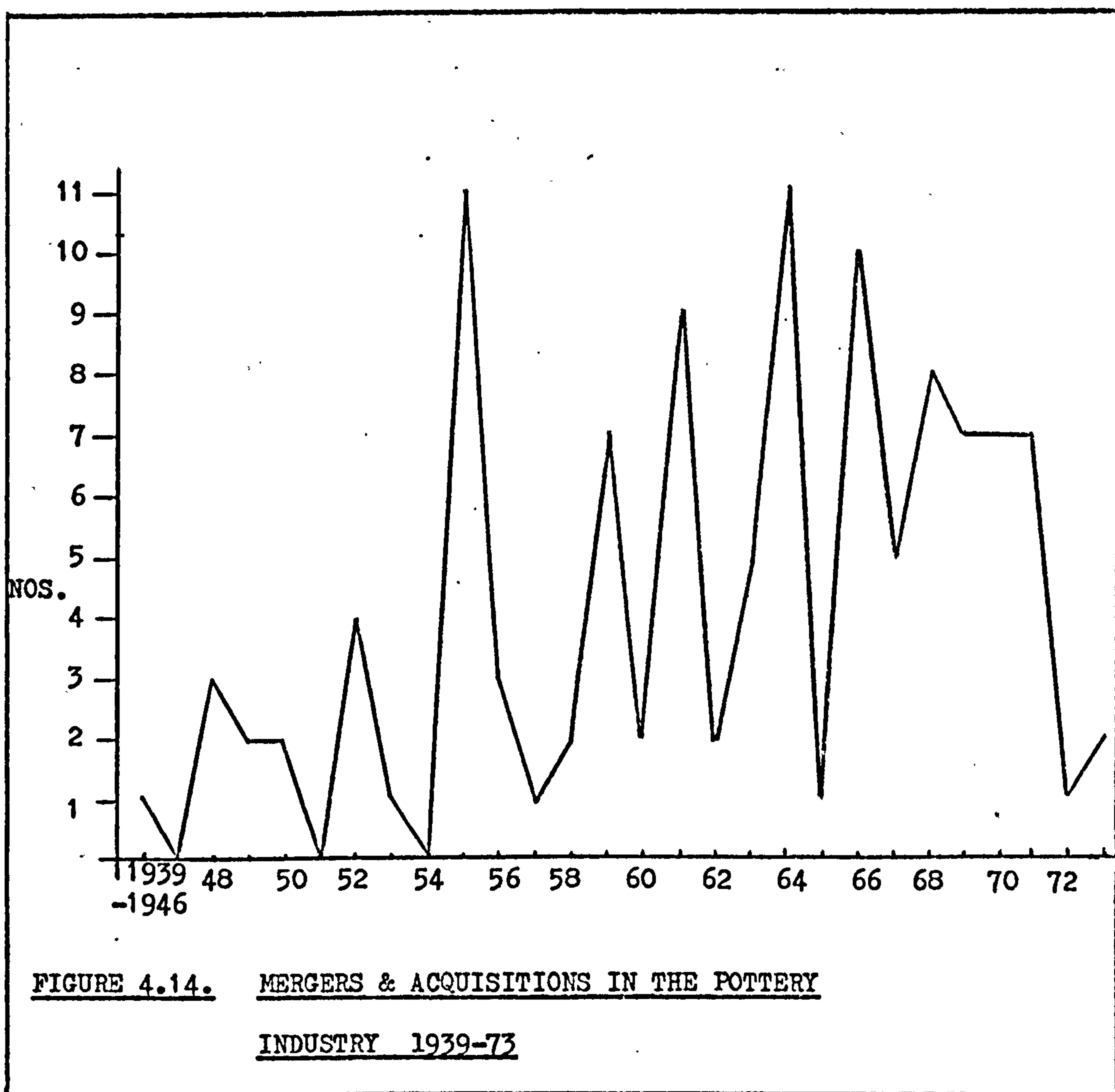
site since the 1800's. It also required utilisation at near capacity on shift working to be profitable. Whilst the market potential was there to justify expenditure, the cost of installation and operation of the tunnel kiln were frequently beyond the capital resources of small firms. The introduction 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 implementation 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.



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 be 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 either one 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 one technological improvement, but no firm is consistently among the first" (D. SHELLEY LTD)

Table 4.7. presents the major innovations by kiln builder(overleaf).



	<u>BUILDER</u>	<u>DATE</u>
<u>MODERN COAL INTERMITTENT</u>	self-built	circa 1880
(Minton's Oven)		
<u>GAS-FIRED TUNNEL KILNS</u>	Dressler	circa 1913
experimental		
glost firing	Gibbons	1932
biscuit firing	Gibbons	1934
decorative (muffled)	Gibbons	1937
<u>ELECTRIC-FIRED TUNNEL KILNS</u>	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
<u>GAS FIRED INTERMITTENTS</u>	Gibbons	1939
experimental		
glost/biscuit	Birks/W, Mid. Gas	1958
<u>ELECTRIC FIRED INTERMITTENTS</u>		
decorative	Lockett(self-built)	1946
biscuit	Hawkins/MEB	1952
glost	Hawkins/MEB	1953
<u>GAS FIRED CERAMIC FIBRE LINED KILN</u>		
biscuit	Shelley/ICI	1974
glost	Shelley	1975
<u>ELECTRIC FIRED CERAMIC FIBRE LINED KILN</u>		
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 surveillance 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	$\Sigma$
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 some 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 importance 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 substantiate 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 an 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

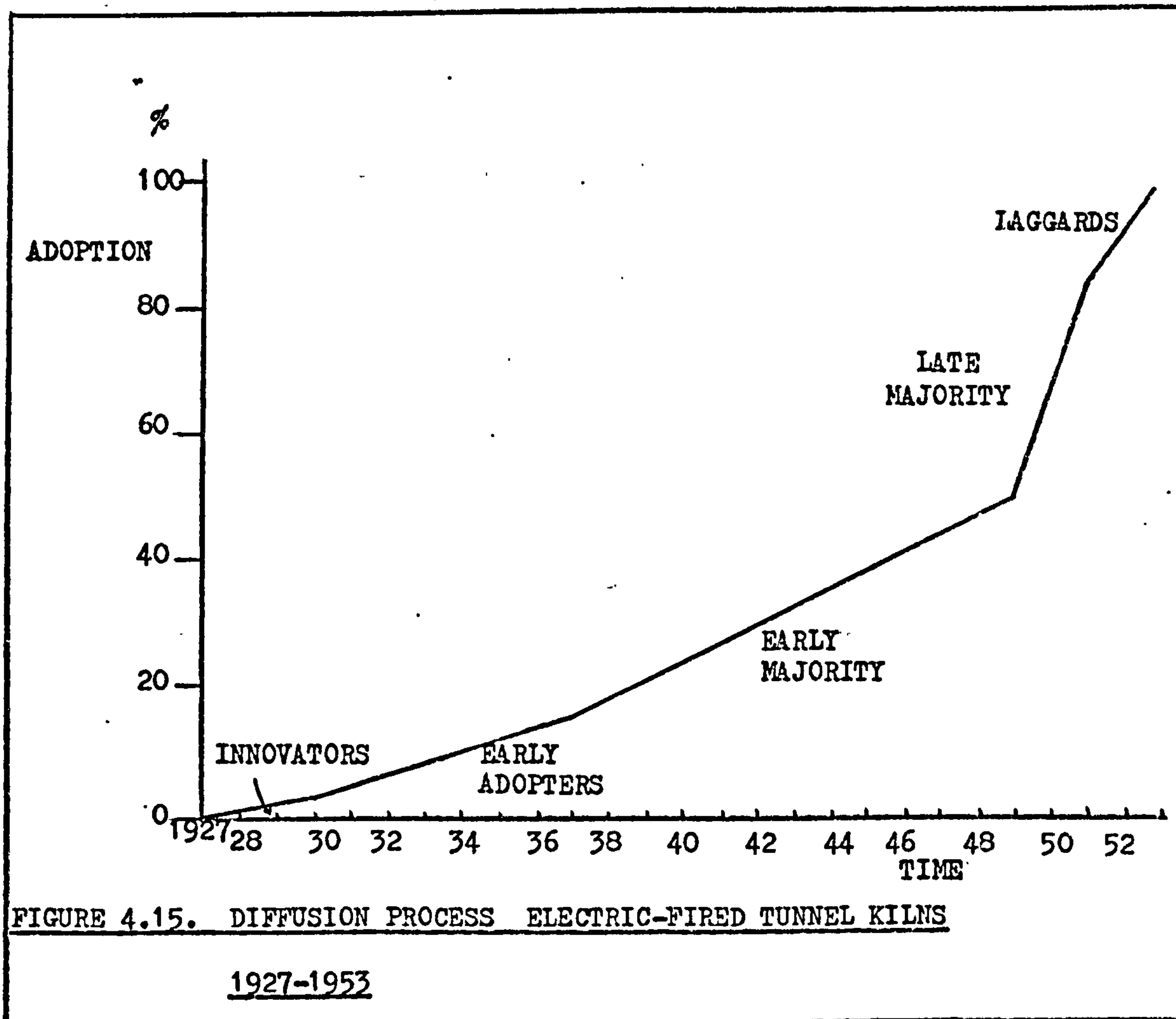
Between 1927 and 1953 62 pottery manufacturers adopted this type of kiln. Table 4.11. presents the complete list, delineated using Roger's adopter categories, and Figure 4.15. presents the results in a cumulative/diffusion form expressed over time.

	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 Bilttons (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 electric 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...





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

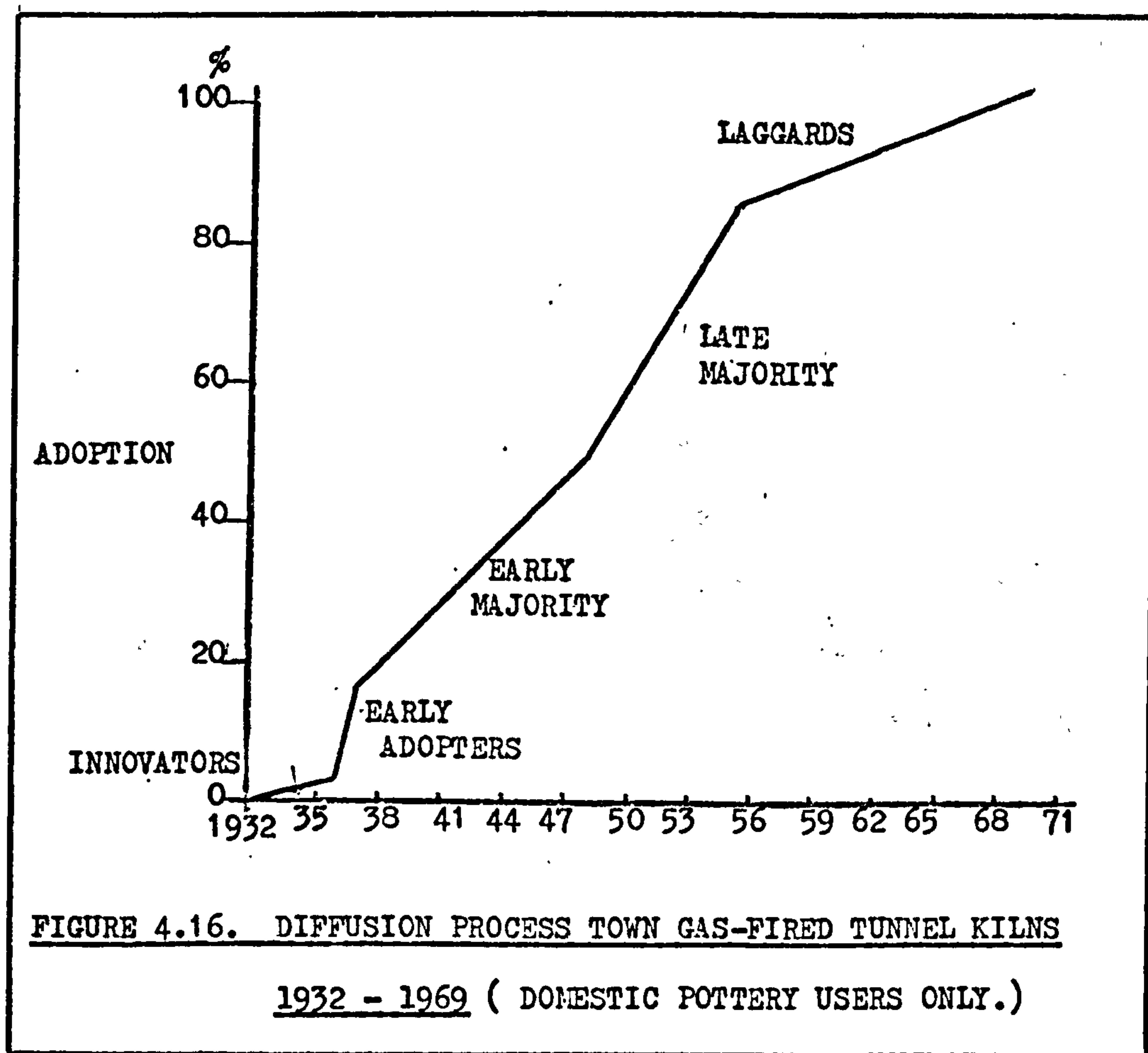
Between 1932 and 1969 85 pottery manufacturers adopted this type of kiln. Table 4.12. presents the complete list (again using Roger's adopter categories),

	Conway Pottery Portland Pottery	INNOVATORS 1932-36
Smith + Warrilow T.A. Simpson Mintons J.T. Grice Copelands (Spode) Denis Alexander	C.W.S. Alcock Lindley, Bloor J. Maddock Minton-Hollins T + R Boote	EARLY ADOPTERS 1936-37
Geo. Wade Howard Pottery Modern Ceramics Biltons(1912)Ltd Booth + Colclough Barker Bros. Wade Heath Johnson Bros. J + G Meakin A.Wood + Sons A.G. Richardson S. Fielding RH + SL Plant T.C. Wild A. Meakin W. Kent	Sadler Pottery Elgreave Pottery Doulton Wedgwood Broadhurst Pottery Bridgwood Gibsons Pottery Floral China Enoch Wedgwood Globe Pottery W.H. Grindley Shaw + Copestake W.Adams Beswick	EARLY MAJORITY 1937-48
J.E. Heath Crown Staffs Geo. Jones Myott + Sons J. Shaw + Son Denton China Burgess + Leigh British Anchor E. Brain Barratts of Staffs Hammersley China New Chelsea Porcelain Price Bros. A.J. Wade Dunn-Bennett A.B. Jones	Cartwright + Edwards A. Clough Staffs Pottery Midwinter N.S. Pottery Thos.Poole/Gladstone Staffs Teaset Adderley E. Cotton Taylor + Kent Eddowes Paragon China J. Aynsley Shore + Coggins	LATE MAJORITY 1948-55
Wildblood + Taylor Swinerton Pottery Amerson Pottery Trentham Victoria J. Tams H + E Smith	Arrowsmiths A.T. Finney Grove China Thos. Cone Paramount Pottery A.J. Wilkinson	LAGGARDS 1955-69

TABLE 4.12. DIFFUSION PROCESS FOR GAS-FIRED TUNNEL KILNS



and Figure 4.16. present the cumulative diffusion curve.



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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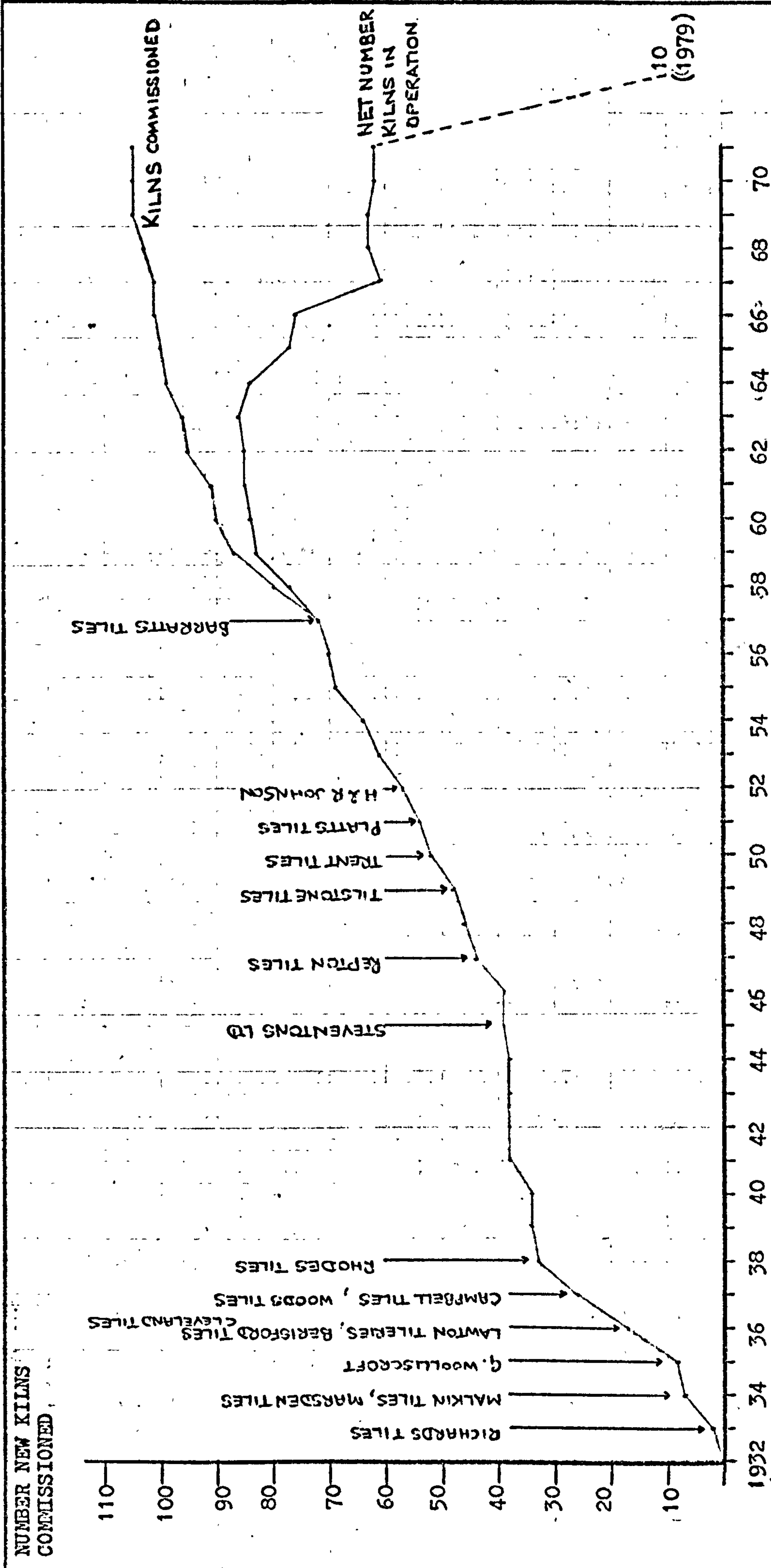


FIGURE 4.17 DIFFUSION PROCESS TOWN-GAS FIRED KILNS 1933-1971:

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 discontinuous 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):

<u>INNOVATION</u>	<u>INNOVATORY END-USERS</u>		
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 AMERSON POTTERY		CHINA
Elec. fibre lined Intermittents (1972-)	AYNSLEY ROSINA		CHINA
Gas fibre lined Intermittents (1974-)	COALPORT (WEDGWOOD) BRAMHAM POTTERY	DUDSON BROS.	

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.

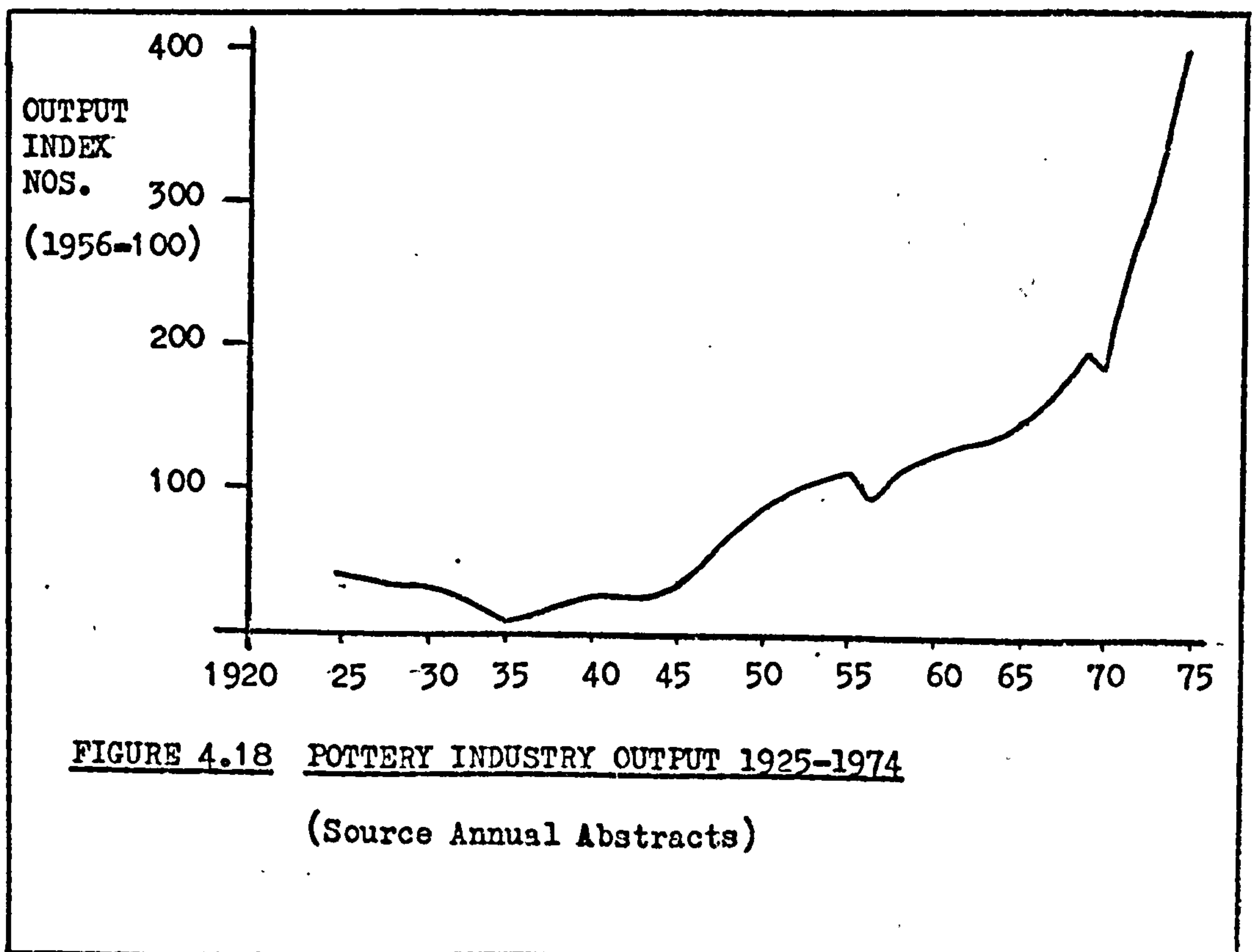
It seems less likely that firms adopt because so-and-so has but rather because there are observable benefits from doing so; however varying degree of managerial conservatism of the same facts may account for some adopting earlier than others (4.117). On the other hand, the recent launch of SAFFIL ceramic 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 withheld) 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

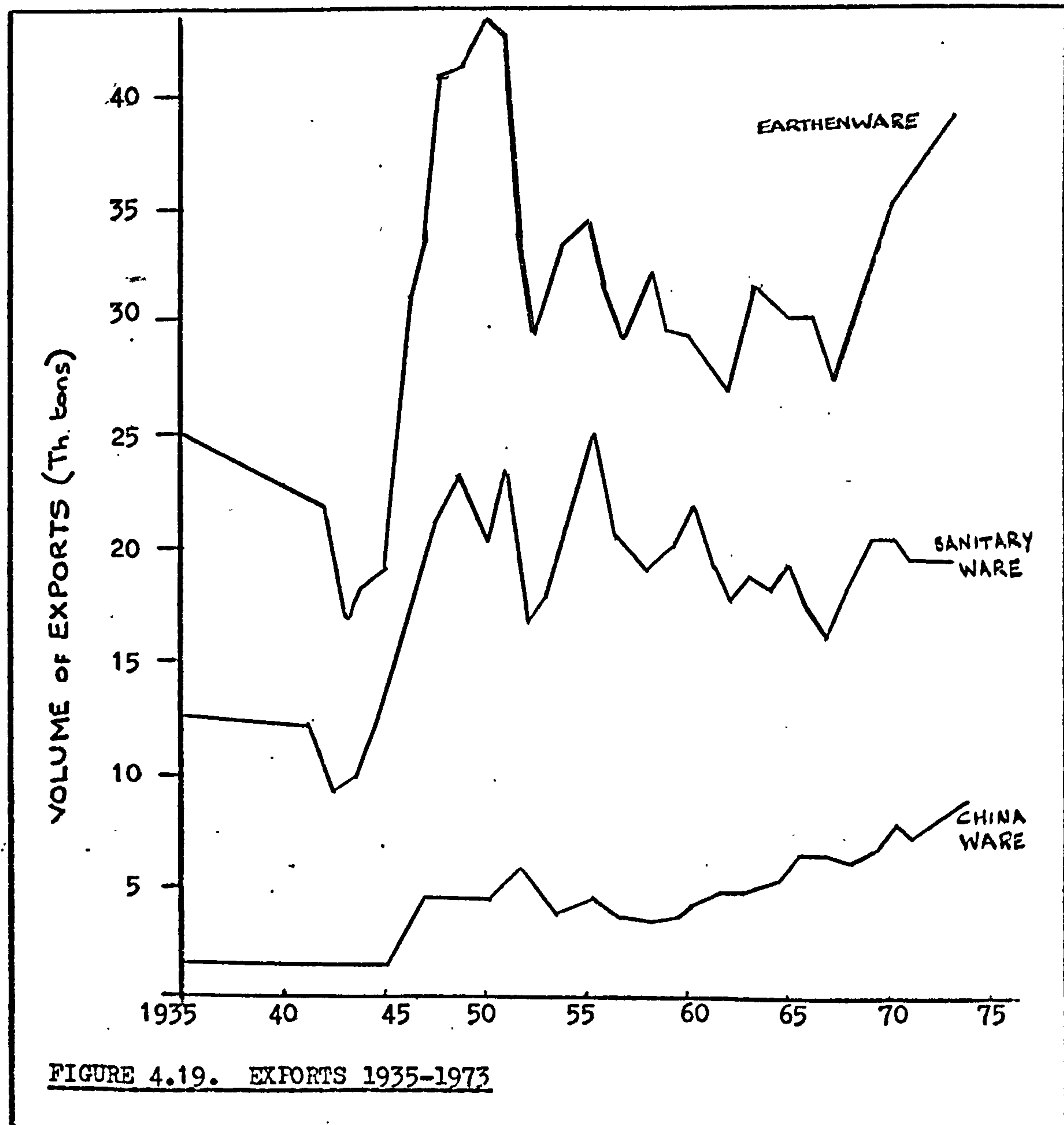
A number of writers consider the rate of adoption and diffusion to be predominantly (or entirely) a function of economic performance; what is less clear is to whether past or future projected performance should be considered. In practice it becomes difficult to isolate any particular variable in such a definite way, because economic performance 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).





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).



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 Minton's 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 discussed 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 sterling) 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 33 $\frac{1}{2}$ % 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 performance 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 FOREFRONT 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 forefront 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.

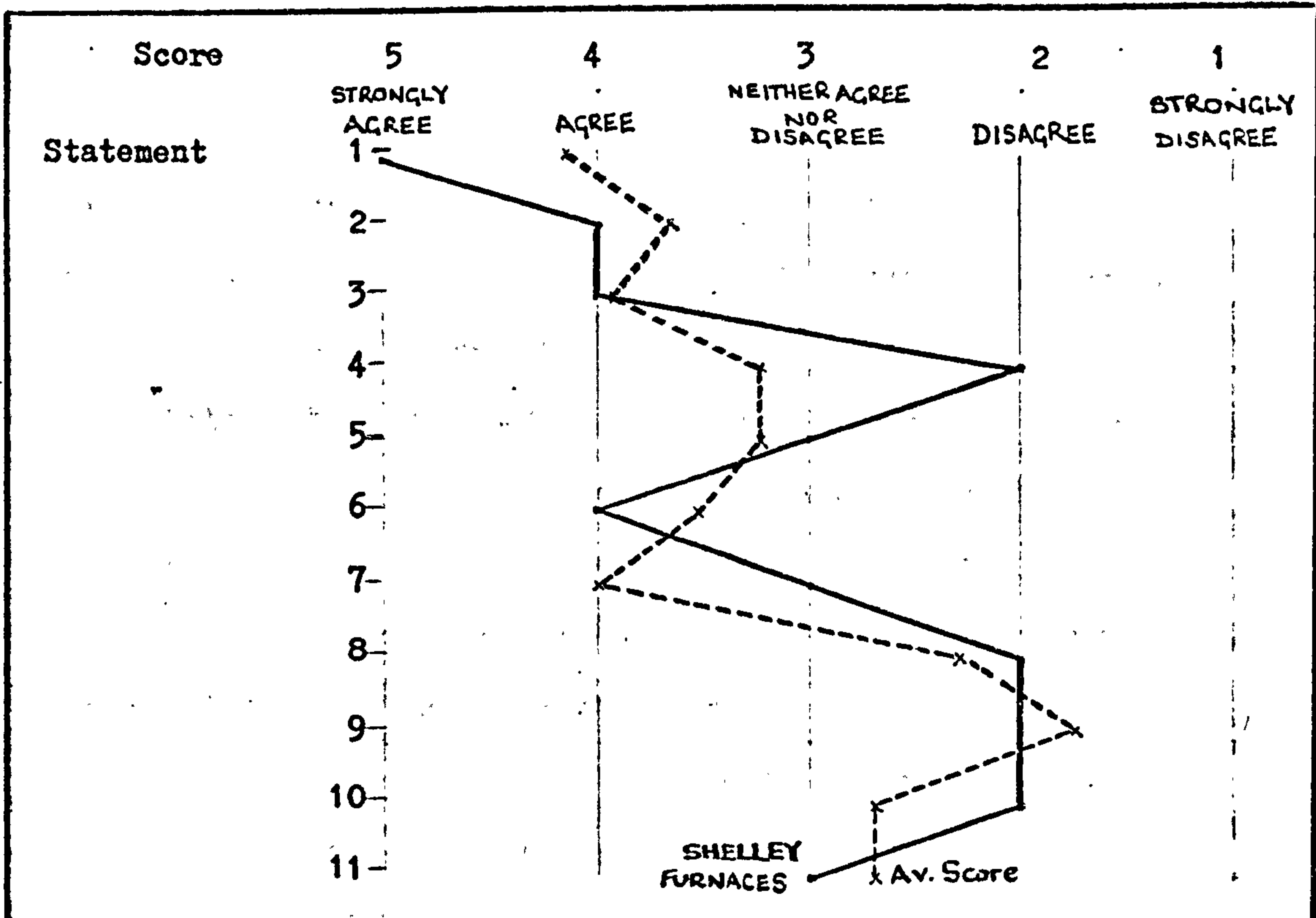


FIGURE 4.20 RESPONSES MADE BY SHELLEY FURNACES

VIS a VIS AN ESTIMATED INDUSTRY AVERAGE

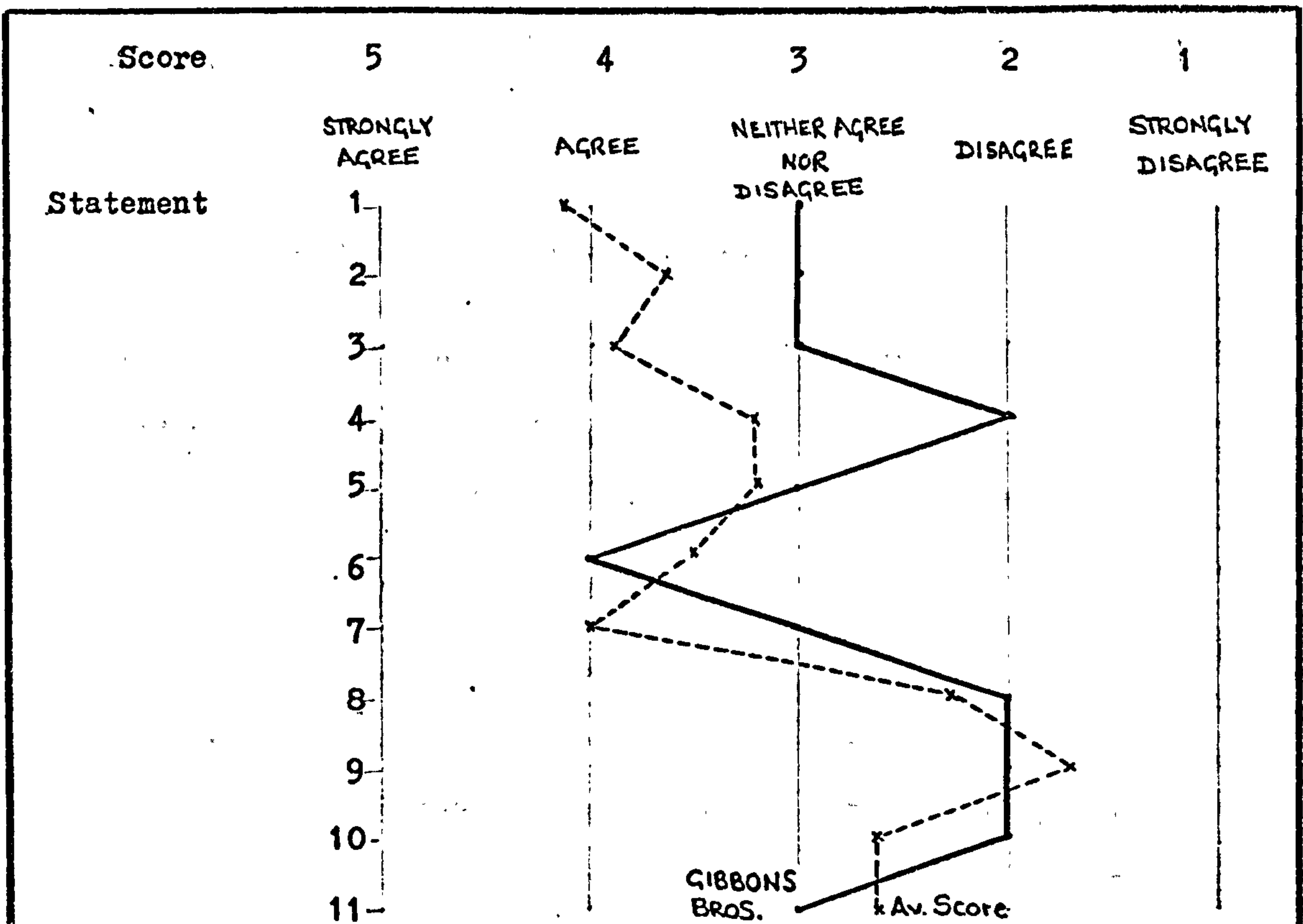


FIGURE 4.21. RESPONSES MADE BY GIBBONS BROS.

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 accruing 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 accruing 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



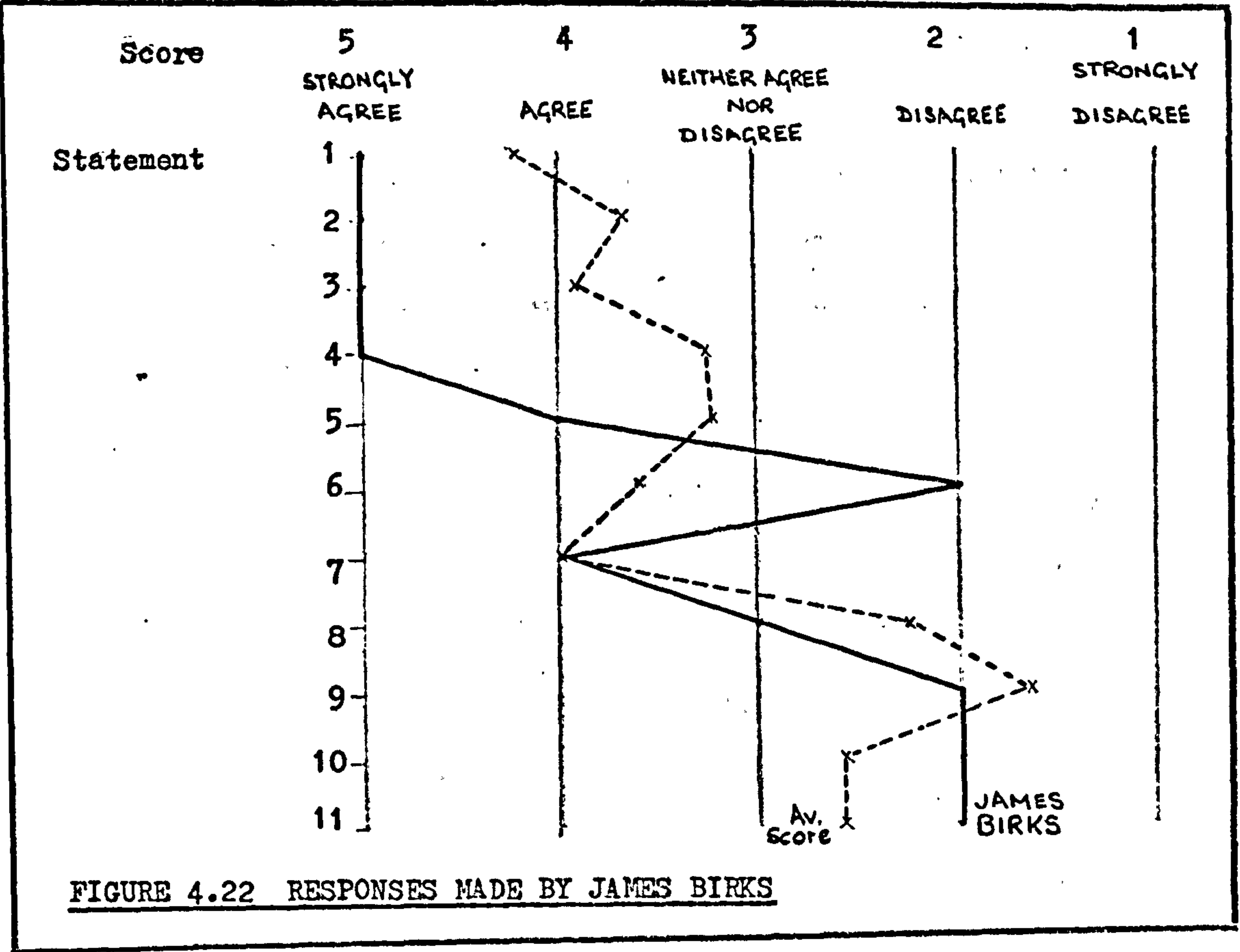


FIGURE 4.22 RESPONSES MADE BY JAMES BIRKS

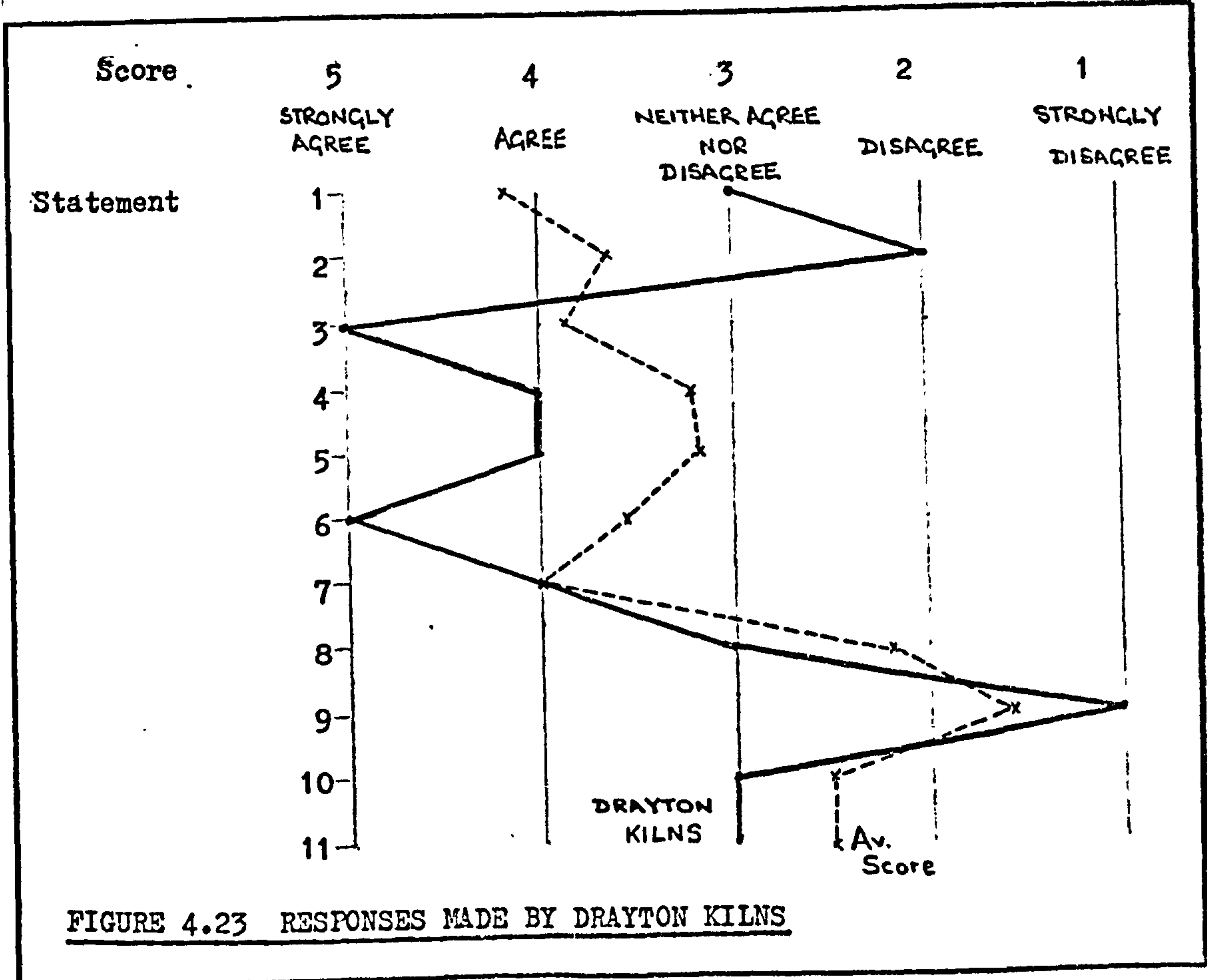
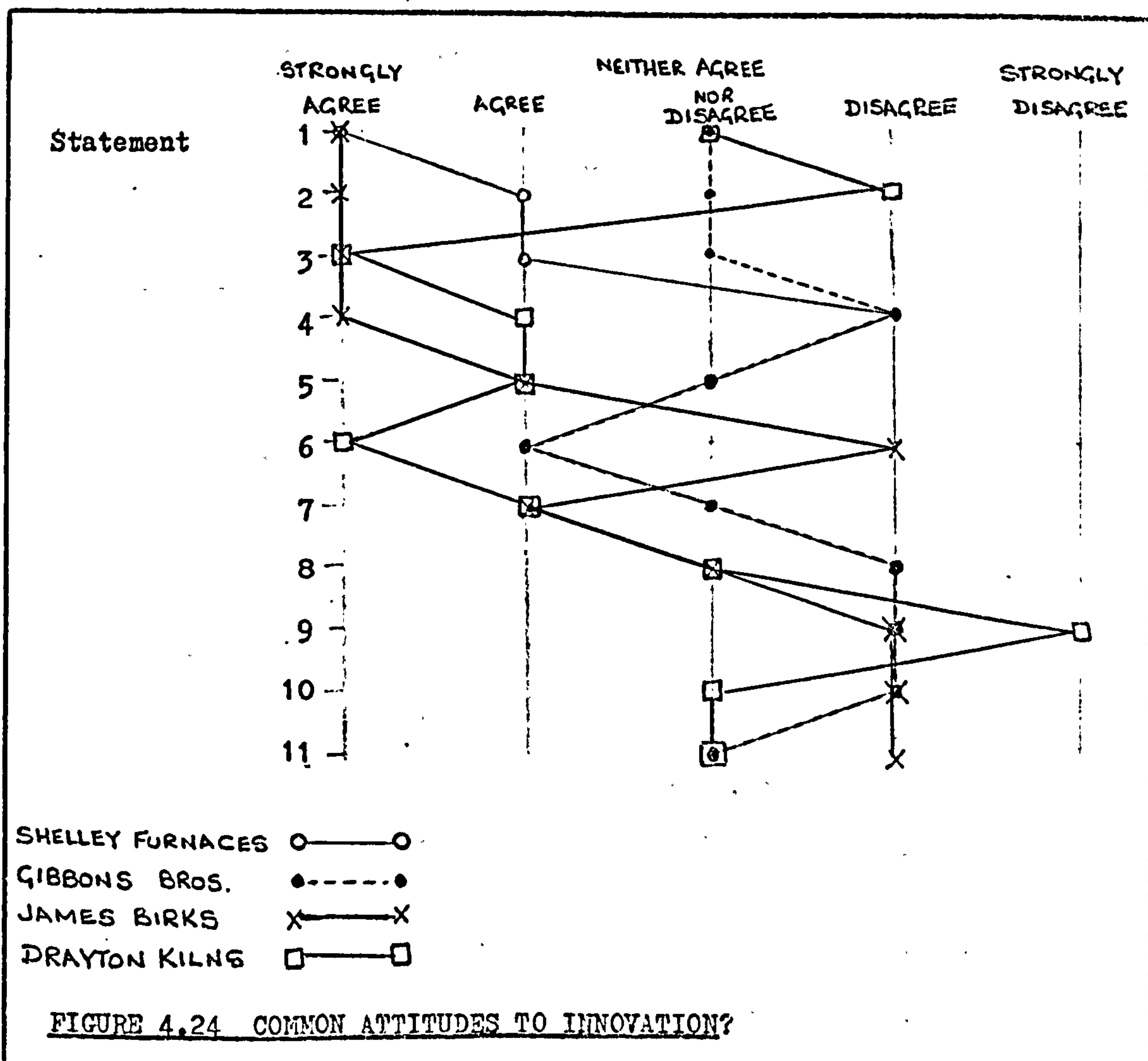


FIGURE 4.23 RESPONSES MADE BY DRAYTON KILNS

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 profitability (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,



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.

Consideration was given to relating responses to the size of R & D budget indicated by each respondent; a number of observations were made:

- (i) R & D Budget Size and Statement 1 : " we believe there is a need to be at the forefront of pottery kiln development".

(Table 4.17 illustrates responses).

SIZE R & D BUDGET (as % of turnover)	RESPONSE TO STATEMENT 1				
	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	STRONGLY DISAGREE	NO ANSWER
LESS THAN 1%	2		5		
1 - 5	3	3			2
+ 5%	1				

TABLE 4.17

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) R & D Budget Size and Statement 3 : " we listen to what the customer wants and then we make it".



(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 proportionally 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 argued 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 ...

Economic Reasons:

"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 continuous 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.).

#### General Managerial Attitudes :

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 attendant 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, capital 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 far 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 nationalisation), 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 significantly was the decision by Scholefield (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 inefficient 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:-



CUMULATIVE NUMBER ELECTRIC INTERMITTENTS  
IN OPERATION

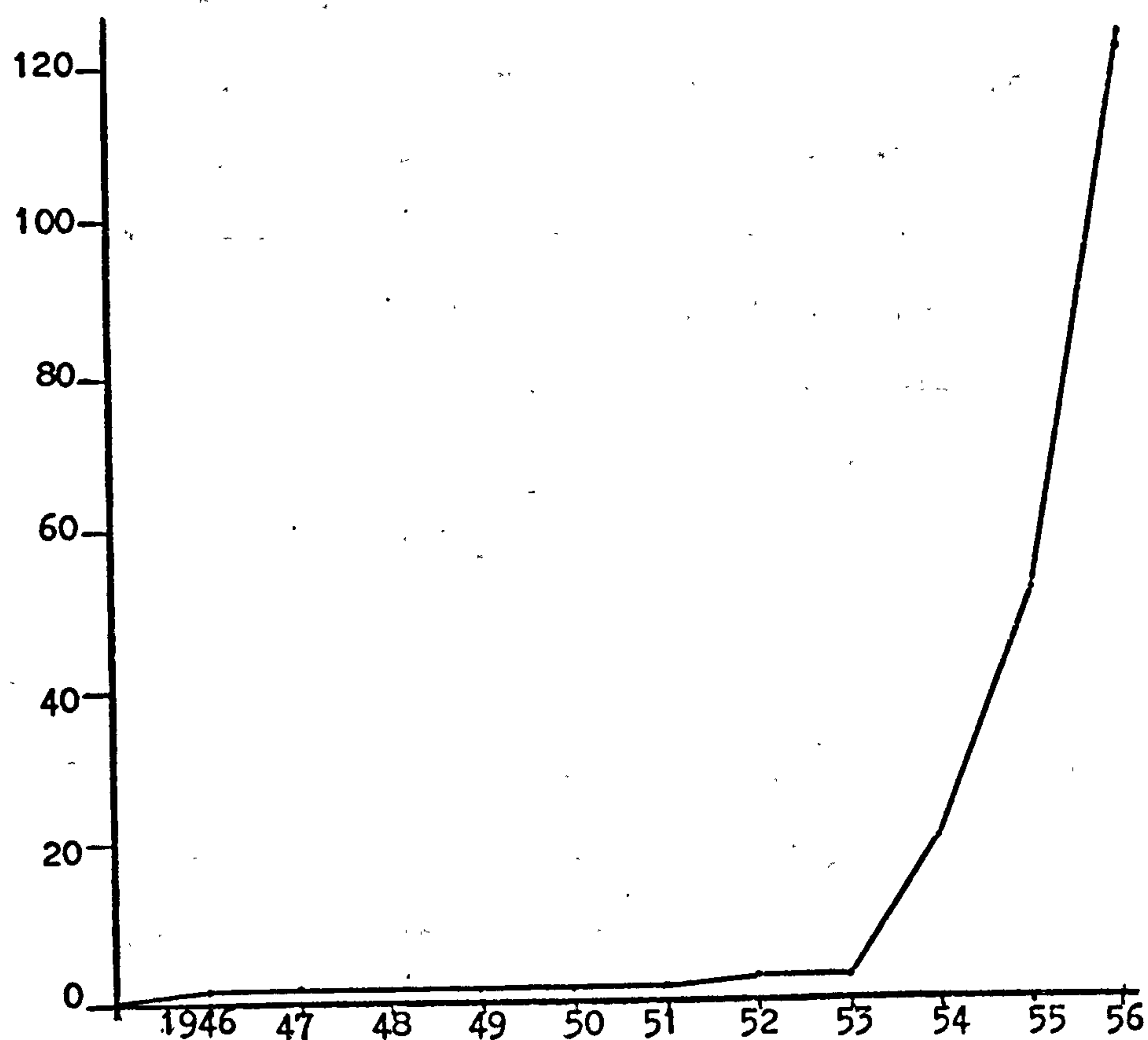


FIGURE 4.25    ELECTRIC INTERMITTENT KILNS IN OPERATION  
1946-1956

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).

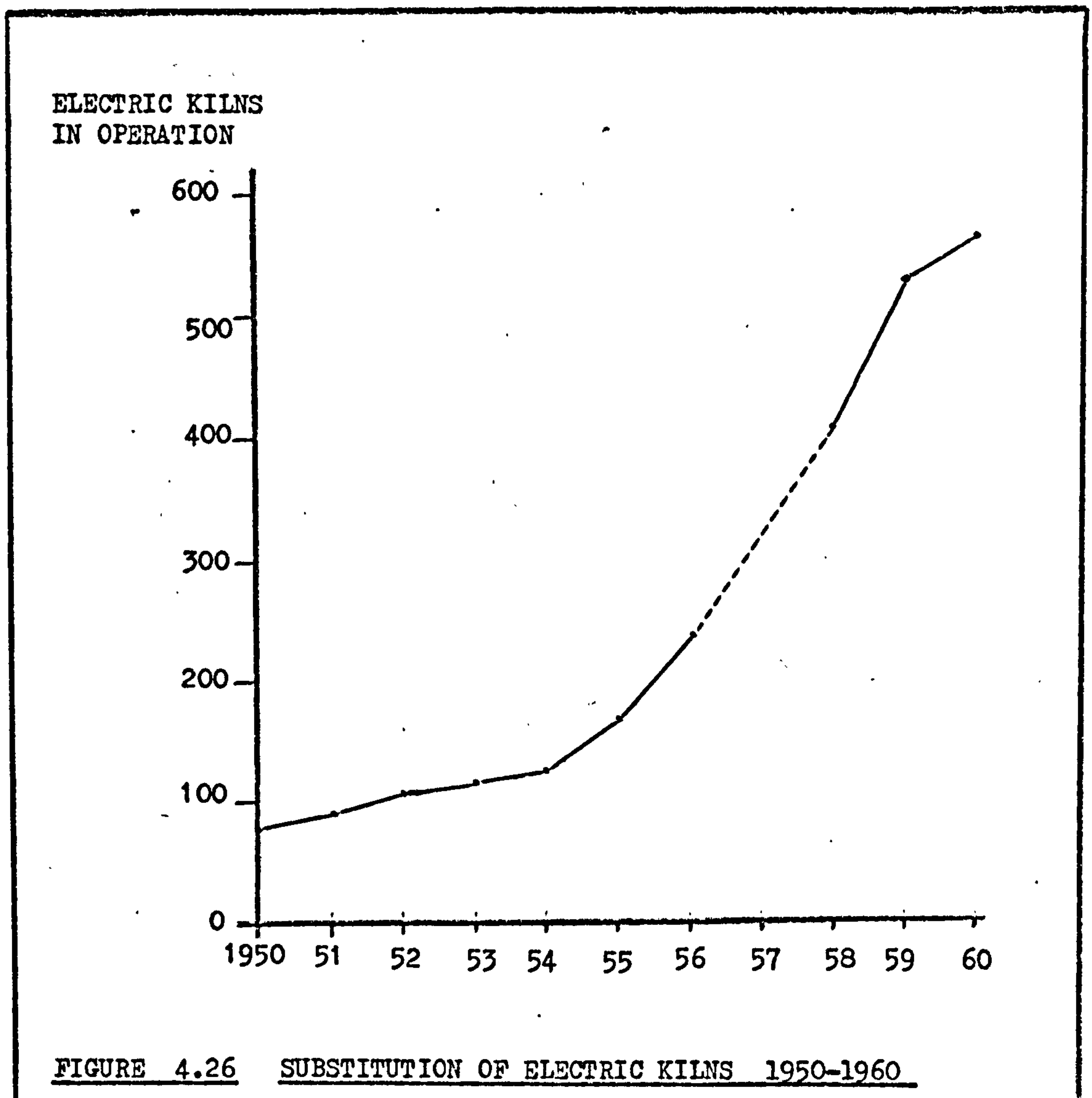
The Sanitary (Smoke Abatement) Act was introduced in 1867; "... any fireplace or furnace which does not, as far as practicable, consume smoke arising from the combustible use.. within the district of a nuisance authority... shall be prosecuted". Though pursued with more vigour by the nuisance authorities, 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.

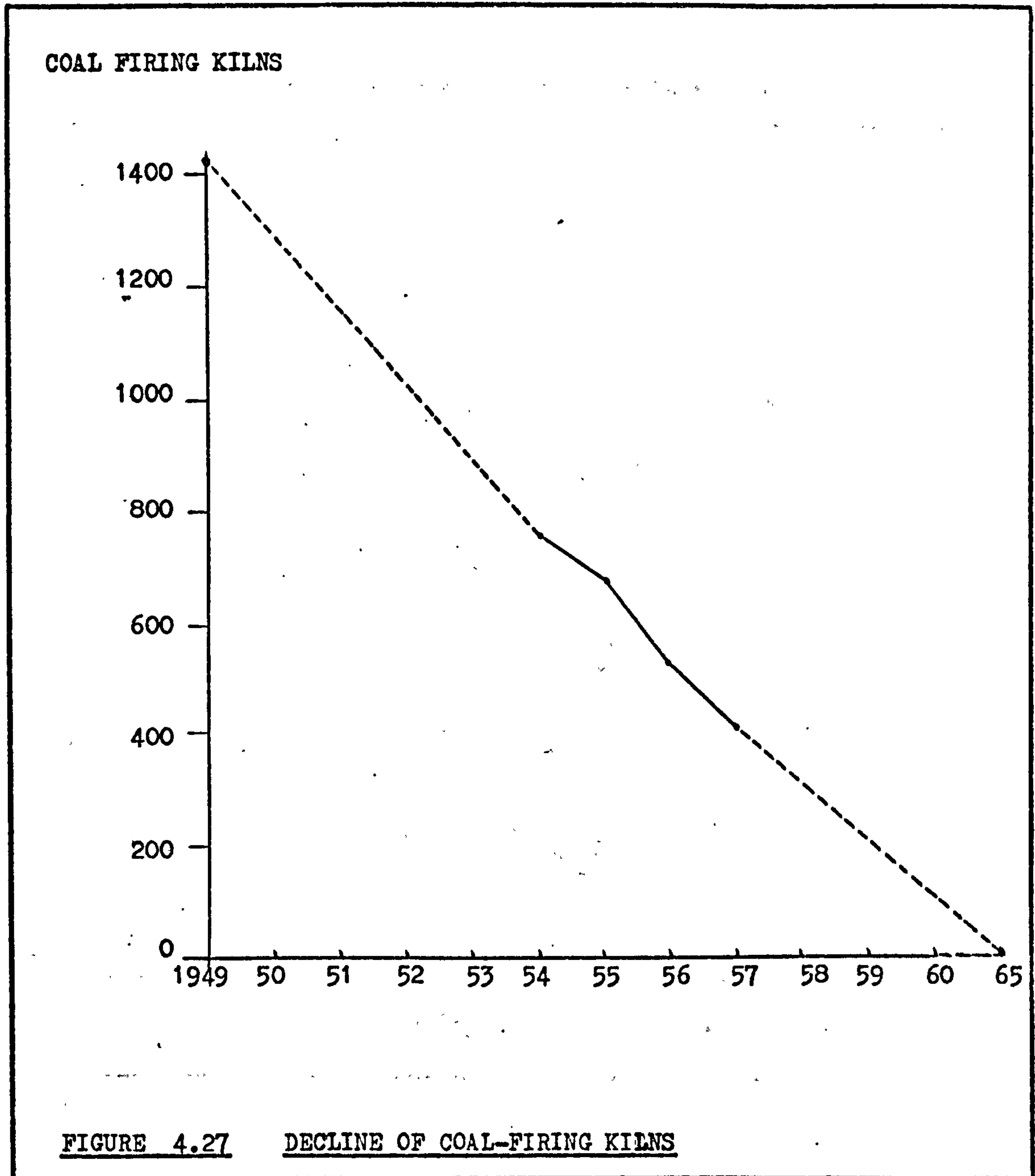
Similarly, the Smoke Abatement Act (1920) had little effect upon the pottery industry. By this time, in addition to the still large number of coal-burning kilns, there were the equally pollutant producer-gas tunnel kilns beginning to appear.

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.



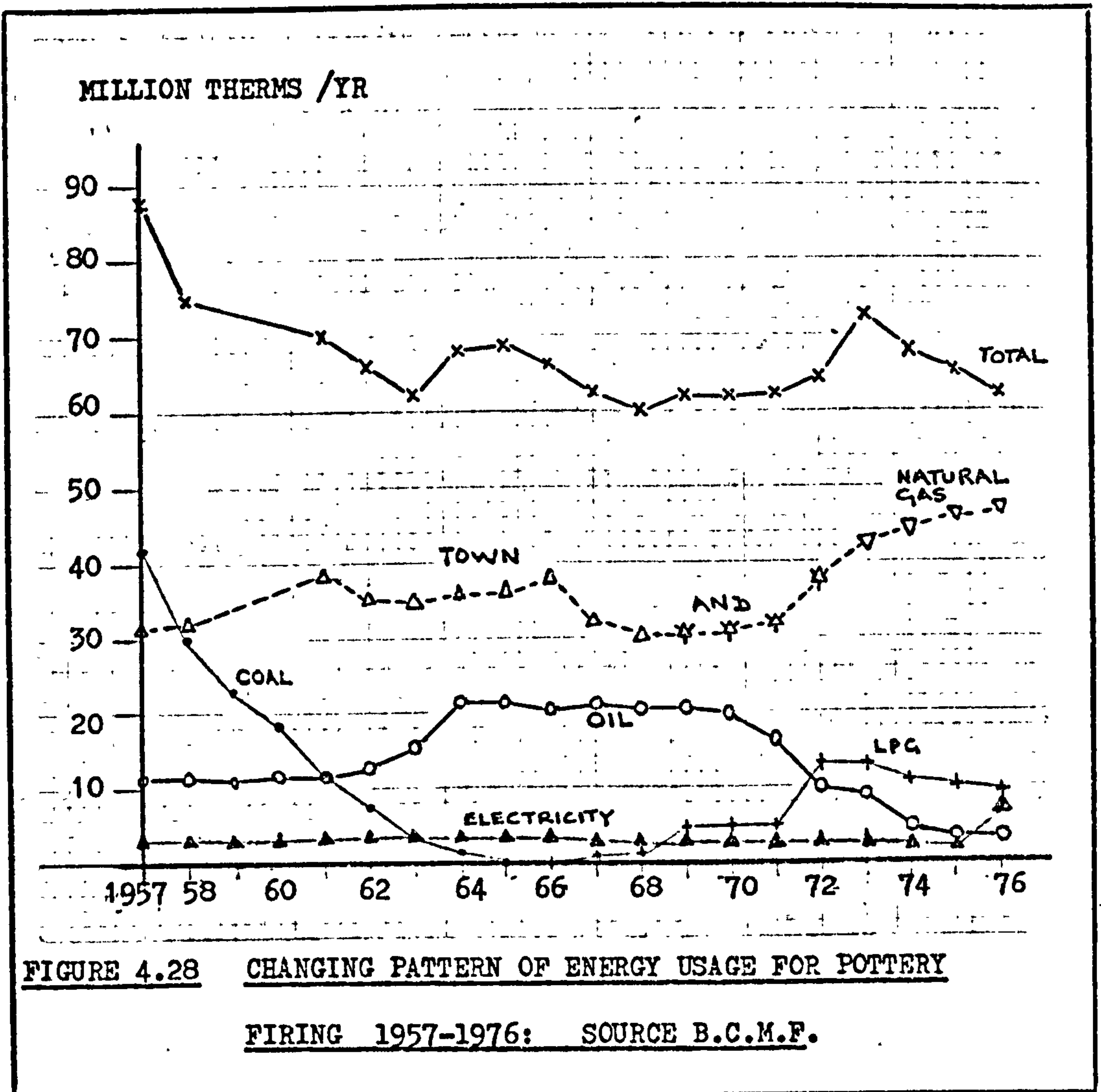


In the intervening years between 1956 and 1958, when the Bill finally gained Royal Assent, powerful manufacturer lobbies pleaded for more time to make the necessary transition from coal to alternative fuels. Coal firing continued after 1958 as manufacturers chose to pay the fines imposed; arguments that 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.



Galbraith comments "... the old bottle kilns were rendered obsolete by the Clean Air Acts and were demolished 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.



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 withdrawal of favourable tariffs by the MEB circa 1954 tended to decelerate the growth rate. The rise in electricity costs has terminated the diffusion of electric tunnel kilns. Electric firing is now mainly restricted to the glazing 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

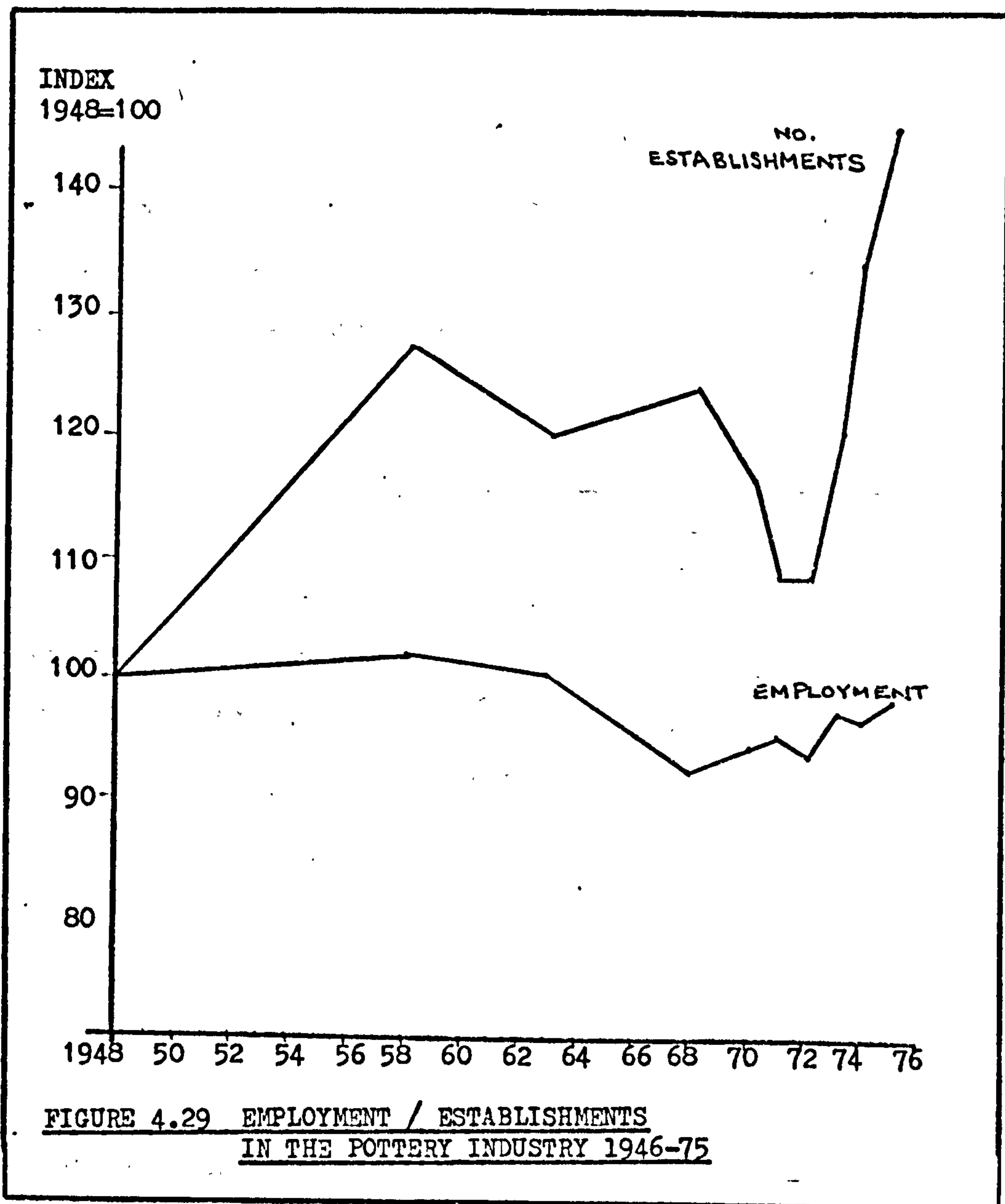
traditionally the pottery worker has accepted the principle of flexibility between jobs in the factory. He has not resisted change of job either in the short run (say an overload in one particular process) or long term as one technology has supplemented another. Figure 4.29 (overleaf) shows how employment 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 operative to find a position elsewhere with a less technologically 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.





INNOVATION ANDINFORMATION 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.

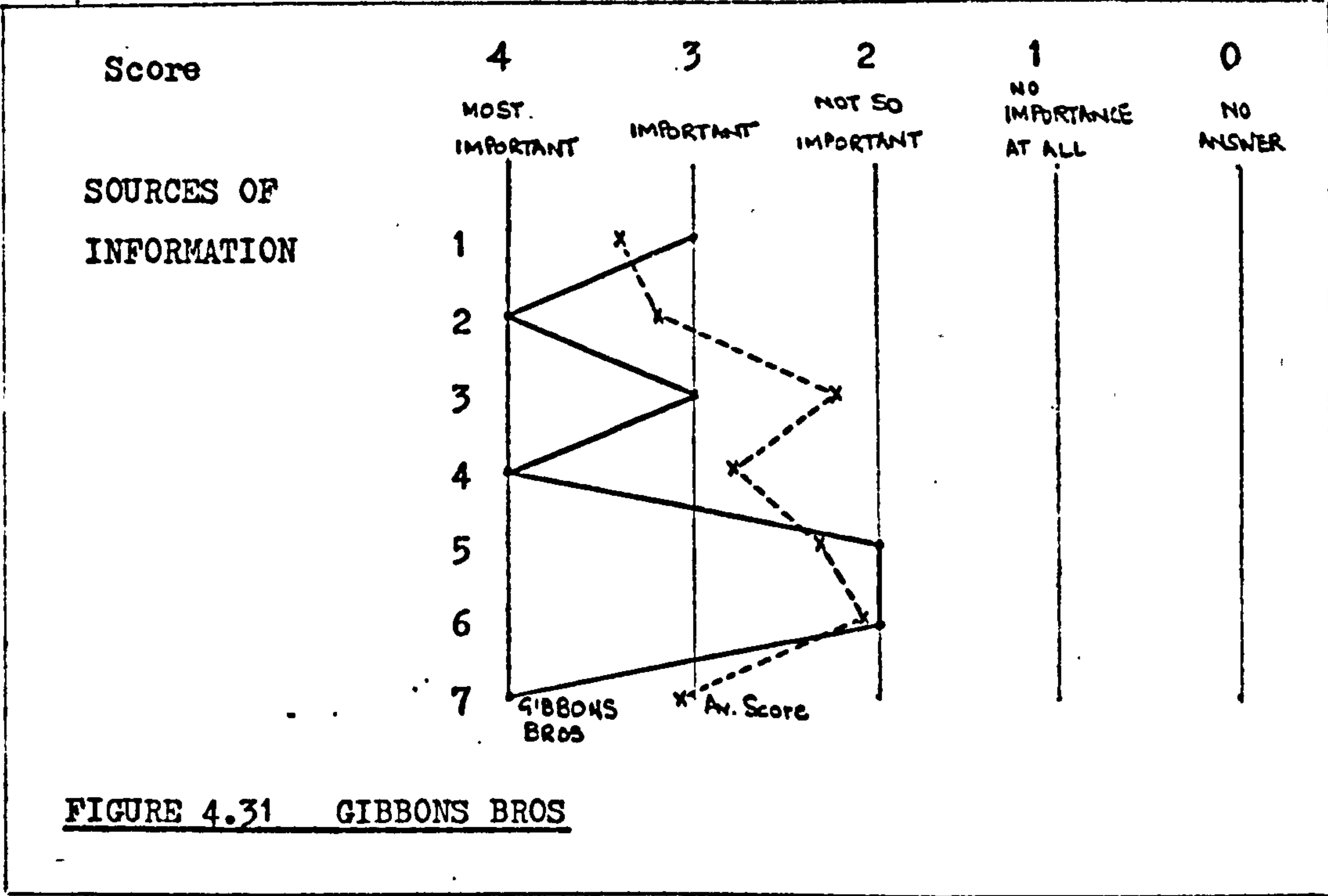
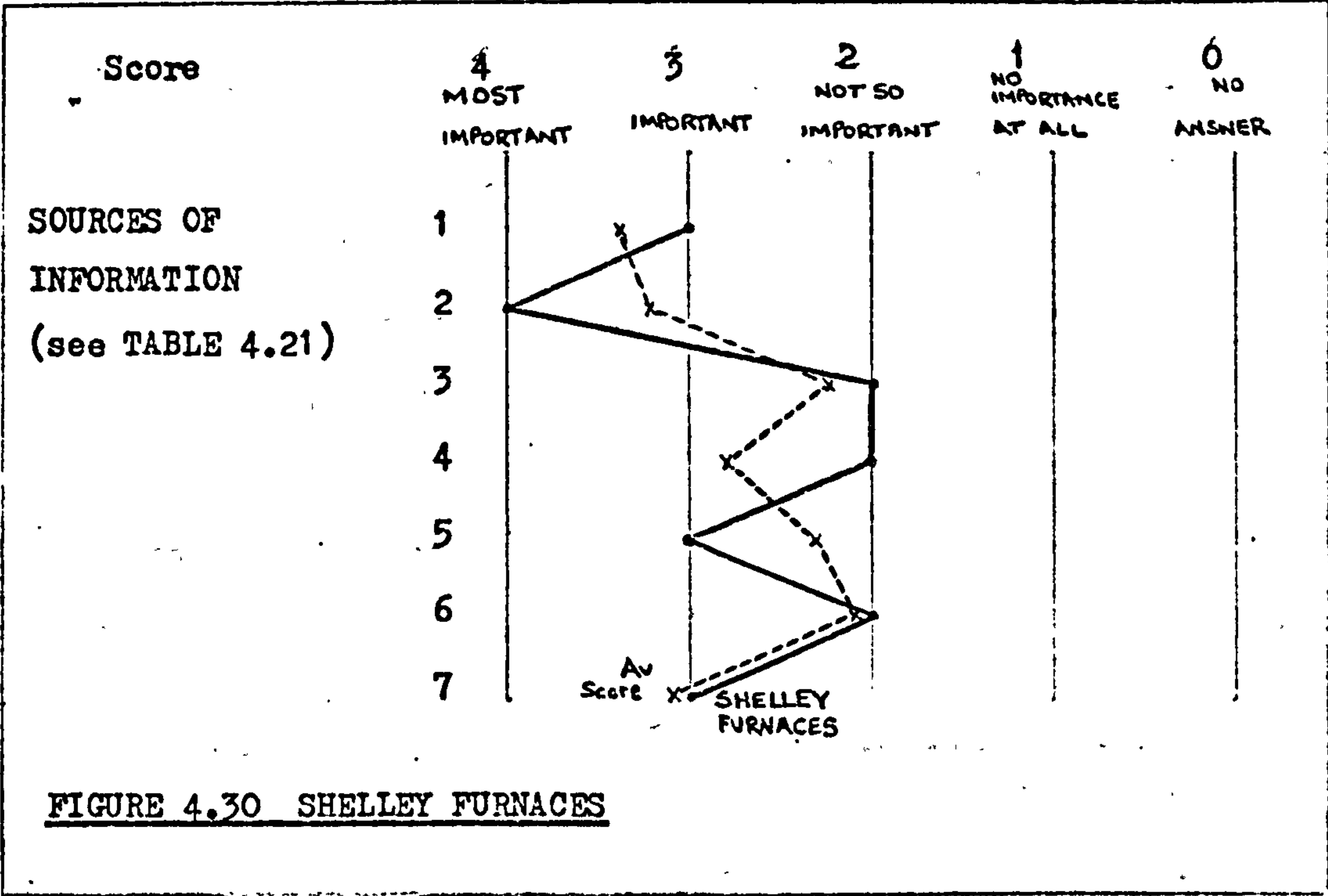
It does seem that kiln builders themselves do not bother to contribute articles; technical papers highlighting an adoption of a technological innovation invariably are written by either end-users or the materials-suppliers to the kiln builder (4.155).

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),

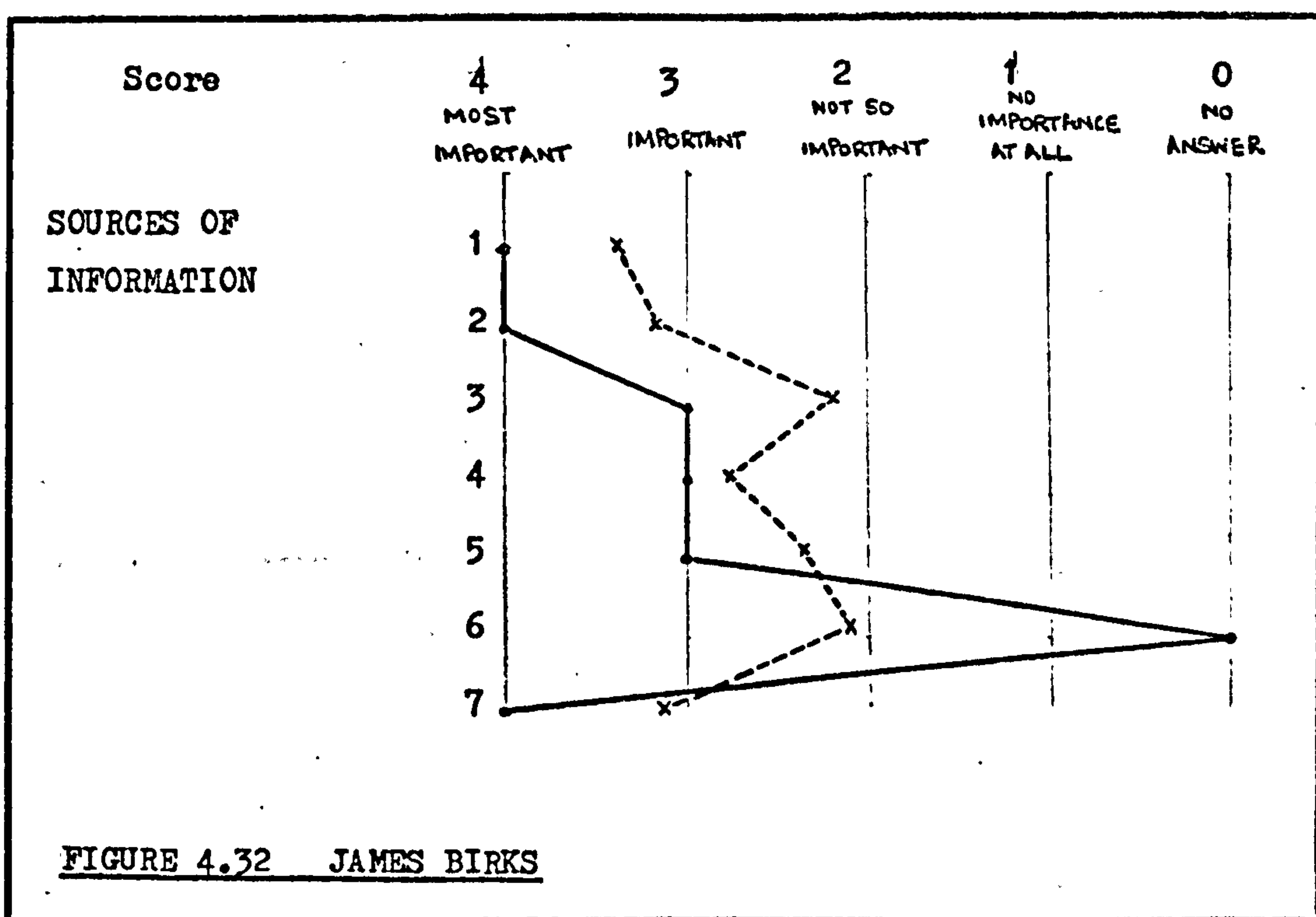


Figures 4.30 (SHELLEY FURNACES) and 4.31 (GIBBONS BROS) illustrate the responses made by the designated 'innovators':-



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:-



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 contrast 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				

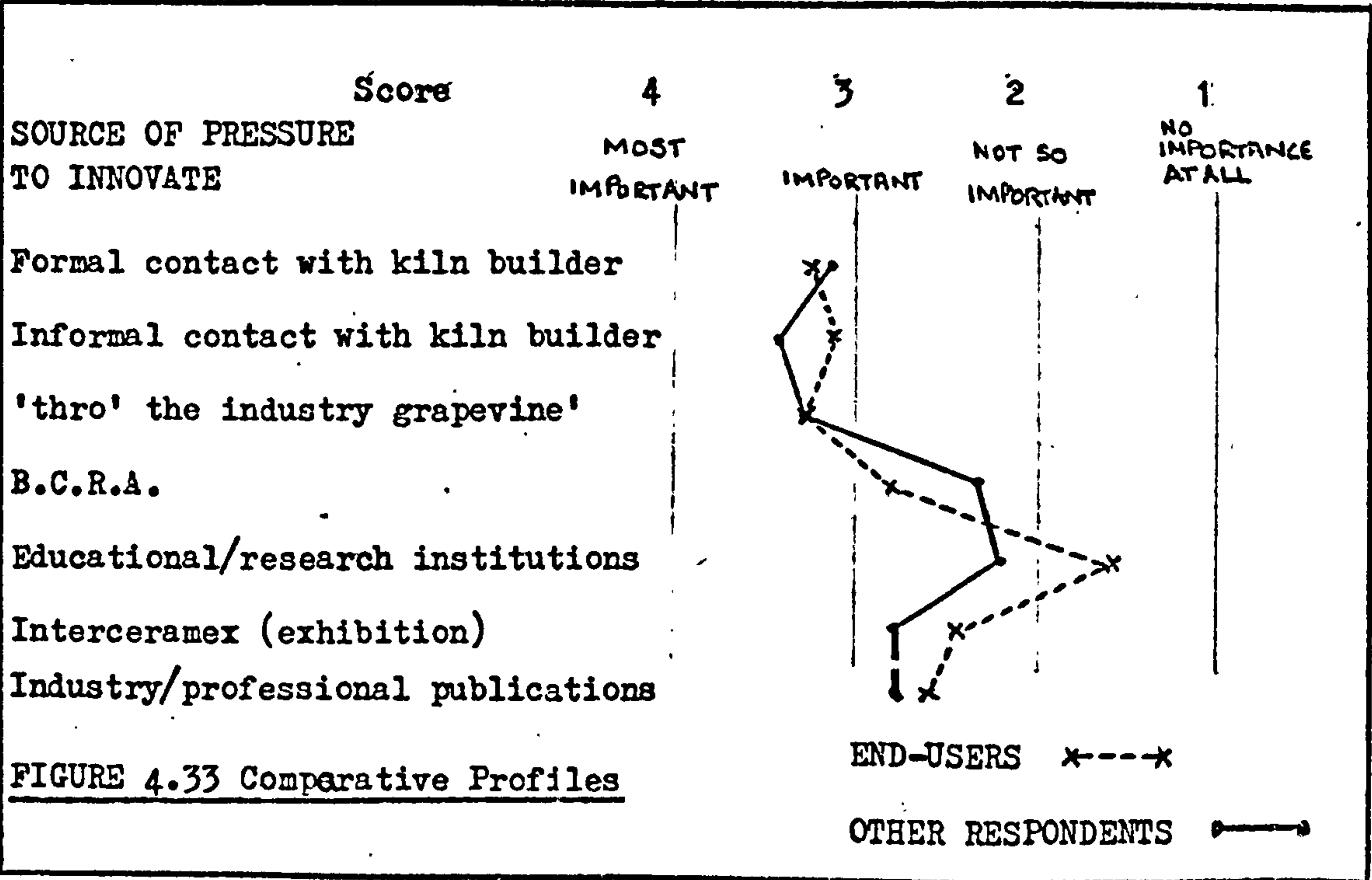


TABLE 4.23 Other respondents.

	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	

≤ 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:-



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 sponsor / 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 & Renney : "The Jet-Burner - A New Concept in Fast Precision Firing".  
American Ceramic Society Bulletin Vol. 41 No.3 1962 p.160
- 4.41 Further 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 et al : "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, installation 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 Service
- 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"  
 Maintenance 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 computing 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 aggravates 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 questioned 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 elicit 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 isn't, an innovation.



This self-nomination approach does have a reporting-back problem; one's 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 inferred. 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 identification 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 emphasises 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 initially 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 questionable 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 occurring 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

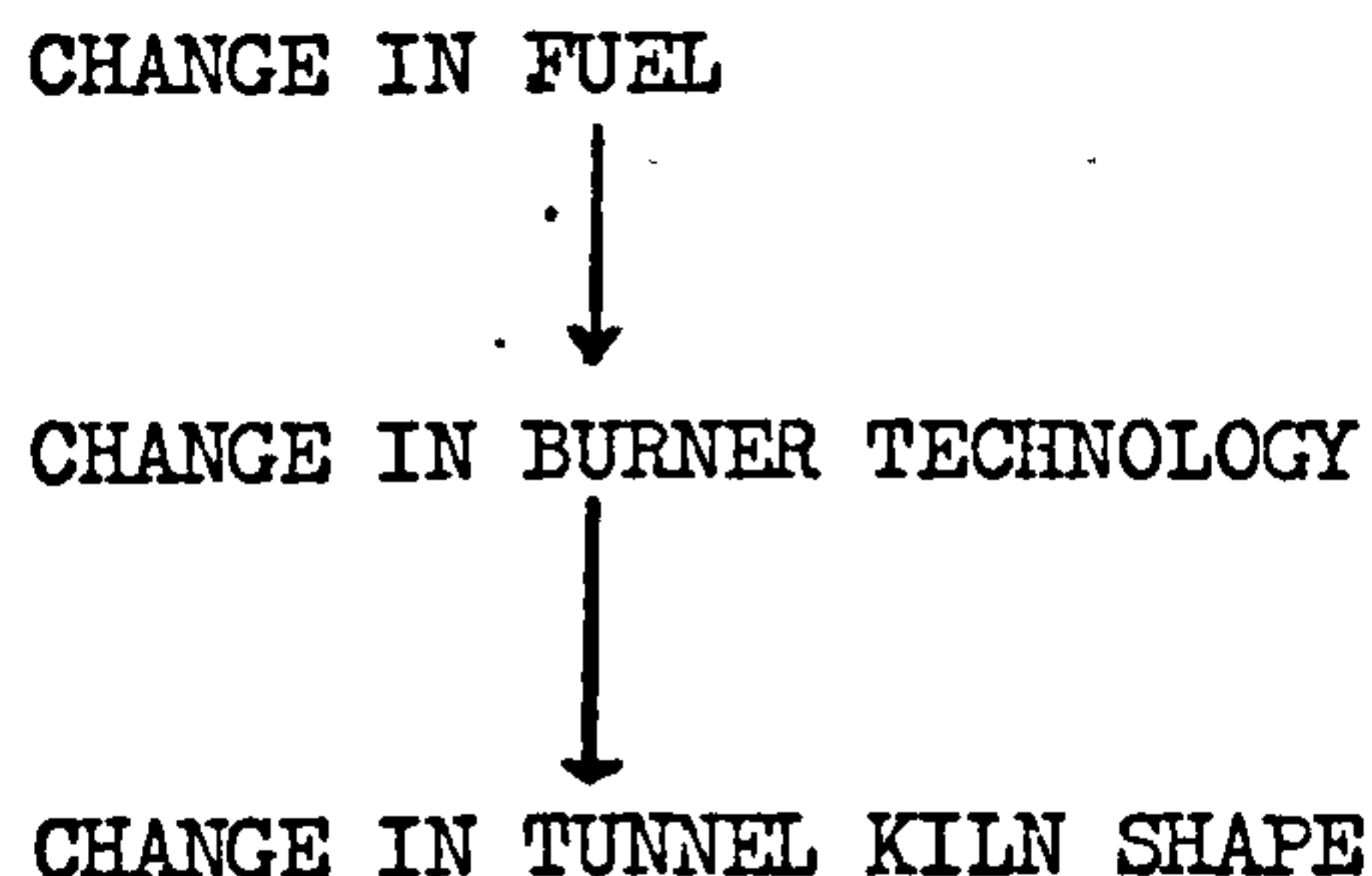
In adopting a process rather than results orientated approach this Thesis concludes by highlighting those factors found influencing technological innovatory behaviour. The literature contains varied reasons why organisations engage in innovatory behaviour. Such reasons have recently moved away from explanations 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

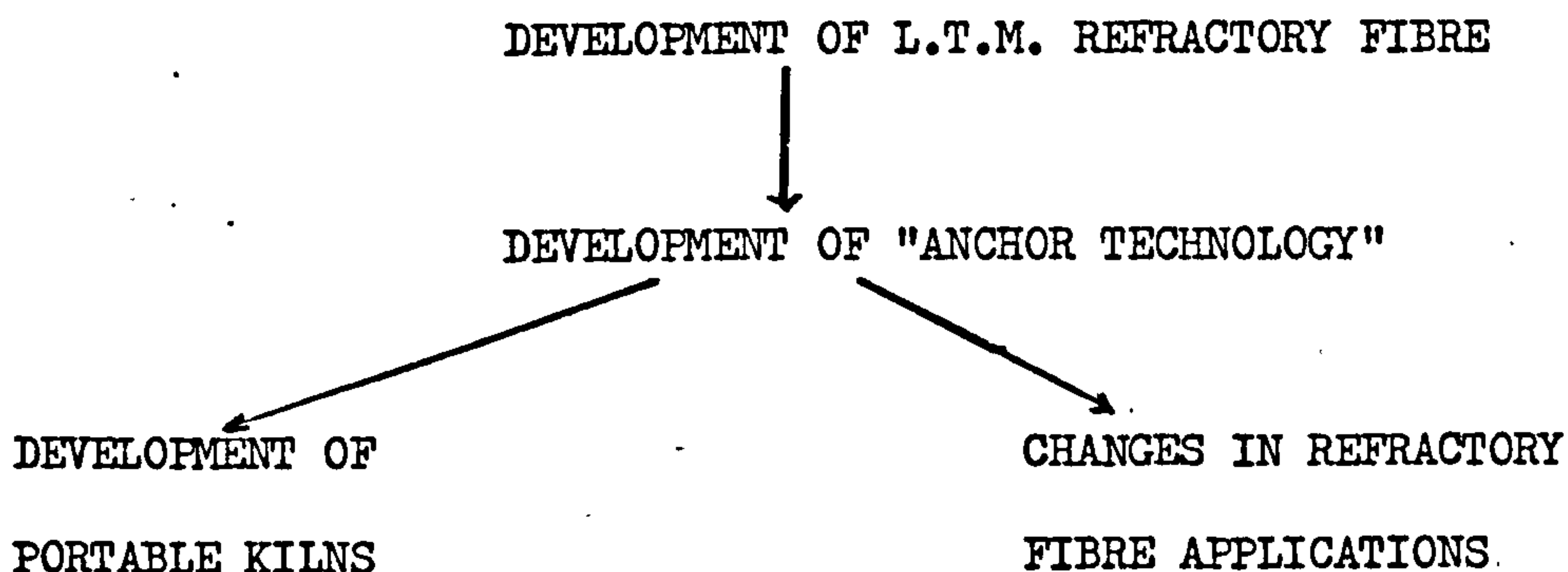
It was clear from the study that industrial diffusion cannot be meaningfully investigated without due consideration of competing technologies. At any period in time an innovation may be competing for adoption not only with the technology it is threatening to supplant but also parallel innovations and competing technology, as occurred 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



(ii) MODERN INTERMITTENTS



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 sufficient 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 conjunction 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 endeavour 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 credited 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, in response 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 managerial 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. Scarcity 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 traditional, 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 1GENERALISATIONS 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, cosmopolitaness, 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 discontinuance.

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 cosmopolitaness 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, cosmopolitaness, 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 characterized 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 cosmopolitaness.
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 2SURVEY IKILN 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

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Telephone 0782 45531

Our ref

Your ref

B/MAC/LW

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 anonymity 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 BIRK  
                                 KILN BUILDER & CONTRACTOR

STATUS OF RESPONDENT

SIZE OF FIRM

Number of Employees

23			
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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.  
PYKE 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:

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

Extremely Important	Very Important	Not so Important	Not Important At all
✓			
	✓		
		✓	
	✓		
✓			
✓	✓		
✓			
✓	✓		

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



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

(XVII)

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

✓
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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

✓
---

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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

✓



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

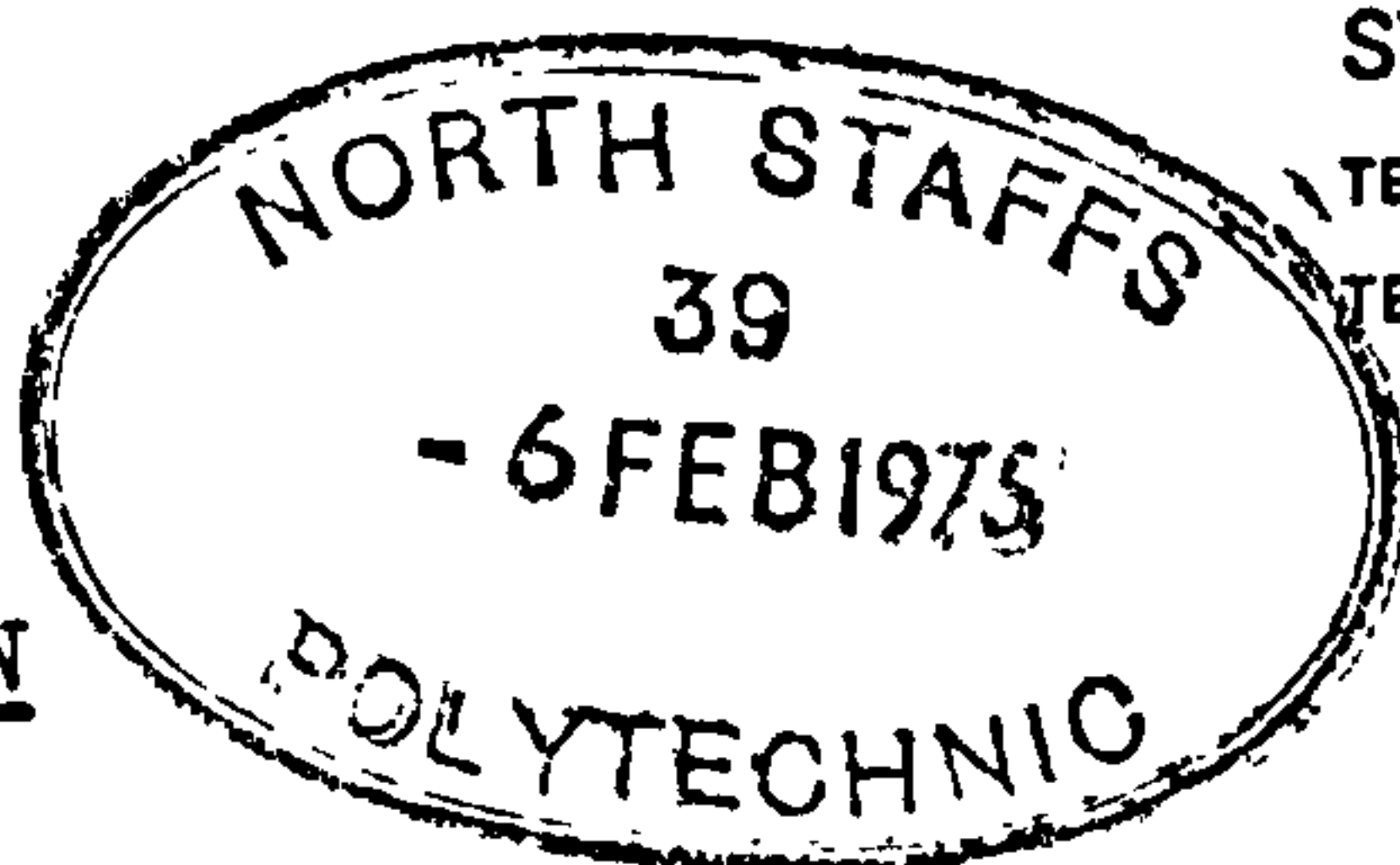
If a new idea doesn't quite go according to plan then it is quite easy for kilns to explode or become a fire hazard, therefore all instrumentation refractory and low Thermal Mass Materials have to be thoroughly tested etc. Also they can affect the economic

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.

A handwritten signature in cursive script, reading "Sam H. Jerrett".

Director

5 February 1976

DIRECTOR: SAM H. JERRETT, O.B.E., T.D., D.L., C.I.CERAM.

SECRETARY: DERICK TURNER, M.B.E.



**University of Salford**

**Salford M5 4WT**

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**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 .....

A handwritten signature in dark ink, appearing to read 'R S Mason', written over a dotted line.

**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 POLYTECHNICDEPARTMENT OF BUSINESS AND LEGAL STUDIESPOTTERY KILN INDUSTRY  
SURVEY IINOTES 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.
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M.A. Clements,  
Department of Business and Legal Studies,  
North Staffordshire Polytechnic,  
College Road,  
STOKE-CN-TRENT ST4 2LE.



POTTERY KILN INDUSTRY SURVEY II

Name of Firm (if applicable)

SPODE LTD.

Name and Status of Respondant

R. B. JONESDIVISIONAL TECHNICAL MANAGERROYAL 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. & L.  
Competitive pressures  
Customer influence  
Supplier influence  
Other sources (please specify and rank)

2
1
4
3

Don't 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)

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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

February 1977.

APPENDIX 7THE 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 fibres 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) Initially 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 abandoned 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 kilms.

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' comparison 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 Queens 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 insulating 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 from 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 conjunction 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 literature 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"  
Advertising & Marketing Winter 1975 P56.
- (11) Symes: Op cit P.4



BIBLIOGRAPHY

- ABBAKUMOV: Combustion of natural gas in high temperature  
tunnel kilns  
Ceram. Ind. Journal Vol.86 No 1003 1977
- ALDERSLEY: Energy as a scarce resource  
Trans. Journal British Ceramic Soc. Vol.  
76 No. 1 1977
- ALFORD + MASON: Generating New Products  
-
- ALLEN: Performance of Information channels in the  
transfer of technology  
Indust. Mgmt. Review Autumn 1966
- ALLEN: Communication networks in R & D laboratories  
R & D Managment Oct. 1970
- AMMER: Is your purchasing department a good buy?  
H.B.R. March/April 1974
- ANDERSON + BOWMAN: Education and economic development  
- 1965
- ANSOFF + STEWART: Strategies for a technology based business  
H.B.R. Nov/Dec. 1969
- ANSOFF + BRANDENBERG: A language of organisational design  
Mgmt. Science Aug. 1971.
- ARCHER: Design as an element in a new approach to  
Britain's Industrial future.  
Quarterly Review of Marketing Winter 1976.
- ARGYRIS: Personality and organisation: the conflict  
between the system and individual  
-
- ARNDT: A test of the two step flow in diffusion of  
a new product.  
Journalism Qtly. Vol. 45 1968

- ASH: Ceramic fibre-blanket furnace linings  
Brit. Clayworker Vol 79 No 935 1970
- ASH: A World Survey of low thermal mass design  
and construction techniques  
Refractory Engineering Autumn 1975
- AUGUST + CUTLER: New product testing. CLARK uses consumer  
research techniques  
Indust. Mkting Aug. 1976
- AUSTIN: Intermittent firing of bone china  
Trans. Journal British Ceramic Soc.  
Vol. 75 No. 2 1976
- BAKER + SIEGMAN: The effects of perceived means and needs on  
the generation of ideas for R & D  
I.E.E.E. Engineering Mgmt. Vol. EM14 Dec 1967
- BAKER: Accelerating the acceptance of new product  
offerings 11th Mkting Seminar Univ. Strathclyde  
May 1973
- BAKER: Marketing new industrial products  
Macmillan 1976
- BANTING: Unsuccessful innovation in the industrial  
market  
J. Mkting Jan. 1978.
- BAKER: Developments in furnace lining techniques  
Refractory Engineering Summer 1973
- BARNES: Organisational systems and engineering groups  
Harvard Graduate School Rept. 1960
- BARNES + AYARS: Reducing new product risk thro' understanding  
buyer behaviour  
Indust. Mkting. Mgmt Vol 6 No. 3 1977
- BARNETT: Innovation. The basis of cultural change  
McGraw-Hill 1953
- BAUMGARTEN: The innovation communicator in the diffusion  
process  
J. Mkt. Res. Vol 12 Feb. 1975.

- BAUMGARTEN: etal      Managment education, company climate and  
innovation  
J. General Mgmt Vol 4 No. 2 1976
- BEAL + JOHN:            Role performance of change agents  
Rural Sociallogical Soc. of San Francisco 1967
- BEISHON + PETERS:    Systems behaviour  
Open Univ. Press 1972
- BENNIS:                The planning of change. Readings in the  
applied behavioural sciences  
- 1962
- BERELSON:             Voting  
Free Press 1954
- BERENSON:             The R & D-Marketing Interface. A general  
analogue model for technology diffusion  
J. Mkting April 1968
- BERLINER:             Kilns  
New York 1951
- BISHOP:                The utilisation of coal for kiln firing  
Euroclay No. 3 1975
- BOARD OF TRADE:      Pottery  
Working Pty Rept. HMSO London 1946
- BODROGHY:             Forecasting the demand for novel products  
Indust. Mkting Res. Assoc. Journal May 1974.
- BOGGIS:                Seekers, takers, makers. A taxonomy for the  
trabsfer process  
11th Mkting Seminar. Univ. Strathclyde May 1973
- BOHNING:              Periodic and continuous kilns: when to use  
each type and why  
Interceram. Vol. 25 No. 3 1976
- BOOZ etal:             Management of new products  
Free Press 1965



- BOYD + MASSEY: Marketing Managment. An analytical problem solving approach to marketing  
Harcourt,Brace,Jovanovich 1972
- BRANDT + DUNCALFE: A new fiber lined tunnel kiln design  
Ceramic Bulletin Col 57 No. 5 1978
- BRIGHT: Some managment lessons from technological innovation research  
Univ. Bradford Mgmt. Centre 1968
- BRIGHT: Technological forecasting for industry and government  
Prentice Hall 1972
- BRISCOE etal: The market development of new industrial products  
European J. Mkting Vol. 6 No. 1 1972
- BROWN + COX Empirical regularities in the diffusion of innovation  
- Sept 1971
- BROWN: Decision analysis for the manager  
Holt Saunders 1974
- BROWNE + KEMP: A three stage product review process  
-
- BRUSH: Todays kilns ready for tomorrows demands  
Ceramic Industry Magazine Aug. 1971
- BRUTTON: You never know till you try  
Design Nov. 1975
- BRYAN etal: Application fo recuperative burners in gas-fired furnaces  
Communication No.952 presented at a meeting of the Institution of Gas Engineers.  
London Nov. 1974
- BUCHNER: How British industry buys  
- 1967

- BUETOW:** Evaluating new ideas  
Business Quarterly Spring 1974
- BUNGE:** Scientific research: the search for the  
system  
Berlin 1967
- BURNS + STALKER:** The managment of innovation  
Tavistock 1961
- BURNS:** Innovation. The Managment connection  
Lexington
- BUZZELL etal:** Marketing. A contemporary analysis  
- 1964
- CANTLAY:** Technological innovations in the textile  
industry and their effects upon consumer  
behaviour  
11th Mkting Seminar. Univ. Strathclyde  
May 1973.
- CANTON:** Diffusion theory and the product launch  
Indust. Mkting. July 1977
- CARDOZO + CAGLEY:** Experimental study in industrial buying  
behaviour  
J. Mkt Res. Aug 1971
- CARTER + WILLIAMS:** Industry and technical progress. Factors  
governing the speed of application of science  
Oxford Univ. Press 1957
- CARTER + WILLIAMS:** The characteristics of technically progressive  
firms  
J. Indust. Economics Vol. 7 1960
- CASETTI:** Why do diffusion processes conform to logistic  
trends?  
Geographical Analysis Vol 1 1969
- CASETTI + SEMPLE:** Concerning the testing of spatial diffusion  
hypothesis  
Geographical Analysis Vol 1 1969

- CASEY:** From the laboratory to the market place  
Indust. Mktng Mgmt. Vol 6 1977
- CASWELL + WILKENS:** Emerging role of the risk manager  
Business Horizons Vol 18 No.6 Dec 1975
- CATT:** Management against innovation  
Business Graduate Summer 1976
- CAVES:** American industry. Structure, conduct and  
performance  
Prentice Hall 1972
- CENTRAL ADVISORY COUNCIL  
FOR SCIENCE & TECHNOLOGY:** Technological innovation in Britain  
HMSO 1968
- CHADWICK:** Operating experiences of intermittent electric  
firing with heat regeneration  
Trans Journal British Ceramic Soc. Vol 75 No.1  
1976
- CHAKRABARTI:** The effects of techno-economic and organisational  
factors on the adoption of NASA innovations by  
commercial firms in the USA  
PhD dissertation, Northwestern Univ. 1972
- CHAKRABARTI:** The role of champion in product innovation  
California Mgmt Review Winter 1974
- CHANDLER:** Strategy and structure  
M.I.T. Press -
- CHECKLAND:** Towards a system based methodology for real  
world problem solving  
J. Systems Engineering Winter 1972
- CHURCHMAN + SCHAINBLATT:** The researcher and the manager  
A dialectic of implementation  
Mgmt Science Vol XI Feb. 1965
- CLARK:** Ceramic fiber blanket as a furnace hot face  
lining  
Blast Furnace + Steel Plant Vol 58.No.9 1970
- CLEMENS:** Decision making and industrial selling  
European Res. May 1974



- CLEMENTS: The role of advertising in launching technological products: a users perspective  
Advertising Association 1980
- CLUB OF ROME: Limits to growth  
Pan Books 1973
- COLEMAN: Introduction to mathematical sociology  
- 1964
- COLEMAN: Medical innovation. A diffusion study  
- 1966
- COLEMAN et al: Social processes in physicians' adoption  
of a new drug  
- 1968
- COLLINS: Use of models in the social sciences  
Tavistock 1974
- COLSON: Kiln Building with space-age materials  
Van Nostrand Reinhold 1977
- COMER + CHAKRABARTI: The information industry for the industrial  
marketer  
Indust. Mkting Mgmt. Vol 7 No 1 Feb 1978
- COOK: A review of some methodological aspects of  
diffusion research  
MSc dissertation Univ. Bradford 1970
- COOPER + SCHENDEL: Strategic responses to technological threats  
Business Horizons Vol 19 No. 1 Feb 1976
- COOPER + LITTLE: Determinants of market research expenditures  
for new industrial products  
Indust. Mkting Mgmt Vol 6 No. 2 1977
- COPULSKY: Cannibalism in the market place  
J. Mkting Vol 40 Oct 1976
- COREY: The development of markets for new materials  
Harvard Graduate School 1956

- COUDAMY: A new generation of intermittent kilns  
Interceram Vol. 26 No.4 1977
- COUGHENOUR: The problem of reliability of adoption data  
in survey research  
Rural Sociology Vol 30 1965
- CRAWFORD: Product development  
Univ. Michigan Business Review Jan 1977
- CUNNINGHAM + HAMMOUDA Product planning in engineering companies.  
A recent research survey.  
European J. Mkting Summer 1969
- CUNNINGHAM: Innovation in a sales/distribution system  
11th Mkting Seminar. Univ Strathclyde  
May 1973
- CUNNINGHAM + WHITE: The determinants of choice of supplier  
European J. Mkting Winter 1973
- CUNNINGHAM + WHITE: The behaviour of industrial buyers in their  
search for suppliers of machine tools.  
J.Mgmt Studies May 1974.
- CYERT + MARCH: A behavioural theory of the firm  
Prentice Hall 1963
- CZEPIEL: Word of mouth processes in the diffusion  
of a major technological innovation  
J. Mkt. Res May 1974
- DALTON: Conflict between line and staff managerial  
officers  
American Soc. Review Vol 15 1950
- DANIEL: Reorganising for results  
H.B.R. Nov. 1966
- DANIELS: Energy, coal and the ceramic industry  
Brit. Ceram. Review No. 31 1977
- DAVIDSON: Why most consumer brands fail  
Mkting April 1977

DAVIES + HOLMES: Energy conservation: the efficient use of electricity  
Brit. Ceram. Res. Assoc. Note 260 1976

DAVIES: Making the most of innovation  
Indust. Mkting Mgmt Vol 2 No 1 1977

DEANE: The first industrial revolution  
Cambridge V.P. 1969

de BONO The innovation dilemma  
Indust. Mkting Mgmt Vol 2 No 2 1977

de COTTIS + DYER: The dimensions and determinants of project performance  
Indust. Mkting Mgmt Vol 2 No 6 1977

de KLUYVER: Innovation and industrial product life cycles  
California Mgmt Review Autumn 1977

DEPARTMENT OF ENERGY: Production and reserves of oil and gas in U.K.  
H.M.S.O. May 1974

DEPARTMENT OF THE ENVIRONMENT: 110th Annual Report on Alkali  
H.M.S.O. 1974

DEWHURST: The long range research that produced glass fiber reinforced tires  
Research Mgmt Vol 13 No.3 1970

DHALLA + YUSPEH: Forget the product life cycle concept  
H.B.R. Jan/Feb 1976

DICKINSON: The role of packaging in the innovation process  
11th Mkting Seminar Univ. Strathclyde May 1973

DINSDALE: Ceramics: a symposium  
Brit. Ceram. Soc. 1953

DIXON: Death of a nice idea  
New Scientist 18 May 1972



EVANS: Large tunnel kilns for sanitaryware  
Pottery Manufacturers Meeting Trentham  
S-O-T 13 Nov 1975

EVENING SENTINEL: Interceramex '76 Special  
20th Sept. 1976

EVENING SENTINEL: Interceramex '78 Special  
19th Sept. 1978

EXTON: The levels of innovation  
Advanced Management Journal April 1974

EYLES: Royal Doulton 1815-1965  
Hutchinson London 1965

FARIS: Handbook of modern sociology  
Rand McNally 1964

FAST: New venture departments: organising for  
innovation  
Indust. Mkting Mgmt Vol 7 No. 2 April 1978

FAY + DONAHEY: Fuel conservation in kiln firing. An overview  
American Ceram. Soc. Bull. Vol 56 No. 8 1977

FELDMAN + CARDOZO: The industrial revolution and models of  
buyer behaviour  
J. Purchasing Nov. 1969

FELDMAN + ARMSTRONG: Identifying buyers of a major automotive  
innovation  
J. Mkting Vol. 39 Jan 1975

FESTINGER: Theory of cognitive dissonance  
- 1957

FIDLER: Ceramic fiber-lined furnaces installation  
procedures  
Indust. Heating Vol. 39 No. 10 1972

FIDLER: Energy conserving ceramic fibre linings for  
heat treating furnaces  
Indust. Heating Vol 41 No. 5 1974

- FILDES + LOFTHOUSE:** Market share strategy and the product life cycle. A comment.  
J. Mkting Vol. 39 No.4 1975
- FISHER:** Diffusion of innovation. A synthesis of research approaches  
11th Mkting Seminar. Univ. Strathclyde May 1973
- FOGG:** New business planning. The internal development process  
Indust. Mkting Mgmt Vol 5 1976
- FOSTER:** The management of innovation: the development of SAFFIL as a case study  
Unpublished paper I.C.I. (Mond Div) Nov. 1977
- FORD:** Good ideas - the wrong corporate orientation  
Human Resource Mgmt. Autumn 1976
- FORD + RYAN:** The marketing of technology  
European J. Mkting Vol 11 No 6 1977
- FOX:** Systematic companywide adaptations to changing conditions  
Mgmt International Review Vol. 15 No.6 1975
- FRANK:** Heat savings in tunnel kilns  
Ceram. Information Vol 10 No. 103 1975
- FRASER:** Kilns and kiln-firing for the craft potter  
Pitman -
- FRAYATT:** Major fuel savings with ceramic fibre  
Maintenance Engineer Vol 18 No.3 1974
- FREEMAN:** Research and development in electronic capital goods  
Nat. Institute Economic Review No. 34 Nov. 1965
- FREEMAN:** Report on the role of small firms in innovation in the U.K. since 1945  
Commission of Enquiry on Small Firms HMSO 1971
- FREEMAN:** Success and failure in industrial innovation.  
Project SAPPHO Phase I  
Univ. Sussex 1972

- GABOR: Innovations. Scientific, technical and social  
Oxford Univ. Press 1970
- GALEONE: Reduction of production costs by saving fuel  
Ceramurgia Vol 7 No.4 1977
- GARNER: Chronicles on the Potteries  
1850
- GAYE+ SMYTH: The British pottery industry  
Butterworths 1974
- GERSTENFELD: Effective management of research and development  
Addison-Wesley 1970
- GHIA: Up to 45% fuel savings. Calculation on  
burners using gaseous fuels at reduced  
nominal pressures  
Sprechsaal Vol 109 No. 11 1976
- GIDDY: The product life cycle in international business  
theory  
Columbia J. World Business Spring 1978
- GILFILLAN: The sociology of invention  
Univ. Chicago 1935
- GILL: Kiln of the past: Kiln for the future  
Ceram Ind. Journal Vol 85 No.997 1976
- GILLET: Innovation in marketing. A practitioners  
viewpoint  
11th Mkting Seminar. Univ. Strathclyde May 1973
- GITTENS: Kilns and firing  
Trans J. Brit. Ceram. Soc. Vol 75 1976
- GREEN + LANGEARD: A cross-national comparison of consumer  
habits and innovator characteristics  
J. Mkting Vol 39 No 3 1975
- GREGORY: The design method  
Butterworth 1960



- GREGORY: Kiln building  
Pitman 1977
- GRILICHES: Hybrid Corn: An exploration in the economics  
of technological change  
Econometrica Vol 25 1957
- GROENEVELD: New approaches in Industrial marketing  
involving subjective probability  
-
- GRØNHAUG: Exploring environmental influences in  
organisational buying  
J. Mkt. Res. Vol. 8 Aug 1976
- GRØNHAUG: Exploring a complex organisational buying  
decision  
Mkting Mgmt. Vol 6 No. 6 1977
- GRUBER + MARQUIS: Factors in the transfer of technology  
N.I.T. Press 1969
- GRUBER: Todays kilns ready for tomorrows demand  
Ceramic Indust. Mgmt Aug 1971
- HÄGERSTRAND: The propagation of innovation waves  
Lund Studies in Geography No. B4 1952
- HÄGERSTRAND: Innovation diffusion as a spatial process  
- 1967
- HAGGERTY: The process of technological innovation  
N.A.S. Pub. No. 1726 1969
- HÄKSANSSON + WOOTZ: Risk reduction and the industrial purchaser  
Euro. J. Mkting Vol 9 No. 1 1975
- HAMBERG: Invention in the industrial research laboratory  
J. Political Economy Vol. 71 -
- HANAN: Corporate growth through venture management  
H.B.R. Jan/Feb 1969

- HANCOCK: Dynamic marketing for a changing world  
AMA Proceedings Chicago 1960
- HARDWICK: Burner system saves fuel  
Ceram. Indust. Journal Vol 86 1002 1977
- HARMS: Recent experience in fast-firing ceramic products  
Ceramics Vol 24 No. 289 1973
- HARMS: The integration of the fast firing kiln in  
the modern porcelain factory  
Interceram. Vol. 26 No. 4 1977
- HAVELOCK: Planning for innovation through dissemination  
and utilisation of knowledge  
Univ. Michigan -
- HAYWARD: Diffusion of innovation in the flour milling  
industry  
Euro. J. Mkting Vol 6 No. 3 1972
- HAYWARD: Study of the characteristics of innovation  
in the capital equipment field  
SSRC Rept.2269/2 July 1976
- HAYWARD et al: Innovation profiles. A new tool for capital  
equipment manufacturers  
Euro J. Mkting Vol 11 No. 4 1977
- HICKS: Modification of existing tunnel kilns can  
save energy, cut heat loss  
American Ceram. Soc. Bull. Vol 54 No. 9 1975
- HILL: The damp squib of invention follow-through  
Design -
- HILL + HLAVACEK: The venture team. A new concept in market  
organisation  
J.Mkting Vol 36 July 1972
- HIND: Pottery ovens, fuels and firing  
Brit. Pottery Manufacturers Federation 1937
- HIPPEL: Successful industrial products from customer  
ideas  
J.Mkting Jan 1978

- DOELEMEN: High speed burners  
Klei Keram Vol 28 1978
- DRESSLER: Symposium on importance of thermal history  
problems of firing ceramic ware in tunnel  
kilns  
American Ceram. Soc. Bulletin Vol 18 No 111939
- DRUCKER: Management: Tasks, responsibilities, practices  
Harper Row 1974
- EILOART: Fanning the flame of innovation  
New Scientist 11th Sept. 1969
- ELLIOTT +  
MARGERISON: Affective dissonance amongst professional  
personnel  
Research Rept. Univ. Bradford 1970
- ELLIS: Innovation in retailing  
International Journal Physical Distribution  
Vol 6 No. 3 1976
- ENGEL et al: Consumer Behaviour ( 3rd ed.)  
Holt 1976
- ENIS: Extending the product life cycle  
Business Horizons June 1977
- ENOS: Petroleum, progress and profits  
M.I.T. Press 1962
- ENOS: The rate and direction of inventive activity  
Princeton Univ. Press 1962
- EPSTEIN: Competition and innovation in general  
transmission equipment  
Indust. Mktng Mgmt Vol 7 No. 1 1978
- ETZIONI: Modern organisations  
Prentice Hall 1964
- EVAN + BLACK: Innovation in business organisations: some  
factors associated with success or failure  
of staff proposals  
J. Business Vol 40 1967



- HOFER: Toward a contingency theory of business strategy  
-
- HOLMES: Developments in pottery firing 1967-1977  
Brit. Ceram. Soc. Paper May 1978
- HOMANS: The human group  
Harcourt 1950
- HOMANS: Social behaviour, its elementary forms  
- 1961
- HOPKINS: New emphasis in product planning and strategy  
development  
Indust. Mktng Mgmt Vol 6 1977
- HOVELAND et al: Communications and persuasion  
Yale Univ. Press 1953
- HOWARD + SHETH: Theory of buyer behaviour  
Wiley 1969
- JACKSON: Creativity, innovation and the average firm  
Chartered Mechanical Engineer Oct. 1975
- JAIN: Thermal efficiency of brick kilns  
Indian Ceramics Vol 20 No. 10 1978
- JAMES: Emotional buying in the industrial market  
Scientific Business Spring 1966
- JEFFERS: The resurgence of coal as fuel  
Brick Clay Record Vol 164 No. 1 1974
- JEFFERS: There is an answer to the fuel problem-  
its coal  
Brick Clay Record Vol. 167 No. 5 1975
- JEFFERS: T.E.S. opportunity for ceramics  
Brick Clay Record Vol. 169 No. 5 1976
- JEFFERS: New coal firing system installed at Lee Brick  
Brick Clay Record Vol 171 No. 4 1977

- JEFFERS:** Installation system cuts fiber lining costs  
Brick Clay Record Vol 171 No. 6 1977
- JEWES etal:** The sources of invention  
Macmillan 1969
- JONES:** The adoption and diffusion of agricultural practices  
World Agricultural Economics & Rural Sociology  
Vol 9 1966
- JONES:** New product development  
Conference Board Record Sept. 1976
- KAETHER:** The tunnel muffle kiln use nowadays  
Keram Z. Vol 28 No. 8 1976
- KAPLAN:** Some organisational factors affecting creativity  
IRE Trans. Engineering Mgmt March 1960
- KAPLAN:** The conduct of inquiry. Methodology for behavioural sciences  
Intertext 1964
- KATZ + KAHN:** The social psychology of organisations
- KATZ + LAZARFELD:** Personal influence. The part played by people in the flow of mass communication  
Free Press 1955
- KATZ:** Traditions of research on the diffusion of innovation  
American Sociological Review Vol 28 1963
- KEITH + WARE:** Wide shuttle kiln offers greater economy of fuel and capital investment  
American Ceram. Soc. Bull. Vol 56 No. 4 1977
- KETTERING:** Concentration, invention and innovation  
U.S. Senate Antitrust Subcommittee 1965
- KING:** Adoption and Diffusion research in marketing. An overview.  
American Mktng Assoc. Fall conference 1966

- KLAPPER: The effects of mass communication  
- 1960
- KNIGHT: A description model of the intra-firm innovation  
process  
J. Business Vol 40 No. 4 1967
- KOESTLER: The Art of creation  
Pan Books 1959
- KOTLER: Marketing Management. Planning, analysis and  
control  
Prentice Hall 1976
- KOTLER + ZALTMAN: Targeting prospects for a new product  
J. Adv. Res. Feb 1976
- KUHN: The structure of scientific revolutions  
Chicago Univ. Press 1970
- LAMBERT et al: The industrial buyer and the past choice  
evaluation process  
J. Mkting Res. Vol 14 No. 2 1977
- LANCASTER + WHITE: Industrial diffusion, adoption and  
communication  
European J. Mkting Vol 10 No 5 1976
- LANCASTER + WHITE: Diffusion and adoption. A review  
Quarterly Review of Mkting Spring 1976
- LANGE: The energy bridge  
Canadian Clay Ceramics Vol 47 No. 1 1976
- LANGE: Recuperation as used in ceramic and glass  
industries  
Indust. Heating Vol 41 No. 2 1974
- LANGMAN: Furnace Builders. Users warm to alumina fibres.  
Chartered Mechanical Engineer Sept. 1977
- LANGRISH: Wealth from knowledge  
Macmillan 1972



- LAURENCE:** Organisational buying behaviour  
Indust. Mkting Digest Vol 3 No. 1 1978
- LAWRENCE + LORSCH:** Organisation and environment. Managing  
differentiation and integration  
Harvard 1967
- LAYTON + HARLOW:** Ten innovations  
Central Advisory Council for Science and  
Technology 1968
- LAZARSFELD:** The peoples choice  
N.Y. Free Press 1944
- LAZER + BELL:** The communication process and innovation  
J.Adv. Res. Sept. 1966
- LaGARCE + PRELL:** Transactional marketing: An understanding  
of the industrial marketing process  
Indust. Mkting Mgmt Vol 7 No. 1 1978
- LEHMANN + O'SAUGHENESSY:** Difference in attribute importance for  
different industrial products  
J. Mkting Vol 38 April 1974
- LEVITT:** Marketing myopia  
HBR July/Aug. 1960
- LEVITT:** Innovation imitation  
HBR Sept/Oct 1966
- LIBIEN:** Product design is everybodys business  
Managerial Planning Jan/Feb. 1977
- LIKERT:** The human organisation  
McGraw-Hill 1967
- LINGL:** Energy Conscious kiln design  
Canadian Clay & Ceramics Sept. 1977
- LINGL:** Dryer and kiln development today with regard  
to the future development of the energy situation  
Berlin Dtsch. Keram. Ges. Vol 55 No. 1 1978

- LIPSEY + STEINER: Economics  
Harper 1966
- LITTLE: New focus on new product ideas  
Business Quarterly Summer 1974
- LITTLER: How to lessen the risk factor in innovation  
Indust. Advertising and Marketing March 1974
- LUCAS: Energy Crisis  
Trans J. Brit. Ceram. Soc. Vol 73 No. 4 1974
- LUCK: Interfaces of a product manager  
J.Mkting Vol. 33 Oct. 1969
- LUFFMAN: Industrial buyer behaviour  
Euro. J. Mkting Summer 1974
- LYNN: An investigation of the rate of development  
and diffusion of technology in our modern  
society  
Nat. Com. on Technology, Automation &  
Economic Progress: Washington 1966
- MANSFIELD: Technical change and the rate of imitation  
Econometrica Vol 29 Oct. 1961
- MASFIELD: Size of firm, market strucutre and innovation  
J. Political Economics Vol LXXXI No. 6 Dec 1963
- MANSFIELD: Innovation and technical change in the railroad  
industry.  
Nat. Bureau of Economic Research N.Y, 1965
- MANSFIELD: Industrial research and technological innovation  
Norton 1968
- MANSFIELD: Research and innovation in the modern corporation  
Norton 1971
- MARCEAN: Communication and development. A reconsideration  
-
- MARCH + SIMON: Organisations  
Wiley 1958

- MARSCHAK:** Contributions in mangement  
Univ. California 1960
- MARSHALL:** An introduction to the use of todays fuel oils  
American Ceram. Soc. Bull. Vol 54 No. 9 1975
- MARTIN:** New products new profits  
American Mgmt. Assoc. 1964
- MATERIALS ADVISORY BOARD:** Report on the Ad Hoc Committee on principles  
of research - engineering interaction  
U.S. National Research Council 1966
- McALEER:** Do industrial advertisers understand what  
influences their markets?  
J. Mkting Vol. 38 Jan. 1974
- McCLELLAND + ATKINSON:** The Achievement motives  
- 1953
- McFADDEN + REMMEY:** The jet burner. A new concept in fast  
precision firing  
American Ceram. Soc. Bull. Vol 41 No. 3 1962
- McIVER:** Six alternatives to innovation  
Indust. Mkting Digest Vol 3 No. 4 1978
- McTAVISH:** Problems of resource allocation to innovation  
11th Mkting Seminar. Univ. Strathclyde May 1973
- MENDHEIM:** Latest technical developments in the design  
of tunnel kilns  
Interceram. Vol 21 No. 3 1972.
- MENZEL + KATZ:** Social relations and innovation: the medical  
profession  
Public Opinion Quarterly Vol 19 1955
- MERTON:** Social theory and social structure  
Free Press 1957
- MIDGLEY:** Innovation in the fashion market. A status  
report.  
11th Mkting Seminar Univ. Strathclyde May 1973



- MIDGLEY: Innovation and new product planning  
- 1977
- MOGEE + BEAN: The role of the purchasing agent in industrial  
innovation  
Indust. Mkting Mgmt Vol 5 No. 4 1976
- MOORE + RENEK: The professional employee in industry  
J. Business Vol 27 Jan 1955
- MORTON: Organising for innovation. A system approach  
to technical managment  
Free Press 1971
- MUELLER: The innovative ethic.  
American Mgmt Assoc. 1971
- MUSE + KEGERREIS: Technological innovation and marketing  
management. Implications for corporate policy  
J. Mkting Vol 33 Oct. 1969
- MYERS + MARQUIS: Successful industrial innovations  
National Science Foundation No. 17 1969
- NARAYANA + MARKIN: Consumer behaviour and product performance  
An alternative conceptualisation  
J. Mkting Vol 39 No. 4 1975
- NELSON: The rate and direction of inventive activity.  
Economic and social forces  
Princeton Univ. Press 1962
- NELSON + PECK: Technology, economic growth and public  
policy  
Brooking Institute 1967
- NEWALL: Industrial buyer behaviour  
Euro J. Mkting Vol 11 No. 3 1977
- NICHOLSON: Technological forecasting as a mangement  
technique  
H.M.S.O. 1968

- NICHOLSON: Market research and R & D priorities  
Mgmt Decision Vol 9 Summer 1971
- NICOSIA: Consumer decision processes  
Prentice Hall 1966
- NICOSIA + WIND: Emerging models of organisational buying  
processes  
Indust. Mkting Vol. 6 1977
- NIEDERGESASS: The efficient use of gas in the ceramics  
aid refractories industries  
Keram Z Vol 27 No. 10 1975
- NISTRI: Advanced technology in the prefabrication  
of tunnel kilns  
Industrie Ital. Latierizi Vol. 31 No.2 1977
- NORRIS: Thermal efficiency in potteries  
Ceramics Vol 25 No. 292 1974
- OATES: How Gould manages innovation  
International Mgmt. Dec. 1975
- OFFNUT: Refractories gearing for tomorrows demands  
Ceramic Age April 1972
- OGDEN: Ceramic fiber furnace linings extend service  
temperatures economically  
Indust. Heating Vol 40 No. 5 1973
- OGDEN: Applications and economics in the use of new  
higher temperature ceramic fibre insulating  
refractories  
Refractory Engineering Winter 1973
- O'MEARA: Selecting profitable products  
HBR Jan/Feb 1961
- OPRON: The Renault method  
Design Sept. 1976
- O'SHAUGHNESSY: Aspects of industrial buying behaviour  
relevant to supplier account strategies  
Indust. Mkting Mgmt Vol 6 No. 1 1977

- OWEN: Rover. Step by step  
Design Aug. 1976
- OZANNE + CHURCHILL: Adoption research. Information sources in  
the industrial purchasing decision.  
American Mktng Assoc. Conference Fall 1968
- OZANNE + CHURCHILL: Five dimensions of the industrial adoption  
process  
J. Mkt. Res. Vol 8 Aug 1971
- PALDA: The hypothesis of hierarchy of effects  
J. Mkt. Res. Feb 1966
- PARKER: The economics of innovation  
Longmans 1974
- PARMENTER + GARBER: Creative scientists rate creativity factors  
Research Mgmt Nov. 1971
- PARSONS: Structure and process in modern societies  
Glencoe Free Press
- PARSONS: The framework of technological innovation  
Macmillan 1968
- PEAT et al: A comment on identifying buyers of a  
major automotive innovation  
J.Mktng Vol.39 No. 4 4 1975
- PEDRAGLIO: Getting into shape to manage new products  
European Business Summer 1971
- PENA + VALDES: Changing from gas to oil-firing  
Ceram. Indust. Journal Vol 85 No. 996 1976
- PESSEMEIR: New product decisions. An analytical approach  
McGraw-Hill 1966
- PETERS: Waste heat utilisation from kilns and dryer  
plant  
Ziegel Industrie No. 12 1975



- PETERSON: A note on optimal adopter category determination  
J. Mkt Res. Vol 10 Aug. 1973
- PETERSON: Working R + D into corporate strategy  
Conference Board Record Jan. 1976
- PETIT: A behavioural theory of management  
Academy of Mgmt. Journal Dec. 1967
- PETRINI: Experiment with different time disposition  
of a given extension programme  
Uppsala Agricultural College. Sweden 1967
- PETTIGREW: The industrial purchasing decision as a  
political process  
Euro J. Mkting Vol 9 No. 1 1975
- PERROW: The analysis of goals in complex organisations  
American Sociological Review Vol 26 No 6 1961
- PERRY: Chemical engineers handbook  
McGraw-Hill 1950
- PFIFFNER + SHERWOOD: Administrative organisation  
Prentice-Hall 1960
- PILKINGTON: The float glass process  
Royal Society A.3/4 London 1969
- PINSON et al: An explanation of the general theory of marketing  
J. Mkting Vol 36 July 1972
- POLLI + COOK: Validity of the product life cycle  
J. Business Oct. 1969
- POWELL + ROSEMAN: An investigation of the sub-processes of  
diffusion  
Rural Sociology Vol 37 No. 2 June 1972
- PREHODA: Designing the future; the role of technological forecasting  
Chilton Books 1967
- HRH PRINCE PHILLIP: Foreward in the Engineer 1976

- PROCTOR: What's new in innovation?  
Quarterly Review of Mktng Autumn 1975
- PROCTOR: The high velocity burner in kiln firing  
Euroclay No. 1 1976
- PUGH: Context of organisational structures  
Administrative Science Quarterly Vol 14 1969
- RAO et al: A study of the motivation patterns of farmers  
towards the adoption of high-yielding varieties  
of wheat  
Behavioural Science and Community Development  
Vol 5 No. 1 1971
- RAY: The diffusion of new technology. A study of  
ten processes in nine industries  
Nat. Institute Economic Review March 1969
- REDLICH: Innovation in business  
American J. Economics and Sociology Vol 10  
April 1951
- REEKIE: On the shelf  
Centre for the study of Industrial Innovation  
1971
- REEKIE: The marketing: R & D interface Causes of new  
project failure  
11th Mktng Seminar. Univ. Strathclyde May 1973
- REYNOLDS: Problem orientation. An emerging dimension of  
adoption research.  
Rural Sociology Vol 36 No. 2 1971
- REYNOLDS: Problem orientation  
Rural Sociology Vol 36 No. 3 1971
- RHODES: Kilns: Designs, construction and operation  
Pitman 1969
- RICHARDSON: Refractories today  
J. Institute of Fuel Vol 45 No. 372 1972
- RINK: The product life cycle in formulating  
purchasing strategy

- ROBERTS: A basic study of innovators; how to keep and capitalise on their talents  
Research Mgmt Vol 11 Pt. 4 1968
- ROBERTS: Technology strategy for the European firm  
Indust. Mktng Mgmt Vol 4 Aug 1975
- ROBERTSON: The process of innovation and the diffusion of innovation  
J. Mktng Vol 31 Jan. 1967
- ROBERTSON: The management of industrial innovation  
Occasional Paper No. 7 Industrial Economics and Research Foundation 1970
- ROBERTSON: Innovative behaviour and communication  
Holt R.W. 1971
- ROBERTSON: Information flow and industrial innovation  
Aslib Proceedings Vol 25 No. 4 1973
- ROBERTSON: Avoid being a me-too product dunce  
Bus. Admin. July 1974
- ROBEY + JOHNSTON: Lateral influences and vertical authority in organisational buying  
Indust. Mktng Mgmt Vol 6 No. 6 1977
- ROBINSON: Style changes: cyclical, inexorable and foreseeable  
-
- ROBINSON: -  
Food Engineering Vol 47 May 1975
- ROE: Making a scientist  
Appollo Books 1959
- ROGERS et al: The importance of personal influence in the adoption of technological changes  
Social Forces Vol 36 1957
- ROGERS + BURIDGE: Muck vegetable growers. Diffusion of innovation among specialist farmers  
- 1961



- ROGERS: Diffusion of innovations  
Free Press 1962
- ROGERS + SVENNING: Modernisation among peasants. The impact of  
communication  
- 1969
- ROGERS + SHOEMAKER: Communication of innovations  
Collier Macmillan 1971
- ROGERS: Adopting the periodic kiln for heat recovery  
Brick Clay Record Vol 170 No. 6 1977
- ROGERS: Periodic kilns and energy efficiency  
Brick Clay Record Vol 171 No. 1 1977
- ROLLA: Advanced technology in the prefabrication of  
tunnel furnaces for the ceramic and brick industry  
Refrattari Laterizi Vol 2 No. 5 1977
- ROTHBERG: Playing it safe in new product decisions  
S.A.M. Adv. Mgmt Journal Autumn 1975
- ROTHBERG (ed): Corporate strategy and product innovation  
Free Press 1972
- ROTHWELL + ROBERTSON: The role of communications in industrial  
innovation  
Research Policy Vol 2 1973
- ROTHWELL: Marketing and successful industrial innovation  
11th Mktng Seminar. Univ. Strathclyde May 1973
- ROTHWELL + ROBERTSON: The contribution of poor communication  
to innovative failure  
Aslib Proceedings Vol 27 No. 10 1975
- ROTHWELL: Innovation in the U.K. textile machinery  
industry. The results of a postal questionnaire  
survey  
R & D Mgmt Vol 6 No. 3 1976

- ROTHWELL: Characteristics of successful innovators  
R + D Mgmt Vol 7 No. 3 1977
- RUBENSTEIN + HABERSTROH: Some theories of organisation  
Dorsey Press 1966
- RUSHING: The effects of industry size and division of  
labor on administration  
Admin. Science Quarterly Sept. 1967
- RUTTAN: Usher and Schumpeter on innovation, invention  
and technological change  
Quarterly J. Economics Nov. 1959
- RYAN + GOSS: The diffusion of hybrid seed corn in two  
Iowa communities  
Rural Sociology Vol 8 1943
- RYAN + MURRAY: Spreading the word  
Mgmt. Dec. 1975
- RYAN + MURRAY: Diffusion of pharmaceutical innovation  
Euro. J. Mkting Vol 11 No. 1 1977
- SALT + HOLMES: Energy conservation: efficient operation of  
kilns and gas-fired dryers  
Brit. Ceram. Res. Assoc. Technical Note 256 1976
- SALTER: Productivity and technical change  
Dept. Applied Economics Cambridge Univ. Press  
1966
- SANDERS: Ceramic fiber furnaces lining systems.  
Applications, manufacture, installation  
Indust. Heating Vol 41 No. 4 1974
- SCHERER: Firm size, market structure, opportunity and  
the output of patented invention  
American Economic Review Dec. 1965
- SCHERER: Industrial market structure and economic  
performance  
Rand McNally 1971
- SCHMOOKLER: Invention and economic growth

- SCHMOOKLER: The economic sources of inventive activity  
J. Economic History March 1962
- SCHMOOKLER: The rate and direction of inventive activity  
Princeton Univ. Press 1962
- SCHON: Champions for radical new innovations  
HBR March / April 1963
- SCHON: Technology and change  
Delacorte Press 1967
- SCHON: Technology and change. The new heraclitus  
Pergamon Press 1967
- SCHORR: Many new products fizzle despite careful  
planning and publicity  
Wall St. Journal 5 April 1961
- SCHRAMM: Studies of innovation and of communication  
to the public  
- 1961
- SCHUMPETER: The theory of economic development  
Harvard Univ. Press 1934
- SCHUMPETER: Business cycles Vol 1  
McGraw-Hill 1939
- SCHUMPETER: Capitalism, socialism and democracy  
Harper Row 1950
- SCIENCE MUSEUM: Josiah Wedgwood: The arts and science united  
- 1978
- SCOTT: Organisation theory  
Irwin 1967
- SCOWCROFT + PADGETT: The structure and thermal behaviour of  
ceramic fibre blanket  
BCRA Technical Papers Vol 72 No. 3 1974
- SEARLE: Kilns and kiln building  
- 1915



- SEIDMAN:** Barriers to technical innovation  
Science and Public Affairs Vol 27 No. 3 1971
- SEILER:** Improving the efficiency of R & D  
McGraw-Hill 1965
- SEILER:** Systems analysis in organisational behaviour  
Irwin 1968
- SELLS:** Coal firing technology for existing side-fired tunnel kilns  
American Ceram. Soc. Bull. Vol 56 No. 4 1977
- SELZNICK:** Leadership in administration  
Harper Row 1957
- SEVERIENS:** Product innovation, organisational change and risk  
S.A.M. Advanced Mgmt Journal Autumn 1977
- SHEPARD:** Innovation resisting and innovation producing organisation  
J. Business Oct. 1967
- SHETH:** Recent developments in organisational buying behaviour  
College of Commerce. Univ. Illinois 1976
- SHIMSHONI:** The mobile scientist in the American instrument industry  
Minerva Vol 8 No. 1 1970
- SICNSKI:** A two step flow of communication verification of an hypothesis in Poland  
Polish Sociology Bulletin Vol 1 1963
- SIEGERT:** How can the expensive imported fuel oils and gas be replaced by indigenous fuels in the heavy clay and ceramic industries  
Berlin Dtsch. Keram. Ges. Vol 53 No. 1 1976
- SILVERMAN:** The theory of organisations  
Heinemann 1970
- SIVASH + KUZNETSOVA:** Utilisation of secondary energy resources in tunnel kilns  
Refractories Vol 17 No. 12 1976

- SLEVIN:** The innovation boundary. A specific model and some empirical results  
Admin Science Quarterly Dec. 1971
- SMALL:** How to transfer technology  
Mgmt Today Sept 1977
- SMITH:** Modern techniques in firing whiteware  
Brit. Ceram. Review No. 14 1973
- SMITHSON:** Fuel and energy economy in industry. A review of the major areas for investigation  
Trans. J. Brit. Ceram. Soc. Vol 74 No. 6 1975
- SMOLSKI:** New system for the firing of structural ceramic tunnel kilns with solid fuel  
Z.I. International No. 8 1977
- SOHR:** Rapid firing kiln of the 'package kiln' type for porcelain cups  
Keram Z. Vol 28 No. 3 1976
- SORENSEN:** U.S. marketers can learn from European innovators  
H.B.R. Sept/Oct 1972
- SOUDER + CHAKRABARTI:** Government influence and industrial innovation  
Indust. Mkting Mgmt. Vol 7 No. 1 Feb 1978
- SOUDER:** Effectiveness of product development methods  
Indust. Mkting Mgmt. Vol 7 No. 5 Oct 1978
- SPITZ:** Product planning for today and tomorrow
- STANTON:** Communication research 1948-49  
Free Press 1949
- STEELE:** Innovation in big business
- STERN et al:** Perceived risk. A synthesis  
Euro J.Mkting Vol 11 No. 4 1977
- STONE:** How county agricultural agents teach  
Michigan Agricultural Extension Service 1952

- SUANE: Types of burners and their optimum field of application  
Keram Z Vol 28 No. 12 1976
- SURENDORF: Clean air requirements in the ceramic industry  
Berlin Dtsch. Keram. Ges. Vol 53 No. 3 1976
- SWANSON et al: Readings in social psychology  
Holt R.W. 1973
- SWEET + OGDEN: Improved ceramic fibres  
Indust. Process Heating Vol 3 No. 1 1973
- SYMES: Energy savings in intermittent processes  
Energy Seminar Univ. Aston 11 May 1977
- TAGIURI + LITWIN: Organisational climate  
- 1968
- TARDE: The laws of imitation  
Holt Reinhart 1903
- TARLING: Getting new technical ideas onto the market  
has its problems  
Advertising & Marketing Winter 1975
- TAUBER: How market research discourages major innovation  
Bus. Horizon Vol 17 No. 3 June 1974
- TAYLOR: A striking characteristic of innovators  
J.Mkt. Res. Vol 14 Feb 1977
- TESAR et al: The role of marketing in the introduction  
of technologically new products: the case of  
the Electric Car.  
J. Academy of Mktng Science Vol 2 Autumn 1974
- THOMAS + GOODWIN: An examination of the management of the R & D:  
Marketing interface in several British companies  
Qtly Review of Mktng Autumn 1976
- THOMPSON: Bureaucracy and innovation  
Admin Science Qtly June 1965
- THOMPSON: Approaches to organisational design  
Pittsburgh 1966



- TORDOFF: Fiberwall-lined kilns have potential in the ceramic industry  
Ceramics June 1973
- TOWERS: Venture management  
Free Press 1970
- TROLDAHL: A field study of a modified two step flow of communication model  
Public Opinion Qtly Vol 30 1967
- TWISS: Managing technological innovation  
Longmans 1974
- UDELL + O'NEILL: Encouraging the non-corporate inventors  
Bus. Horizons Aug 1977
- URBAN: A new product analysis and decision model  
Mgmt Science Vol 4 April 1968
- USHER: A history of mechanical invention  
Harvard Univ. Press 1954
- USHER: Technical change and capital formation  
National Bureau of Economic Res. (U.S.) 1955
- VAN den BAN: A revision of the two step flow of communications hypothesis  
Gazette Vol 10 1964
- VESPER + HOLMDAHL: How venture management fares in innovation companies  
Res. Mgmt May 1973
- VIEHE: Fast firing in tunnel kilns with the ISO-JET system  
Interceram Vol 24 No. 1
- VON HIPPEL: Successful industrial products from customer ideas  
J. Mkting Jan 1978
- WALKER: Why anchors come out  
Indust. Heating Vol 38 No. 6 1971

- WARRILLOW: A sociological history of the City of Stoke-on-Trent  
Ironmarket Press 1977
- WASSON: The importance of the product life cycle to the industrial marketer  
Indust. Mktng Mgmt Vol 5 1976
- WAY REPORT: Machine tool industry  
HMSO 1970
- WEBB: New burners for the ceramic industry  
Brit. Ceram. Review No 14 1973
- WEBER: The theory of social and economic organisation  
Free Press 1964
- WEBER: Planning corporate growth with inverted product life cycles  
Long Range Planning Vol 9 No. 5 Oct 1976
- WEBSTER: On the applicability of communication theory to industrial markets  
J. Mkt. Res. Vol 5 Nov. 1968
- WEBSTER: New product adoption in industrial markets. A framework for analysis  
J. Mktng Vol 33 July 1969
- WEBSTER: Informal communication in industrial markets  
J. Mkt. Res. Vol 7 May 1970
- WEBSTER: Communication and diffusion processes in industrial markets  
Euro J. Mktng Vol 5 No. 4 1971
- WEBSTER + WIND: A general model for understanding organisational buying behaviour  
J. Mktng Vol 36 April 1972
- WELLER: Overseas marketing and selling  
Pitmans 1971
- WELLER + CLEMENTS: New product planning  
U.N.C.T.A.D. 1979

- WHITE: The diffusion and adoption of new products  
with particular reference to textile chemicals  
(unpub) M. Phil thesis. Huddersfield Polytechnic  
1974
- WHITFIELD: Creativity in industry  
Pelican Books 1974
- WHITTEMORE: Energy consumption in ceramic processes  
American Bulletin Ceram. Soc. Vol 53 No. 5 1974
- WHYTE: The use of word-of-mouth  
Fortune Nov. 1954
- WILLS: Technological forecasting  
Pelican Books 1972
- WIND: Industrial source loyalty  
J. Mkt Res. Nov. 1970
- WILSON (ed): Marketing of industrial products  
Hutchinson 1965
- WOODWARD: Industrial organisation. Behaviour and control  
- 1970
- WOUDHUYSEN: Information bridges the invention/demand gap  
Design July 1977
- WRIGHT + CANTOR: The opinion seekers and avoiders: steps  
beyond the opinion leader concept  
Pacific Sociology Review Vol 10 1967
- WULFF: The traditional crafts of Persia  
M.I.T. Press 1966
- ZALTMAN et al: Metatheory in consumer behaviour  
2nd American Conference of the Assoc. for  
Consumer Research  
Illinois 1971
- ZALTMAN: Metatheory and consumer research  
Holt R.W. 1973



- Supplier analysis for capital equipment purchases  
Procurement Sept 1974
- Refractory fibres. A growing success  
Refractories Journal June 1974
- Modules overcome ceramic fibre problems  
Ceramics Industries Journal Dec. 1974
- F.S.C.S. A new approach to kiln construction  
British Ceramic Review No. 2 1975
- Influence of the energy crisis on choosing a tunnel kiln  
Ceramic Information Vol. 10 No. 103 1975
- Lasers and kiln construction  
Chemical Technology Vol 6 No. 4 1975
- How research and development is funded by the Dept of Industry and how market research can help in its evaluation  
I.M.R.A. Journal May 1975
- New biscuit kiln a fuel saver  
Ceramics Industries Journal June 1975
- Successful product innovations. 3 case histories  
Euro. J. Mkting Vol 10 No. 6 1976
- The breakdown of U.S. innovations  
Business Week 10 Feb. 1976
- Refractory fibres  
Euroclay No. 2 1976
- How ceramic fiber improves tunnel kiln performance  
Brick Clay Record April 1976
- New directions in kiln design  
American Ceram. Soc. Bull Vol 56 No. 9 1977

- Kiln converted to pave way for new plant  
Ceramic Industries Journal Vol 86 No. 1003 1977

- Ceramics. Energy update. Staff report  
American Ceram. Soc. Bull. Vol 56 No. 6 1977

- Kiln is half usual cost  
Ceramic Industries Journal Vol 86 No. 1002 1977

- Veneer lining success  
Refractories Journal Vol 52 No. 4 1977

- New product development  
Euro. J. Mktg Vol 12 No. 3 1978